Santos
GLNG Project

# GLNG
## Gas Transmission Pipeline

## Aquatic Values Management Plan
## Mainland KP 0-406, KP 406-410 (Tidal Area)
## and Curtis Island KP414-420

Document Number: 3380-GLNG-4-1.3-0128

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | N. Gibson | | 23/09/13 |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | C. Moore | | 23.9.13 |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Project Manager - Pipeline | G. Jones pp | | 23-9-13 |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 24/04/13 | E | For Submission | NG | DP | GJ |
| 14/06/13 | F | For Submission | NG | DP | GJ |
| 24/06/13 | G | For Submission | NG | CM | GJ |
| 23/09/13 | H | For Submission | NG | CM | GJ |
| | | | | | |

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## SUPPORTING DOCUMENTATION

- Erosion and Sedimentation Control Plan – Pipeline Construction KP0 – 70 (3380-SAIP-4-1.3-7038).
- Erosion and Sedimentation Control Plan – Pipeline Construction KP70 – 200 (3380-SAIP-4-1.3-1833).
- Erosion and Sedimentation Control Plan – Pipeline Construction KP200 – 406 (ESCP KP200 - 406) – (3380-SAIP-4-1.3-7039).
- Erosion and Sedimentation Control Plan – Pipeline Construction KP402 – 409 (3380-SAIP-4-1.3-7259).
- Erosion Sediment Control Plan – Curtis Island (3380-SAIP-4-1.3-7156).
- Acid Sulfate Soils Management Plan GTP and Launch Pad (3380-SAIP-4-3.3-1832).
- Species Management Plan (3380-GLNG-3-1.3-0036).
- Significant Species Management Plan (3380-GLNG-4-1.3-0104).

## ABBREVIATIONS

| | |
|---|---|
| APIA | Australian Pipeline Industry Association |
| ASS | Acid Sulphate Soils |
| ARI | Average Recurrence Interval |
| AUSRIVAS | Australian River Assessment System |
| AVA | Aquatic Values Assessment |
| AVMP | Aquatic Values Management Plan |
| BOM | Bureau of Meteorology |
| CEMP | Construction Environmental Management Plan |
| CG | Coordinator-General |
| CM | Construction Manager |
| CSG | Coal Seam Gas |
| DAFF | Department of Agriculture, Fisheries and Forestry |
| DEEDI | Department of Employment, Economic Development and Innovation (Now DSDIP) |
| DEHP | Department of Environment and Heritage Protection (Previously DERM) |
| DERM | Department of Environment and Resource Management (Now DEHP) |
| DO | Dissolved Oxygen |
| DPIF | Department of Primary Industries and Fisheries |
| DSDIP | Department of State Development, Infrastructure and Planning (Previously DEEDI) |
| DSEWPC | Department of Sustainability, Environment, Water, Population & Communities |
| EA | Environmental Authority |
| EC | Environmental Coordinator |
| EHSMS | Environment, Health and Safety Management System |
| EIS | Environmental Impact Statement |
| EM | Environmental Manager |
| EMP | Environmental Management Plan |
| EMRS | Environmental Monitoring and Reporting System |
| EP Act | *Environmental Protection Act (Qld) 1994* |
| EPBC Act | *Environmental Protection and Biodiversity Conservation Act (Cth) 1999* |
| ESA | Environmentally Sensitive Area |
| ESCP | Erosion and Sediment Control Plan |
| FOC | Fibre Optic Cable |
| GBRWHA | Great Barrier Reef World Heritage Area |
| GIS | Geographic Information System |
| GLNG | Gladstone Liquefied Natural Gas |
| GPS | Global Positioning System |
| GTP | Gas Transmission Pipeline |
| HDD | Horizontal Directional Drilling |
| HSE | Health, Safety and Environment |
| HS&S | Health, Safety and Security |
| HS&SM | Health, Safety and Security Manager |
| HWMP | Hydrotest Water Management Plan |
| IMS | Incident Management System |
| KP | Kilometre Point |
| LiDAR | Light Detection and Radar |
| LNG | Liquefied Natural Gas |
| LRMP | Landscape Rehabilitation Management Plan |
| NC Act | *Nature Conservation Act (Qld) 1992* |
| OH&S | Occupational Health and Safety |
| PM | Project Manager |
| PPE | Personal Protective Equipment |

| | |
|---|---|
| PPL | Petroleum Pipeline License |
| QG Pipeline | Queensland Gas Pipeline |
| RE | Regional Ecosystem |
| ROW | Right of Way |
| SEIS | Supplementary Environmental Impact Statement |
| SEO | Site Environmental Officer |
| SMP | Species Management Plan |
| SO | Stream Order |
| SQEP | Suitably Qualified and Experienced Professional |
| SSMP | Significant Species Management Plan |
| SWMS | Safe Work Method Statement |
| TSS | Total Suspended Solids |
| VM Act | *Vegetation Management Act (Qld) 1999* |
| WHA | World Heritage Area |

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## EXECUTIVE SUMMARY

GLNG proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport coal seam gas (CSG) from the CSG fields at Roma and Fairview to the proposed liquefied natural gas (LNG) facility on Curtis Island. There are a total of 265 watercourses to be traversed by the 420km GTP.

The purpose of this Aquatics Values Management Plan (AVMP) is to address the requirements of EPBC Condition 37 and 38, Environmental Authority condition D35 and the Coordinator-General's evaluation report, Appendix 3, Part 3, Condition 3. The Plan identifies the overall aquatic values[1] and potential suitable habitat for listed species within major watercourses between kilometre point (KP) 0 to KP 420 on the Mainland and Curtis Island sections of the GTP. The Plan also identifies appropriate construction methodology and detailed mitigation measures for each watercourse crossing based on the surveyed aquatic value of each watercourse.

This AVMP is supported by Aquatic Values Assessments (AVA) for Major Watercourses and Minor watercourses, which outline the detailed methodology and results for the field survey assessments across the entire GTP. The field surveys were undertaken at all major watercourses, stream order (SO)[2] 3 or above, of which there are 50. Of these major watercourses, 10 were assessed as having High aquatic values, with 20 being found to have Moderate aquatic value and the remaining 20 were assessed as having Negligible to Low aquatic values. A representative sample (20%) of minor watercourses (SO 1 or 2) was assessed in the field. The majority of minor watercourse had negligible to low aquatic value, with only 6 being identified as having moderate aquatic value. Of these minor watercourses only one in the tidal section of the GTP contained habitat for a conservation significant species.

There are also four tidal watercourses that are traversed by the GTP between KP 406-410 (one major and three minors) and these were assessed and determined to have moderate aquatic value. The crossing locations for the tidal watercourses, including Humpy and Targinie Creek (major and minor watercourse respectively), have changed significantly since the initial proposed GTP alignment (refer Figure 6). The superseded crossing locations of Humpy and Targine Creeks (both major watercourses at these crossing locations) were assumed to have high aquatic values due to them being located within estuarine wetlands and were therefore required to be crossed via a trenchless crossing method. The selection of tunneling to cross The Narrows and avoid impacts to marine habitat has also resulted in the avoidance of disturbance to estuarine wetlands. The final alignment (refer figure 6) and crossing locations of these creeks has resulted in these watercourses neither having high aquatic values nor requiring a trenchless crossing methodology. Refer to Section 13.12 for details on aquatic values and crossing methodology for tidal watercourses.

[1] *Negligible* – aquatic habitat and aquatic life not present; *Low* – aquatic habitat present but aquatic life not present, site contains water only during heavy rainfall events, otherwise site is dry; *Moderate* – aquatic habitat and aquatic life present, but conservation significant or endemic species unlikely to occur; *High* – aquatic habitat and aquatic life present, and conservation significant and endemic species and their breeding places likely to occur.

[2] Stream order is typically a representation of stream size and is a numerical ordering system of each stream section based on its position in a catchment. Small streams that commence in the catchment headwaters are considered first order streams, and as they connect with other streams further down the catchment, they progressively get larger and become higher order streams (DERM 2010c).

For the purposes of this AVMP the 10 watercourses with High aquatic values were investigated in further detail to establish suitable construction methodologies, as these watercourses have potential suitable habitat for listed significant species under either or both State and Commonwealth Governments.

Based on the field surveys, it has been determined that there are no listed (under State or Commonwealth legislation) aquatic flora species located within the surveyed area. There are three aquatic fauna species that are listed under State or Commonwealth legislation, that have the potential to be found within the Mainland surveyed area, these are the white-throated snapping turtle (*Elseya albagula*), Fitzroy River turtle (*Rheodytes leukops*) and the platypus (*Ornithorhynchus anatinus*). During field surveys it was determined that suitable habitat for the Fitzroy River turtle was found at four sites, Baffle Creek, Dawson River (Upstream) (albeit unlikely), Mimosa Creek and Dawson River (Downstream). While Hutton Creek, Baffle Creek, Dawson River (Upstream), Mimosa Creek, Dawson river (Downstream), Calliope River, Harper Creek and the two Larcom Creek crossings were surveyed to contain suitable habitat for both the white-throated snapping turtle and/or platypus. Within the Tidal area (KP406-410) it was determined that there are no freshwater or marine aquatic fauna species that have the potential to be found within the surveyed area. There is one terrestrial species listed under both State and Commonwealth legislation that has the potential to be found in the surveyed area, being the *Xeromys myoides* (commonly known as water mouse or false water rat). This species was not identified at any of the tidal watercourses and only one out of the four tidal watercourses (Targinie Creek) has been mapped as general habitat.

The purpose of this AVMP is to assist in determining the most appropriate construction methodology at each watercourse that will minimize impacts to aquatic values including EPBC Act listed flora and fauna species. For the 10 watercourses with High aquatic value, studies were undertaken to determine the feasibility of realignment of the GTP to avoid these areas. Ground surveys were conducted from 50 m either side of the ROW to determine the optimal crossing point. Where it was determined not possible to avoid areas of high value, the use of a trenchless watercourse crossing construction methodology (i.e. Horizontal Direct Drilling (HDD)), in comparison to open trench construction methodology was investigated in detail.

The GTP was realigned to avoid a palustrine wetland at KP177. The GTP no longer traverses through this wetland and crosses upstream of Prospect Creek in an area of low to moderate aquatic value. This section of Prospect Creek does not contain suitable habitat for conservation significant species. The GTP was also realigned to avoid the High aquatic value reaches of Mimosa Creek at KP220. The GTP now traverses a section of Mimosa Creek with low to moderate aquatic value which would not support populations of conservation significant species. A minor realignment at Dawson River (Downstream) KP234 was also undertaken to avoid a deep permanent pool at the original crossing location. The revised crossing location is better for construction and has less environmentally significant features but has the same (high) aquatic values.

Given this, it was not possible to realign the GTP to avoid the High aquatic value reaches for the remaining 8 watercourses (Dawson River inclusive). The feasibility of HDD was investigated in detail for these watercourses. Several criteria were examined for this investigation. These included the extent of ecological impact (both aquatic and terrestrial), construction footprint, construction and engineering risk, duration of works, costs involved and social impacts for each method. However, the primary factor to determine the feasibility for HDD was an assessment of site geology to establish the construction risk and feasibility. Investigative boreholes were drilled at each of the watercourses to assess site geology.

For Hutton creek (KP2), Baffle Creek (KP20) and Dawson River (Upstream) (KP29), the presence of highly fractured and weathered rock poses an extreme risk for failure of HDD and a subsequent high potential for uncontrolled release of drilling fluids into the environment. The hard rock in these areas also poses a significant risk on the pipe coating and integrity. It was determined that HDD was not feasible at these locations.

Site Geology surrounding Dawson River (Downstream) (KP233), Calliope River (KP353), Harper Creek (KP360) and both Larcom Creek crossings (KP378 and KP384) contained high levels of loose gravel and sand. The presence of loose gravel and sand indicate that HDD is not possible at these sites as it presents a high risk for bore hole stability during drilling and pull back operations.

A detailed analysis for a suitable construction methodology for each of the 8 remaining High aquatic value watercourses is demonstrated in Appendix G1. Presented in Appendix G2 is a further detailed investigation for technical and geotechnical assessment for the Baffle Creek crossing.

The findings of the site specific assessments indicate open trench crossing is an acceptable construction methodology for all sites. All open trenched major high value watercourses will be crossed during the dry season, where possible, to minimise the chances of high flows.

Recommended mitigation measures for construction of watercourse crossings include:

- Construction in the dry season where possible.
- Where construction is conducted in wet situations or substantial pools are present:
    - Use of minor dam and flow diversion (flume and/or pump) crossing methodology (if stream is flowing).
    - Salvaging fish and other aquatic fauna from isolated workspace prior to de-watering.
    - Minimising construction time within the watercourse.
    - Monitoring water quality upstream and downstream of construction site to ensure the effectiveness of erosion and sediment control measures.
- Pre-clearance surveys conducted prior to commencement of construction to ensure sites are rehabilitated to pre-construction conditions.
- Watercourses which were identified to have suitable habitat for aquatic conservation significant species (of which there are 8), will be inspected by suitably qualified ecologist immediately prior to construction to ensure there are no active nests or burrows in the vicinity of the ROW.

Specific recommendations for Mainland sites assessed in the field surveys are included in the Site Assessment Sheets (Appendix C), and detailed construction methodologies and mitigation measures for each site are presented in Tables 13-1, 13-9 and 13-10 of this plan.

In summary, there is to be no impact upon any listed aquatic flora or fauna species or aquatic ecological communities (as listed under State or Commonwealth legislation), at the majority of watercourses within the surveyed area as they have been determined to lack suitable habitat to sustain any populations of these species. At the 8 sites where potential habitat of listed species was observed (under State or Commonwealth legislation), additional mitigation measures will ensure that potential impacts on the species are appropriately mitigated during open trenching activities.

The impact assessment demonstrates that, where the appropriate mitigation measures are used as set out in this Plan, there will be minimal impact to local aquatic environments within the surveyed area.

# 1 INTRODUCTION

## 1.1 Background and Context

The GLNG project is a joint venture partnership between Santos GLNG Pty Ltd, PETRONAS Australia Pty Ltd, Total E&P Australia and KOGAS (hereafter referred to as GLNG). GLNG proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport coal seam gas (CSG) from the CSG fields at Roma and Fairview to a proposed liquefied natural gas (LNG) facility on Curtis Island. The GTP forms one component of the Gladstone Liquefied Natural Gas (GLNG) Project (hereafter referred to as the Project), which includes:

- Exploration and production of CSG in the Surat Basin and Bowen Basin gas fields.
- Construction and operation of the GTP from the CSG fields to the LNG facility on Curtis Island (refer to Figure 1).
- Construction and operation of the LNG facility.

On the 28 May 2010, GLNG received its environmental approval from the Queensland Coordinator-General. On 22 October 2010, the project received its environmental approval from the Commonwealth Environment Minister under the *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act 2008/4096).

As an outcome of the State's environmental approval process and through discussions with Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), GLNG is committed to developing an Aquatic Values Management Plan (AVMP) so as to inform the design and construction phases, in addition to identifying strategies to avoid, minimise and mitigate potential impacts.

This Plan is the final Plan of a series of AVMPs that have been prepared to address the requirements the Commonwealth government. Revision E therefore includes all previously approved revisions of this Plan and the four tidal watercourses. The AVMP's addressed watercourses and/or amendments within the following sections of the project.

- All mainland and Curtis Island watercourses between kilometer post (KP) 0 and KP 406 and KP410 to KP420 (excluding Baffle creek) (Rev A and B).
- Baffle Creek KP20.4 (Rev C).
- Amendments (Rev D).
- All tidal watercourses (KP406 - 410) (Rev E-G).
- Reroutes and minor amendments (Rev H).

It should be noted that separate management plans have been developed to address environmental constraints related to the AVMP, including:

- Breeding places (Species Management Plan (SMP) – (3380-GLNG-3-1.3-0036)).
- Threatened and conservation significant species (Significant Species Management Plan (SSMP) (3380-GLNG-4-1.3-0104)
    - KP0-30 (Approved).
    - KP30-40 (Approved).
    - KP40-130 (Approved).
    - KP130-312 (Approved).
    - KP312-408 (Approved).
    - KP408-420 (Under development).
- Soils

  - ESCP – Pipeline Construction ROW KP0 – KP70 (ESCP KP0 – 70) – (3380-SAIP-4-1.3-7038).
  - ESCP – Pipeline Construction ROW KP70 – KP200 (ESCP KP70 – 200) – (3380-SAIP-4-1.3-1833).
  - ESCP – Pipeline Construction ROW KP200 – KP406 (ESCP KP200 – 406) – (3380-SAIP-4-1.3-7039).
  - ESCP – Pipeline Construction (ESCP KP402 – 409) – (3380-SAIP-4-1.3-7259).
  - ESCP – Pipeline Construction Curtis Island (3380-SAIP-4-1.3-7156).
  - Soil Management Plan (3380-SAIP-4-1.3-1991).
  - Acid Sulfate Soils Management Plan GTP Route and Launch Pad (3380-SAIP-4-3.3-1832).
- GLNG Mainland Environmental Management Plan (Mainland EMP) (3380-GLNG-3-8.2-0027).
- GLNG Marine Crossing Environmental Management Plan (Marine Crossing EMP) (3380-GLNG-4-8.2-0021).
- GLNG Curtis Island Environmental Management Plan (Curtis Island EMP) (3380-GLNG-4-8.2-0022).

## 1.2 Purpose

The purpose of this AVMP is to identify the overall aquatic ecological values and determine appropriate construction methodology to minimise impacts. The Plan details potentially suitable habitat for relevant species within the proposed watercourse crossings on the Mainland, Tidal areas and Curtis Island sections of the GTP.

Proposed construction methodologies and potential impacts associated with construction, operation and decommissioning of the pipeline have been identified. The Plan also details mitigation and management measures to minimise the impact associated with the project. Mitigation measures are outlined in Section 11 and have been prepared in accordance with identified aquatic values and relevant management plans.

# 2 LEGISLATIVE FRAMEWORK

## 2.1 Legislation

The following legislation has been considered during the preparation of this AVMP:

- *Environment Protection and Biodiversity Conservation Act 1999.*
- *Environmental Protection (Water) Policy 2009.*
- *Environmental Protection Act (EP Act) 1994.*
- *Fisheries Act 1994.*
- *Fisheries Regulation 2008.*
- *Land Protection (Pest and Stock Route Management) Act 2002.*
- *Native Title Act 1993.*
- *Nature Conservation Act (NC Act) 1992.*
- *Petroleum and Gas (Production and Safety) Act 2004.*
- *Sustainable Planning Act 2009.*
- *Vegetation Management Act (VM Act) 1999.*
- *Water Act 2000.*
- *Water Regulation 2002.*
- *Workplace Health and Safety Act 2011.*
- *Workplace Health and Safety Regulations 2011*.

## 2.2 Guidelines, Policies and Plans

The following guidelines and policies have been considered during the preparation of this AVMP:

- Australian Pipeline Industry Association's (APIA) Code of Environmental Practice – Onshore Pipelines, March 2009.
- Fish Habitat Management Operational Policy FHMOP 008 Waterway barrier works development approvals (DEEDI 2009).
- Activities in a watercourse, lake or spring associated with mining operations WAM/2008/3435 (DERM 2010).
- Fish Salvage Guidelines (DPIF 2004).
- Code for Self-assessable Development: Minor Waterway Barrier Works. Code no. WWBW01 (DEEDI 2011).
- Code for Self-assessable Development: Temporary Waterway Barrier Works WWBW02 (DAFF 2013).
- Australian Code of Electrofishing Practice (SCFFA 1997).

Relevant standards include:

- Australian Standard AS2885 – Pipelines – Gas, Liquid and Petroleum (AS 2008).
- Australian Standard AS2885.1 – Pipelines – Gas and Liquid Petroleum Part 1: Design and Construction (AS 2007).
- Australian Standard 4801:2000 Occupational Health and Safety Management Systems – Specification with guidance for use, and AS/NZS ISO 14001:1996 Environmental Management Systems.

- Santos Environment Health, Safety and Management System (EHSMS) Standards as per the CEMP (3380-SAIP-4-1.3-1814).

## 2.3 Approvals, Licences and Permits

This Plan has addressed all relevant approval conditions including:

- The CG's evaluation report for the GLNG Project Environmental Impact Statement (EIS) and Supplementary Environmental Impact Statement (SEIS).
- DEHP Environmental Authority PEN 102664411 for the Petroleum Pipeline Licence (PPL) 166.
- DEHP Environmental Authority PEN 102968511 for the Petroleum Pipeline Licence (PPL) 167.
- DEHP Environmental Authority PEN 102968511 for the Petroleum Pipeline Licence (PPL) 168.
- EPBC Act Approval – EPBC approval No 2008/4096.

Additional approvals/permits applicable to the construction of watercourses between KP0 and KP406 and Curtis Island will be addressed under the following documents:

- Code for Self-assessable Development: Temporary Waterway Barrier Works WWBW02 (DAFF 2013).
- Code for Self-assessable Development. Minor Waterway Barrier Works. Code no. WWBW01 (DEEDI 2011).
- Development Approval Fisheries Queensland Reference No. 2012NA0527.
- Development Application for a Development Permit for Operational Works (Prescribed Tidal works) (3380-GLNG-4-8.2-0063).
- Development Application for a Development Permit for Operational Works (removing, destroying or damaging marine plants) (3380-GLNG-4-1.3-0103).
- Development Application for a Development Permit for Operational Works (constructing or raising waterway barrier works) (3380-GLNG-4-8.2-0110).
- Fish Salvage Guidelines (DPIF 2004).

All relevant permits and approvals will be obtained prior to the commencement of construction in respective watercourses.

# 3 ENVIRONMENTAL MANAGEMENT FRAMEWORK

## 3.1 Santos GLNG Environment Health and Safety Management System (EHSMS)

This section provides an introduction to the EHSMS for operations. An overview of the Santos EHSMS is provided together with further information on key components of the system considered to be specifically relevant to the construction of the pipeline.

The framework has been developed to ensure compliance with Australian Standard 4801:2000 Occupational Health and Safety (OHS) Management Systems – Specification with guidance for use, and AS/NZS ISO 14001:1996 Environmental Management Systems – Specification with guidance for use. The Santos EHSMS applies to all Santos operations.

## 3.2 Overall EHSMS Structure

The EHSMS framework consists of multiple layers, the key components being management and hazard standards.

The documents that comprise each level of the EHSMS are maintained in electronic form on a central server (The Well) that is accessible to all Santos sites and employees.

## 3.3 EHSMS Management Standards (1-80029)

Management Standards are documents which define the requirements necessary to ensure that environmental, health and safety risk is systematically managed. Management standards have been developed as part of the EHSMS.

## 3.4 EHSMS Hazard Standards (HSHS (0-19))

Hazard Standards detail the controls required to manage the risks of specific hazards to acceptable levels. These apply to all Santos operations. They contain specific requirements for planning and undertaking activities and include checklists and references to internal and external approvals and controls.

# 4 AQUATIC VALUES MANAGEMENT PLAN STUDY AREA DESCRIPTION

## 4.1 GTP Alignment and Crossing Location Selection

The GTP alignment is approximately 420 km in length, with a maximum 40 m wide right of way (ROW) which includes a 30 m easement and a 10 m work area. The ROW originates approximately 90 km north of Roma and 37 km north-east of Injune, within the Fairview Coal Seam Gas Fields, and extends north through Arcadia Valley to the Dawson Highway before travelling primarily east prior to terminating within the south-western extremity of Curtis Island (refer Figure 1).

The ROW for the GTP follows the existing Queensland Gas Pipeline (QG Pipeline) for the majority of its length (approximately 300 km). A segment of the alignment to the north of Injune deviates from the QG Pipeline, traversing the eastern side of the Arcadia Valley. The GTP traverses The Narrows and continues within Curtis Island to the liquefaction facility. The proposed GTP ROW is illustrated in Figure 1. The selection of the pipeline route takes into consideration the results of the initial aquatic values assessment conducted as part of the EIS plus additional targeted surveys of watercourses.

The criteria used to determine the most appropriate route for the GTP were based on the APIA Code of Environmental Practice (2009) and are outlined in Section 2 of the GLNG Mainland Environment Management Plan (EMP). The current route was chosen to minimise environmental disturbance and the crossing of watercourses with high aquatic values. Where possible, watercourses will be crossed in the middle of a reach perpendicular to flow in order to reduce environmental impacts.

This AVMP discusses the entirety of the pipeline ROW between KP0 and KP406 (Mainland), KP406 and KP410 (Tidal area) and KP414 and KP420 (Curtis Island). This originates in the Fairview area, approximately 90 km north east of Roma, and terminates in the Gladstone area before the Marine Crossing section of the Pipeline and continues on Curtis Island (refer Figure 1). The pipeline is located within the Maronoa Regional Council, Central Highlands Regional Council, Banana Shire Council and the Gladstone Regional Council jurisdiction area. The ROW of the GTP is predominately 40 m wide however is reduced to 30 m ROW in Environmentally Sensitive Areas (ESAs) or an area of cultural significance. The width of the ROW for each watercourse is detailed in Appendix A.

The majority of the GTP alignment traverses the Fitzroy Basin (Dawson River sub-catchment). The remainder of the alignment (approximately 70 km of the Eastern segment) traverses the Calliope River Basin and Curtis Island. The GTP bisects two major rivers: the Calliope River and the Dawson River (Upstream and Downstream) (refer Section 13), as well as traverses The Narrows (Marine Crossing via a tunnel) between the Tidal area part of the Mainland and Curtis Island (refer Figure 1).

# 5 WATERCOURSE IDENTIFICATION

## 5.1 Watercourse Identification Process

The GLNG EMPs (3380-GLNG-4-8.2-0020; 3380-GLNG-4-8.2-0021; 3380-GLNG-4-8.2-0022 identified a total of 183 watercourses traversed by the GTP between KP0 and KP420. These included watercourses from stream order[3] 1 to 8, as identified from available drainage data from DERM[2].

Following the development of the EMPs a study of high resolution aerial photography and Light Detection and Radar (LiDAR) captured over the pipeline alignment was undertaken. This study indicated vast discrepancies between the DERM datasets[4] and the high resolution project data. As a result, a watercourse identification process was undertaken based on extensive desktop review of LiDAR and aerial photography, in conjunction with field verification of watercourse features at proposed crossing locations.

The desktop analysis to identify watercourses included consideration of the following:

- The definition of a watercourse as described in the *Water Act 2000.*
- Watercourses defined by DERM 1:100 000 ordered (2010c) and 1:250 000 drainage network.
- Evidence of riparian vegetation.
- Presence of distinct formed banks.
- Whether the watercourse forms part of a greater stream network.

Through this process a total of 265 watercourse crossing locations were identified between KP 0 and 420. A total of 261 of these watercourse crossings occur on the Mainland and Curtis Island, with remaining four occurring in the Tidal area of the GTP ROW (i.e. Humpy and Targinie creeks).

## 5.2 Summary of Watercourses: Mainland and Curtis Island

A summary of the watercourses intersected by the GTP ROW on the Mainland and Curtis Island based on the watercourses stream orders is presented below in Table 5-1. Appendix A – Watercourse Crossings Location Table outlines the location of watercourse crossings intercepted by the GTP ROW on the Mainland and Curtis Island.

[3] Stream order is typically a representation of stream size and is a numerical ordering system of each stream section based on its position in a catchment. Small streams that commence in the catchment headwaters are considered first order streams, and as they connect with other streams further down the catchment, they progressively get larger and become higher order streams (DERM 2010c).

[4] DERM datasets reviewed included 1:100000 drainage data and 1:250000 drainage data (DERM 2010c)

**Table 5-1 Summary of Watercourses Intersected by the GTP ROW on the Mainland and Curtis Island**

| Stream Order | Number of crossings |
|---|---|
| 1 | 150 |
| 2 | 65 |
| 3 | 30 |
| 4 | 8 |
| 5 | 7 |
| 6 | 4 |
| 8 | 1 |
| Total | 265 |

Watercourse crossings have been split into two categories: minor and major watercourses.

Minor watercourses are defined as those with a stream order of 1 or 2. For the purposes of this AVMP, the aquatic values have been described for a representative sample of minor watercourses. This has been used to derive appropriate construction methodology and mitigation measures to be used for minor watercourses.

Major watercourses are defined as being stream order 3 or greater. The methodology and detailed results of the Aquatic Values Assessment (AVA) for Major Watercourses associated with this Plan are outlined in Appendix B. For the purposes of the AVMP, both palustrine wetlands at KP 177 and KP 297 have been considered as a major watercourse, as it has been mentioned in Government Agency Conditions.

It is noted that the EPBC Approval (No. 2008/4096) conditions identifies Targinie Creek as a major watercourse. However, since the EBPC approval was granted (October 2010) a reroute through the tidal area has occurred, resulting in the crossing location for Targinie Creek to have changed. The new crossing location for Targinie Creek has been assessed as stream order 2, classifying it as a minor watercourse. Detailed information on Targinie Creek is provided in this AVMP as although a minor watercourse it has the potential to contain EPBC species and is therefore still relevant for this approval.

Appendix A details the construction methodology which will be adopted at all major watercourse crossings.

# 6 AQUATIC VALUES ASSESSMENT METHODOLOGY

The assessment of aquatic values for each watercourse crossing has been conducted as a two stage process consisting of a desktop study and field investigations.

The AVMP considers a number of environmental factors, including but not limited to:

- Riparian zone and condition (e.g. weeds, erosion, vegetation present and regrowth/remnant).
- Physical habitat features of the channel (e.g. undercut banks, in-stream timber, overhanging and trailing-bank vegetation, substrate diversity and deep pools).
- Biological diversity and overall ecological values of each watercourse (i.e. aquatic flora, macroinvertebrate, fish, turtles and platypus).
- Animal breeding places for conservation significant species and riverine corridors for aquatic animal migration. In this AVMP the focus of these assessments will be on aquatic species. The Significant Species Management Plan (SSMP) has identified the location of nesting and habitat trees in the riparian zone and the management and mitigation measures for these species. Significant species evident in riparian zones are listed in Section 7. Surveys of animal breeding places will also be undertaken as part of pre-clearing survey.
- Habitat for species with high conservation value, with specific focus on the white-throated snapping turtle (*Elseya albagula*), Fitzroy River turtle (*Rheodytes leukops*), platypus (*Ornithorhynchus anatinus*) and water mouse (*Xeromys myoides*) (refer Section 8).

## 6.1 Desktop Assessment

The desktop assessment involved the following steps:

- Review of aerial photography.
- GIS analysis to identify the location of the crossings, the Stream Order of each of the watercourses intercepted and the health of the local catchment (e.g. land use and clearing). GIS data sources included, but was not limited to DERMs Regional Ecosystem (RE) (2010d) and Regrowth Mapping (2010e) and DERM's Wetland Mapping (2010f).
- Review of relevant environmental databases (DERMs Wildlife Online (2010h) and *Census of Queensland Flora 2010 (*Bostock and Holland 2010)) to identify records of significant aquatic and semi-aquatic species known from the locality.
- Review of Queensland Herbariums RE Description Database (2011).
- Review of the GLNG Project EIS and SEIS.
- Review of The State of the Rivers reports for the Dawson River and major tributaries (DPI 1995) and the Comet, Nogoa and Mackenzie Rivers (DPI 2000) which provide an assessment of aquatic values through the evaluation of key components, including:
    - Reach environs.
    - Channel habitat diversity.
    - Channel form and dimensions.
    - Bed and bank sediments.

- Bank stability.
- Bed and bar stability.
- Riparian and aquatic vegetation.
- Aquatic habitat.
- Scenic recreational and conservation values.
- Overall condition rating.
- Review of previous ecological and aquatic assessments of the various watercourses within the Fitzroy Basin.

- Review of previous ecological and aquatic assessments of the various watercourses within the Calliope Basin.

### 6.2 Field Investigations of Minor Watercourses

A representative subset of minor watercourses (53 from 213 (25%)) was surveyed in the field (refer to Appendix D). The watercourses intercepted by the GTP ROW mainland and Curtis Island provided in Appendix A. The findings of these surveys are detailed in Appendix D.

The AUSRIVAS's Sampling and Processing Manual (DNRM 2001) was used to guide the assessment of the representative minor watercourses during field work. At each minor watercourse that was inspected, information relating to the following environmental attributes was recorded:

- Whether the GTP ROW intercepts a permanent pool, tidal watercourse or ephemeral reach and/or palustrine wetland.
- In-stream habitat complexity (e.g. undercut banks, woody debris, macrophyte beds).
- Riparian structure and composition, especially with regard to DERMs RE mapping (2010d).
- Targeted search for threatened flora.
- Habitat potential for threatened fauna species, Fitzroy River turtle, platypus and white-throated snapping turtle.
- Threatening processes (e.g. weeds, erosion, cattle tracks, roads, and infrastructure).
- Photographic reference points – crossing location, and looking upstream and downstream of the crossing.

### 6.3 Field Investigations of Major Watercourses

Comprehensive surveys of aquatic ecology were undertaken at all 50 major watercourses intersected by the GTP by frc environmental between January and April 2012. The findings of these surveys instigated other crossing locations to be assessed at Baffle Creek, Palustrine Wetland / Prospect Creek and Mimosa Creek. These further assessments were conducted in September and October 2012. These included habitat assessments, *in situ* water quality measurements, and surveys of aquatic plants and animals (i.e. macroinvertebrates, fish and turtles). The findings of the frc environmental survey are detailed in Appendix B and C.

#### 6.3.1 Habitat Assessment

The in-stream habitat condition at each major watercourse crossing was assessed using the AUSRIVAS protocol described in the Queensland AUSRIVAS Sampling and Processing Manual (DNRM 2001). The following environmental parameters were assessed:

- Riparian vegetation and adjacent land use.
- Bank stability.
- Substrate composition (silt or clay, sand, pebble, cobble and boulder).
- Channel diversity.
- In-stream habitat (in-stream vegetation and substrate characteristics).
- Water quality – including pH, electrical conductivity, turbidity and dissolved oxygen.

### 6.3.2 Habitat Bioassessment Scores

Habitat quality at each site was also assessed using an index of habitat condition. This is a standardized numerical approach that enables direct comparison of habitat condition amongst sites. This process involved completing the habitat bioassessment score datasheets from the Australia-Wide Assessment of River Health: Queensland AUSRIVAS Sampling and Processing Manual (DNRM 2001). Completion of the datasheets included numerically scoring the site for nine criteria that relate to different aspect of habitat quality (e.g. substrate cover and stability, flow velocity, bank stability and pool:riffle ratios). Scores for all nine criteria were summed and each site was allocated to one of four categories based on this aggregated score (i.e. excellent, good, moderate and poor), as follows:

- Excellent >110.
- Good 75 to 110.
- Moderate 39 to 74.
- Poor ≤38.

### 6.3.3 Water Quality

*In situ* water quality was assessed at major watercourse crossings at the time of survey. Water quality was not assessed at sites that were dry or where the water level was too low.

The following water quality parameters were measured using a Hydrolab Quanta water quality meter:

- Water temperature.
- pH.
- Electrical conductivity.
- Dissolved oxygen.

A Hach 2100Q turbidity meter was used to measure turbidity.
The Hydrolab Quanta water quality meter and the Hach 2100Q were calibrated in accordance with manufacturer's specifications.

The water quality results were compared to the water quality objectives (WQOs) scheduled under the Queensland's Environmental Protection (Water) Policy 2009 for waterways in relevant sub-regions as presented in the Developing Water Quality Guidelines for the Protection of the Freshwater Aquatic Ecosystems in the Fitzroy Basin Phase 1 report (DERM 2011a), including the Upper and Lower Dawson River sub-regions and the Comet River sub-region. The WQOs for electrical conductivity and pH were developed using local reference sites for low flow conditions. The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009a). There is no WQO for temperature.

Water quality results for watercourses within the Calliope basin were compared to the Queensland Water Quality Guidelines (QWQG) for the Central Coast region (DERM 2009).

Water quality monitoring during the pre-construction phase will provide site-specific background data for use in construction and post-construction monitoring (refer Section 15). This will provide appropriate background data for each site individually, and will enable site-specific factors (e.g. adjacent landuse) and antecedent flow conditions to be accounted for.

### 6.3.4 Aquatic Flora

The macrophyte community at each site was assessed along a 100 m reach within the creek and / or riverbanks (50 m upstream and downstream of the centre of the ROW). Plants were identified to species, and the following environmental parameters were recorded:

- Taxonomic richness.
- Total percent cover (% of substrate (bed or bank) covered by each aquatic species).
- Growth form of each species (submerged, floating (free-floating or rooted) and emergent).
- Whether the plant was native or introduced to Australia.
- Whether the plant was listed under State or Commonwealth legislation.

Total percent cover of each species was assessed visually and the presence of listed protected species, under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* was determined for each site.

Macrophyte species were identified in the field, where practical. Representative specimens were collected for identification in the laboratory (or by the Queensland Herbarium, if required). Species were identified as native or non-native according to the *Census of Queensland Flora 2010* (Bostock and Holland 2010).

### 6.3.5 Macroinvertebrates

At each major watercourse crossing, macroinvertebrates were assessed in bed and edge habitats. Five samples were taken from each habitat type, with each sample consisting of five sweeps of an area of 30 $cm^2$. A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples.

Abundance, taxonomic richness, PET richness and SIGNAL 2 scores were calculated using the macroinvertebrate data for each sample. These metrics are standard indices that are used to describe and report the current ecological health watercourses. The results from all five samples at each site were pooled, and the indices were re-calculated and were compared with the relevant Fitzroy Basin biological water quality objectives (WQOs) (DERM 2011a) which were also used as quadrant boundaries for SIGNAL 2 / family bi-plots (Chessman 2003). While the guidelines were developed using macroinvertebrate samples collected using AUSRIVAS field sampling methodology (DNRM 2001) and are not directly applicable, this comparison was still useful for providing an overall preliminary indication of ecosystem health.

Macrocrustaceans were also collected using the replicated macroinvertebrate sampling method, although baited traps, seine net and / or electrofishing was also used to sample these taxa. All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root LR-24 backpack electrofisher.

### 6.3.6 Freshwater Fish

Fish communities were surveyed using a combination of electrofishing (backpack and boat), baited traps and seine nets. All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root LR-24 backpack electrofisher in shallow water, and a Smith-Root boat 2.5 GPP electrofishing system in deep water. At sites where the conductivity of the water was too low or high to effectively electrofish, or the water level was too low, fish communities were surveyed with a seine net with a 20 to 50 mm mesh size. Fish communities were also surveyed with four to five small (2 mm mesh size) baited traps and two to three opera traps (x10 mm mesh size), which were set at each site for approximately two hours.

Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification. The sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approvals CA 2009/03/343 and CA 2012-02-593 issued to FRC Environmental.

Fish communities at each site were assessed for:

- Total abundance (total number of individuals caught at a site).
- Taxonomic richness (total number of species caught at a site).
- Abundance at each life-history stage.
- Abundance of exotic species.
- Abundance of listed protected species.

### 6.3.7 Turtle Surveys

Turtle habitat was assessed by noting the occurrence of deep permanent pools, and other species-specific habitats for turtles, such as riffles for Fitzroy River turtle (Tucker et al. 2001). Where such habitats were not present at a site, it was determined that suitable habitat for turtles did not exist at the site.

Turtle traps were set at sites where the water was deep enough to provide suitable turtle habitat and the allowed use of cathedral traps. Turtle traps were not set where the site was dry or the water level was too low.

Four baited cathedral traps were set along the bank and next to cover (e.g. vegetation and snags) for four hours at sites that held sufficient water. The design of the traps was similar to traps used by DERM's turtle research group. The traps had a series of collapsible chambers (approximately 3.5 m in height and 0.7 m in diameter) and two, one-way entrances in the lower baited chamber. Traps were set so that the top of the chamber allowed turtles access to the surface to breathe. Traps were closely monitored to ensure that no turtles or other air-breathing species were entangled or trapped below the surface. The sampling of turtles was conducted under Animal Ethics Approvals CA 2009/03/343 and CA 2012-02-593 and QLD Scientific Purposes Permit WISP05080608 issued to frc environmental. Observations for turtles were made at all sites while electrofishing.

### 6.3.8 Soils

Extensive soils investigations have been undertaken along the GTP ROW. The findings of soil surveys and management of soils are presented in the Soil Management Plan (3380-SAIP-4-1.3-1991). The Soil Management Plan (3380-SAIP-4-1.3-1991) considers the impact and management of Good Quality Agricultural Land.

## 6.4 Limitations

The following limitations apply to the aquatic values assessment:

- The GTP ROW alignment used to collate the information was based on Revision C2, the alignment used in the EMP. The alignment has subsequently been updated to Revision A8 which includes minor route changes. Adjustments to the GTP ROW alignment will have negligible impact on the location of watercourse crossings with most cases being relocated within 5 m. Surveys were conducted covering the ROW and 50 m upstream and downstream of the crossing location. It is therefore unlikely that the change in alignment will have any impact on the aquatic value found at these crossings.
- Ground truthing for proposed re-routes occurred in September and October 2012. However as construction is planned for the dry season, this is considered appropriate to meet the aims of the study.
- Ground truthing activities along the ROW have been limited to key ecological areas such as areas mapped as endangered, of concern, essential habitat, major watercourses and a representative sample of minor watercourses.

## 6.5 Methodology for Assigning Overall Aquatic Value to Watercourses

Wet season field investigations, literature reviews and database searches were used to inform the assignment of overall wet season aquatic value for each watercourse crossing. Wet season values for re-routes were assigned based on professional judgment and the results of the wet season surveys at the alternate locations. Consistent with the purpose of this Plan, the assessments focused on listed riparian, aquatic and water dependent flora and fauna and potential habitat for listed aquatic species. The assessments did not focus on terrestrial species which have the potential to utilise riparian corridors or watercourses. The assessment of terrestrial listed species is addressed in the relevant SSMP. Four categories of aquatic value were used (High, Moderate, Low, Negligible), based on the following criteria:

### 6.5.1 High Value

- Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the *Environment Protection and Biodiversity Conservation Act 1999* and / or the *Nature Conservation Act 1992*, and / or those species listed as priority species in the *Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity* document (DERM 2010).
- Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species is detailed in Appendix E. The preferred habitat for conservation significant species was assessed using a combination of:
    - Habitat condition [e.g. the Bioassessment scores method (DNRM 2001).
    - Levels of disturbance (e.g. erosion, riparian vegetation condition).
    - Likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS).
    - Relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River Turtle (Tucker et al. 2001); in-stream habitat and connectivity for freshwater

fish, including undercut banks, substrate characteristics and large woody debris).

### 6.5.2 Moderate Value

- Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.
- Aquatic life included:
  - Submerged and/or floating attached aquatic plants.
  - Native freshwater fish (such as rainbowfish, spangled perch, glass perchlets and purple spotted gudgeons).
  - Aquatic invertebrates (including crayfish, shrimps, snails, mussels and insects).
- Life history stage (i.e. juvenile, intermediate, adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.
- Aquatic habitat was assessed using:
  - Habitat condition (e.g. the Bioassessment scores method (DNRM 2001)).
  - Levels of disturbance (e.g. erosion, riparian vegetation condition).
  - Habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, and large woody debris).

### 6.5.3 Low Value

- Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.
- Emergent aquatic plants, such as sedges and nardoo, may be have been present.
- Field investigations also indicated the presence of structural habitat elements, including:
  - Woody debris.
  - Cobbles.
  - Undercut banks.
- Habitat condition was determined using:
  - The Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams.
  - Levels of disturbance (e.g. erosion, riparian vegetation condition).

### 6.5.4 Negligible Value

- Where field investigations indicated:
  - An absence of aquatic habitats.
  - Absence of aquatic life (e.g. no aquatic fauna or aquatic plants, including no sedges).
- Habitat condition was typically poor:
  - Low Bioassessment Scores (DNRM 2001).
  - High levels of disturbance (e.g. extensive erosion, no riparian vegetation).

### 6.5.5 Dry Season Aquatic Values

Dry season aquatic values were also based on the above four criteria and resulted in an overall aquatic value of either:

- High.
- Moderate.
- Low.
- Negligible.

For freshwater systems, they were determined using previous dry season surveys for several sites to inform of permanence of pools / water, and expert judgment regarding permanence of pools / water at sites not visited during the dry season. Sites that were dry during the wet season were considered likely to also be dry during the dry season, as were sites that were previously shown to be dry during the dry season. Sites that contained water during the wet season, even as disconnected pools within the channel, were conservatively assessed as possibly having temporary water that may persist for some time into the dry season. In these cases, dry season aquatic values were assessed as moderate, in accordance with the criteria above.

As tidal watercourses are estuarine, fewer fluctuations are expected between wet and dry season conditions than for ephemeral freshwater streams. Therefore the dry season values were conservatively determined to be the same as the wet season values for the four tidal watercourses.

# 7 DESKTOP STUDY OF AQUATIC VALUES

The GTP ROW occurs within the Fitzroy River Basin and Calliope River Basin. Within the Fitzroy River Basin, the alignment between KP 0 and KP 338 traverses the Dawson River and Comet River sub-catchments (refer Figures 1, 2, 3, 4 and 5). This section describes the aquatic values of these areas.

## 7.1 Fitzroy River Basin

The Fitzroy Basin is the largest basin on Australia's east coast (156,000 $km^2$), and is characterised by large variations in river flows (Kennard et al. 2010). Rainfall within the Fitzroy Basin typically occurs during October to April, resulting in summer dominated stream flows. The ephemeral nature of many of the watercourses within the Fitzroy Basin is a result of the prolonged dry periods during the winter months, as well as inter-annual variability in summer rainfall. An assessment of the environmental values of the Fitzroy Basin (URS 2009) concluded that, in general, the catchment contains slightly to moderately disturbed aquatic habitat.

### 7.1.1 Protected and Significant Areas

The Great Barrier Reef World Heritage Area (GBRWHA), is downstream of the Fitzroy River Basin, as is one Ramsar site, Shoalwater and Corio Bay. Construction for the GTP will occur well upstream of the coast, such that impacts on the WHA are expected to be negligible. Sediment and erosion control measures will be implemented to prevent downstream impacts. The works will not occur within any catchments which discharge into Shoalwater and Corio Bay.

In addition, there are 183 protected areas and ten wetlands of National Importance (listed on Directory of Important Wetland Areas) within the Fitzroy River basin. The majority of these areas are within catchments other than those intercepted by the GTP ROW, or upstream of the proposed works and are sufficiently displaced to ensure that any potential impacts to downstream receiving environments are unlikely due to the implementation of the management measures outlined in this plan.

The GTP ROW will not be constructed in any protected areas, however construction will occur within the catchment area for and upstream of the following protected areas:

- Expedition (Limited Depth) National Park occurs downstream (1.5km) of the Baffle Creek catchment crossings and approximately 2.5 km downstream of the upstream crossing on the Dawson River. The Hutton Creek catchment is located upstream of this National Park.
- Expedition State Forest occurs between KP130 and KP148.
- Callide Timber Reserve occurs between KP311 and KP315.
- Beilba State Forest occurs downstream of the GTP crossings within Hutton Creek and Baffle Creek catchments, in addition to the crossing on the Dawson River (upstream).
- The northern limit of Roundstone State Forest, which borders the southern banks of Mimosa Creek, occurs approximately 15 km downstream of the Mimosa Creek crossing.
- Lake Nuga Nuga, which is a nationally important wetland approximately 8 km downstream of the GTP ROW at its nearest point.
- The other nationally important wetlands located downstream of the GTP ROW are the Fitzroy River Delta, Fitzroy River Floodplain and Boggomoss Springs.

Impacts on these wetlands are considered unlikely given the distance between pipeline construction and these wetlands and the implementation of the management measures outlined in this plan.

### 7.1.2 Threatened and Significant Species

Based on DERM's Wetland Info (2010f), a total of 841 vertebrate fauna species are expected to exist in the Fitzroy catchment, including:

- 44 bony fish.
- 44 amphibians.
- 443 birds.
- 123 mammals.
- 187 reptiles.

Of these species, 72 are threatened species under State and/or Commonwealth legislation. The majority of these threatened species are not dependent on wetlands or watercourses. However, these species may use resources within these systems, including food, water and shelter and the systems as movement corridors. Those species listed as threatened under the EPBC Act are outlined in Table 7-1 (refer Section 7.4).

Two threatened fish species, both listed as vulnerable under the EPBC Act, occur in the Fitzroy River Basin. These are Queensland lungfish (*Neoceratodus forsteri*) and the Murray cod (*Maccullochella peelii peelii*). The record for the lungfish is over 140 years old and there have been no recent sightings. The Fitzroy River Basin is outside the natural distribution of the Murray cod however, it has been introduced to permanent water bodies such as large dams. Queensland Fisheries notes that this species has yet to become established within these areas (NMCRT 2010). It is therefore, unlikely that this species will be encountered or impacted on during the proposed works.

Of the five threatened frog species known from the Fitzroy River Basin, two species (Kroombit tinkerfrog (*Taudactylus pleione*) and the cascade treefrog (*Litoria pearsoniana*)) have a restricted range and are only found within Kroombit Tops National Park. Kroombit Tops National Park is upstream of the proposed works and is sufficiently distant from the GTP ROW that no impacts are anticipated.

The tusked frog *(Adelotus brevis*) which is listed as vulnerable under the NC Act 1992 is known to occur in the Fitzroy River basin, including Carnarvon National Park. The rough-collared frog (*Cyclorana verrucosa)* which is listed as near threatened under the NC Act 1992 is also known to occur in the Fitzroy River basin and within the Dawson River sub-catchment. The GTP ROW will likely intercept habitat for these species, including potential breeding habitats (e.g. palustrine wetlands).

Thirteen species of bird dependent on riverine and wetlands ecosystems have been recorded in the Fitzroy River Basin. Wetland ecosystems are generally limited within the GTP ROW however, a number of wetland species were identified, including the cotton-pygmy goose (*Nettapus coromandelianus*) and the black-necked stork (*Ephippiorhynchus asiaticus*) both of which are listed as Near Threatened under the NC Act 1992. The cotton-pygmy goose is also classed as a Migratory species under the EPBC Act. These records are mainly associated with large farm dams and wetlands within close proximity to the GTP ROW and in close proximity to other anthropogenic corridors (e.g. Arcadia Valley Road).

Other wetland species such as the Australasian bittern (*Botaurus poiciloptilus*) and the Australian painted snipe (*Rostratula australis*) have also been recorded from the Fitzroy River Basin; however habitat for these species within and directly adjacent/downstream of the GTP ROW is limited (e.g. large wetland systems). Records for these species within the vicinity of the GTP ROW are limited.

No threatened mammals that are dependent on riverine and/or wetland ecosystems are present within the Fitzroy River Basin. However, threatened mammals are known to utilise resources within these ecosystems, examples being the northern quoll (*Dasyurus hallucatus*) and little pied bat (*Chalinolobus picatus*).

In addition to these threatened species, two species of conservation significance [platypus (*Ornithorhynchus anatinus*) and the white-throated snapping turtle (*Elseya albagula*) are known from the Fitzroy River Basin (refer SSMP (3380-GLNG-3-1.3-0031). These species are listed as least concern under the NC Act 1992, however the platypus is recognised as an iconic species by DEHP, and the white-throated snapping turtles is listed by DEHP as a high-priority under the Back on Track species prioritisation framework.

Two species of threatened species of freshwater aquatic plant are known from the Fitzroy Basin, *Eleocharis blakeana* and *Eriocaulon carsonii*. No threatened intertidal wetland plants species are known from this catchment.

A number of freshwater species are endemic to the Fitzroy River Basin, including the Fitzroy River turtle (*Rheodytes leukops*), the leathery grunter (*Scortum hillii*), the southern Saratoga (*Scleropages leichardti*). The freshwater gastropod (snail) (*Larina strangei)*, is endemic to the Dawson River subcatchment.

The Significant Species Management Plan (SSMP) has been prepared to identify threatened species known or likely to occur within and within the vicinity of the GTP ROW. The SSMP provides an overview of the ecology and distribution of these species, including likelihood of occurrence within the GTP ROW. The species management profile for each conservation significant aquatic species is detailed in Appendix E. The species management profile for significant species that utilize riparian corridors or watercourses are detailed in the relevant SSMP. The SSMP also outlines mitigation measure to avoid, minimise, mitigate and where necessary offset impacts to significant species. The SSMP also includes management profiles for conservation significant species which are likely to utilise watercourses and / or riparian corridors.

## 7.2 Dawson River Sub-catchment

The Dawson sub-catchment of the Fitzroy Basin comprises approximately 50,800 $km^2$ of land encompassing the major Dawson and Don Rivers and associated tributaries. The sub-catchment is bound by the Auburn, Calliope, Ulam, and Dee Ranges to the east, Lynd and Expedition Ranges to the west, the Great Dividing Range to the south and south-west.

As a result of the low gradient of the sub-catchment, tributaries of the Dawson River are typically characterised by long, winding, upper and middle reaches. Headwaters typically flow through relatively narrow valleys and gorges. The flow pattern is generally from south to north.

According to the State of the Rivers report (DPI 1995), streambank erosion typically occurs downstream of road crossings where appropriate battering and stabilising works have not been undertaken or maintained. Furthermore, streambank erosion is common where

overgrazing of the stream bed and banks have occurred, and where bank scouring has occurred as a result of runoff from nearby cattle pads (DPI 1995).

An examination of the overall condition rating for the Dawson sub-catchment (DPI 1995) concludes that the majority of the sub-catchment is considered to exhibit a moderate condition. Specifically, the State of the Rivers (DPI 1995) report found:

- Widespread degradation of the riparian zone, resulting from clearing of natural vegetation, the invasion of exotic species, and generally high disturbance levels in the reach environs.
- Aquatic habitats in generally poor condition due to low levels of instream and overhanging stream cover, low diversity of instream habitat attributes in most stream beds, and generally low diversity of channel habitat types.
- Relatively stable banks throughout the catchment, displaying moderate to low susceptibility to the dominant process of erosion.
- Relatively stable beds and bars throughout the catchment, although aggradation processes were dominant at more than half the sites surveyed.
- A number of sites identified with significant conservation values.
- Most stream lengths surveyed within the catchment described as being in moderate to poor overall condition.
- Grazing activities identified as the most common detrimental influence impacting upon stream and riparian attributes.

The Dawson River sub-catchment is known to contain habitat for the Fitzroy River turtle and conservation significant species such as the white-throated snapping turtle and the platypus. The Fitzroy River turtle has been recorded from the Dawson River upstream and downstream of the GTP ROW (e.g., Baralaba Weir and Theodore Weir).

### 7.3 Calliope River Basin

The north-eastern segment of the GTP ROW, between KP338 and KP420, bisects the Calliope River Basin (refer Figures 5 and 6). This basin comprises an area of approximately 2,236 $km^2$, and encompasses the Calliope River and its tributaries and Curtis Island. The Calliope River Basin is thus bound by the Pacific Ocean to the east and north, by Arthurs Seat State Forest along the south-eastern boundary, and finally Bulburin National Park, Kalpowar and Borilla State Forests demarcate the approximate southern boundary of the basin. The Calliope River sub-catchment is bound by Calliope Range State Forest and the Dawson River sub-catchment boundary to the west.

Current water quality conditions within the Calliope River sub-catchment are influenced by a number of anthropogenic activities, including grazing, agriculture, industry and urban-based activities. Based on the extent of catchment clearing and existing land use patterns, the condition of the Calliope River sub-catchment was reported as poor to moderate in the 1992 National Land and Water Audit (C & R Consulting 2005).

#### 7.3.1 Protected and Significant Areas

Within the Calliope River Basin there is one WHA, the GBRWHA. However, as works in the Calliope River are at least 40 km upstream of the WHA, there are unlikely to be impacts on the WHA where controls outlined in this AVMP are implemented.

In addition to the WHA, there are 20 protected areas and three wetlands of National Importance (i.e. listed on Directory of Important Wetland Areas). The majority of these areas are within other sub-catchments than those intercepted by the GTP ROW, upstream of the

proposed works and/or are sufficiently displaced such that impacts on downstream receiving environments are unlikely where the appropriate mitigation measures are put in place.

The works in the Tidal area (KP406-KP410) will intersect one State protected area (Targinie State Forest) and one estuarine wetland (DERM 2012).

Environmentally Sensitive Area (ESA) mapping for the ROW between KP406 and KP410 shows:

- No Category A ESAs either in the vicinity of or downstream of the ROW
- Four Category B ESAs are located downstream of the ROW:
  - Referable wetlands
  - Endangered RE
  - Marine Plants
  - World Heritage Areas, and
- Three Category C ESAs are located in the vicinity of the ROW:
  - Of Concern Regional Ecosystems
  - Essential Habitat, and
  - State Forest.

### 7.3.2 Threatened and Significant Species

Based on DERM's Wetland Info website, a total of 507 vertebrate fauna species are known from the Calliope River Basin, including 33 bony fish, 27 amphibians, 299 birds, 70 mammals and 79 reptiles. Of these species, 29 are threatened under State and/or Commonwealth legislation. However, it should be noted that a number of other species not identified within this database are known to occur within the Calliope River sub-catchment, including the tusked frog, dolphins, dugongs and four species of marine turtles. Those species listed as threatened under the EPBC Act are outlined in Table 7-1 (refer Section 7.4).

The majority of the 29 threatened species are not dependent on wetlands or watercourses. However, these species may use resources within these aquatic systems, including food, water and shelter, and use watercourse corridors as movement corridors. Some of these species (e.g. estuarine crocodile, shorebirds (e.g. eastern curlew) and marine turtles) are dependent on coastal and marine environs rather than the freshwater wetlands and riverine habitats discussed in this document. The potential impacts of the works on significant species are outlined in the SSMP and the relevant Environmental Management Plans (EM Plans).

The threatened species known from this catchment include one species of frog (Tusked frog), eight species of birds (three shorebird species and five wetland species), seven species reptiles (marine turtles and estuarine crocodile) and marine mammals (e.g. cetaceans and porpoises).

The distribution of the Fitzroy River turtle does not include the Calliope River Basin, with the species restricted to the Fitzroy River Basin. The white-throated snapping turtle has also not been recorded from this catchment, however the species is known from the surrounding catchments and basins, including Raglan Creek and the Fitzroy River Basin. The platypus, which is an iconic species under the *Nature Conservation Act 1992*, is known from this catchment. Three threatened aquatic plants are known from the Calliope River Basin: *Maundia triglochinoides*, *Eriocaulon carsonii* and *Thelypteris confluens*. However, the recorded distribution of all three species is south of the GTP ROW, and targeted searches did not find these species along the GTP ROW. The SSMP outlines the threatened species known, likely to occur within, and within the vicinity of the GTP ROW. The SSMP provides an

overview of the species ecology and likelihood of occurrences within the GTP ROW. The SSMP also outlines mitigation measures to avoid, minimise, and mitigate impacts, and to provide offsets for impacts where necessary.

The water mouse (*Xeromys myoides*) is known to occur within the Tidal (mudflats) areas. However works within the watercourses from KP406 to 410 are significantly separated from known burrows or breeding (Essential) habitat (refer Appendix E). Impacts may occur to a limited amount of foraging (General) habitat for this species around one of the four tidal watercourses (Targinie Creek) located between KP408 and KP409. Details of these impacts, along with the mitigation measures are outlined in Section 13.13 and in the SSMP (excerpt refer Appendix E). Threatened mammals species (cetaceans and porpoises) are known from downstream habitats (i.e. Port Curtis and The Narrows), including dugongs (*Dugong dugong*) and the Australian snubfin dolphin (*Orcaella heinsohni*). However the strategy of tunneling under The Narrows avoids impacts to the marine habitat of these species.

## 7.4 EPBC Act Fauna Species associated with the GLNG GTP

Table 7-1 presents all the species that are listed as threatened under Commonwealth legislation. It is noted that the 60 species outlined within the table below, do or have the potential to utilize the wetlands, watercourses and/or estuarine areas impacted by the GLNG GTP. It is noted that these 60 species occur or have the potential to occur across both the Fitzroy River Basin and the Calliope River Basin.

**Table 7-1 EPBC Act fauna species with wetland, watercourse and estuarine associations for the Santos GLNG GTP (Fitzroy and Calliope River Basins)**

| **EPBC Act Listed Species** | | **Location**<br>Coastal / Inland<br>Estuarine / Freshwater |
|---|---|---|
| Squatter pigeon | *Geophaps scripta scripta* | Inland and Coastal freshwater |
| Star finch | *Neochmia ruficauda ruficauda* | Inland freshwater |
| Black-breasted button-quail | *Turnix melanogaster* | Inland and Coastal freshwater |
| Red goshawk | *Erythrotriorchis radiatus* | Inland and Coastal freshwater |
| Australasian bittern | *Botaurus poiciloptilus* | Inland and Coastal – freshwater and estuarine |
| Black-throated finch | *Poephila cincta cincta* | Inland freshwater |
| Large-eared pied bat | *Chalinolobus dwyeri* | Inland freshwater |
| South-eastern long-eared bat | *Nyctophilus corbeni* | Inland freshwater |
| Northern quoll | *Dasyurus hallucatus* | Inland and Coastal – freshwater and estuarine |
| Ornamental snake | *Denisonia maculata* | Inland freshwater (especially gilgais / melonholes) |
| Dunmall's snake | *Furina dunmalli* | Inland and Coastal freshwater |
| Brigalow scaly-foot | *Paradelma orientalis* | Inland and Coastal freshwater |
| Yakka skink | *Egernia rugosa* | Inland and Coastal freshwater |
| Collared delma | *Delma torquata* | Inland and Coastal freshwater |
| Fitzroy River turtle | *Rheodytes leukops* | Inland freshwater |

| EPBC Act Listed Species | | Location<br>Coastal / Inland<br>Estuarine / Freshwater |
|---|---|---|
| Rainbow bee-eater | *Merops ornatus* | Inland and Coastal – freshwater and estuarine |
| Fork-tailed swift | *Apus pacificus* | Inland and Coastal – freshwater and estuarine |
| White-bellied sea-eagle | *Haliaeetus leucogaster* | Inland and Coastal – freshwater and estuarine |
| Great egret | *Ardea alba* | Inland and Coastal – freshwater and estuarine |
| Cattle egret | *Ardea ibis* | Inland and Coastal – freshwater and estuarine |
| Australian painted snipe | *Rostratula australis* | Inland and Coastal – freshwater and estuarine |
| Australian cotton pygmy-goose | *Nettapus coromandelianus* | Inland and Coastal – freshwater |
| Eastern osprey | *Pandion cristatus* | Inland and Coastal – freshwater and estuarine |
| Masked lapwing | *Vanellus miles* | Inland and Coastal – freshwater and estuarine |
| Black-faced monarch | *Monarcha melanopsis* | Coastal – freshwater and estuarine |
| Spectacled monarch | *Monarcha trivirgatus* | Coastal – freshwater and estuarine |
| Satin flycatcher | *Myiagra cyanoleuca* | Inland and Coastal – freshwater and estuarine |
| Rufous fantail | *Rhipidura rufifrons* | Coastal – freshwater |
| Oriental cuckoo | *Cuculus optatus* | Coastal – freshwater and estuarine |
| Dollarbird | *Eurystomus orientalis* | Inland and Coastal – freshwater and estuarine |
| Eastern reef egret | *Egretta sacra* | Coastal – freshwater and estuarine |
| Lesser sand plover | *Charadrius mongolus* | Coastal and rarely inland – freshwater (floodplain/lake margin and wetlands) and estuarine |
| Red-capped plover | *Charadrius ruficapillus* | Coastal and occasionally inland – freshwater (floodplain/lake margin and wetlands) and estuarine |
| Pacific golden plover | *Pluvialis fulva* | Coastal and occasionally inland – freshwater and estuarine |
| Double-banded plover | *Charadrius bicinctus* | Coastal and occasionally inland – freshwater (floodplain/lake margin and wetlands) and estuarine |
| Common sandpiper | *Actitis hypoleucos* | Coastal and rarely inland – freshwater (floodplain/lake margin and wetlands) and estuarine |
| Little curlew | *Numenius minutus* | Coastal and rarely inland – Freshwater (floodplain/lake margin and wetlands) and estuarine |
| Marsh sandpiper | *Tringa stagnatilis* | Coastal and rarely inland – Freshwater (floodplain/lake margin and wetlands) and estuarine |
| Red knot | *Calidris canutus* | Coastal – freshwater and estuarine |
| Terek sandpiper | *Xenus cinereus* | Coastal – freshwater and estuarine |
| Sharp-tailed sandpiper | *Calidris acuminata* | Coastal – estuarine and freshwater |
| Black-tailed godwit | *Limosa limosa* | Coastal – estuarine and freshwater |
| Bar-tailed godwit | *Limosa lapponica* | Coastal – estuarine and freshwater |
| Eastern curlew | *Numenius* | Coastal – freshwater and estuarine |

| EPBC Act Listed Species | | Location<br>Coastal / Inland<br>Estuarine / Freshwater |
|---|---|---|
| | *madagascariensis* | |
| Whimbrel | *Numenius phaeopus* | Coastal – freshwater and estuarine |
| Common greenshank | *Tringa nebularia* | Inland and Coastal – freshwater and estuarine |
| Grey-tailed tattler | *Tringa brevipes* | Coastal – estuarine and freshwater |
| Great knot | *Calidris tenuirostris* | Coastal and rarely inland – freshwater (floodplain/lake margin and wetlands) and estuarine |
| Red-necked stint | *Calidris ruficollis* | Coastal – estuarine and freshwater |
| Ruddy turnstone | *Arenaria interpres* | Coastal – freshwater and estuarine |
| Red-necked avocet | *Recurvirostra novaehollandiae* | Inland and Coastal – freshwater(floodplain/ lake margin and wetlands) and estuarine |
| Sanderling | *Calidris alba* | Coastal – estuarine and freshwater |
| Broad-billed sandpiper | *Limicola falcinellus* | Coastal – estuarine and freshwater |
| Black-winged stilt | *Himantopus himantopus* | Inland and Coastal – freshwater (floodplain/ lake margin and wetlands) and estuarine |
| Curlew sandpiper | *Calidris ferruginea* | Coastal and rarely inland – freshwater (floodplain / lake margin and wetlands) and estuarine |
| Greater sand plover | *Charadrius leschenaultii* | Coastal – estuarine and rarely shallow freshwater lake / wetland margins |
| Latham's snipe | *Gallinago hardwickii* | Inland - Freshwater (floodplain/ lake margins and wetlands) and rarely coastal estuaries |
| Grey plover | *Pluvialis squatarola* | Coastal – estuarine and rarely shallow freshwater lake /wetland margins |
| Little tern | *Sternula albifrons* | Coastal – freshwater and estuarine |
| Caspian tern | *Hydroprogne caspia* | Coastal – estuarine and rarely inland – freshwater (floodplain/lake margin and wetlands) |

**Source: Santos GLNG GTP Significant Species Management Plan Rev T (Whole GTP SSMP)**

*Note: This table now consists of all the species likely to be encountered by the Santos GLNG GTP. For further information on the habitat attributes or species profiles for any of the species listed within the table above, please refer to the SSMP 3380-GLNG-4-1.3-0104.*

# 8 CONSERVATION SIGNIFICANT SPECIES

## 8.1 Fitzroy River Turtle (*Rheodytes leukops*)

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act and NC Act. The species is endemic to riverine habitats of the mid-and lower Fitzroy River Basin, where it has habitat preferences for deep perennial pools with rocky, gravelly or sandy substrates, connected by shallow riffles (Cogger 1996; Limpus et al. 2007). It is commonly found in habitats with high water clarity and beds of ribbon weed (*Vallisneria* sp.) (Cogger 1996).

Descriptive patterns of movement suggest that Fitzroy River turtles:

- Move slightly upstream from riffles during moderate flow events and move downstream from riffles under base flows conditions.
- Have no obvious directional movement patterns under flood conditions.
- Move into refugial pool habitats adjacent to riffles during the dry season, when most riffles become dry.
- Have a mean local home range of approximately 420 m, although inter-individual variation in home range size is large (Tucker et al. 2001).

Fitzroy River turtles nest from September to October on river sandbanks 1–4 m above water level (Cann 1998).

The wet season survey found suitable habitat for Fitzroy River turtle at three locations along the GTP ROW, Baffle Creek and both Dawson River crossings (upstream and downstream). Marginal habitat for Fitzroy River turtle (*Rheodytes leukops*) exists along Hutton Creek, however wet season aquatic surveys indicated that there was no preferred habitat for this species within the vicinity of the ROW. The full and approved management profile for this species (extracted from SSMP 3380-GLNG-4-1.3-0104) is detailed in Appendix E. Results of the wet season aquatic values surveys are detailed in Appendix B and C.

Construction in both Dawson River crossings and Baffle Creek will be scheduled to avoid the breeding season of this species. It is expected that the mitigation measures outlined in this Plan will appropriately mitigate any potential impact on this species.

## 8.2 Murray Cod (*Maccullochella peeli peeli)*

Murray cod (*Maccullochella peelii peelii*) are naturally found in the Murray Darling Basin. The GLNG Pipeline does not traverse the Murray Darling Basin; the waterways crossed from KP 0 to 406 are in the Fitzroy and Calliope Basins. While they are not naturally found in the Fitzroy River Basin, Murray cod have reportedly been stocked in reservoirs for recreational fishing. However, there are no reports of the Murray cod becoming established in this river system, and it has not been reported in surveys of the region (as summarised in Marsden and Power 2007). As such, the Murray cod has not been considered further in this assessment, as there is no evidence to suggest that it occurs in the rivers and streams of the Fitzroy Basin, such as the waterways crossed by the pipeline.

## 8.3 White Throated Snapping Turtle (*Elseya albagula*)

The White-throated snapping turtle is listed as least concerned under the NC Act. It is also listed as a Back on track species under the NC Act. This species is known to occur within the Burnett, Mary, Fitzroy, Raglan and Calliope River catchments (DERM 2010l). The species is

widely distributed within the riverine systems it occupies, inhabiting permanent waters of the uppermost spring-fed pools to the freshwater-brackish water interface.

The species prefers flowing waters with high degree if instream complexity, including log tangles, undercut banks, and irregular rocky substrata. However, the species has been recorded from shallow turbid reaches of the Burnett and Fitzroy River which do not match their preferred habitat criteria (DERM 2010l, Thomson *et al* 2006).

January to August is the peak breeding season for males, while females leave the water once per year between March and September.

The wet season survey found suitable habitat for white-throated snapping turtle at eight locations along the GTP. These watercourses are Hutton Creek, Baffle Creek, Dawson River (Upstream), Dawson River (Downstream), Calliope River, Harper Creek and both Larcom Creek crossings. The full management profile for this species (extracted from SSMP 3380-GLNG-3-1.3-0031) is detailed in Appendix E. Results of the wet season aquatic values surveys are detailed in Appendix B and C.

As the breeding season for this species coincides with the dry season, it was not considered practicable to avoid the breeding season. Construction during the dry season is deemed to have less overall impact on Aquatic Values. It is expected that the mitigation measures outlined in this Plan will appropriately mitigate any potential impact on this species.

### 8.4 Platypus (*Ornithorhynchus anatinus*)

The Platypus is listed as special least concerned under the NC Act. The platypus is an egg-laying, semi-aquatic mammal endemic to Australia. Platypus inhabit freshwater ecosystems, including a wide variety of permanent streams, rivers and lakes. The species also inhabits temporary and/or manmade water bodies, particularly when these are linked directly to streams or rivers (DERM 2010m and APC date unknown).

Adult platypus will utilise a number of different camping burrows (up to about a dozen) within a period of a few weeks. Camp burrows may be shared, are generally 3-5 m long and are constructed just below the water's surface or where above the water surface they are often hidden by overhanging vegetation or an undercut bank (DERM 2010m and APC date unknown).

They are typically crepuscular species (active at dawn and dusk), however activity patterns are dependent on a number of factors (e.g. locality, degree of human activity, day length, air and water temperatures, water body productivity (Strahan 1995)). As such the Platypus could also be considered nocturnal or diurnal depending on these factors.

Mating occurs between June and October, however in Qld mating generally occurs in August (DERM 2010m and APC). Maternity burrows are constructed in banks rising 1m or more above the water and can reach up to 30m in length, which can mean that although the entrance to a burrow may be obvious, the actual nursing chamber (at the end of the burrow) may be much further downstream. (DERM 2010m and APC date unknown).

The wet season survey found suitable habitat for Platypus at eight locations along the GTP. These watercourses are Hutton Creek, Baffle Creek, Dawson River (Upstream), Dawson River (Downstream), Calliope River, Harper Creek and both Larcom Creek crossings. The full management profile for this species (extracted from SSMP 3380-GLNG-3-1.3-0031) is detailed in Appendix E. Results of the wet season aquatic values surveys are detailed in Appendix B and C.

Construction in these watercourses will be, where possible, scheduled to avoid the breeding season of this species. It is expected that the mitigation measures outlined in this Plan will appropriately mitigate any potential impact on this species.

### 8.5 Water Mouse or False Water Rat (*Xeromys myoides*)

The water mouse (*Xeromys myoides*) is listed under the Commonwealth EPBC Act as vulnerable. The species occurs in three discrete populations in Australia; the coastline of the Northern Territory, central south Queensland and south-east Queensland. The central south Queensland population is relevant to the GLNG GTP Project in Gladstone, as this population extends from Cannonvale (Whitsunday Coast) in the north to Agnes Water in the south.

The habitat associated with the water mouse includes mangrove communities and associated saltmarsh, sedgelands, clay pans, heathlands and freshwater wetlands.

The breeding regime for the water mouse is poorly understood (Commonwealth of Australia 2009a and 2009b), but it is thought to produce two to three young at any time of the year.

The species has been recently recorded from a number of coastal areas around Gladstone, including Kangaroo Island and Curtis Island. No individuals have been identified within the GTP ROW within the surveyed area from KP406 to KP410, therefore no essential habitat is associated with the tidal watercourses. Some general habitat exists at Targinie Creek (one of the four tidal watercourses) but this is limited and at the outer reaches of its likely range.

The approved management profile for this species (extracted from the SSMP 3380-GLNG-4-1.3-0104) is detailed in Appendix E.

# 9 CONSTRUCTION METHODOLOGY

## 9.1 Overview

The GLNG GTP will transport CSG year-round from the existing and future fields in the Roma, Fairview and Arcadia Valley areas. The pipeline system is comprised of a 42 inch (1.07 m diameter) GTP and associated infrastructure and a telecommunications fibre optic cable (FOC) which will be buried and covered by at least 750 mm of soil. At watercourse crossings, the burial requirements are more stringent to take account of the natural effects of scour and riverbed erosion. In some places the burial depth will exceed 3 m. The FOC will be laid in parallel and in the same trench as the pipeline.

The pipeline will be fabricated from high quality, high strength carbon steel and will be protected with an external coating of Dual Fusion Bonded Epoxy.

The pipeline is designed and developed to the highest standards and shall fully comply with the requirements of Australian Standard AS 2885 (2008). AS 2885 (2008) contains requirements for the design, material selection (including coating selection), construction and operation of pipelines in watercourse crossings.

Prior to operation, all welds will be individually checked using Automatic Ultrasonic Testing or Radiographic Testing (X-ray) to assure their quality and the complete pipeline system will then be hydrostatic pressure tested as a minimum to pressures 25% higher than the normal operating pressure. The pipeline will also be subject to a detailed geometrical control survey (calliper survey) to detect any dents or ovality prior to pipeline commissioning.

The risks of leaks are therefore extremely low and largely relate to external influences such as third party interference. Safety systems will moreover allow control by way of block valves to ensure a rapid response to restrict the loss of gas in the extremely unlikely event that the pipeline should rupture.

### 9.1.1 Types of Construction Methodologies

There are three different types of construction methodologies for pipeline crossings including:

- Horizontal directional drilling (HDD).
- Dry (open) trenching.
- Wet trenching.

These technologies generally follow these key activities as part of the GTP construction:

- Survey of the pipeline route.
- Provision of access tracks along the ROW and temporary facilities.
- Clear and grade the GTP ROW.
- Pipeline stringing and bending (i.e. laying out the pipeline for welding and bending to accommodate the terrain).
- Pipe welding.
- Trenching.
- Pipe placement in the trench (lowering in and laying), including backfilling and compacting of the trenches.
- Hydrostatic testing of the GTP.
- Site rehabilitation.

## 9.2 Horizontal Directional Drilling (HDD)

Horizontal Directional Drilling (HDD) was investigated in detail at all watercourses which were assessed as having high aquatic values and possible presence of listed riparian, aquatic and water dependent flora and fauna.

This approach involves drilling under the watercourse from bank to bank below the level of the bed of the watercourse, thereby avoiding direct disturbance of the watercourse. The pipeline is then pulled through the drill hole. HDD crossings may be undertaken to minimize the adverse environmental effects at significant watercourse crossings where pre construction surveys have indicated a high potential for riparian / aquatic biodiversity values. Nevertheless, a HDD does not guarantee that all adverse environmental effects will be prevented.

The key issues that must be considered when deciding to employ the use of HDD construction methodology are:

- The technique cannot be undertaken for watercourses that contain boulders, coarse gravel or where heterogeneous substrate will be encountered.
- Additional invasive geotechnical investigations are required pre-construction to assess the substratum.
- Of the available pipeline crossing construction methodologies discussed herein, this approach has the largest footprint due to the requirement for a launching pad, retrieval pad, stringing area and additional access track. This will result on impediment onto land outside of the ROW.
- The construction duration is at least three months, operating day and night.
- There is risk of damage to the pipe or pipe pull-back during construction.
- There is risk of borehole instability/collapse and consequent loss of drilling fluid into the watercourse, noting that the drilling fluid contains bentonitic clays, chemical additives and hazardous materials.
- The contaminated drilling mud generated during construction will require disposal, in addition to which there is potential for generation of contaminated wastewater associated with the borehole drilling.
- Impacts on traffic and transport are higher due to the need to mobilise (and de-mobilise) larger and additional plant to the site; including transport of drilling muds and spent fluids.
- There are significant noise and vibration impacts associated with the drilling.
- Whilst there is no need to obstruct or divert flow to undertake the drilling, this benefit may be offset by the requirement to construct an additional access track to facilitate construction.
- There is a significant risk to water quality in the event that drilling fluid, mud or wastewater unexpectedly escapes into the environment.
- Dependent upon the proximity of the site to sensitive receivers and/or farm operations, there is potential for significant impacts on the social environment due to the high volume of traffic and noise and vibration impacts associated with the works.

## 9.3 Dry Trenching – Standard Mainline Construction

Dry trenching is the default method for construction, this is due to the speed of use and lower impact of noise and overall disturbance footprint. The APIA Code of Environmental Practice

for Onshore Pipelines (2009) states that open trenching "…*is often applied in dry or shallow low flow watercourses, but may also be applied in sensitive watercourses where rapid construction is considered the best means of minimising environmental impact*".
The method is versatile as there are a number of different construction approaches that may be adopted:

- Standard mainline construction.
  - Excavating from each bank.
  - Minor dam / pumping.
  - Minor dam / flume.
- Wet Trenching.

### 9.3.1 Standard Mainline Construction

Standard dry trenching involves excavating an open trench across the watercourse. The excavator will work within the watercourse, excavating backwards from and placing trench spoil in a designated location outside the riverbed. If bedrock is encountered, rock breakers will be used. The pre-fabricated pipeline is then lowered into the trench and the trench is backfilled immediately.

This method is often used in dry watercourses or for shallow low flow watercourses, but can also be adopted for creeks with more sensitive aquatic values where rapid construction is considered the most best means of minimising environmental impacts. This approach is illustrated in Appendix F, noting that the standard mainline approach will only utilise one excavator.

The key issues that must be considered when deciding to employ the use of standard mainline construction methodology are:

- Requires disturbance of the creek banks and bed to excavate the trench.
- Duration of construction approximately 10 days.
- Low engineering risk during construction.
- Relatively small works footprint, corresponding to slightly less than the full ROW.
- Potential for erosion and sedimentation, and subsequent impacts on water quality.

Erosion and sediment control measures will be implemented as per the approved ESCP.

There is potential for fauna to fall into the open trench, although this will be managed by the Species Management Plan (SMP) (3380-GLNG-3-1.3-0036), which is part of the GLNG EMP (3380-SAIP-4-1.3-1814).

### 9.3.2 Dry Trenching – Excavate from Both Banks

This approach is similar to standard mainline construction, however, it employs the use of two long reach boom excavators, one located on each bank. The excavators generally will not work from within the watercourse. The key features of this approach are largely as described in relation to standard mainline construction, with the exception that this approach is limited by the depth and width of the watercourse. For example, this approach is not feasible for watercourses >10 m in width. This approach is illustrated in Appendix F.

### 9.3.3 Dry Trenching – Minor Dam and Pumping (Flow Diversion)

Watercourse flow diversion techniques involve the construction of temporary dams upstream and downstream of the watercourse crossing and diversion of the water flow around the site,

thereby providing an opportunity to create a dry working area by de-watering the area between the dams.

The minor dam and pumping method requires the construction of two minor dams and watercourse flows are pumped around the minor dams. The dams will be constructed of suitable material such as steel plates, geotextile bags filled with gravel, sand or another suitable fill material, or inflatable dams such as Aquadams. Earthen materials will be avoided. One of the minor dams may be modified to form an access way (refer Section 9.5.3). This approach is illustrated in Appendix F.

The key issues that must be considered when deciding to employ the use of minor dam and pumping construction methodology are:

- There is a risk of malfunction of the pump system (e.g. due to blockage of the pipes/hoses and/or the pump running out of fuel overnight).
- Duration of construction is approximately 1-3 weeks.
- The works footprint will likely extend across the full ROW.
- Fish passage is effectively blocked, although environmental flow regime is maintained.
- Fish trapped in the impounded area require management (i.e. relocation of native species) (refer Fauna Handling Procedure (3380-SAIP-4-1.3-1965)).
- Water pumped from the impoundment area may require treatment prior to discharge/disposal.
- There is lower risk of erosion and sedimentation compared with the previous two dry trenching methods due to diversion of flows around the works area. The potential for erosion and sedimentation may be adequately managed through implementation of the ESCP.
- The downstream minor dam will be removed prior to removal of the upstream minor dam. This process requires careful management to minimise erosion and sedimentation.

### 9.3.4 Dry Trenching – Minor Dam and Flume (Flow Diversion)

This approach is similar to the minor dam and pumping methodology, with the exception that instead of bypassing flows by means of a pump, low flows are maintained during construction via a flume pipe. The flume pipe conveys flows from upstream of the minor dam, through the works site and into the watercourse downstream of the dam. In this case, the access way will be constructed as a second minor dam and the flume pipe will go through both minor dams. This approach is illustrated in Appendix F.

The flume pipe will be installed before the minor dams are erected and will remain in place for the full duration of construction. The flume will be sized to convey low / environmental flows. Given the relatively short duration of construction, this will typically be flows up to the 1 month average recurrence interval (ARI). Given that there is a paucity of flow data for the watercourses in the study area, an appropriate sized flume pipe will be selected based on engineering judgment. The flume pipe will be aligned with the direction of flow and will be placed in such a manner as to minimise erosion of the bank or bed of the creek.

The key issues that must be considered when deciding to employ the use of minor dam and flume construction methodology are effectively the same as those outlined above in relation to the minor dam and pumping methodology.

### 9.3.5 Dry Trenching – Cofferdam (Flow Diversion)

The cofferdam is a temporary enclosure to divert the flow of a watercourse facilitate pipeline construction in dry conditions. The cofferdam is suitable for watercourses with loose and cohesive soil bed and with a high water flow rate, where other minor dam structures could be inadequate. A detailed design drawing of this method is provided in Appendix F.

The typology of cofferdam suitable for the purpose is a braced steel barrier formed by a single wall of sheet piling. Sheet pilings cannot be installed in rock and gravel soils.

Similar to the minor dam, the cofferdam will be installed starting from the upstream side of the watercourse. The cofferdam will be positioned at the edge of the ROW and perpendicularly to the river bed (refer Figure 9-1).

When the water has been diverted, the installation of the sheet piling will continue along the flow river and will be closed on the opposite side of the ROW, (refer Figure 9-1 and Appendix F). A high capacity pump will be used to dewater the isolated working area.

Trench excavation will commence at a safe distance from the cofferdam toward the watercourse bank. Once the construction of this crossing section is completed and backfilled, the longitudinal sheet pilings in the flow direction and some of the perpendicular sheets will be removed and reinstalled in order to divert the flow to the opposite side of the river. After removal, the sheet piling must be inspected noting the presence of any distortion, deformation or damage before the reinstallation in the opposite side.

The same process will occur on the opposite side of the watercourse, performing the tie-in with the previously installed pipe. When the final backfilling will be completed all the sheet pilings will be removed.

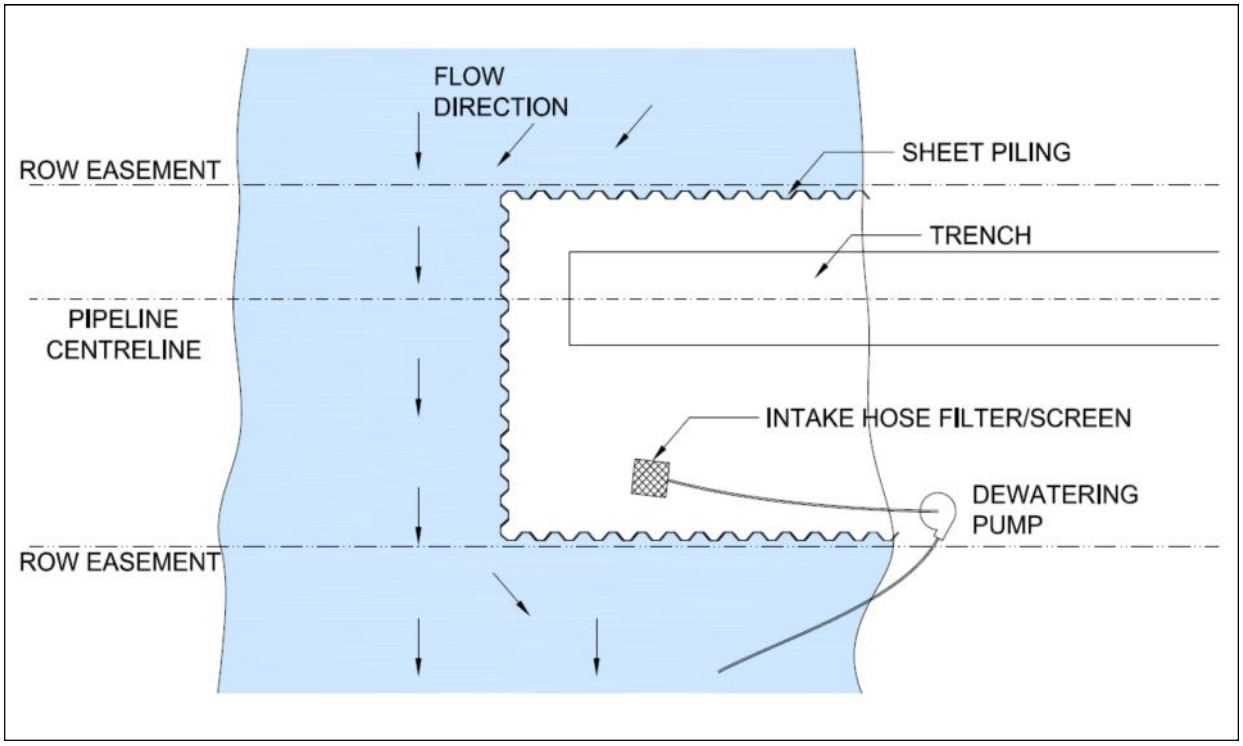


**Figure 9-1Typical Cofferdam Installation**

## 9.4 Wet Trenching

Wet trenching is an extension of the standard mainline construction methodology where the works are conducted when there is water within the watercourse. The benefit of this methodology is it causes minimal disruption to flows, however there is an increased potential for erosion and sedimentation.

This approach in some instances will be the most practicable methodology where, for example, the watercourse is a minor watercourse with shallow, stagnant or temporarily ponded water. Under these conditions, the relative impacts of wet trenching will be significantly less than those associated with construction of minor dams and flow diversions. Due to the increased impact for erosion and sedimentation associated with wet trenching, it is not recommended to be used in flowing watercourses.

## 9.5 Access Way Methodologies

In addition to the works required to lay the pipeline, there is a requirement to construct an access way across the watercourse to facilitate the movement of vehicles, plant and equipment across the watercourse, and also to permit access for cranes to lift the pipeline sections into the trench (not applicable for HDD).

There are four different methodologies for access ways, consisting of:

- Normal crossings.
- Fords/bed level crossings.
- Causeways with flumes.
- Pre-fabricated bridge or steel ramp.

In order to prepare the site for construction of the access way (irrespective of the adopted approach), a hydraulic excavator equipped with a ditching bucket shall clear the sides and bottom of watercourses to remove vegetation, collapsed earth and other debris across the full extent of the running track. This clearing out operation is intended to reduce sediment loading and ensure safe access for construction. These preparatory works may require modification for environmentally sensitive sites.

### 9.5.1 Normal Crossing

A normal crossing will be adopted for minor watercourses that are dry at the time of construction. Bed stabilisation works are not required where the load bearing strength of the bed is sufficient to support the construction machinery. The bank will be graded down to provide safe access for vehicles and additional stabilisation will be required. This method is illustrated in Appendix F, noting that mats will not be installed for a normal crossing.

### 9.5.2 Ford / Bed Level Crossing

A ford is a bed level crossing that is typically stabilised with mats or other materials. The banks are graded down to the ford to provide safe access for vehicles, however, there is minimal disturbance of the creek bed. This method is illustrated in Appendix F**.**

The key features of this approach are similar to those associated with the normal crossing, including:

- Small works footprint.
- Duration of construction is 1 day.

- Negligible engineering risk.
- Minimal disturbance of the creek bed or flows.
- Some potential for erosion and sedimentation, which may be effectively managed through implementation of the ESCP.

### 9.5.3 Causeway

This approach involves construction of a causeway, or minor dam, across the watercourse. It will typically involve the installation of either a pump or a flume to divert flows through/around the causeway, and the key features of this approach will be the same as the two dry trenching with minor dam options provided in Section 9.3.3 and 9.3.4. These two approaches to constructing a causeway are illustrated in Appendix F (showing a causeway with a pumped flow diversion and a causeway with a flume).

In order to establish a suitable access way, the causeway will be constructed from stones or similar materials. The stone infill will be capped with either bog mats or similar materials to prevent dislodgement of the stones by vehicles transiting the causeway. The construction duration will be approximately 3-5 days.

### 9.5.4 Pre-fabricated Elevated Bridge / Steel Ramp

In this case, a 'bridge' will be constructed across the watercourse to provide vehicular access. It will consist of a pre-fabricated structure or two steel ramps. This method is illustrated in Appendix F. The key features of this approach include:

- Only feasible for watercourses <10 m in width.
- Construction duration of 2-4 days.
- Small works footprint.
- Low-moderate engineering risk.
- Some re-grading of the banks will be required otherwise there is minimal disturbance of the watercourse bed.
- Does not disrupt low flows and will be unlikely to act as a barrier to fish passage
- Potential for erosion and sedimentation will be managed through implementation of the ESCP.
- Specific requirements apply in relation to the distance between the two banks and available clearance below the structure for safe work practices.

## 9.6 Interim Bank Stabilisation Options

Bank stabilisation works are intended to take place after the completion of construction of the pipeline crossing. The works will minimise the risk of erosion and sedimentation in the interim period prior to implementation of the re-vegetation works under the Land Rehabilitation/Reinstatement Management Plan (3380-SAIP-4-1.3-1834). The selected bank stabilisation approach will typically vary dependent upon the bank steepness and creek hydrology.

An overview of the different approaches is provided below.

### 9.6.1 Hydromulching

Hydromulching involves the application of a slurry of mulch, seed fertiliser, and binding agent mixed in water in a purpose-built truck or tailor-mounted tank. This approach is used for grass establishment and is best used on slopes of <10% over linear sections of bank no greater than 10 m. It has a higher requirement for watering than mulching. If used where

slopes are >15%, tackifiers such as starch/gum based products or polymers are added to the hydromulch. Hydromulching is generally preferred over hydroseeding for its benefits for seedling establishment and growth.

### 9.6.2 Erosion Control Blanket

Erosion control blankets (meshes or mats) are typically made of light weight mulch, straw or wood fibre held together by a natural or synthetic matting, and take between one and two days to install. They are effective at stabilising moderately steep banks subject to sheet flow for a period of months until vegetation becomes established. They are designed to biodegrade over time (in approximately 1-2 years).

Erosion control blankets/mats are effective at minimising rain drop impact and surface erosion, decreasing compaction and soil crusting, and conserving soil moisture. The addition of mulch increases the rate of germination of seedlings, controls soil temperatures and promotion of vegetation establishment.

Erosion control mats comprise of a stabilising mesh to anchor the mulched material, a root reinforcing mesh to control erosion around the roots, and mat reinforcing to limit distortion of the mat (e.g. during high flow events). Compost blankets are more commonly used for steeper slopes.

### 9.6.3 Bonded Fibre Matrix

Bonded fibre matrix is composed of a recycled organic material such as wood fibre, recycled paper, and/or cane topping, water seed, fertiliser and a bonding agent. It is typically sprayed onto a slope after hydroseeding and dries to form an erosion control blanket. The fibres used in bonded fibre matrices provide increased strength over hydromulch. This method is useful for establishing grassed slopes for steeper slopes, and is often preferred for use in wet environments due to the use of non-re-wettable tackifiers.

### 9.6.4 Grass Seeding

This approach involves the application of grass seeds to the creeks banks, followed by mulching and watering to assist in the growth and establishment of seedlings. Mulching holds the seed and fertiliser in place, protects the soil from erosion, conserves essential surface moisture (to assist in seed germination and growth) and reduces overall water usage.

Grass is somewhat effective at stabilising gently sloping banks and trapping sediment, but may require re-application following a rainfall event.

### 9.6.5 Rip Rap / Stone Pitching

This approach involves the placement of rock material in the watercourse to reshape the profile of the banks and bed of the watercourse. Rip rap may be put in place over the course of a day. It is usually employed where the banks are very steep or rocky, flows are higher in velocity, and vegetation can only provide limited protection. Whilst an effective means of bank stabilisation, the use of rip rap has potential to negatively impact access to the watercourse by people or stock.

The adoption of rip rap for interim bank stabilisation works requires careful assessment prior to proceeding to ensure the works do not result in unanticipated impacts on the watercourse.

### 9.6.6 Reno Mattress

Reno mattresses will be used where appropriate for bank and scour protection and as channel linings for erosion control. The wire baskets are filled at the site with suitable material prior to placement. Reno mattresses have a similar function to rip rap, but with the addition of a basket to minimise the dislodgement of rocks during high flow conditions. This approach is therefore suitable for creeks with steep banks, which can be subject to high discharges.

The use of reno mattresses has implications for creek access and public safety, similar to rip rap. In addition, careful assessment is required prior to proceeding, to ensure the works do not result in unanticipated impacts on the watercourse.

### 9.6.7 Mulching

Mulching involves the placement of vegetative matter on the ground. Mulching will be applied to mid slopes clay-soil surfaces to limit runoff turbidity and to control soil temperature and moisture loss.

Mulching may be applied over the course of a day, and is effective at interim stabilisation and sediment trapping. Mulching may require regular maintenance, such as after rainfall events during which some of the material may be washed away. This approach is not as effective for use on creek crossings with steep banks, erosive soils and/or higher base flows.

## 9.7 Hydrostatic Testing

### 9.7.1 Process

During the pre-commissioning stage of the GTP the integrity of the pipeline is verified by undertaking hydrostatic testing. The hydrostatic testing process involves the pipeline being sectionalised, based on elevation limits, and the ends of each section being terminated with test headers. Each section is filled with filtered (50 micron) clean water and pressurised. A strength test is maintained for a minimum of 2 hours to verify the ‘as built’ strength of the pipe. The pressure is then lowered slightly for the 24 hour (minimum) leak test to confirm that there are no leaks. The section is then depressurised to slightly above the section static head. If the water is not required for or unable to be transferred to adjoining sections the water is then tested/analysed and discharged in accordance with Environmental Authority and CG report conditions.

### 9.7.2 Water Quality & Process

The source of hydrotest water is selected on the basis of satisfying the water quality requirements of the relevant EAs and is detailed in Table 9-1 below. In some instances, additives may be required (i.e. lime, flocculent etc) in order for hydrotest water to meet environmental compliance. No other chemicals / additives will be required.

**Table 9-1 Water Quality Parameters for Discharge of Hydrostatic Test Water to Land**

| Parameter | Maximum Value |
|---|---|
| pH | 6.5 – 8.5 (Range) |
| Arsenic (mg/L) | 2.0 |
| Cadmium (mg/L) | 0.05 |
| Chromium (mg/L) | 1 |
| Copper (mg/L) | 5 |
| Iron (mg/L) | 10 |
| Lead (mg/L) | 5 |
| Manganese (mg/L) | 10 |

| | |
|---|---|
| Zinc (mg/L) | 5 |
| Nitrogen (mg/L) | 5 |
| Phosphorus (mg/L) | 1 |
| Electrical Conductivity (µS/cm) | 2000 |

The only parameter likely to increase during the period of time that the water is inside the pipe may be the iron content due to the possible solution of iron from the inside of the pipe. Since the pipe is internally coated, such iron solution will be limited to the weld location and is expected to be minimal if not negligible.

There is a small amount of water associated with the operation of pigs used for hydrotesting. As the pigs approach the end of a section, any residual particles inside the pipe will be suspended in the flushing water in front and immediately behind the pigs. This water will then be collected and stored (i.e. in tanks), allowed to settle, then filtered and tested, prior to discharge. Discharge will occur in accordance with the EA conditions including the water quality parameters outlined in Table 9-1.

Where feasible, hydrostatic test water will be reused across sections of the GTP. When water is unable to be reused it will be dealt with in one of two ways. First option will be to have the water filtered, then tested to ensure water quality requirements are achieved and it will then be passed through a diffuser (irrigation) system onto vegetated land. Discharge via this irrigation method will ensure compliance with EA conditions.

The second method for disposal of hydrostatic test water will utilise the use of storing the water in a purpose built dam. The water will then go through the same filtration, testing process as per previous method, before it is pumped away. There is also the potential to have this stored water used for alternative purposes such as dust suppression on roads, watering of stock and/or use in agriculture.

### 9.7.3 Mitigation Measures

- Any release of hydrostatic test water will be in accordance with the Hydrotest Water Management Plan (3380-SAIP-4-1.3-1840),
- Hydrostatic test water will not be released within 100 m of the nearest watercourse,
- Hydrostatic test water will be released in a manner that:
  - Vegetation is not damaged.
  - Soil erosion and soil structure damage is avoided.
  - Hydrotest water does not migrate outside nominated land discharge areas.

### 9.7.4 Other Construction Details

This section provides details of other aspects of the construction process, primarily as they relate to the pipe stringing and laying.

Pipeline stringing will take place outside of the riparian zone in the ROW for all watercourses, maintaining either a 50 m vegetation buffer for high value watercourses or 10 m vegetation buffer for all other watercourses. The vegetation buffer will be maintained at all watercourses until construction is imminent. Stringing may occur on the access track through a watercourse for all watercourses excluding those with high aquatic values.

For all watercourses, prior to installation in the trench, the following actions will occur:

- Establishment of dry conditions within the watercourse (no wet trenching to occur).

- The pipe string will be fully prepared and all welding, field joints coating and coating repairs checked.
- Automatic Ultrasonic Testing will be carried out on field joints and a holiday detector is passed over the pipe section to check integrity.
- Prior to laying the pipe, the trench will be surveyed to ensure that that the burial depth is adequate. At this time, a hold point is implemented for Company approval prior to pipe laying.

For all high value watercourses the processes listed above will all be conducted outside the watercourse. Once the pipe is been fully prepared (i.e. welded and coated etc.) it will carried into the watercourse for placement in the trench. Where this is not possible due to safety concerns over carrying heavy prefabricated (in some cases, concreted) pipe, welding huts will be utilised for all fabrication processes that are required to occur within the watercourse. These huts will contain any waste and prevent possible contaminants and dust reaching the water body.

After the pipe has been fully prepared (on the ROW for high value watercourses), the section fabricated for the watercourse crossing will be lifted and transported with side booms (pipe layers) and lowered into the trench. When practicable, wheel-mounted cranes (pipe laying cranes or side booms) situated on the riverbanks can carry and lay the pipe into the trench.

Once the pipeline is placed in the trench the buoyancy control measures are installed in accordance with the Buoyancy Control Procedure. The pipe will be re-surveyed to ensure that it has sufficient cover and is in the correct position within the trench.

Once these activities are completed the backfill operation can commence. Backfilling shall be carried out in accordance with Bedding-Padding-Backfilling Procedure. The river bank will be reinstated and consolidated as required in accordance with the construction drawings. These works will employ rocks or sand bag barriers to prevent erosion satisfactory to the construction specifications and relevant regulations. Clean gravel or native cobbles will be used for the upper section of trench backfill in all watercourses overlain by the same layered sequence as present within that location. For open-cut watercourse crossings, watercourse banks will be stabilized and temporary sediment barriers will be installed within 24 hours of completing in-stream construction activities. For dry crossings, streambed and bank stabilisation will be completed before returning flow to the watercourse.

# 10 POTENTIAL IMPACTS ON WATERCOURSES AND WETLANDS

## 10.1 Construction Phase

Construction of the GLNG GTP has the potential to impact watercourses. The level of potential impact is influenced by both environmental factors (e.g. vegetation type, soil type and structure, weather etc.) and construction methodologies. The potential impacts associated with the construction phase for watercourse crossings are summarized in Table 10-1.

**Table 10-1 Potential Impacts Associated with Construction Phase for Watercourse Crossings**

| Aspect | Potential Impacts |
|---|---|
| Construction Duration / Timing | • Disruption to the breeding, nesting and/or migration of aquatic species in the event that the construction coincides with these activities.<br>• Disturbance and displacement of fauna utilising the riparian corridor and/or watercourse for the duration of construction. |
| Clearing of Riparian Vegetation | • Loss of remnant vegetation.<br>• Fragmentation of the riparian corridor and edge effects.<br>• Loss of linear connectivity of the riparian corridor.<br>• Loss of habitat used for roosting, nesting and/or as refugia.<br>• Displacement of fauna utilising the riparian corridor.<br>• Loss of habitat complexity and microclimates.<br>• Increased potential for weed invasion.<br>• Localised loss of feeding and foraging resources.<br>• Localised loss of prey species.<br>• Increased competition for resources.<br>• Fauna injury or mortality.<br>• Erosion of the banks due to wind transport, sheet flow and creek flows. Potential for bank collapse after high flow events.<br>• Increased turbidity and sedimentation of the watercourse.<br>• Increased water temperature and alterations to water quality processes due to loss of shading.<br>• Increased evaporative losses.<br>• No filtration of stormwater runoff by vegetation. |
| Grading | • Disturbance of Acid Sulfate Soils (ASS) and/or contaminated soils (if present).<br>• Erosion of the banks due to wind transport, sheet flow and creek flows. Potential for bank collapse after high flow events.<br>• Increased turbidity and sedimentation of the watercourse.<br>• Destruction of burrows or nests. |

| Aspect | Potential Impacts |
|---|---|
| HDD Works | • Additional work space required on land for the launch pad, pipe stringing areas and construction of access way across the watercourse, resulting in infringement on land outside of the ROW – impacts as for vegetation clearing (see above).<br>• Interception of groundwater.<br>• Bore hole instability and/or collapse, resulting in the loss of drilling fluid into the watercourse.<br>• Accidental spills of drilling fluid (including mud and hazardous materials).<br>• Damage to the pipe or pipe pull-back, resulting in environmental impacts. Requires more exploration to link the damage to the pipe with impact on the environment.<br>• Generation of contaminated drilling mud and potentially also contaminated wastewater.<br>• Disruption to access to the watercourse by landholders and/or stock.<br>• Additional traffic and transport impacts due to the need to transport specialist equipment from overseas. Also requires more and larger equipment than other construction techniques.<br>• Noise and vibration impacts for the 3 month construction period on (natural and human) sensitive receptors.<br>• Generation of light for night works (HDD construction occurs 24 hours/day), and subsequent impacts on sensitive (natural and human) receivers, particularly bats. |
| Trenching Works | • As for grading works (see above).<br>• Direct disturbance of the creek bed.<br>• Modification of creek flows.<br>• Entrapment of fauna.<br>• Injury or mortality of benthic fauna.<br>• Temporary barrier to aquatic fauna movements.<br>• Localised loss of any aquatic flora.<br>• Localised loss of habitat and foraging resources for aquatic fauna.<br>• Exposure of bed sediments to the air.<br>• Modification of bed geochemistry.<br>• Generation of water from de-watering activities (where required).<br>• Disruption to access to the watercourse by landholders and/or stock.<br>• Traffic and transport impacts – increased volume of vehicles on roads accessing the site. |
| Wet Trenching | • As for trenching works (see above). |

| Aspect | Potential Impacts |
|---|---|
| | • Increased potential for erosion and sedimentation.<br>• Alterations to water chemistry through disruption of bed sediments.<br>• Injury or mortality to fauna.<br>• Potential for localized loss of aquatic flora and fauna. |
| Minor Dam and Flow Diversion Works | • As for trenching works (see above).<br>• Obstruction to the passage of aquatic fauna.<br>• Entrapment of aquatic fauna between the minor dams.<br>• Accidental ingress of aquatic biota in the intake pipe/flume/pump.<br>• Blockage of the pipe/flume/pump and consequent loss of flow downstream of the minor dams.<br>• Generation of water from de-watering activities.<br>• Exposure of a larger portion of the bed for a longer time period, and consequent localised loss of aquatic habitat.<br>• Accidental spills of fuel from the pump (where applicable). |
| Demand on Resources / Waste Generation | • Generation of general construction waste.<br>• Potential for generation of a small amount of spoil material.<br>• Generation of waste by construction workers (e.g. from lunches, etc.).<br>• Consumption of fuels, energy and other resources.<br>• Use of materials to construct temporary dams and access ways (e.g. mats for fords). |
| Flooding | • Damage or loss of vehicles, plant and equipment, and resultant environmental impacts.<br>• Damage or loss of temporary structures such as minor dams. |
| Use of Vehicles, Plant and Equipment | • Accidental spills of fuel, hydraulic fluids or other materials, and resultant contamination of land and/or water.<br>• Erosion and mobilisation of sediments into the watercourse.<br>• Introduction of pest species.<br>• Generation of dust and other emissions.<br>• Noise and vibration impacts on sensitive (natural and human) receivers. |

The level of each of these impacts has been assessed to determine the appropriate crossing methodology. These matrices are presented in Tables 12-1 and 12-2.

## 10.2 Operational Phase

Operation of the GLNG GTP has the potential to impact on watercourses. These potential impacts are summarised in Table 10-2 below. The main potential impacts associated with the

operation phase are associated with operational monitoring tasks and potential contamination of surface water associated with day to day general operation of the GTP. Access to the pipeline easement for operational activities is required on a regular basis for:

- Pipeline surveillance and inspections to identify areas of erosion and subsidence, areas requiring vegetation management, including weed control if necessary, check cathode protection, identify possible leaks, monitoring third party activity and identifying any unacceptable risk to the pipeline.
- Monitoring and auditing of environmental conditions.
- Performance of maintenance activities.
- Construction of facilities or additional infrastructure.

**Table 10-2 Potential Impacts Associated with Operational Phase for Watercourse Crossings**

| Aspect | Potential Impacts |
|---|---|
| GTP General Operations | • Contamination of surface water from leaks or spills. |
| Operational Monitoring – Use of Vehicle and Plant | • Introduction of weeds into riparian areas.<br>• Erosion and mobilisation of sediments into the watercourse.<br>• Accidental spills of fuel, hydraulic fluids or other materials, and resultant contamination of land and/or water. |

## 10.3 Decommissioning Phase

Activities associated with the decommissioning of the GLNG GTP are expected to have limited impact on watercourses. This is due to the GTP being left in situ following decommissioning. The main potential impacts are associated with the purging and cleaning of the pipe and the removal of associated infrastructure. Associated infrastructure will be removed by cutting at ground level. The decommissioned pipe will be inert and at atmospheric pressure, thus presenting negligible environmental impact and low environmental risk. Management plans will be reviewed and amended at the time of decommissioning to adopt current best practice. Potential impacts of the decommissioning phase are summarised in Table 10-3 below.

**Table 10-3 Potential Impacts Associated with Decommissioning Phase for Watercourse Crossings**

| Aspect | Potential Impacts |
|---|---|
| Purging and cleaning of pipe | • Contamination of surface water. |
| Use of Vehicle and Plant during decommissioning | • Introduction of weeds into riparian areas.<br>• Erosion and mobilisation of sediments into the watercourse.<br>• Accidental spills of fuel, hydraulic fluids or other materials, and resultant contamination of land and/or water. |

# 11 CONSTRUCTION MITIGATION MEASURES

In order to reduce the risk of environmental impacts, several levels of mitigation and management measures have been proposed. The most appropriate construction methodology for each crossing has been selected in order to reduce the overall impact to watercourses. The mitigation measures for permanent watercourse crossings have been developed in accordance to the following:

- Australian Pipeline Industry Association's (APIA) Code of Environmental Practice: Onshore Pipelines (the Code; March 2009), and are consistent with the AS2885 – *Pipelines – Gas, Liquid and Petroleum*.
- Fish Salvage Guidelines (DPIF 2004).
- Code for Self-assessable Development. Minor Waterway Barrier Works. Code no. WWBW01 (DEEDI 2011).
- Code for Self-assessable Development: Temporary Waterway Barrier Works. Code no. WWBW02 (DAFF 2013).
- Commonwealth Approval Conditions (EPBC Approval No. 2008/4096).
- Coordinator General's Conditions.
- Environmental Authority Conditions (PEN102664411).
- GLNG Project EIS and SEIS
- *Water Act 2000* (Water Act; Queensland Government (Qld Govt.) 2000).

General mitigation measures that will be applied during various phases of construction of watercourse crossings are listed in Section 11.1, while specific environmental management and mitigation measures are specified in Section 11.2. These mitigation measures include measures to prevent minimize and/or mitigate impacts on aquatic habitats, water quality and aquatic biota that may arise during construction works. With the implementation of these mitigation measures, construction works are unlikely to have a significant impact on in-stream ecology.

## 11.1 General Mitigation Measures

### 11.1.1 Pre-Construction Mitigation Measures

**Table 11-1 Pre-Construction Mitigation Measures**

| Aspect | Mitigating Measures |
|---|---|
| Pre-clearance | • All watercourses will be recorded as outlined under the Pre-Clearance Survey Methodology in accordance with EPBC guidelines where appropriate.<br>• The crossings shall be constructed as close to perpendicular to the axis of the watercourse channel as engineering and routing conditions permit.<br>• If the GTP parallels a watercourse, as far as is reasonably practicable, a buffer of at least 100 m for watercourses and 200 m from any wetland, lake or spring will be retained between the water body and the construction ROW. These buffers shall be clearly marked in the field with signs and highly visible flagging until construction activities are complete.<br>• Any significant vegetation (e.g. trees to be retained) or other significant features (e.g. heritage sites) will be avoided. These features will be clearly identified with highly visible flagging until construction is complete.<br>• Photos of all watercourse crossings and environmentally sensitive areas will be taken to provide record for the restoration process. |
| Approvals, Permits & Licences | • The works will not proceed until the relevant approvals and permits have been obtained. |
| Construction Techniques | • Site specific watercourse crossing techniques will be determined by the Contractor in consultation with the relevant regulatory authorities following consideration of environmental sensitivities (natural and social).<br>• Where reasonable and feasible, HDD will be adopted for major watercourses including those within the known distribution of *R. leukops* and *E. albagula.*<br>• Site specific management plans and engineering drawings shall be developed for major watercourse crossings detailing the construction and environmental management requirements.<br>• Works will be confined to the 40 m ROW, this will be reduced to 30 m in key locations within ESA.<br>• The works footprint within the watercourses will be minimised as far as is reasonably practical. |
| Construction Scheduling | • Construction will be programmed so as to minimise the amount of time works are undertaken within the watercourse.<br>• Construction activities will, where possible, be scheduled to minimise potential impacts on landholders.<br>• Watercourse crossing works will be scheduled during the dry season to target dry or low flow periods and minimise the risk of flooding, where possible.<br>• The construction of watercourse crossings within the know distribution of *R. leukops* will not take place during the nesting and breeding season of this species. |
| Ancillary Facilities | • Where possible, any site compound areas and other facilities will be located no less than 15 m from the top of bank.<br>• Where possible, all ancillary plant and equipment (e.g. water pumps) will be placed outside of the watercourse (i.e. landward of top of bank). |
| Vehicles, Plant & Equipment | • All plant and equipment required will be on-site and in good working order prior to work commencing on the watercourse crossing.<br>• All hydraulic, fuel and lubricating systems of machinery used in the watercourse crossings will be in good repair in order to minimise the risk of water pollution.<br>• Re-fuelling, wash downs and maintenance of vehicles will take place in designated areas a minimum of 30 m from the watercourse banks within a suitably bunded area.<br>• Construction machinery will have the necessary weed certifications prior to access to the watercourse.<br>• Vehicles, plant and equipment will be regularly maintained and inspected for leakages of fuel and/or oils.<br>• The Contractor will consider the use of biodegradable/environmentally friendly hydraulic fluids for plant and equipment.<br>• Access to/across the watercourse by vehicles, plant and equipment will be by a designated access way only. |
| Inductions & Training | • As stated in the CEMP (3380-SAIP-4-1.3-1814) all Project personnel, sub-contractors and consultants will receive training on the GTP environmental obligations during inductions, toolbox talks, and as per the Project Environmental Induction and Training Plan.<br>• All relevant personnel are to be inducted on the use of this AVMP during site inductions and Toolbox Talks. Site inductions and toolbox talks will highlight the specific environmental requirements and activities being undertaken at each watercourse crossings, including any additional measures for major watercourses identified in technical appendices.<br>• Participation in training and induction activities will be recorded in each individual's Environmental, Health, Safety and Security Passport. |

| Aspect | Mitigating Measures |
|---|---|
| Erosion & Sediment Controls | • Where the stream bed consists of rocks, pebbles or coarse gravel overlaying finer material, this material shall be removed and stockpiled separately for replacement during reinstatement.<br>• The crossings will typically be at right angles to the direction of water flow to minimise scour potential.<br>• Erosion and sediment controls will be implemented in accordance with the ESCP.<br>• Erosion sediment control measures will be installed on slopes where appropriate to filter surface runoff water even if the watercourse is dry.<br>• Sediment barriers will be installed across the entire construction ROW at all watercourse crossings to prevent the flow of sediments into the watercourse. Removable sediment barriers may be used in the travel lane. These may be removed during the day to enable construction and replaced after the day's works are complete and/or when heavy rainfall is imminent.<br>• Silt curtains will be deployed upstream and downstream of the works site prior to the commencement of construction.<br>• Sediment and erosion control measures will be installed as required on watercourse approaches and banks to prevent any runoff from entering watercourses.<br>• Diversion banks will be used at the crest of and on the slopes of, approaches to stream crossings to divert sheet flow away from the backfilled trenches.<br>• Each diversion bank will have a stabilised outlet to safely disperse channelised flows.<br>• Where required, terracing or surface water diversion berms will be placed along the top and intermediate points down the bank slope to encourage runoff to discharge on to stable (i.e. vegetated) areas or via sediment settling basins and not directly to the watercourse.<br>• Erosion sediment control measures will be located on the lower side of topsoil and bed and bank stockpiles and installed between the watercourse and the construction area to minimise sediment releases.<br>• For sites with highly dispersive soils watercourse banks will be protected during construction through the use of an erosion control blanket, mat or mesh. Synthetic mesh is not recommended for use along watercourses where wildlife that forage the riparian corridor are present. |
| Flora & Fauna | • Any snags or other woody debris located within the creek, within the ROW shall be removed and set aside, for re-instatement after the conclusion of construction.<br>• The AVA identifies the known distribution of the Fitzroy River turtle (*Rheodytes leukops*) or the white throated snapping turtle (*Elseya albagula*). The construction of watercourse crossings falling within this area will not take place during the nesting and breeding season of the Fitzroy River turtle (*Rheodytes leukops*).<br>• The preferred technique for crossing of watercourses inhabited by the Fitzroy River turtle or the white throated snapping turtle is, where reasonable and feasible, HDD. A minimum buffer must be established that exceeds the maximum recorded distance of nesting from the watercourse. |
| Traffic and Access | • Site access will be managed in consultation with the relevant landholders and/or regulatory authorities.<br>• Existing access roads and tracks will be used where reasonable and feasible.<br>• New access ways across watercourse crossings will be located within the ROW so as to avoid sensitive sites.<br>• Access ways established for purposes of the watercourse crossings construction works will be designed to accommodate the intended traffic types and volumes. |
| Social | • Notification of the relevant Aboriginal stakeholders will be undertaken by GLNG. Notification is required (up to 60 days) prior to the commencement of works in any creek or other location nominated in the Cultural Heritage Clearance Report, in accordance with the requirements of the Cultural Heritage Management Plan.<br>• Notification of the works and ongoing liaison with landholders and other affected residents or businesses will be conducted as required in accordance with the Community Relations Management Plan (3380-SAIP-4-1.3-1811). |

### 11.1.2 Construction Mitigation Measures

**Table 11-2 Construction Mitigation Measures**

| Aspect | Mitigating Measures |
|---|---|
| Vegetation Clearing | • Where practicable, clearing of slopes leading to watercourses will be delayed until construction of the crossing is imminent, thus minimising the risk of erosion and sedimentation.<br>• In watercourses of high aquatic value, a vegetated buffer of 50 m will, where possible, be maintained until construction is imminent. At watercourses with less than high aquatic value, a vegetated buffer of 10 m will be maintained until construction is imminent.<br>• All site offices, stockpiling/laydown areas and plant and equipment storage areas (including heavy machinery) will be sited to avoid clearing of remnant vegetation (i.e. preferably located on existing cleared lands).<br>• Large mature trees will be retained where possible and trees will be trimmed in preference to removal to retain the root stock for stabilisation of the banks.<br>• Where possible, larger plants and root stock will be retained for stabilization of the banks after the completion of works.<br>• Where possible, vegetation will not be felled so as to fall into watercourses.<br>• Cleared vegetation will be stockpiled away from watercourses.<br>• At watercourse crossings identified within the AVMP as comprising ecologically sensitive locations, mechanical slashers shall be considered for use in clearing activities. |
| Grading | • Grading of the banks for purposes of access will be minimised, and will be delayed until construction of the watercourse crossing or access way is imminent, so as to minimise the potential for mobilisation of sediments into the watercourse.<br>• Where possible, any cuttings in watercourse banks (if required) will be in the downstream direction.<br>• Stream bed and bank materials will be graded away (upslope) from the stream bed and placed in temporary stockpiles. Stockpiles will be located at least 10 m beyond the bank of any watercourse so that it does not interfere with the watercourse and will be protected on the downslope side by a silt fence and/or an adequate stockpile berm.<br>• Suitable location of spoil stockpiles will be decided on a site specific basis at the time of construction by the Site Engineer and Site Environmental Officer (SEO).<br>• Where the stream bed consists of rocks, pebbles or coarse gravel overlaying finer material, this material shall be removed and stockpiled separately for replacement during reinstatement. |
| Erosion and Sediment Controls | • The implemented erosion and sediment controls will be inspected regularly, including after rainfall or significant flow events, and maintained to ensure their ongoing functionality.<br>• Scour protection measures will be employed as required at the outlet of any flume pipes or bypass pipes.<br>• Drainage and discharge structures will be constructed so as to avoid alterations to the natural bed and bank profile.<br>• Dust suppression techniques will be employed to minimise the dust transport and deposition of dust.<br>• For sites with highly dispersive soils watercourse banks will be protected during construction through the use of an erosion control blanket, mat or mesh. Synthetic mesh is not recommended for use along watercourses where wildlife that forage the riparian corridor are present.<br>• Visual monitoring of the watercourse will be undertaken for the duration of the construction works as outlined in Section 15.1.3. Works will cease if a turbid plume is observed downstream of the works site. |
| De-watering | • De-watering will cease when water levels within the watercourse reach the critical level necessary to sustain aquatic fauna such as fish. Any aquatic fauna (i.e. fish, turtles or frogs) trapped in any impoundments areas will be salvaged in accordance with the Contractor Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Fish Salvaging Guidelines (DPIF 2004), after which time, de-watering may re-commence.<br>• The translocation of fish or other aquatic fauna is likely to require a General Fisheries Permit, Rehabilitation Permit and/or an Animal Ethics approval. Salvage and translocation of aquatic fauna shall be undertaken by a suitably qualified individual.<br>• All de-watering will be through appropriate erosion and sediment control devices a sufficient distance away from watercourses and mindful of potential to damage vegetation.<br>• There will be no release or de-watering of contaminants with potential to cause environmental harm to waters, land or ground water.<br>• Where well point de-watering is necessary to stabilise saturated soils (e.g. for high water table areas), or trench de-watering is required, appropriate water quality management and erosion and sediment control measures will be adopted for discharge water.<br>• Where de-watering is required, appropriate measures will be undertaken to protect water quality, which may include:<br>- Directing the water to a sediment basin.<br>- Assessing water quality prior to land application or re-use (e.g. for dust mitigation) in accordance with the monitoring requirements outlined in Section 15.2.<br>- Containing and treating water onsite or removing water off-site for treatment/disposal if it does not meet criteria for disposal on-site.<br>• Pipeline trench water will be released to land in accordance with the Water Quality Management Plan (3380-SAIP-4-1.3-7043) for disposal provided that the water is of a suitable quality.<br>• Any pumps used for de-watering or bypassing shall be bunded to prevent fuel spill contamination.<br>• Where flows are pumped around the site, water will be pumped to a geofabric lined containment area prior to controlled release back into the watercourse. |

| Aspect | Mitigating Measures |
|---|---|
| Hydrotest Water | • Any release of hydrostatic test water will be in accordance with the Hydrotest Water Management Plan (3380-SAIP-4-1.3-1840).<br>• Hydrostatic test water will not be released within 100 m of a watercourse.<br>• Hydrostatic test water will be released in a manner that:<br>  - Vegetation is not damaged.<br>  - Soil erosion and soil structure damage is avoided.<br>  - Hydrotest water does not migrate outside nominated land discharge areas. |
| Pipelaying | • Trenching on approaches to wet watercourses will leave hard trench plugs in place for the maximum period possible pending pipe laying.<br>• The pipe section designated for the crossing will be fabricated prior to trenching or directional drill completion to enable rapid installation.<br>• Trench plugs will be excavated and replaced with trench blocks or sack breakers above the slope and, as required, down the slope to prevent turbid water from directly entering watercourses.<br>• Appropriate measures such as concrete coated pipe or anchors shall be employed to weight the pipeline down in the trench as necessary.<br>• Tie-in points will be located on high ground well away from the banks. |
| Access Tracks | • Existing access roads and tracks will be used where reasonable and feasible.<br>• New access ways across watercourse crossings will be located within the ROW so as to avoid sensitive sites.<br>• All works associated with the construction of access tracks and watercourse crossings will be in accordance with the ESCP.<br>• Where ford/bed level crossings are used the crossing location will be stabilised with mats or other materials where required.<br>• Where causeway crossings are required, mitigation measures associated with minor dams will be in accordance with Section 11.2.2 and Section 11.2.3. |
| Soils | • In the event suspected contaminated material is uncovered during the works, the Procedure for Managing Unexpected Contamination contained within the Contaminated Land Management Plan (3380-SAIP-4-1.3-1993) will be implemented.<br>• In the event that suspected ASS are uncovered during the works, they will be managed in accordance with the Acid Sulphate Soils Management Plan (3380-SAIP-4-1.3-1832). |
| Hydrology | • As far as is reasonable and feasible, the works will be undertaken so as to minimise partial or full obstruction of flows.<br>• Where the adopted construction methodology requires the obstruction of flows, measures will where possible be implemented to bypass or divert flows downstream of the obstruction. The watercourse obstruction will remain in place for as short a time as possible.<br>• In-stream structures will be periodically checked and any build-up of sediment or debris upstream of the structure removed. The removed material will not be stockpiled where it has the potential to result in sedimentation of surface water (e.g. on slopes which drain to the watercourse). |
| Flora and Fauna | • Where possible, any snags or other woody debris located within the watercourse will not be removed. In the event that this is not possible due to proximity to the construction works, the snags will be removed from the watercourse prior to construction, set aside, and returned to the watercourse after the conclusion of construction.<br>• Where water is diverted around the works site via pumping, the intake will be screened to prevent the ingress of biota.<br>• Where temporary barriers are proposed for major watercourses, flume pipes will be the preferred method of diverting flows. Flumes will be designed and appropriately sized to enhance fish passage and accommodate flows. The pipe will be installed such that it is partially buried to provide continuity with the bed of the watercourse.<br>• Any fauna that becomes entrapped in the trench or similar shall be managed in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and Species Management Plan (3380-GLNG-3-1.3-0036).<br>• The risk of introducing weeds or other pests will be minimised by implementing the Pest and Weed Management Plan (3380-SAIP-4-1.2-1842).<br>• In the event of a fish kill resulting from the construction or placement of watercourse barrier works, Queensland Fisheries Service and the Environmental Manager (EM) should be notified as soon as possible. Depending on the circumstances, it may also be necessary to notify the authorities via the Pollution Hotline (telephone: 1300 130 372). |
| Waste | • Any debris on the watercourse crossing works site will as a minimum be collected on a daily basis and disposed of in accordance with the Waste Management Plan (3380-SAIP-4-1.3-1806).<br>• All waste material generated on-site will be recycled, re-used or disposed of at a suitably licenced waste facility in accordance with the Waste Management Plan (3380-SAIP-4-1.3-1806). |
| Incidents and Emergency Management | • The Site Foreman will monitor the rainfall / watercourse flow conditions in accordance with the instruction provided in Section 15.4.<br>• In the event of a flood warning, all vehicles, plant and equipment should be relocated a minimum of 30 m from the top of bank or above the 2 year ARI flood level (if known to be higher). All works should cease in advance of the flood event, and any temporary structures within the watercourse secured as far as is reasonably practicable.<br>• In the event of an accidental spill, the management measures outlined in the Emergency Response Plan – Spill Prevention and Response (3380-SAIP-4-1.2-1831) shall be implemented.<br>• In the event of an accidental spill or other pollution event (e.g. of sediment laden water) impacting on a watercourse, notification should be provided to the authorities via the Pollution Hotline (telephone: 1300 130 372), the EM and the landholder. |

### 11.1.3 Post Construction Mitigation Measures

**Table 11-3 Post Construction Mitigation Measures**

| Aspect | Mitigating Measures |
|---|---|
| Erosion and Sediment Control | • The interim bank protection works will be implemented as soon as is reasonably practical after the completion of construction.<br>• After the completion of construction, an assessment will be undertaken to determine the need for scour protection around the pipeline.<br>• Any bank or scour protection materials will be placed so as to conform with the existing natural contours, as appropriate, with topsoil spread over the sandbags or gabions (where used).<br>• A suitably qualified and experienced person (SQEP) with expertise in geomorphology will provide advice on the use of bank or bed stabilisation methods. Options for re-instatement include:<br>- Salvaging of existing bed material prior to the construction and placing it back into the watercourse or spring at completion of construction. If the existing bed material is unable to be salvaged, a comparable sediment sized material is recommended to cover the bed >0.1 m thick.<br>- If the bed sediments are fine (mud/silt), the bed material may be replaced with sand to prevent future erosion. If the sediment is coarser (gravel, cobble, pebbles), replacement material to be used in re-instatement works will be washed prior to placing in the creek.<br>- Stockpiled timber from pipeline construction clearing activities may also be utilised by spreading the timber randomly over the pipeline construction area leading down to the watercourse crossing.<br>• Additional erosion and sediment controls will be installed as required, such as:<br>- The application of terracing and surface water diversion berms along the top of bank and at intermediate points down the bank slope. Runoff water may be directed to stable (e.g. vegetated) areas or directed via sediment basins, and not allowed direct into the watercourse.<br>- The quality of groundwater is not adversely impacted.<br>- The installation of silt and sediment fences on slopes to filter surface runoff.<br>- Avoiding vehicle tracks up slopes on rehabilitation areas.<br>• Care shall be taken with the placement of any materials used to stabilise the bed or banks to ensure that the original conditions are re-instated and that the materials will not act as an impediment to fish passage. |
| Hydrology | • Any in-stream structures will be removed as soon as is reasonably practical following the completion of construction.<br>• Where dams are in place, the upstream dam will be removed slowly to allow water to flush the sediment from the workspace area. Sediment laden water will be pumped to a sediment basin or onto vegetated areas. The bypass pipe shall remain operational for as long as is possible during the process of de-commissioning the dam(s). |
| Site Rehabilitation | • Watercourse bed and banks will be re-instated as close as possible to their original profile. The banks will be compacted to stabilise them.<br>• Photos of all watercourse crossings and environmentally sensitive areas will be taken to provide record for the restoration process.<br>• The riparian zone will be re-vegetated in accordance with the Land Rehabilitation/Reinstatement Management Plan (3380-SAIP-4-1.3-1834) and the GLNG Project Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (3380-GLNG-3-1.3-0037). This will include re-vegetation of a buffer within the ROW 10 m from top of bank, which will be maintained in accordance with the Land Rehabilitation/Reinstatement Management Plan (3380-SAIP-4-1.3-1834).<br>• In the event that it was not possible to avoid impacts on any river improvement works carried out in River Improvement Areas by the River Improvement Trusts, the site will be rehabilitated to a suitable standard in accordance with the Land Rehabilitation/Reinstatement Management Plan (3380-SAIP-4-1.3-1834). |
| Traffic and Access | • After the completion of works, appropriate measures will be installed to discourage use of de-commissioned access ways for safety reasons and for purposes of assisting site recovery. These may be temporary or permanent structures. |
| Waste | • All waste material generated from the de-mobilisation of the site will be recycled, re-used or disposed of at a suitably licenced waste facility in accordance with the Waste Management Plan (3380-SAIP-4-1.3-1806). |

## 11.2 Construction Method Specific Mitigation Measures

### 11.2.1 Trenching Construction Mitigation Measures

In addition to general construction mitigation measures outlined in Table 11-1, 11-2 and 11-3, the following mitigation measures will be applied where trenching construction methods are required for watercourse crossings:

- The amount of time the trench is open or pipe is exposed will be minimised. Backfill will commence as soon as possible after pipelaying.
- The trench width and depth will be minimised to reduce spoil generation. Trench shoring or other alternative measures will be used if required.
- If flowing water is present, environmental flow regime will be maintained by using appropriately sized pumps or flumes.
- Where it is necessary to divert water flow around the crossing site, it will be pumped into a geofabric-lined contaminant area and subject to a controlled release a suitable distance downstream of the crossing site.
- Sediment laden water will be dealt with according to the ESCP.
- The risk of fauna entrapment in the trench will be minimised with regular inspections in accordance with the Species Management Plan (3380-GLNG-3-1.3-0036).

### 11.2.2 Dam and Pump Construction Mitigation Measures

In addition to general construction mitigation measures outlined in Table 11-1, 11-2 and 11-3, the following mitigation measures will be applied where dam and pump construction methods are required for watercourse crossings:

- Dams will be constructed of appropriate materials so as to minimise sedimentation (e.g. steel plates, sand bags, gravel bags, sheet piling or inflatable dams). The use of unprotected earthen dams will be avoided.
- Any minor dams will where possible be lined with an impermeable liner and sand bags.
- Regular inspections to ensure pump remains operational and sufficient fuel for overnight use.
- Any pumps used for de-watering or bypassing will be bunded to prevent fuel spill contamination.
- Water uptake hoses will be fitted with inlet filters or screens.
- Openings in pump intake screens will be appropriately sized to prevent the ingress of biota.
- In the event that fish are trapped, this will be dealt with in accordance with the Species Management Plan (3380-GLNG-3-1.3-0036).
- Discharge of diverted watercourse water directly back into the watercourse will be in a controlled fashion so as to prevent scour or sedimentation of the bed.

### 11.2.3 Dam and Flume Construction Mitigation Measures

In addition to general construction mitigation measures outlined in Table 11-1, 11-2 and 11-3, the following mitigation measures will be applied where dam and flume construction methods are required for watercourse crossings:

- Dams will be constructed of appropriate materials so as to minimise sedimentation (e.g. steel plates, sand bags, gravel bags, sheet piling or inflatable dams). The use of unprotected earthen dams will be avoided.
- Where possible, minor dams will be lined with an impermeable liner and sand bags.
- Where temporary barriers are proposed for major watercourses, flume pipes will be the preferred method of diverting flows.
- Flume pipes will be designed so as to maintain environmental flow regime.
- Where reasonable and feasible, the flume pipes will be designed to enhance fish passage, being as short as possible and with a minimum diameter of 500 mm.
- Suitable natural materials as available on site shall be placed along the bottom of the length of the pipe to simulate riffles.
- Where possible, the pipe will be installed such that it is partially buried to provide continuity with the bed of the watercourse.
- Flumes shall be maintained so that they remain free of debris.
- Discharge of diverted watercourse water directly back into the watercourse will be in a controlled fashion so as to prevent scour or sedimentation of the bed.

### 11.2.4 Cofferdam (Flow Diversion) Mitigation Measures

In addition to general construction mitigation measures outlined in Table 11-1, 11-2 and 11-3, the following mitigation measures will be applied where Cofferdam construction methodologies are employed:

- Sheet piling only applicable for loose and cohesive soils
- De-watering should cease when water levels within the impoundment area reach the critical level necessary to sustain aquatic fauna such as fish. Any aquatic fauna (i.e. fish, turtles or frogs) trapped in any impoundment areas will be salvaged in accordance with Fauna handling Procedure (3380-SAIP-4-1.3-1965) and the DPIF (2004) Fish salvage guidelines, after which time, dewatering may re-commence.
- All de-watering, including any well point de-watering necessary to stabilise saturated soils must be conducted in accordance with the procedure outlined in the Water Quality Management Plan (3380-SAIP-4-1.3-1947)
- Any pumps used for de-watering or bypassing will be bunded to prevent fuel spill contamination.
- Water uptake hoses will be fitted with inlet filters or screens.
- Openings in pump intake screens will be appropriately sized to prevent the ingress of biota.

### 11.2.5 HDD Construction Mitigation Measures

In addition to general construction mitigation measures outlined in Table 11-1, 11-2 and 11-3, the following mitigation measures will be applied where HDD construction methodologies are employed:

- Directional bore entry and exit points will be located outside of the riparian corridor where reasonable and feasible.
- Volumes of drilling mud/fluids will be monitored during construction to permit the early detection of any losses to the environment.
- The risk of the accidental release of contaminated drilling fluids, cave-ins and bed collapse due to HDD works will be minimised by selecting an appropriate boring depth below the watercourse.
- In the event of an accidental spill or release of contaminated drilling fluids, works will cease immediately and the procedure outlined in Section 20.3 will be implemented.
- Waste drilling mud will be contained in a suitably bunded and roofed facility prior to disposal at a suitably licenced facility.
- Noise and vibration impacts resulting from HDD works will be managed in accordance with the Noise and Vibration Management Plan (3380-SAIP-4-1.3-1838).

## 11.3 Operational Phase Mitigation Measures

**Table 11-4 Operational Phase Mitigation Measures**

| Aspect | Mitigation Measures |
|---|---|
| Erosion and Sediment Control | • Should erosion and sedimentation occur, appropriate corrective action will be undertaken, including installing, maintaining and monitoring erosion and sediment controls such as silt fences, berms and diversion drains.<br>• Vehicle access will be restricted to stable ground where practicable. Additional care will be taken near watercourses and drainage lines.<br>• The reinstated pipeline trench will be routinely checked for subsidence and exposure of the pipe, particularly at watercourse crossings and drainage depressions.<br>• Stability of the pipeline easement and, in particular, the condition of watercourse bed, banks and riparian vegetation will be inspected in accordance with an agreed inspection program. |
| Acid Sulphate Soils | • During pipeline operations, the disturbance of acid sulphate soils will be avoided or minimised. Barriers or other control measures will be implemented to ensure such soils are not released to surrounding land and water. |
| Traffic and Access | • After the completion of works, appropriate measures will be installed to discourage use of de-commissioned access ways for safety reasons and for purposes of assisting site recovery. These may be temporary or permanent structures.<br>• The pipeline easement will only be used as an access for activities essential to ensuring the continued safe operation of the pipeline and protection of the local environment. The easement will not be used as a general thoroughfare.<br>• Access to the pipeline easement will, as far as is practicable, be via existing tracks.<br>• The width of access tracks will be kept to a minimum practicable to enable safe vehicular movement.<br>• Access to and along the pipeline easement will be minimised following periods of prolonged or heavy rainfall.<br>• Access to the pipeline easement will be managed to minimise potential weed impacts. |
| Pests and Weeds | • The risk of introducing weeds or other pests will be minimised through implementation of the Pest and Weed Management Plan (3380-GLNG-3-1.3-0006).<br>• Weed monitoring and subsequent weed control will continue under the control of the Contractor for 2 years after completion of pipeline construction. During pipeline operation and decommissioning this responsibility will be handed to the Pipeline Operator.<br>• Monitoring during operation will determine the success of management measures or requirements for further actions. Any pest or weed species identified during site inspections and audits will be recorded, and appropriate management measures will be employed in response to the presence of these species.<br>• An Operational Weed Monitoring and Control Program will be development and implemented and will include (but not limited to):<br>- The rate of monitoring and control post completion will be as follows:<br>o Post rain event – once a month for three months.<br>o Otherwise, once every two months.<br>o In response to landholder or operator request.<br>- Weed monitoring and control activities will include all Project Areas (e.g. tracks, ROW and storage areas).<br>- Weed control will be undertaken by appropriately qualified and experienced Contractors who are appropriately licensed under the *Agricultural Chemicals Distribution Control Act 1966.* |
| Flora and Fauna | • A buffer of riparian vegetation will be maintained for watercourses. If regrowth trees within this buffer require removal, it will, where practicable, be done by hand.<br>• Implement the relevant operational phase actions contained in the GLNG Project Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (3380-GLNG-3-1.3-0037). |
| Pipeline Integrity | • Pipeline integrity will be monitored and maintained to prevent the release of product to the environment. |
| Waste | • The refueling or maintenance of equipment and vehicles will be conducted as far away as is reasonably practical from any surface water body to reduce the risk of contamination in the event of accidental fuel or oil release.<br>• Hazardous wastes will not be stored or handled within the vicinity of any surface water.<br>• The Waste Management Plan will be implemented during operation. |
| Pipeline Spill Prevention and Response | • Detailed Pipeline Spill Prevention and Response Plans will be developed for all operational pipelines where spills may be detrimental to public safety or the environment. Plans will address local issues, such as areas of particular environmental, social or cultural sensitivity.<br>• Pipeline Spill Prevention and Response Plans will address:<br>- Monitoring and detections systems.<br>- Notification and reporting procedures (both internal and external).<br>- Call-out procedures; contact lists and incident investigation procedures.<br>- Measures required to halt the spill (i.e. control of pumps, valves, etc.).<br>- Environmental impact assessment (high level to identify environmental risks). |

| Aspect | Mitigation Measures |
|---|---|
| | - Personnel responsibilities.<br>- Equipment requirements, location, storage, maintenance and transport.<br>- Communications and logistics.<br>• Spill response procedures will comply with all relevant regulatory requirements.<br>• Workforce training will be conducted in spill response and recovery procedures. Spill response exercises will be regularly conducted. |

### 11.4 Decommissioning Phase Mitigation Measures

Management plans will be reviewed and amended at the time of decommissioning to adopt current best practice.

**Table 11-5 Decommissioning Phase Mitigation Measures**

| Aspect | Mitigation Measures |
|---|---|
| Purging and Flushing | • Pipework will be flushed or purged using steam, water or inert gas.<br>• A project specific Water Source and Disposal Plan will be developed in consultation with the appropriate regulatory agencies.<br>• No water will be returned directly to watercourses without appropriate approvals.<br>• Water will be tested for hydrocarbon and chemical residue prior to disposal.<br>• Where contaminant levels exceed specified legislative values, flushed water shall be disposed of at an approved waste facility. |
| Traffic and Access | • Upon decommissioning, appropriate measures will be installed to discourage use of decommissioned access ways for safety reasons and for purposes of assisting site recovery. These may be temporary or permanent structures.<br>• The easement will not be used as a general thoroughfare.<br>• Access to the pipeline easement for decommissioning activities will, as far as is practicable, be via existing tracks.<br>• The width of access tracks will be kept to a minimum practicable to enable safe vehicular movement.<br>• Access to the pipeline easement will be managed to minimise potential weed impacts. |
| Erosion and Sediment Control | • Should erosion and sedimentation occur, appropriate corrective action will be undertaken, including installing, maintaining and monitoring erosion and sediment controls such as silt fences, berms and diversion drains.<br>• Vehicle access will be restricted to stable ground where practicable. Additional care will be taken near watercourses and drainage lines. |
| Rehabilitation | • Implement the relevant decommissioning phase actions contained in the GLNG Project Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (3380-GLNG-3-1.3-0037).<br>• On decommissioning of the pipeline, rehabilitation to pre-clearance conditions will be undertaken within all previously restricted vegetation growth areas, in accordance with EPBC Act Approval Condition 3d.<br>• Should there be a requirement to clear vegetation to access the ROW to remove above ground infrastructure; areas of impact will be rehabilitated to pre-clearance condition in accordance with the GLNG Project Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (3380-GLNG-3-1.3-0037). |
| Waste | • All waste material generated from the decommissioning of the site will be recycled, re-used or disposed of at a suitably licenced waste facility.<br>• The refueling or maintenance of equipment and vehicles will be conducted as far away as is reasonably practical from any surface water body to reduce the risk of contamination in the event of accidental fuel or oil release. |

# 12 SELECTION OF CROSSING METHODOLOGY

## 12.1 Crossing Methodology Selection for Pipeline Construction

This section complements the earlier sections of this AVMP that have discussed construction methodology. Section 9 discussed the outline of the limitations of each methodology and broadly the impacts. Section 10 discussed the potential impacts, while the mitigation measures were discussed in Section 11. This section will examine the selection of crossing methodology. A detailed site specific construction methodology assessment for each watercourse addressed in this Plan is provided in Appendix G1 and G2.

When selecting crossing methodology for each watercourse, the following items have been considered:

- Protection of aquatic values.
- Hydrology/Hydraulics
- Construction works' footprint i.e. disturbance area.
- Expected duration of works.
- Geotechnical requirements.
- Engineering risk.
- Cost of construction methodology.
- Other Physical Factors.

Constraints and impacts associated with each crossing methodology are provided in Table 12-1.

The level of impact associated with each constraint has been determined for each construction methodology and expressed as High (H), Moderate (M) or Low (L) in Table 12-1.

**Table 12-1 Pipeline Crossing Methodology – Methodology Constraints and Impacts**

| Methodology | Protection of Aquatic Value | Hydrology / Hydraulics | Social Factors | Geotechnical Requirements | Works Footprint | Construction Duration | Engineering Risk | Cost of construction |
|---|---|---|---|---|---|---|---|---|
| ***HDD*** | L-M<br>Although there is no direct disturbance to the watercourse, potential impact can occur through bore hole collapse or loss of drilling fluids to the environment which has the potential for a significant impact on water quality and aquatic values. | L<br>There is no requirement to (partially or fully) obstruct flow, divert flow or de-water a section of the creek for the HDD works | H<br>Long duration of construction, increase volume/duration of traffic and increased noise and vibration impacts. | H<br>Cannot be undertaken for creeks that contain boulders, coarse gravel, or where heterogeneous substrates may be encountered within the one bore hole. | H<br>Larger footprint due to the space required for construction pads, stringing area and additional access track. This will impinge on the land outside of the ROW. | H<br>At least 3 months per crossing, operating day and night. | H<br>Large diameter bore required, with risk of bore hole instability/ collapse Loss of drilling fluid into the watercourse from collapse or break out. Damage to the pipe or pipe-pull back during construction effecting pipe integrity. | H<br>High costs involved and due to the potential for failure and bore hole abandonment, cost could increase substantially due to rectification works. |
| ***Dry*** - Standard Mainline Construction | M<br>There is a requirement to excavate the watercourse bed, which will disrupt any aquatic fauna present in sediment and removal of aquatic flora. | L<br>This would be adopted during times of no flow therefore impacts on hydrology would be negligible. Bed materials are reinstated after works. | M<br>Moderate impacts due to increased traffic, noise and works footprint. Impacts will be reduced to the ROW. | L<br>Fewer invasive geotechnical investigations required. | M<br>Disturbance area is mainly limited to the ROW. | L<br>Approximately 2-5 days. | L<br>Low potential for engineering risk and the potential impacts are easier to manage through known trench construction methods and mitigation procedures. | L<br>Relatively low cost |
| ***Dry*** - Excavate from each Bank | M<br>There is a requirement to excavate the watercourse bed, which will disrupt any aquatic fauna present in sediment and removal of | L<br>This would be adopted during times of no flow therefore impacts on hydrology would be negligible. Bed materials | M<br>Moderate impacts due to increased traffic, noise and works footprint. Impacts will be reduced to the ROW. | M<br>Not feasible for watercourses >10 m wide. | M<br>Disturbance area is mainly limited to the ROW. | L<br>Approximately 2-5 days. | L<br>Low potential for engineering risk and the potential impacts are easier to manage through known trench construction | L<br>Relatively low cost |

| Methodology | Protection of Aquatic Value | Hydrology / Hydraulics | Social Factors | Geotechnical Requirements | Works Footprint | Construction Duration | Engineering Risk | Cost of construction |
|---|---|---|---|---|---|---|---|---|
| | aquatic flora. | are reinstated after works. | | | | | methods and mitigation procedures. | |
| ***Dry*** - Minor Dam / Pumping | M-H<br>There is a requirement to excavate the watercourse bed, which will disrupt aquatic fauna and flora. It also has low potential for short term increases in turbidity however diversion of flows should mitigate this. Fauna salvage would be required and temporary barrier would impact fauna passage. | M<br>Disruption of flow due to the presence of the dam. However, low flows would be conveyed through the obstruction via pumping. | M<br>Moderate impacts due to increased traffic, noise and works footprint. Impacts will be reduced to the ROW. | L<br>Fewer invasive geotechnical investigations required. | M<br>Disturbance area is mainly limited to the ROW. | M<br>Approximately 1-3 weeks. | L - M<br>Low potential for engineering risk and the potential impacts are easier to manage through known trench construction methods and mitigation procedures. | L<br>Relatively low cost |
| ***Dry*** - Minor Dam / Flume | M-H<br>There is a requirement to excavate the watercourse bed, which will disrupt aquatic fauna and flora. It also has low potential for short term increases in turbidity however the presence of flume pipes should mitigate this. Fauna passage would be maintained by flume pipes. | M<br>Disruption of flow due to the presence of the dam. However, low flows would be conveyed through the obstruction via the flume pipes. | M<br>Moderate impacts due to increased traffic, noise and works footprint. Impacts will be reduced to the ROW. | L<br>Fewer invasive geotechnical investigations required. | M<br>Disturbance area is mainly limited to the ROW. | M<br>Approximately 1-3 weeks | L - M<br>Low potential for engineering risk and the potential impacts are easier to manage through known trench construction methods and mitigation procedures. | L<br>Relatively low cost |

| Methodology | Protection of Aquatic Value | Hydrology / Hydraulics | Social Factors | Geotechnical Requirements | Works Footprint | Construction Duration | Engineering Risk | Cost of construction |
|---|---|---|---|---|---|---|---|---|
| ***Wet Trenching*** | M-H<br>Excavation of the watercourse bed would result in increases in turbidity. Fauna passage would be impacted during works. | L<br>Minimal disruption to flows. | M<br>Moderate impacts due to increased traffic, noise and works footprint. Impacts will be reduced to the ROW. | L<br>Fewer invasive geotechnical investigations required. | M<br>Disturbance area is mainly limited to the ROW. | L<br>Approximately 2-5 days. | L<br>Low potential for engineering risk and the potential impacts are easier to manage through known trench construction methods and mitigation procedures. | L<br>Relatively low cost |

*H = High, M = Moderate, L = Low.

These factors are discussed in detail below.

### 12.1.1 Protection of Aquatic Values

- The protection of aquatic values throughout watercourses is considered a high priority for the Project.
- Protection of conservation significant species is of very high importance.
- Passage of aquatic fauna is considered important.
- Reduction of disturbance footprint and length of construction period is considered important.

### 12.1.2 Hydrology/Hydraulics

- Presence of water:
  - Dry watercourse – preference for standard mainline trenching.
  - Wet watercourse – consider alternative approach.
- Volume and depth of water:
  - If unable to adequately convey flows via pumping, adopt flume pipe (field verification and/or ecological reports).
- Width and/or depth of watercourse:
  - Dependent upon the cross sectional configuration of the watercourse at the location of the crossing, it may not be possible to excavate from both banks (e.g. where the watercourse width is greater than 10 m).
- Construction safety (OH&S):
  - Flumes generally adopted for safety purposes – construction risk (e.g. flash flooding) for watercourses with large sub-catchments.
  - Dry conditions are preferable from a safety perspective.
- Larger watercourses with steep banks will generally require additional workspace.

### 12.1.3 Construction Works' Footprint

The construction works' footprint is referred to as the amount of disturbance expected from application of the particular construction methodology. Where possible, these impacts will be minimized. In general:

- Significant extra work space is required for HDD due to stringing and other construction activities.
- Generally, works for standard mainline construction and dam and pump or flume can be restricted to the ROW. In some instances, extra work space is required for some activities outside of the ROW (e.g. stockpiling of materials, additional equipment and preservation of topsoil etc.).
- The works' footprint associated with each methodology is detailed in Table 13-9.

### 12.1.4 Expected Duration of Works

The construction duration is the time taken to complete the construction works, where a long duration is expressed as High (H) and is presented in Table 12-1. The methodology with the shortest construction time is generally the preferred option to minimise environmental and social impacts.

- HDD construction may take up to 3 months.

- Standard mainline construction is approximately 2-5 days.
- Minor dam and pump or flume construction is approximately 1-3 weeks.

### 12.1.5 Geotechnical Requirements

The geotechnical requirements are the physical requirements or constraints that the physical environment presents at the crossing point. The most important issues considered are:

- Homogeneity of the soil stratigraphy of the watercourse bed.
- Potential collapse of tunnel or trench.
- Risk of loss of drilling fluid.

### 12.1.6 Engineering Risk

Engineering Risk is the risk associated with the selected construction methodology and potential safety and environmental issues.

### 12.1.7 Cost of Construction Methodology

The cost of construction methodology refers to the whole cost to construct through the watercourse crossings, which includes the minimization of demand on resources and/or waste generation. This cost, practicality/technical feasibility, is commensurate with the relative/achievable environmental benefits as per the table in Appendix G1. The Triple Bottom Line Assessment shows that the use of HDD can result in higher and longer lasting impacts, with the greatest potentials coming from the following factors:

- Noise.
- Waste.
- Longer duration of the works.
- Impacts due to travel to the works.

### 12.1.8 Social

- Proximity to sensitive receivers and possibility of noise and vibration impacts and traffic impacts.
    - Significant impacts associated with HDD.
- Landowner issues.
    - Attempts have been made to reduce the amount of extra work space required for HDD.

## 12.2 Crossing Methodology Selection for Access Way Construction

When selecting the appropriate access way construction methodology, consideration is given the factors listed above in Section 12.1. A summary of the constraints and impacts with each methodology is summarised in Table 12-2.

**Table 12-2 Access Way Construction Methodology – Engineering Constraints / Impacts**

| Methodology | Works Footprint | Construction Duration | Engineering Risk |
|---|---|---|---|
| Ford (e.g. with mats) | L | L<br>1 day. | L<br>Negligible. |
| Causeway with Flume | M<br>Larger area required for construction. Footprint may be larger due to requirement for aprons and scour protection works. | L<br>Approximately 3-5 days. | M<br>Potential for blockage of flume pipes. Potential for de-stabilisation of causeway material. Structure will require additional consideration of design and monitoring requirements. |
| Prefabricated Elevated Bridge / Steel Ramp | L | L<br>Approximately 2-4 days. | L - M |

*H = High, M = Moderate, L = Low

# 13 SITE SPECIFIC OVERALL AQUATIC VALUE AND CONSTRUCTION METHODOLOGY

Considerations for the suitable construction methodologies and mitigation measures have been determined on a site specific basis. These are detailed in Tables 13-1 (major watercourses, environmental values), 13-9 (high aquatic value watercourses) and 13-10 (major watercourses, mitigation measures).

The following sub-sections provide an overview of the aquatic values of the watercourses intercepted by the GTP on the Mainland (including the Tidal area) and Curtis Island.

Detailed descriptions of aquatic values for all watercourses are presented in the Aquatic Values Assessments in Appendix B, C and D.

Sections 13.1 and 13.2 provide an overview of minor and major watercourses assessed as having negligible to moderate aquatic value (respectively) and therefore have no potential habitat for conservation significant species.

A detailed description of the aquatic values is provided for those watercourses which were identified as having high aquatic values and hence potential habitat for conservation significant species. This is provided on a site specific basis (refer Section 13.3-13.11). Trenchless methodology was assessed in detail for all watercourses which were identified as having high aquatic values (refer Table 13-9). For major watercourses of all aquatic values, Table 13-10 demonstrates the site specific mitigation measures.

Additionally, a detailed description of two Tidal watercourses is provided in Section 13. Humpy Creek (KP407) is provided as the only major tidal watercourse for the GLNG GTP. Humpy Creek contains moderate aquatic value and is provided to demonstrate the construction methodology and justification of chosen method and the site specific mitigations for all four of the watercourses within the Tidal area (refer Section 13.12).

The second Tidal watercourse, Taginie Creek's (KP408) has been included in Section 13.13 and in Table 13-1 and 13-10 , as although a minor watercourse this creek has the potential to contain EPBC listed species (the water mouse).

A full list of major watercourses and their locations is detailed in Appendix A. The construction methodology, width of the ROW and the additional workspace required for each crossing is also detailed in Appendix A. Figures 1-6 illustrate the major watercourses intercepted by the entire GTP ROW.

For ease of reference, watercourse crossings have been presented in the order of which the pipeline traverses, beginning at KP0.

**Table 13-1 Environmental Values and Significant Species Consideration for Major Watercourse Crossings (including Targinie Creek (Minor Watercourse))**

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| Hutton Creek | 2.1 | 6 | Yes | Potential | Potential | 11.3.25 Least Concern | High | High | HDD not reasonably possible due to geotechnical and ecological constraints – Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flume | Not preferred |
| Christmas Creek | 2.7 | 4 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench |
| Baffle Creek (western alignment) | 19.8 to 21.6 | 4 | Yes | Potential | Potential | 11.10.1 | High | High | HDD not reasonably possible due to geotechnical and ecological constraints Refer Appendix G2 | Open (Dry) Trench – Minor Dam & Flume | Not preferred |
| Unnamed Watercourse 1 | 28.7 | 3 | No | Unlikely | Unlikely | 11.3.25/11.9.5a Endangered | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench |
| Dawson River (Upstream) | 29.8 | 5 | Yes | Potential | Potential | 11.3.2 Of Concern | Moderate | Moderate to High | HDD not reasonably possible due to geotechnical and ecological constraints Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flume | Not preferred |
| Bully Frog Creek | 46.0 | 3 | No | Unlikely | Unlikely | 11.3.2 Of Concern | Negligible | Low | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench |
| Unnamed Watercourse 2 | 57.4 | 3 | No | Unlikely | Unlikely | Non-remnant | Negligible | Low | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench |
| Ironbark Creek | 62.3 | 3 | No | Unlikely | Unlikely | 11.3.2/11.3.25 Of Concern | Low | Low (possibly Moderate in an above | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench |

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| | | | | | | | | average wet season) | | | |
| Unnamed watercourse 3 | 80.8 | 3 | No | Highly Unlikely | Highly Unlikely | Non-remnant | Negligible to Low | Negligible to Low | - | Open (Dry) Trench | Open (Dry) Trench |
| Clematis Creek | 108.6 | 5 | No | Unlikely | Unlikely | 11.3.2 Of Concern | Low | Moderate | - | Open (Dry) Trench | Open (Dry) Trench |
| May Creek | 111.3 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench | Open (Dry) Trench |
| Deep Creek | 124.5 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench | Open (Dry) Trench |
| Unnamed watercourse 4 | 133.9 | 3 | No | Unlikely | Unlikely | 11.5.2/11.10.7/11.10.7a/11.10.1 Least Concern | Low | Low | - | Open (Dry) Trench | Open (Dry) Trench |
| Prospect Creek | 177.7 | 4 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench | Open (Dry) Trench |
| Unnamed watercourse 5 | 184.1 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench | Open (Dry) Trench |
| Conciliation Creek | 207.4 | 5 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Avoid if possible |
| Brolga Gully | 214.8 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |
| Mimosa Creek | 220.1 | 6 | No | Unlikley | Unlikely | Non-remnant | Low | Moderate | - | Open (Dry) Trench – Minor Dam & Flow Diversion | Avoid if possible |
| Denby Creek | 231.1 | 3 | No | Unlikely | Unlikely | 11.3.2/11.3.4/11.3.25 Of concern | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| Dawson River (Downstream) | 233.9 | 8 | Yes | Potential | Potential | 11.3.2/11.3.25 Of concern | High | High | HDD not reasonably possible due to geotechnical and ecological constraints Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |
| Back Creek | 234.3 | 3 | No | Unlikely | Unlikely | 11.3.2./11.3.1 Endangered | Low | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Kianga Creek | 239.7 | 4 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Banana Creek | 252.4 | 5 | No | Unlikely | Unlikely | Non-remnant | Low | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Banana Creek | 252.6 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Police Camp Creek (KP 263.66) | 263.6 | 4 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Police Camp Creek (KP 269.96) | 269.9 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Spring Creek | 272.4 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Sellheim Creek | 280.2 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Neville Creek | 285.8 | 3 | No | Unlikely | Unlikely | Non- | Low | Moderate | - | Open (Dry) Trench | Reassess if |

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| | | | | | | remnant | | | | – Standard Mainland Construction | required*** |
| Orange Creek | 295.6 | 6 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |
| Unnamed Watercourse 7 | 296.6 | 4 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Kroombit Creek | 296.8 | 6 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |
| Palustrine Wetland | 297.7 | 3 | No | Unlikely | Unlikely | Non-remnant | Negligible to Low | Negligible to Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Callide Creek | 298.9 | 5 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |
| Callide Creek (Old Channel) | 300.3 | 5 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Unnamed Watercourse 8 | 303.7 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Unnamed Watercourse 8 | 305.5 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Collards Creek | 319.1 | 3 | No | Unlikely | Unlikely | 11.11.15/11.3.25/11.11.4/11.11.4a Least concern | Low | Low | | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| Bell Creek | 334.5 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Calliope River | 352.3 | 5 | Yes | Potential | Potential | 11.3.4/11.3.25 Of concern | High | High | HDD not feasible due to geotechnical conditions, ecological and alignment constraints in CICSDA and prohibitive costs Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flume | Open (Dry) Trench – Minor Dam & Flume |
| Unnamed Watercourse 9 | 354.3 | 3 | No | Unlikely | Unlikely | Non-remnant | Low | Low | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Unnamed Watercourse 10 | 359.5 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |
| Harper Creek | 360.3 | 4 | Yes | Potential | Potential | Non-remnant | High | High | HDD not feasible due to geotechnical conditions, ecological and alignment constraints in CICSDA and prohibitive costs Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |
| Alarm Creek | 364.8 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |
| Gravel Creek | 375.6 | 3 | No | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Reassess if required*** |
| Larcom Creek (KP378.06) | 378.0 | 4 | Yes | Potential | Potential | Non-remnant | High | High | HDD not feasible due to geotechnical conditions, ecological and alignment constraints in GSDA and prohibitive costs Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |

| Watercourse / Wetland | KP | Stream order | Listed* Species Habitat Present | Breeding place for Listed* Species | Potential impact on Listed* Species | EHP RE mapping | Aquatic Value Dry Season (crossing and reach)** | Aquatic Value Wet Season (crossing and reach)** | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| Larcom Creek (KP384.76) | 384.7 | 3 | Yes | Potential | Potential | Non-remnant | High | High | HDD not feasible due to geotechnical conditions, ecological and alignment constraints in GSDA and prohibitive costs Refer Appendix G1 | Open (Dry) Trench – Minor Dam & Flow Diversion | Open (Dry) Trench – Minor Dam & Flow Diversion |
| Humpy Creek | 407.87 | 3 | No | Highly Unlikely | Highly Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench – Minor Dam & Flume |
| Targinie Creek | 408.51 | 2 | Yes | Unlikely | Unlikely | Non-remnant | Moderate | Moderate | - | Open (Dry) Trench – Standard Mainland Construction | Open (Dry) Trench – Minor Dam & Flume |

* Refers to species listed in the *Environmental Protection and Biodiversity Act 1999* and the *Nature Conservation Act 1992*
**Refer to Section 6.5 for definitions of these classes of aquatic value
*** If wet conditions are encountered during construction, albeit unlikely, construction methodology will be assessed according to the conditions present at the time. Options for wet conditions include Minor dam and flume, Minor dam and pumping and wet trenching.

## 13.1 Minor Watercourses

### 13.1.1 Overall Aquatic Value

A representative sample (25%) of minor watercourses was selected during the desktop study to be assessed in the field. The purpose of this field assessment was to provide a representative understanding of the environmental values and ecological conditions of minor watercourses along the GTP ROW.

The overall aquatic value of the minor watercourses within the surveyed area ranges from Negligible to Moderate, which is consistent with what is known of the wider catchment. Agricultural development (in particular clearing for grazing and access to watercourses by cattle), road crossings and dams have significantly impacted on the aquatic values of the watercourse crossings in the surveyed area. Most watercourses within the survey area are characterised by having soils of moderate to high erosion potential and of the watercourses surveyed most have limited and fragmented riparian vegetation present.

The minor watercourses within the study area are characterised by having ephemeral flow, flowing after heavy rain events but are usually found to be dry.

Based on the field survey data, it has been determined that there are no listed (under State or Commonwealth legislation) aquatic flora species located within the surveyed area. There are three aquatic fauna species and one terrestrial species that are listed under State or Commonwealth legislation, that have the potential to be found within the Mainland and Tidal surveyed area, these are the white-throated snapping turtle (*Elseya albagula*), the Fitzroy River turtle (*Rheodytes leukops*), the platypus (*Ornithorhynchus anatinus*) and the water mouse (*Xeromys myoides)*. However, during the conducted field surveys no listed species were encountered and all minor watercourses were deemed to have unsuitable habitat to maintain populations of any of the listed species, with the exception of Targinie Creek which is located in the outer limit of water mouse habitat and is addressed in Section 13.13.

The below illustrations (1 and 2) show examples of minor watercourses with negligible to low and moderate aquatic value respectively. An example of a tidal minor watercourse with moderate aquatic value is also presented (Illustration 3).



**Illustration 1: Minor Watercourse 21 (KP65.65) with negligible to low aquatic value (Wet season 2012)**



**Illustration 2: Minor Watercourse 144 (KP345.59) with moderate aquatic value (Wet season 2012)**



**Illustration 3: Minor Watercourses 203 (KP408.51) with moderate aquatic value (Wet season 2012)**

### 13.1.2 Construction Methodology and Mitigation Measures

Minor watercourses have been separated into two classes based on their construction methodologies. Construction methodologies were chosen based on the factors outlined in Section 12.

Class 1 minor watercourses will be crossed using a standard dry trenching methodology as conditions are likely to be dry at the time of crossing. A bed level crossing will be established to maintain access through the watercourse. This methodology will enable rapid construction throughout this watercourse hence reducing the overall works footprint. At the completion of construction, the banks will be reinstated and stabilised by grass seeding which will assist in controlling erosion and sedimentation during rainfall events.

Class 2 Watercourses will also be crossed using open dry trenching methodology, however the uses of a minor dam and flume (and/or pump) will be utlised to ensure dry conditions are maintained. Construction is scheduled to be carried out in the dry season crossing to assist in decreasing the chance of wet conditions.

In some instances, a minor dam and flume has been adopted at completely dry watercourses. These are generally watercourses with large/steep catchments and the use of a minor dam and flume will ensure safety to all construction personnel in the event of rainfall and rapid flows. This will also minimise environmental disturbance caused from heavy/rapid flows. A normal crossing will be established to maintain access through the watercourse, however in the event wet conditions are encountered, a causeway would be constructed. This methodology will enable rapid construction throughout these watercourses hence

reducing the overall works footprint. At the completion of construction, the banks will be reinstated and stabilised by grass seeding which will assist in controlling erosion and sedimentation during rainfall events.

## 13.2 Major Watercourses (Negligible to Moderate Aquatic Value)

### 13.2.1 Overall Aquatic Values

All 51 major watercourses were investigated in the field for aquatic values and 41 were assessed as having negligible to moderate aquatic value. 20 sites were found to have low aquatic value and 21 were moderate, the remaining 10 were deemed to have high aquatic values and are not addressed in this section, but in Section 13.3-13-11. Of the major watercourses with negligible to moderate aquatic values, one site, the palustrine wetland at KP297 was found to have negligible to low aquatic value and Sellheim Creek at KP280 was found to have low aquatic values increasing to moderate in the wet season. The full results of the aquatic values surveys are detailed in the Aquatic Values Asessments in Appendix B and C.

All watercourses within the survey area are characterised by having soils of moderate to high erosion potential and of the watercourses surveyed most only have fragmented riparian vegetation present.

The flow regime for the rivers within the study area is dominated by unpredictable, highly intermittent summer flow, with some reaches having variable, extremely intermittent summer flow. Thus, most stream reaches tend to be dry during winter, and the magnitude, duration and timing of summer flows varying greatly between years. Physical water quality was characterised by average pH and varying dissolved oxygen levels. The sites also produced varied electrical conductivity and turbidity results, likely related to local situations and characteristics.

Based on the field survey data, it has been determined that there are no listed (under State or Commonwealth legislation) aquatic flora species located within the surveyed area. There are three aquatic fauna species and one terrestrial species that are listed under State or Commonwealth legislation, that have the potential to be found within the surveyed area, these are the white-throated snapping turtle (*Elseya albagula*), the Fitzroy River turtle (*Rheodytes leukops*), the platypus (*Ornithorhynchus anatinus*) and the water mouse (*Xeromys myoides)*. All of these major watercourses (with negligible to moderate aquatic values) were deemed to have unsuitable habitat to maintain populations of any of the listed species.

One major watercourse with moderate aquatic value (Humpy Creek) is presented in Section 13.12. This watercourse is presented as an example of the construction methodology selection and the proposed mitigation measures as a representation for all four Tidal watercourses (refer Section 13.12).

The below illustrations (4, 5 and 6) show examples of major watercourses with low and moderate aquatic value respectively.



**Illustration 4: Palustrine Wetland KP297.71 showing negligible to low aquatic value (Wet season 2012)**



**Illustration 5: Police Camp Creek KP269.96 showing low aquatic value (Wet season 2012)**



**Illustration 6: Bell Creek (KP334.54) showing moderate aquatic value (Wet season 2012)**

### 13.2.2 Construction Methodology and Mitigation Measures

Construction methodologies have been selected for the predicted conditions at the time of crossing at major watercourses with negligible to moderate aquatic value. The proposed construction methodology for each watercourse is detailed in Appendix A. The following approach has been used to assign methodology for each watercourse:

a. Dry trenching with minor dam and flume (and/or pump) for watercourses with flowing water or temporary pools with a moderate aquatic value or less;
b. Dry trenching for watercourses where there is no water present and with a moderate aquatic value or less.

In the event that conditions at the time of construction differ from the expected, the above approach will be used to assign new methodologies to these watercourses.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.3 Hutton Creek (KP2.09)

### 13.3.1 Overall Aquatic Value

Hutton Creek is a stream order 6 system, having large permanent pools at the crossing location and an intermittent flow regime. The floodplain has been extensively cleared for grazing, and the soils in the area have high erosion potential. The land is classed as non-agricultural land.

The GTP ROW intersects the mid reach of Hutton Creek, where the riparian zone is in poor-moderate condition and mapped as non-remnant. The riparian zone consists primarily of *Casuarina cunninghamiana*, *Melaleuca vimilalis*, with emergent *Eucalyptus tereticornis* which is consistent with RE11.3.25. Hollow-bearing trees were present within and in close proximity to the GTP ROW.

Previous ecological investigations of the Hutton Creek GTP ROW (Aurecon, 2009) concluded that this section of the creek is likely to support a stable population of platypus as a result of the creek's hydrology and geomorphology. Previous surveys and the current field investigation found platypus burrows downstream of but not within the GTP ROW.

Two species of freshwater turtle were caught during the current field survey: Kreft's river turtle (*Chelymys krefftii*) and saw shelled turtle (*Wollumbinia latisternum)*. It is also possible that populations of the white-throated snapping turtle (*Elseya albagula*) occur in the vicinity of the watercourse crossing. Previous studies (Hamann et al. 2007) found this species in the headwaters of Hutton Creek (i.e. to the west of the proposed crossing) and near the junction of Hutton Creek and Boyd Creek (i.e. downstream of and to the east of the proposed crossing). Marginal habitat for Fitzroy River turtle (*Rheodytes leukops*) exists along Hutton Creek, however wet season aquatic surveys indicated that there was no preferred habitat for this species within the vicinity of the ROW.

Only emergent aquatic plants were found within and near the GTP ROW on Hutton Creek, and included *Juncus* sp., *Cyperus* sp., *Persicaria decipiens* and *Marsilea* sp.. The freshwater fish that were found at the site during field investigations were carp gudgeons (*Hypseleotris* spp.), glass perchlets (*Ambassis agassizii*) and eastern rainbowfish (*Melanotaenia splendida*). The introduced goldfish (*Carassius auratus*) was also found at this site. Other notable aquatic fauna included river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.).



**Illustration 7: Hutton Creek KP2.09 Looking downstream from the proposed crossing location (et season 2012)**

### 13.3.2 Selection of Construction Methodology

Based on the information presented in Section 13.3.1, Hutton Creek is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that Hutton Creek should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology and a significantly larger disturbance footprint to adjacent remnant vegetation.

A critical factor that was used to determining the suitability of using HDD was site geology. The geology at the proposed crossing is predominantly lower Jurassic age deposits of sandstone comprising quartzose sandstone, minor siltstone and shale, and easily decomposable and sub-labile sandstone, mudstone, occasional shale and coal. Borehole results can be typically summarised as alluvium (about 1m) overlying residual soil, in turn overlying slightly weathered rock comprising inter bedded sandstone and siltstone. The alluvium was also encountered to depths of 7.25m inter bedded very stiff sandy clay and dense clayey sand. New boreholes indicated highly fragmented (boulders) rocks in the borehole. Existence of highly weathered rocks with fragmented (boulders) to fractured rocks presents a high risk for HDD because of increased potential of frac out and subsequent uncontrolled release of drilling fluids to the environment. The presence of hard fractured rock also poses a high risk of damage to the pipe coating and cathodic protection systems. The geology of the area presents unsuitable conditions for safe and effective execution of HDD. These geological risks would increase risks to the environment with potential for uncontrolled release of drilling fluids directly to the watercourse.

HDD was also determined to have a significantly larger footprint than dry trenching. This is partly due to the need for a significant amount of extra space required for HDD launch and receiving pads and stringing area which would result in the clearing of approximately an additional 1.62 ha of Least concern RE 11.3.25 (*Eucalyptus tereticornis* or *Eucalyptus camaldulensis* woodland fringing drainage lines).

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.3.3 Construction Methodology and Mitigation Measures

Construction is estimated to take place between March and April 2013, at the beginning of the dry season. The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species may be able to be minimised. To further mitigate the impact on both species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks.

Bank protection and reinstatement will be an important component of the proposed works. Hutton Creek bank profiles will be reinstated to pre disturbance conditions. Banks will be stabilised using a combination of rock armoring and jute matting (or similar). High banks and vegetated areas will be stabilised using hydro mulching.

Hutton Creek is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.4 Baffle Creek (KP20.4)

For Baffle Creek two sites have been considered: the eastern alignment at KP20.4 on the original right of way (ROW), and the proposed re-route on an alternate western alignment. Figure 3 illustrates the location of both alignments. The ROW in this section of the GTP is 30 m wide, as the Baffle Creek area contains Environmentally Sensitive Areas (ESAs) and an area of cultural significance.

The following provides an overview of the aquatic values for Baffle Creek at the two assessed crossing locations in addition to the proposed construction methodology and specific mitigating measures for Baffle Creek.

The construction methodology and the additional workspace required for the crossing is also detailed in Table 13-4.

The location of both Baffle Creek crossings is detailed in Table 13-2. Figure 3 illustrates the potential crossing locations of Baffle Creek.

**Table 13-2 Locations of Baffle Creek Crossings**

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Eastings | Northings |
|---|---|---|---|---|---|
| Baffle Creek (Eastern) | 20.4 | 4 | Least concern | 687722.56 | 7167722.50 |
| Baffle Creek (Western) | 19.8-21.4 | 4 | Least concern | 687364.88 | 7167681.78 |

**Table 13-3 Environmental Values and Significant Species Consideration for Baffle Creek Crossings**

| Watercourse/ Wetland | KP | Stream order | Listed Species Habitat Present | Breeding place for Listed Species | Potential impact on Listed Species | DERM RE mapping | Overall Aquatic Value (crossing and reach)* | Feasibility of HDD | Suitable Construction Methodology with Appropriate Mitigation | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Dry to low flow conditions | Moderate to high flow conditions |
| Baffle Creek (western alignment) | 19.8 to 21.6 | 4 | Yes | Potential | Potential | 11.10.1 | High | HDD not reasonably possible due to geotechnical and ecological constraints | Open (Dry) Trench | Not preferred |
| Baffle Creek (eastern alignment) | 20.4 | 4 | Yes | Potential | Potential | 11.10.1 | High | HDD feasible but very high risk of failure | N/A | N/A |

*Refer to Section 6.5 for definitions of these classes of aquatic value

**Table 13-4 Construction Methodology at Baffle Creek**

| Watercourse/ Wetland | Approximate Additional Workspace Required | Construction Methodology | | | | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| | | Access Way | Pipeline Construction | Bank Reinstatement | Reference drawings | |
| Baffle Creek (western alignment) | 45,950m$^2$ | Causeway | Minor Dam and Flume | Mulching | 3381-40-3403 | Apr-Jun 2013 |

### 13.4.1 Baffle Creek (western alignment) – Overall Aquatic Value

Baffle Creek is a 4th order tributary of the Dawson River, having large permanent pools and riffles at the RCR47 crossing location and an intermittent flow regime. The channel is located in a deep sandstone gorge with native forest dominating the riparian zone. Bedrock is present along the creek banks. The land is classed as non-agricultural land.

The GTP ROW intersects the mid reach of Baffle Creek, where the riparian zone is in good condition and mapped as non-remnant. The riparian zone consists primarily of *Eucalyptus* sp. and *Callistemon* sp., and is mapped as RE11.10.1.
One adult saw shelled turtle (*Wollumbinia latisternum* sny. *Elseya latisternum*) was caught at the site. Baffle Creek may support populations of Fitzroy River turtle and white-throated snapping turtle at locations where permanent pools exist during the drier months, such as in the vicinity of the GTP ROW. Previous studies (Hamann et al. 2007) have found white-throated snapping turtle to the north-west and to the east of the Baffle Creek GTP ROW. Suitable habitats for Fitzroy River turtles (i.e. riffles, pools and sandy banks) occur at this site. Baffle Creek is also thought to support populations of platypus, although burrows were not found within or near the GTP ROW.

One species of submerged aquatic plant was found near the GTP ROW on Baffle Creek (*Potamogeton* sp.); all other aquatic plants found during field investigations were emergent forms, including *Juncus* sp., *Cyperus* sp. and *Lomandra* spp.. The freshwater fish that were found at the site were gudgeons (*Hypseleotris* spp.) and eastern rainbowfish (*Melanotaenia splendida*). Other notable aquatic fauna included river prawns (*Macrobrachium australiense*).

The results of water quality and macroinvertebrate surveys indicated that Baffle Creek was in good to very good ecological health at the crossing location (Table 13-5).

**Table 13-5 Parameters Measured and Water Quality Objectives at Baffle Creek (western alignment)**

| Parameter | Units | Water Quality Objectives | Baffle Creek (Western) | Significance |
|---|---|---|---|---|
| temperature | °C | – | 26.2 | NA |
| electrical conductivity | µS/cm | <370 (baseflow)<br><210 (high flow) | 144 | compliant |
| turbidity | NTU | <50 | 38.6 | compliant |
| dissolved oxygen | % saturation | 85–110 | 75.7 | below WQO |
| pH | | 6.5–8.5 | 7.27 | compliant |
| taxonomic richness | – | 12–21 (composite bed)<br>23–33 (edge) | 27 (pool); 34 (riffle)<br>29 | above WQO<br>compliant |
| PET richness | – | 2–5 (composite bed)<br>2–5 (edge) | 6 (pool); 8 (riffle)<br>5 | above WQO<br>compliant |
| SIGNAL 2 | – | 3.33–3.85 (composite bed)<br>3.31–4.20 (edge) | 4.13 (pool); 4.71 (riffle)<br>3.73 | above WQO<br>compliant |



**Illustration 8: Baffle Creek (western alignment) Looking downstream from the proposed crossing location (September 2012)**



**Illustration 9: Baffle Creek (western alignment) Looking upstream from the proposed crossing location (September 2012)**

### 13.4.2 Baffle Creek (eastern alignment) – Overall Aquatic Value

Baffle Creek is a 4th order tributary of the Dawson River with an intermittent flow regime and significant permanent pools. The upper Baffle Creek catchment has been cleared for grazing. However, at the GTP ROW location, Baffle Creek is confined within a sandstone gorge with very little vegetation clearing. Soils are of high erosion potential and the land is classed as non-agricultural.

Between the stream channel and cliff faces the riparian zone contains a diverse array of species, including *Melaleuca viminalis,* eucalypts, rainforest trees and vines. In-stream habitat diversity is high, and includes deep and shallow pools, riffles, undercut banks, overhanging vegetation, woody debris, large boulders and sandy banks. No submerged aquatic macrophytes were observed, however *Bacopa monnieri* and *Cyperus* spp. species were present on the banks.

It is likely that this area is an important refuge habitat for aquatic and a terrestrial fauna during the dry season. During recent ground truthing activities a number of threatened flora species (State and/or National) were identified within the riparian zone and surrounding sandstone escarpments. In addition, the threatened large-eared pied bat (*Chalinolobus dwyeri*) and the little pied bat (*Chalinolobus pictus*) were recorded from the area.

Baffle Creek may support populations of Fitzroy River turtle and white-throated snapping turtle at locations where permanent pools exist during the drier months, such as in the vicinity of the GTP ROW. Previous studies (Hamann et al. 2007) have found white-throated snapping turtle to the north-west and to the east of the Baffle Creek GTP ROW. Suitable habitats for Fitzroy River turtles (i.e. riffles, pools and sandy banks) occur at this site. Baffle Creek is also thought to support populations of platypus, although burrows were not found within or near the GTP ROW.

During the field survey the following species of freshwater fish were caught: eastern rainbow fish (*Melanotaenia splendida*) and bony bream (*Nematolosa erebi*). Yabbies (*Cherax destructor*) and river prawns (*Macrobrachium australiense*) were also caught during the field survey.

The results of water quality and macroinvertebrate surveys indicated that Baffle Creek was in moderate ecological health at the crossing location (Table 13-6). The lower ecological health here compared to the western crossing may have been related to recent rainfall and flows resulting in high turbidity and sweeping macroinvertebrates downstream.

**Table 13-6 Parameters Measured and Water Quality Objectives at Baffle Creek (eastern alignment)**

| Parameter | Units | Water Quality Objectives | Baffle Creek (Eastern) | Significance |
|---|---|---|---|---|
| temperature | °C | – | 15.1 | NA |
| electrical conductivity | µS/cm | <370 (baseflow)<br><210 (high flow) | 417 | above WQO |
| turbidity | NTU | <50 | 67.5 | above WQO |
| dissolved oxygen | % saturation | 85–110 | 104.3 | compliant |
| pH | | 6.5–8.5 | 7.90 | compliant |
| taxonomic richness | – | 12–21 (composite)<br>23–33 (edge) | 10<br>21 | below WQO<br>below WQO |
| PET richness | – | 2–5 (composite)<br>2–5 (edge) | 2<br>5 | compliant<br>compliant |
| SIGNAL 2 | – | 3.33–3.85 (composite)<br>3.31–4.20 (edge) | 3.12<br>3.63 | below WQO<br>compliant |



**Illustration 10: Baffle Creek (eastern alignment) Looking upstream from the proposed crossing location (February 2012)**



**Illustration11: Baffle Creek (eastern alignment) Looking upstream from the proposed crossing location (February 2012)**

### 13.4.3 Selection of Construction Methodology

Based on the information presented in Section 13.4.1, Baffle Creek is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that Baffle Creek should be crossed using a dry trenching methodology on the western alignment only, as HDD is generally infeasible in this area due to terrain and geological constraints and dry trenching is not feasible on the eastern alignment due to the steep terrain.

The most critical factor used in to determining the suitability of using HDD is site geology. The geology at the proposed crossing is lower to middle Jurassic age deposits of sandstone, minor siltstone. Thin layers of topsoil and/or residual soil beneath moderately to slightly weathered sandstone near the surface which continued to the termination of 60m. Moderately weathered rock is medium or high strength, while the slightly weathered rock is high strength.

Boulders and likelihood of weathered, fragmented and fractured rocks present a high risk for using HDD because of increased potential of frac out and subsequent uncontrolled release of drilling fluids to the environment. The presence of hard fractured rock also poses a high risk of damage to the pipe coating and cathodic protection systems. The geology of the area presents unsuitable conditions for safe and effective execution of HDD. These geological risks would increase risks to the environment with potential for uncontrolled release of drilling fluids directly to the watercourse.

These geological and consequently environmental risk factors led to GLNG to select the dry trench crossing methodology for Baffle Creek.

A detailed assessment into the selection of this construction methodology is located in Appendix G2. A summary of the crossing methodology selection is detailed in Table 13-7 below.

### 13.4.4 Construction Methodology and Mitigation Measures

Construction will take place during the dry season, currently estimated as between April and June 2013.Construction through Baffle Creek will be scheduled outside of the breeding season (September to October) for the Fitzroy River turtle (*Rheodytes leukops*: Vulnerable *EPBC Act*). The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species may be able to be minimised. To further mitigate the impact on all species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks.

Bank protection and reinstatement will be an important component of the proposed works. Baffle Creek bank profiles will be reinstated to near stable pre disturbance conditions. Banks will be stabilised using a combination of rock armoring, catch drains and retaining walls. Vegetated areas will be stabilised using hydro mulching.

Baffle Creek is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

**Table 13-7 Summary of Crossing Methodology Selection**

| Watercourse | Crossing Method | Protection of aquatic values | Hydrology / hydraulics | Estimated Construction Works' footprint | Duration of works | Geotechnical suitability | Engineering Risk | Estimated Cost | Other Factors | Preferred methodology |
|---|---|---|---|---|---|---|---|---|---|---|
| **Baffle Creek KP20.4** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected moderate flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2 ha Least Concern RE 11.10.1 | Approx. 6 months | Not suitable due to hard and fractured rock layers and heterogeneous substrate. Presents very high risk for safe and effective execution of HDD | Extreme | $7 million | | Not preferred |
| | Open Trench (western alignment) | High Aquatic Value<br>Protection achieved through use of minor dam and flume to maintain biological connectivity and minimise turbidity.<br>Experienced aquatic ecologist to survey prior to construction | Expected moderate flow during construction - Flows maintained through flume pipes | 5.2 ha Least Concern RE 11.10.1 | Approx. 1 month | Suitable conditions for open trench | Low | $2.5 million | | Preferred |

**Table 13-8 Site Specific Mitigation Measures and Timings for Major Watercourses at Baffle Creek**

| Watercourse / Wetland | KP | Overall Aquatic Value (crossing and reach)* | Date surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|
| Baffle Creek | 20.4 | High | 24-Feb-12 | • Horizontal Directional Drill (HDD) construction<br>• General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• HDD impact mitigating measures Section 11.2.4.<br>• Water quality monitoring, if flowing (refer Section 15). | Apr-Jun 2013 |
| Baffle Creek (western alignment) | 19.8-21.4 | High | 6-Sept-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Platypus, where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Apr-Jun 2013 |

*Refer to Section 6.5 for definitions of these classes of aquatic value

## 13.5 Dawson River Upstream (KP29.83)

### 13.5.1 Overall Aquatic Values

The Dawson River at KP29.8 is a 5th order watercourse within intermittent flow and permanent pools both upstream and downstream of the GTP ROW. At the time of survey the watercourse contained a large volume of turbid water, and the gravel ford at the crossing location was not passable due to high water levels. The soils are of moderate to high erosion potential and land is classed as non-agricultural. The local Dawson River catchment has been moderately cleared for grazing, and the area is mapped as RE11.3.2. The riparian vegetation is a mix of eucalypt, angophora and *Allocasuarina* species, and is in moderate condition due to impacts by clearing, weeds and cattle. The State of the Rivers report (DPI 1995) indicated that this section of the Dawson River has very poor channel diversity (less than 20%), very good riparian vegetation condition (greater than 80%), and good aquatic habitat condition (60-80%).

No turtles were caught during the field survey. However, the upper reaches of the Dawson River are known to support populations of white-throated snapping turtle (Hamann et al 2007) and are suspected to support populations of Fitzroy River turtle (Limpus et al. 2007). It is therefore possible for a resident population of either species to inhabit refugial pools in the vicinity of but not within the GTP ROW. The Dawson River is also known to support platypus, although platypus and burrows were not observed during the field survey.

There were a number of emergent macrophyte species during the wet season survey, including *Juncus*, sp., *Cyperus* sp., *Lobelia* sp., *Ludwigia peploides*, and *Altenanthera denticulate*. Freshwater fish caught during the survey included eastern rainbowfish (*Melanotaenia splendida*), carp gudgeons (*Hypseleotris* spp.) and bony bream (*Nematolosa erebi*). River prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.) were also caught during the survey.



**Illustration 12: KP29.83 Looking downstream of the proposed crossing (2012 wet season)**

### 13.5.2 Selection of Construction Methodology

Based on the information presented in Section 13.5.1, the Dawson River (Upstream) is considered to have moderate to high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that the Dawson River (upstream) should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology and a significantly larger disturbance footprint to adjacent environmentally sensitive areas.

A critical factor that was used to determining the suitability of using HDD was site geology. The geology at the proposed crossing is Quaternary age alluvium comprising of clay, sand and gravel soil deposits overlying lower Triassic age formation consisting of mudstone, sandstone and occasional conglomerate. Boreholes indicate alluvium overlying residual soil or extremely weathered material and in turn highly or moderately weathered inter bedded siltstone and mudstone with some sandstone grading to slightly weathered and fresh rock.

The alluvium was described as medium plasticity clay and sandy clay of very stiff consistency while the residual soil and extremely weathered material were described as low plasticity, indistinctly fissured sandy gravelly clay and sandy clay of very stiff to hard consistency. Highly and moderately weathered rock was encountered at depths ranging between 8.75m and 13m typically as very low and low strength. Slightly weathered and fresh rock was encountered at depths ranging between 18m and 18.36m and it is medium strength. Boulders and likelihood of gravel existence, weathered, fragmented and fractured rocks present a high risk for using HDD because of increased potential of frac out and subsequent uncontrolled release of drilling fluids to the environment. The presence of hard

fractured rock also poses a high risk of damage to the pipe coating and cathodic protection systems. The geology of the area presents unsuitable conditions for safe and effective execution of HDD. These geological risks would increase risks to the environment with potential for uncontrolled release of drilling fluids directly to the watercourse.

The HDD methodology was also determined to have a significantly larger footprint than dry trenching. This is partly due to the need for significant amount of extra space required for the HDD launch and receiving pads and the stringing area. The required location of these extra work spaces would result in the additional clearing of 0.86 ha of Of Concern vegetation (RE 11.3.2).

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.5.3 Construction Methodology and Mitigation Measures

Construction will take place during the dry season, currently estimated as between May to June 2013.Construction through the Dawson River will be scheduled outside of the breeding season (–September to October) for the Fitzroy River turtle (*Rheodytes leukops*: Vulnerable *EPBC Act*). The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species may be able to be minimised. To further mitigate the impact on all species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks.

Bank protection and reinstatement will be an important component of the proposed works. Dawson River (Upstream) bank profiles will be reinstated to pre disturbance conditions. Banks will be stabilised using a combination of rock armoring and jute matting (or similar). Higher banks and vegetated areas will be stabilised using hydro mulching.

The Dawson River (Upstream) is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.6 Palustrine Wetland (KP177.3)

### 13.6.1 Overall Aquatic Value

The original GTP ROW was aligned to traverse a EHP mapped palustrine wetland (2010d) that is located west of Prospect Creek (refer Figure 4, page 19). The wetland and surrounding area are mapped as non remnant, and is substantially modified due to agricultural practices.

No suitable habitat for the Fitzroy River turtle, white-throated snapping turtle or platypus occurs at the site, and no species endemic to the Fitzroy River Basin were found at the site. While the Wildlife Online database (DERM 2010h) indicates that no conservation significant aquatic species have been recorded within 10 km of this wetland, and terrestrial ecology studies (Ecologica Consulting 2012) have not found conservation significant frog species within 20 km of the ROW, the site did contain numerous large tadpoles. The site therefore represents suitable breeding habitat for frogs, and it is possible that it provides suitable habitat for conservation significant frog species, including tusked frog (*Adelotus brevis*) and rough-collared frog (*Cyclorana verrucosa*). Macroinvertebrates were also present at the site, including freshwater mussels and viviparid snails (*Notopala sublineata*) that likely persist in a dormant state in the mud during dry times. The site also contained a number of macrophyte species (e.g. *Marsilea drummondii*), two species of native fish (carp gudgeons and glass perchlets – *Ambassis agassizii*), one exotic fish species (mosquitofish, *Gambusia holbrooki*), and one species of crustacean (glass shrimp).



**Illustration 13: KP177.30 at crossing location (2012 wet season)**

Due to the potential presence of the tusked frog (*Adelotus brevis*) and rough-collared frog (*Cyclorana verrucosa*), which are listed under the *NC Act,* GLNG has realigned the GTP to

avoid this wetland. This realignment results in two less watercourse crossings, with the remaining crossing on Prospect Creek being of low to moderate aquatic value.

### 13.6.2 Prospect Creek

The GTP ROW bisects the mid reach of Prospect Creek (stream order 4), where the riparian vegetation is fragmented and measures approximately 10 m. In order to minimise the clearing footprint associated with this vegetation, the GTP ROW is positioned at an existing farm track crossing, approximately 70 m in width. The farm track crossing currently restricts water flow during the dry season and has created two separate pool environments upstream and downstream of the crossing. The GTP ROW will bisect Prospect Creek perpendicularly to avoid unnecessary clearing within the riparian zone.

At the proposed Prospect Creek crossing the State of the Rivers report (DPI 1995) indicates that this segment exhibits moderate channel diversity (40-60%), with poor (20-40%) aquatic habitat condition, and very poor (less than 20%) aquatic and riparian vegetation condition. A review of recent aerial photography confirms the disturbed state of the riparian vegetation at the proposed crossing point. The State of the Rivers report (DPI 1995) concludes that the overall condition of watercourses in the area is considered moderate (40-60%). Disturbance by cattle and feral pigs to the bank and bed of the watercourse within the ROW was considerable at the time of survey.

Aquatic surveys indicated that no permanent aquatic habitat exists along this watercourse for species such as the white-throated snapping turtle, Fitzroy River turtle or platypus. At the time of survey, large beds of macrophytes and high macrophyte diversity were found within and surrounding the ROW, including cape waterlilly – *Nymphaea caerulea*, curly pondweed - *Potamogeton crispis*, and water ribbon – *Triglochin procerum*. Aquatic fauna included native freshwater fish (i.e. glass perchlets, carp gudgeons), the exotic fish *Gambusia holbrooki*, crustaceans (i.e. river prawns and glass shrimp) and other macroinvertebrates.



**Illustration 14: Looking downstream from the crossing (2012 beginning of the dry season)**

### 13.6.3 Construction Methodology and Mitigation Measures

Based on the information provided in Section 13.6.2, Prospect Creek was assessed as having moderate aquatic values in the wet season, but low aquatic values in a typical dry season. Prospect Creek should be crossed using dry trenching methodology as it was assessed that this methodology will cause the least amount of disturbance. The installation of a minor dam and flume will ensure dry conditions are maintained. The flume will be designed to accommodate flow and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks.

Bank protection and reinstatement will be an important component of the proposed works. Watercourse bank profiles will be reinstated to pre disturbance conditions and will be stabilised utilising grass seeding.

This crossing will be constructed during the dry season when the crossing location will likely be dry. If wet conditions are encountered during construction of the minor dams, fish salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring during wet conditions will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.7 Mimosa Creek (KP220.1)

### 13.7.1 Overall Aquatic Values

Mimosa Creek is a major intermittent tributary (stream order 6) of the Dawson River, located to the west of the Dawson Range. The soils in the area have moderate to high erosion potential and the area is classed as non-agricultural land. The local Mimosa Creek catchment has been heavily cleared for grazing and cropping. However, the width of riparian vegetation at the proposed crossing point is approximately 40 m (both banks) and is primarily *E. tereticornis, M. viminalis* and *C. cunninghamia*. The vegetation is consistent with the RE mapping, which indicates the area is a heterogeneous RE comprising 11.3.2, 11.3.4 and 11.3.25.

The State of the Rivers report (DPI 1995) indicates that Mimosa Creek has very poor channel diversity and aquatic vegetation condition (less than 20%), and very poor aquatic habitat. However, the report indicates that this stretch of the creek exhibits very good riparian vegetation condition (greater than 80%).

At the time of survey water levels were high and Mimosa Creek provided habitat for freshwater fish, including purple spotted gudgeons (*Mogurnda adspersa*), spangled perch (*Leiopotherapon unicolor*), carp gudgeons (*Hypseleotris* spp.), and glass perchlets (*Ambassis agassizii*). Freshwater macroinvertebrates included long-armed river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.). Several emergent macrophyte species were also present including *Cyperus* spp. and *Juncus* sp.. It is possible that Mimosa Creek provides habitat for white-throated snapping and Fitzroy River turtles, due to the size and sandy habitats of Mimosa Creek, the proximity of the proposed crossing site to refugia habitat and the Dawson River, and the presence of suitable habitat further upstream in Mimosa Creek. The banks within the proposed crossing area may also provide suitable nesting habitat for the abovementioned species, sandy substrates are present with good riparian cover. However, no turtles were caught during the detailed aquatic ecology surveys.

GLNG has realigned the GTP to traverse Mimosa Creek in a section of low to moderate aquatic value to minimise impacts on aquatic values.



**Illustration 15: Mimosa Creek KP220.1 Looking downstream of proposed crossing (outside ROW) (2012 wet season)**

### 13.7.2 Mimosa Creek – Realignment

The State of the Rivers report (DPI 1995) indicates that Mimosa Creek has very poor channel diversity and aquatic vegetation condition (less than 20%), and very poor aquatic habitat. However, the report indicates that this stretch of the creek exhibits very good riparian vegetation condition (greater than 80%).

At the time of survey water levels were low and Mimosa Creek provided little habitat for freshwater fish, only one purple spotted gudgeon (*Mogurnda adspersa*) was caught in a pool outside the ROW. However surveys conducted during the wet season found higher species richness and abundance. Freshwater macroinvertebrates included long-armed river and glass shrimp (*Caridina* spp.). Several emergent macrophyte species were also present including *Cyperus* spp. and *Juncus* sp..

The revised watercourse crossing has significantly less riparian vegetation, with a natural gap in vegetation of about 50m. There was also less woody habitat at this location and overall only moderate aquatic value during the wet season, and low aquatic value during a typical dry season.



**Illustration 16: Mimosa Creek Realignment Looking downstream of proposed crossing (2012 dry season)**

### 13.7.3 Construction Methodology and Mitigation Measures

Based on the information provided in Section 13.7.2, Mimosa Creek was assessed as having moderate aquatic values in the wet season, but low aquatic values in a typical dry season. Mimosa Creek should be crossed using dry trenching methodology as it was assessed that this methodology will cause the least amount of disturbance.

The installation of a minor dam and flume will ensure dry conditions are maintained. The flume will be designed to accommodate flow and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. During the trenching, lowering in and backfilling activities the flumes may be blocked and a flow diversion by pumping technique used. This will ensure dry conditions are maintained while facilitating accelerated construction within the watercourse before returning flows via the flumes at the completion of backfilling works. The time period whereby flumes will be temporarily blocked will be minimized to the greatest extent possible. Natural stream flows will be maintained by controlled pumping through this time period. Impacts on downstream aquatic values as a result of pumping are expected to be negligible.

Bank protection and reinstatement will be an important component of the proposed works. Mimosa Creek bank profiles will be reinstated to pre disturbance conditions. Banks and vegetation areas will be stabilised utilising a combination of jute matting (or similar) and hydro mulching.

This crossing will be constructed during the dry season when the crossing location will likely be dry. If wet conditions are encountered during construction of the minor dams, fish salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring

during wet conditions will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.8 Dawson River Downstream (KP233.9)

### 13.8.1 Overall Aquatic Values

The Dawson River is a large (stream order 8) river that extends approximately 781 km from it headwaters near the Injune/Roma area downstream to where it meets the Fitzroy River. The soils in the area have moderate to high erosion potential and the area is classed as non-agricultural land.

The local Dawson River catchment has been heavily cleared for grazing and cropping. The State of the Rivers report (DPI 1995) indicates that the Dawson River (Downstream) reach within the crossing area exhibits very poor channel diversity (less than 20%), very good riparian vegetation condition (greater than 80%), and very poor aquatic habitat condition. The crossing area has good riparian structure and complexity, moderate channel diversity and moderate habitat values (runs, pools, riffles). The riparian vegetation is mapped as a heterogeneous RE consisting of RE11.3.2 and RE11.3.25, and at the GTP ROW the riparian vegetation is dominated by *Eucalyptus* spp. and *Melaleuca* spp., although the understory is dominated by weeds including Parthenium. There is evidence for feral pig disturbances in the vicinity of the GTP ROW.

A survey in 2010 revealed a number of submerged aquatic plant species, including *Otellia alismoides and Potamogeton crispus,* which were intermittently distributed along the length of the site. Emergent aquatic plants recorded at the site include *Cyperus* spp., *Juncus* sp. and *Alternanthera denticulata*. The recent 2012 survey caught a number of fish species, including sleepy cod (*Oxyeleotris lineolatus*), purple spotted gudgeon (*Mogurnda adspersa*), bony bream (*Nematolosa erebi*), eastern rainbowfish (*Melanotaenia splendida*), glass plerchlets (*Ambassis agassizii*) and banded grunter (*Amniataba percoides*). We note that several of the sleepy cod had large sores and appeared to be of poor health. The long-armed river prawn (*Macrobrachium australiense*) was common and other aquatic macroinvertebrates were also caught.

Kreft's river turtle (*Emydura krefftii*) was also caught in the 2012 survey. While Fitzroy River turtles were not caught, the presence of essential habitat for Fitzroy River turtles at the site, including a large pool, riffles and rapids, and sandy banks with good riparian vegetation (i.e. RE11.3.25) was noted during the survey. The Fitzroy River turtle is known within the Dawson River (DERM 2010a), and has been recorded from the permanent pool associated with Baralaba Weir. Previous studies (Hamann et al. 2007) have also found the white-throated snapping turtle in the Dawson River to the north of the GTP ROW. The reach in which the Dawson River crossing occurs is considered highly likely to support the Fitzroy River turtle and the white-throated snapping turtle. The Dawson River is also likely to support a stable population of platypus, although no platypus or platypus burrows were observed near the GTP ROW during field surveys.

The GLNG GTP has been realigned at Dawson River to approximately 100m downstream from the original crossing location. The revised crossing location presents better conditions for construction and there are less environmentally significant features present than at the original site. The original crossing location, for which information is presented above, was located at a deep permanent pool with persistent aquatic life that extended the full width of

the river. The new crossing location has a limited area of flow which extends only approximately 10m across, the remainder of the crossing location is a dry sandy area. The full details of the new crossing location are provided in Appendix I.

The revised crossing location is still considered to be within the potential Fitzroy River turtle distribution area, although no turtles were recorded during the recent surveys (June 2013). Given the potential presence of Fitzroy River turtle, the new crossing location was determined to also have high aquatic values. For this reason the new location will be treated the same as the original crossing location and all methodology and mitigation measures will apply.



**Illustration 17: Dawson River KP233.9 Looking upstream of the original proposed crossing (2012 wet season)**



**Illustration 18: Dawson River KP233.9 Looking downstream of the original proposed crossing (flow channel) (2012 wet season)**



**Illustration 19: Dawson River KP233.9 Looking downstream of the revised crossing (June 2013)**

### 13.8.2 Selection of Construction Methodology

Based on the information presented in Section 13.8.1, the Dawson River (Downstream) is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that the Dawson River should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology and a significantly larger disturbance footprint associated with HDD.

A critical factor that was used to determine the suitability of using HDD was site geology. The geology at the site consists of alluvium clay, sand and gravel, with local occurrences of partly laterised soil overlying sandstone, siltstone, claystone, shale, conglomerate and intermediate volcanics. There are isolated beds comprising acidic and intermediate lava, tuff, and coarse to fine grained sedimentary rocks. Faulting is reported as the contact between the latter two formations. Alluvium was stiff to very stiff medium plasticity clay with some sand and gravel extending to 10m depth overlying inter bedded medium dense to very dense sand and gravelly sand to 20m depth and, in turn, hard sandy clay to 28m. The underlying residual soil was encountered to the termination depth of 35m.

Hydraulic fracturing, natural fractured path as well as existence of fault line bring high risk to HDD due to the potential for uncontrolled release of drilling fluids to the environment. The presence of sand and gravel pose a high level of risk to HDD. This is due to the potential of borehole collapse during drilling and pull back operations. The geology of the area presents unsuitable conditions for effective execution of HDD.

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.8.3 Construction Methodology and Mitigation Measures

Preliminary site construction took place between June and August 2013. Construction of the GTP crossing will occur from November to mid-December. This schedule will allow construction through the Dawson River to be scheduled outside of the breeding season for the Fitzroy River turtle (*Rheodytes leukops*: Vulnerable *EPBC Act*). The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland (also in the dry season) and in avoiding the breeding season for the Fitzroy River Turtle, construction during platypus breeding season is unavoidable. To mitigate the impact on all species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. If active nests are found within the ROW, a 100 m exclusion zone will be marked out and appropriate action will be taken in consultation the DEHP. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. During the trenching, lowering in and backfilling activities the flumes may be blocked and a flow diversion by pumping technique used. This will ensure dry conditions are maintained while facilitating accelerated construction within the watercourse before returning flows via the

flumes at the completion of backfilling works. The time period whereby flumes will be temporarily blocked will be minimized to the greatest extent possible. Natural stream flows will be maintained by controlled pumping through this time period. Impacts on downstream aquatic values as a result of pumping are expected to be negligible. If at the time of construction, the river contains a high level of water in which a minor dam and flume would be inadequate, a cofferdam and flow diversion technique may need to be adopted.

Bank protection and reinstatement will be an important component of the proposed works. Dawson River (downstream) bank profiles will be reinstated to pre disturbance conditions. Banks will be stabilised using a combination of rock armoring and jute matting (or similar). Higher banks and vegetated areas will be stabilised using hydro mulching.

The Dawson River (Downstream) is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.9 Calliope River (KP352.37)

### 13.9.1 Overall Aquatic Values

At the GTP ROW the Calliope River is a 5$^{th}$ order, unregulated system with perennial baseflow. The Calliope River flows in an easterly direction and discharges into Port Curtis, north of Gladstone. The soils in the area have moderate to high erosion potential and the surrounding area is classed as pasture land suitable for native pastures and limited cultivation of improved pasture. The local Calliope River catchment has been heavily cleared for grazing, although the riparian vegetation in the vicinity of the GTP ROW is in good condition. This vegetation is considered structurally complex and is dominated by eucalypts, Melaleuca species and dry rainforest species, with weed and pastoral grasses in the understorey. The area is currently mapped as a heterogeneous RE consisting of RE11.3.4 and RE11.3.25.

The reaches of the Calliope River have high to very high ecological value (C&R Consulting 2005). An outstanding feature of Calliope River is the extent and diversity of aquatic macrophyte assemblages, particularly in the periods following peak flow events. As noted by C&R Consulting (2005), aquatic ecological values of the Calliope River include:

- Deep water/freshwater refugia
- Riffle habitats
- High integrity fish communities
- Habitat diversity in the flood channel
- Relatively intact riparian zone
- Frontage woodland on alluvial terraces, levees and floodplains
- Floodplain wetlands
- Remnant vegetation (i.e. mapped as Regional Ecosystems)

At the GTP ROW, the Calliope River is represented by a large high flow channel, greater than 80 m wide. Two secondary channels lie within the main channel, with one of these channels supporting the perennial base flow. Habitat complexity within this channel is high,

with shallow and deep pools, riffles, backwaters and large wood debris all present. Fish diversity was high, and included eastern rainbowfish (*Melanotaenia splendida*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), Pacific blue-eye (*Pseudomugil signifier*), southern mouth almighty (*Glossamia aprion gillii*), banded grunter (*Amniataba percoides*), purple spotted gudgeons (*Mogurnda adspersa*), spangled perch (*Leiopotherapon unicolor*) and long-finned eels (*Anguilla reinhardtii*). Macroinvertebrates included long-armed river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.), and aquatic plants present at the time of survey included submerged and emergent species, such as *Potamogeton crispus*, *Ottelia alismoides*, *Fimbristylus* sp. *Pandanus* sp., *Eclipta prostrata*, *Cyperus* spp. and *Persicaria* spp..

It is unlikely that the Calliope River contains Fitzroy River turtles, as this system is outside the known distribution of these species. It is possible that suitable habitat for white-throated snapping turtle and platypus occurs in the vicinity of the GTP ROW. The works within this watercourse are localised and sufficiently displaced from the GBRWHA, the GBR Coast Marine Park and Port Curtis wetlands that impacts on the values of these areas are unlikely.



**Illustration 20: Calliope River (KP352.37) Facing downstream at proposed GTP crossing (Wet season 2012)**

### 13.9.2 Selection of Construction Methodology

Based on the information presented in Section 13.9.1, the Calliope River is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that the Calliope River should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology, a larger disturbance footprint associated with HDD

and restrictions associated with Queensland government State Development infrastructure corridor for the LNG gas transmission pipelines.

A critical factor that was used to determining the suitability of using HDD was site geology. The geology at the proposed crossing is dominated by siltstone, mudstone, sandstone, limestone, conglomerate and tuff. On the surface alluvium composed of gravel, sand, silt and clay locally overlie conglomerate. The area consist several faults. The top 25 m consists of soils varying loose silty sand, clayey sand and sandy clay and below are weathered and fractured rocks including granite. Loose sand is a concern of drilling in which it can cause continuous collapse. It is also possible that upon withdrawal of the drill bit, loose sand may mix with drilling fluids. Actual rock layers may spread within 25 m depth and hard rock like granite may be encountered as boulders of thick layers. Moreover, there is potential for drilling fluid to spread into ground through fractured lines. The presence of a fault is also a concern. Cavities in lime stone allow drilling fluid to flow inside to spoil the ground. The presence of gravel could lead to coating damage and in effectiveness of cathodic protection system. This has the potential to lead to an operational leak of gas. Considering all the risks, HDD is not feasible in this location. The geology of the area presents unsuitable conditions for safe and effective execution of HDD.

HDD would require additional workspaces beyond the ROW for the HDD launch and receiving pads and the stringing area. However due to the location of the crossing within the Callide Infrastructure Corridor State Development Area (CICSDA) substantial re-alignments are not permitted. Furthermore, the required work spaces would also infringe on the Australia Pacific Liquefied Natural Gas (APLNG) ROW.

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.9.3 Construction Methodology and Mitigation Measures

Construction will take place during the dry season, currently estimated as between September and October 2013. The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species may be able to be minimised. To further mitigate the impact on both species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. If active nests are found within the ROW, a 100 m exclusion zone will be marked out and appropriate action will be taken in consultation the DEHP. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks.

Bank protection and reinstatement will be an important component of the proposed works. Calliope River bank profiles will be reinstated to pre disturbance conditions. Banks will be stablised using a combination of rock armoring and jute matting (or similar). Higher banks and vegetated areas will be stabilised using hydro mulching.

The Calliope River is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.10 Harper Creek (KP360.34)

### 13.10.1 Overall Aquatic Values

Harper Creek is 4$^{th}$ order intermittent tributary of Calliope River. The soils in the area have moderate to high erosion potential and the surrounding area is classed as pasture land suitable for native pastures and limited cultivation of improved pasture. The local Harper Creek catchment has been heavily cleared for agriculture, although at the GTP ROW the riparian vegetation is about 90 m in width and in moderate condition. The canopy layer was dominated by of eucalypts, *Melaleuca* species and dry rainforest species, with weed and pastoral grasses in the understorey. The area is currently mapped as non-remnant.

There was a large permanent pool at the GTP ROW location. This pool contains a good diversity of freshwater fish, including eastern rainbowfish (*Melanotaenia splendida*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), Pacific blue-eye (*Pseudomugil signifier*), southern mouth almighty (*Glossamia aprion gillii*), purple spotted gudgeon (*Mogurnda mogurnda*), and spangled perch (*Leiopotherapon unicolor*). Macroinvertebrates included long-armed river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.), and aquatic plants present at the time of survey included submerged and emergent species, such as *Ottelia ovalifolia*, *Ottelia alismoides*, *Potamogeton crispus*, *Ceratophyllum demersum*, *Nymphoides* sp., *Azolla pinnata*, *Cyperus* spp. and *Persicaria* sp.. The invasive paragrass (*Urochloa mutica*) was also present at the site. Krefft's river turtle (*Emydura krefftii*) and saw-shelled turtles (*Wollumbinia latisternum*) were caught during the survey.

This pool is likely a critical refugial and breeding habitat for aquatic species in Harper Creek, as much of the creek upstream and downstream of this pool would likely be dry during dry periods.

It is unlikely that the Calliope River Basin contains Fitzroy River turtle, as this system is outside the known distribution of this species. It is possible that this permanent pool provides suitable habitat for white-throated snapping turtle and platypus. The works within this watercourse are localised and sufficiently displaced from the GBRWHA, the GBR Coast Marine Park and Port Curtis wetlands that impacts on the values of these areas are unlikely.



**Illustration 21: Harper Creek (KP360.34) Facing upstream at proposed GTP crossing (Wet season 2012)**

### 13.10.2 Selection of Construction Methodology

Based on the information presented in Section 13.10.1, the Harper Creek is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that Harper Creek should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology, a larger disturbance footprint associated with HDD and restrictions associated with Queensland government State Development infrastructure corridor for the LNG gas transmission pipelines.

A critical factor that was used to determining the suitability of using HDD was site geology. The geology at the proposed crossing indicates an early to middle age beds of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. The top 23 m is soils of varying layers – loose silty sand, gravels, sandy clay etc. Below is very high strength weathered rocks. Loose sand is a concern of drilling where they could continuously collapse and upon withdrawal of the drill bit, loose sand may mix with drilling fluids. Actual rock layers may spread within 23 m depth and are likely to be hard. Borehole HACBH01 indicates 3.2m of sandy clay followed by loose gravel up to 23.1m. Borehole HACBH02 indicates gravels almost from ground level up to 14.8m. From both these boreholes, rock layer is encountered below 23m. Trial pit indicates top soil with clay up to 4m. These results indicate that HDD is impossible due to existence of gravels and the subsequent collapse of the drill hole. Existence of lime stone boulders could also pose risk to HDD with potential to damage pipe coating a cathodic protection. The geology of the area presents unsuitable conditions for safe and effective execution of HDD.

HDD would also require additional workspaces beyond the ROW, however due to the location of the crossing within the Callide Infrastructure Corridor State Development Area (CICSDA) substantial re-alignments are restricted by the State Government. Furthermore, the required work spaces would also infringe on the APLNG ROW.

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.10.3 Construction Methodology and Mitigation Measures

Construction will take place during the dry season, currently estimated as between September and October 2013. The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species may be able to be minimised. To further mitigate the impact on both species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. If active nests are found within the ROW, a 100 m exclusion zone will be marked out and appropriate action will be taken in consultation the DEHP. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. During the trenching, lowering in and backfilling activities the flumes may be blocked and a flow diversion by pumping technique used. This will ensure dry conditions are maintained while facilitating accelerated construction within the watercourse before returning flows via the flumes at the completion of backfilling works. The time period whereby flumes will be temporarily blocked will be minimized to the greatest extent possible. Natural stream flows will be maintained by controlled pumping through this time period. Impacts on downstream aquatic values as a result of pumping are expected to be negligible.

Bank protection and reinstatement will be an important component of the proposed works. Harper Creek bank profiles will be reinstated to pre disturbance conditions. It is likely that the banks and vegetation areas will be stabilised using a combination of rock armoring, jute matting (or similar) and/or hydro mulching to ensure the watercourse and banks are protected.

The Harper Creek is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

## 13.11 Larcom Creek (KP378.07 and KP384.76)

### 13.11.1 Overall Aquatic Value

Larcom Creek is a major tributary of the Calliope River and has perennial water at both crossing locations (i.e. the upstream crossing at KP384.4 and the downstream crossing at KP378.1). The soils in the area have moderate to high erosion potential and the surrounding area is classed as pasture land suitable for native pastures and limited cultivation of improved pasture. The surrounding area at both sites is cleared for grazing.

At the downstream crossing location (KP378.1, stream order 4), the riparian vegetation is approximately 130 m in width and dominated by *Melaleuca viminalis* and *Allocasuarina* sp., which is consistent with the DEHP's mapping of a heterogeneous RE consisting of RE11.3.4 and RE11.3.25. In-stream habitat included deep and shallow pools, riffles and runs, backwaters, large woody debris and aquatic plant beds. Freshwater fish that were caught included eastern rainbowfish (*Melanotaenia splendida*), southern mouth almighty (*Glossamia aprion gillii*), purple spotted gudgeon (*Mogurnda adpsersa*), empire gudgeon (*Hypseleotris compressa*), carp gudgeons (*Hypseleotris* spp.), long-finned eels (*Anguilla reinhardtii*), glass perchlets (*Ambassis agassizii*), Rendahl's catfish (*Porochilus rendahli*) and Pacific blue-eyes (*Pseudomugil signifier*). Macroinvertebrates that were caught included long-armed river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.). Aquatic plants that were present included *Ottelia alismoides*, *Potamogeton orchreatus*, *Potamogeton crispus*, *Myriophyllum* sp., *Callitriche* sp., *Persicaria* sp. and *Alternanthera denticulata*. The GTP ROW is parallel to and slightly downstream of the Mount Alma Road crossing.

At the upstream crossing location (KP384.4) the riparian vegetation is approximately 35 m in width and dominated by *Callistemon* sp. and *Melaleuca viminalis.* In-stream habitat included large deep pools and large woody debris. Freshwater fish that were caught included fly-specked hardyhead (*Craterocephalus stercusmuscarum*) and purple spotted gudgeons (*Mogurnda adspersa*). Macroinvertebrates that were present included long-armed river prawns (*Macrobrachium australiense*) and glass shrimp (*Caridina* spp.). Aquatic plants that were present included *Valisneria nana*, *Ottelia ovalifolia*, *Callitriche* sp., *Spirodella* sp., *Azolla pinnata, Persicaria* spp. and *Cyperus* spp.. Krefft's river turtles (*Emydura krefftii*) were also caught.

It is unlikely that the Calliope River Basin contains Fitzroy River turtles, as this system is outside the known distribution of this species. The downstream location (KP378.1) is unlikely to support white-throated snapping turtles or platypus, although it there is potential for these species to occur in the vicinity of the GTP ROW at the upstream crossing location (KP384.4). The works within this watercourse are localised and sufficiently displaced from the GBRWHA, the GBR Coast Marine Park and Port Curtis wetlands that impacts on the values of these areas are unlikely.



**Illustration 22: Larcom Creek (KP378.07) facing downstream at proposed GTP crossing (Wet season 2012)**



**Illustration 23: Larcom Creek (KP384.76) facing upstream at proposed GTP crossing (Wet season 2012)**

### 13.11.2 Selection of Construction Methodology

Based on the information presented in Section 13.11.1, Larcom Creek is considered to have high aquatic values. GLNG investigated the feasibility of using trenchless crossing methodologies (i.e. HDD) to minimize potential impacts to aquatic values and riparian vegetation. However, it was subsequently determined that Larcom Creek should be crossed using a dry trenching methodology. The principle reason for selecting this methodology was related to site geology, a larger disturbance footprint associated with HDD and restrictions associated with Queensland government State Development infrastructure corridor for the LNG gas transmission pipelines.

A critical factor that was used to determining the suitability of using HDD was site geology. The geology at both Larcom Creek crossings (KP 378 and KP384) was assessed. The geology at KP 378 is comprised of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. Surface alluvium composed of gravel, sand; silt and clay locally overlie beds of conglomerate. Numerous faults are likely. Trial pits indicated moderately weathered sand stone with sandy gravel and clay. Sandy and gravelly clay is noticed from borehole with high strength and fractured rock below. HDD is not the preferred methodology because of the likelihood of encountering hard materials and boulders for drilling even above 12m. . The existence of grained rocks similar to gravel indicates that there is a potential high risk for HDD during drilling and pull back operations. Further hindrance is expected with hard materials where refusal could occur for the selected drill bit.

The site geology at the second Larcom Creek crossing at KP 384 is comprised of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. Borehole BHLC01 indicates traces of gravel up to 7.2m followed gravelly mixed soil up to 12.6m. Below this depth, material is hard rock and drilling was refused at 17.7m. Conversely BH-LAR01 shows soil up to 5.6m and below fine grained siltstone and mudstone up to 17.66m. Further down is coarse grained sand stone. The presence of gravel is unsuitable for HDD due to borehole collapse. The presence of hard rock is also a concern with increases the potential for frac out and subsequent accidental release of drilling fluids. The presence of gravel and hard rock also increases the potential for damage to the pipe coating and cathodic protection.

The geology of the area presents unsuitable conditions for safe and effective execution of HDD at both locations.

At both crossings HDD would require additional workspaces beyond the ROW for the HDD launch and receiving pads and pipe stringing area, however due to the location of the crossing within the Callide Infrastructure Corridor State Development Area (CICSDA) substantial re-alignments are restricted by the State Government. Furthermore, the required work spaces would also infringe on the APLNG ROW.

A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.11.3 Construction Methodology and Mitigation Measures

Construction will take place during the dry season, currently estimated as between September to November 2013. The breeding season for the white-throated snapping turtle (*Elseya albagula:* least concerned *NC Act*; Back on Track species *NC Act*) coincides with the dry season. The dry season is considered optimal time for construction to avoid impacts on high aquatic values during the wet season. Therefore, it is not practicable to avoid the breeding season for this species. The mating season for the platypus (*Ornithorhynchus anatinus*: Special least concerned *NC Act*) generally occurs in August in Queensland and therefore with the above estimated construction dates, impacts to this species can be

minimised. To further mitigate the impact on both species, prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. If active nests are found within the ROW, a 100 m exclusion zone will be marked out and appropriate action will be taken in consultation the DEHP. This will reduce any impact on the species.

The installation of a minor dam and flume will ensure dry conditions are achieved within the works area and flows to the watercourse are maintained. The flume will be designed to accommodate flow at the time of construction and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. During the trenching, lowering in and backfilling activities the flumes may be blocked and a flow diversion by pumping technique used. This will ensure dry conditions are maintained while facilitating accelerated construction within the watercourse before returning flows via the flumes at the completion of backfilling works. The time period whereby flumes will be temporarily blocked will be minimized to the greatest extent possible. Natural stream flows will be maintained by controlled pumping through this time period. Impacts on downstream aquatic values as a result of pumping are expected to be negligible.
Bank protection and reinstatement will be an important component of the proposed works. Both Larcom Creek's bank profiles will be reinstated to pre disturbance conditions. At a minimum the banks and vegetated areas will be stabilised using a combination of jute matting (or similar) and hydro mulching.

The Larcom Creek is likely to be flowing at the time of construction. During the construction of the minor dams, fish and fauna salvage will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

### 13.12 Humpy Creek (KP407.87)

The crossing locations for tidal watercourses, including Humpy Creek, have changed significantly due to a major change in alignment at the north eastern end of the pipeline. This alignment change is to enable GLNG to cross The Narrows via tunnel rather than trenching or HDD (original alignment) across Gladstone Harbour. This has resulted in the crossing location of Humpy Creek (and all tidal watercourses) being located in an area of lower aquatic value (refer Figure 6) than originally predicted on the original alignment. This has therefore meant that Humpy Creek and Targinie Creek were determined to not require to be crossed by via trenchless methods.

#### 13.12.1 Overall Aquatic Values

Humpy Creek is a tidal tributary of Mosquito Creek, located within the north eastern region of the GTP ROW. The upstream reaches of this watercourse are ephemeral, and mapped by DERM (2010) as a stream order 3. The GTP ROW intersects the creek (KP407.87) approximately 700 m downstream of the limit of tidal influence[5]. The high electrical conductivity at this site as well as the aquatic fauna present indicated that the site is estuarine, due to the presence of both marine and freshwater species (Appendix B). Water

[5] DERM advised that the tidal limit of influence for Humpy Creek is 23°45'40.79"S and 151° 7'24.58"E

quality generally complied with the relevant mid-estuarine WQOs, with the exception of dissolved oxygen and turbidity, which exceeded the WQOs (though turbidity was below the upper estuarine WQO).

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant. Trailing vegetation at the site is moderate, consisting largely of grasses, with ironbark and other eucalypt species present. Riparian vegetation consists mainly of grasses and scattered juvenile mangroves (club mangrove *Aegialitis annulata*, yellow mangrove *Ceriops tagal* and black mangrove *Lumnitzera racemosa*). No freshwater aquatic flora, seagrasses or algae were recorded at the site. Saltwater couch (*Sporobolous virgnicus*), which is a marine plant under the *Fisheries Act 1994*, was present along either margin of the watercourse below the high water bank.

The local Humpy Creek catchment has been heavily cleared for agricultural land use practices (i.e. grazing and fruit orchards), particularly within the upper catchment and mid reaches. As a result, trailing vegetation within these regions is fragmented. The vegetation within this area is consistent with *Eucalyptus tereticornis* on alluvial plains (RE11.3.3), however the canopy vegetation between Humpy and Targinie Creeks have died off (likely due to historic farming activities).

The area contains soils of a high erosion potential with the surrounding area classed as pasture land suitable to native pastures without ground disturbance. The watercourse at the crossing location consists of a predominately sand and gravel substrate, with some silt / clay, and pebbles and occasional cobbles and boulders.

The GTP ROW intersects the creek below the limit of tidal influence and as such the volume of water is dependent on both upstream-catchment flows and tidal movement. At the GTP crossing location the watercourse consists of a 10 m wide high flow channel, with a winding 1.5 m active low flow channel. Both the 4 m left and 2 m right bank are steep and moderately eroded (refer to Field Data Sheets in Appendix B4).

As a result of the tidal nature and geomorphology of Humpy Creek, no suitable habitat for freshwater aquatic species of conservation significance (e.g. platypus or freshwater turtles) exists. Humpy Creek is also unlikely to support any significant marine and/or estuarine species (e.g. marine turtles, porpoises and sawfish), due to the geomorphology of the watercourse and species habitat association. Humpy Creek is located outside the limits of potential foraging habitat for the water mouse (*Xeromys myoides*).

The tidal influence on Humpy Creek was evident in the fauna that were surveyed, which included macroinvertebrate and fish communities dominated by estuarine species and freshwater species with a high tolerance to salinity. Macrocrustaceans caught at Humpy Creek included prawns (*Penaeus* sp.) and mud crab (*Scylla serrata*).

Fish species caught included estuarine species such as silver scat (*Scataphagus multifasciatus*), crescent grunter (*Terapon jarbua*), greenback mullet (*Liza subviridis*), northern whiting (*Sillage sihama*), silver biddy (*Gerres* sp.), gobies (*Pseudogobius* sp. 1 and *Favonigobius exquitus*), estuary glassfish (*Ambassis marianus*) and Pacific blue-eye (*Pseudomugil signifier*).



**Illustration 24: Humpy Creek (KP407.87) facing downstream at proposed GTP crossing (Wet season 2012)**

### 13.12.2 Construction Methodology and Mitigation Measures

Based on the above Section 13.12.1, Humpy Creek was assessed as having moderate aquatic values in both the wet and dry seasons. This watercourse will be crossed using dry trenching methodology to minimise the works footprint. The installation of a minor dam and flume will ensure dry conditions are maintained. The flume will be designed to accommodate flow and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. This crossing is currently scheduled to be constructed from October to December 2013 in which the watercourse is likely to have low freshwater flow and before the intense wet period in January and February. Bank protection and reinstatement will be an important component of the proposed works. Humpy Creek bank profiles will be reinstated to pre disturbance conditions and will be stabilised using one or a combination of grass seeding, jute matting and/or hydro mulching.

The width of the ROW through this watercourse will be reduced to 30 m, to reduce impacts on vegetation. The existing bed material from each of the tidal watercourses will be stockpiled, as denoted on the detailed construction layout drawings in Appendix F. This drawing illustrates the chosen construction methodology at this site. Results from preliminary Phase 1 ASS investigations indicate the presences of soils with existing and potentially acidity are present at Humpy creek, if ASS are encountered these will be managed in accordance with the ASSMP (3380-SAIP-4-3.3-1832). Fish salvage and the relocation of any aquatic fauna encountered during construction of the minor dams will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring in accordance with

Chapter 15 of this plan will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

### 13.13 Targinie Creek (minor watercourse) (KP408.51)

The crossing locations for tidal watercourses, including Targinie Creek, have changed significantly due to a major change in alignment at the north eastern end of the pipeline. This alignment change is to enable GLNG to cross The Narrows via tunnel rather than trenching or HDD (original alignment) across Gladstone Harbour. This has resulted in the crossing location of Targinie Creek (and all tidal watercourses) being located in an area of lower aquatic value (refer Figure 6) than predicted on the original alignment. This has therefore meant that Humpy Creek and Targinie Creek were determined to not require crossing by trenchless methods.

#### 13.13.1 Overall Aquatic Values and Terrestrial Considerations

Targinie Creek is a tidal tributary of Mosquito Creek, located within the north eastern region of the GTP ROW. The upstream reaches of this watercourse are ephemeral, and mapped by DERM (2010) as a stream order 2. The GTP ROW intersects the creek (KP408.5) within the vicinity of the limit of tidal influence[6]. The soils are of high erosion potential and the area is classed as land not suitable for agricultural activities.

Analyses of water quality and aquatic fauna indicated that this site is estuarine (see Appendix D3). Electrical conductivity was relatively high and there was a mixture of both freshwater and marine fish and macroinvertebrates. Water quality generally complied with the mid-estuarine WQOs, with the exception of dissolved oxygen which exceeded the WQO range. Interestingly, there was higher diversity of freshwater macroinvertebrates than marine macroinvertebrates, but higher diversity of marine and estuarine fish compared to freshwater fish (Appendix A). Fish species caught included eastern rainbowfish (*Melanotaenia splendida*), (*Terapon jarbua*), estuarine glassfish (*Ambassis marinaus*), and Pacific blue-eye (*Pseudomugil signifier*).

Survey of the site revealed the substrate of the watercourse at the crossing location to consist mainly of bedrock and coarser materials such as boulders, cobbles, pebble and gravel (Illustration 2). At the GTP crossing location the watercourse consists of a large pool, with a fast flowing riffle section immediately downstream. The mean channel width is approximately 20 m, with the left and right high banks approximately 2 m and 3 m high respectively.

The presence of freshwater in the two habitats and the flowing conditions reflects the recent climatic patterns within the local and greater catchment area and also the fact that tidal inundation is restricted (i.e. geomorphology of the area and inundation is likely only when tides are of a sufficient magnitude).

As a result of the tidal nature of Targinie Creek, no suitable habitat for freshwater aquatic species (e.g. platypus or freshwater turtles exists). Targinie Creek is also unlikely to support any significant marine and/or estuarine species (e.g. marine turtles, porpoises and sawfish).

[6] DERM advised that there is no tidal limit of influence defined for Targinie Creek

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant. Trailing vegetation at the site is moderate, with some localised clearing and thinning activities as a result of agricultural land use. Riparian vegetation consists largely of grasses, with eucalypts, melaleuca, Moreton Bay ash, ironbarks and black mangroves (*Lumnitzera racemosa*) also present. No freshwater aquatic plants or seagrasses were recorded at the site, although algae was evident on the substrate. Saltwater couch (*Sporobolous virgnicus*), which is a marine plant under the *Fisheries Act 1994*, was present along either margin of the watercourse below the high water bank which is evident in Illustration 3.

Riparian vegetation within the proposed crossing site is considered highly fragmented, with an approximate width of 1 m. Earlier surveys noted rubber vine and lantana to be prominent on the northern bank, with the southern bank heavily cleared with introduced grasses dominant.

Targinie Creek is mapped as being located within 'general habitat' for the terrestrial conservation significant species, the water mouse (*Xeromys myoides*). The creek is located within the outer limits of potential foraging habitat for the water mouse (refer to map included in Appendix E). Management of this species will be in accordance with the species profile from the SSMP 3380-GLNG-4-1.3-0104 (refer Appendix E).



**Illustration 25: Targinie Creek (KP408.51) facing upstream at proposed GTP crossing (Wet season 2012)**

### 13.13.2 Construction Methodology and Mitigation Measures

Targinie Creek will be crossed using dry trenching methodology to minimise the works footprint and impact to remnant vegetation (habitat). The installation of a minor dam and

flume will ensure dry conditions are maintained. The flume will be designed to accommodate flow and allow fish passage. A causeway will be constructed to allow access for vehicles and machinery which will maintain stream flow and fish passage and also minimise the amount of grading required on the banks. This crossing is currently scheduled to be constructed from October to December 2013 in which the watercourse is likely to have low flow and before the intense wet period in January and February. Bank protection and reinstatement will be an important component of the proposed works. Targinie Creek bank profiles will be reinstated to pre disturbance conditions and will be stabilised using one or a combination of grass seeding, jute matting and/or hydro-mulching. The bed substrate will be reinstated after trenching using local materials (rock with possible grouting) so as to not alter the hydrology of the watercourse.

The width of the ROW through this watercourse will be reduced to 30 m, to reduce impacts on vegetation and habitat. The existing bed material from each of the tidal watercourses will be stockpiled, as denoted on the detailed construction layout drawings in Appendix F. This drawing illustrates the chosen construction methodology at this site. In the event that ASS soils are encountered, these will be managed in accordance with the ASSMP (3380-SAIP-4-3.3-1832). Fish salvage and the relocation of any aquatic fauna encountered during construction of the minor dams will be conducted in accordance with the Fauna Handling Procedure (3380-SAIP-4-1.3-1965) and the Species Management Plan (3380-GLNG-3-1.3-0036). Water quality monitoring in accordance with Chapter 15 of this plan will ensure any changes to water quality will be detected rapidly and actions can be taken to rectify mitigation measures.

It is anticipated that the mitigation measures outlined in Section 11.1, trenching mitigation measures in Section 11.2.1 and minor dam impact mitigation measures in Section 11.2.2 and 11.2.3 will adequately protect the aquatic values at this site.

Additional mitigation measures will be put in place in this area to minimize impacts to the water mouse. These measures include, but are not limited to, the following:

- All vegetation clearing will comply with clearing approval conditions.
- Direct temporary lighting away from light-sensitive areas such as intertidal zones.
- Implementation of the ESCP to ensure there is no sediment runoff into habitat areas.
- All construction phase activities will be in accordance with the noise and vibration management measures outlined in the Marine Crossing EMP. Construction operations reducing or ceasing at night within close proximity to water mouse habitat.

For the comprehensive management measures for this species with construction, refer to species profile (Appendix E extracted from the SSMP (3380-GLNG-4-1.3-0104)).

### 13.14 Summary of Selection of Construction Methodology

Table 13-9 presents a summary of the selection of construction methodology for each high aquatic value watercourse with potential habitat for aquatic listed species. A detailed assessment into the selection of this construction methodology is located in Appendix G1.

### 13.15 Summary of Aquatic Values, Construction Methodology and Mitigation Measures for Major Watercourses

Table 13-9 presented a summary of environmental values and aquatic conservation significant species consideration for major watercourses with high aquatic value as well as the selected construction methodology. Table 13-10 presents the site-specific mitigating measures for protecting the aquatic values at each major watercourse crossing (refer Appendix B and C).

**Table 13-9 Summary of Crossing Methodology Selection for High Aquatic Value Watercourses**

| Watercourse | Crossing Method | Protection of aquatic values | Hydrology / hydraulics | Estimated Construction Works' footprint | Duration of works | Geotechnical suitability | Engineering Risk | Estimated Cost | Other Factors | Preferred methodology |
|---|---|---|---|---|---|---|---|---|---|---|
| **Hutton Creek KP2.09** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected moderate flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2.85 ha of Least concern RE 11.3.25 for drill pads and stringing area | Approx. 6 months | Not suitable due to fractured rock layers and heterogenous substrate. Presents very high risk for safe and effective execution of HDD | Extreme | $7.25 million | | Not preferred |
| | Open Trench | High Aquatic Value<br>Protection achieved through use of minor dam and flume to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected moderate flow during construction - Flows maintained through flume pipes | 1.23 ha of Least concern RE 11.3.25 for ROW and extra work areas. | Approx. 3 weeks | Suitable conditions for open trench | Low | $1.8 million | | Preferred |
| **Baffle Creek KP20.4** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected moderate flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2 ha Least Concern RE 11.10.1 | Approx. 6 months | Not suitable due to hard and fractured rock layers and heterogeneous substrate. Presents very high risk for safe and effective execution of HDD | Extreme | $7 million | | Not preferred |
| | Open Trench (western alignment) | High Aquatic Value<br>Protection achieved through use of minor dam and flume to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected moderate flow during construction - Flows maintained through flume pipes | 5.2 ha Least Concern RE 11.10.1 | Approx. 1 month | Suitable conditions for open trench | Low | $2.5 million | | Preferred |
| **Dawson River (Upstream) KP29.83** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected low flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2.21 ha Of concern RE 11.3.2 | Approx. 4 months | Not suitable due to fractured rock layers and heterogenous substrate. Presence of gravel layers indicate potential of borehole collapse during drilling and pull-back operations. Presents high risk for safe and effective execution of HDD | High | $3.2 million | | Not preferred |
| | Open Trench | High Aquatic Value<br>Protection achieved through use of minor dam and flume to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected low flow during construction - Flows maintained through flume pipes | 1.35 ha Of concern RE 11.3.2 | Approx. 2 weeks | Suitable conditions for open trench | Low | $1.2 million | | Preferred |
| **Dawson River (Downstream) KP233 (original and revised crossing)** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected moderate flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2.85 ha Non remnant vegetation | Approx. 4 months | Not suitable due to presence of sand and gravel layers. Presents extreme risk for safe and effective execution of HDD due to potential for borehole collapse during drilling and pull-back operations | Extreme | $3.5 million | | Not preferred |

| Watercourse | Crossing Method | Protection of aquatic values | Hydrology / hydraulics | Estimated Construction Works' footprint | Duration of works | Geotechnical suitability | Engineering Risk | Estimated Cost | Other Factors | Preferred methodology |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open Trench | High Aquatic Value<br>Protection achieved through use of minor dam and flume (pump) to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected moderate flow during construction - Flows maintained through flume pipes or flow diversion (pump/coffer dam) | 1.2 ha Non remnant vegetation | Approx. 3 weeks | Suitable conditions for open trench | Low | $1.2 million | Additional costs may be involved if coffer dam is required. | Preferred |
| **Calliope River KP352.3** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected low flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 0.4 ha Non remnant | Approx. 4.5 months | Not suitable due to presence of gravel and loose sand. Presents high risk for safe and effective execution of HDD due to potential for borehole collapse during drilling and pull-back operations | High | $3.5 million | Requires realignment for HDD. Restrictions associated with CICSDA. Stringing area would encroach on APLNG ROW | Not preferred |
| | Open Trench | High Aquatic Value<br>Protection achieved through use of minor dam and flume to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected low flow during construction - Flows maintained through flume pipes | 0.39 ha Of concern RE 11.3.4/11.3.25<br>4.04 ha Non remnant | Approx. 2 weeks | Suitable conditions for open trench | Low | $1.2 million | | Preferred |
| **Harper Creek KP360.3** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected low flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2.6 ha Non remnant | Approx. 4 months | Not suitable due to loose gravel. Presents a high risk of safe and effective execution of HDD due to potential for borehole collapse during drilling a pull-back operations. | High | $1.5 million | Restrictions associated with CICSDA. Stringing area would be required outside CICSDA. | Not preferred |
| | Open Trench | High Aquatic ValueProtection achieved through use of minor dam and flume (pump) to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected low flow during construction - Flows maintained through flow diversion/s | 2.09 ha Non remnant | Approx. 2 weeks | Suitable conditions for open trench | Low | $1.2 million | | Preferred |
| **Larcom Creek 1 KP378** | HDD | High Aquatic Value<br>No disturbance to watercourse by use of HDD | Expected low flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 0.4 ha Non remnant | Approx. 4 months | Not suitable due to loose gravel. Presents a high risk of safe and effective execution of HDD due to potential for borehole collapse during drilling a pull-back operations. | High | $3.3 million | Restrictions associated with CICSDA. Stringing area would need to be accommodated in ROW. | Not preferred |

| Watercourse | Crossing Method | Protection of aquatic values | Hydrology / hydraulics | Estimated Construction Works' footprint | Duration of works | Geotechnical suitability | Engineering Risk | Estimated Cost | Other Factors | Preferred methodology |
|---|---|---|---|---|---|---|---|---|---|---|
| | Open Trench | High Aquatic Value Protection achieved through use of minor dam and flume (pump) to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected low flow during construction - Flows maintained through flow diversion/s | 1.61 ha Non remnant | Approx. 2 weeks | Suitable conditions for open trench | Low | $1.2 million | | Preferred |
| **Larcom Creek 2 KP384** | HDD | High Aquatic Value No disturbance to watercourse by use of HDD | Expected low flow during construction - Hydrology maintained by avoiding disturbance to the watercourse | 2.8 ha Non remnant | Approx. 4 months | Not suitable due to loose gravel. Presents a high risk of safe and effective execution of HDD due to potential for borehole collapse during drilling a pull-back operations. | High | $2.9 million | Requires realignment for HDD. Restrictions associated with CICSDA. Stringing area would encroach on APLNG ROW. HDD alignment would extend beyond CICSDA | Not preferred |
| | Open Trench | High Aquatic Value Protection achieved through use of minor dam and flume (pump) to maintain biological connectivity and minimise turbidity. Experienced aquatic ecologist to survey prior to construction | Expected low flow during construction - Flows maintained through flow diversion/s | 2.09 ha Non remnant | Approx. 2 weeks | Suitable conditions for open trench | Low | $1.2 million | | Preferred |

**Table 13-10 Site Specific Mitigation Measures and Timings for Major Watercourses (including Targinie Creek (Minor Watercourse))**

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Hutton Creek | 2.09 | High | High | 24-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season.<br>• Implement works outside of breeding season for Platypus.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Mar-Apr 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Baffle Creek (western alignment) | 19.8-21.4 | High | High | 6-Sept-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Platypus.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Apr-Jun 2013 |
| Christmas Creek | 2.66 | Moderate | Moderate | 24-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | Mar-Apr 2013 |
| | | | | | | |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Unnamed Watercourse 1 | 28.76 | Low | Low | 15-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Implement works during the dry season where possible.<br>The following will be implemented if wet conditions are present:<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15). | May 2013 |
| Dawson River (Upstream) | 29.83 | Moderate | Moderate to High | 15-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season.<br>• Implement works outside of breeding season for Fitzroy River turtle.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | May-June 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Bully Frog Creek | 46.01 | Negligible | Low | 14-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Implement works during the dry season where possible.<br>The following will be implemented if wet conditions are present:<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15). | March 2013 |
| Unnamed Watercourse 2 | 57.48 | Negligible | Low | 15-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Implement works during the dry season where possible.<br>The following will be implemented if wet conditions are present:<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15). | March 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Ironbark Creek | 62.33 | Low | Low (possibly Moderate in an above average wet season) | 16-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Implement works during the dry season where possible.<br>The following will be implemented if wet conditions are present:<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15). | Dec 2012 -Jan 2013 |
| Unnamed Watercourse 3 | 80.8 | Negligible to Low | Negligible to Low | 20-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | Dec 2012 - Jan 2013 |
| Clematis Creek | 108.6 | Low | Moderate | 20-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if wet (refer Section 15). | Feb-Mar 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| May Creek | 111.3 | Low | Low | 20-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3. | Feb-Mar 2013 |
| Deep Creek | 124.5 | Low | Low | 28-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3. | Feb-Mar 2013 |
| Unnamed Watercourse 4 | 134 | Low | Low | 29-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | Feb-Mar 2013 |
| Prospect Creek | 177.7 | Moderate | Moderate | 17-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if wet (refer Section 15). | Jul-Aug 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Unnamed Watercourse 5 | 184 | Moderate | Moderate | 29-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Ensure pipeline crossing is as close as possible to existing gas pipe corridor.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if wet (refer Section 15). | June-Jul 2013 |
| Conciliation Creek | 207.4 | Moderate | Moderate | 19-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | June 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Brolga Gully | 214.8 | Moderate | Moderate | 29-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | June 2013 |
| Mimosa Creek | 220.1 | High | High | 18-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | Jun-13 |
| Denby Creek | 231.1 | Moderate | Moderate | 28-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section | May 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| | | | | | 15). | |
| Dawson River (Downstream) (original and revised crossing) | 233.9 | High | High | 28-Apr-12<br>28-Jun-13 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Section 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Fitzroy River turtle.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Jun-Aug & Nov-Dec 2013 |
| Back Creek | 234.3 | Low | Moderate | 28-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | May-Jun 2013 |
| Kianga Creek | 239.7 | Moderate | Moderate | 27-Apr-12 | • General impact mitigating measures Tables 11-1, | May-Jun 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| | | | | | 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | |
| Banana Creek | 252.4 | Low | Moderate | 27-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | May 2013 |
| Banana Creek | 252.6 | Low | Low | 27-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | May 2013 |
| Police Camp Creek (KP 263.66) | 263.6 | Low | Low | 26-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | May 2013 |
| Police Camp Creek (KP 269.96) | 269.9 | Low | Low | 26-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | May 2013 |
| Spring Creek | 272.4 | Low | Low | 22-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | May 2013 |
| Sellheim Creek | 280.2 | Low | Moderate | 6-Jan-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | Apr-May 2013 |
| Neville Creek | 285.8 | Low | Moderate | 23-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Orange Creek | 295.6 | Low | Low | 24-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | April 2013 |
| Unnamed Watercourse 7 | 296.6 | Low | Low | 25-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |
| Kroombit Creek | 296.8 | Moderate | Moderate | 24-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | April 2013 |
| Palustrine Wetland | 297.7 | Negligible to Low | Negligible to Low | 23-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Callide Creek | 298.9 | Moderate | Moderate | 23-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | April 2013 |
| Callide Creek (Old Channel) | 300.3 | Low | Low | 22-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |
| Unnamed Watercourse 8 | 303.7 | Low | Low | 22-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |
| Unnamed Watercourse 8 | 305.5 | Low | Low | 22-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | April 2013 |
| Collards Creek | 319.1 | Low | Low | 21-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | August 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Bell Creek | 334.5 | Moderate | Moderate | 21-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | October 2013 |
| Calliope River | 352.3 | High | High | 20-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season.<br>• Implement works outside of breeding season for Platypus, where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Sept-Oct 2013 |
| Unnamed Watercourse 9 | 354.3 | Low | Low | 20-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section | September 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| | | | | | 11.2.1. | |
| Unnamed Watercourse 10 | 359.5 | Moderate | Moderate | 19-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | Sept-Oct 2013 |
| Harper Creek | 360.3 | High | High | 19-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Platypus, where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Sept-Oct 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Alarm Creek | 364.8 | Moderate | Moderate | 19-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage, if wet (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | Sept-Oct 2013 |
| Gravel Creek | 375.6 | Moderate | Moderate | 18-Apr-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1. | Sept-Oct 2013 |
| Larcom Creek (KP378.06) | 378 | High | High | 19-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Platypus, where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Sept-Nov 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Larcom Creek (KP384.76) | 384.7 | High | High | 19-Feb-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Implement works outside of breeding season for Platypus, where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Inspection by experienced Aquatic Ecologist no more than 2 weeks prior to clearing activities to ensure there are no active nests or significant species are present within ROW. | Sept-Nov 2013 |
| Humpy Creek | 407.87 | Moderate | Moderate | 30-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15). | Sept-Dec 2013 |

| Watercourse / Wetland | KP | Aquatic Value Dry Season (crossing and reach)* | Aquatic Value Wet Season (crossing and reach)* | Date Surveyed | Mitigation Measures | Estimated Month of Construction |
|---|---|---|---|---|---|---|
| Targinie Creek | 408.51 | Moderate | Moderate | 30-Mar-12 | • General impact mitigating measures Tables 11-1, 11-2 and 11-3.<br>• Trenching impact mitigating measures Section 11.2.1.<br>• Minor dam impact mitigating measures Sections 11.2.2 and 11.2.3.<br>• Implement works during the dry season where possible.<br>• Fish salvage (refer Section 11.1).<br>• Water quality monitoring, if flowing (refer Section 15).<br>• Additional water mouse mitigation measures refer to SSMP 3380-GLNG-4-1.3-0104. | Sept-Dec 2013 |

*Refer to Section 6.5 for definitions of these classes of aquatic value

# 14 REHABILITATION

The rehabilitation of watercourses and adjacent areas will be undertaken in accordance with the Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (LRMP) (3380-GLNG-3-1.3-0037).This plan specifies management measures to be implemented during and post construction of the GTP in order to meet all relevant approval conditions. These measures are specified below for various phases of development of the GTP.

## 14.1 Pre-Construction Phase

Prior to construction, a pre-clearance survey will be undertaken in accordance with EPBC Act Approval Condition 3(a). The pre-clearing survey will gather information on the floristic health and composition of the existing vegetation communities. During the pre-clearance survey, the following information will be documented:

- Topsoil and landforms/contours.
- Drainage.
- Vegetation/species composition.
- Environmentally Sensitive Areas.
- Bank stability.
- Habitat resources.
- Level of disturbance.

A range of completion criteria have been selected to guide rehabilitation for broad ecosystems identified in the ROW, including the riparian areas. Completion criteria will provide information on the best existing condition for each ecosystem and are considered to be the minimum target for rehabilitation.

The vegetation within the riparian zone of a watercourse should achieve high densities, particularly in the lower stratum in order to keep weed infiltration to a minimum. The upper stratum in some instances may take on the structure of an open or closed forest community.

Other pre-construction rehabilitation management measures include:

- Monitoring points strategically located and set up prior to rehabilitation works commencing, including the establishment of permanent photologging points for monitoring purposes within watercourses and riparian areas.
- Salvaging of existing bed material prior to construction.

## 14.2 Post-Construction Phase

Weather permitting, rehabilitation and reconsolidation of impacted watercourses shall commence immediately after the pipeline has been lowered into the trench and backfilled. This will include:

- Early rehabilitation of riparian buffers in order to restore natural stream functions and aquatic habitat, including reseeding with locally sourced species.
- Where appropriate, rehabilitation of the bed and bank structure such that the original dimensions and shape of the watercourse, spring or wetland is reproduced.
- Where possible, promoting a heterogeneous substrate in watercourse crossings, including:

  - Replacing large woody debris to stabilise banks and to provide in-stream complexity.
  - Using a combination of rocks, gravels and cobbles in the stream bed, including bed material salvaged prior to construction.
  - The use of large rocks and logs to moderate flows.
- Re-profiling of the GTP ROW to original and stable contours, including re-establishing watercourses, wetlands, overland flow paths and other topographic features.

As specified in the LRMP (3380-GLNG-3-1.3-0037) all revegetation shall be consistent with the plant density, floristic composition and distribution of the adjacent remnant communities. Where possible, revegetation will encourage the natural re-establishment of significant species and ecological communities into the disturbed areas.

All rehabilitation work will be undertaken in accordance with the Pest and Weed Management Plan (3380-SAIP-4-1.2-1842) to ensure existing weeds are not transferred into additional areas and that new weeds are not introduced.

Any additional spoil resulting from trenching works will be dealt with in accordance with the Soil Management Plan (3380-SAIP-4-1.3-1991).

### 14.3 Operational Phase

During the operation phase, a cleared area to a maximum of 10 m in width will be maintained along the GTP ROW and centered directly above the pipeline to facilitate access. This will be revegetated with grass species. To protect the structural integrity of the pipeline, rehabilitation objectives for the operation phase will restrict vegetation growth to understory species and mid-level species within 10 m of the pipeline. Deep rooted species will not be allowed to grow back into this area.

### 14.4 Decommissioning Phase

On decommissioning of the pipeline, rehabilitation to pre-clearance conditions will be undertaken in accordance with EPBC Act Approval Condition 3d. This will include re-establishment of large trees (i.e. trees which will grow greater than 10 min height) within all previously restricted vegetation growth areas. A further review will be undertaken at the time of decommissioning to determine an appropriate rehabilitation policy in accordance with best practice at that time.

# 15 WATER QUALITY MONITORING FOR WATERCOURSE CROSSINGS

Construction of the GLNG GTP across watercourses will be scheduled during the dry season where possible when the majority of watercourses will be dry. In the event that a watercourse is wet at the time of construction, water quality monitoring will take place as described below.

The Mainland and Curtis Island EMPs propose a number of measures for monitoring of water quality at watercourse crossings. These have been translated into an in-stream monitoring program and de-watering monitoring program. Monitoring of erosion and sediment control features will be undertaken in accordance with the relevant ESCP. Existing water quality within the study area and the Water Quality Objectives (WQO) have been described in the AVA for Major Watercourses (refer Appendix B and C).

## 15.1 In-stream Monitoring Program

Monitoring of *in situ* water quality will be conducted during the construction of wet condition watercourse crossings. The objective of the in-stream monitoring program is to detect any increases in turbidity resulting from the works and to manage the potential impacts from construction on instream and downstream aquatic values.

The monitoring program is divided into two categories of monitoring and is as follows:

- Category A – monitoring program for High Aquatic Value Watercourses and High Ecological Value (HEV) Aquatic Ecosystems.
- Category B – monitoring program for all other watercourses with the potential to have aquatic value.

Each wet watercourse is either monitored under Category A or Category B monitoring.

Category A watercourses are those that have been identified as either having high aquatic value and/or being upstream of a High Ecological Value (HEV) ecosystem, and therefore have the potential to impact a HEV. These watercourses were identified and determined through both desktop and field investigations.

Category B watercourses are all those remaining watercourses that at the time of construction have water present and therefore the potential for aquatic values.

Water quality monitoring will be conducted in accordance with the Monitoring and Sampling Manual 2009 (DERM 2009b) which includes appropriate calibration of water quality instruments. All monitoring records will be stored in accordance with EA conditions.

### 15.1.1 Location and Category of Monitoring

All watercourses will be monitored under Category B with the exception of the following the watercourses which have been deemed to potentially impact a HEV and therefore will be monitored under the more extensive monitoring program, Category A.

Category A watercourses are as follows:

- Hutton Creek
- Dawson River (Upstream)
- Conciliation Creek
- Brolga Gully
- Mimosa Creek
- Dawson River (Downstream)
- Back Creek

- Kianga Creek
- Police Camp (KP263) Creek
- Police Camp (KP269) Creek
- Orange Creek
- Unnamed Watercourse 7
- Callide Creek
- Callide Creek (Old Channel)
- Collards Creek
- Calliope River
- Unnamed Watercourse 9
- Unnamed Watercourse 10
- Harper Creek
- Alarm Creek
- Gravel Creek
- Larcom Creek (KP378.06)
- Larcom Creek (KP384.76)
- Unnamed Minor Watercourse 202 (Tidal)
- Humpy Creek (Tidal)
- Unnamed Minor Watercourse 203 (Tidal)
- Targinie Creek (Tidal) (minor watercourse)

Category B watercourses are as follows:

- All remaining watercourses.

**Category A** monitoring is to commence **10 days** prior to the commencement of clear and grade and /or construction for a period of 10 consecutive days and will follow the below program (Sections 15.1.2, 15.1.3 and 15.1.4). Category A also requires an aquatic environment inspect to be undertaken, refer Section 15.1.2.

**Category B** monitoring is to commence **3 days** prior to the commencement of clear and grade and /or construction for a period of 3 consecutive days and will follow the below program (Sections 15.1.2, 15.1.3 and 15.1.4).

All data will be collected and recorded in the Field Data Sheet (FDS) (Appendix H).

### 15.1.2 Pre-Construction Baseline Monitoring

Pre-construction monitoring will be undertaken at each watercourse crossing to establish a baseline. This will commence either 10 or 3 days (determined by category) prior to the commencement of clearing of riparian vegetation or construction and will be the primary responsibility of the Site Environmental Officer (SEO). The pre-construction monitoring will include the following activities:

- The field data sheet (FDS) provided in Appendix H will be completed, and include a photographic record of the creek, including instream conditions.
- Two suitable monitoring sites will be identified, one upstream and one downstream of the ROW. Site selection will be as close to 50 m upstream and 50 m downstream of the ROW, as safe access permits.
- The following data will be recorded:
    - Depth (m).
    - Dissolved Oxygen (DO) (% saturation).

  - pH.
  - Turbidity (NTU).
  - Temperature (ºC).
  - Conductivity (µm/cm).
- Two replicate samples will also be collected for laboratory analysis of Total Suspended Solids (TSS) (mg/L) at the crossing location.
- The results will be recorded in the FDS and stored in the water quality logbook. Copies of lab data sheets and chain of custody forms will be appended to the field data sheet where required.

The following is the schedule that will be followed for pre-construction water monitoring, which is to be conducted at approximately the same time each day and at above mentioned 3 locations:

- GTP Crossing Location:
  1. FDS – Day 1 Part A & B. Day 2 onwards Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.

- 50 m Downstream:
  1. FDS – Day 1 Part A & B. Day 2 onwards Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.

- 50 m Upstream:
  1. FDS – Day 1 Part A & B. Day 2 onwards Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.

High aquatic value watercourses will also require an aquatic environment inspection. This inspection entails the GTP crossing location to be inspected by an Aquatic Ecologist, no more than two weeks prior to clear and grade and/or construction.

### 15.1.3 Construction Phase Monitoring

During construction, the below monitoring will be conducted by either SEO:

On each day of clear and grade or construction prior to the commencement of works and at the end of each day's work, the following monitoring is to occur:

- GTP Crossing Location:
  1. Visual and photographic inspection of erosion and sediment control measures to be in accordance with the relevant ESCP.
  2. Visual and photographic inspection of water diversion, flumes pipes etc.

Regular monitoring to occur throughout the process of clear and grade and/or construction, will be as follows:

- GTP Crossing Location:
  1. Visual and photographic monitoring of instream conditions, for sediment and/or hydrocarbons.*****

- Downstream:

1. Visual and photographic monitoring of instream conditions, for sediment and/or hydrocarbons.*****

***If sediment plume resulting from construction activities is witnessed, outside contained areas or construction areas, the following will occur:**

1. Works to cease.
2. Photo records to be collected of plume.
3. Erosion and sediment control measures to be inspected.
4. Photo records to be collected of erosion and sediment control measures.
5. Monitoring to occur at the time of incident. This will consist of a complete days monitoring program as per Section 15.1.2, including the following:
   - GTP Crossing Location:
     1. FDS – Part B only.
   - 50 m Downstream:
     1. FDS – Part B only.
     2. In situ monitoring – 3 x mid water column sample, record in FDS.
     3. Turbidity monitoring – 3 x mid water column sample, record in FDS.
   - 50 m Upstream:
     1. FDS – Part B only.
     2. In situ monitoring – 3 x mid water column sample, record in FDS.
     3. Turbidity monitoring – 3 x mid water column sample, record in FDS.
6. If plume has dispersed construction can recommence, or repeat step 5 each day until plume disperses and then construction may recommence.

### 15.1.4 Post Construction Monitoring

Monitoring is to commence at the completion of construction for three consecutive days, resulting in 3 sample sets (or until the watercourse returns to baseline levels). Sampling is to be done at approximately the same time each day and at 3 locations (GTP crossing location, 50 m downstream and 50 m upstream) and is as follows:

- GTP Crossing Location:
  1. FDS – Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.*

- 50 m Downstream:
  1. FDS – Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.*

- 50 m Upstream:
  1. FDS – Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.*

***If water quality is outside variation previously witnessed, the following will occur: plume is witnessed to following will occur:**

1. Monitoring will be ongoing for a further THREE days or until water quality stabilizes, each day completing a full days monitoring program as per Section 15.1.2.
   - GTP Crossing Location:
     1. FDS – Part B only.
   - 50 m Downstream:
     1. FDS – Part B only.

2. In situ monitoring – 3 x mid water column sample, record in FDS.
3. Turbidity monitoring – 3 x mid water column sample, record in FDS.

- 50 m Upstream:
  1. FDS – Part B only.
  2. In situ monitoring – 3 x mid water column sample, record in FDS.
  3. Turbidity monitoring – 3 x mid water column sample, record in FDS.

## 15.2 De-watering Monitoring

Monitoring will also be undertaken to assess the quality of wastewater resulting from trench de-watering. As outlined in Section 11, trench water may be discharged to land or re-used for dust suppression. The discharge of trench water will be managed in accordance with the Water Quality Management Plan (3380-SAIP-4-1.3-7043).

Trench water will be discharged to land in accordance with the EA conditions. Trench water will be released to stabilised land with appropriate / adequate ground cover to prevent erosion in such a way that:

- Vegetation is not damaged.
- Soil erosion is avoided.
- It does not drain to surface waters.
- Does not adversely affect the quality of groundwater.

## 15.3 Post Rehabilitation Monitoring

As part of the implementation of the Landscape Rehabilitation Management Plan for the GLNG GTP Corridor (LRMP) (3380-GLNG-3-1.3-0037), monitoring will be conducted after the rehabilitation works are complete to ensure that the riparian re-vegetation and bank stabilisation works are effective and are not causing any unanticipated impacts on the watercourse.

## 15.4 Flood Monitoring

It is anticipated that the pipeline construction works on the Mainland and Curtis Island will take approximately 12 – 18 months with the majority of works in watercourses scheduled for construction in the dry season. The probability of a flood occurring during this timeframe is low, however, flooding can represent a significant hazard.

Monitoring of creek flows and flood conditions will also be conducted to ensure that the risk to the health and safety of construction workers is minimised, and that the risk of adverse impacts on the environment due to the impacts of flooding on construction activities are minimised.

The primary mechanism by which flood monitoring will be undertaken is via receipt of flood warnings from the Bureau of Meteorology (BoM). Flood warnings are available on the BoM's website (http://www.bom.gov.au/qld/warnings/) or by telephoning 1300 659 219. In addition, there are a number of rainfall gauges within the study area which will provide accurate data for flood monitoring. These are listed in Table 15-1.

**Table 15-1 Locations of Rainfall Gauges**

| Rainfall Gauge Station Name | Station Number | Owner | Eastings MGA Z55 | Northings MGA Z55 | Location Relative to GTP |
|---|---|---|---|---|---|
| Moonah | 35148 | BOM (AUS) | 692704 | 7146287 | South of KP 0 |
| Waddy Brae | 35180 | BOM (AUS) | 695313 | 7166105 | East of KP 19 |

| | | | | | |
|---|---|---|---|---|---|
| Linga Longa | 35120 | BOM (AUS) | 684308 | 7193495 | West of KP 49 |
| Mount Kingsley | 35151 | BOM (AUS) | 686278 | 7202704 | West of KP 59 |
| Austral Park | 35263 | BOM (AUS) | 678417 | 7223852 | West of KP81 |
| Allambee | 35280 | BOM (AUS) | 678785 | 7248219 | West of KP107 |
| Bauhinia Downs Store | 35007 | BOM (AUS) | 732143 | 7280611 | North of KP174 |
| Karamea | 35227 | BOM (AUS) | 780699 | 7285382 | South of KP224 |
| Lloyona | 39332 | BOM (AUS) | 753749 | 7298089 | North of KP232 |
| Lynwood | 39160 | BOM (AUS) | 233145 | 7301382 | South of KP291 |
| Figtree | 39197 | BOM (AUS) | 273055 | 7338801 | North of KP344 |
| Mount Alma | 39125 | BOM (AUS) | 283504 | 7341523 | North of KP358 |
| Calliope Station | 39020 | BOM (AUS) | 293109 | 7341576 | South of KP368 |
| Hazeldean | 39334 | BOM (AUS) | 292576 | 7341846 | South of KP368 |
| Mount Larcom Post Office | 39068 | BOM (AUS) | 294021 | 7365308 | East of KP392 |
| Gladstone Radar | 039123 | BOM (AUS) | 323092 | 7360708 | South of KP406-409 |
| Southern Curtis Island | 39241 | BOM (AUS) | 327741 | 7371509 | East of KP418 |

## 15.5 Water Quality Monitoring Standards and Guidelines

The following minimum quality assurance/quality control (QA/QC) requirements must be complied with:

- Water quality monitoring will be conducted in accordance with the Monitoring and Sampling Manual 2009 (DERM 2009b).
- Water quality monitoring will be conducted by a suitably qualified professional
- Water quality instruments must be maintained, calibrated and operated in accordance with the manufacturer's instructions.
- Should laboratory analysis of water quality sample(s) be required, this will be undertaken by a NATA accredited laboratory.
- Any water quality samples sent to a laboratory for analysis shall be sent under cover of a chain of custody form and within the relevant holding times.

## 15.6 Health and Safety Considerations

Water quality sampling can be a hazardous activity and will be conducted in accordance with the relevant Safe Work Method Statement (SWMS).

## 16 ROLES AND RESPONSIBILITIES

All project personnel are responsible for the environmental performance of their activities and for complying with the General Environmental Duty as set out in Section 319(1) of the EP Act (1994), which states:

> "*A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to minimise the harm*."

Furthermore, the Duty to Notify Environmental Harm as set out in Section 320 requires that all Project personnel:

> "...*notify the administering authority when undertaking activities that cause or threaten serious or material environmental harm*."

This duty also requires that all Project personnel to:

> "...*notify the administering authority where a person carries out activities and becomes aware of the act of another person which causes or threatens serious or material environmental harm*" or when "... *activities have or are reasonably likely to negatively affect the water quality of an aquifer or activities have caused the unauthorised connection of two or more aquifers*".

All personnel (staff and/or subcontractors) must comply with the conditions of the Environmental Authorities (PEN102664411, PEN103428811 and PEN 102968511) issued by DEHP, all other project conditions and the management measures laid out in the GLNG Mainland Environmental Management Plan (Mainland EMP) (3380-GLNG-3-8.2-0027), GLNG Marine Crossing Environmental Management Plan (Marine Crossing EMP) (3380-GLNG-4-8.2-0021) and GLNG Curtis Island Environmental Management Plan (Curtis Island EMP) (3380-GLNG-4-8.2-0022).

The different roles and responsibilities assigned to members of the Contractor team are as outlined in Table 16-1.

**Table 16-1 Roles and Responsibilities**

| Position | Responsibilities |
|---|---|
| Project Manager (PM) | • Ensuring adequate human and financial resources, organisational means and proper assets for the effective implementation of this Plan are provided.<br>• Empower all project staff to stop work when potential environmental harm is perceived.<br>• Ensuring that Watercourse Management is conducted, approved and communicated. |
| Construction Manager (CM) | • Ensure that all construction personnel are inducted and aware of their individual responsibilities regarding protection of watercourses and compliance with water quality protection requirements imposed by Federal and State government conditions.<br>• Ensure that all relevant construction personnel are trained and aware of environmental compliance requirements throughout the life of the Project. |

| Position | Responsibilities |
|---|---|
| | • Ensure sub-contractors comply with environmental requirements to protect environmental values.<br>• Ensure adequate resources are available and applied to achieve compliance with project conditions and provide protection of relevant environmental values.<br>• Communicate with the Environmental representatives to manage any environmental issues affecting construction activities.<br>• Participate in the CEMP audit process and ensure that audit findings are adequately addressed.<br>• Delegate authority (when necessary) to stop work and/or order the implementation of control measures as advised by the Environmental representative or a relevant authority representative (e.g. DERM).<br>• Direct construction works in a planned and regulated manner that avoids or minimises impact environmental values within the work area.<br>• Ensure construction personnel conduct construction works in accordance with statutory and approval requirements.<br>• Allocating staff with suitable Personal Protection Equipment (PPE) as per their respective responsibilities and work requirements. |
| Health, Safety, & Security Manager (HSSM) | • Ensures compliance to all relevant applicable:<br>- Santos GLNG HS&S Management Standards.<br>- Statutory HS&S obligations.<br>- Codes of Practice and Guidelines. |
| Environmental Manager (EM) | • Responsible for overseeing the implementation of the AVMP during the life of the Project.<br>• Reviewing the AVMP for adequacy and functionality.<br>• Ensure subcontractors and all staff are properly informed and aware of environmental responsibilities in the project.<br>• Delegate authority to environmental staff on site to implement adequate management measures in regards to fauna and flora protection.<br>• Coordinate inspection, monitoring and environmental audits to identify any non-conformance with regards to environmental management.<br>• Ensure that task-specific environmental training is developed and delivered prior to environmentally sensitive works.<br>• Ensuring that the AVMP is issued and up-to-date. |
| Environmental Coordinator (EC) | • Ensure all environmental management systems are finalised and communicated throughout the relevant project personnel.<br>• Provide practical advice to project personnel regarding management actions related to environmental risks and responsibilities.<br>• Liaise and engage in pre-dredging communication with the fishing industry to identify any locations or periods of particular importance |

| Position | Responsibilities |
|---|---|
| | and/or sensitivity to minimise impact on sensitive areas.<br>• Ensure planning of dredging activities is undertaken to reduce impacts at ecologically sensitive or economically important areas.<br>• Maintain the Environmental Complaints Register.<br>• Update and manage the AVMP. |
| Site Environmental Officer (SEO) | • Ensure all personnel comply with this plan.<br>• Implementation and maintenance of the AVMP through feedback received and recorded into the Environmental Complaints Register or any other means such as daily general inspections.<br>• Participate in a monitoring program.<br>• Prepare incident reports and implement corrective actions.<br>• Recommend additions or changes to the AVMP based on experience gained from incident resolving and daily implementation of the rehabilitation plan and continuous improvement. |
| Surveyor | • Accurately identify in the field the areas to be affected by construction activities.<br>• Mark on site the different clearing areas and boundaries by using wooden pegs (or equivalent). |
| Suitably Qualified and Experienced Professional (SQEP) | • Comply with the AVMP at all times.<br>• Comply with all the environmental requirements while conducting work on site.<br>• Provide technical and specialised advice on relevant environmental topics.<br>• Provide specialised activities relevant to their qualifications. |

## 17 TRAINING AND AWARENESS

In accordance with Santos Management Standard EHSMS06, all personnel and visitors are required to undertake appropriate environmental training and induction programs.

As part of the training programme, all project personnel must complete site specific environmental awareness training which is to be conducted by the SEO. As a minimum, the training will consist of a presentation and an assessment. The site induction will address the following:

- Status of watercourses, including identification of major watercourses and high aquatic value watercourses.
- Location of sensitive areas (e.g. turtle nesting areas, wetlands and habitat trees)
- Vegetation protection areas and other no go zones.
- Procedure relating to previously unidentified watercourses.
- Procedures and actions associated with fauna entrapment and salvage.
- Water quality monitoring requirements outlined in this Plan.
- Responses and reporting of environmental issues.
- HSE issues associated with working in and around watercourses.

This training will be developed with the assistance of the EC and delivered by the SEO. This will be undertaken within the initial induction process, ongoing toolbox meetings and relevant Construction Method Statements.

Where possible, personnel will also be provided with photographs and given general information on significant species associated with watercourses to enable them to identify these species should they be encountered.

Awareness of environmental issues and constraints for specific parts of the Project (environmentally and ecologically sensitive areas) must be raised through the use of tailored toolbox talks provided by either the SEO or a SQEP for topics such as (but not limited to):

- Erosion and sediment controls used in and around watercourses.
- Protected species.
- Management of wastes around watercourses, in particular drilling fluid/mud.
- Weeds and pest management.
- Incidence response procedures, including the Flood Warning System.

# 18 CONTINGENCY MEASURES

GLNG recognises that contingency measures and adjustments to the management strategies may need to be considered in the event that a detrimental impact is recorded, and/or performance measures or targets are not met.

In the event that unanticipated significant impacts on watercourses occur during the course of the works, the current mitigation strategies will be reviewed in conjunction with a Suitably Qualified and Experienced Professional (SQEP) and any recommended changes implemented and incorporated into AVMP review.

Any new mitigation measures will be discussed with DSEWPC and DEHP prior to implementation, noting that this may not be possible under extenuating circumstances. In this case, any action deemed necessary by the SEO and EM to mitigate any unanticipated environmental impact will be promptly implemented and DSEWPC and DEHP advised accordingly.

## 18.1 Identification of Additional Watercourses

In the event that watercourses or other aquatic habitat features other than those identified in this plan are identified within the project area during pre-clearance surveys or construction activities, DSEWPC and/or DEHP will be consulted and contingency measures determined and implemented, where required.

It is possible, albeit unlikely, that during the clearing of the ROW, a previously unidentified watercourse or aquatic habitat feature is encountered. Under these circumstances, the following process shall be implemented:

- Works in the region of the feature will cease immediately.
- The SEO will take a Global Positioning System (GPS) mark of the location of the feature and complete a photograph record looking across the watercourse, upstream and downstream.
- If the SEO considers that the feature is a watercourse, the SEO shall complete the Field Data Sheet provided in Appendix H.
- Additional field investigation by a SQEP in the form of an assessment of aquatic values may be required. Both this Plan and the AVMP shall be updated accordingly.
- Works may proceed once the appropriate environmental approval has been obtained and the mitigation measures as outlined in the AVMP have been implemented.

## 18.2 Assessment of Construction Methodology

The scheduling of construction works will be conducted as to optimize conditions, therefore, the chosen methodologies for many watercourses assume dry conditions. In the event that wet conditions are encountered in a watercourse at the time of construction, the appropriate methodology will be re-assessed by a SQEP in conjunction with the CM and EM.

# 19 REVIEW AND REPORTING

## 19.1 Review of the Plan

Monitoring of the AVMP will be achieved through the compilation of incidental, weekly and monthly reporting. Reporting will be undertaken in accordance with the aims and objectives of the CEMP.

The AVMP will be updated as required during the life of the project to include changes to any of the activities identified in this Plan. Such changes may include a proposed change to the construction methodology at a particular watercourse, changes to management measures, or changes to monitoring activities. The first revision will be conducted during the Pre-construction phase.

Changes to the AVMP as a result of actions other than in accordance with a plan approved by the Minister under these conditions, will trigger a variation to the AVMP.

## 19.2 Water Quality Records

Water quality monitoring data generated as part of implementation of this AVMP will be collated in accordance with the Environmental Monitoring and Reporting System (EMRS) (3380-SAIP-4-1.3-1846). All photos and sampling site location details will also be collated in an electronic database.

The information collated as part of the EMRS will include:

- Location of all water quality monitoring sites.
- Completed pre-construction field data sheets for all watercourses.
- Completed water quality data reporting sheets for all watercourses.
- Copies of chain of custodies and laboratory results.
- Records of any non-compliances with the water quality targets or other incidents.
- Remedial or corrective actions implemented to address any issues.

The records will also be made available to the DSEWPC and/or DEHP upon request.

## 19.3 Incidents

Incidents that result in impacts on a watercourse such as accidental spills of fuel, hydraulic fluids or other chemicals will be recorded using the Event Incident Reporting Form. Details of Level 1 incidents including time and date of incident, cause of the incident (if known) and any corrective actions implemented, will be recorded and reported to the Pollution Hotline within 24 hours of its occurrence.

All incidents in breach of EPBC conditions must be reported to the relevant Commonwealth regulatory authority within five business days.

## 19.4 Annual Environmental Return

This information collected as part of the EMRS will support the Annual Environmental Return, which will be submitted to DSEWPC electronically, within 20 business days of each anniversary date from the date of Commonwealth approval. The Annual Environmental Return will document the following information:

- Addresses compliance with CG, EA and EPBC conditions.

- Detail where there was any unavoidable impacts on watercourses, mitigation measures applied to avoid impacts on watercourses and any rehabilitation work undertaken in connection with any unavoidable impact on watercourses.
- Detail all non-compliances with CG, EA and EPBC conditions.
- Detail any amendments needed to plans to achieve compliance with these conditions.

# 20 CORRECTION AND PREVENTION

The EM will review any corrective and preventative actions required if an incident occurs. These will be approved and documented by the Principal Contractor.

## 20.1 Preventative Actions

Preventative actions will be managed as follows:

- Environmental Incidents along with their corrective and preventative actions will be recorded in the Incident Management System (IMS). Corrective and preventative actions will be updated into the CEMP (3380-SAIP-4-1.3-1814). Future audits will check for compliance with the CEMP (3380-SAIP-4-1.3-1814) and that the necessary preventative actions are in place.
- Reviews of environmental performance will be undertaken through consideration of key performance indicators, objectives and targets, and benchmark performance.
- Where assessed by the SEO (as necessary), a preventative action will be raised and action undertaken as a Corrective Action. Preventative actions may include changes to specific procedures or training requirements, or other management areas.

## 20.2 Non-Conformances

For clarity, environmental non-conformances will be referred to as environmental issues to differentiate them from project non-conformances, which typically relate to quality defects in items of plant or materials. An environmental issue will be detected through verification processes such as monitoring, inspections, audits and receipt of complaints.

The process for managing environmental issues will be in accordance with GLNG Internal and Project Policies and Procedures. When an environmental issue is detected, the following actions will occur:

- The incident will be recorded in the IMS.
- The nature of the event will be investigated by the SEO.
- Advice may be sought from a specialist where the extent of the issue is beyond the expertise of the in-house resource.
- Monitoring will be undertaken where the issue is complaint driven and the impact may be outside the project parameters.
- The effectiveness or need for new/additional controls will be reviewed.
- An appropriate preventative and corrective action will be entered into the environmental IMS and implemented.
- Strategies will be identified to prevent reoccurrence.
- The IMS will be closed-out.
- Environmental documentation (i.e. the CEMP (3380-SAIP-4-1.3-1814) and AVMP) will be reviewed and revised.

Where the issue impacts on a third party (i.e. is outside the project area or in breach of regulatory conditions) the SEO will also issue an Incident Report. In addition to the above, where an issue of a more serious nature has been identified, the following will apply:

- Stop work.
- Implement an immediate action to rectify the incident and stop further damage.
- Report the incident.

- Identify corrective and preventative actions.
- If the incident impacts upon State and/or Commonwealth interests, the incident report will also be forwarded to the relevant authority.
- The incident will be reported in monthly management reports.
- Associated environmental issues and corrective actions will be tracked.

### 20.3 Emergency Preparedness and Response

An Incident Response Plan will be prepared for the project and will be outlined in the CEMP (3380-SAIP-4-1.3-1814). This Plan will document suitable incident procedures to ensure effective response in the event of an emergency (including environmental emergencies such as fire, flood and large fuel spills).

The emergency procedures shall be tested on a six-monthly basis. Records of all site emergencies will be maintained (including results of emergency practice drills). The Emergency Response Controller for the Project will be defined within the Incident Response Plan. This will also include the use of contingency measures to check open trenches during and after rainfall events.

An up-to-date list of emergency response personnel and organisations will be maintained at each site office and compound.

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**FIGURES**

**Figure 1 – Proposed Gas Transmission Pipeline Route**

**Figure 2 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP0-70**

**Figure 3 – Watercourse and Wetlands Proposed GTP Crossing Location Maps Baffle Creek**

**Figure 4 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP70-200**

**Figure 5 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP200-420**

**Figure 6 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP406-410**

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# APPENDICES

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**APPENDIX A – Major Watercourse Crossing Location Table**

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Hutton Creek | 2.092 | 6 | Least concern | 11.3.25 | 692134.342 | 7151525.586 | 40 | 0.93 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3400 | Mar-Apr 2013 |
| Christmas Creek | 2.657 | 4 | | Non-remnant | 691931.500 | 7152026.242 | 30 | 0.93 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3401 | Mar-Apr 2013 |
| Baffle Creek | 19.8 to 21.6 | 4 | Least Concern | 11.10.1 | 687364.88 | 7167681.78 | 30 | 5.2 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3403 | Apr-Jun 2013 |
| Unnamed Watercourse 1 | 28.757 | 3 | Endangered | 11.3.25/11.9.5a | 689498.538 | 7174788.033 | 30 | 1.73 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3470 | May 2013 |
| Dawson River (Upstream) | 29.832 | 5 | Of concern | 11.3.2 | 690146.742 | 7175586.978 | 30 | 6.52 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3406 | May-Jun 2013 |
| Bully Frog Creek | 46.012 | 3 | Of concern | 11.3.2 | 690349.366 | 7190703.816 | 30 | 0.92 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3407 | March 2013 |
| Unnamed Watercourse 2 | 57.481 | 3 | | Non-remnant | 688604.131 | 7201768.538 | 40 | 1.68 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3408 | March 2013 |
| Ironbark Creek | 62.331 | 3 | Of concern | 11.3.2/11.3.25 | 687904.123 | 7206559.276 | 40 | 0.95 ha* | Causeway** | Standard Mainline Construction | Jute Matting (or similar) | 3381-40-3409 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.819 | 3 | | Non-remnant | 680167.093 | 7223205.791 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.843 | 3 | | Non-remnant | 680159.898 | 7223227.668 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.926 | 3 | | Non-remnant | 680133.959 | 7223306.544 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Clematis Creek | 108.661 | 5 | Of concern | 11.3.2 | 681335.006 | 7250440.092 | 30 | 1.54 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3410 | Feb-Mar 2013 |
| May creek | 111.385 | 3 | | Non-remnant | 682198.491 | 7253018.746 | 40 | Nil | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3472 | Feb-Mar 2013 |
| Deep Creek | 124.560 | 3 | | Non-remnant | 690239.665 | 7262901.727 | 40 | 0.93 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3411 | Feb-Mar 2013 |
| Unnamed Watercourse 4 | 133.969 | 3 | Least concern | 11.5.2/11.10.7/11.10.7a/11.10.1 | 697307.913 | 7268587.112 | 30 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3473 | Sep-Nov 2013 |
| Prospect Creek | 177.762 | 4 | | Non-remnant | 736556.275 | 7279710.650 | 30 | 0.46 | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3416 | Sep-Oct 2012 |
| Unnamed Watercourse 5 | 184.116 | 3 | | Non-remnant | 742484.868 | 7281889.332 | 30 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3474 | Jul-Sep 2013 |
| Conciliation Creek | 207.477 | 5 | | Non-remnant | 764464.780 | 7289412.666 | 30 | 1.86 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3417 | June 2013 |
| Brolga gully | 214.881 | 3 | | Non-remnant | 771697.889 | 7290884.682 | 40 | Nil | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3476 | June 2013 |
| Mimosa Creek | 220.133 | 6 | | Non-remnant | 776470.805 | 7290629.671 | 30 | 2.8 ha* | Causeway | Minor Dam and Flume | Mulching | 3381-40-3418 | June 2013 |
| Denby Creek | 231.187 | 3 | Of concern | 11.3.2/11.3.4/11.3.25 | 786327.930 | 7293279.936 | 30 | 0.68 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3420 | May-June 2013 |
| Dawson River (Downstream) | 233.969 | 8 | Of concern | 11.3.2/11.3.25 | 788686.35 | 7294533.32 | 30 | 6.52 ha* | Causeway | Minor Dam and Flow diversion | Mulching | 3381-40-3421 | Jun-Aug & Nov-Dec 2013 |

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| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Back creek | 234.350 | 3 | Endangered | 11.3.2/11.3.1 | 788870.562 | 7294211.211 | 30 | | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3477 | Nov-Dec 2013 |
| Kianga Creek | 239.742 | 4 | | Non-remnant | 793337.720 | 7295957.882 | 40 | 0.53 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3424 | May-Jun 2013 |
| Banana creek | 252.437 | 5 | | Non-remnant | 804230.943 | 7300351.984 | 40 | 4.51 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3478 | May 2013 |
| Banana creek | 252.668 | 3 | | Non-remnant | 195802.936 | 7300430.096 | 40 | | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3479 | May 2013 |
| Police camp creek (KP 263.66) | 263.663 | 4 | | Non-remnant | 206303.261 | 7302368.132 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3480 | May 2013 |
| Police camp creek (KP 269.96) | 269.963 | 3 | | Non-remnant | 212266.688 | 7303141.752 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3481 | May 2013 |
| Spring Creek | 272.458 | 3 | | Non-remnant | 214450.210 | 7304324.481 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3482 | May 2013 |
| Sellheim Creek | 280.213 | 3 | | Non-remnant | 221693.653 | 7306547.625 | 30 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3483 | Apr-May 2013 |
| Neville creek | 285.846 | 3 | | Non-remnant | 226831.714 | 7308280.646 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3484 | April 2013 |
| Orange Creek | 295.658 | 6 | | Non-remnant | 235998.685 | 7311276.673 | 30 | 1.5 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3485 | April 2013 |
| Unnamed Watercourse 7 | 296.665 | 4 | | Non-remnant | 237002.114 | 7311372.699 | 40 | 0.9 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3486 | April 2013 |
| Kroombit Creek | 296.833 | 6 | | Non-remnant | 237168.190 | 7311388.585 | 40 | 1.5 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3431 | April 2013 |
| Palustrine Wetland | 297.713 | 3 | | Non-remnant | 238043.236 | 7311466.936 | 40 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3487 | April 2013 |
| Callide Creek | 298.949 | 5 | | Non-remnant | 239238.163 | 7311711.384 | 40 | 1.7 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3433 | April 2013 |
| Callide Ck (Old Channel) | 300.312 | 5 | | Non-remnant | 240540.172 | 7311892.166 | 40 | 0.77 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3434 | April 2013 |
| Unnamed Watercourse 8 | 303.790 | 3 | | Non-remnant | 243843.655 | 7312792.755 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3488 | April 2013 |
| Unnamed Watercourse 8 | 305.509 | 3 | | Non-remnant | 245483.633 | 7313305.779 | 40 | 0.29 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3494 | April 2013 |
| Collards Creek | 319.194 | 3 | Least concern | 11.11.15/11.3.25/11.11.4/11.11.4a | 256920.603 | 7319450.222 | 40 | 1.48 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3489 | August 2013 |
| Bell Creek | 334.538 | 3 | | Non-remnant | 266678.268 | 7326216.541 | 40 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3440 | October 2013 |
| Calliope River | 352.374 | 5 | Of concern | 11.3.4/11.3.25 | 280475.758 | 7335673.070 | 30 | 4.04 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3442 | Sep-Oct 2013 |
| Unnamed Watercourse 9 | 354.362 | 3 | | Non-remnant | 281345.236 | 7337398.275 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3490 | Sept 2013 |
| Unnamed Watercourse 10 | 359.557 | 3 | | Non-remnant | 285012.795 | 7340719.107 | 40 | Nil | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3491 | Sep-Oct 2013 |

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| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Harper Creek | 360.338 | 4 | | Non-remnant | 285715.107 | 7341058.561 | 30 | 2.62 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3443 | Sep-Oct 2013 |
| Alarm Creek | 364.802 | 3 | | Non-remnant | 289946.035 | 7342432.822 | 40 | 1.28 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3444 | Sep-Oct 2013 |
| Gravel Creek | 375.634 | 3 | | Non-remnant | 294998.086 | 7350750.225 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3735 | Sep-Oct 2013 |
| Larcom Creek (KP378.06) | 378.069 | 4 | | Non-remnant | 295960.583 | 7352966.538 | 30 | 2.67 ha* | Causeway | Minor Dam and Flow diversion | Mulching | 3381-40-3492 | Sep-Nov 2013 |
| Larcom Creek (KP384.76) | 384.764 | 3 | | Non-remnant | 299009.039 | 7358584.985 | 40 | 1.8 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3447 | Sep-Nov 2013 |
| Humpy Creek | 407.87 | 3 | | Non-remnant | 309247.255 | 7371282.870 | 30 | 0.86 ha* | Causeway | Minor Dam and Flume (Pump) | Grass Seeding | 3381-40-3451 | Sep-Dec 2013 |

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**APPENDIX B1 – Aquatic Values Assessment Major Watercourses KP0-70**

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**APPENDIX B2 – Aquatic Values Assessment Major Watercourses KP70-200**

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**APPENDIX B3 – Aquatic Values Assessment Major Watercourses KP200-406**

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**APPENDIX B4 – Humpy Creek (KP407), Field Data Sheets, Photographs, Laboratory Results and Herbarium Results**

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**APPENDIX C – Site Assessment Sheets Major Watercourses**

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**APPENDIX D1 – Aquatic Values Assessment for Minor Watercourses KP0-70, 200-406 and Curtis Island**

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# APPENDIX D2 – Aquatic Values Assessment for Minor Watercourses KP70-200

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**APPENDIX D3 – Field Data Sheets, Photographs, Laboratory Results and Herbarium Results Minor Watercourses KP406-409**

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**APPENDIX E – Significant Species Management Profiles**

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**APPENDIX F – Design and Construction Drawings**

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# APPENDIX G1 – Triple Bottom Line Assessment for Construction Methodology and Site Specific Methodology Assessments

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**APPENDIX G2 – Baffle Creek Crossing: Analysis of Open Cut and Horizontal Directional Drilling and Open Cut and Horizontal Directional Drilling Options Technical and Geotechnical Assessment**

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**APPENDIX H – Field Monitoring Sheets**

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**APPENDIX I – Addendum Aquatic Assessment for Revised Dawson River (Downstream) Crossing**

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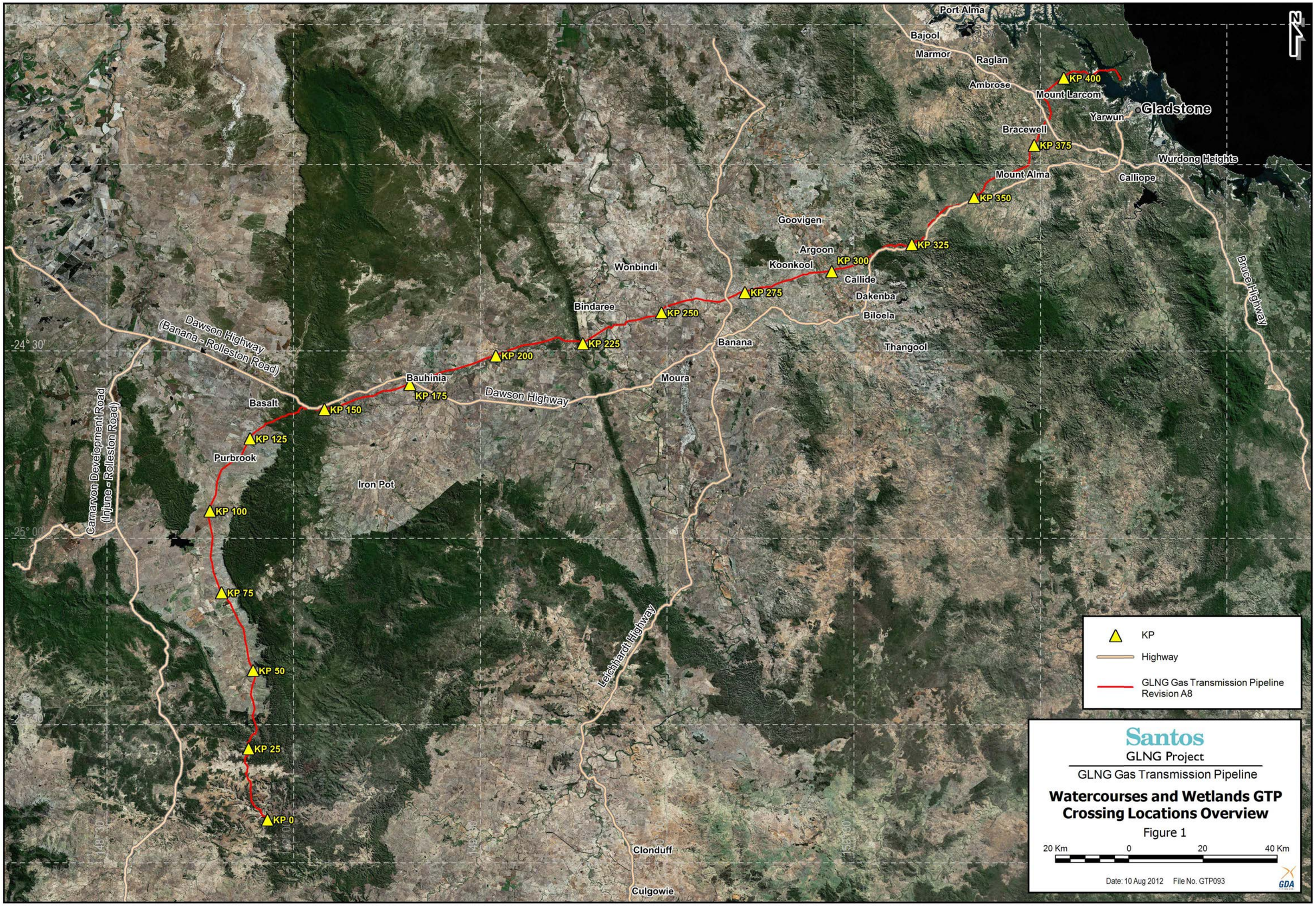
**FIGURES**

**Figure 1 – Proposed Gas Transmission Pipeline Route**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Gladstone
Yarwun
Bracewell
KP 375
Wurdong Heights
Mount Alma
Calliope
KP 350
Goovigen
KP 325
Argoon
Koonkool
KP 300
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KP 275
Dakenba
Biloela
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Banana
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KP 200
Bauhinia
KP 175
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KP 150
Dawson Highway
Bruce Highway
Carnarvon Development Road
(Injune - Rolleston Road)
KP 125
Purbrook
Iron Pot
KP 100
KP 75
KP 50
KP 25
KP 0
Leichhardt Highway
Clonduff
Culgowie
-24° 30'
-25° 00'
148° 30'
149° 00'
149° 30'
150° 00'
150° 30'
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GLNG Gas Transmission Pipeline
Revision A8
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Watercourses and Wetlands GTP
Crossing Locations Overview
Figure 1
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40 Km
Date: 10 Aug 2012
File No. GTP093
GDA

**Figure 2 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP0-70**

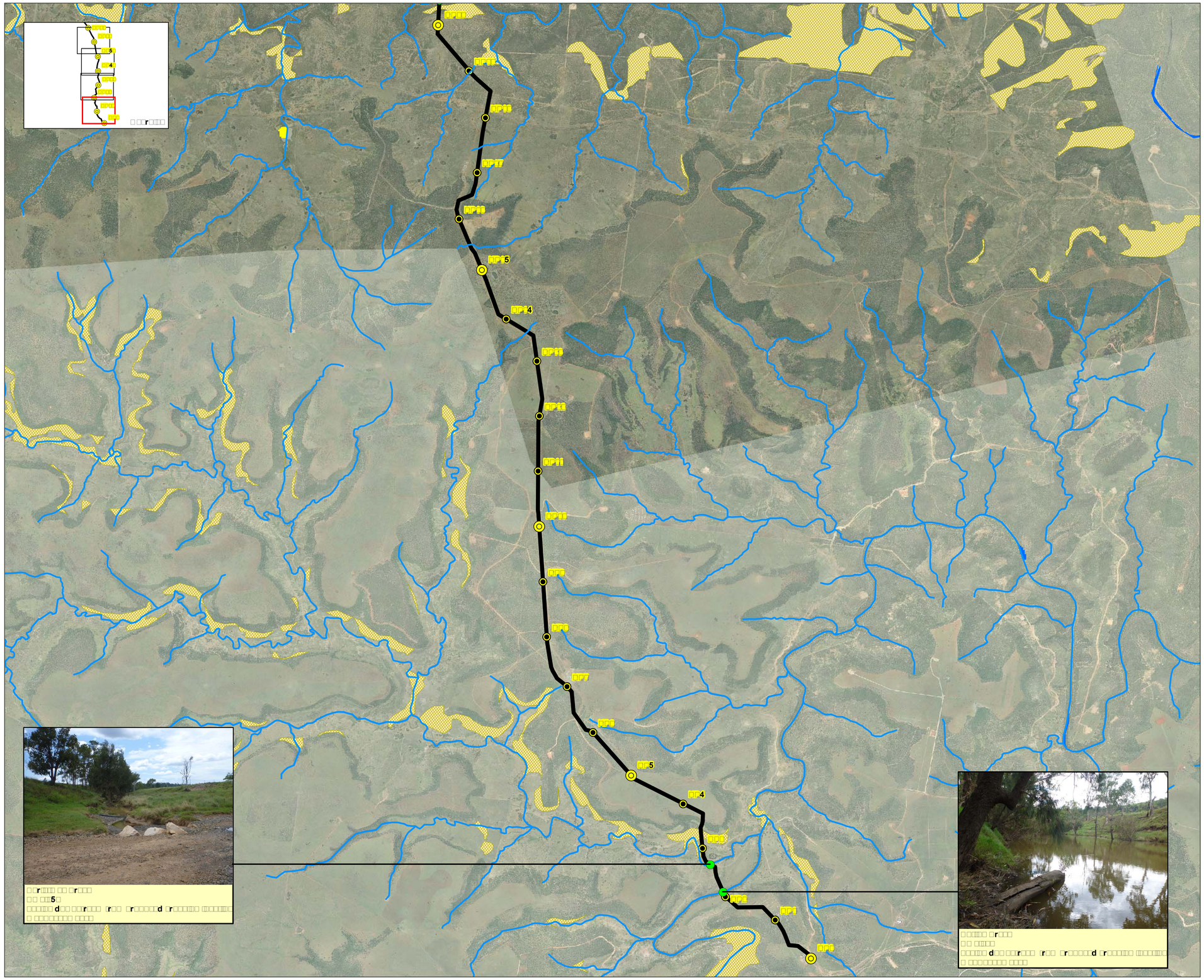

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**Figure 3 – Watercourse and Wetlands Proposed GTP Crossing Location Maps Baffle Creek**

BAFFLE CREEK

BAFFLE CREEK

BAFFLE CREEK

**Location of Baffle Creek crossing**

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# GLNG GAS TRANSMISSION PIPELINE

## Figure 2
## Location of Baffle Creek crossing

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**Figure 4 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP70-200**

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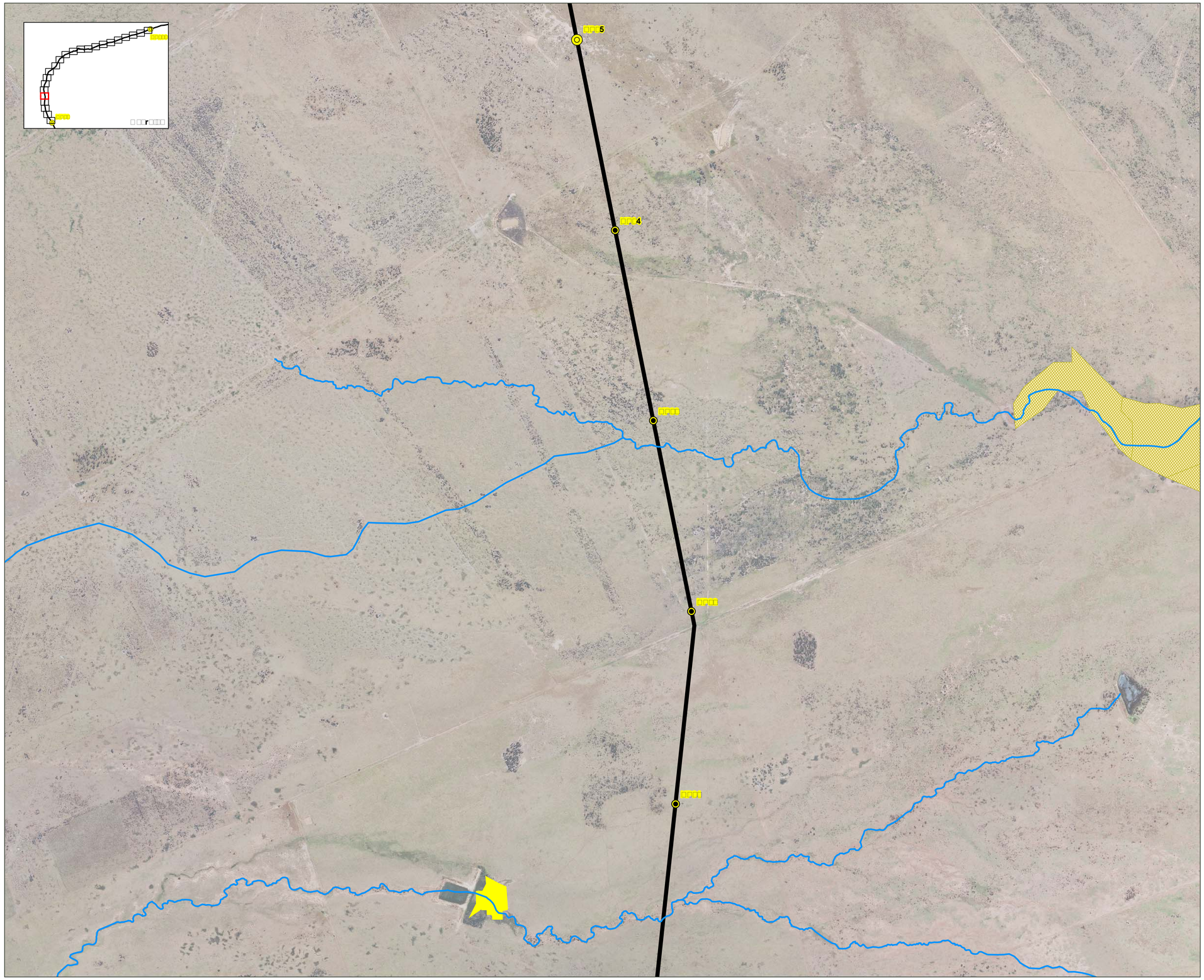


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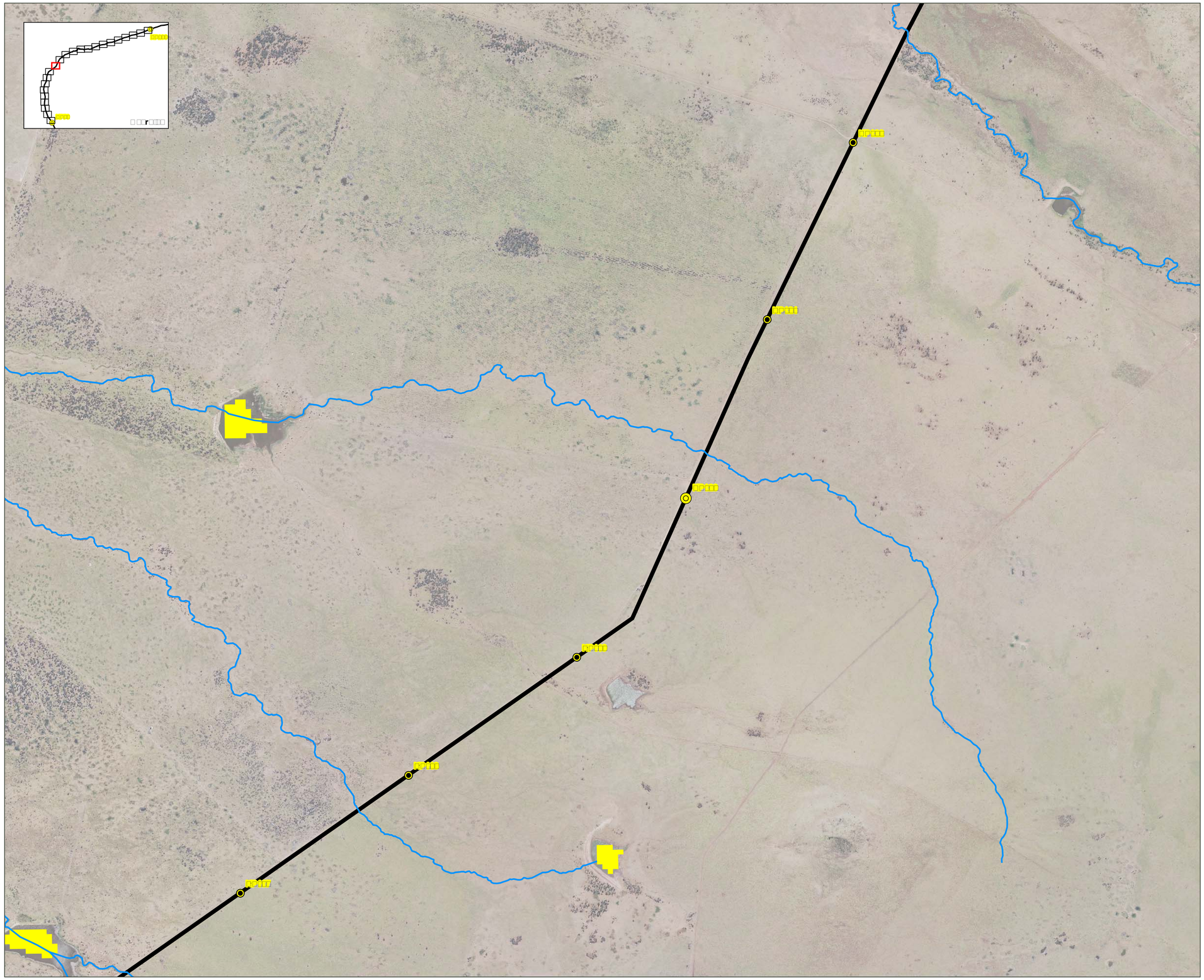

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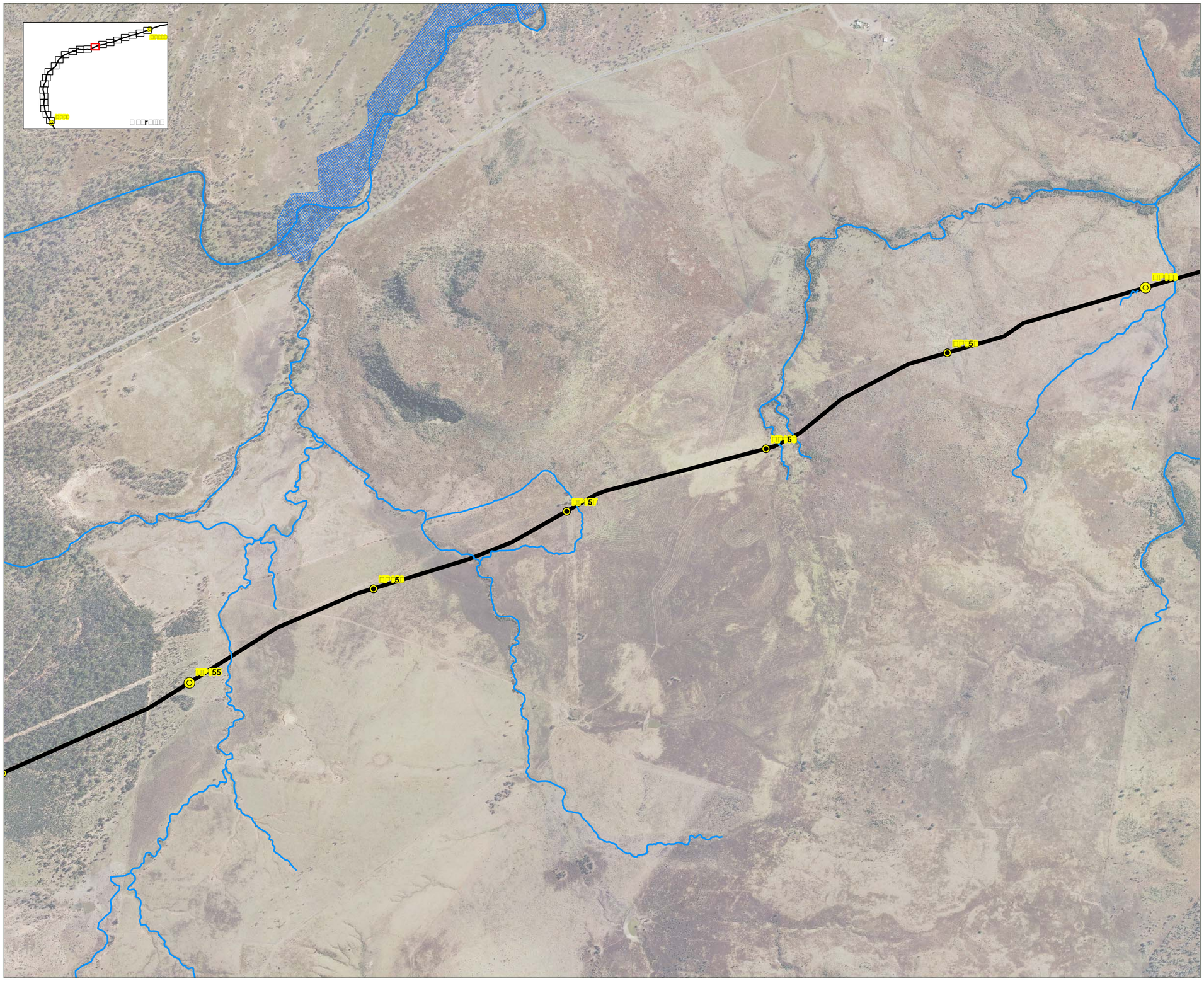
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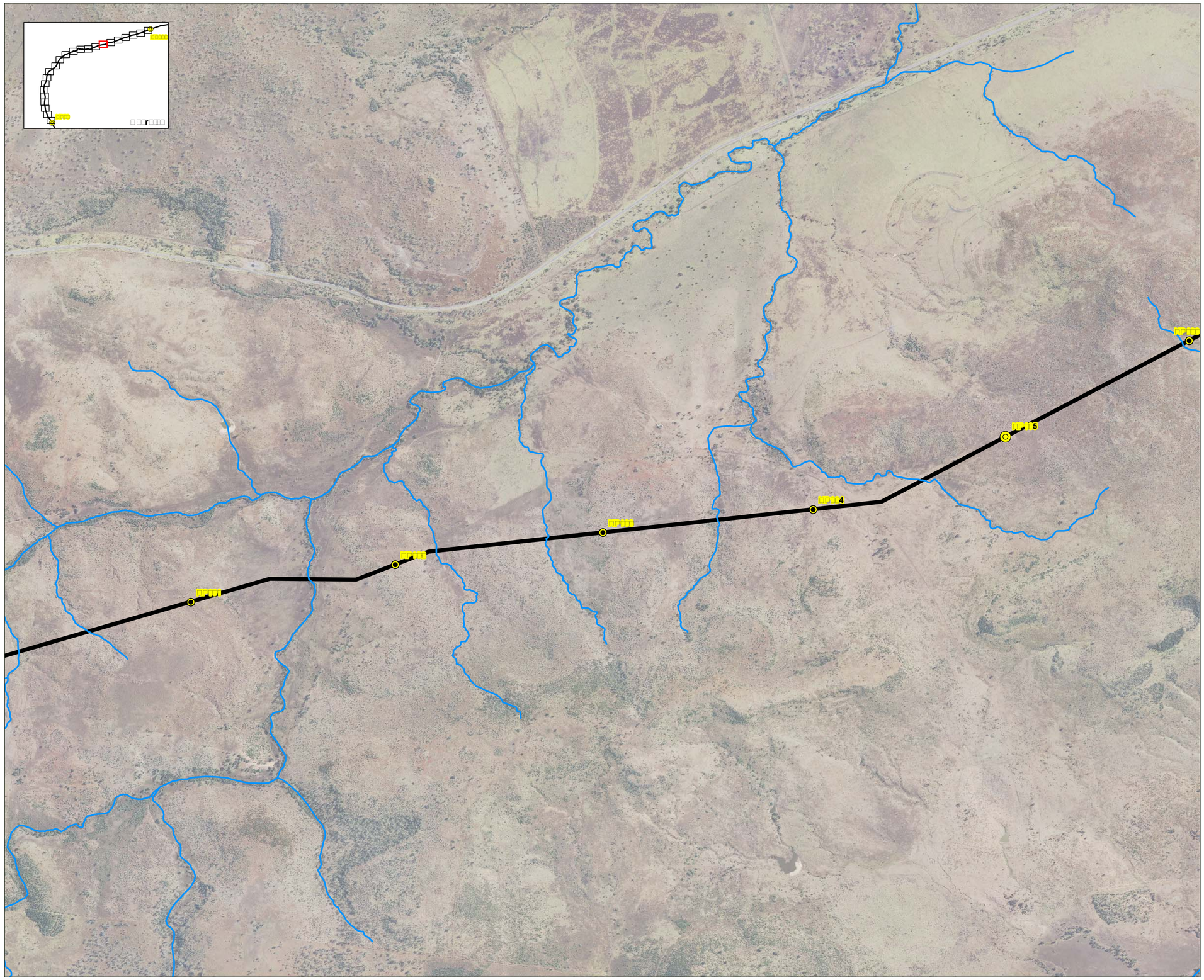


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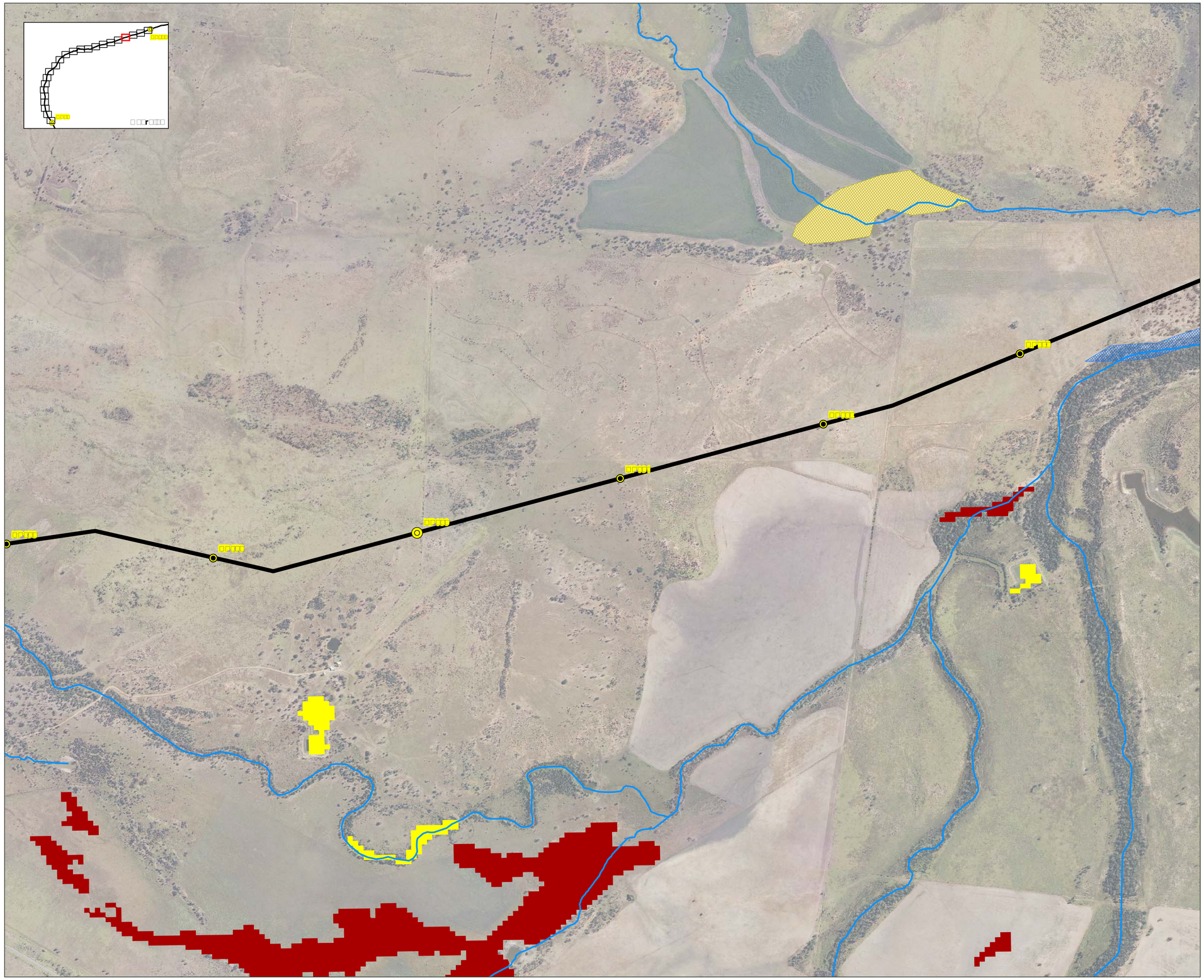

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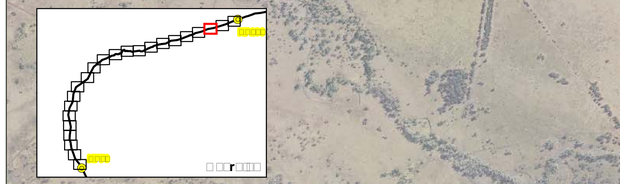

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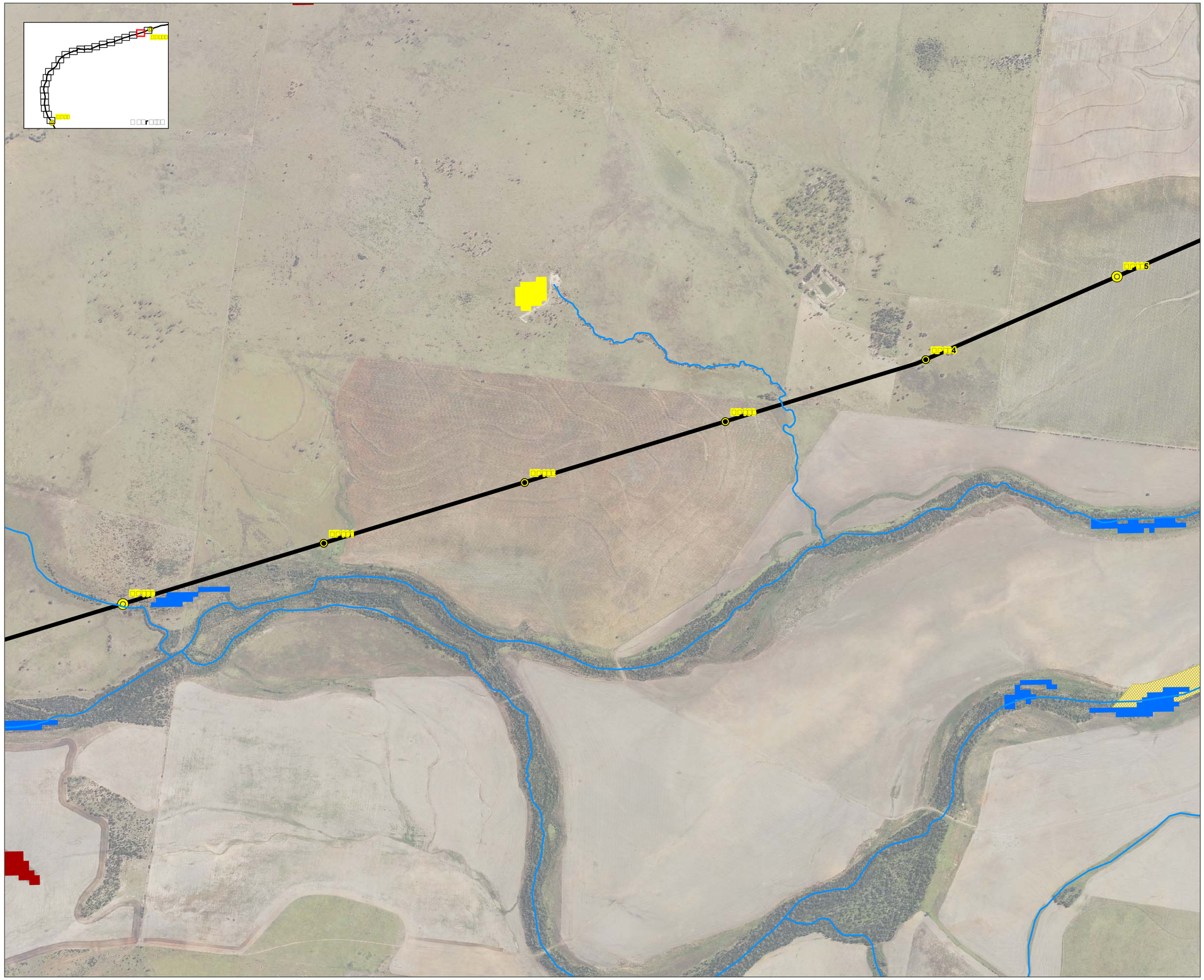

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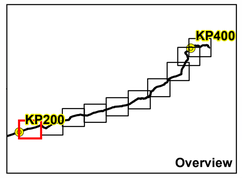
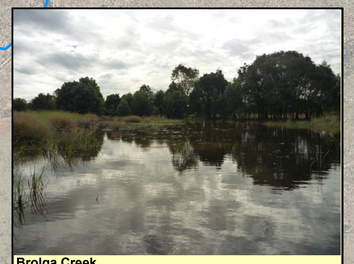
**Figure 5 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP200-420**






Conciliation Creek
KP 207.477
Facing Zamia Creek Junction
Wet Season 2012



Brolga Creek
KP 214.881
Facing GTP crossing location
Wet Season 2012

KP200 KP201 KP202 KP203 KP204 KP205 KP206 KP207 KP208 KP209 KP210 KP211 KP212 KP213 KP214 KP215 KP216 KP217 KP218 KP219 KP220 KP221

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GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

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# GLNG Gas Transmission Pipeline Corridor

Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

Watercourse

Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine

Water Body
- Marine
- Estuarine
- Lacustrine
- Riverine
- Palustrine

Areas that May Include Wetlands
- 51-80% wetland
- 1-50% wetland

Rail

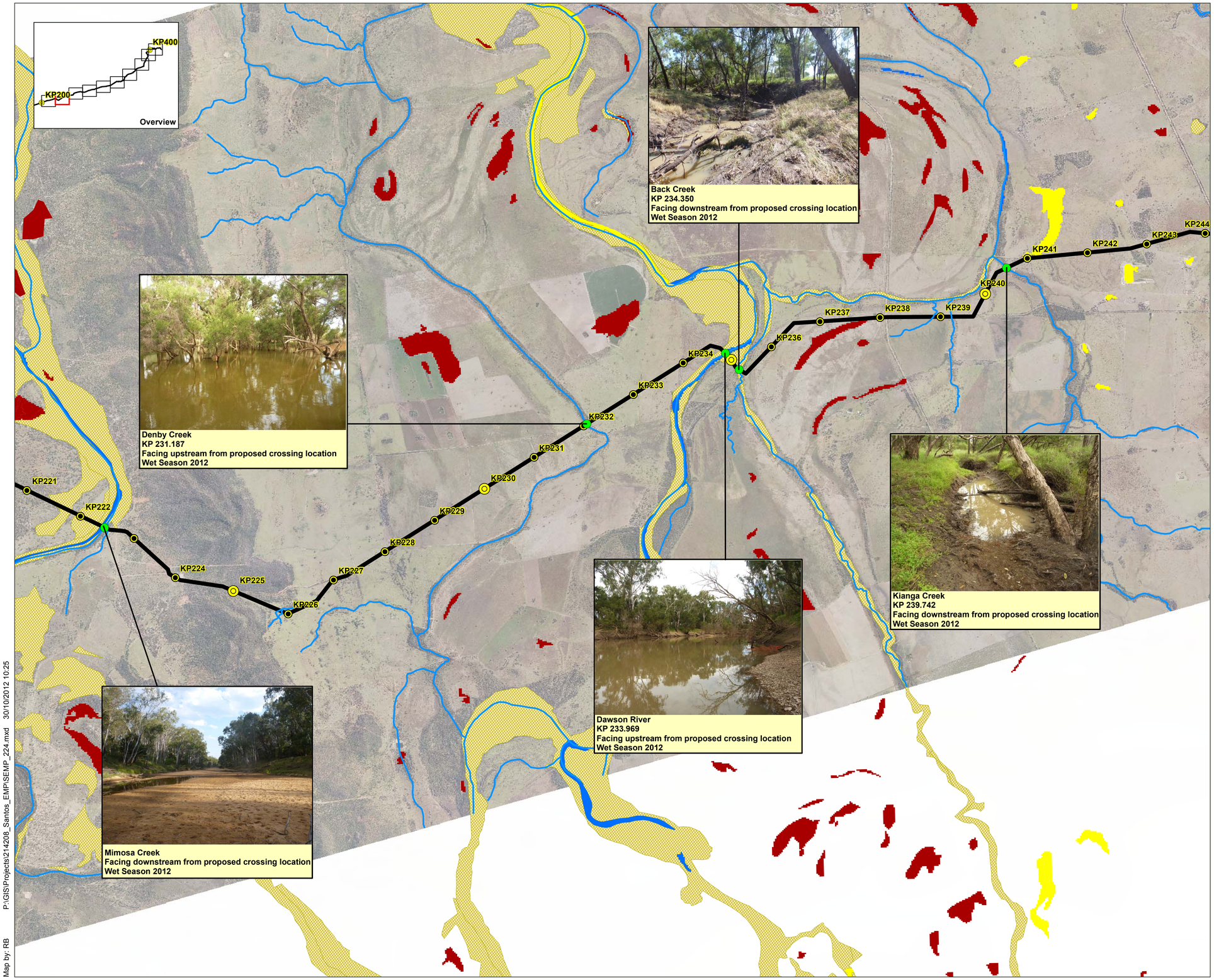
Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 1 of 10)

Date: 30/10/2012

Version: b

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## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure 5** (Page 2 of 10)

Map by: RB
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Coordinate system: GCS_GDA_1994

Date: 30/10/2012

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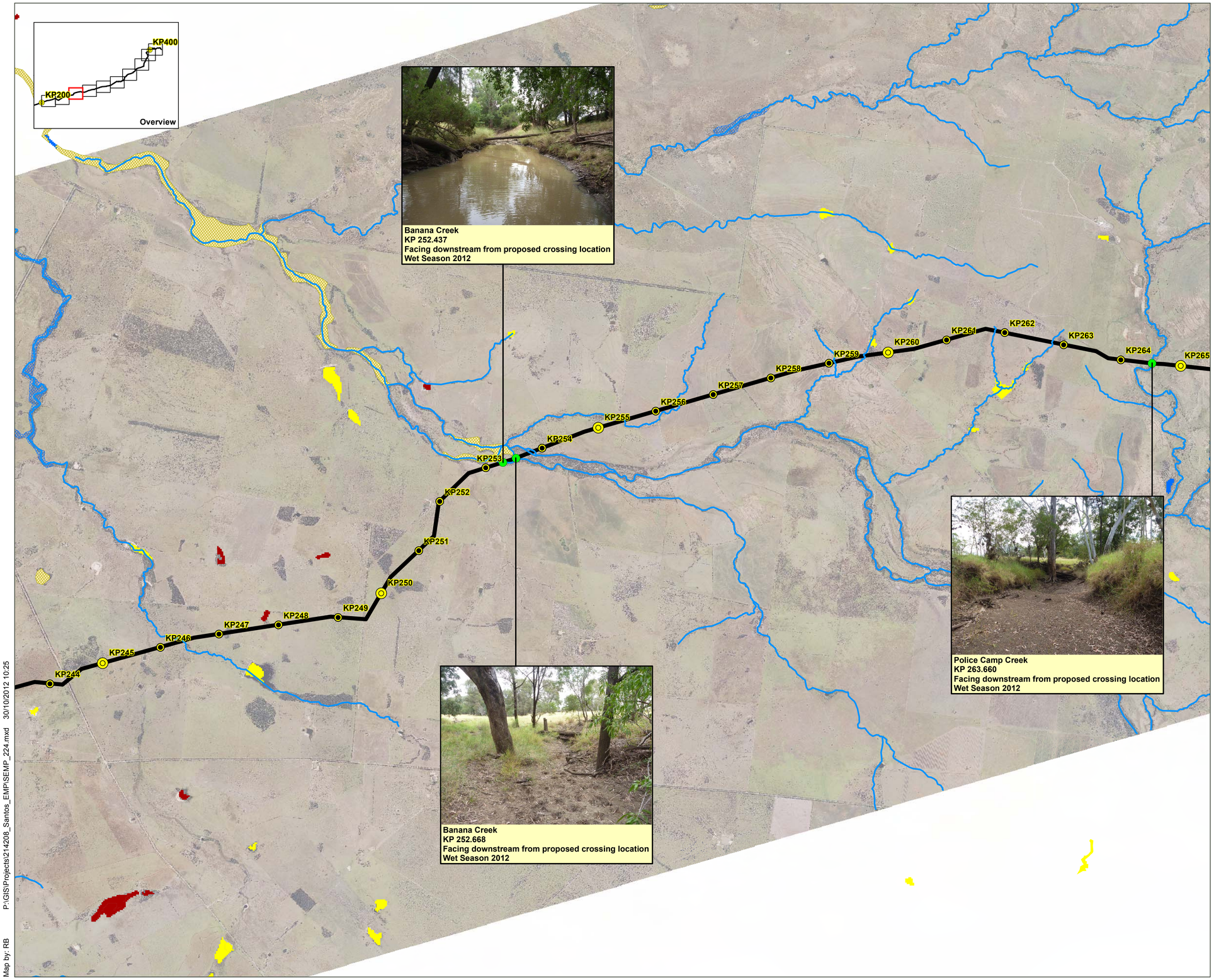


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Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 3 of 10)

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GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

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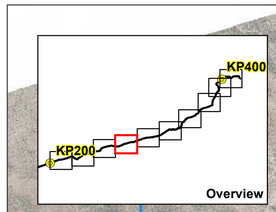
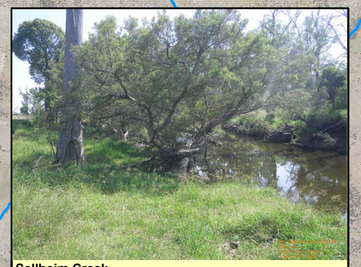
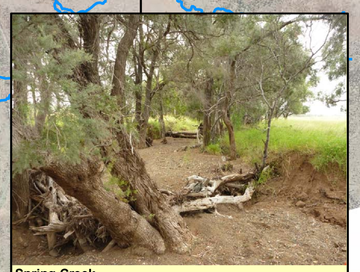




Police Camp Creek
KP 269.960
Facing upstream from proposed crossing location
Wet Season 2012


Sellheim Creek
KP 280.213
Facing downstream from proposed crossing location
Wet Season 2012


Spring Creek
KP 272.458
Facing upstream from proposed crossing location
Wet Season 2012

KP266 KP267 KP268 KP269 KP270 KP271 KP272 KP273 KP274 KP275 KP276 KP277 KP278 KP279 KP280 KP281 KP282 KP283 KP284 KP285 KP286

Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000

0 0.5 1 1.5 2 2.5 Kilometers

GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

Santos
GLNG Project

# GLNG Gas Transmission Pipeline Corridor

Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

Watercourse

Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine

Water Body
- Marine
- Estuarine
- Lacustrine
- Riverine
- Palustrine

Areas that May Include Wetlands
- 51-80% wetland
- 1-50% wetland

Rail

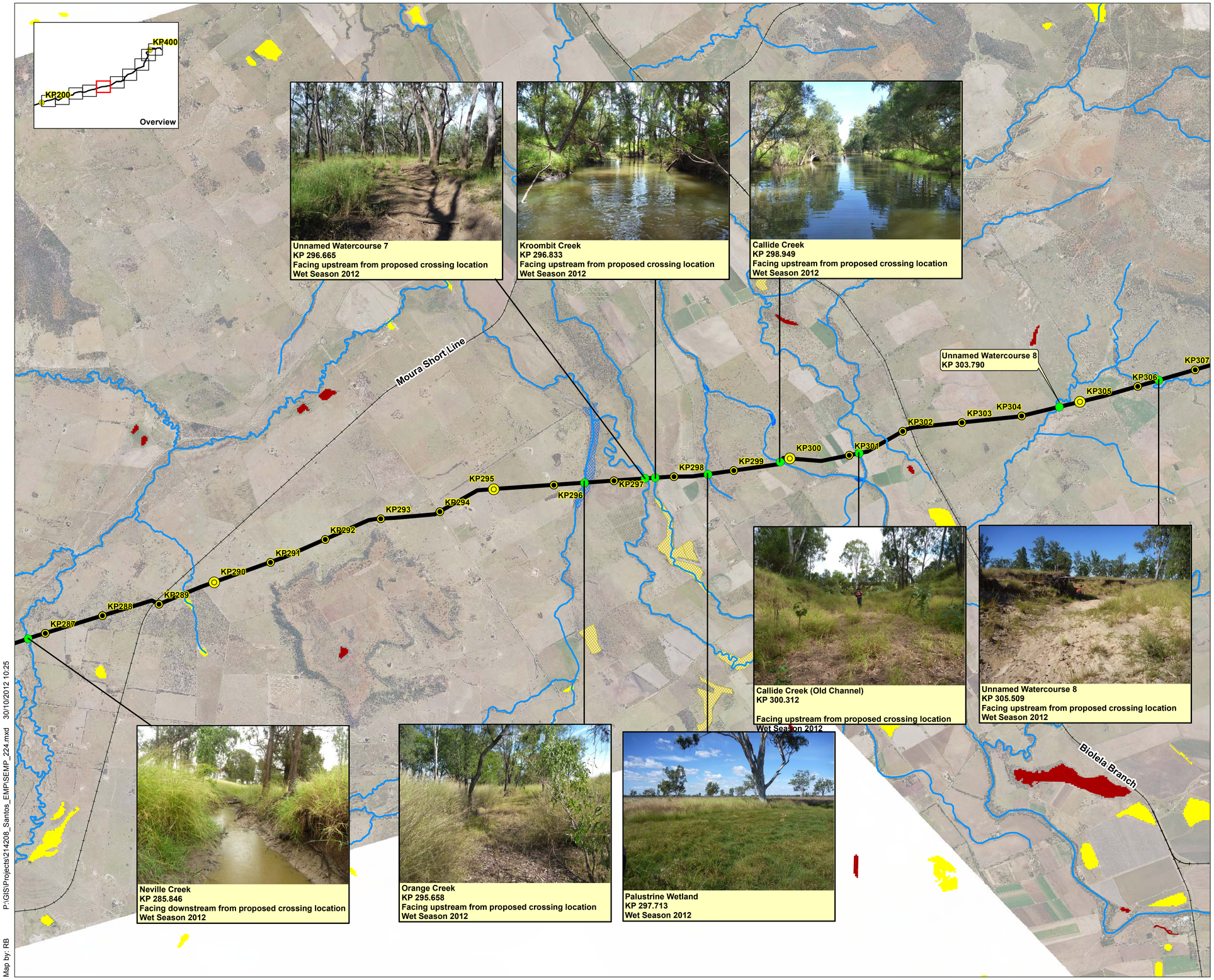
Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 4 of 10)

Date: 30/10/2012

Version: b




Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000

0 0.5 1 1.5 2 2.5 Kilometers

GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

Santos
GLNG Project

# GLNG Gas Transmission Pipeline Corridor

- Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

- Watercourse
- Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine

Water Body
- Marine
- Estuarine
- Lacustrine
- Riverine
- Palustrine

Areas that May Include Wetlands
- 51-80% wetland
- 1-50% wetland

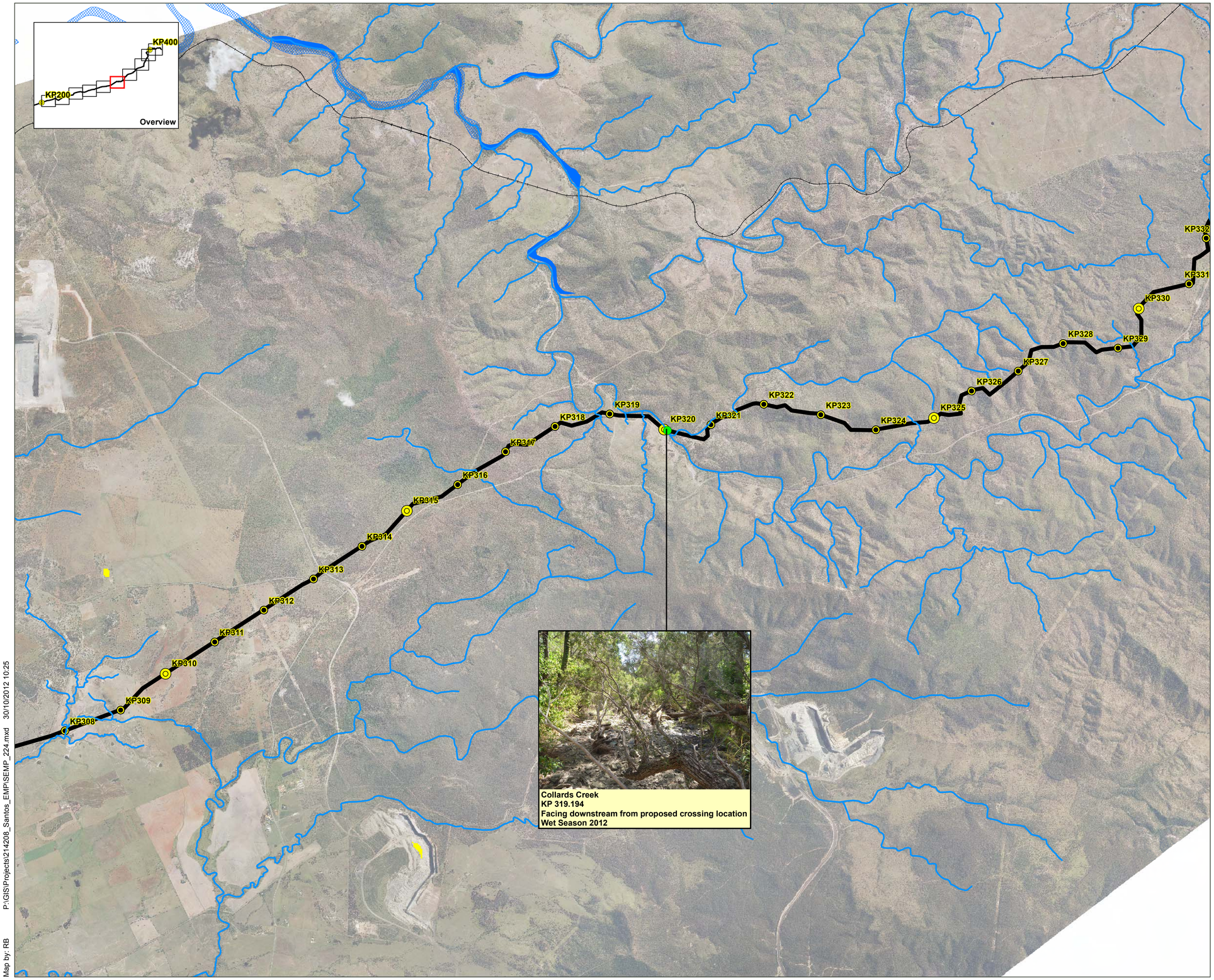
- Rail

Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 5 of 10)

Date: 30/10/2012 Version: b

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# GLNG Gas Transmission Pipeline Corridor

- Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

- Watercourse
- Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine

Water Body
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- Estuarine
- Lacustrine
- Riverine
- Palustrine

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Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 6 of 10)

Map by: RB
P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000
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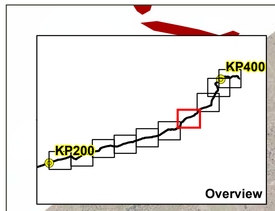
GLNG No: 3380-GLNG-4-1.3-0082
Coordinate system: GCS_GDA_1994

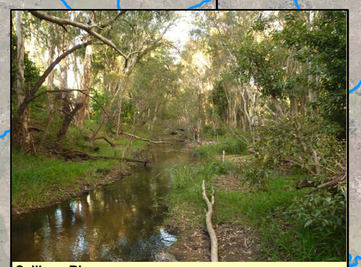
Date: 30/10/2012

Version: b





Unnamed Watercourse 9
KP 354.362
Facing downstream from proposed crossing location
Wet Season 2012


Calliope River
KP 352.374
Facing downstream from proposed crossing location
Wet Season 2012


Bell Creek
KP 334.538
Facing upstream from proposed crossing location
Wet Season 2012

KP357
KP356
KP355
KP354
KP353
KP352
KP351
KP350
KP349
KP348
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KP346
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KP344
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KP336
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KP334
KP333
KP332
KP331
KP330
Moura Short Line
Calliop

Map by: RB
P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000
0 0.5 1 1.5 2 2.5 Kilometers

GLNG No: 3380-GLNG-4-1.3-0082
Coordinate system: GCS_GDA_1994

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# GLNG Gas Transmission Pipeline Corridor

Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

Watercourse

Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
- Palustrine

Water Body
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- Palustrine

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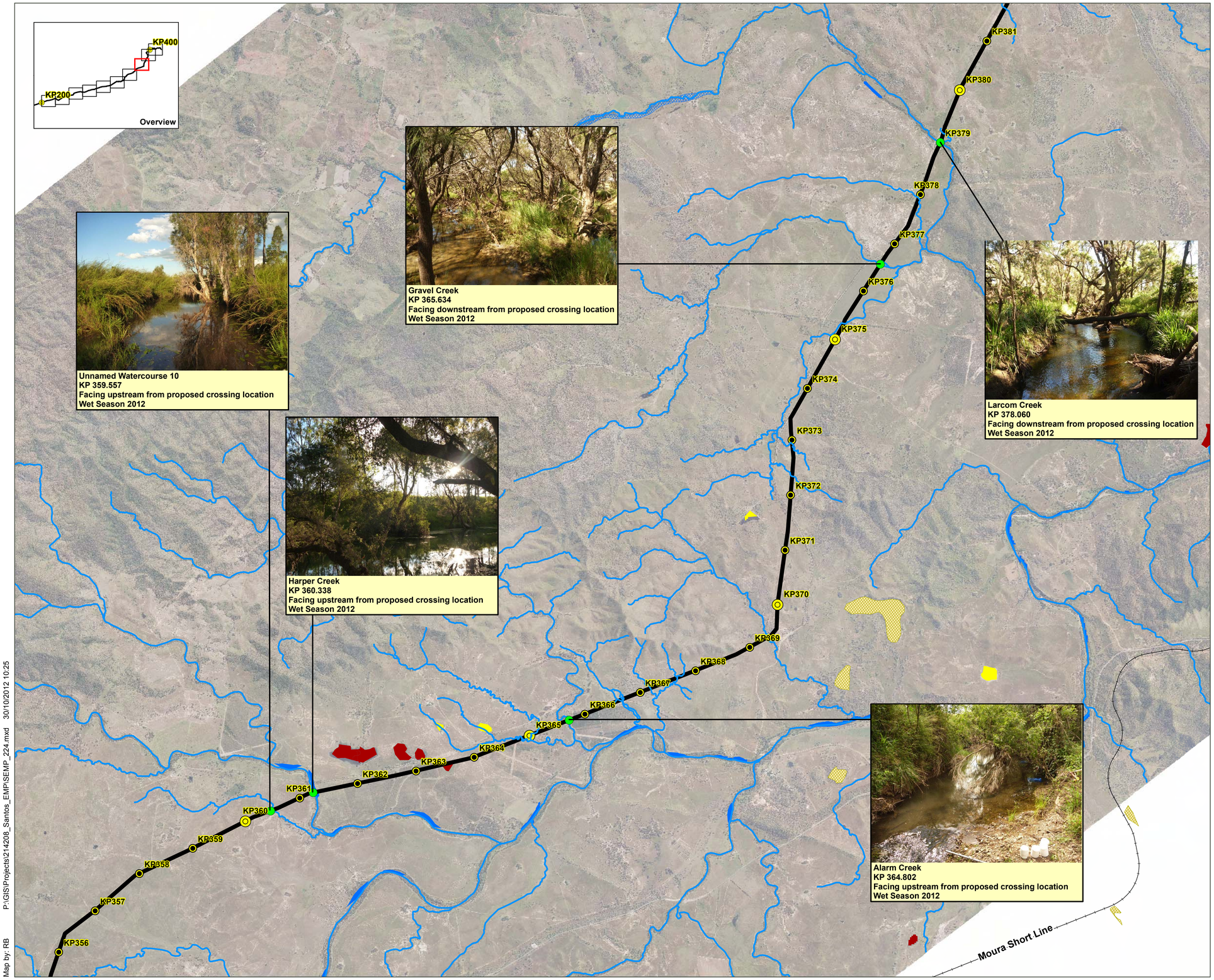
Rail

Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 7 of 10)

Date: 30/10/2012 Version: b




Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000

0 0.5 1 1.5 2 2.5 Kilometers

GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

Santos GLNG Project

# GLNG Gas Transmission Pipeline Corridor

- Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

- Watercourse
- Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
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- Palustrine

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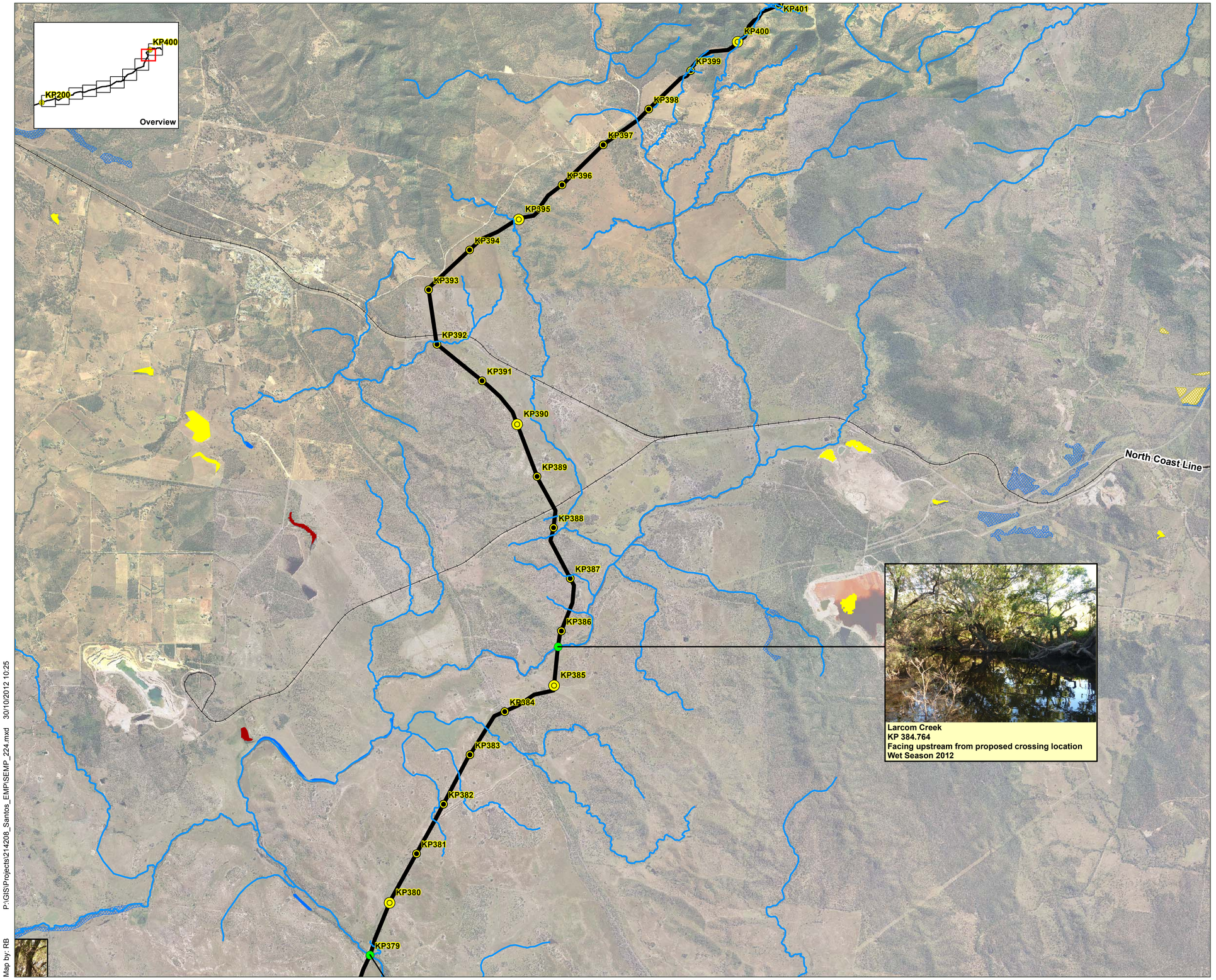
Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 8 of 10)

Date: 30/10/2012 Version: b

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# GLNG Gas Transmission Pipeline Corridor

- Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

- Watercourse
- Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
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- 51-80% wetland
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- Rail

Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000

0 0.5 1 1.5 2 2.5 Kilometers

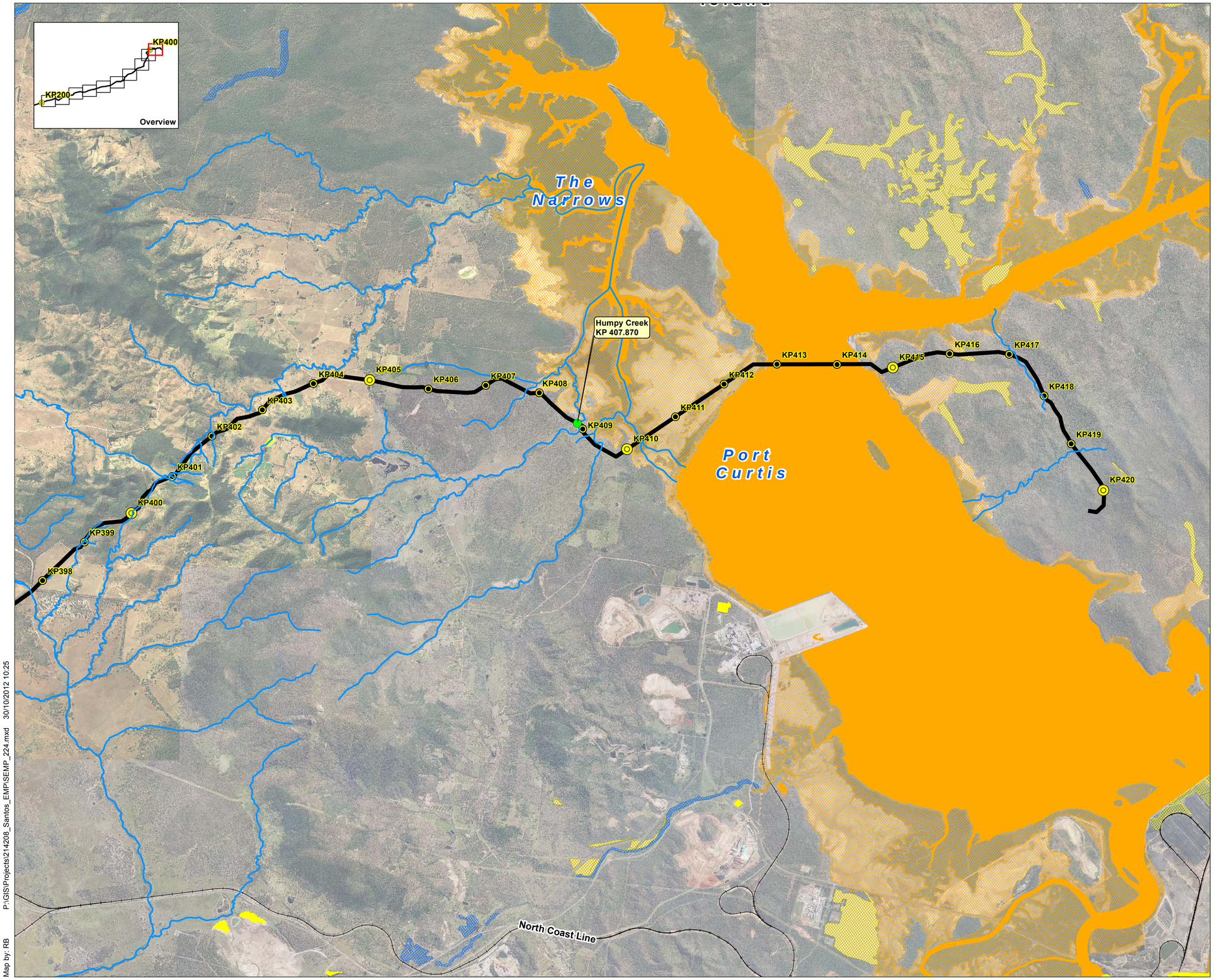
GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 9 of 10)

Date: 30/10/2012 Version: b




Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_224.mxd 30/10/2012 10:25

A1 scale: 1:35,000

0 0.5 1 1.5 2 2.5 Kilometers

GLNG No: 3380-GLNG-4-1.3-0082

Coordinate system: GCS_GDA_1994

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# GLNG Gas Transmission Pipeline Corridor

- Gas Transmission Pipeline (GTP)

Kilometre Post Distance Marker
- 5km
- 1km

- Watercourse
- Watercourse Crossing Location

Wetland Regional Ecosystem
- Marine
- Estuarine
- Riverine
- Lacustrine
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Water Body
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Source:
Gas Transmission Pipeline (GTP): Santos, Oct 2012.
Watercourses: Santos, Apr 2012.
Watercourse Crossing Locations: Santos, Jul 2012.
Queensland Wetland Data Version 2: Department of Environment and Resource Management, Sep 2009.
Aerial: Santos, 2011.

## Aquatic Values Management Plan Major Watercourses KP200 - KP406

**Figure** 5 (Page 10 of 10)

Date: 30/10/2012 Version: b

**Figure 6 – Watercourse and Wetlands Proposed GTP Crossing Location Maps KP406-410**

Great Barrier Reef Marine Park Region

N

Humpy Creek superseded crossing

Targinnie Creek superseded crossing

KP406

KP406.5

KP407

KP407.5

KP408

KP408.5

KP409

1

2

1. Humpy Creek KP 407.87
Facing Downstream from proposed crossing



2. Targinnie Creek KP 408.5
Facing Upstream from proposed crossing



- Watercourse Crossings Location
- Superseded Crossing Location
- KPs (A8 Revision)
- GLNG Pipeline RCR25 (Revision Superseded 2010)
- GLNG GTP Mainland & Marine Crossing Tunnel, Current A8 Alignment
- Marine Tunnel Launch & Receiving Pads
- Estuarine Wetland
- Great Barrier Marine Park Region Boundary Source: Queensland EPA November 2008
- Hydrology
- Access Tracks

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GLNG Gas Transmission Pipeline

# Watercourses and Wetland GTP Crossing Locations KP 406- KP410

250 0 250 500m

Date: 3 April 2013 File No. GTP205 [Sheet 1 of 1]

GDA

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# APPENDICES

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**APPENDIX A – Major Watercourse Crossing Location Table**

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Hutton Creek | 2.092 | 6 | Least concern | 11.3.25 | 692134.342 | 7151525.586 | 40 | 0.93 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3400 | Mar-Apr 2013 |
| Christmas Creek | 2.657 | 4 | | Non-remnant | 691931.500 | 7152026.242 | 30 | 0.93 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3401 | Mar-Apr 2013 |
| Baffle Creek | 19.8 to 21.6 | 4 | Least Concern | 11.10.1 | 687364.88 | 7167681.78 | 30 | 5.2 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3403 | Apr-Jun 2013 |
| Unnamed Watercourse 1 | 28.757 | 3 | Endangered | 11.3.25/11.9.5a | 689498.538 | 7174788.033 | 30 | 1.73 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3470 | May 2013 |
| Dawson River (Upstream) | 29.832 | 5 | Of concern | 11.3.2 | 690146.742 | 7175586.978 | 30 | 6.52 ha* | Causeway | Minor dam and Flume | Mulching | 3381-40-3406 | May-Jun 2013 |
| Bully Frog Creek | 46.012 | 3 | Of concern | 11.3.2 | 690349.366 | 7190703.816 | 30 | 0.92 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3407 | March 2013 |
| Unnamed Watercourse 2 | 57.481 | 3 | | Non-remnant | 688604.131 | 7201768.538 | 40 | 1.68 ha* | Causeway** | Standard Mainline Construction | Mulching | 3381-40-3408 | March 2013 |
| Ironbark Creek | 62.331 | 3 | Of concern | 11.3.2/11.3.25 | 687904.123 | 7206559.276 | 40 | 0.95 ha* | Causeway** | Standard Mainline Construction | Jute Matting (or similar) | 3381-40-3409 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.819 | 3 | | Non-remnant | 680167.093 | 7223205.791 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.843 | 3 | | Non-remnant | 680159.898 | 7223227.668 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Unnamed watercourse 3 | 80.926 | 3 | | Non-remnant | 680133.959 | 7223306.544 | 35 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3471 | Dec 2012 - Jan 2013 |
| Clematis Creek | 108.661 | 5 | Of concern | 11.3.2 | 681335.006 | 7250440.092 | 30 | 1.54 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3410 | Feb-Mar 2013 |
| May creek | 111.385 | 3 | | Non-remnant | 682198.491 | 7253018.746 | 40 | Nil | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3472 | Feb-Mar 2013 |
| Deep Creek | 124.560 | 3 | | Non-remnant | 690239.665 | 7262901.727 | 40 | 0.93 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3411 | Feb-Mar 2013 |
| Unnamed Watercourse 4 | 133.969 | 3 | Least concern | 11.5.2/11.10.7/11.10.7a/11.10.1 | 697307.913 | 7268587.112 | 30 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3473 | Sep-Nov 2013 |
| Prospect Creek | 177.762 | 4 | | Non-remnant | 736556.275 | 7279710.650 | 30 | 0.46 | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3416 | Sep-Oct 2012 |
| Unnamed Watercourse 5 | 184.116 | 3 | | Non-remnant | 742484.868 | 7281889.332 | 30 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3474 | Jul-Sep 2013 |
| Conciliation Creek | 207.477 | 5 | | Non-remnant | 764464.780 | 7289412.666 | 30 | 1.86 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3417 | June 2013 |
| Brolga gully | 214.881 | 3 | | Non-remnant | 771697.889 | 7290884.682 | 40 | Nil | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3476 | June 2013 |
| Mimosa Creek | 220.133 | 6 | | Non-remnant | 776470.805 | 7290629.671 | 30 | 2.8 ha* | Causeway | Minor Dam and Flume | Mulching | 3381-40-3418 | June 2013 |
| Denby Creek | 231.187 | 3 | Of concern | 11.3.2/11.3.4/11.3.25 | 786327.930 | 7293279.936 | 30 | 0.68 ha* | Causeway | Minor Dam and Flume | Grass Seeding | 3381-40-3420 | May-June 2013 |
| Dawson River (Downstream) | 233.969 | 8 | Of concern | 11.3.2/11.3.25 | 788686.35 | 7294533.32 | 30 | 6.52 ha* | Causeway | Minor Dam and Flow diversion | Mulching | 3381-40-3421 | Jun-Aug & Nov-Dec 2013 |

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| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Back creek | 234.350 | 3 | Endangered | 11.3.2/11.3.1 | 788870.562 | 7294211.211 | 30 | | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3477 | Nov-Dec 2013 |
| Kianga Creek | 239.742 | 4 | | Non-remnant | 793337.720 | 7295957.882 | 40 | 0.53 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3424 | May-Jun 2013 |
| Banana creek | 252.437 | 5 | | Non-remnant | 804230.943 | 7300351.984 | 40 | 4.51 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3478 | May 2013 |
| Banana creek | 252.668 | 3 | | Non-remnant | 195802.936 | 7300430.096 | 40 | | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3479 | May 2013 |
| Police camp creek (KP 263.66) | 263.663 | 4 | | Non-remnant | 206303.261 | 7302368.132 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3480 | May 2013 |
| Police camp creek (KP 269.96) | 269.963 | 3 | | Non-remnant | 212266.688 | 7303141.752 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3481 | May 2013 |
| Spring Creek | 272.458 | 3 | | Non-remnant | 214450.210 | 7304324.481 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3482 | May 2013 |
| Sellheim Creek | 280.213 | 3 | | Non-remnant | 221693.653 | 7306547.625 | 30 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3483 | Apr-May 2013 |
| Neville creek | 285.846 | 3 | | Non-remnant | 226831.714 | 7308280.646 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3484 | April 2013 |
| Orange Creek | 295.658 | 6 | | Non-remnant | 235998.685 | 7311276.673 | 30 | 1.5 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3485 | April 2013 |
| Unnamed Watercourse 7 | 296.665 | 4 | | Non-remnant | 237002.114 | 7311372.699 | 40 | 0.9 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3486 | April 2013 |
| Kroombit Creek | 296.833 | 6 | | Non-remnant | 237168.190 | 7311388.585 | 40 | 1.5 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3431 | April 2013 |
| Palustrine Wetland | 297.713 | 3 | | Non-remnant | 238043.236 | 7311466.936 | 40 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3487 | April 2013 |
| Callide Creek | 298.949 | 5 | | Non-remnant | 239238.163 | 7311711.384 | 40 | 1.7 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3433 | April 2013 |
| Callide Ck (Old Channel) | 300.312 | 5 | | Non-remnant | 240540.172 | 7311892.166 | 40 | 0.77 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3434 | April 2013 |
| Unnamed Watercourse 8 | 303.790 | 3 | | Non-remnant | 243843.655 | 7312792.755 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3488 | April 2013 |
| Unnamed Watercourse 8 | 305.509 | 3 | | Non-remnant | 245483.633 | 7313305.779 | 40 | 0.29 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3494 | April 2013 |
| Collards Creek | 319.194 | 3 | Least concern | 11.11.15/11.3.25/11.11.4/11.11.4a | 256920.603 | 7319450.222 | 40 | 1.48 ha* | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3489 | August 2013 |
| Bell Creek | 334.538 | 3 | | Non-remnant | 266678.268 | 7326216.541 | 40 | Nil | Bed Level Crossing | Standard Mainline Construction | Grass Seeding | 3381-40-3440 | October 2013 |
| Calliope River | 352.374 | 5 | Of concern | 11.3.4/11.3.25 | 280475.758 | 7335673.070 | 30 | 4.04 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3442 | Sep-Oct 2013 |
| Unnamed Watercourse 9 | 354.362 | 3 | | Non-remnant | 281345.236 | 7337398.275 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3490 | Sept 2013 |
| Unnamed Watercourse 10 | 359.557 | 3 | | Non-remnant | 285012.795 | 7340719.107 | 40 | Nil | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3491 | Sep-Oct 2013 |

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| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | ROW Width(m) | Approximate Additional Workspace Required | Construction methodology | | | | Estimated month of construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Access Way | Pipeline | Bank Reinstatement | Ref_drawing | |
| Harper Creek | 360.338 | 4 | | Non-remnant | 285715.107 | 7341058.561 | 30 | 2.62 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3443 | Sep-Oct 2013 |
| Alarm Creek | 364.802 | 3 | | Non-remnant | 289946.035 | 7342432.822 | 40 | 1.28 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3444 | Sep-Oct 2013 |
| Gravel Creek | 375.634 | 3 | | Non-remnant | 294998.086 | 7350750.225 | 40 | Nil | Causeway | Standard Mainline Construction | Grass Seeding | 3381-40-3735 | Sep-Oct 2013 |
| Larcom Creek (KP378.06) | 378.069 | 4 | | Non-remnant | 295960.583 | 7352966.538 | 30 | 2.67 ha* | Causeway | Minor Dam and Flow diversion | Mulching | 3381-40-3492 | Sep-Nov 2013 |
| Larcom Creek (KP384.76) | 384.764 | 3 | | Non-remnant | 299009.039 | 7358584.985 | 40 | 1.8 ha* | Causeway | Minor Dam and Flow diversion | Grass Seeding | 3381-40-3447 | Sep-Nov 2013 |
| Humpy Creek | 407.87 | 3 | | Non-remnant | 309247.255 | 7371282.870 | 30 | 0.86 ha* | Causeway | Minor Dam and Flume (Pump) | Grass Seeding | 3381-40-3451 | Sep-Dec 2013 |

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**APPENDIX B1 – Aquatic Values Assessment Major Watercourses KP0-70**

# Gladstone Liquefied Natural Gas (GLNG) Pipeline Project

## Aquatic Values Assessment
## KP0-KP70
## 3380-GLNG-4-1.3-0083

*Prepared for:*

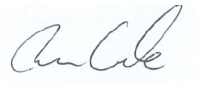
**GLNG Operations Pty Ltd**

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

frc reference: 111016

**Document Control Summary**

| | |
|---|---|
| Project No.: | 111016 |
| Status: | Issued for Use |
| Project Director: | Lauren Thorburn |
| Project Manager: | Ben Cook |
| Title: | Gladstone Liquefied Natural Gas (GLNG) Pipeline Project – Aquatic Values Assessment KP0-KP70: 3380-GLNG-4-1.3-0083 |
| Project Team: | B. Cook, S. Walker, D. Holzheimer, L. West, L. James, J. Charlish, C. Forward, L. Thorburn |
| Client: | GLNG Operations Pty Ltd |
| Client Contact: | Angela Hampson |
| Date: | 28 August 2012 |
| Edition: | Rev 0 |
| Checked by: | L. Thorburn__  _____ |
| Issued by: | B. Cook __  _____ |

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# Summary

Gladstone Liquefied Natural Gas (GLNG) Operations Pty Ltd proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport Coal Seam Gas (CSG) from the CSG fields at Roma and Fairview to a proposed Liquefied Natural Gas (LNG) facility on Curtis Island. A condition of EIS approval for the project was the requirement for a detailed Aquatic Values Management Plan (AVMP) to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the right of way (ROW) between KP0 and KP70 to support the development of the AVMP. A separate AVA will be prepared for the crossing at Baffle Creek (KP20.4). This Aquatic Values Assessment (AVA) presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

Overall results of the detailed field assessments showed that:

- habitat condition of waterways varied from moderate to good, with most sites having moderate habitat condition; four of the eight site were dry at the time of survey
- water quality was sometimes non-compliant with Water Quality Objectives (WQOs) for turbidity, electrical conductivity and dissolved oxygen
- aquatic flora diversity and cover varied among sites but was relatively low
- macroinvertebrate taxonomic richness and abundance varied among sites and were characteristic of waterbodies with moderate water and habitat quality
- freshwater fish diversity and abundance reflected expected ranges for ephemeral streams of the region, and
- Hutton Creek had turtles, and the Dawson River had suitable habitat for turtles.

# 1 Introduction

Gladstone Liquefied Natural Gas (GLNG) Operations Pty Ltd proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport Coal Seam Gas (CSG) from the CSG fields at Roma and Fairview to a proposed Liquefied Natural Gas (LNG) facility on Curtis Island. The GTP forms one component of the GLNG Project, which includes:

- exploration and production of CSG in the Surat Basin and Bowen Basin gas fields
- construction and operation of the GTP from the CSG fields to the LNG facility on Curtis Island, and
- construction and Operation of the LNG Facility.

Following evaluation of an initial Environmental Impact Statement (EIS) and a supplementary EIS, the Coordinator General (CG) advised that the GLNG Project could proceed subject to conditions. One of these conditions was the requirement for a detailed Aquatic Values Management Plan (AVMP) to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the right of way (ROW) between KP0 and KP70 to support the development of the AVMP. A separate AVA will be prepared for the crossing at Baffle Creek (KP20.4). This Aquatic Values Assessment (AVA) presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora (macrophytes)
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

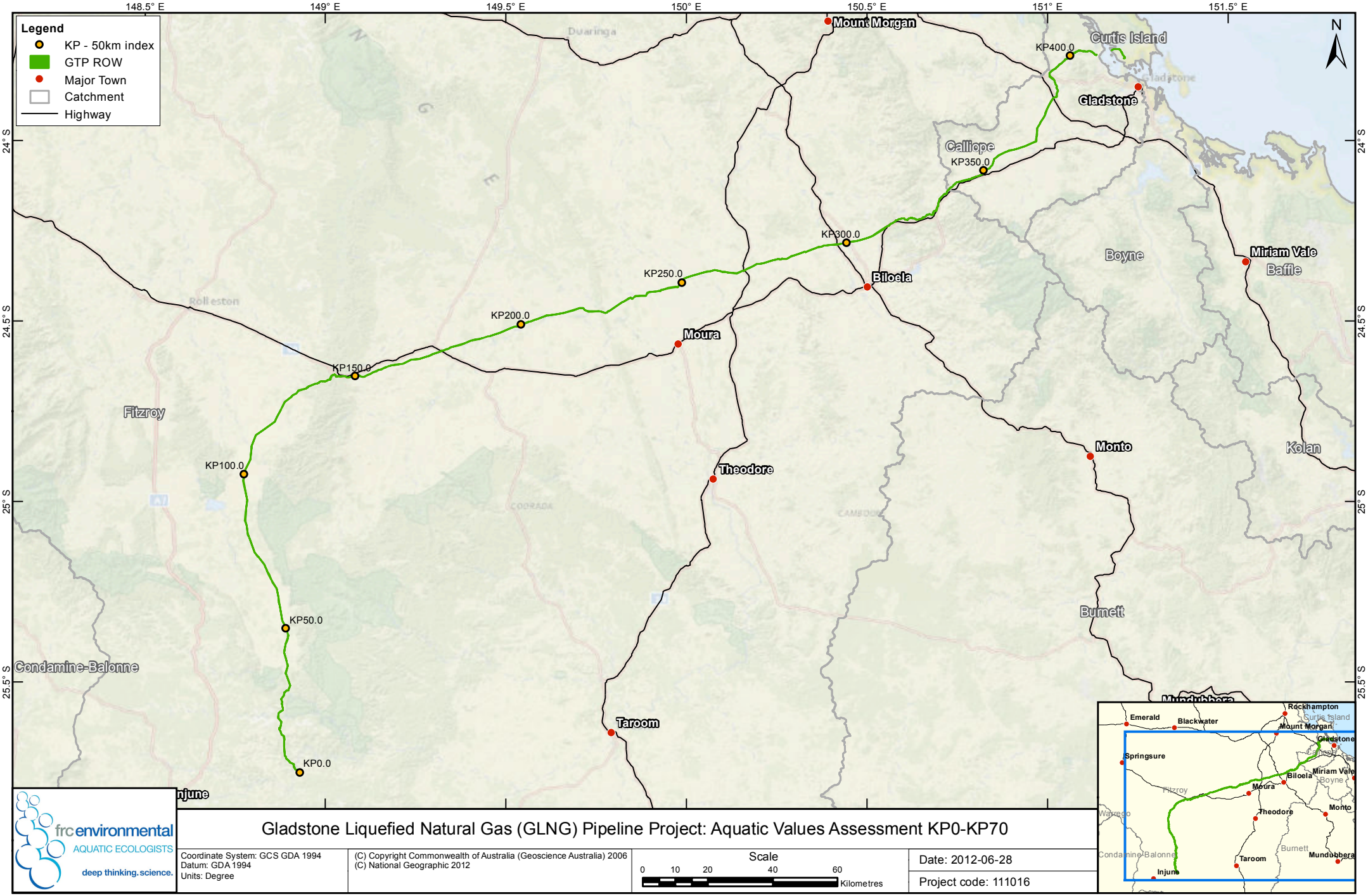
Other AVMPs and AVAs present the findings of aquatic ecology assessments for the remaining major watercourse crossings along the GTP ROW (i.e. KP70–KP200 and KP200–KP430).

# 2 Study Area

## 2.1 The Gas Transmission Pipeline Right of Way (GTP ROW)

The study area for this AVA is the GLNG Gas Transmission Pipeline Right of Way (GTP ROW, Figure 2.1) between KP0 and KP70, with the exception of the Baffle Creek crossing (Figure 2.2). Seven major watercourse crossings (i.e. watercourses with a stream order of 3 or greater) were identified within the GTP ROW between KP0 and KP70 from Department of Environment and Heritage Protection (EHP) wetland mapping (Table 2.1). One minor watercourse (Edwards Creek at KP25.3, stream order 2) was also assessed in detail along with the major watercourses, as preliminary investigations revealed that this location may have high aquatic ecological values.

All other minor watercourse crossings between KP0 and KP70 (i.e. first and second order streams; 30 crossings in total) were not assessed as part of this AVA, as the aquatic values of these watercourse crossings were assessed by GLNG Operations Pty Ltd. These results are presented in a separate AVA for minor watercourses.

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Scale
0 10 20 40 60
Kilometres

Date: 2012-06-28
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Figure 2.1 Alignment of the GLNG GTP ROW.

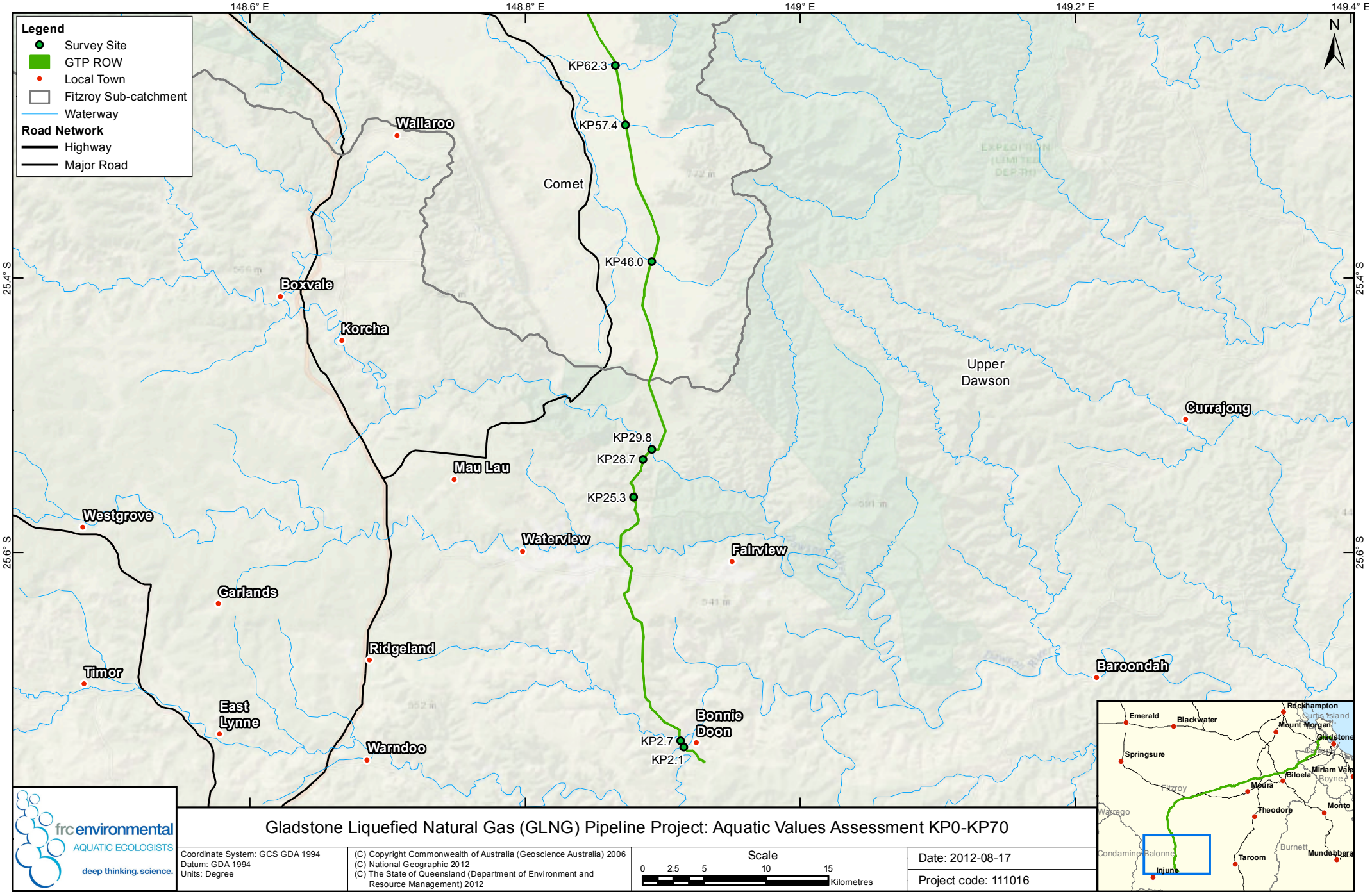


Figure 2.2 Location of the major waterway crossings that were assessed in the current study.

Table 2.1 Major watercourse crossings along the GTP ROW between KP0 and KP70.

| Watercourse/Wetland | KP | Stream order | Easting | Northing |
|---|---|---|---|---|
| Hutton Creek | 2.1 | 6 | 692134.34 | 7151525.58 |
| Christmas Creek | 2.7 | 4 | 691931.50 | 7152026.24 |
| Edwards Creek | 25.3 | 2 | 688763.07 | 7171730.48 |
| Unnamed watercourse 1 | 28.7 | 3 | 689498.53 | 7174788.03 |
| Dawson River (southern) | 29.8 | 5 | 690146.74 | 7175586.98 |
| Bully Frog Creek | 46.0 | 3 | 690349.36 | 7190703.81 |
| Unnamed watercourse 2 | 57.4 | 3 | 688604.13 | 7201768.53 |
| Ironbark Creek | 62.3 | 3 | 687904.12 | 7206559.27 |

## 2.2 Aquatic Values of the Region

The GTP ROW traverses the upper Dawson River sub-catchment and the Comet River sub-catchment within the Fitzroy River Basin (Figure 2.2). The flow regime of these sub-catchments is dominated by 'unpredictable, highly intermittent summer flow' with some reaches having 'variable, extremely intermittent summer flow' (Kennard et al. 2010). Thus, most stream reaches tend to be dry during winter, and the magnitude, duration and timing of summer flows varies greatly between years. As for other dryland river systems, permanent pools and waterholes are 'critical habitat areas' for aquatic biota (*sensu* Abell et al. 2007) and provide refugia habitat that enable aquatic species to persist during dry periods (Sheldon et al. 2010). Permanent waterbodies in the Fitzroy River system therefore have high aquatic ecological values.

Catchment areas in the Fitzroy River Basin, including the Dawson River and Comet River sub-catchments, have been extensively cleared for grazing; thus, aquatic habitat is typically in a slightly to moderately disturbed condition (URS 2009). However, they also have overall high ecological values (URS 2009), in part due to the presence of significant aquatic species and significant aquatic places.

Significant species include those with legislated conservation significance [e.g. in the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Queensland's *Nature Conservation Act 1992* (NC Act)] and species that are endemic to the Fitzroy River Basin.

Aquatic species with legislated conservation significance from the upper Dawson River sub-catchment include:

- Murray cod (*Maccullochella peelii*; listed as endangered under the EPBC Act), which is not naturally found in the Fitzroy River Basin but has been stocked in reservoirs for recreational fishing. However, it reportedly has not become established in this river system and is unlikely to occur in the Project Area
- white throated snapping turtle (*Elseya albagula*) is listed at Least Concern under the NC Act and the Fitzroy River Turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act
- Platypus (*Ornithorhynchus anatinus*) is listed at Least Concern under the NC Act
- five species of frog listed as threatened under the EPBC Act. Two of these species are endemic to the Fitzroy River Basin and are protected within Kroombit Tops National Park: Kroombit tinker frog (*Taudactylus pleione*), and cascade treefrog (*Litoria pearsoniana*). The other three species of threatened frog, including tusked frog (*Adelotus brevis*) and rough-collared frog (*Cyclorana verrucosa*), are more widespread in eastern Queensland and may occur in aquatic habitats intercepted by the GTP ROW
- Boggomoss snail (*Adclarkia dawsonensis*) is listed as critically endangered under the EPBC Act. This species is known from two localities in the greater Taroom area within the Dawson River sub-catchment (Stanisic 2008). Identified threats to this species include: land clearing, fire, grazing, weeds, earthworks, and changed hydrology, and
- records for several wetland bird species that are listed as Near Threatened in the Nature Conservation Act, including black-necked stork (*Ephippiorhynchus asaticus*) and cotton pygmy goose (*Nettapus coromandelianus*), are from the Fitzroy River Basin.

The Fitzroy River Basin also contains several endemic aquatic species:

- Fitzroy River turtle (*Rheodytes leukops*); also listed as vulnerable under the EPBC Act
- southern saratoga (*Scleropages leichardti*)
- leathery grunter (*Scortum hillii*), and
- the freshwater gastropod (snail, *Larina strangei*), which is endemic to the Dawson River sub-catchment.

While permanent waterbodies in the Fitzroy River Basin have high aquatic ecology values due to the overall dryland ecology of this river basin, many intermittent and ephemeral systems also have aquatic values, especially ephemeral wetlands and larger ephemeral watercourses (e.g. stream order 3 and above). These aquatic habitats provide:

- corridors and habitat for upstream migration of endemic species, including southern saratoga and leathery grunter, and other aquatic fauna (e.g. bony bream, spangled perch, glass perchlets, and river prawns) during temporary wet periods, and
- habitat for species dependent on drying, such as various species of aquatic flora that undergo flowering and seed set in response to wetland or watercourse drying.

# 3 Overview of Methods and Results

## 3.1 Aquatic Habitat Assessment

Aquatic habitat condition was assessed using two approaches:

- the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland AUSRIVAS Sampling and Processing Manual (DNRM 2001), and
- the Habitat Bioassessment Scoring method (DNRM 2001).

The results for the habitat condition assessments showed that:

- grazing was the dominant adjacent land use to major watercourses, although Edwards Creek (KP25.3) was surrounded by relatively undisturbed native vegetation
- most sites are ephemeral streams and some were dry at the time of survey; however some had substantial water
- the channels of watercourses were generally straight to mildly sinuous
- substrate was dominated by silt or clay and sand at most sites; Edwards Creek (KP25.3) had high substrate diversity that included cobbles and bedrock
- riparian vegetation was dominated by scattered eucalypt trees with a dense understory of grasses at most sites; Brigalow was present at Bully Frog Creek (KP45.9), and
- in-stream habitat was dominated by emergent aquatic vegetation, large woody debris and pools.

The results for the habitat bioassessment scores showed that:

- six sites [Hutton Creek (KP2.1), Christmas Creek (KP2.6), Edwards Creek (KP25.3), unnamed watercourse 1 (KP28.7), the Dawson River (KP29.8) and Ironbark Creek (KP62.3)] had moderate aquatic habitat, due to moderate substrate cover, moderate habitat diversity, and moderate streamside vegetation[1], and

[1] while the Dawson River had moderate aquatic habitat values it had moderate to high aquatic ecological values overall, as it may support aquatic species of conservation significance

- two sites [Bully Frog Creek (KP45.9) and unnamed watercourse 2 (KP57.4)] had poor aquatic habitat, due to little substrate cover, poor bank stability, and poor habitat diversity.

Further details for the aquatic habitat assessment methods and results are presented in Appendix A, and site assessment sheets are presented in the AVMP.

## 3.2 Water Quality

*In situ* water quality was assessed at sites containing sufficient water at the time of survey. The water quality parameters measured were:

- temperature
- pH
- electrical conductivity
- dissolved oxygen, and
- turbidity.

The water quality results were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin (DERM 2011).

Only five sites had sufficient water that enabled assessment of in situ water quality. The results of these assessments showed that:

- water temperature ranged from 24.9 °C to 29.5 °C
- pH was within the WQO range at all five sites
- electrical conductivity exceeded the WQO at two sites
- dissolved oxygen was below the WQO range at three sites, and
- turbidity exceeded the WQO at three sites.

Further details for the water quality assessment methods and results are presented in Appendix B.

## 3.3 Aquatic Plants

The aquatic plant community at each site was assessed along a 100 m reach of the stream and adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following were recorded:

- taxonomic richness
- Percent cover (% of substrate (bed or bank) covered by each aquatic species
- growth form of each species (submerged, floating (free-floating or rooted) and emergent)
- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Results of the aquatic plant survey showed that:

- taxonomic richness ranged from zero at Bully Frog Creek (KP45.9) and unnamed watercourse 2 (KP57.4) to 11 at the Dawson River (KP29.8)
- percent cover was greatest at the Dawson River (KP29.8) and was about 35%
- almost all species of aquatic plant were emergent in growth form
- several exotic species of aquatic plant were found, including reed sweet grass, and
- no listed species of conservation significance were found.

Further details for macrophyte assessment methods and results are presented in Appendix C.

## 3.4 Macroinvertebrates

Benthic macroinvertebrates were assessed at five sites in bed and edge habitats. Samples were identified to the family level, and the following metrics were calculated:

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2.

Richness, PET richness and SIGNAL 2 scores were assessed against local Water Quality Objectives (WQOs) for the Dawson River.

Results of the macroinvertebrate surveys showed that:

- Abundance of macroinvertebrates was highest at Christmas Creek (KP2.6) for bed habitat and highest at Edwards Creek (KP25.3) for edge habitat.
- Mean taxonomic richness was greater in edge habitat than bed habitats. All sites had comparable diversity for each habitat type, respectively. Taxonomic richness was within the WQO at three of the four sites in bed habitat and for all four sites for edge habitat.
- Mean PET richness was highest at Hutton Creek (KP2.1) for both bed and edge habitats; mean PET richness was lowest at Christmas Creek (KP2.6) in bed and edge habitats. Total PET richness was within the Fitzroy Basin WQO range at each site, except and the Dawson River (KP29.8) for bed habitat, and Christmas Creek (KP2.6) for edge habitat, although PET richness met the lower WQO.
- SIGNAL 2 score was highest and within the WQO at the Dawson River (KP29.8) in bed habitat; the SIGNAL 2 score at all other sites was below the WQO for bed habitat. Hutton Creek (KP2.1) and the Dawson River (KP29.8) had similar high SIGNAL 2 scores and were within the WQO for edge habitats; SIGNAL 2 scores at all other sites were below the WQO for edge habitat.
- Quantitative analyses of community composition showed that samples from the same site were more similar than those between sites, except Hutton Creek (KP2.1) and the Dawson River (KP29.8). Other pair-wise site combinations had average dissimilarity of macroinvertebrate communities of greater than 70% in bed habitat, and over 65% in edge habitat. Macrocrustaceans, microcrustaceans and non-biting midge larvae contributed the greatest amount to between site differences in macroinvertebrate community composition.
- River prawns were the most commonly found taxa of macrocrustacean, although shrimps and yabbies were also caught at some sites.

Further details for macroinvertebrate assessment methods and results are presented in Appendix D.

## 3.5 Freshwater Fish

Freshwater fish communities were surveyed using a combination of electrofishing (backpack and boat), baited traps and seine nets. The following metrics were calculated using the fish community data for each site:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage
- proportion and abundance of exotic species, and
- abundance of listed protected species.

Fish surveys were conduced for only five sites as the other four sites were dry. Results for these sites showed that:

- five native species of fish were caught (six species in total), with the most commonly found species being carp gudgeons (*Hypseleotris* spp.) and eastern rainbowfish (*Melanotaenia splendida*)
- abundance was greatest at Hutton Creek (KP2.1) and the Dawson River (KP29.8); no fish were caught at Edwards Creek (KP25.3)
- taxonomic richness ranged from 2 to 4 species at each site
- juvenile and intermediate (i.e. sub-adult) life history stages dominated fish communities, but all sites contained a small proportion of adult fish
- a single goldfish (*Carassius auratus*) was caught at Hutton Creek (KP2.1). Goldfish are listed in Schedule 6 of Queensland's Fisheries Regulation 2008. Exotic species were not caught at the other sites, and
- no listed species of conservation significance were found.

Further details for freshwater fish assessment methods are presented in Appendix E.

## 3.6 Turtles

Turtle traps were set at sites where the water was deep enough to provide suitable turtle habitat and the allow use of cathedral traps. These sites were:

- Hutton Creek (KP2.1), and

- Dawson River (KP29.8).

Turtle traps were not set where the site was dry or the water level was too low.

Turtles at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site), and
- abundance of listed protected species.

Results for the turtle survey showed that:

- Hutton Creek (KP2.1) had 6 Krefft's river turtle (*Emydura macquarii krefftii*) and one female saw-shelled turtle (*Wollumbinia latisternum*); no turtles were caught at the Dawson River (KP29.8), and
- No species listed under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* were caught, although suitable habitat for protected species of turtle was observed at some sites.

Further details for turtle assessment methods are presented in Appendix F.

## 3.7 Description of Aquatic Values

Wet season field investigations, literature reviews and database searches were used to inform the assignment of overall wet season aquatic value for each watercourse crossing. Four categories of aquatic value were used (High, Moderate, Low, Negligible), based on the following criteria:

### 3.7.1 High Value

Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the *Environment Protection and Biodiversity Conservation Act 1999* and / or the *Nature Conservation Act 1992*, and / or those species listed as priority species in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity document (DERM 2010).

Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species was assessed using a combination of:

- habitat condition [e.g. the Bioassessment scores method (DNRM 2001)
- levels of disturbance (e.g. erosion, riparian vegetation condition),
- likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS), and
- relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River Turtle, Tucker et al. 2001; in-stream habitat and connectivity for freshwater fish, including undercut banks, substrate characteristics, large woody debris).

### 3.7.2 Moderate Value

Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.

Aquatic life included:

- submerged and / or floating attached aquatic plants
- native freshwater fish (such as rainbowfish, spangled perch, glass perchlets, purple spotted gudgeons),
- aquatic invertebrates (including crayfish, shrimps, snails, mussels, and insects).

Life history stage (i.e. juvenile, intermediate, adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.

Aquatic habitat was assessed using:

- habitat condition (e.g. the Bioassessment scores method (DNRM 2001))
- levels of disturbance (e.g. erosion, riparian vegetation condition), and
- habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, large woody debris).

### 3.7.3 Low Value

Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.

Emergent aquatic plants, such as sedges and nardoo, may be have been present.

Field investigations also indicated the presence of structural habitat elements, including:

- woody debris
- cobbles and / or
- undercut banks.

Habitat condition was determined using:

- the Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams, and
- levels of disturbance (e.g. erosion, riparian vegetation condition)..

### 3.7.4 Negligible Value

Where field investigations indicated:

- an absence of aquatic habitats and
- absence of aquatic life (e.g. no aquatic fauna or aquatic plants, including no sedges).

Habitat condition was typically poor as indicated by:

- low Bioassessment Scores (DNRM 2001), and
- high levels of disturbance (e.g. extensive erosion, no riparian vegetation).

### 3.7.5 Dry Season Aquatic Values

Dry season aquatic values were also based on these four criteria, using previous dry season surveys for several sites to inform of permanence of pools / water, and expert judgment regarding permanence of pools / water at sites not visited during the dry season. Sites that were dry during the wet season were considered likely to also be dry during the

dry season, as were sites that were previously shown to be dry during the dry season. Sites that contained water during the wet season, even as disconnected pools within the channel, were conservatively assessed as possibly having temporary water that may persist for some time into the dry season. In these cases, dry season aquatic values were assessed as moderate, in accordance with the criteria above.

# 4 Conclusions and Recommendations

## 4.1 Summary of Aquatic Values

The aquatic values of major watercourses within the GTP ROW between KP0 and KP70 are summarised in Table 4.1.

Table 4.1 Summary of aquatic values of major watercourses between KP0 and KP70.

| Assessment of Watercourse / Wetland | | | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **KP** | **Stream order** | **Significant species Habitat (Aquatic)** | **Breeding place for significant species** | **DEHP Regional Ecosystem mapping** | **Overall Aquatic Value (crossing and reach)*** |
| Hutton Creek | 2.1 | 6 | Likely | Likely | Non-remnant; 11.3.25 | High |
| Christmas Creek | 2.7 | 4 | Unlikely | Unlikely | Non-remnant | Moderate |
| Edwards Creek | 25.3 | 2 | Unlikely | Unlikely | 11.10.1 | moderate |
| Unnamed watercourse 1 | 28.7 | 3 | Unlikely | Unlikely | 11.9.5a | Low |
| Dawson River (southern) | 29.8 | 5 | Possible | Possible | 11.3.2 | Moderate to high |
| Bully Frog Gully | 46.0 | 3 | unlikely | unlikely | 11.9.5; 11.9.4a; 11.9.5a | Negligible to Low |

| Assessment of Watercourse / Wetland | | | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **KP** | **Stream order** | **Significant species Habitat (Aquatic)** | **Breeding place for significant species** | **DEHP Regional Ecosystem mapping** | **Overall Aquatic Value (crossing and reach)*** |
| Unnamed watercourse 2 | 57.4 | 3 | unlikely | unlikely | Non-remnant | Negligible to Low |
| Ironbark Creek | 62.3 | 3 | unlikely | unlikely | Non-remnant | Low to Moderate |

## 4.2 General Impact Mitigating Measures

Various pipeline crossing methodologies have the potential to impact aquatic values of watercourses. These broadly include:

- **Fuel and oil spills**, which are toxic to aquatic flora and fauna even in low concentrations. Major spills (i.e. in the order of tens to hundreds of litres) will have a locally significant impact on aquatic ecosystems.
- **Introduction of invasive aquatic plant species** on machinery, such as *Urochloa mutica* (para grass), *Hymenachne amplexicaulis*, *Eichhomia crassipes* (water hyacinth) and *Salvinia molesta*. These aquatic weeds are common in parts of Queensland, although were not found within local watercourses along the GTP ROW between KP0 and KP70. These aquatic weeds have the potential to 'choke' aquatic habitats, thereby reducing the habitat values of the site and suitability for native aquatic species.
- Earth works causing erosion and sedimentation, which can:
  - Increase turbidity of water, which reduces respiratory and feeding efficiency of fish and macroinvertebrates, and impacts aquatic plants by reducing light penetration. However, it should be noted that waterways in the area are often naturally turbid and the species that inhabit these watercourses are tolerant of relatively high turbidity. Thus, slight short-term increases in turbidity would be unlikely to have adverse ecological impacts on aquatic ecosystems. Significant and / or prolonged increases in turbidity, however, may impact aquatic flora and fauna.

  - Smother habitat for aquatic species and in-fill pools with sediment. Habitats that may potentially be smothered by sediment include large and small woody debris, detritus, tree roots, sand and gravel bars, cobble and riffle habitats, undercut banks, overhanging and trailing bank vegetation. Many of these habitats were found in the local waterways within the survey area.

- **Riparian vegetation clearing,** which can have numerous impacts for aquatic flora and fauna. These include:
  - decreasing bank stability and increasing erosion and sedimentation
  - decreasing supply of leaves and woody material to stream that provides food and habitat resources for aquatic species
  - increase exposure of aquatic fauna to solar radiation (i.e. reduced shading of watercourse), and
  - increase water temperature due to increased solar radiation of watercourse.
- **Access crossings**, which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low flow periods, and
  - cause localized loss of in-stream habitat and localise destruction of aquatic biota.
- **Trench construction**, which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low flow periods, and
  - cause localised loss of in-stream habitat and localised destruction of aquatic biota.
- **Site** remediation, which if done poorly, can lead to sustained erosion and sedimentation, and sustained impacts to aquatic ecosystems.

Mitigation measures for these activities are presented in Table 4.2.

Table 4.2 General aquatic environment impact mitigating measures for various watercourse crossing methodologies.

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Fuel and oil spills | · Establish designated vehicle maintenance areas, refuelling stations and fuel storage areas in bunded areas more than 50 m from nearby waterways and dams<br>· Report all spills over 20 litres to and Environmental Officer or delegated person<br>· Have appropriate spill containment and clean-up kits in the field, with spill kits accessible to construction crews at all times. Kits will contain equipment for clean up of fuel and oil on land or dry creek beds, and spills to water (e.g. floating booms)<br>· Manage all spills in accordance with Australian Standard 1940-2004 |
| Introduction of invasive aquatic plants | · Weed washdown and inspections, as performed to control the spread of other weeds in the region (e.g. *Parthenium hysterophorus*) |
| Soil erosion and sedimentation | · Implement sediment and stormwater control measures<br>· Minimize the area of earth that is disturbed<br>· Operate vehicles and machinery on specified access tracks (i.e. do not make more than one access track) |
| Riparian vegetation clearing | · Minimize the amount of vegetation that needs to be cleared<br>· Ensure that adjacent riparian vegetation or aquatic habitats are not disturbed by machinery or falling trees |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| *Access track crossings | · Implement sediment and stormwater control measures<br>· Move any in-stream habitat structures (e.g. woody debris, boulders) to adjacent sections of the stream<br>· Ensure access track is not higher than the bed level of the stream<br>· Maintain fish passage at access tracks, by ensuring that:<br>– the access track is constructed track in the dry season<br>– the access track is as narrow as reasonably practical<br>– the flume pipes are as large as reasonably practical in diameter<br>– the bottom of the flumes are below bed level, and natural bed material and / or rocks and gravel are placed in the bottom of the flumes<br>– the flumes are maintained so that they remain free of debris, and<br>– the work area is rehabilitated once the crossing is removed, including re-instatement of the bed and bank shape and revegetation of the banks. |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| *Trench construction | · Where possible, trench during the dry season, when stream bed is dry<br>· Move any in-stream habitat structures (e.g. woody debris, boulders) to adjacent sections of the stream<br>· Implement designed in accordance with the Australian Pipeline Industry Association Code of Practice and other relevant standards, such that (AE 2001; APIA 2009), which requires that:<br>– works are completed within one work-day where practical, to minimise the impact on aquatic fauna<br>– upstream and downstream dams are installed on the edge of the temporary workspace, to maximise the area of the workspace. These dams should:<br>o be constructed of an appropriate material for each creek (e.g. steel plates, flumes, sand bags or aquadam)<br>o be made impermeable by using polyethylene liner or sand bags<br>· if there is flowing water is present, an effort will be made to maintain flow, including variations in flow patterns (e.g. increased flow due to increased rainfall), using appropriate pumps (e.g. increased pumping effort in response to increased stream flow)<br>· pump intakes are to be screened to ensure that no fish are trapped<br>· fish are salvaged from the isolated workspace and translocated to appropriate waterways (see above)<br>· sediment-laden water is pumped into sumps or onto vegetation, and<br>· operation of the clean-water pump sustains flow below the downstream dams until the downstream dam is removed. |
| Site remediation | · Implement well-designed and high quality site remediation works<br>· Set ecological targets for remediation works and conduct monitoring by qualified aquatic ecologists (e.g. once off during the following wet season) |

* denotes activities that may require waterway barrier works permits from Department of Agriculture, Fisheries and Forestry

### 4.2.1 Fish Salvage

Once flow is diverted from isolated workspaces (see Table 4.2 – trench construction), stranded fish should be captured and translocated to waterholes downstream of the diversion channel in accordance with the Department of Agriculture, Forestry and Fisheries (DAFF) guideline: Fish Salvage Guidelines (DPI&F 2004), as summarised below:

- fauna should be captured by suitably-qualified aquatic ecologists during a one-off intense fauna survey approximately one week prior to the destruction of the channel
- salvaged fauna should be translocated to suitable waterholes in the same local catchment (to prevent the transfer of exotic fish or aquatic disease and prevent hybridisation between genetically unrelated individuals)
- fish, macrocrustaceans, freshwater mussels, freshwater snails, and turtles should be captured using gear appropriate to the waterways and species present (at the site, this is likely to include electrofishing, seine nets and set traps), and
- aquatic fauna should be handled, transported and released so as to minimise damage to the fish (e.g. handle with wet hands, hold correctly, transport using aerated water).

Various apparatus used to capture / translocate fish will require a General Fisheries Permit, issued by the DAFF, and should be operated by appropriately experienced professionals.

### 4.2.2 Water Quality Monitoring

Pre-construction baseline water quality monitoring and post-construction monitoring be done in accordance with the methods outlined in the AVMP. During construction, visual monitoring for sediment plumes outside the sediment and erosion controls will be done. If observed, construction works will cease and the erosion and sediment control measures will be inspected and repaired or revised as required.

If plumes are observed, water quality monitoring will also be done at one site upstream of the construction site, and one downstream (where safely accessible) in order to verify that the plume was related to construction activities, and to provide a record of monitoring. Baseline and post-construction monitoring will include three replicate samples of in situ water quality using a water quality probe for:

- water temperature
- dissolved oxygen (% saturation)
- conductivity
- pH, and
- turbidity.

Photographs will also be taken at each site.

The water quality monitoring will also be done once a day, at the same time of day, and a record kept, regardless of whether or not a turbid plume is observed.

Monitoring should be done by an appropriately qualified professional in accordance with the Monitoring and Sampling Manual (DERM 2010).

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# Appendix A Aquatic Habitat Condition

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# 1 Survey Design and Methods

## 1.1 In-stream Habitat Condition

The in-stream habitat condition at each site was assessed using the Australian River Assessment System (AUSRIVAS) protocol described in the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001). The following parameters were assessed:

- adjacent land use
- water velocity and depth
- channel diversity
- substrate composition, including sand bars and substrate compaction
- type and condition of riparian vegetation, and
- in-stream habitat (e.g. log jams, leaf packs, trailing vegetation and undercut banks).

## 1.2 Habitat Bioassessment Scores

A Habitat Bioassessment Score (DNRM 2001) is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. The method requires habitat quality to be scored (from zero to twenty) for each of nine criteria:

- substrate or available cover
- embeddedness
- water velocity and depth
- channel alteration
- bed scouring and deposition
- pool:riffle and run:bend ratio
- bank stability
- bank vegetative stability, and
- streamside vegetation cover.

The sum of the scores for each criterion gives the overall habitat score. This is used to allocate sites to one of four categories (Table 1.1):

- excellent habitat condition (overall score >110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74), and
- poor habitat condition (overall score ≤38).

This method is not directly applicable to ephemeral systems in central Queensland; using this method, even pristine ephemeral systems are rarely classed as being in excellent condition, due to the nature of the ephemeral waterways (e.g. limited bottom substrate and available cover provided by sand). Nonetheless it is a useful system for comparing between sites within a region.

Table 1.1 Habitat bioassessment scores used to derive overall condition categories.

| **Habitat Category** | **Category Score Range** | | | |
|---|---|---|---|---|
| | **Excellent** | **Good** | **Moderate** | **Poor** |
| Bed substrate or available cover | 16–20 | 11–15 | 6–10 | 0–5 |
| Embeddedness | 16–20 | 11–15 | 6–10 | 0–5 |
| Water velocity and depth | 16–20 | 11–15 | 6–10 | 0–5 |
| Channel alteration | 12–15 | 8–11 | 4–7 | 0–3 |
| Bed scouring & deposition | 12–15 | 8–11 | 4–7 | 0–3 |
| Pool:riffle and run:bend ratio | 12–15 | 8–11 | 4–7 | 0–3 |
| Bank stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Bank vegetative stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Streamside vegetation cover | 9–10 | 6–8 | 3–5 | 0–2 |
| **Total (Habitat Bioassessment Score for the Site)** | **111–135** | **75–110** | **39–74** | **0–38** |

## 1.3 Regional and Ecological Perspective

The condition of aquatic habitat in each catchment was reviewed, based on the *State of the Rivers* surveys (Telfer 1995; Henderson 2000), and summarised to provide a context for the results of this survey.

# 2 Results

## 2.1 In-stream Habitat Condition

Site assessment sheets have been completed that summarise the aquatic habitat at each site and present photographs of each site; these are provided in the Aquatic Values Management Plan (AVMP).

### Adjacent Land Use

Grazing was the dominant land use surrounding most sites, although Edwards Creek (KP25.3) also had good condition native vegetation in the riparian zone and local catchment area. Sites generally had low to moderate erosion, although Bully Frog Creek (KP45.9) and unnamed watercourse 2 (KP57.4) had considerable bank erosion (Figure 2.1).

Figure 2.1

Erosion at Bully Frog Creek (KP45.9).



## Water Velocity and Depth

Hutton Creek (KP2.1) and the Dawson River (KP29.8) had substantial water with low flow. Christmas Creek (KP2.7) and Edwards Creek (KP25.3) both had water, although there was no flow at Christmas Creek amd water was restricted to an isolated pool at Edwards Creek. Sites KP28.7, KP45.9, KP57.4 and KP63.2 were dry when surveyed.

## Channel Diversity

Channels were generally straight or mildly sinuous. Most sites had moderate to low banks; however, Ironbark Creek (KP62.3) had steep banks.

## Substrate Composition

Substrate composition was dominated by silt or clay and sand at most sites (Figure 2.2).

Edwards Creek (KP25.3) had the most diverse substrate composition, including bedrock, and unnamed watercourse 2 (KP57.4) had the lowest diversity.

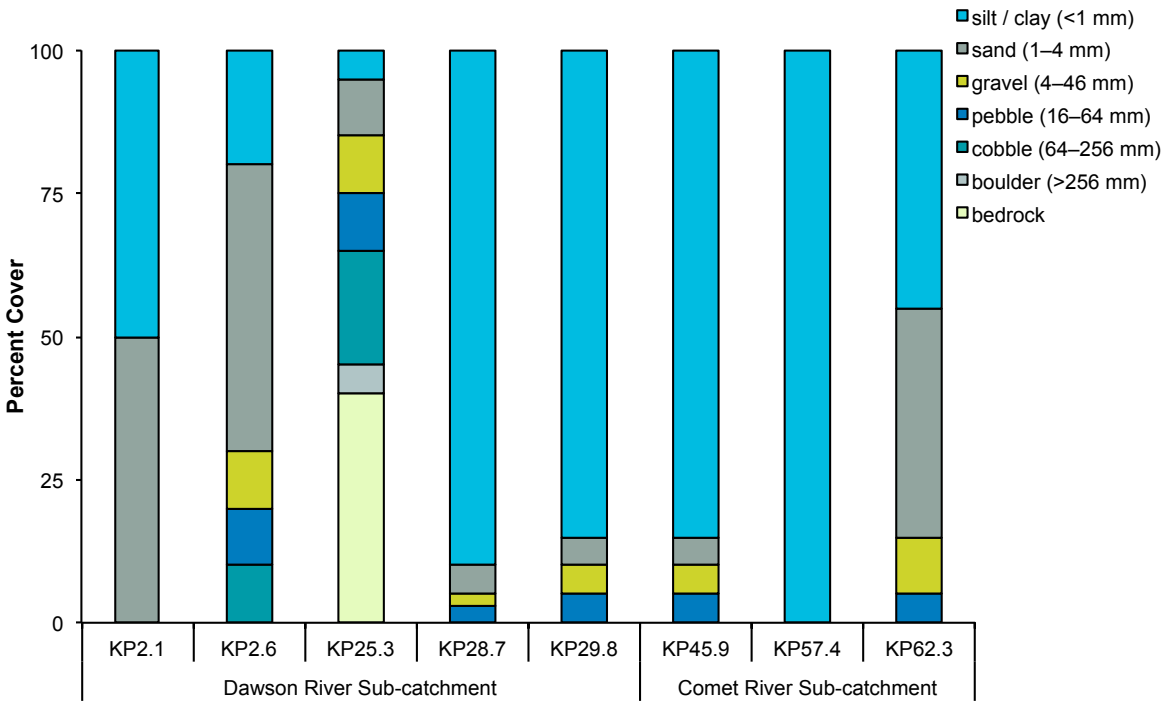


Figure 2.2 Percent cover of substrate types at each site along the GLNG pipeline (KP0 to KP70).

## Riparian Vegetation

The canopy riparian vegetation at most sites was scattered eucalypt trees, and most sites had with a dense understory of grasses (Figure 2.3). Brigalow was present at Bully Frog Creek (KP45.9) and unnamed watercourse 2 (KP57.4), although the condition of riparian vegetaion at these sites was poor.

Figure 2.3

Riparian vegetation at Edwards Creek (KP25.3).



## In-stream Habitat

In-stream habitat provides refuge and food for aquatic fauna (e.g. fish, turtles and macrocrustaceans). In-stream habitat at most sites that contained water was dominated by emergent aquatic vegetation, large woody debris and pools (Figure 2.4).

Figure 2.4

In-stream habitat at the Dawson River (KP29.8).



## 2.2 Habitat Bioassessment Scores

Most sites had moderate habitat quality, and two sites [Bully Frog Creek (KP45.9) and unnamed watercourse 2 (KP57.4)] had poor habitat (Figure 2.5).

The poor habitat scores for these two sites was due to:

- little bottom substrate or habitat (e.g. boulders, woody debris and vegetation)
- poor bank vegetation stability
- poor habitat diversity, and
- extensive embeddedness (as a result of substrate dominated by fine sediment).

Overall moderate habitat scores were due to:

- more bottom substrate or available cover (e.g. boulders, woody debris and vegetation)
- better habitat diversity
- better streamside cover, and
- better bank vegetation stability.

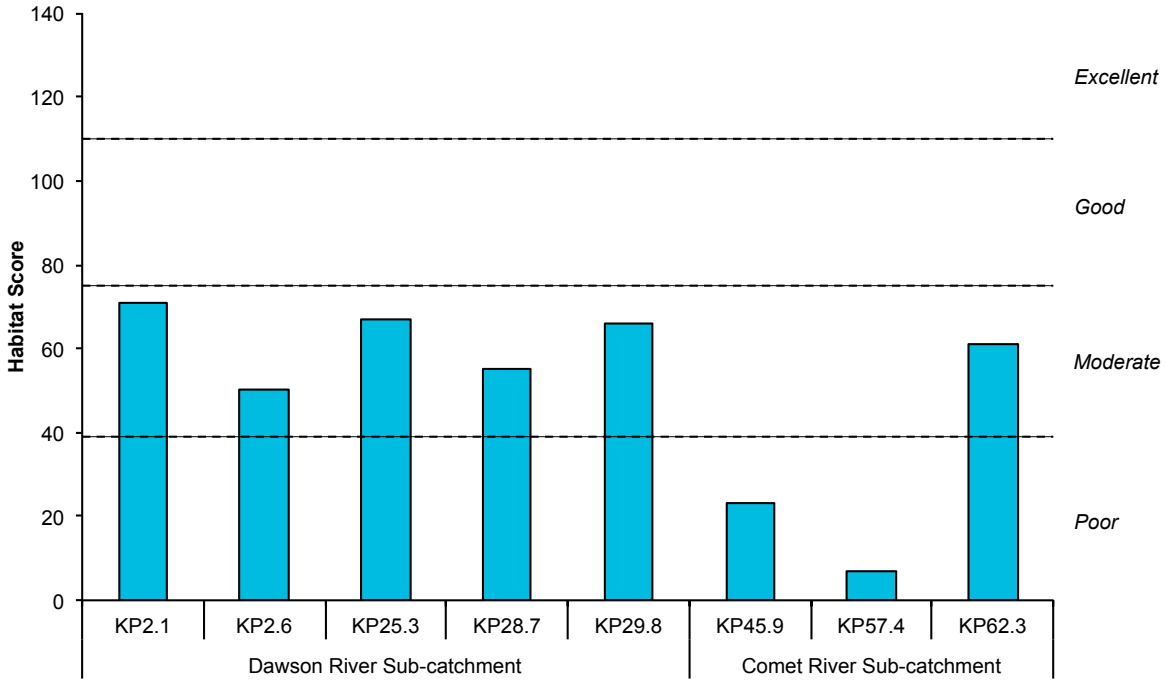


Figure 2.5 Habitat Bioassessment Score at each site along the GLNG pipeline (KP0 to KP70).

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

### Reach Environments

In the State of the Rivers survey, the condition of the reach environments varied across the Dawson River sub-catchment, although most stream segments were of moderate condition, as shown for most sites in the current study. Stream segments with very poor or poor condition were mainly in the western, southern and north-upland tributaries, and in the Don and Callide tributaries of the Dawson River. Stream segments with good to very good ratings were mostly in the upper and regulated Dawson River sub-catchments). Factors that impacted the condition of the reach environments included the extent of vegetation clearing along the stream for cropping and exposure to cattle grazing and watering (Telfer 1995).

### Riparian Vegetation and Adjacent Land Use

In the State of the Rivers survey, riparian vegetation throughout the catchment was in very poor to poor condition, although the condition of riparian vegetation in the Upper Dawson River sub-catchment was high (Telfer 1995). The reported impacts to riparian vegetation were clearing, grazing by cattle and invasion of weed species. This is consistent with riparian vegetation condition and land uses observed at sites in the current survey. Eucalypt-dominated communities were the most commonly identified vegetation types within the riparian zones of the catchment, followed by Brigalow, softwood scrub, and cypress pine communities. Grasslands and medium (10 to 30 m) and small (<10 m) trees were the most dominant structural types of vegetation (Telfer 1995). The most extensive adjacent land use in the State of the Rivers survey was grazing of beef cattle on native pastures (mostly in areas cleared of native timber) (Telfer 1995).

### Bank Stability

In the State of the Rivers survey, the stability of the banks throughout the catchment was generally good, with most banks being stable or very stable. Erosion was the most extensive process occurring throughout the catchment, and was the dominant process in 94% of stream segments. Erosion commonly occurred at bends, at obstacles, and at irregular locations along both the lower and upper banks. The presence of stock and

clearing of vegetation were the major factors contributing to the disturbance of banks (Telfer 1995), as noted for many sites in the current study.

### Channel Diversity

In the State of the Rivers survey, channel diversity throughout the catchment was mostly low to very low. Generally, channel diversity was highest in the North Upland and Don and Callide sub-catchments. Run habitat was the most commonly identified channel habitat type throughout the catchment, followed by pools and then riffles (Telfer 1995).

### In-stream Habitat

In the State of the Rivers survey, the condition of in-stream habitat was considered to be generally poor to moderate. Similarly, the overall habitat value for aquatic life was rated at most sites (71%) as very poor to good, similar to most sites in the current study. Sub-catchments that exhibited aquatic habitat in mostly good to very good condition included the upper tributaries sub-catchment and the Upper Dawson River sub-catchment. Individual branches, individual logs, and leaf and twig cover were the most common in-stream habitat. Vegetative debris is the predominant aquatic habitat in this catchment, which highlights the importance of riparian zones to aquatic organisms in the Dawson River sub-catchment (Telfer 1995).

## 3.2 Comet River Sub-catchment

### Reach Environments

The Comet River has two sub-catchments: the Eastern tributaries sub-catchment (where the pipeline ROW is located) covers an area of 10 821 $km^2$; the Western tributaries sub-catchment covers an area of 6474 $km^2$. The Eastern tributaries sub-catchments contain approximately 2820 km of streams; and the Western tributaries sub-catchments contain approximately 2001 km of streams. In the Eastern sub-catchment, 84% of streams were rated as very good, 13% as poor and only 3% as very poor. In the Western sub-catchment, 86% of streams were rated as moderate to very good, and 14% were rated as poor to very poor (Henderson 2000).

Despite these good ratings, 60% of streams in the Eastern sub-catchments and 52% of streams in the Western sub-catchments were subject to high, very high or extreme

disturbance. The most common form of disturbance was grazing with some influence from man-made structures such as fords, culverts, roads and water extraction infrastructure (Henderson 2000). Grazing and riparian vegetation clearing were the dominant disturbances observed in the current study.

## Riparian Vegetation and Adjacent Land Use

Across both the Eastern and Western tributaries sub-catchments, riparian vegetation included grasses, medium sized trees (10 to 30 m), small trees (<10 m), shrubs, and rushes. Native species that were common in the riparian zone included (Henderson 2000):

- *Eucalyptus* spp.
- Kangaroo Grass (*Themeda triandra*)
- *Melaleuca* spp.
- *Lomandra* spp.
- *Acacia* spp.
- *Casuarina* spp., and
- Brigalow (*Acacia harpophylla*).

Most of the riparian zones across the Eastern tributaries sub-catchment were in very poor to moderate condition (72% of stream length), whereas the condition of riparian vegetation in the Western tributaries sub-catchment was largely good to very good (63% of stream length). Exotic grasses were at 73% of sites, and were common at all sites in the present study. Exotic plants commonly observed were (Henderson 2000):

- green panic (*Panicum maximum*)
- Noogoora burr (*Xanthium pungens*), and
- Parthenium (*Parthenium hysterophorus*).

## Bank Stability

Stream banks were either stable or very stable in both the Eastern (68% of stream length) and Western (87% of stream length) tributaries sub-catchments. Erosion was widespread throughout both sub-catchments and occurred at bends, obstacles and seepage points. Erosion was observed at 63% of sites in the Eastern tributaries and 55% of sites in the Western tributaries sub-catchments. Aggradations were prominent at bends and

obstacles at 18% of sites in the Eastern tributaries and at 10% of sites in the Western tributaries sub-catchments. The major factor influencing bank stability was the presence of stock in the riparian zone, although run-off, water flow and clearing of vegetation were also common factors (Henderson 2000).

## Channel Diversity

Channel habitat diversity was low or very low in both the Eastern tributaries (99% of sites) and Western tributaries (98% of sites) sub-catchments. Pools and runs were the most prevalent habitat types in both sub-catchments. In the Eastern tributaries sub-catchment the average depth and width of (Henderson 2000):

- pools were 1.0 m deep and 8.7 m wide
- runs were 1.0 m deep and 6.6 m wide, and
- riffles were 0.1 m deep and 5.6 m wide.

In the Western tributaries sub-catchment, the average depth and width of (Henderson 2000):

- pools were 2.0 m deep and 8.8 m wide
- runs were 0.5 m deep and 6.0 m wide, and
- riffles were 0.3 m deep and 18.0 m wide.

The substrate of pools across the sub-catchments was dominated by silt, while runs had some silt and some sand, and riffles has mostly of larger particles (e.g. gravel and cobbles). Organic matter made up between 5 and 26% of streambed sediment in pools, runs and riffles (Henderson 2000).

## In-stream Habitat

Aquatic habitat was poor or very poor condition at most sites in both the Eastern (73% of stream length) and Western (59% of stream length) tributaries sub-catchments. Logs, branches, leaves and twigs and tree roots were the most widespread forms of in-stream habitat. The riparian canopy and overhanging vegetation provided aerial cover, though Telfer (1995) suggested that poor riparian vegetation reduced the supply of vegetative debris, resulting in poor aquatic habitat (Henderson 2000).

# 4 References

DNRM, 2001. *Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual*. Queensland Department of Natural Resources and Mines, Rocklea.

Henderson, C. 2000, *State of the Rivers: Comet, Nogoa and Mackenzie Rivers*, Queensland Department of Natural Resources, Indooroopilly.

Telfer, D., 1995, *State of the Rivers, Dawson River and Major Tributaries*, report prepared for Department of Natural Resources and Mines.

# Appendix B Water Quality

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Figure 2.5 Turbidity at each site along the GLNG pipeline (KP0 to KP70). 7

# 1 Survey Design and Methods

## 1.1 Water Quality Measured *In Situ*

Water quality was measured *in situ* at sites containing sufficient water at the time of survey. Water quality was not assessed at sites that were dry or where the water level was too low.

The following water quality parameters were measured using a Hydrolab Quanta water quality meter:

- water temperature
- pH
- electrical conductivity, and
- dissolved oxygen.

A Hach 2100Q turbidity meter was used to measure turbidity.

The Hydrolab Quanta water quality meter was calibrated daily and the Hach 2100Q was calibrated at the beginning of the field surveys.

The water quality results were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin, including the Dawson River (DERM 2011b) and Comet River Sub-basins (DERM 2011a) (Table 1.1). The WQOs for electrical conductivity and pH are based on reference data from the following sites (DERM 2011a):

- Dawson River at Utopia Downs and Robinson Creek at Glenleigh in the upper Dawson Sub-basin, and
- Brown River at Warrinilla and Carnarvon Creek at Rewan in the Comet Sub-basin.

The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009), and these have been presented as the WQOs scheduled under the EPP Water.

Table 1.1 Water Quality Objectives (WQOs) for the Fitzroy River Basin for protection of moderately disturbed aquatic ecosystems.

| Parameter | Units | Water Quality Objectives for Fitzroy Basin | |
|---|---|---|---|
| | | Upper Dawson | Comet River |
| temperature | °C | – | – |
| pH | pH units | 6.5–8.5 | 6.5–8.5 |
| electrical conductivity | µS/cm | 370 | 375 |
| dissolved oxygen [a] | % saturation | 85–110 | 85–110 |
| turbidity | NTU | 50 | 50 |

Source DERM (2011b, 2011c)

[a] dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth

– not available

µS/cm = microSiemens per centimetre

NTU = nephelometric turbidity unit

## 1.2 Regional and Ecological Perspective

Literature on water quality in each catchment was reviewed, and summarised to provide a context for the results of this survey.

# 2 Results

## 2.1 Temperature

The temperature ranged from 20.8 °C at the Dawson River (KP29.8) to 29.5 °C at Edwards Creek (KP25.3) (Figure 2.1). There is no WQO for water temperature.

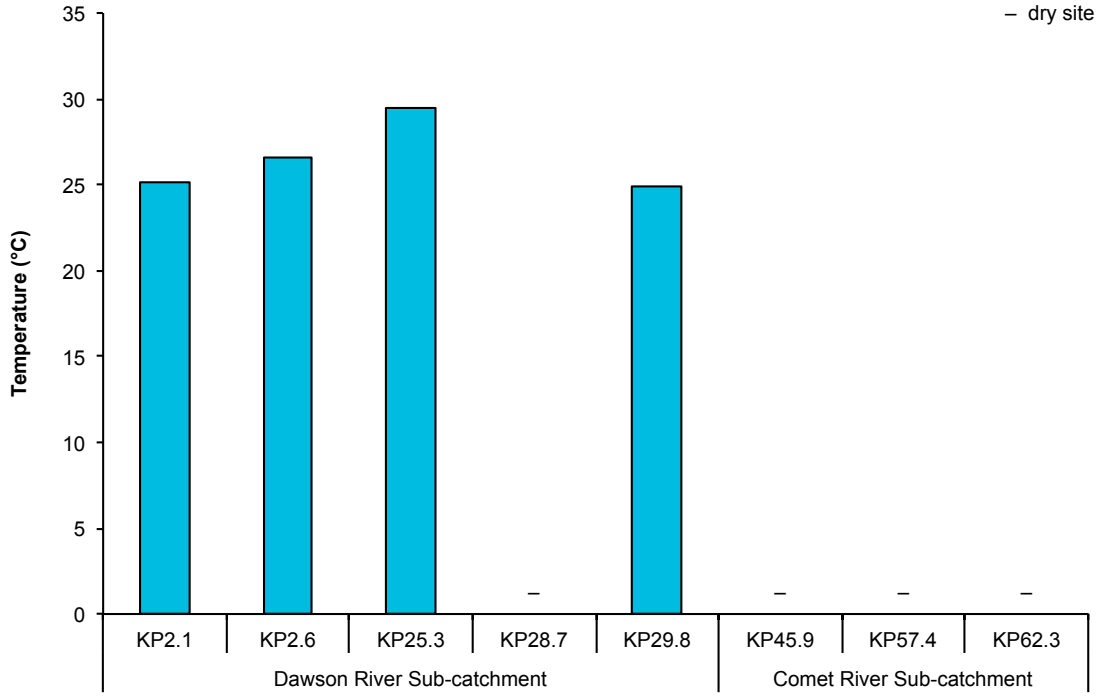


Figure 2.1 The temperature of water at each site along the GLNG pipeline (KP0 to KP70).

## 2.2 pH

The pH was within the WQO range at all sites and varied little between sites (Figure 2.2).

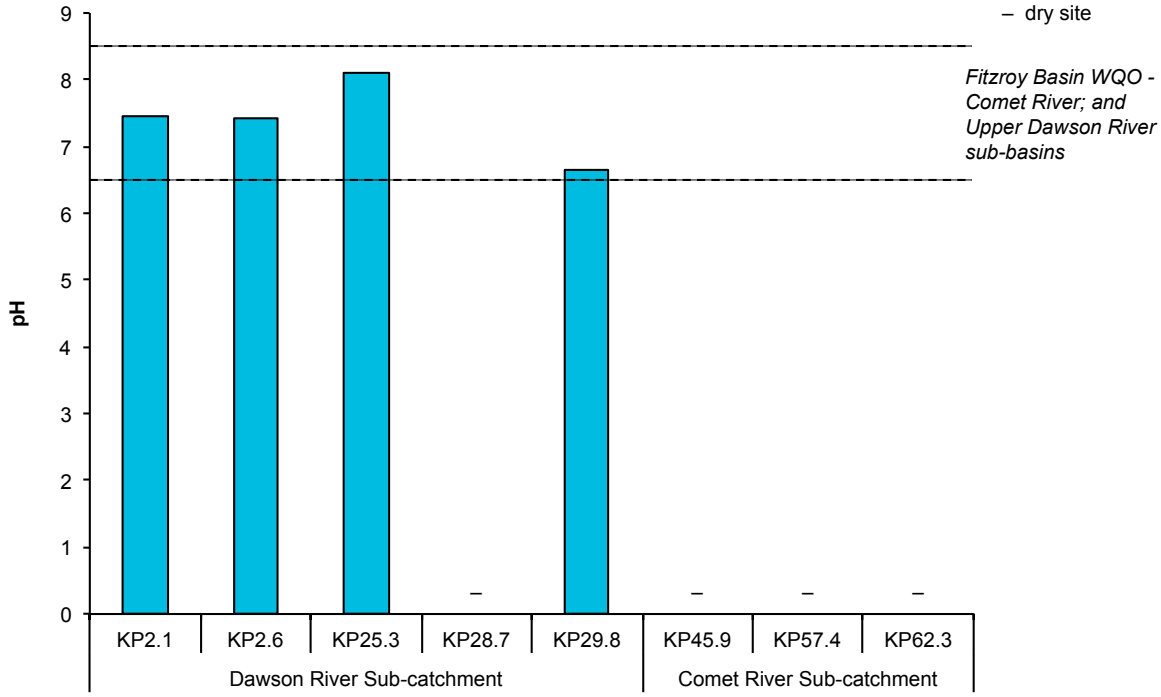


Figure 2.2 The pH at each site along the GLNG pipeline (KP0 to KP70).

## 2.3 Electrical Conductivity

The electrical conductivity was above the WQO at Hutton Creek (KP2.1) and Christmas Creek (KP2.7) (Figure 2.3). Electrical conductivity was below the WQO at the three remaining sites that contained water.

Electrical conductivity depends on a number of factors including catchment run-off and local geology.

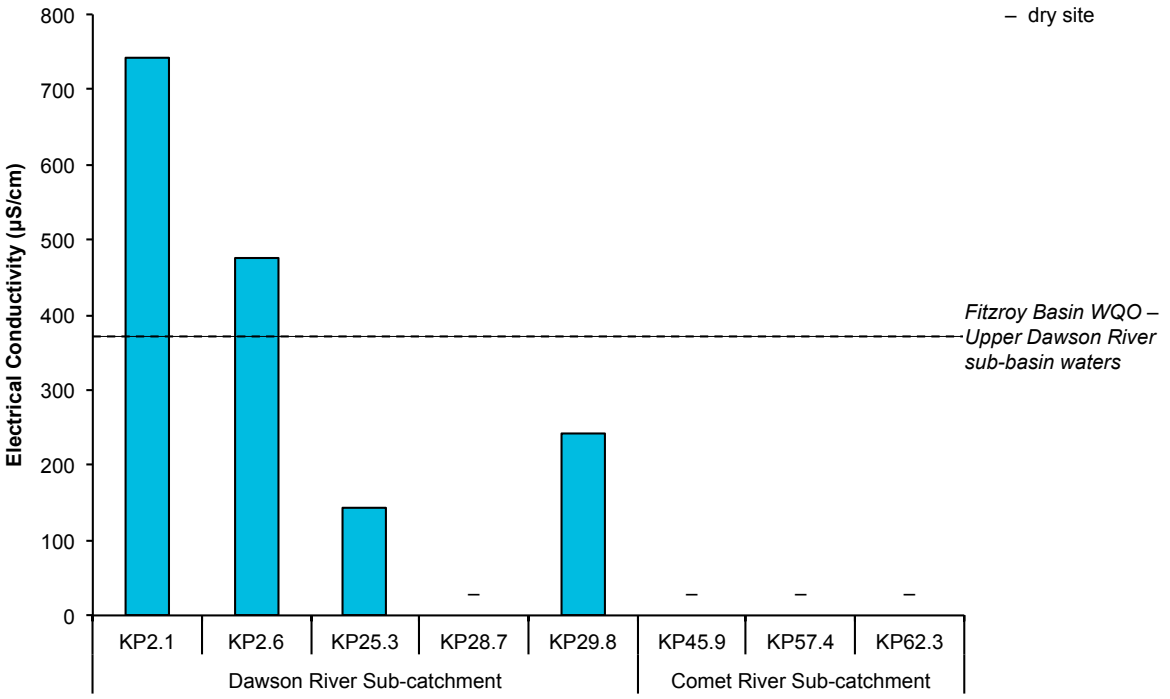


Figure 2.3 Electrical conductivity at each site along the GLNG pipeline (KP0 to KP70).

## 2.4 Dissolved Oxygen

The percent saturation of dissolved oxygen was slightly below the WQO range at two sites [Hutton Creek (KP2.1) and the Dawson River (KP29.8)], and within the WQO range for Christmas Creek (KP2.6) and Edwards Creek (KP25.3).

The differences in the percent saturation of dissolved oxygen at each site are likely to reflect the:

- time of day measurements were taken (plants photosynthesise during the day, producing oxygen)
- photosynthetic rates of algae and macrophytes (which are affected by light availability and temperature)
- rate of oxygen uptake by micro-organisms in the waterway associated with decomposing organic matter, and
- amount of surface mixing (caused by wind, water movement and bird activity).

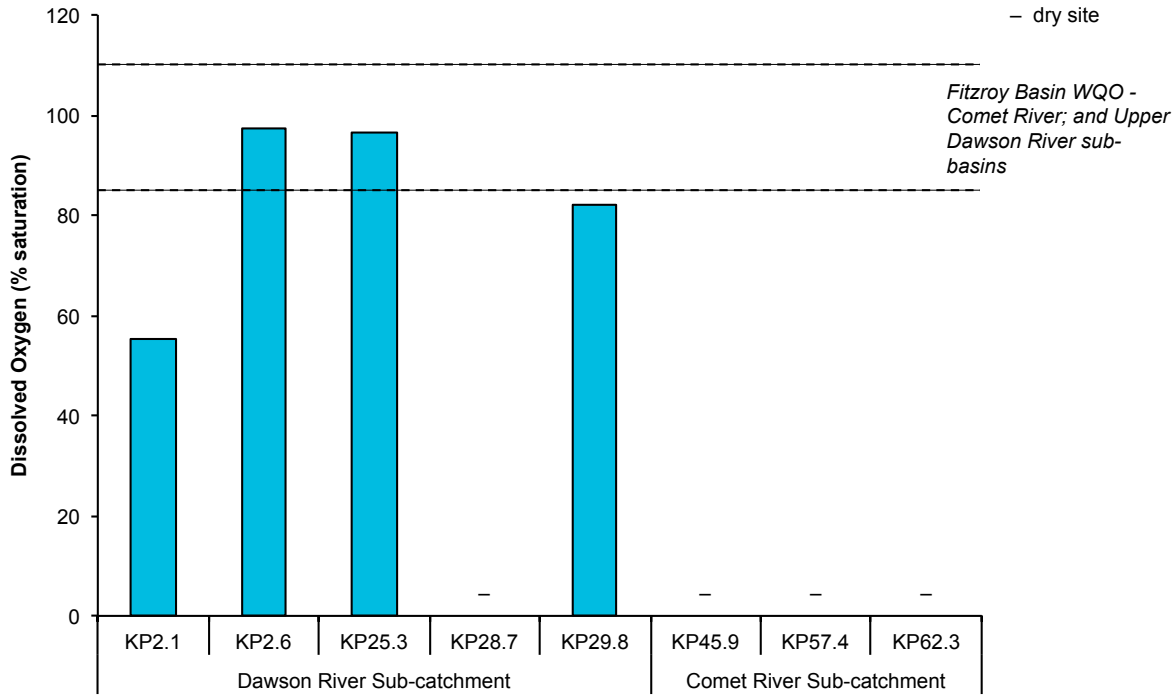


Figure 2.4 Percent saturation of dissolved oxygen at each site along the pipeline (KP0 to KP70).

## 2.5 Turbidity

Turbidity was below the WQO at Hutton Creek (KP2.1) and was above the WQO at the other three sites that contained water (Figure 2.5). Turbidity is a potential indicator of sedimentation and erosion.

Variation in turbidity between sites was likely due to differences in local factors, such as sediment type, macrophyte or vegetation cover and severity of erosion, such as erosion associated with cattle access.

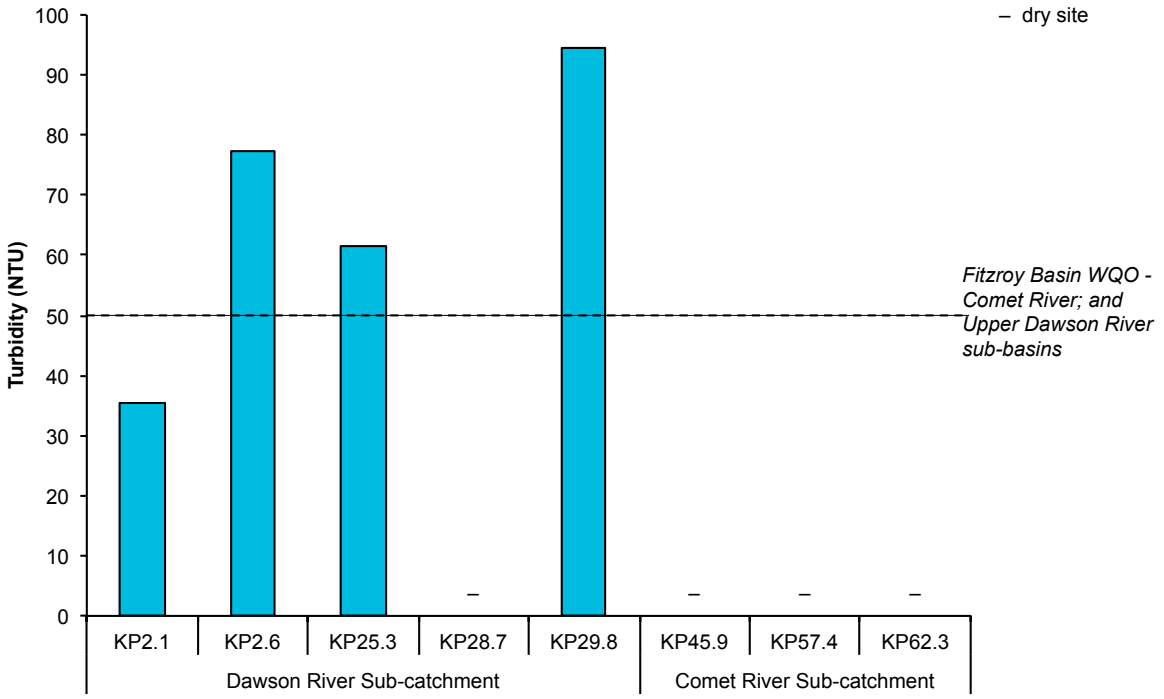


Figure 2.5 Turbidity at each site along the GLNG pipeline (KP0 to KP70).

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Agricultural land use dominates the Dawson River sub-catchment:

- 77% of the area is grazed
- 12% is state forest
- 7% is cropped, and
- 3% is national park (EPA 2001).

Within the Dawson River sub-catchment there are eight sub-catchments, which vary in their aggregate emission rates of nitrogen and phosphorus. Total nitrogen emitted from this sub-catchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001).

The primary sources for nitrogen are:

- grazing (43%)
- state forests (39%), and
- cropping (9%)

The primary sources for phosphorus are:

- grazing (80%)
- cropping (12%), and
- state forests (4%) (Joo 2000).

## 3.2 Comet River Sub-catchment

Cropping dominates land use in the Comet sub-catchment and although grazing is also common. Approximately 12% of the sub-catchment is national park and 9% is state forest (Henderson 2000). Turbidity and suspended solids are very high, as are the concentrations of nutrients. The concentrations of total nitrogen and phosphorus in run-off from cropping are very high (Noble et al. 1996; Henderson 2000), resulting in high cyanobacteria (blue-green algae) densities throughout the sub-catchment at times of low flow (Noble et al. 1996; Henderson 2000). However, high turbidity (which limits light

penetration) limits the growth of cyanobacteria (Henderson 2000). The widespread distribution of herbicides in surface waters of the sub-catchment is a matter of local concern (Noble et al. 1996; Henderson 2000).

Immediately downstream of the sub-catchment, the waters of the Mackenzie River received a report card score of 'D' (poor) for waters above the Isaac River confluence (Meecham 2003). Water quality in this catchment is threatened by:

- increased chemical loads associated with irrigation and grazing
- flow regulation reducing availability of aquatic habitat, and
- increased sediment run-off associated with interactions between grazing, fire, drought and rainfall (Meecham 2003).

These factors are also likely to have a major influence on water quality within the Comet River sub-catchment.

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# Appendix C Aquatic Flora

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# 1 Survey Design and Methods

## 1.1 Aquatic Flora Assessment

The aquatic vegetation at each site was assessed along a 100 m reach of the stream and the adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following environmental parameters were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species
- growth form of each species (submerged, floating (free-floating or rooted) and emergent) (Table 1.1)
- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Table 1.1 Aquatic flora growth forms.

| Growth Form | Description |
|---|---|
| submerged | • predominantly grow beneath the surface of the water<br>• flowers may project above the water surface<br>• some leaves may float on the water surface |
| floating | • can be either free-floating or rooted<br>• free-floating species are usually not attached to the substrate<br>• rooted species are attached to the substrate and normally have at least the mature leaves floating on the water surface |
| emergent | • rooted in the substrate<br>• stems, flowers and most of the mature leaves project above the water surface |

source: Sainty & Jacobs 2003

Percent cover of each species was assessed visually and the presence of listed protected species, under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* was determined for each site.

Aquatic flora species were identified in the field, where practical. Representative specimens were collected for identification in the laboratory (or by the Queensland Herbarium, if required). Species were identified as native or exotic according to the *Census of Queensland Flora 2007* (Queensland Herbarium 2007).

## 1.2 Regional and Ecological Perspective

The literature on aquatic vegetation in each catchment was reviewed, and summarised to provide a context for the results.

# 2 Results

## 2.1 Taxonomic Richness

Taxonomic richness varied between sites, ranging from 0 to 11. The highest taxonomic richness was at the Dawson River (KP29.8) (Figure 2.1; Table 2.1). No aquatic flora was observed at Bully Frog Creek (KP46.0) or unnamed watercourse 2 (KP57.4).

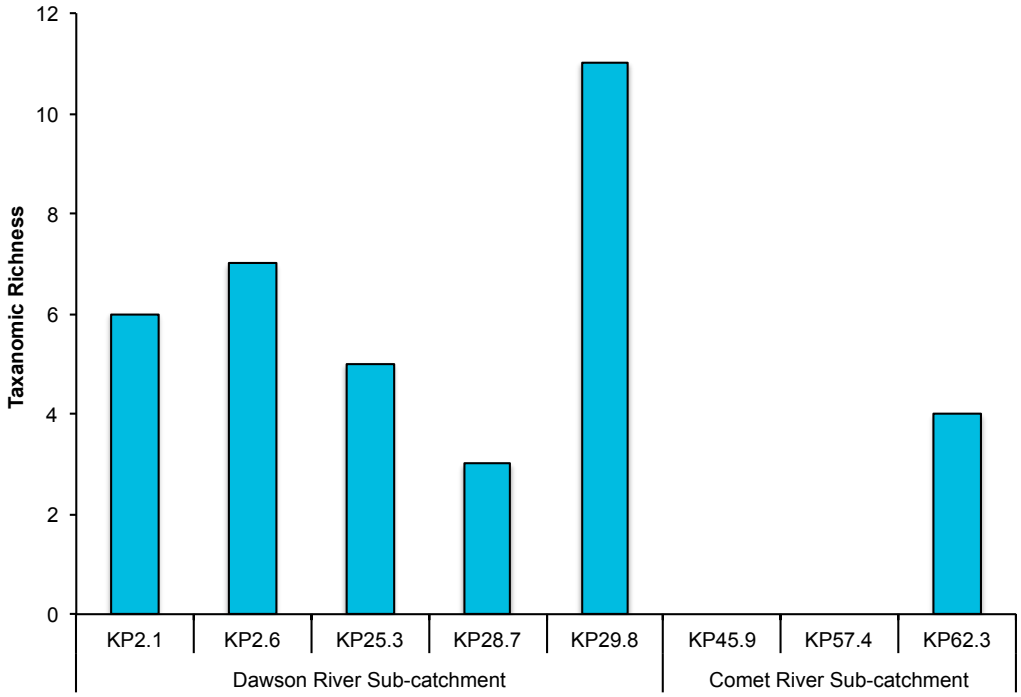


Figure 2.1 Taxonomic richness of aquatic flora at each site along the GLNG pipeline (KP0 to KP70).

## 2.2 Percent Cover

The percent cover of aquatic flora (as a percentage of the total substrate) ranged from 0 to 40% (Figure 2.2; Table 2.1). The highest cover was at the Dawson River (KP29.8) and the lowest percent cover (of the sites where aquatic flora was found) was at Christmas Creek (KP2.7) and Edwards Creek (KP25.3).

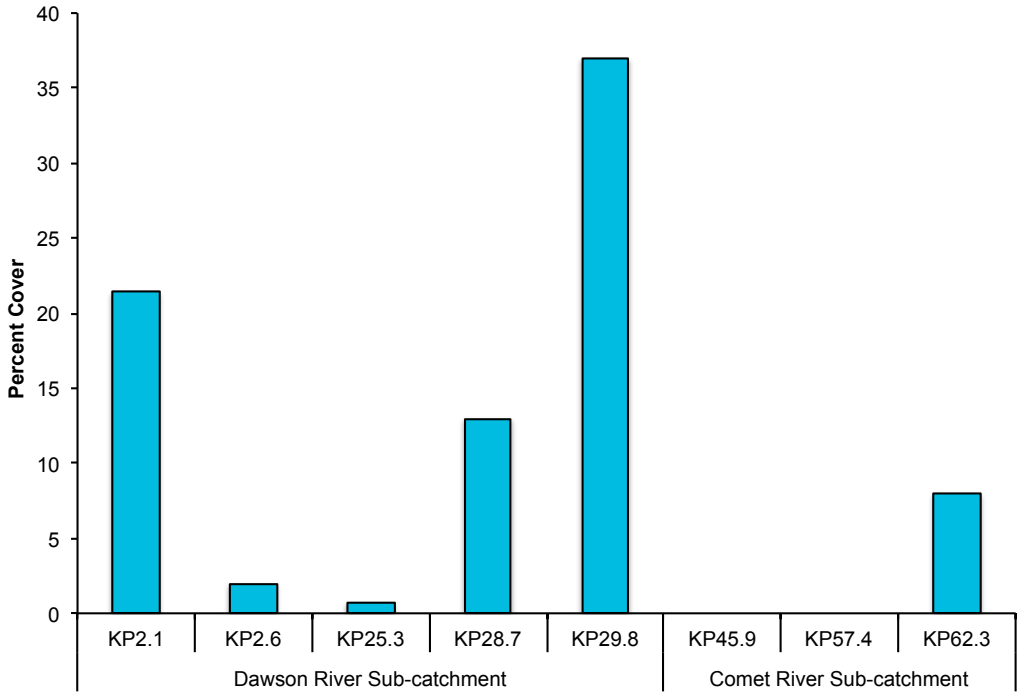


Figure 2.2 Percent cover of aquatic flora at each site along the GLNG pipeline (KP0 to KP70).

Table 2.1 Abundance of each aquatic flora species at each site along the GLNG pipeline (KP0 to KP70).

| | | | Dawson River Sub-catchment | | | | | | Comet River Sub-catchment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Form** | **KP2.1** | **KP2.6** | **KP25.3** | **KP28.7** | **KP29.8** | **KP45.9** | **KP57.4** | **KP62.3** | **Total** |
| *Alternanthera denticulata* | lesser joyweed | E | – | – | – | – | 1 | – | – | – | **1** |
| *Carex inversa* | knob sedge | E | – | – | – | 5 | 2 | – | – | – | **7** |
| *Cyperus difformis* | Dirty dora | E | – | – | – | – | – | – | – | 2 | **2** |
| *Cyperus distans* | slender flatsedge | E | 0.5 | 0.5 | – | – | – | – | – | – | **1** |
| *Cyperus gracilis* | gracile flatsedge | E | – | – | – | 2 | 2 | – | – | – | **4** |
| Cyperus sp. [1] | – | E | – | 0.5 | – | – | – | – | – | – | **0.5** |
| Cyperus sp. [1] | – | E | – | – | – | – | – | – | – | 1 | **1** |
| *Cyperus trinervis* | Australian flat sedge | E | – | – | – | – | – | – | – | – | **0.05** |
| *Elatine gratioloides* | waterwort | E | – | – | – | – | 1 | – | – | – | **1** |
| *Eleocharis acuta* | acute spikerush | E | – | – | – | – | 1 | – | – | – | **1** |
| *Eleocharis cylindrostachys* | spikerush | E | – | – | 0.15 | – | – | – | – | – | **0.15** |
| *Fimbristylis dichotoma* | common fringerush | E | – | – | 0.05 | – | – | – | – | – | **0.05** |
| *Glyceria maxima* | reed sweetgrass | E | – | 0.1 | 0.3 | – | – | – | – | – | **0.4** |
| *Juncus continuus* | sand rush | E | 0.05 | 0.2 | 0.15 | – | – | – | – | – | **0.5** |
| *Juncus usitatus* | common rush | E | – | – | – | 5 | 5 | – | – | 1 | **11** |
| *Leptochloa digitata* | umbrella canegrass | E | – | 0.1 | – | | | – | – | – | **0.1** |
| *Lomandra longifolia* | mat rush | E | 0.2 | 0.3 | 0.1 | 1 | 1 | – | – | 1 | **4.1** |
| *Ludwigia peploides* | water primrose | E | – | – | – | – | 1 | – | – | – | **1** |
| *Marsilea* sp. | nardoo | FA | 0.5 | – | – | – | | – | – | – | **0.5** |
| *Paspalum distichum* | water couch | E | | – | – | – | 15 | – | – | – | **15** |
| *Persicaria decipiens* | slender knotweed | E | 0.2 | 0.3 | – | – | 1 | – | – | 3 | **4.55** |
| *Persicaria hydropiper* | water pepper | E | – | – | – | – | 7 | – | – | – | **7** |

| | | | Dawson River Sub-catchment | | | | | | Comet River Sub-catchment | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Form** | **KP2.1** | **KP2.6** | **KP25.3** | **KP28.7** | **KP29.8** | **KP45.9** | **KP57.4** | **KP62.3** | **Total** |
| *Rumex crispus* | curled dock | E | 20 | – | – | – | – | – | – | – | **20** |
| | **% of exotic species** | | – | **5** | **40** | – | – | – | – | – | **0.5** |
| | **Total** | | **21.45** | **2** | **0.75** | **13** | **37** | – | – | **8** | **82.9** |

– not present

E – emergent; S – submerged; FA – floating-attached

1 could not be identified to species level due to a lack of reproductive parts

## 2.3 Growth Form Diversity

Aquatic plants were all of an emergent growth form at all sites, except at Hutton Creek (KP2.1), where *Marsilea* sp. (nardoo) was observed to have a floating attached growth form (Table 2.1). It should be noted that *Marsilea* sp. can also be of emergent growth form depending on site characteristics.

The lack of submerged and floating attached aquatic flora reflected the creek's ephemeral hydrology. Submerged aquatic flora cannot survive dry periods nor high turbidity (high turbidity reduces light in the water column and inhibits photosynthesis); emergent forms are most tolerant of dry conditions.

## 2.4 Exotic Species

Several exotic species were identified along the GLNG Pipeline, including:

- reed sweetgrass, and
- curled dock

Exotic aquatic plants species comprised 40% of the aquatic plant community at Edwards Creek (KP25.3) and 5% of the aquatic plant community at Christmas Creek (KP2.6) (Table 2.1). Reed sweetgrass and curled dock are environmental weeds.

## 2.5 Listed Species of Conservational Significance

There were no species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* observed in the surveys.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Duding the GLNG Project Environmental Impact Statement (EIS) surveys, 13 species of emergent aquatic flora were recorded from the upper Dawson River sub-catchment (frc environmental 2009). The most common and abundant species were:

- awnless barnyard grass (*Echinochloa colona*)
- common rush (*Juncus usitatus*), and
- mat rush (*Lomandra longifolia*).

Two exotic species were recorded: reed sweetgrass and curled dock (*Rumex crispus*).

State of the Rivers (Telfer 1995) sites in the sub-catchment were dry at the time of sampling (91%), and sites with water did not support aquatic vegetation. A similar result was obtained during a reconnaissance of the upper Dawson sub-catchment (frc environmental 2007).

frc environmental (2007) reported ten different species of aquatic flora at seven sites, with richness ranging from zero to eight species at any one site. All aquatic flora had an emergent growth form (there were no floating or submerged species). Subsequently, frc environmental (2008) reported nine species with richness ranging from one to six species at any one site and cover of less than or equal to 10%. The most abundant and common aquatic flora was the common rush.

## 3.2 Comet River Sub-catchment

Duding the GLNG Project Environmental Impact Statement (EIS) surveys, 14 species of emergent aquatic flora, on floating attached species and four submerged species were recorded from the Comet River sub-catchment (frc environmental 2009). The most common and abundant species were:

- awnless barnyard grass
- water couch (*Cynodon dactylon*), and
- common rush.

Two exotic species were recorded: reed sweetgrass and curled dock.

The State of the Rivers assessment (Henderson 2000), rated the aquatic vegetation communities of the Comet River sub-catchment mostly as very poor. This was likely to reflect the high turbidity at the time of survey, which prevented an accurate assessment at many sites; turbidity was considered too high to accurately estimate cover at 18% of sites. Aquatic vegetation recorded in the Comet River sub-catchment included:

- common reed (*Phragmites australis*)
- water fern (*Azolla* spp.), and
- *Blyxa* spp..

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# Appendix D Macroinvertebrate Communities

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# 1 Survey Design and Methods

## 1.1 Sample Collection

### Macroinvertebrate Samples

Benthic macroinvertebrates were assessed at each site in bed and edge habitats. Five samples were taken from each habitat type, with each sample consisting of five sweeps of an area of 30 $cm^2$. A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples.

### Macrocrustacean Samples

Macrocrustaceans are not planktonic and include the orders Amphipoda, Isopoda and Decapoda. Macrocrustaceans (e.g. prawns, shrimps and yabbies) were caught using a combination of backpack electrofishing, baited traps and seine nets. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*. Macrocrustaceans were also caught in macroinvertebrate surveys, using a macroinvertebrate sampling net.

Details of fishing methods and survey efforts are presented in Appendix E.

## 1.2 Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003). All macrocrustaceans were identified and counted in the field and specimens were returned to the environment.

## 1.3 Data Analysis

The following indices were calculated for each sample (further information is provided overleaf):

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2 scores.

These metrics were used to indicate the current ecological health of surveyed waterways. The mean and standard error was calculated for each habitat type at each site. The total number of species and total abundance for each habitat type at each site were also calculated by pooling the data from the five samples. Results were compared to the relevant biological water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy River Basin (DERM 2011), including the Dawson River catchment (Table 1.1). While the guidelines were developed using macroinvertebrate samples collected using AUSRIVAS sampling methods and are not directly applicable, this comparison was still useful for providing an overall preliminary indication of ecosystem health.

Table 1.1 Fitzroy Basin biological water quality objectives.

| Indicator | Habitat | WQO |
|---|---|---|
| composite [a] | taxonomic richness | 12–21 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.33–3.85 |
| edge | taxonomic richness | 23–33 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.31–4.2 |

source: DERM (2011)

[a] comprises all bed habitat within the site, including sandy pool, rocky pool, riffle, run and cascade

### *Abundance*

Abundance is the total number of macroinvertebrates.

### *Taxonomic Richness*

Taxonomic richness is the number of taxa (in this assessment, families). Taxonomic richness is a basic, unambiguous and effective diversity measure. However, it is affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxon, so rare and common taxa are considered equally.

### *PET Richness*

While some groups of macroinvertebrates are tolerant to pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat condition and water quality than in sites of degraded condition. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score, the greater the inferred degradation.

### *SIGNAL 2 Scores*

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence or absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxon, and
- divided by the total of the weight factors for each taxon.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 1.1). Boundaries based on the Fitzroy Basin biological water quality objectives were used for this study.

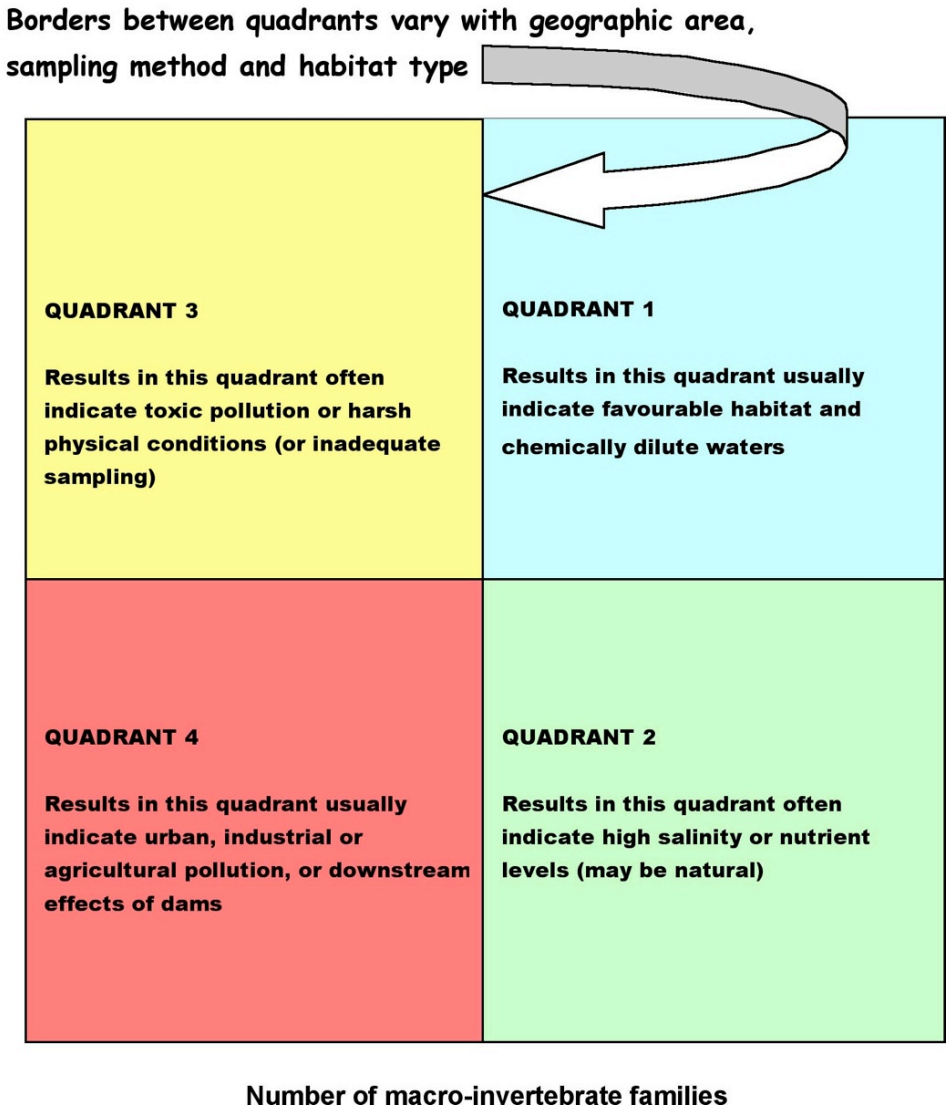


Figure 1.1 Quadrant diagram for SIGNAL 2 / family bi-plot.

### Multivariate Analyses

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or indices (such as richness, PET richness and SIGNAL 2 scores) derived to represent the community (i.e. univariate analyses). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

We examined differences in community composition between sites, using a one-way analysis of similarity (ANOSIM). Before analysis, community data was log-transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, using the averaged data for each habitat at each site, using non-metric multi-dimensional scaling (nMDS) ordinations. Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

## 1.4 Regional and Ecological Perspective

The literature on macroinvertebrate communities in each catchment was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

## 2.1 Abundance

### Mean Abundance

Mean abundance (i.e. the average number of individuals of the five samples from each site) varied between sites and between habitats at each site. Christmas Creek (KP2.6) had the highest abundance of macroinvertebrates in bed habitat, whereas Edwards Creek had the highest abundance of macroinvertebrates in edge habitat (Figure 2.1). The high abundance of macroinvertebrates at Christmas Creek (KP2.6) was due to the high abundance of microcrustaceans (Cladocera and copepods); and the high variability around the mean at this site was due to different samples having very different numbers of microcrustaceans.

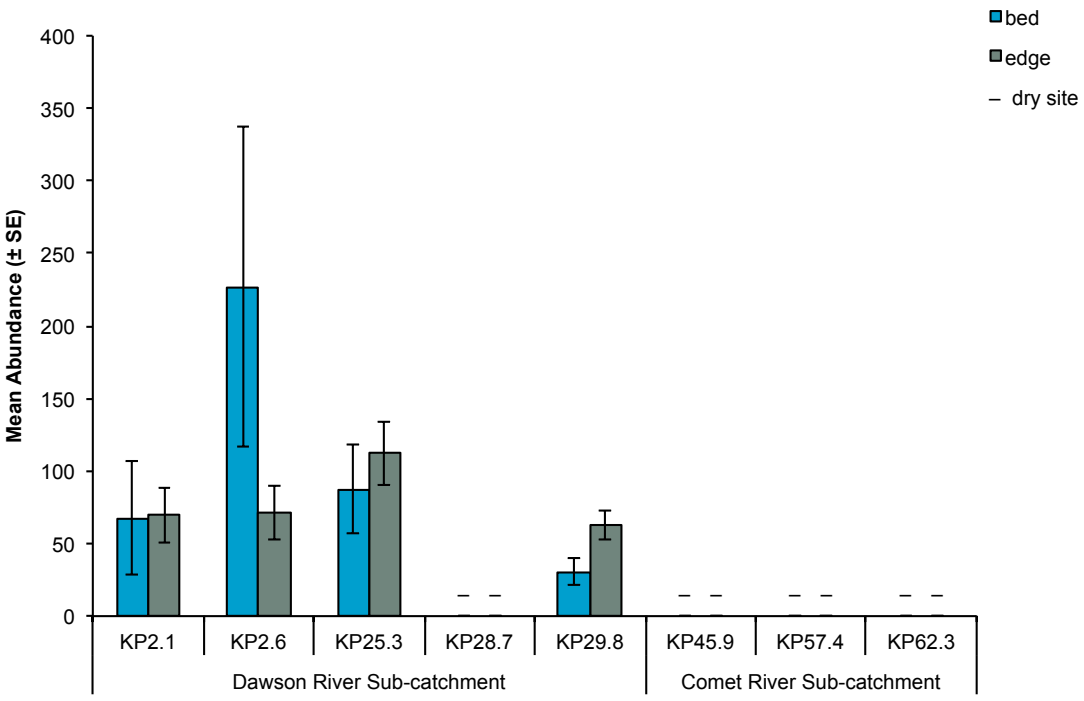


Figure 2.1 Mean abundance of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## Total Abundance

Total abundance of macroinvertebrates was highest for bed habitat at Christmas Creek (KP2.6), due to the large number of microcrustaceans at the site. Bed and edge habitats had similar abundances at Hutton Creek (KP2.1), although at all other sites containing water, edge habitat had higher abundances of macroinvertebrates than bed habitat (Figure 2.2).

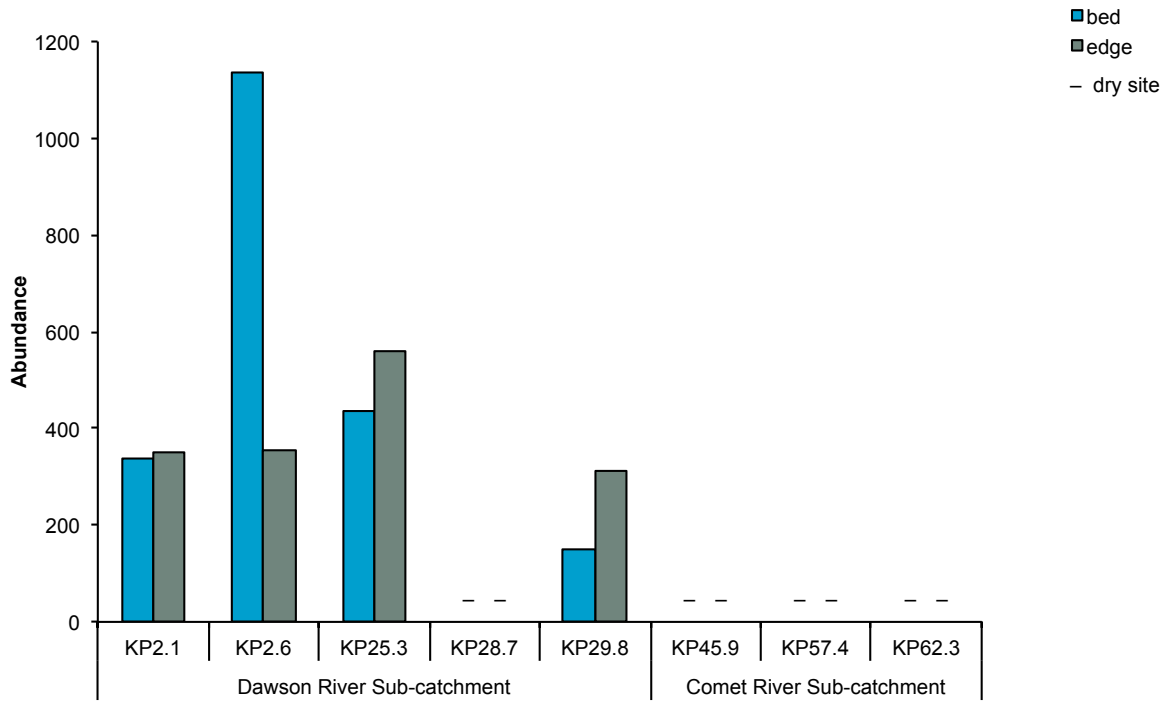


Figure 2.2 Total abundance of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## 2.2 Taxonomic Richness

### Mean Taxonomic Richness

Mean taxonomic richness was greater in edge habitat than bed habitat. All sites had comparable diversity for each habitat type (Figure 2.3). Taxonomic richness of macroinvertebrates had no obvious relationship to the overall habitat condition, indicating that changes in community composition were likely to be related to site-specific factors such as habitat availability or patchy recruitment processes of macroinvertebrates.

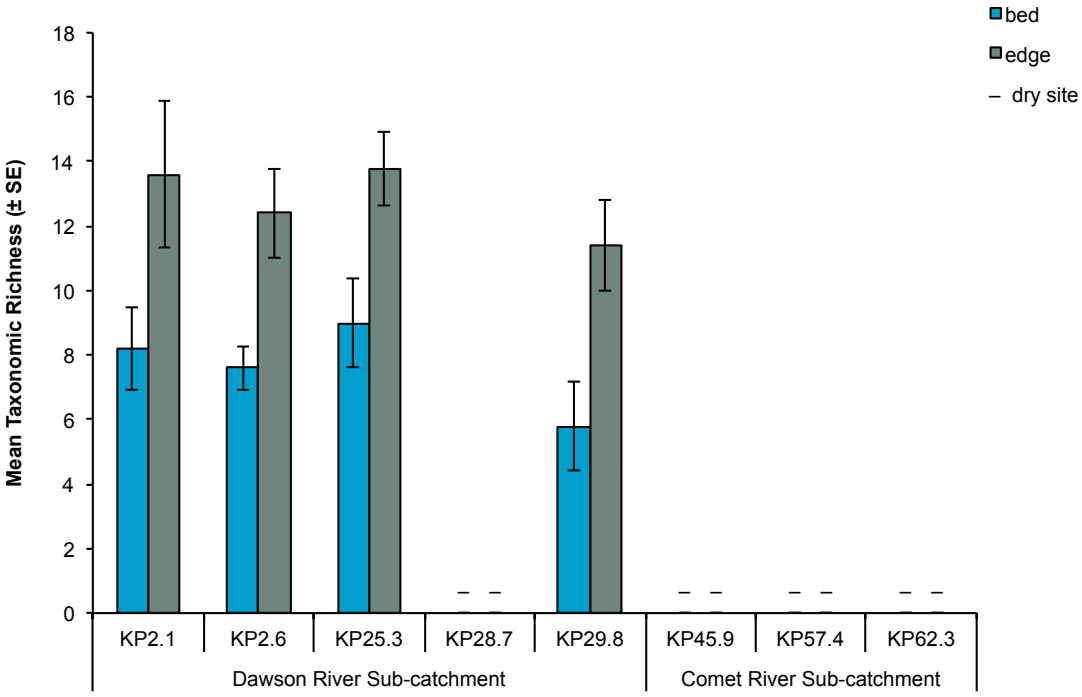


Figure 2.3 Mean taxonomic richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## Total Taxonomic Richness

Total taxonomic richness ranged from 12 to 21 taxa in bed habitat and from 21 to 33 taxa in edge habitat. Taxonomic richness was highest at Hutton Creek (KP2.1) in both bed and edge habitats. Taxonomic richness of macroinvertebrates was within the WQO range for the Fitzroy River Basin at three of the four sites in bed and in all four sites for edge habitat (Figure 2.4; Figure 2.5).

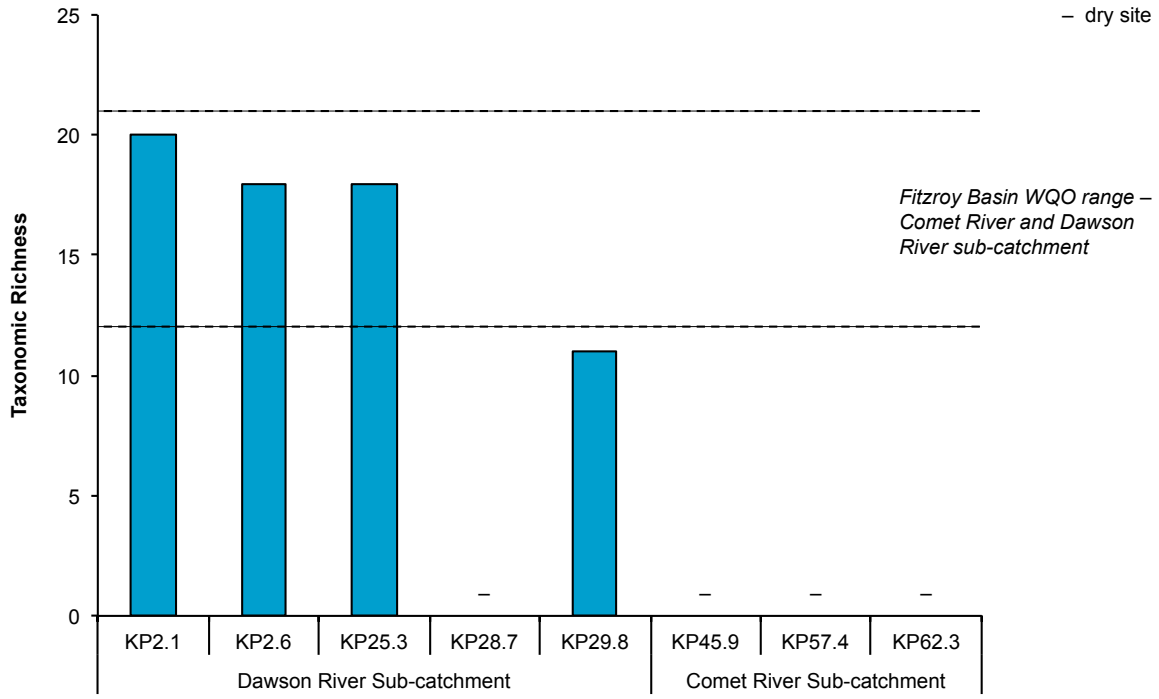


Figure 2.4 Total taxonomic richness of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP0 to KP70).

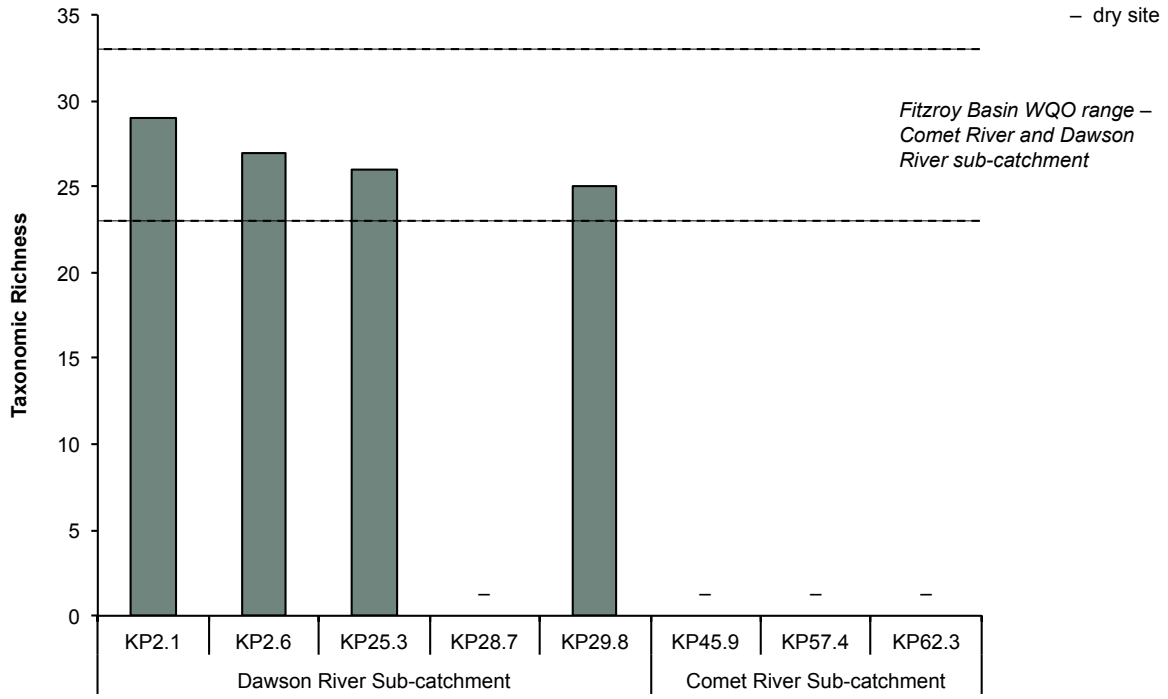


Figure 2.5 Total taxonomic richness of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## 2.3 PET Richness

### Mean PET Richness

PET taxa are sensitive to pollutants and changes in water quality, as well as habitat degradation. In both bed and edge habitat, mean PET richness was highest at Hutton Creek (KP2.1). Mean PET richness was lowest at the Dawson River (KP29.8) in bed habitat and at Christmas Creek (KP2.6) in edge habitat (Figure 2.6).

Overall, mean PET richness was higher in edge habitat than in bed habitat. Similar to other indices, PET richness was likely to be related to site-specific habitat availability and condition.

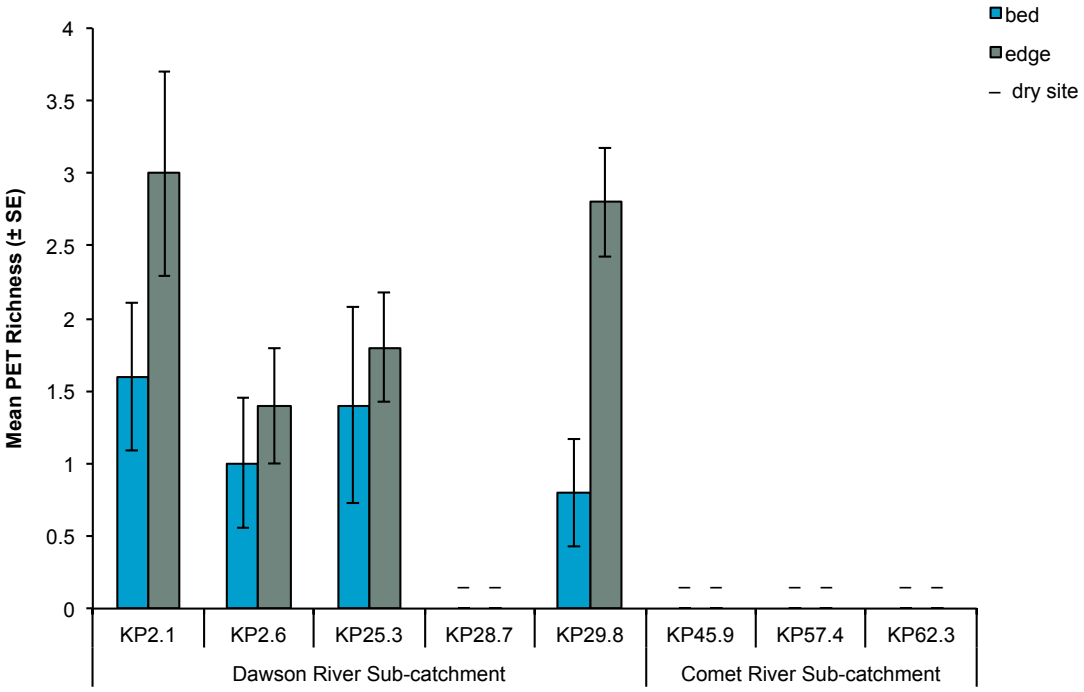


Figure 2.6 Mean PET richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## Total PET Richness

Total PET richness ranged from 2 to 4 taxa in bed habitat and from 2 to 5 taxa in edge habitat. The highest PET richness in bed habitat was at Hutton Creek (KP2.1) and Edwards Creek (KP25.3); the highest total PET richness in edge habitat was at Hutton Creek (KP2.1) and Edwards Creek (KP25.3). Total PET richness was within the Fitzroy Basin WQO range at each site.

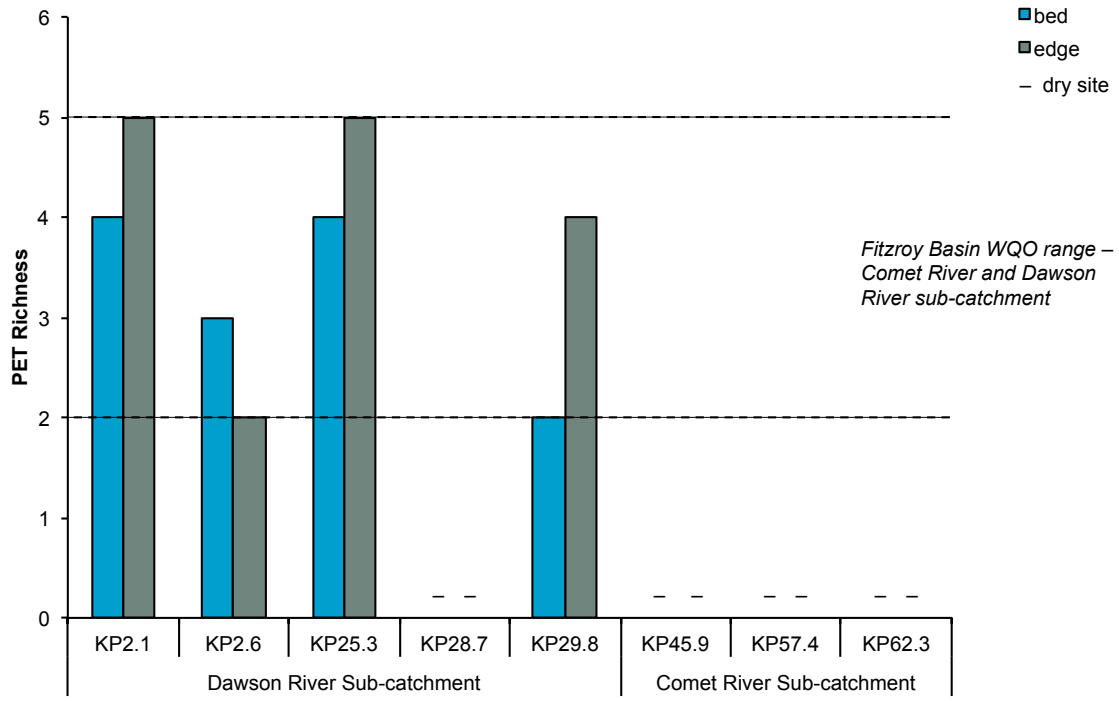


Figure 2.7 Total PET richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## 2.4 SIGNAL 2 Scores

### Mean SIGNAL 2 Scores

Mean SIGNAL 2 scores were low (<4) in bed and edge habitat. Bed and edge habitat had similar SIGNAL 2 scores at most sites (Figure 2.8).

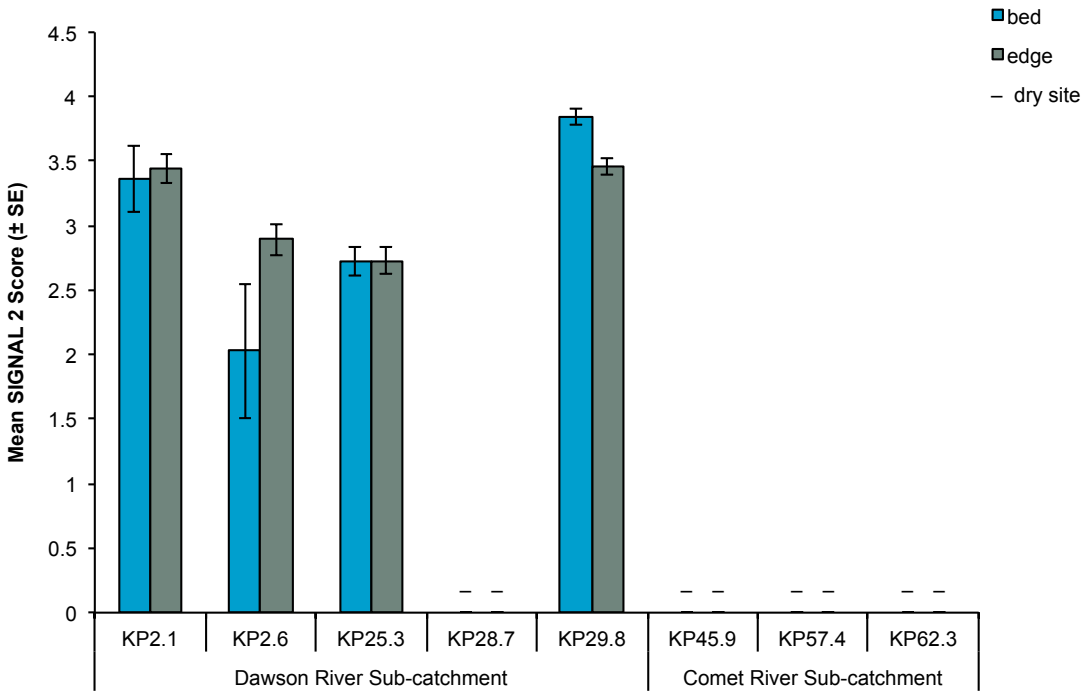


Figure 2.8 Mean SIGNAL 2 scores of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## Total SIGNAL 2 Scores

SIGNAL 2 scores ranged from 2.4 to 3.6 in bed habitat and from 2.7 to 3.7 in edge habitat. Total SIGNAL 2 scores were generally lower than the Fitzroy Basin WQO for bed habitat (Figure 2.9), and only half the sites were within the WQO for edge habitat (Figure 2.10).

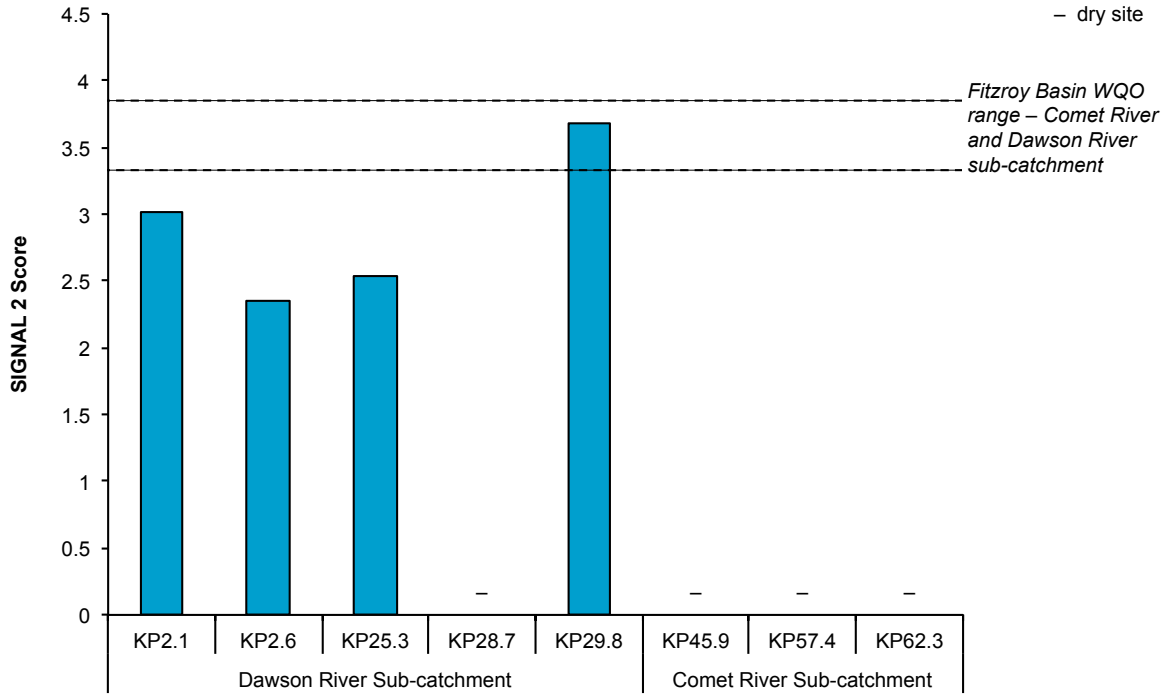


Figure 2.9 Total SIGNAL 2 scores of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP0 to KP70).

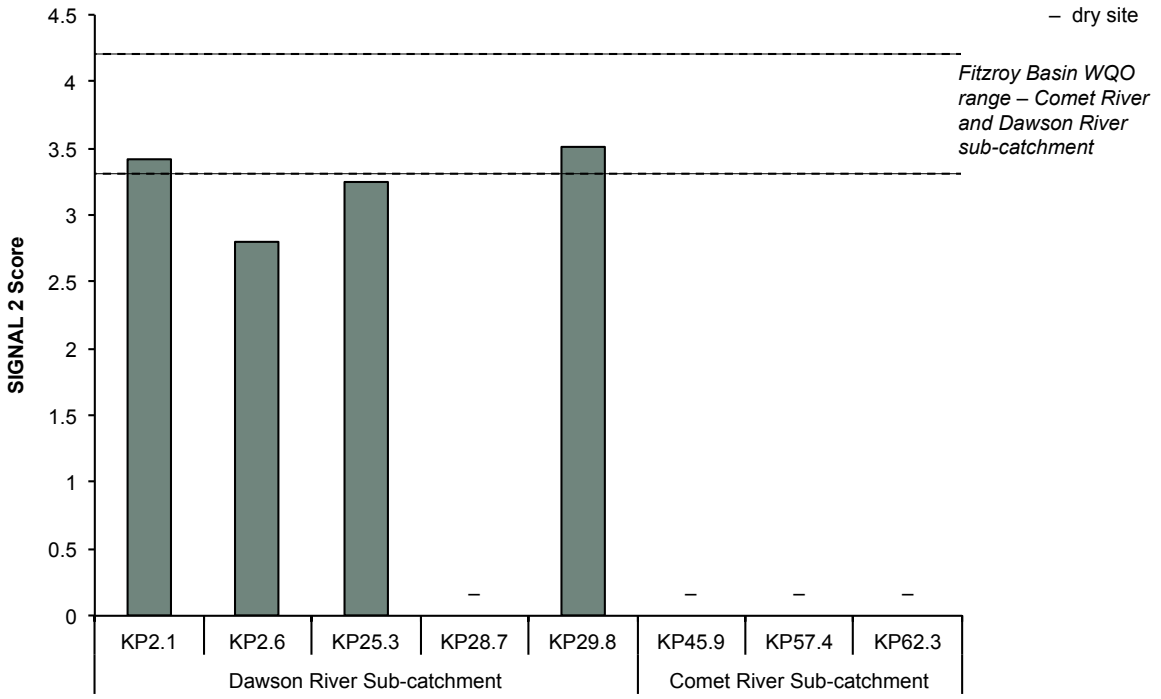


Figure 2.10 Total SIGNAL 2 scores of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plot for bed habitat showed:

- three sites [Hutton Creek (KP2.1), Christmas Creek (KP2.6) and Edwards Creek (KP25.3)] were in quadrant 2, which indicates high salinity or high nutrients, and
- one site [Dawson River (KP29.8)] in quadrant 3, which indicates pollution or harsh physical conditions (Figure 2.11).

The SIGNAL 2/ family bi-plot for edge habitat showed that:

- two sites [Hutton Creek (KP2.1) and Dawson River (KP29.8)] were in quadrant 1, which indicates favourable habitat and water quality for macroinvertebrates, and
- two sites [Christmas Creek (KP2.6) and Edwards Creek (KP25.3)] were in quadrant 2, which indicates high salinity or high nutrients (Figure 2.12).

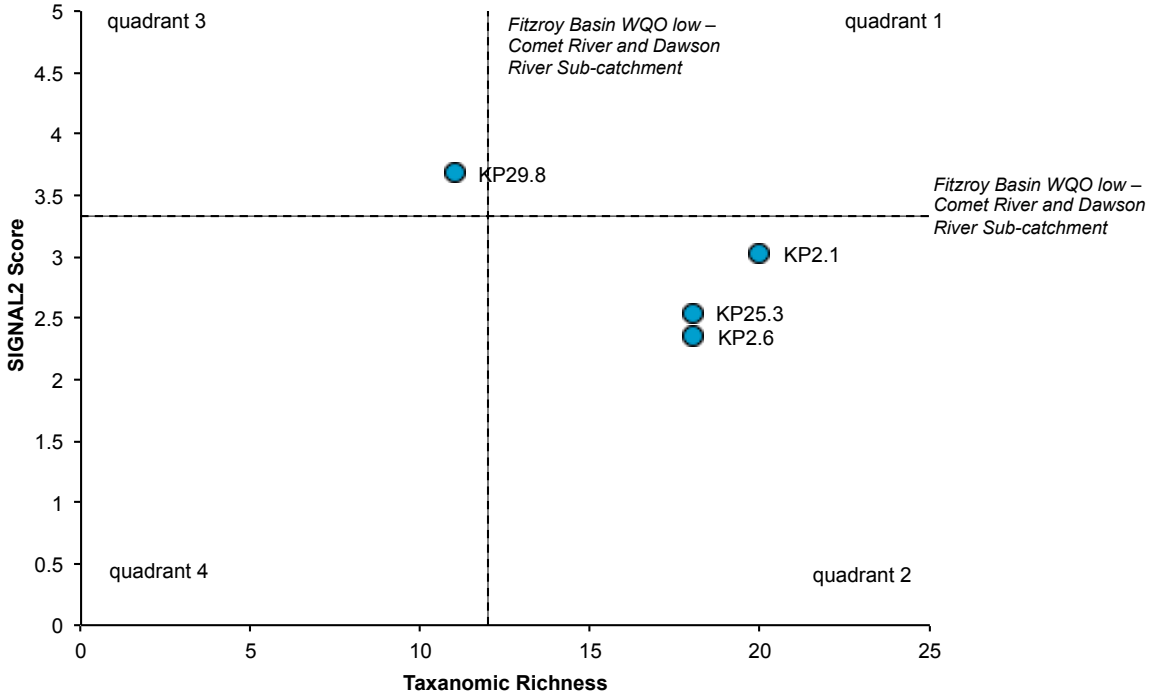


Figure 2.11 SIGNAL 2 / family bi-plot of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP0 to KP70).

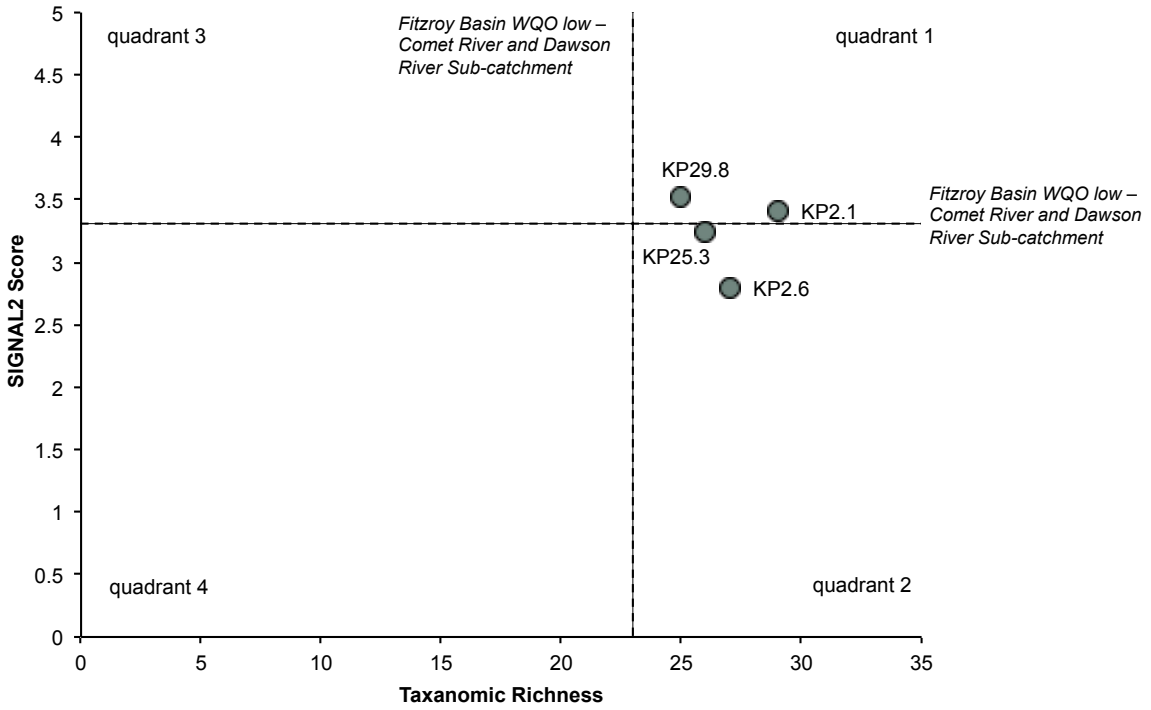


Figure 2.12 SIGNAL 2 / family bi-plot of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP0 to KP70).

## 2.5 Community Composition

### Bed Habitat

Macroinvertebrate community composition in bed habitat varied between sites (ANOSIM Global R statistic=0.632, p<0.001), although within-site variation was also high, indicated by the spread of samples from each of the sites in the nMDS plot (Figure 2.13). The differences in community structure between sites might be related to site-specific habitat availability and condition and patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, p<0.05), except between Hutton Creek (KP2.1) and the Dawson River (KP29.8). SIMPER analyses showed that these two sites had an average dissimilarity in their macroinvertebrate communities in bed habitat of 58%; all other pair-wise site combinations had average dissimilarity of macroinvertebrate communities of greater than 70%. Taxa that most commonly contributed the greatest to dissimilarity in macroinvertebrate communities between sites included yabbies (family Palaemonidae), shrimp (family Atyidae), microcrustaceans and non-biting midge larvae (sub-family Chironominae). Other tolerant taxa, and the PET taxa, contributed to a lesser extent to between site dissimilarity in macroinvertebrate communities in bed habitat.

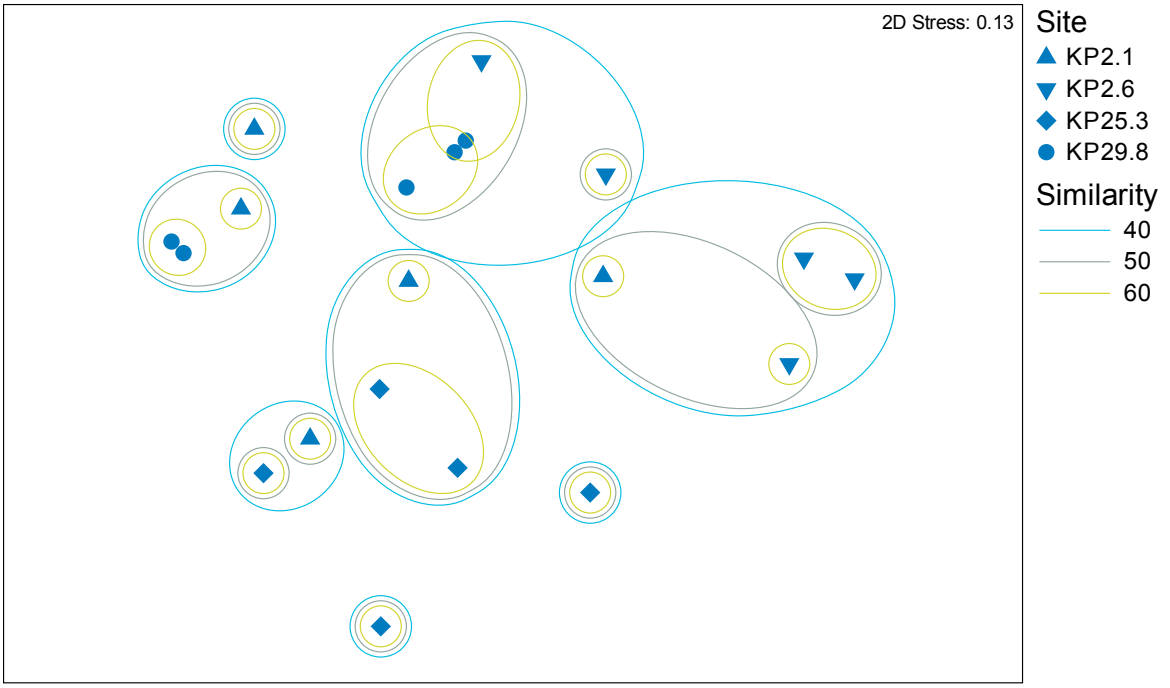


Figure 2.13 Non-metric multidimensional scaling ordination in bed habitat.

## Edge Habitat

Macroinvertebrate community composition in edge habitat varied between sites (ANOSIM Global R statistic=0.511, p<0.001) although within-site variation was also commonly high, indicated by the spread of samples from most sites in the nMDS plot (Figure 2.14). Similar to bed habitat, the differences in community structure between sites might be related to site-specific habitat availability and condition. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, p<0.05), except between Hutton Creek (KP2.1) and the Dawson River (KP29.8). SIMPER analyses showed that these two sites had an average dissimilarity in their macroinvertebrate communities in edge habitat of 55%; all other pair-wise site combinations had average dissimilarity of macroinvertebrate communities of greater than 65%. Taxa that most commonly contributed the greatest to dissimilarity in macroinvertebrate communities between sites were similar to bed habitat and included yabbies, shrimp and non-biting midge larvae (sub-family Tanypodinae). Other tolerant taxa, and the PET taxa, contributed to a lesser extent to between site dissimilarity in macroinvertebrate communities in edge habitat.

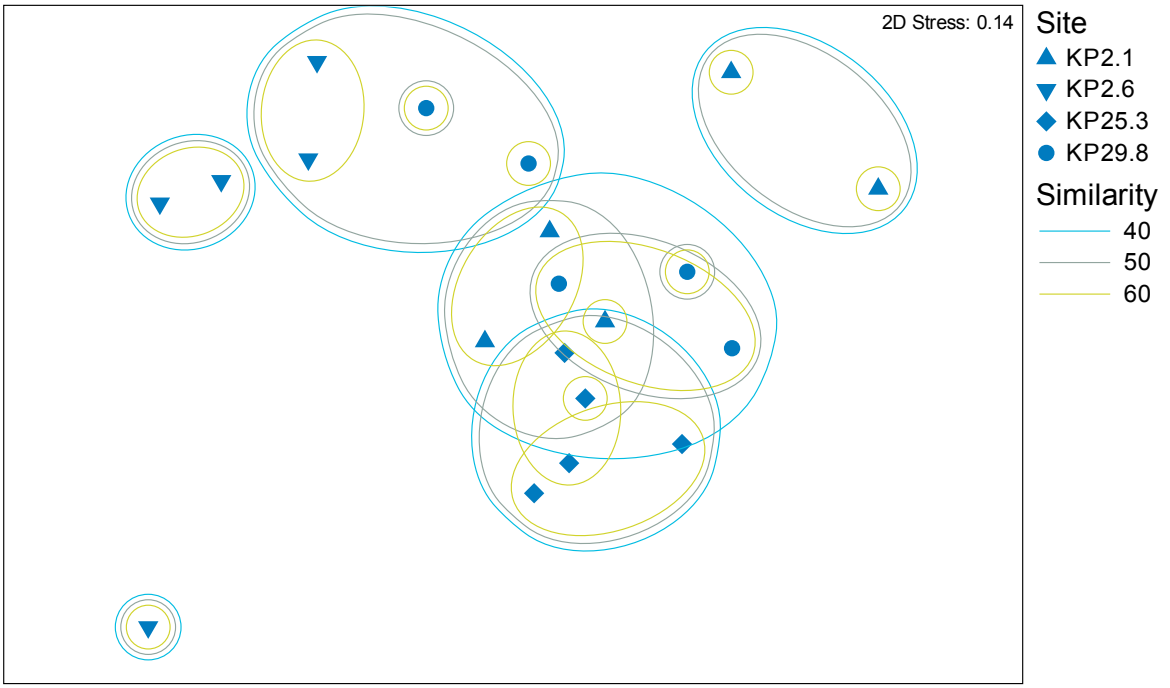


Figure 2.14 Non-metric multidimensional scaling ordination in edge habitat.

## 2.6 Macrocrustaceans

Three macrocrustacean taxa were caught:

- freshwater prawn (*Macrobrachium australiense*)
- freshwater glass shrimp (family Atyidae, genus *Caridina*) (Figure 2.15), and
- yabbies (*Cherax destructor)* (Figure 2.16).

Figure 2.15

Freshwater glass shrimp caught in the Dawson River sub-catchment.



Figure 2.16

Yabby caught in the Dawson River sub-catchment.



The most abundant and widespread species caught was the freshwater prawn, which were caught at all five sites that contained water.

Table 2.1 Abundance of macrocrustaceans at each site along the GLNG pipeline (KP70 to KP200).

| **Family** | **Dawson River Sub-catchment** | | | | **Total** |
|---|---|---|---|---|---|
| Common Name | **KP2.1** | **KP2.6** | **KP25.3** | **KP29.8** | |
| **Atyidae** | | | | | |
| Freshwater shrimp | 20 | – | – | 128 | **148** |
| **Palaemonidae** | | | | | |
| Freshwater prawn | 245 | 33 | 54 | 226 | **676** |
| **Parastacidae** | | | | | |
| yabby | – | 2 | – | – | **3** |
| **Total** | **265** | **35** | **54** | **354** | **827** |

The yabby (*Cherax destructor*) is listed as vulnerable on the International Union for Conservation of Nature and Resources (IUCN) Red List of Threatened Species, but is not listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), or Queensland's *Nature Conservation Act 1992*.

No species, listed under the EPBC Act or Queensland's *Nature Conservation Act 1992,* were caught.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Data on macroinvertebrate communities was obtained from the Department of Environment and Heritage (DEHP) site 130302A (Dawson River at Taroom) from 1994 to 2004. Taxonomic richness was between 17 and 32 individuals in edge habitat and between 7 and 25 individuals in pool habitat (sandy and rocky), which was similar to taxonomic richness in the current wet season survey.

The PET richness in the Dawson River at Taroom was between one and six individuals in edge and pool habitats. This was similar to PET richness in the current survey, indicating that PET richness is similar at other sites throughout the region.

Macroinvertebrate communities in edge habitat in the Dawson River were within quadrants 1 and 2 of the family bi-plot. Macroinvertebrate communities in bed habitat in the Dawson River were within quadrants 2 and 4, indicating that there are potentially large differences in the quality of water and / or habitat condition (e.g. sedimentation of bed habitats). Overall, surrounding land uses are likely to impact macroinvertebrate communities in the catchment.

## 3.2 Dawson River Sub-catchment

The former Queensland Department of Natural Resources and Water sampled macroinvertebrates from the Comet River sub-catchment between 1995 and 1998. The richness of macroinvertebrate communities varied over time and between locations, and ranged from 21 to 29 individuals in edge habitat and 15 to 26 individuals in bed habitat, which is consistent with the results of the current study.

The PET richness from bed and edge habitats in the Brown and Comet Rivers are indicative of a healthy habitat and / or water quality. Similar to the current study, macroinvertebrate communities in the Brown and Comet Rivers displayed clustering within quadrants 2, indicating that communities are affected by high nutrients and / or salinity.

# 4 References

Chessman, B., 2003. *Signal 2 A Scoring System for Macro-Invertebrates ('water-bugs') in Australian Rivers*. Monitoring River Health Initiative Technical Report Number 31. Commonwealth of Australia, Canberra.

Clarke, K.R., 1993, 'Non-parametric multivariate analyses of changes in community structure', *Australian Journal of Ecology* 18: 117-143.

DERM, 2011. *Developing Water Quality Guidelines for the Protection of the Freshwater Aquatic Ecosystems in the Fitzroy Basin – Phase 1*. Department of Environment and Resource Management, Brisbane.

EHMP, 2007. *Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report*. South East Queensland Healthy Waterways Partnership, Brisbane.

# Appendix E Freshwater Fish

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# 1 Survey Design and Methods

## 1.1 Data Collection

Fish communities were surveyed using a combination of backpack electrofishing, baited traps, and seine and dip nets (Table 1.1). Fish communities were assessed at four of the eight sites, as the following sites were dry:

- KP28.7
- KP45.9
- KP57.4, and
- KP62.3.

All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root LR-24 backpack electrofisher in shallow water. At sites where the conductivity of the water was too low or too high to effectively electrofish, or the water level was too low, fish communities were surveyed with a seine and dip nets with a 20 to 50 mm mesh size.

Fish communities were also surveyed with five small (2 mm mesh size) baited traps, which were set at each site for approximately a minimum of two hours. Bait traps were not set at sites where water level was too low.

Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification.

The sampling of fishes was conducted under General Fisheries Permit No. 153223 and Animal Ethics Approval No. CA 2012/02/593 issued to frc environmental.

Table 1.1 Electrofishing and net efforts for fish surveys.

| Site | Method | Habitat | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|---|
| **Dawson River Sub-catchment** | | | | | | | |
| KP2.1 | seine net | pool | 21/02/12 | – | – | – | 2 x 10 m |
| | box traps (5) | | | 0815 | 1030 | – | 11.25 hr |
| | opera traps (1) | | | 0815 | 1030 | – | 2.25 hr |
| | backpack electrofishing | | | 0955 | 1010 | 150 V | 59 s |
| | | | | | | 30 Hz | |
| | | | | | | 12 % | |
| KP2.6 | seine net | pool | 21/02/12 | – | – | – | 1x 10 m, 1x 20 m |
| | box traps (5) | | | 1110 | 1310 | – | 10 hr |
| | opera traps (1) | | | 1110 | 1310 | – | 2 hr |
| KP25.3 | box traps (5) | pool | 21/02/12 | 1600 | 1700 | – | 1 h |

## 1.2 Data Analysis

Fish communities at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage
- abundance of exotic species, and
- abundance of listed protected species.

## 1.3 Regional and Ecological Perspective

The literature on fish communities in the Dawson River and Coment River sub-catchments was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

Five native species of fish were caught at sites along the GTP ROW between KP0 and KP70 (Table 2.1):

- Spangled perch (*Leiopotherapon unicolor*) (Figure 2.1)
- Eastern rainbowfish (*Melanotaenia splendida*) (Figure 2.2)
- Carp gudgeons (*Hyspeleotris* spp.) (Figure 2.3)
- Glass perchlets (*Ambassis agassizii*) (Figure 2.4), and
- Bony bream (*Nematolosa erebi*) (Figure 2.5).

The exotic goldfish (*Carassius auratus*) was also recorded from Huton Creek (Figure 2.6).

Figure 2.1

Spangled perch from Christmas Creek (KP2.6).



Figure 2.2

Eastern rainbowfish from Dawson River (KP29.8).



Figure 2.3

Carp gudgeon from Dawson River (KP29.8).



Figure 2.4

Glass perchlet from Hutton Creek (KP2.1).

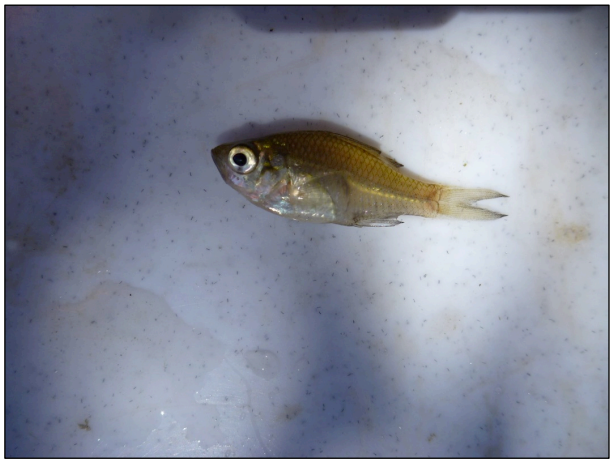

Figure 2.5

Bony bream from Dawson River (KP29.8).



Figure 2.6

Goldfish from Hutton Creek (KP2.1).



## 2.1 Abundance

The abundance of fish varied between sites. Fish were most abundant at Hutton Creek (KP2.1) and the Dawson River (KP29.8), where the catch was dominated by carp gudgeons (*Hypseleotris* spp.) and eastern rainbowfish (*Melanotaenia splendida*). There were no fish at Edwards Creek (KP25.3) (Figure 2.7; Table 2.1). The composition and abundance of fish communities in ephemeral waterways, such as those in this survey, are known to be highly variable both spatially and temporally.

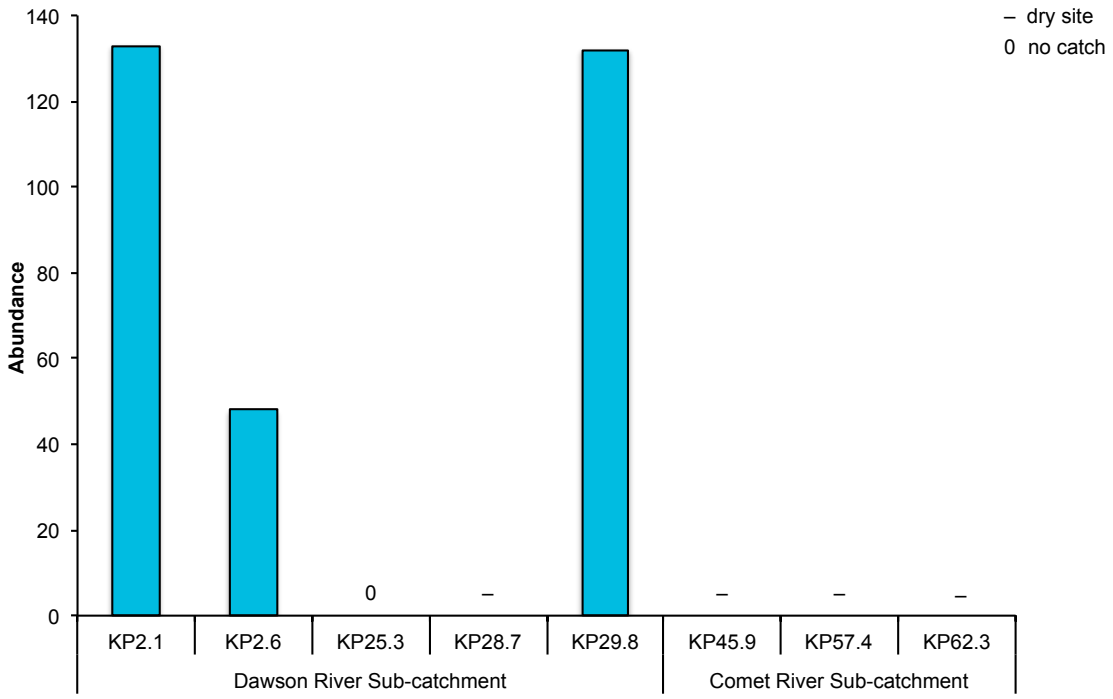


Figure 2.7 Abundance of fish at each site along the GLNG pipeline (KP0 to KP70).

Table 2.1 Abundance of each fish species at each site along the GLNG pipeline (KP0 to KP70).

| Species | Common Name | Dawson River Sub-catchment | | | Total |
|---|---|---|---|---|---|
| | | KP2.1 | KP2.6 | KP29.8 | |
| *Ambassis agassizii.* | glassfish | 3 | 8 | – | **11** |
| *Carassius auratus* | goldfish | 1 | – | – | **1** |
| *Hypseleotris* spp. | carp gudgeon | 53 | 9 | 87 | **149** |
| *Leiopotherapon unicolor* | spangled perch | – | 2 | – | **2** |
| *Melanotaenia splendida* | eastern rainbowfish | 76 | 29 | 14 | **135** |
| *Nematalosa erebi* | bony bream | – | – | 31 | **37** |
| | **Total** | **133** | **48** | **132** | **335** |

## 2.2 Taxonomic Richness

Taxonomic richness varied between sites. The fish community was most diverse at Hutton Creek (KP2.1) and Christmas Creek (KP2.6), although an exotic species (goldfish) was recorded from Hutton Creek. The fish community was least diverse at the Dawson River (KP29.8), of the sites that had fish present (Figure 2.8). The low number of species at some sites may reflect the ephemeral nature of the watercourses surveyed.

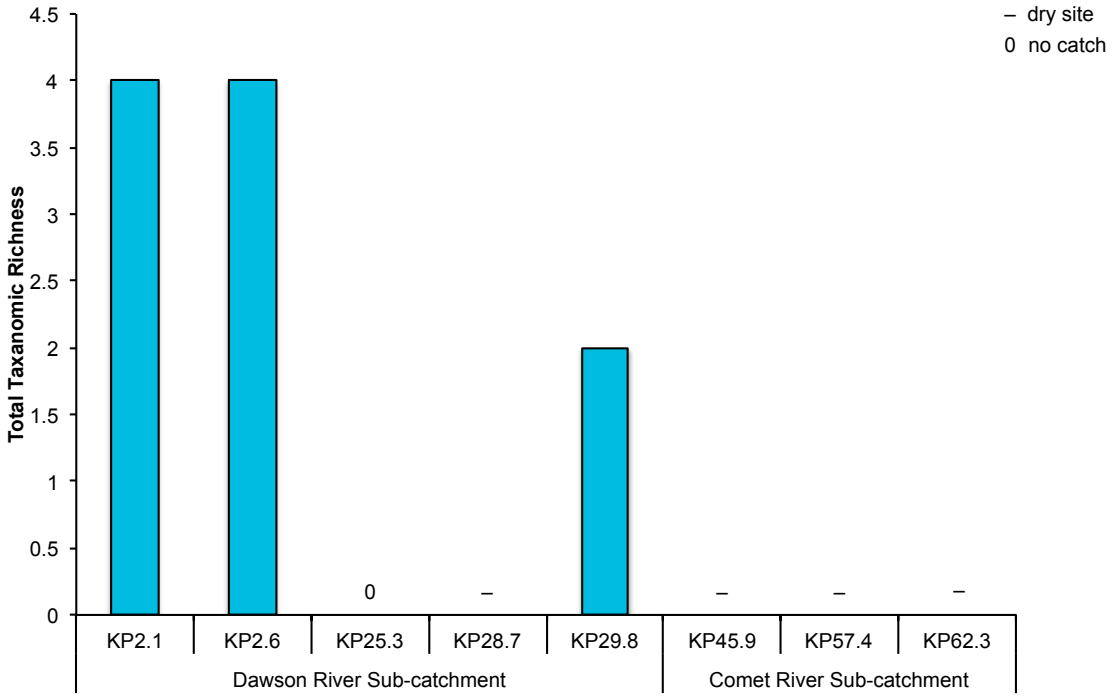


Figure 2.8 Taxonomic richness of fish at each site along the GLNG pipeline (KP0 to KP70).

## 2.3 Life-history Stages

The abundance of each life-history stage varied between sites. The juvenile and intermediate life-history stages dominated fish communities (Figure 2.9). Due to the fast growth rates (i.e. maturation periods within 12 months) of most of species in the survey area, this is the expected distribution of life-history stages. That is, most species breed in autumn and summer, so in February / March most juveniles had developed to the intermediate life-history stage. However, a relatively large proportion of juveniles were observed at some sites, especially the Dawson River (KP29.8). This could be related to the heavy late wet season rainfall and associated high water levels in these watercourses.

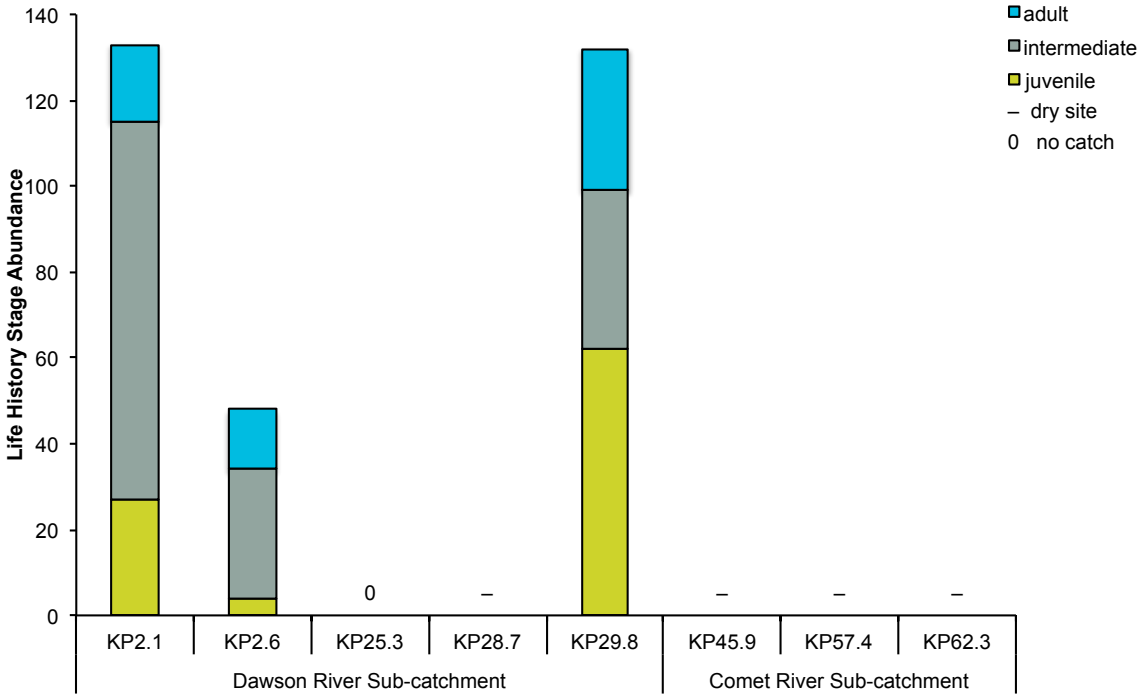


Figure 2.9 Life-history stages of fish at each site along the GLNG pipeline (KP0 to KP70).

## 2.4 Exotic Species

A single goldfish was caught at Hutton Creek (KP2.1). Goldfish are listed as non-indigenous species in Schedule 6 of Queensland's Fisheries Regulation 2008. Exotic species were not caught at the other sites.

## 2.5 Listed Species of Conservation Significance

No species listed under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* were caught in this survey.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Twenty species from 12 families have been recorded in the Dawson River sub-catchment. Berghuis and Long (1999) sampled two sites in the upper Dawson River during surveys of the Fitzroy Basin undertaken between 1994 and 1996, and caught 775 fish comprising ten species. More recently, in a dry season survey of four sites in the Dawson River sub-catchment, 267 fishes comprising eight species were caught (frc environmental 2007); and in a wet season survey of eight sites, a total of 481 fish comprising 20 species were caught. In dry season surveys in the Dawson River sub-catchment, 316 fishes comprising nine species were caught (frc environmental 2008). During the GLNG EIS, 255 species comprising seven species were caught in the upper Dawson River sub-catchment (frc environmental 2009). The species of fish caught in these surveys are listed in Table 3.1.

The most abundant fish species caught in the Dawson River sub-catchment in these surveys were bony bream (*Nematolosa erebi*), carp gudgeons (*Hypseleotris* spp.) and eastern rainbowfish (*Melanotaenia splendida*) (Berghuis & Long 1999; frc environmental 2009). The most abundant fish species caught along the GLNG pipeline (KP0–70) were:

- eastern rainbowfish (*Melanotaenia splendida*), and
- carp gudgeons.

Surveys completed by the Department of Primary Industries and Fisheries (Berghuis & Long 1999) did not report any exotic species in the Dawson River sub-catchment, although they were recorded in the Fitzroy Basin. Guppies were caught in an urban creek near Rockhampton. Goldfish were also seen (but not caught) near Rockhampton (Berghuis & Long 1999). Since then, goldfish have been caught in Juandah Creek and the Dawson River (Ecowise 2008; frc environmental 2008), and mosquitofish were caught in the Dawson River in November 2007 and June 2008 (frc environmental 2007; Ecowise 2008), as well as in the current surveys. Mosquitofish are declared noxious species in Queensland under the Fisheries Regulation 2008. Goldfish and guppies are listed as a non-indigenous fish under the Fisheries Regulation 2008.

No species recorded in the catchment is listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992*.

Table 3.1 Fish species known from the Dawson River sub-catchment, and their presence / abundance in the current survey area.

| Family<br>*Species* | Common Name | Dawson River Sub-catchment | Current Survey |
|---|---|---|---|
| **Ambassidae** | | | |
| *Ambassis agassizii* | Agassiz's glassfish | ✓ | ✓ |
| **Antherinidae** | | | |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | ✓ | – |
| **Clupeidae** | | | |
| *Nematolosa erebi* | bony bream | ✓ | ✓ |
| **Cyprinidae** | | | |
| *Carassius auratus* [a] | goldfish | ✓ | ✓ |
| **Eleotridae** | | | |
| *Hypseleotris* spp. | common carp gudgeon | ✓ | – |
| *Mogurnda adspersa* | purple spotted gudgeon | ✓ | – |
| *Oxyeleotris lineolata* | sleepy cod | ✓ | – |
| *Philypnodon grandiceps* | flathead gudgeon | ✓ | – |
| **Melanotaeniidae** | | | |
| *Melanotaenia splendida* | eastern rainbowfish | ✓ | ✓ |
| **Osteoglossidae** | | | |
| *Scleropages leichardti* | southern saratoga | ✓ | – |
| **Percichthyidae** | | | |
| *Macquaria ambigua oriens* | golden perch | ✓ | – |
| **Plotosidae** | | | |
| *Neosilurus hyrtlii* | Hyrtl's tandan | ✓ | – |
| *Porochilus rendahli* | Rendahl's catfish | ✓ | – |
| *Tandanus tandanus* | freshwater catfish | ✓ | – |
| **Poeciliidae** | | | |
| *Gambusia holbrooki* [a] | mosquitofish | ✓ | – |
| *Poecilia reticulata* [b] | guppy | ✓ | – |

| Family<br>*Species* | Common Name | Dawson River Sub-catchment | Current Survey |
|---|---|---|---|
| **Pseudomugilidae** | | | |
| *Pseudomugil signifer* | pacific blue eye | ✓ | – |
| **Terapontidae** | | | |
| *Leiopotherapon unicolor* | spangled perch | ✓ | ✓ |
| *Scortum hillii* | leathery grunter | ✓ | – |

Sources: (Berghuis & Long 1999; frc environmental 2007; Marsden & Power 2007; Ecowise 2008; frc environmental 2008; 2009)

[a] exotic non-indigenous species, declared noxious under the Fisheries Regulation 2008

[b] exotic non-indigenous species

## 3.2 Comet River Sub-catchment

The Queensland Department of Primary Industries and Fisheries (DPI&F) surveyed one site in the Comet River and 207 fishes comprising eight species were caught, all of which were native (Berghuis & Long 1999). Eastern rainbowfish and spangled perch were the most abundant species caught in this study (Berghuis & Long 1999). A survey of eight sites in the Rolleston region by frc environmental (frc environmental 2004) reported spangled perch in Bootes and Meteor Creeks, both tributaries of the Comet River. These species were also recorded in the Comet River sub-catchment during the GLNG EIS (frc environmental 2008), and fly-specked hardyhead and purple spotted gudgeon were also found. None of these studies, nor the current survey, recorded any exotic species in the Comet River sub-catchment. The species of fish caught in these surveys are listed in Table 3.2.

Table 3.2 Fish species known from the Comet River sub-catchment, and their presence / abundance in the current survey area.

| **Family**<br>Species | **Common Name** | **Comet River sub-Catchment** | **Current Survey** |
|---|---|---|---|
| **Ambassidae** | | | |
| *Ambassis agassizii* | Agassiz's glassfish | ✓ | – |
| **Atherinidae** | | | |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | ✓ | – |
| **Clupeidae** | | | |
| *Nematalosa erebi* | bony bream | ✓ | – |
| **Eleotridae** | | | |
| *Hypseleotris compressa* | empire gudgeon | ✓ | – |
| *Hypseleotris* spp. | common carp gudgeon | ✓ | ✓ |
| *Mogurnda adspersa* | purple spotted gudgeon | ✓ | ✓ |
| *Oxyeleotris lineolatus* | sleepy cod | ✓ | – |
| **Melanotaeniidae** | | | |
| *Melanotaenia sp.* | rainbowfish | | |
| *Melanotaenia splendida* | eastern rainbowfish | ✓ | ✓ |
| **Plotosidae** | | | |
| *Tandanus tandanus* | eel-tailed catfish | ✓ | – |
| *Neosilurus hyrtlii* | Hyrtl's tandan | ✓ | – |
| **Terapontidae** | | | |
| *Leiopotherapon unicolor* | spangled perch | ✓ | ✓ |
| *Scortum hillii* | leathery grunter | ✓ | – |

Sources: (Berghuis & Long 1999; frc environmental 2004; 2008; 2009)

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# Appendix F Freshwater Turtles

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# 1 Survey Design and Methods

## 1.1 Field Sampling

Turtle traps were set at sites where the water was deep enough to provide suitable turtle habitat and the allow use of cathedral traps. These sites were:

- Hutton Creek (KP2.1), and
- Dawson River (KP29.8).

Turtle traps were not set where the site was dry or the water level was too low, or where access was too dangerous to take turtle traps, such as Baffle Creek (KP20.4).

Four baited cathedral traps were set along the bank and next to cover (e.g. vegetation and snags) for four hours. The design of the traps was similar to traps used by the Department of Environment and Heritage Protection's (DEHP) turtle research group. The traps had a series of collapsible chambers (approximately 3.5 m in height and 0.7 m in diameter) and two, one-way entrances in the lower baited chamber. Traps were set so that the top of the chamber allowed turtles access to the surface to breathe. Traps were closely monitored to ensure that no turtles or other air-breathing species were entangled or trapped below the surface. The sampling of turtles was conducted under Animal Ethics Approval No. CA 2012/02/593 and QLD Scientific Purposes Permit WISP05080608 issued to frc environmental. Observations for turtles were made at all sites while electrofishing.

## 1.2 Data analysis

Turtles at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site), and
- abundance of listed protected species.

## 1.3 Regional and Ecological Perspective

The literature on fish turtle in the Dawson River and Comet River sub-catchment was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

Freshwater turtles were not caught in the Dawson River (KP29.8), but the following turtles were caught at Hutton Creek (KP2.1):

- 6 Krefft's river turtle (*Emydura macquarii krefftii*) – 4 male, 2 female (Figure 2.1), and
- 1 female saw-shelled turtle (*Wollumbinia latisternum*) (Figure 2.2).

These species are not listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or Queensland's *Nature Conservation Act 1992*, as listed under the Nature Conservation (Wildlife) Regulation 2006 (NCWR).

The carapace length of the Krefft's river turtles ranged from 160 mm to 255 mm. The carapace length of the saw-shelled turtle was 165 mm.

Figure 2.1

Krefft's river turtle caught at Hutton Creek (KP2.1).



Figure 2.2

Saw-shelled turtle caught at Hutton Creek (KP2.1).



## 2.1 Habitat for Turtles

While turtles were not caught at the Dawson River (KP29.8), this site had suitable habitat for turtles. The Dawson River had large deep pools, similar to the pool habitat at Hutton Creek where Krefft's river turtles and saw shelled turtles were caught.

# 3 Regional and Ecological Perspective

The Fitzroy River Basin has a high conservation value with respect to freshwater turtles, as there are several species endemic to the region. Six species have been recorded in the Fitzroy River Basin, with all six also having been recorded in the Dawson River sub-catchment (Limpus et al. 2007):

- Krefft's river turtle (*Emydura macquarii krefftii*)
- Fitzroy River turtle (*Rheodytes leukops*)
- white-throated snapping turtle (*Elseya albagula*)
- broad-shelled river turtle (*Chelodina expansa*)
- snake-necked turtle (*Chelodina longicollis*), and
- saw-shelled turtle (*Wollumbinia latisternum*).

The Fitzroy river turtle is listed as Vulnerable under the EPBC Act and the NCWR. The white-throated snapping turtle is not listed as a threatened species, but it is ranked as a high priority species under the DEHP's *Back on Track* species prioritisation framework.

The Fitzroy River turtle is endemic to the natural permanent riverine habitats of the Fitzroy River Basin, although it has not been recorded in the Upper Dawson River sub-catchment (Limpus et al. 2007). However, EHP's turtle group suggest that Fitzroy River turtle likey occurs further upstream in the Dawson River than Taroom, where it would inhabits reaches with deep pools, riffles and sandy banks (Tucker et al. 2001; Limpus et al. 2007). The Dawson River site (KP29.8) had marginal habitat for Fitzroy River turtles; it is difficult to determine if Fitzroy River turtle would occur this far up in the Dawson River sub-catchment.

The white-throated snapping turtle was only described in 2006 (Thomson et al. 2006); previously it had been regarded as part of the more common and widely distributed northern snapping turtle (*Elseya dentata*). Within the Fitzroy River Basin, this species occurs from the barrage on the lower Fitzroy River to the uppermost spring fed pools in the Upper Dawson, Mackenzie and Comet Catchments (Limpus et al. 2007; frc environmental 2009). The white-throated snapping turtle has been recorded almost exclusively in close association with permanent flowing stream reaches, typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and / or submerged logs and fallen trees (Haman et al. 2007). It is possible that white-throated snapping turtle occurs in several of the watercourses surveyed in the current study, such as Hutton Creek (KP2.1) and the Dawson River (KP29.8).

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Santos
GLNG Project

**APPENDIX B2 – Aquatic Values Assessment Major Watercourses KP70-200**

# Gladstone Liquefied Natural Gas (GLNG) Pipeline Project

## Aquatic Values Assessment KP70-KP200

## Document 3380-GLNG-4-1.3-0077

*Prepared for:*

**GLNG Operations Pty Ltd**

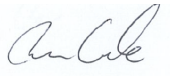
frc environmental

PO Box 2363
Wellington Point Qld 4160

Telephone: + 61 7 3286 3850
Facsimile: + 61 7 3821 7936

frc Ref: 111016

**Document Control Summary**

| | |
|---|---|
| Project No.: | 111016 |
| Status: | Report |
| Project Director: | Lauren Thorburn |
| Project Manager: | Ben Cook |
| Title: | Gladstone Liquefied Natural Gas (GLNG) Pipeline Project – Aquatic Values Assessment (KP70–KP200) |
| Project Team: | B. Cook, S. Walker, D. Holzheimer, L. West, L. James, J. Charlish, C. Forward, L. Thorburn |
| Client: | GLNG Operations Pty Ltd |
| Client Reference: | Document 3380-GLNG-4-1.3-0077 |
| Client Contact: | Angela Hampson |
| Date: | 26 October 2012 |
| Edition: | 111016Rvi |
| Checked by: | L. Thorburn _  ____ |
| Issued by: | B. Cook _  _ |

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## Summary

Gladstone Liquefied Natural Gas (GLNG) Operations Pty Ltd proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport Coal Seam Gas (CSG) from the CSG fields at Roma and Fairview to a proposed Liquefied Natural Gas (LNG) facility on Curtis Island. A condition of EIS approval for the project was the requirement for a detailed Aquatic Values Management Plan (AVMP) to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the right of way (ROW) between KP70 and KP200 to support the development of the AVMP. This Aquatic Values Assessment (AVA) presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora (macrophytes)
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

Two watercourse crossings from a previous alignment that are not within the GTP ROW (i.e. sites KP177.3 and KP177.7) are also included as comparative sites.

Overall results of the detailed field assessments showed that:

- habitat condition of waterways was poor to moderate, and five of the nine site were dry at the time of survey
- water quality was often non-compliant with Water Quality Objectives (WQOs) for turbidity, electrical conductivity and dissolved oxygen
- macrophyte diversity and cover varied among sites but were often relatively low
- macroinvertebrate taxonomic richness and abundance varied among sites and were characteristic of waterbodies with moderate water and habitat quality, or water quality with slightly high salinity or nutrient concentrations

- freshwater fish diversity and abundance reflected expected ranges for ephemeral streams of the region, and one noxious species (*Gambusia holbrooki*) was found at three sites, and
- no sites had turtles or suitable habitat for turtles.

Generic and site-specific recommendations for pipeline and road crossings of these watercourses are presented. An open trench construction method is the recommended method for all sites. The dry season is the recommended time for works to be conducted. If works are not possible during the dry season, additional controls will be necessary, including:

- restricting the timing of construction to periods of low to moderate flow
- the use of dams and flow by-passes, and
- fish salvage and water quality monitoring.

As these watercourses may retain water and aquatic life for some time into the dry season, these additional controls may also be necessary in the dry season if water is present.

# 1 Introduction

Gladstone Liquefied Natural Gas (GLNG) Operations Pty Ltd proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport Coal Seam Gas (CSG) from the CSG fields at Roma and Fairview to a proposed Liquefied Natural Gas (LNG) facility on Curtis Island. The GTP forms one component of the GLNG Project, which includes:

- exploration and production of CSG in the Surat Basin and Bowen Basin gas fields
- construction and operation of the GTP from the CSG fields to the LNG facility on Curtis Island, and
- construction and Operation of the LNG Facility.

Following evaluation of an initial Environmental Impact Statement (EIS) and a supplementary EIS, the Coordinator General (CG) advised that the GLNG Project could proceed subject to conditions. One of these conditions was the requirement for a detailed Aquatic Values Management Plan (AVMP) to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the right of way (ROW) between KP70 and KP200 to support the development of the AVMP. This Aquatic Values Assessment (AVA) presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora (macrophytes)
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

Two watercourse crossings from a previous alignment that are not within the GTP ROW (i.e. sites KP177.3 and KP177.7) are also included as comparative sites.

Subsequent AVMPs and AVAs will present the findings of aquatic ecology assessments for the remaining major watercourse crossings along the GTP ROW (i.e. KP0–KP70 and KP200–KP430).

## 1.1 The Gas Transmission Pipeline Right of Way (GTP ROW)

The study area for this AVA is the GLNG Gas Transmission Pipeline Right of Way (GTP ROW, Figure 1.1) between KP70 and KP200 (Figure 1.2). Seven major watercourse crossings (i.e. watercourses with a stream order of 3 or greater) were identified within the GTP ROW between KP 70 and KP200 from DERM wetland mapping (Table 1.1). Two sites from an old alignment of the GTP ROW )i.e. KP177.3 and KP177.7) were also included in this AVA as comparative sites, with site KP177.3 being a palustrine wetland. The GTP ROW was moved from KP177.3 to Prospect Creek RCR as a strategy to mitigate impacts on the wetland. We have included an assessment of KP187.6 in this AVA, as this site was identified as a watercourse using the Department of Environment and Heritage Protection (EHP) mapping, although topographic maps and LiDAR do not indicate a watercourse at this location.

Minor watercourse crossings between KP70 and KP200 (i.e. first and second order streams; 73 crossings in total) were not assessed as part of this AVA, as the aquatic values of these watercourse crossings were assessed by GLNG Operations Pty Ltd. These results are presented in a separate AVA for minor watercourses.

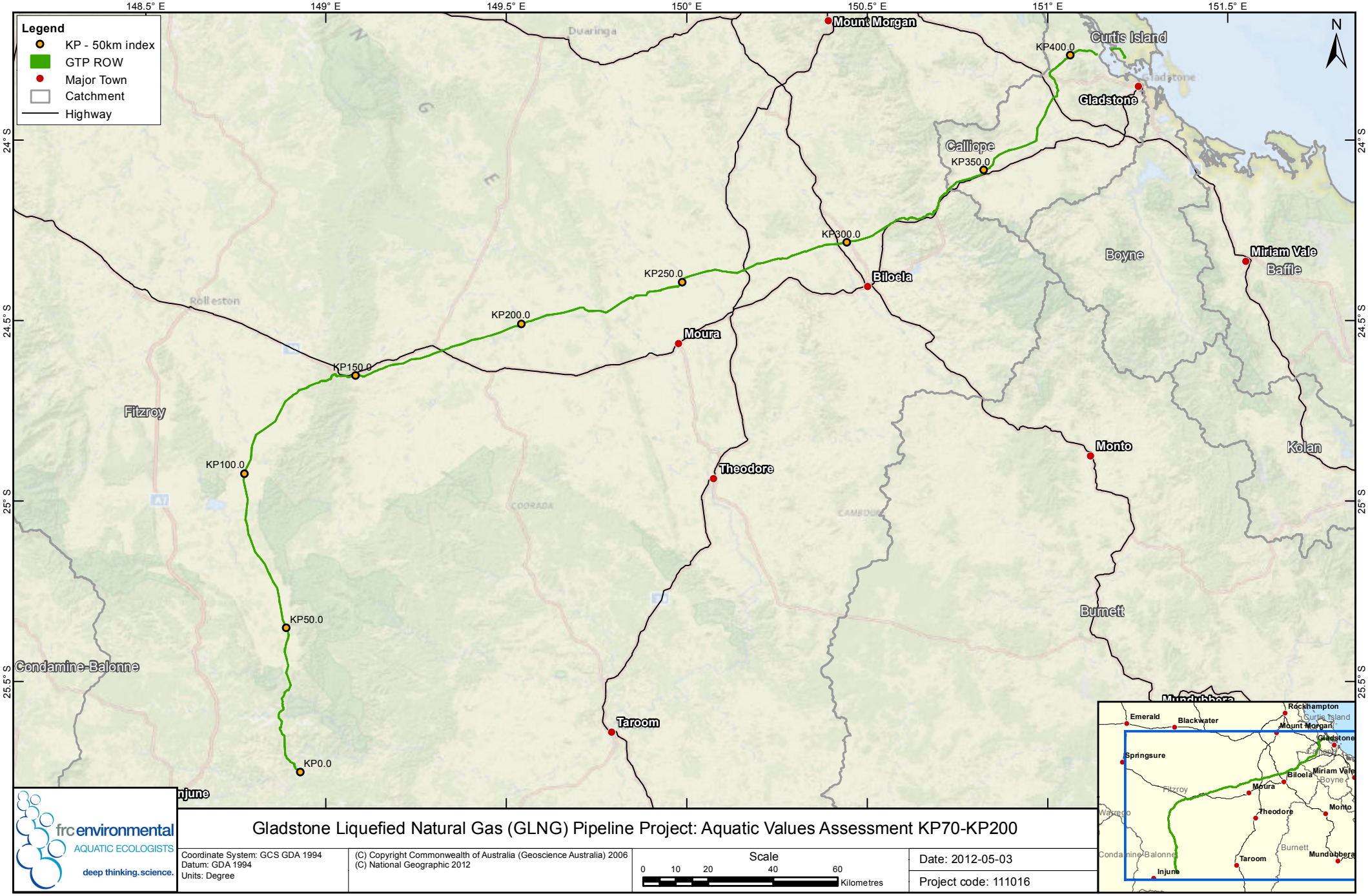


Figure 1.1 Alignment of the GLNG GTP ROW.

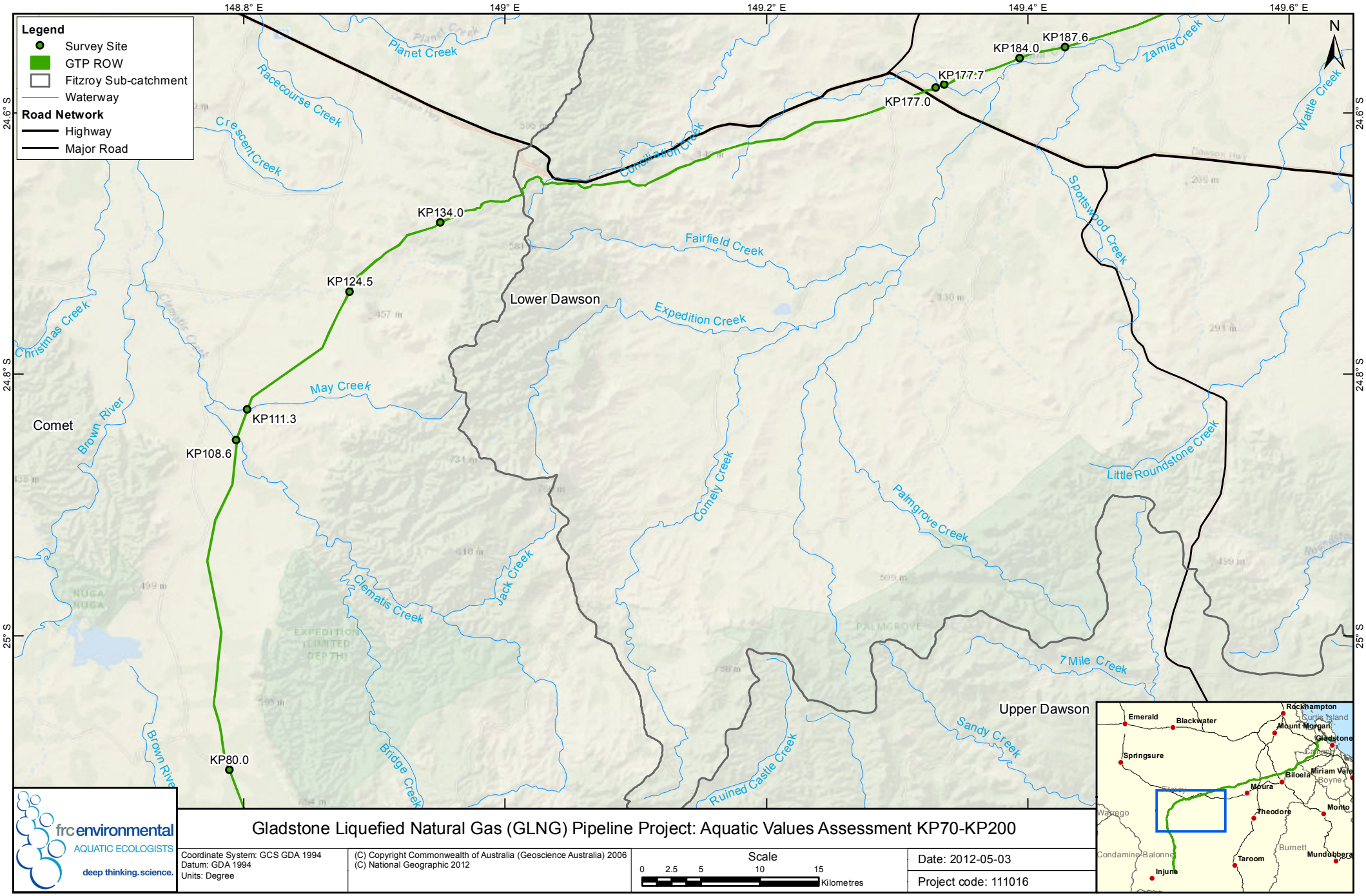


Figure 1.2 Location of the major waterway crossings that were assessed in the current study.

Table 1.1 Major watercourse crossings along the GTP ROW between KP70 and KP200.

| Watercourse / Wetland | KP | Stream order | Easting | Northing |
|---|---|---|---|---|
| Unnamed watercourse 3 | 80.8 | 3 | 680167.1 | 7223205.8 |
| Clematis Creek | 108.6 | 5 | 681335.0 | 7250440.1 |
| May Creek | 111.3 | 3 | 682198.5 | 7253018.7 |
| Deep Creek | 124.5 | 3 | 690239.7 | 7262901.7 |
| Unnamed watercourse 4 | 133.9 | 3 | 697307.9 | 7268587.1 |
| Un-named palustrine wetland | 177.3 | – | 736128.9 | 7279572.5 |
| Prospect Creek | 177.7 | 4 | 736556.3 | 7279710.7 |
| Unnamed watercourse 5 | 184.1 | 3 | 742484.9 | 7281889.3 |
| Unnamed watercourse 6 | 187.6 | 3 [A] | 745990.1 | 7282756.3 |
| Proespect Creek RCR | - | 4 | 735883.9 | 7280331.2 |

– stream orders do not apply to wetlands

[A] as mapped by the Department of Environment and Heritage Protection, however does not display the characteristics of a third order stream

## 1.2 Aquatic Values of the Region

The GTP ROW traverses the upper Comet River sub-catchment (KP70–141) and the lower Dawson River sub-catchment (KP141–200), both of which are catchment areas within the Fitzroy River Basin (Figure 1.2). The flow regime of these river systems is dominated by 'unpredictable, highly intermittent summer flow' with some reaches having 'variable, extremely intermittent summer flow' (Kennard et al. 2010). Thus, most stream reaches tend to be dry during winter, and the magnitude, duration and timing of summer flows varies greatly between years. As for other dryland river systems, permanent pools and waterholes are 'critical habitat areas' for aquatic biota (*sensu* Abell et al. 2007) and provide refugia habitat that enable aquatic species to persist during dry periods (Sheldon et al. 2010). Permanent waterbodies in the Fitzroy River Basin therefore have high aquatic ecological values.

Catchment areas in the Fitzroy River Basin, including the Dawson and Comet River sub-catchments, have been extensively cleared for grazing; thus, aquatic habitat is typically in a slightly to moderately disturbed condition (URS 2009). However, they also have overall high ecological values (URS 2009), in part due to the presence of significant aquatic species and significant aquatic places.
Significant species include those with legislated conservation significance [e.g. in the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the Queensland *Nature Conservation Act 1992* (NC Act)) and species that are endemic to the Fitzroy River Basin.

Aquatic species with legislated conservation significance from the upper Dawson River and upper Comet River sub-catchments include:

- Murray cod (*Maccullochella peelii*; listed as endangered under the EPBC Act), which is not naturally found in the Fitzroy River Basin but has been stocked in reservoirs for recreational fishing. However, it reportedly has not become established in this river system and is unlikely to occur in the Project Area
- white throated snapping turtle (*Elseya albagula*) is listed at Least Concern under the NC Act and the Fitzroy River Turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act
- platypus (*Ornithorhynchus anatinus*) is listed at Least Concern under the NC Act
- five species of frog listed as threatened under the EPBC Act. Two of these species are endemic to the Fitzroy River Basin and are protected within Kroombit Tops National Park: Kroombit tinker frog (*Taudactylus pleione*), and cascade treefrog (*Litoria pearsoniana*). The other three species of threatened frog, including tusked frog (*Adelotus brevis*) and rough-collared frog (*Cyclorana verrucosa*), are more widespread in eastern Queensland and may occur in aquatic habitats intercepted by the GTP ROW
- boggomoss snail (*Adclarkia dawsonensis*) is listed as critically endangered under the EPBC Act (dealt with in detail in the AVMP for KP0 to KP70), and
- records for several wetland bird species that are listed as Near Threatened in the NC Act, including black-necked stork (*Ephippiorhynchus asaticus*) and cotton pygmy goose (*Nettapus coromandelianus*), are from the Fitzroy River Basin.

The Fitzroy River Basin also contains several endemic aquatic species:

- Fitzroy River turtle (*Rheodytes leukops*); also listed as vulnerable under the EPBC Act
- Southern saratoga (*Scleropages leichardti*)
- Leathery grunter (*Scortum hillii*), and

- the freshwater gastropod (snail, *Larina strangei*), which is endemic to the Dawson River sub-catchment.

Significant aquatic places in the Dawson River and Comet River sub-catchments include Wetlands of National Importance:

- Lake Nugu Nugu National Park, and
- Palm Tree Creek and Robinson Creek wetlands.

While permanent waterbodies in the Fitzroy River Basin have high aquatic ecology values due to the overall dryland ecology of this river basin, many intermittent and ephemeral systems also have aquatic values, especially ephemeral wetlands and larger ephemeral watercourses (e.g. stream order 3 and above). These aquatic habitats provide:

- corridors and habitat for upstream migration of endemic species, including southern saratoga and leathery grunter, and other aquatic fauna (e.g. bony bream, spangled perch, glass perchlets, and river prawns) during temporary wet periods, and
- habitat for species dependent on drying, such as various species of macrophyte that undergo flowering and seed set in response to wetland drying.

# 2 Overview of Methods and Results

## 2.1 Aquatic Habitat Assessment

Aquatic habitat condition was assessed using two approaches:

- the Australian River Assessment System (AUSRIVAS) protocol described in the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001), and
- the Habitat Bioassessment Scoring method (DNRM 2001).

The results for the habitat condition assessments showed that:

- grazing was the dominant adjacent land use to major watercourses
- most sites were ephemeral streams and were dry at the time of survey; the few that contained water had little to no flow
- the channels of watercourses were generally straight to mildly sinuous
- substrate was dominated by silt or clay and sand at all sites
- riparian vegetation was dominated by scattered eucalypt trees with a dense understory of grasses at most sites; Parthenium weed occurred in the riparian zone at some sites, and
- in-stream habitat was dominated by emergent aquatic vegetation, large woody debris and pools.

The results for the habitat bioassessment scores showed that:

- four sites (KP108.6 – Clematis Creek, KP133.9 – unnamed watercourse 4, KP177.7 – Prospect Creek and KP184.1 – unnamed watercourse 5) has moderate aquatic habitat, due to moderate substrate cover, moderate habitat diversity, and moderate streamside vegetation
- the wetland site (KP177.3) could not be assessed using this method because it is a wetland not a stream, and
- four sites had poor habitat (KP80.8 – unnamed watercourse 2, KP111.3 – May Creek, KP124.5 – Deep Creek, and KP187.6 – unnamed watercourse 6), due to little substrate cover, poor bank stability, and poor habitat diversity.

Further details for the aquatic habitat assessment methods and results are presented in Appendix A.

## 2.2 Water Quality

*In situ* water quality was assessed at sites containing sufficient water at the time of survey. The water quality parameters measured were:

- pH
- electrical conductivity
- dissolved oxygen, and
- turbidity.

The water quality results were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin (DERM 2011c; b), including the Dawson and Comet sub-basins, which for electrical conductivity and pH are based on reference data from the following sites (DERM 2011a):

- Dawson River at Utopia Downs and Robinson Creek at Glenleigh in the upper Dawson catchment, and
- Brown River at Warrinilla and Carnarvon Creek at Rewan in the Comet catchment.

The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009), and these have been presented as the WQOs scheduled under the EPP Water.

Only four sites had sufficient water that enabled assessment of *in situ* water quality. The results of these assessments showed that:

- pH was within the WQO range at all four sites
- electrical conductivity exceeded the WQO at one site
- dissolved oxygen was below the WQO range at all four sites, and
- turbidity exceeded the WQO at two sites.

These results were typical of ephemeral streams and are consistent with the findings from the wider catchments. Further details for the water quality assessment methods and results are presented in Appendix B.

## 2.3 Aquatic Plants

The aquatic plant or macrophyte community at each site was assessed along a 100 m reach of the stream and adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species
- growth form of each species (submerged, floating (free-floating or rooted) and emergent)
- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Results of the aquatic plant survey showed that:

- taxonomic richness ranged from zero at sites KP124.5 (Deep Creek) and KP187.6 (unnamed watercourse 6) to 12 at site KP177.7 (Prospect Creek)
- percent cover was greatest the wetland site KP177.3 (100%), and exceeded 50% at sites KP133.9 (unnamed watercourse 4), KP177.7 (Prospect Creek) and KP184.1 (unnamed watercourse 5)
- most species were emergent in growth form; growth form diversity of aquatic plants was greatest at site KP177.7, and included emergent, submerged and floating attached species
- four exotic species were found, including species regarded as environmental weeds and Class 1 declared pests under the Land Protection (Pest and Stock Route Management) Act 2002, and
- no listed species of conservation significance were found.

Further details for macrophyte assessment methods and results are presented in Appendix C.

## 2.4 Macroinvertebrates

Benthic macroinvertebrates were assessed at each site in bed and edge habitats. Samples were identified to the family level, and the following metrics were calculated:

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2.

Richness, PET richness and SIGNAL 2 scores were assessed against local Water Quality Objectives (WQOs) for the Comet and Dawson Rivers.

Macroinvertebrate surveys were possible at four sites, although edge habitat was surveyed at only three of these sites (i.e. edge was not surveyed for the wetland at KP177.3). Results for the macroinvertebrates showed:

- abundance of macroinvertebrates was highest at site KP108.6 (Clematis Creek) for both bed and edge habitats; abundance was lowest for bed habitat at site KP177.7 (Prospect Creek)
- taxonomic richness was highest at site KP177.7 (Prospect Creek) for edge habitat and KP177.3 (unnamed palustrine wetland) for bed habitat; taxonomic richness was lowest at site KP184.1 (unnamed watercourse 5) for both bed and edge habitat. However, for both bed and edge habitat, taxonomic richness was within or above the WQO range
- PET richness was highest at site KP108.6 (Clematis Creek) for both bed and edge habitats; PET richness was lowest for site KP177.3 (unnamed palustrine wetland) for bed habitat and at site KP184.1 (unnamed watercourse 5) for edge habitat. PET richness was within the WQO range for bed and edge habitat at all sites except site KP177.3 (unnamed palustrine wetland). However, site KP177.3 is a wetland and therefore the WQO which were developed for stream systems is not applicable
- SIGNAL 2 score was highest at site KP177.7 (Prospect Creek) for bed habitat and site KP108.6 (Clematis Creek) for edge habitat; the total SIGNAL 2 score for site KP177.7 was within the Fitzroy Basin WQO range and below this range for all other sites; the bi-plot analyses showed that site KP177.7 for bed habitat and KP108.25 for edge habitat were within quadrant 1, which indicated favourable habitat. Other site-habitat combinations were within quadrant 2, which indicated elevated nutrients or salinity

- quantitative analyses of community composition showed that samples from the same site were more similar than those between sites; sites KP177.3 (unnamed palustrine wetland) and KP177.7 (Prospect Creek) were most distinctive in terms of the macroinvertebrate community in bed habitat; sites KP108.6 (Clematis Creek) and KP177.7 (Prospect Creek) were most distinctive for macroinvertebrates from edge habitats, and
- glass shrimps and river prawns were the most commonly found taxa of macrocrustacean.

Further details for macroinvertebrate assessment methods and results are presented in Appendix D.

## 2.5 Freshwater Fish

Freshwater fish communities were surveyed using a combination of electrofishing (backpack and boat), baited traps and seine nets. The following metrics were calculated using the fish community data for each site:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage
- proportion and abundance of exotic species, and
- abundance of listed protected species.

Fish surveys were conduced for only four sites (KP108.6, KP177.3, KP177.7 and KP184.1) as the other five sites were dry. Results for these four sites showed that:

- six native species of fish were caught (seven species in total), with the most commonly found species being glassfish (*Ambassis agassizii*) and carp gudgeons (*Hypseleotris* spp.), and the introduced mosquitofish (*Gambusia holbrooki*)
- abundance was greatest at sites KP184.1 (unnamed watercourse 5) and KP177.7 (Prospect Creek)
- taxonomic richness ranged from 3 to 5 species
- juvenile and intermediate (i.e. sub-adult) life history stages were found at all four sites, and adult life history stage was found at three sites
- the declared noxious mosquitofish (*Gambusia holbrooki*) was found at three sites and accounted for more than 50% of the catch at one site (KP184.1), and
- no listed species of conservation significance were found.

Further details for freshwater fish assessment methods are presented in Appendix E.

## 2.6 Turtles

Although the survey was conducted during the wet season, the water level at all major watercourse crossings between KP70 and KP200 was not deep enough to enable cathedral traps to be set for turtles. No turtles were observed at these watercourse crossings.

## 2.7 Description of Aquatic Values

Wet season field investigations, literature reviews and database searches were used to inform the assignment of overall wet season aquatic value for each watercourse crossing. Four categories of aquatic value were used (High, Moderate, Low, Negligible), based on the following criteria:

### 2.7.1 High Value

Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the *Environment Protection and Biodiversity Conservation Act 1999* and / or the *Nature Conservation Act 1992*, and / or those species listed as priority species in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity document (DERM 2010).

Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species was assessed using a combination of:

- habitat condition [e.g. the Bioassessment scores method (DNRM 2001)
- levels of disturbance (e.g. erosion, riparian vegetation condition),
- likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS), and
- relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River Turtle, Tucker et al. 2001; in-stream habitat and connectivity for freshwater fish, including undercut banks, substrate characteristics, large woody debris).

### 2.7.2 Moderate Value

Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.

Aquatic life included:

- submerged and / or floating attached aquatic plants

- native freshwater fish (such as rainbowfish, spangled perch, glass perchlets, purple spotted gudgeons),
- aquatic invertebrates (including crayfish, shrimps, snails, mussels, and insects).

Life history stage (i.e. juvenile, intermediate, adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.

Aquatic habitat was assessed using:

- habitat condition (e.g. the Bioassessment scores method (DNRM 2001))
- levels of disturbance (e.g. erosion, riparian vegetation condition), and
- habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, large woody debris).

### 2.7.3 Low Value

Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.

Emergent aquatic plants, such as sedges and nardoo, may be have been present.

Field investigations also indicated the presence of structural habitat elements, including:

- woody debris
- cobbles and / or
- undercut banks.

Habitat condition was determined using:

- the Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams, and
- levels of disturbance (e.g. erosion, riparian vegetation condition)..

### 2.7.4 Negligible Value

Where field investigations indicated:

- an absence of aquatic habitats and
- absence of aquatic life (e.g. no aquatic fauna or aquatic plants, including no sedges).

Habitat condition was typically poor:

- Low Bioassessment Scores (DNRM 2001), and
- High levels of disturbance (e.g. extensive erosion, no riparian vegetation).

### 2.7.5 Dry Season Aquatic Values

Dry season aquatic values were also based on these four criteria, using previous dry season surveys for several sites to inform of permanence of pools / water, and expert judgment regarding permanence of pools / water at sites not visited during the dry season. Sites that were dry during the wet season were considered likely to also be dry during the dry season, as were sites that were previously shown to be dry during the dry season. Sites that contained water during the wet season, even as disconnected pools within the channel, were conservatively assessed as possibly having temporary water that may persist for some time into the dry season. In these cases, dry season aquatic values were assessed as moderate, in accordance with the criteria above.

### 2.7.6 2.7.6 Summary of Aquatic Values for Major Watercourses within KP70 to KP200

The aquatic values of major watercourse crossings within the GTP ROW between KP70 and KP200 are summaries in Table 2.1.

Table 2.1 Site-specific aquatic values for major watercourses within KP70 to KP200.

| Assessment of Watercourse / Wetland | | | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **KP** | **Stream order** | **Significant species Habitat (Aquatic)** | **Breeding place for significant species** | **DERM RE mapping** | **Overall Aquatic Value (crossing and reach)** |
| Unnamed watercourse 3 | 80.8 | 3 | Unlikely | Unlikely | Non-remnant | Negligible to Low |
| Clematis Creek | 108.6 | 5 | Unlikely | Unlikely | 11.3.2 | Moderate |
| May Creek | 111.3 | 3 | Unlikely | Unlikely – | Non-remnant | Low |
| Deep Creek | 124.5 | 3 | Unlikely | Unlikely | Non-remnant | Low |
| Unnamed watercourse 4 | 133.9 | 3 | Unlikely | Unlikely | 11.5.2/11.10.7/11.10.7a/11.10.1 | Low |
| Unnamed palustrine wetland | 177.3 | - | Likely | Likely | 11.3.16 | High |
| Prospect Creek | 177.7 | 4 | Unlikely | Unlikely | Non-remnant | Moderate |
| Unnamed watercourse 5 | 184.1 | 3 | Unlikely | Unlikely | Non-remnant | Moderate |
| Prospect Ck RCR | | 4 | Unlikely | Unlikely | Non-remnant | Moderate |

# 3 Recommendations

Open trenching is an appropriate construction method for the major watercourse crossings within the GTP ROW between KP70 and KP200 providing that the general mitigating measures are implemented (Table 3.1). The dry season is the recommended time for works to be implemented. If works are not possible during the dry season, additional controls will be necessary, especially for sites KP108.6, KP117.0, KP177.7 and KP184.0. These controls may include the use of dams and flow by-passes during low to moderate flows, as well fish salvage and water quality monitoring. As these watercourses may retain water and aquatic life for some time into the dry season, these additional controls may also be necessary in the dry season if water is present.

Potential impacts of open trenching on aquatic ecosystems include:

- **Fuel and oil spills**, which are toxic to aquatic flora and fauna even in low concentrations. Major spills (i.e. in the order of tens to hundreds of litres) will have a locally significant impact on aquatic ecosystems.
- **Introduction of invasive aquatic plant species** on machinery, such as *Urochloa mutica* (para grass), *Hymanachne amplexicaulis*, *Eichhomia crassipes* (water hyacinth) and *Salvinia molesta*. These aquatic weeds are common in parts of Queensland, although were not found within local watercourses along the GTP ROW between KP70 and KP200. These aquatic weeds have the potential to 'choke' aquatic habitats, thereby reducing the habitat values of the site and suitability for native aquatic species.
- **Earth works causing erosion and sedimentation**, which can:
  - Increase turbidity of water, which reduces respiratory and feeding efficiency of fish and macroinvertebrates, and impacts aquatic plants by reducing light penetration. However, it should be noted that waterways in the area are often naturally turbid and the species that inhabit these watercourses are tolerant of relatively high turbidity. Thus, slight short-term increases in turbidity would be unlikely to have adverse ecological impacts on aquatic ecosystems. Significant and / or prolonged increases in turbidity, however, may impact aquatic flora and fauna.
  - Smother habitat for aquatic species and in-fill pools with sediment. Habitats that may potentially be smothered by sediment include large and small woody debris, detritus, tree roots, sand and gravel bars, cobble and riffle habitats, undercut banks, overhanging and trailing bank vegetation. Many of these habitats were found in the local waterways within the survey area.

- **Riparian vegetation clearing**, which can have numerous impacts for aquatic flora and fauna. These include:
  - decreasing bank stability and increasing erosion and sedimentation
  - decreasing supply of leaves and woody material to stream that provides food and habitat resources for aquatic species
  - increase exposure of aquatic fauna to solar radiation (i.e. reduced shading of watercourse), and
  - increase water temperature due to increased solar radiation of watercourse.
- **Track crossings** for access, which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low flow periods, and
  - cause localized loss of in-stream habitat and localise destruction of aquatic biota.
- **Trench construction**, which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low flow periods, and
  - cause localised loss of in-stream habitat and localised destruction of aquatic biota.
- **Site remediation**, which if done poorly, can lead to sustained erosion and sedimentation, and sustained impacts to aquatic ecosystems.

Mitigation measures for these activities are presented in Table 3.1.

Table 3.1 General aquatic environment impact mitigating measures for open trenching of watercourses.

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Fuel and oil spills | • Establish designated vehicle maintenance areas, refuelling stations and fuel storage areas in bunded areas that are more than 50 m from nearby waterways and dams |
| | • Report all spills over 20 litres to and Environmental Officer or delegated person |
| | • Have appropriate spill containment and clean-up kits in the field, with spill kits accessible to construction crews at all times. Kits will contain equipment for clean up of fuel and oil on land or dry creek beds, and spills to water (e.g. floating booms) |
| | • Manage all spills in accordance with Australian Standard 1940-2004 |
| Introduction of invasive aquatic plants | • Weed washdown and inspections, to control the spread of other weeds in the region (e.g. *Parthenium hysterophorus*) |
| Soil erosion and sedimentation | • Implement sediment and stormwater control measures |
| | • Minimize the area of earth that is disturbed |
| | • Operate vehicles and machinery on specified access tracks (i.e. do not make more than one access track) |
| Riparian vegetation clearing | • Minimize the amount of vegetation that needs to be cleared |
| | • Ensure that adjacent riparian vegetation or aquatic habitats are not disturbed by machinery or falling trees |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Access track crossings* | • Implement sediment and stormwater control measures<br>• Move any in-stream habitat structures (e.g. woody debris, boulders) to adjacent sections of the stream<br>• Ensure access track is not higher than the bed level of the stream unless box or flume culverts are installed<br>• Maintain fish passage at access tracks, by ensuring that:<br>– the access track is constructed track in the dry season<br>– the access track is as narrow as reasonably practical<br>– the flume pipes are as large as reasonably practical in diameter<br>– the bottom of the flumes are below bed level, and natural bed material and / or rocks and gravel are placed in the bottom of the flumes<br>– the flumes are maintained so that they remain free of debris, and<br>– the work area is rehabilitated once the crossing is removed, including re-instatement of the bed and bank shape and revegetation of the banks. |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Trench construction* | • Where feasible, trench during the dry season, when stream bed is dry<br>• Move any in-stream habitat structures (e.g. woody debris, boulders) to adjacent sections of the stream<br>• Implement designed in accordance with the Australian Pipeline Industry Association Code of Practice and other relevant standards (AE 2001; APIA 2009), which require that:<br>– works are completed as soon as reasonably practical, to minimise the impact on aquatic fauna<br>– upstream and downstream dams are installed on the edge of the temporary workspace, to maximise the area of the workspace. These dams should be constructed of an appropriate material for each creek (e.g. steel plates, flumes, sand bags or aquadam), and<br>– if there is flowing water is present, an effort will be made to maintain flow, including variations in flow patterns (e.g. increased flow due to increased rainfall), using appropriate pumps (e.g. increased pumping effort in response to increased stream flow)<br>– pump intakes are to be screened to ensure that no fish are trapped<br>– fish are salvaged from the isolated workspace and translocated to appropriate waterways (see above)<br>– the upstream dam is slowly removed, to allow water to flush the sediment from the workspace area<br>– sediment-laden water is pumped into sumps or onto vegetation<br>– operation of the clean-water pump sustains flow below the downstream dams until the downstream dam is removed. |
| Site remediation | • Implement well-designed and high quality site remediation works that include profiling the bed and banks of watercourses and revegetation<br>• Set ecological targets for remediation works and conduct monitoring by qualified aquatic ecologists (e.g. once off during the following wet season) |

* denotes activities that may require waterway barrier works permits from the Department of Agriculture, Fisheries and Forestry; refer to the Project-Specific Self Assessable Code

### 3.1.1 Fish Salvage

Once flow is diverted from isolated workspaces (see Table 3.1 – trench construction), stranded fish should be captured and translocated to waterholes downstream of the diversion channel in accordance with the Fisheries Queensland (part of the Department of Agriculture, Fisheries and Forestry) guideline: *Fish Salvage Guidelines* (DPI&F 2004), as summarised below:

- fauna should be captured by suitably-qualified aquatic ecologists during a one-off intense fauna survey approximately one week prior to the destruction of the channel
- salvaged fauna should be translocated to suitable waterholes in the same local catchment (to prevent the transfer of exotic fish or aquatic disease and prevent hybridisation between genetically unrelated individuals)
- fish, macrocrustaceans, freshwater mussels, freshwater snails (such as moon snails at KP177.3), and turtles should be captured using gear appropriate to the waterways and species present (at the site, this is likely to include electrofishing, seine nets and set traps), and
- aquatic fauna should be handled, transported and released so as to minimise damage to the fish (e.g. handle with wet hands, hold correctly, transport using aerated water).

Various apparatus used to capture / translocate fish will require a General Fisheries Permit, issued by Fisheries Queensland, and should be operated by appropriately experienced professionals.

### 3.1.2 Water Quality Monitoring

Pre-construction baseline water quality monitoring and post-construction monitoring be done in accordance with the methods outlined in the AVMP. During construction, visual monitoring for sediment plumes will be done. If observed, construction works will cease and the erosion and sediment control measures will be inspected and repaired or revised as required.

If plumes are observed, water quality monitoring will also be done at one site upstream of the construction site, and one downstream (where safely accessible) in order to verify that the plume was related to construction activities, and to provide a record of monitoring. Baseline and post-construction monitoring will include three replicate samples of in situ water quality using a water quality probe for:

- water temperature
- dissolved oxygen (% saturation)
- conductivity
- pH, and
- turbidity.

Photographs will also be taken at each site.

The water quality monitoring should also be done accoriding the the AVMP by an appropriately qualified professional in accordance with the *Monitoring and Sampling Manual* (DERM 2010).

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# Appendix A Aquatic Habitat Condition

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# 1 Survey Design and Methods

## 1.1 In-stream Habitat Condition

The in-stream habitat condition at each site was assessed using the Australian River Assessment System (AUSRIVAS) protocol described in the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001). The following parameters were assessed:

- adjacent land use
- water velocity and depth
- channel diversity
- substrate composition, including sand bars and substrate compaction
- type and condition of riparian vegetation, and
- in-stream habitat (e.g. log jams, leaf packs, trailing vegetation and undercut banks).

## 1.2 Habitat Bioassessment Scores

A Habitat Bioassessment Score (DNRM 2001) is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. The method requires habitat quality to be scored (from zero to twenty) for each of nine criteria:

- substrate or available cover
- embeddedness
- water velocity and depth
- channel alteration
- bed scouring and deposition
- pool:riffle and run:bend ratio
- bank stability
- bank vegetative stability, and
- streamside vegetation cover.

The sum of the scores for each criterion gives the overall habitat score. This is used to allocate sites to one of four categories (Table 1.1):

- excellent habitat condition (overall score >110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74), and
- poor habitat condition (overall score ≤38).

Table 1.1 Habitat bioassessment scores used to derive overall condition categories.

| Habitat Category | Category Score Range | | | |
|---|---|---|---|---|
| | **Excellent** | **Good** | **Moderate** | **Poor** |
| Bed substrate or available cover | 16–20 | 11–15 | 6–10 | 0–5 |
| Embeddedness | 16–20 | 11–15 | 6–10 | 0–5 |
| Water velocity and depth | 16–20 | 11–15 | 6–10 | 0–5 |
| Channel alteration | 12–15 | 8–11 | 4–7 | 0–3 |
| Bed scouring & deposition | 12–15 | 8–11 | 4–7 | 0–3 |
| Pool:riffle and run:bend ratio | 12–15 | 8–11 | 4–7 | 0–3 |
| Bank stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Bank vegetative stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Streamside vegetation cover | 9–10 | 6–8 | 3–5 | 0–2 |
| **Total (Habitat Bioassessment Score for the Site)** | **111–135** | **75–110** | **39–74** | **0–38** |

The Bioassessment Scores method is not an appropriate approach for assessing wetlands. Bioassessment scores were therefore not calculated for the wetland site at KP177.3.

## 1.3 Regional and Ecological Perspective

The condition of aquatic habitat in each catchment was reviewed, based on the *State of the Rivers* surveys (Henderson 2000; Telfer 1995), and summarised to provide a context for the results of this survey.

## 1.4 In-stream Habitat Condition

Site assessment sheets have been completed that summarise the aquatic habitat at each site and present photographs of each site; these are provided in Appendix C of the Aquatic Values Management Plan.

### Adjacent Land Use

Grazing was the dominant land use surrounding most sites. Sites generally had low to moderate erosion. Site KP187.6 had been cleared and cropped.

### Water Velocity and Depth

Most sites that contained water were shallow ephemeral streams with little or no flow. In contrast, site KP177.3 was a shallow (20 to 30 cm deep) wetland. Sites KP80.8, KP111.3, KP124.5, KP133.9 and KP187.6 were dry when surveyed.

### Channel Diversity

Channels were generally straight or mildly sinuous. Most sites had a moderate to flat bank; however, sites KP111.3 and KP124.5 had vertical banks with low stability.

## Substrate Composition

Substrate composition was dominated by silt or clay and sand at all sites.

Sites KP108.5, KP111.3, KP133.9, KP187.6 and Prospect creek RCR had the most diverse substrate composition; and site KP80.8 had the lowest diversity. There was cobble only at sites KP133.9 and Prospect creek RCR (Figure 1.1).

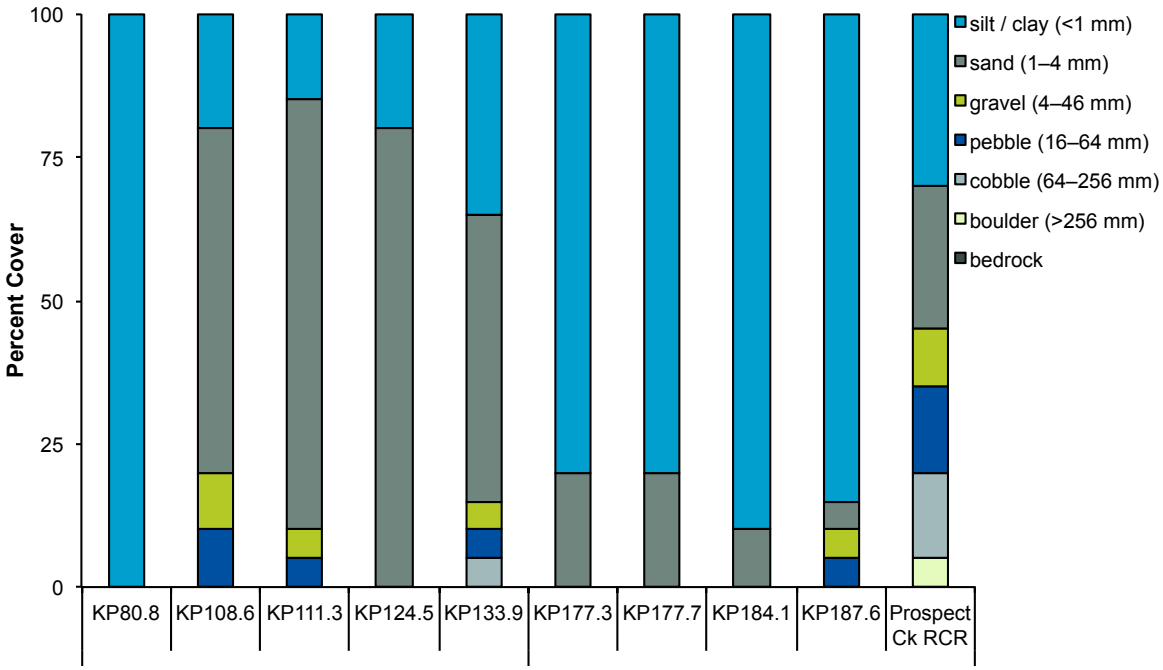


Figure 1.1 Percent cover of substrate types at each site along the GLNG pipeline (KP70 to KP200).

## Riparian Vegetation

The dominant riparian vegetation at most sites was scattered eucalypt trees with a dense understory of grasses (Figure 1.2). Acacia was also common at sites KP177.3 and KP177.6, and melaleuca was dominant at site KP111.3. There was Parthenium weed at sites KP177.3, KP177.7 and KP184.1.

Figure 1.2

Riparian vegetation at site KP184.1.



## In-stream Habitat

In-stream habitat provides refuge and food for aquatic fauna (e.g. fish, turtles and macrocrustaceans). In-stream habitat at most sites that contained water was dominated by emergent aquatic vegetation, large woody debris and pools (Figure 1.3). There was no aquatic vegetation and no habitat at site KP187.6.

Figure 1.3

In-stream habitat at site KP177.7.



Figure 1.4

Absence of aquatic habitat at site KP187.6



## 1.5 Habitat Bioassessment Scores

Four sites had moderate habitat, three sites had poor habitat, and one site (KP177.3) was not assessed using this method because it is a wetland (Figure 1.5). Site KP187.6 has particularly poor aquatic habitat as it had been cleared and ploughed for cropping and no longer resembles a watercourse.

The overall poor habitat scores were due to:

- little bottom substrate or available cover (e.g. boulders, woody debris and vegetation)
- poor bank vegetation stability
- poor habitat diversity, and
- extensive embeddedness (as a result of substrate dominated by fine sediment).

Overall moderate habitat scores were due to:

- more bottom substrate or available cover (e.g. boulders, woody debris and vegetation)
- better habitat diversity
- better streamside cover, and
- better bank vegetation stability.

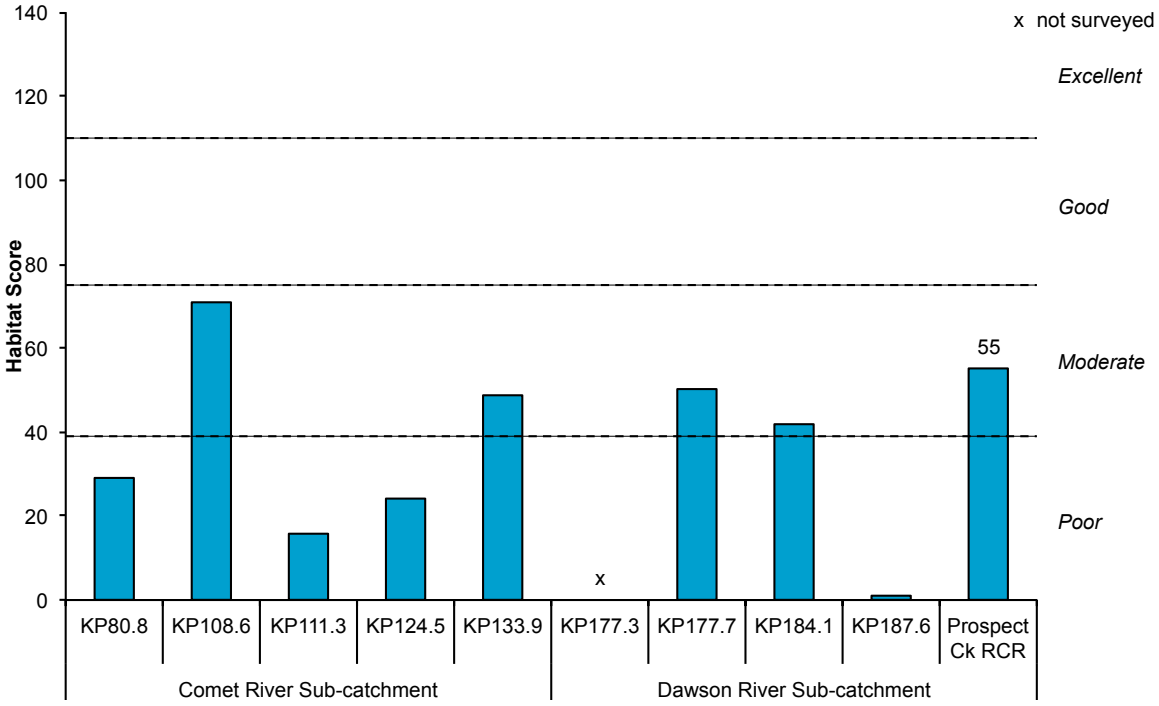


Figure 1.5 Habitat Bioassessment Score at each site along the GLNG pipeline (KP70 to KP200).

# 2 Regional and Ecological Perspective

## 2.1 Dawson River Sub-catchment

### Reach Environments

In the State of the Rivers survey, the condition of the reach environments varied across the Dawson River sub-catchment, although most stream segments were of moderate condition, as shown for sites KP177.7 and KP184.1. Stream segments with very poor or poor condition were mainly in the western, southern and north-upland tributaries, and in the Don and Callide tributaries of the Dawson River. Stream segments with good to very good ratings were mostly in the upper and regulated Dawson River sub-catchments. Factors that impacted the condition of the reach environments included the extent of vegetation clearing along the stream for cropping and exposure to cattle grazing and watering (Telfer 1995).

### Riparian Vegetation and Adjacent Land Use

In the State of the Rivers survey, riparian vegetation throughout the catchment was in very poor to poor condition, although the condition of riparian vegetation in the Upper Dawson River sub-catchment was high (Telfer 1995). The reported impacts to riparian vegetation were clearing, grazing by cattle and invasion of weed species. This is consistent with riparian vegetation condition and land uses observed at sites in the current survey. A passageway through the creek had been created at the Prospect creek RCR site, with large boulders and cobbles created a dam between upstream and downstream. Eucalypt-dominated communities were the most commonly identified vegetation types within the riparian zones of the catchment, followed by Brigalow, softwood scrub, and cypress pine communities. Grasslands and medium (10 to 30 m) and small (<10 m) trees were the most dominant structural types of vegetation (Telfer 1995). The most extensive adjacent land use in the State of the Rivers survey was grazing of beef cattle on native pastures (mostly in areas cleared of native timber) (Telfer 1995).

### Bank Stability

In the State of the Rivers survey, the stability of the banks throughout the catchment was generally good, with most banks being stable or very stable. Erosion was the most extensive process occurring throughout the catchment, and was the dominant process in 94% of stream segments. Erosion commonly occurred at bends, at obstacles, and at

irregular locations along both the lower and upper banks. The presence of stock and clearing of vegetation were the major factors contributing to the disturbance of banks (Telfer 1995), as noted for many sites in the current study. Wild pigs were observed at the Prospeck crekk RCR site, directly impacting on bank stability and submergent plants.

### Channel Diversity

In the State of the Rivers survey, channel diversity throughout the catchment was mostly low to very low. Generally, channel diversity was highest in the North Upland and Don and Callide sub-catchments. Run habitat was the most commonly identified channel habitat type throughout the catchment, followed by pools and then riffles (Telfer 1995).

### In-stream Habitat

In the State of the Rivers survey, the condition of in-stream habitat was considered to be generally poor to moderate. Similarly, the overall habitat value for aquatic life was rated at most sites (71%) as very poor to good, similar to most sites in the current study. Sub-catchments that exhibited aquatic habitat in mostly good to very good condition included the upper tributaries sub-catchment and the Upper Dawson River sub-catchment. Individual branches, individual logs, and leaf and twig cover were the most common in-stream habitat. Vegetative debris is the predominant aquatic habitat in this catchment, which highlights the importance of riparian zones to aquatic organisms in the Dawson River sub-catchment (Telfer 1995).

## 2.2 Comet River Sub-catchment

### Reach Environments

The Comet River has two sub-catchments: the Eastern tributaries sub-catchment (where the pipeline ROW is located) covers an area of 10 821 $km^2$; the Western tributaries sub-catchment covers an area of 6474 $km^2$. The Eastern tributaries sub-catchments contain approximately 2820 km of streams; and the Western tributaries sub-catchments contain approximately 2001 km of streams. In the Eastern sub-catchment, 84% of streams were rated as very good, 13% as poor and only 3% as very poor. In the Western sub-catchment, 86% of streams were rated as moderate to very good, and 14% were rated as poor to very poor (Henderson 2000).

Despite these good ratings, 60% of streams in the Eastern sub-catchments and 52% of streams in the Western sub-catchments were subject to high, very high or extreme disturbance. The most common form of disturbance was grazing with some influence from man-made structures such as fords, culverts, roads and water extraction infrastructure (Henderson 2000). Grazing and ripariave vegetation clearing were the dominant disturbances observed in the current study.

## Riparian Vegetation and Adjacent Land Use

Across both the Eastern and Western tributaries sub-catchments, riparian vegetation included grasses, medium sized trees (10 to 30 m), small trees (<10 m), shrubs, and rushes. Native species that were common in the riparian zone included (Henderson 2000):

- *Eucalyptus* spp.
- Kangaroo Grass (*Themeda triandra*)
- *Melaleuca* spp.
- *Lomandra* spp.
- *Acacia* spp.
- *Casuarina* spp., and
- Brigalow (*Acacia harpophylla*).

Most of the riparian zones across the Eastern tributaries sub-catchment were in very poor to moderate condition (72% of stream length), whereas the condition of riparian vegetation in the Western tributaries sub-catchment was largely good to very good (63% of stream length). Exotic grasses were at 73% of sites, and were common at all sites in the present study. Exotic plants commonly observed were (Henderson 2000):

- green panic (*Panicum maximum*)
- Noogoora burr (*Xanthium pungens*), and
- Parthenium (*Parthenium hysterophorus*).

## Bank Stability

Stream banks were either stable or very stable in both the Eastern (68% of stream length) and Western (87% of stream length) tributaries sub-catchments. Erosion was widespread throughout both sub-catchments and occurred at bends, obstacles and seepage points.

Erosion was observed at 63% of sites in the Eastern tributaries and 55% of sites in the Western tributaries sub-catchments. Aggradations were prominent at bends and obstacles at 18% of sites in the Eastern tributaries and at 10% of sites in the Western tributaries sub-catchments. The major factor influencing bank stability was the presence of stock in the riparian zone, although run-off, water flow and clearing of vegetation were also common factors (Henderson 2000).

## Channel Diversity

Channel habitat diversity was low or very low in both the Eastern tributaries (99% of sites) and Western tributaries (98% of sites) sub-catchments. Pools and runs were the most prevalent habitat types in both sub-catchments. In the Eastern tributaries sub-catchment the average depth and width of (Henderson 2000):

- pools were 1.0 m deep and 8.7 m wide
- runs were 1.0 m deep and 6.6 m wide, and
- riffles were 0.1 m deep and 5.6 m wide.

In the Western tributaries sub-catchment, the average depth and width of (Henderson 2000):

- pools were 2.0 m deep and 8.8 m wide
- runs were 0.5 m deep and 6.0 m wide, and
- riffles were 0.3 m deep and 18.0 m wide.

The substrate of pools across the sub-catchments was dominated by silt, while runs had some silt and some sand, and riffles has mostly of larger particles (e.g. gravel and cobbles). Organic matter made up between 5 and 26% of streambed sediment in pools, runs and riffles (Henderson 2000).

## In-stream Habitat

Aquatic habitat was poor or very poor condition at most sites in both the Eastern (73% of stream length) and Western (59% of stream length) tributaries sub-catchments. Logs, branches, leaves and twigs and tree roots were the most widespread forms of in-stream habitat. The riparian canopy and overhanging vegetation provided aerial cover, though Telfer (1995) suggested that poor riparian vegetation reduced the supply of vegetative debris, resulting in poor aquatic habitat (Henderson 2000).

# 3 References

DNRM, 2001. Queensland Australian River Assessment System (AUSRIVAS). *Sampling and Processing Manual*. Queensland Department of Natural Resources and Mines, Rocklea.

Henderson, C. 2000, *State of the Rivers: Comet, Nogoa and Mackenzie Rivers*, Queensland Department of Natural Resources, Indooroopilly.

Telfer, D., 1995, *State of the Rivers, Dawson River and Major Tributaries*, report prepared for Department of Natural Resources and Mines.

# Appendix B Water Quality

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# 1 Survey Design and Methods

## 1.1 Water Quality Measured *In Situ*

Water quality was measured *in situ* at sites containing sufficient water at the time of survey. Water quality was not assessed at sites that were dry or where the water level was too low.

The following water quality parameters were measured using a Hydrolab Quanta water quality meter

- pH
- electrical conductivity, and
- dissolved oxygen.

A Hach 2100Q turbidity meter was used to measure turbidity.

The Hydrolab Quanta water quality meter was calibrated daily and the Hach 2100Q was calibrated at the beginning of the field surveys.

The water quality results were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in relevant sub-regions as presented in the Developing Water Quality Guidelines for the Protection of Freshwater Aquatic Ecosystems in the Fitzroy Basin document (DERM 2011a), including the Upper and Lower Dawson sub-regions (DERM 2011b) and the Comet River sub-region (DERM 2011c) (Table 1.1).

The WQOs for electrical conductivity and pH are based on reference data from the following sites (DERM 2011a):

- Dawson River at Utopia Downs and Robinson Creek at Glenleigh in the upper Dawson catchment, and
- Brown River at Warrinilla and Carnarvon Creek at Rewan in the Comet catchment.

The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009), and these have been presented as the WQOs scheduled under the EPP Water.

Table 1.1 Water Quality Objectives (WQOs) for the Fitzroy River Basin for protection of moderately disturbed aquatic ecosystems

| Parameter | Units | Water Quality Objectives for Fitzroy Basin | | |
|---|---|---|---|---|
| | | Upper Dawson | Lower Dawson | Coment River |
| temperature | °C | – | – | – |
| pH | pH units | 6.5–8.5 | 6.5–8.5 | 6.5–8.5 |
| electrical conductivity | µS/cm | 370 | 340 | 375 |
| dissolved oxygen [a] | % saturation | 85–110 | 85–110 | 85–110 |
| turbidity | NTU | 50 | 50 | 50 |

Source DERM (2011b; a)

[a] dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth

– not available

µS/cm = microSiemens per centimetre

NTU = nephelometric turbidity unit

## 1.2 Regional and Ecological Perspective

Literature on water quality in each catchment was reviewed, including surveys done for the GLNG EIS, and summarised to provide a context for the results of this survey.

# 2 Results

## 2.1 pH

The pH was within the WQO range at all sites and varied little between sites (Figure 2.1).

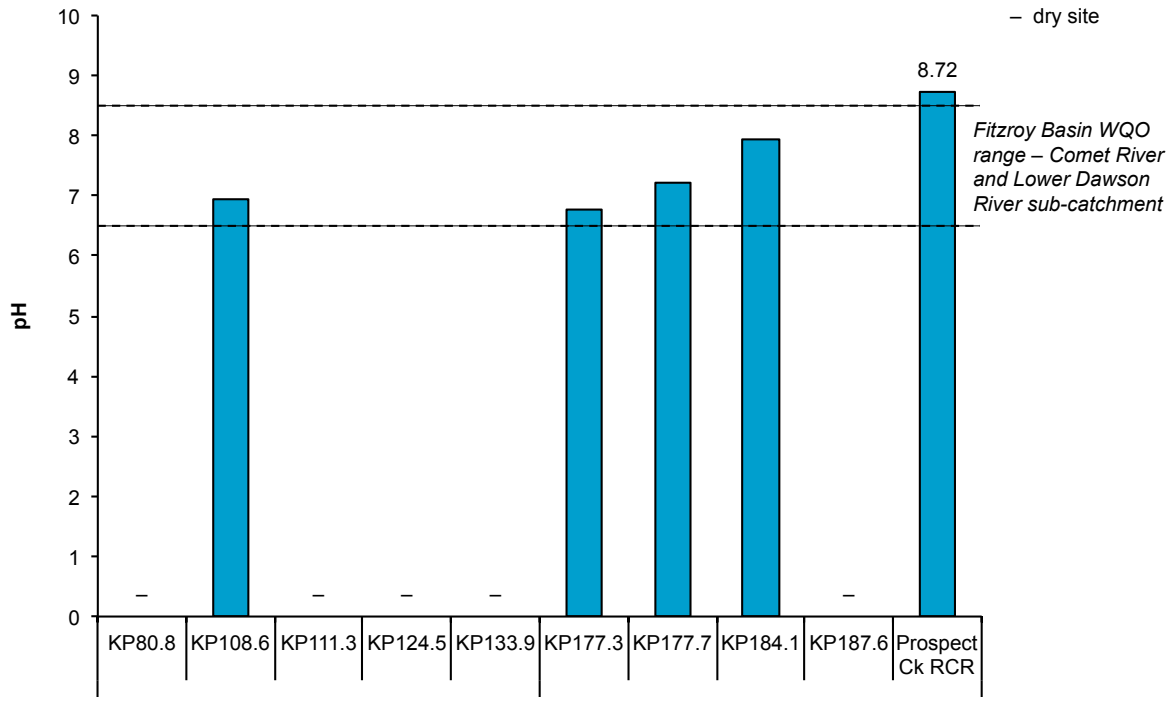


Figure 2.1 The pH at each site along the GLNG pipeline (KP70 to KP200).

## 2.2 Electrical Conductivity

Electrical conductivity was below the WQO at sites KP108.5, KP177.3 and KP184.1. The electrical conductivity was above the WQO at site KP177.7 (Figure 2.2).

Electrical conductivity depends on a number of factors including catchment run-off and local geology. High electrical conductivity was also likely to be related to evaporation and the subsequent concentration of salts in the remaining isolated pools.

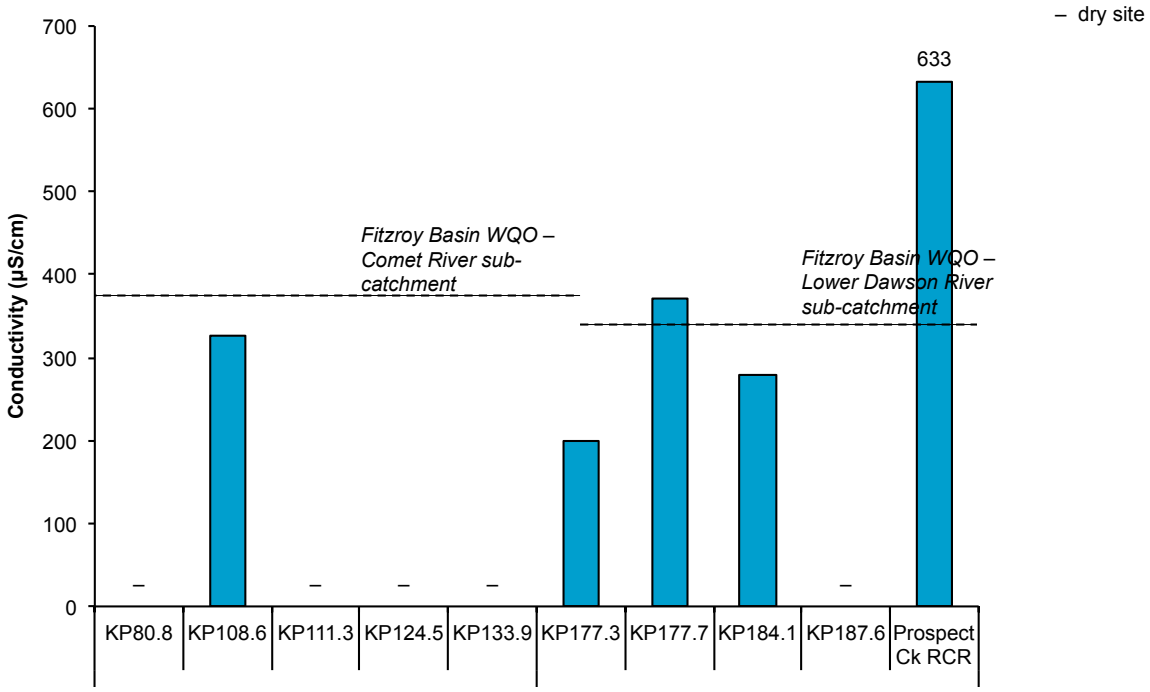


Figure 2.2 Electrical conductivity at each site along the GLNG pipeline (KP70 to KP200).

## 2.3 Dissolved Oxygen

The percent saturation of dissolved oxygen was below the WQO range at all sites, and was higher at site KP184.1 than at all other sites (Figure 2.3). It should be noted that the WQO for percent saturation dissolved oxygen is considered appropriate for flowing water, not disconnected pools or wetlands. The Queensland Water Quality Guidelines (DERM 2009) recommends adopting local water quality guidelines based on local reference site data. While reference data for the watercourses assessed in this AVA was not available, data for dissolved oxygen from the Santos Coal Seam Gas Fields Aquatic Ecology Impact Assessment project (frc environmental 2009) was available from other sites in the Lower Dawson and Comet River sub-regions. The 20$^{th}$ percentile for these data was 47 percent saturation of dissolved oxygen. This indicates that sites KP177.3 and KP177.7 were towards the lower end of the range for percent saturation of dissolved oxygen previously reported. The percent saturation of dissolved oxygen at these two sites was also below the range of percent saturation of dissolved oxygen reported in the Gladstone LNG Gas Transmission Pipeline – Surface Water EIS (URS 2009).

Low percent saturation of dissolved oxygen is typical of non-flowing water bodies, such as isolated pools. The differences in the percent saturation of dissolved oxygen at each site are likely to reflect the:

- time of day measurements were taken (plants photosynthesise during the day, producing oxygen)
- photosynthetic rates of algae and macrophytes (which are affected by light availability and temperature)
- rate of oxygen uptake by micro-organisms in the waterway associated with decomposing organic matter, and
- amount of surface mixing (caused by wind, water movement and bird activity).

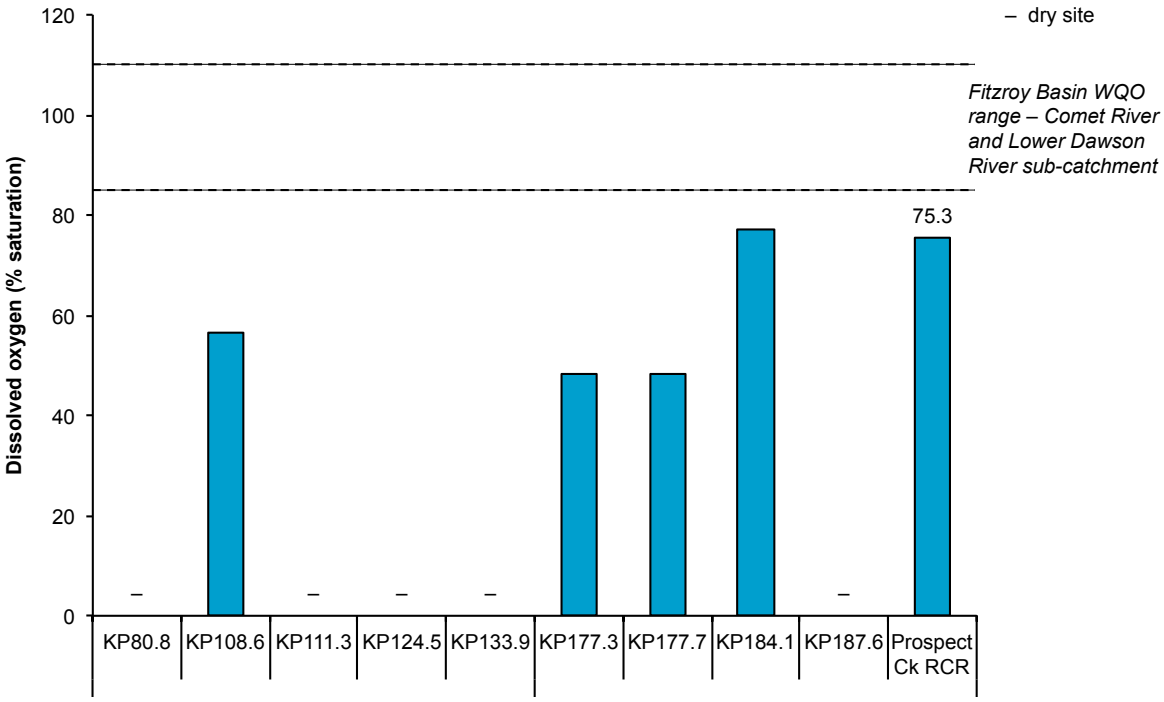


Figure 2.3 Percent saturation of dissolved oxygen at each site along the GLNG pipeline (KP70 to KP200).

## 2.4 Turbidity

Turbidity was below the WQO at sites KP108.5 and KP177.3, and was above the WQO at sites KP177.7 and KP184.1 (Figure 2.4). Turbidity is a potential indicator of sedimentation and erosion. The 80$^{th}$ percentile for turbidity from sites surveyed during the Santos Coal Seam Gas Fields Aquatic Ecology Impact Assessment project (frc environmental 2009) was 1084 NTU, suggesting that the high turbidity at sites KP177.7 nd KP184.1 is much lower than turbidity that has been recorded elsewhere in the sub-regions. The values for turbidity are also within the range of NTU measurments reported in the Gladstone LNG Gas Transmission Pipeline – Surface Water EIS (URS 2009).

Variation in turbidity between sites was likely due to differences in local factors, such as sediment type, macrophyte or vegetation cover and severity of erosion, such as erosion associated with cattle access.

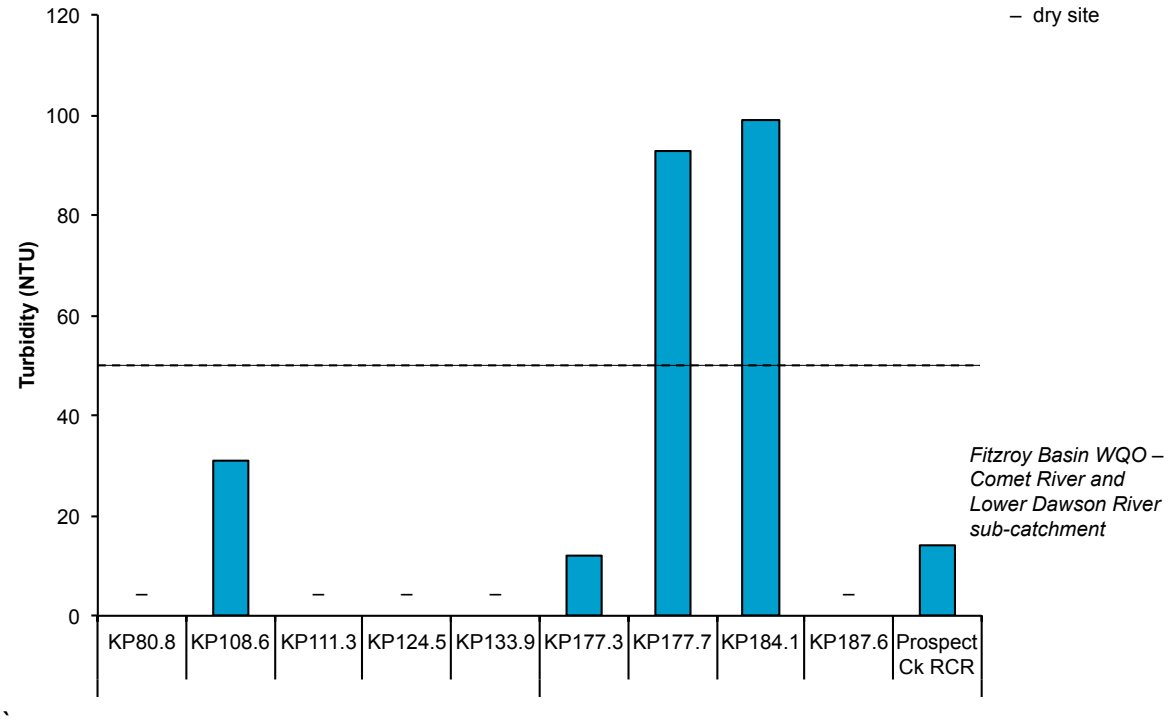


Figure 2.4 Turbidity at each site along the GLNG pipeline (KP70 to KP200).

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Agricultural land use dominates the Dawson River sub-catchment:

- 77% of the area is grazed
- 12% is state forest
- 7% is cropped, and
- 3% is national park (EPA 2001).

Within the Dawson River sub-catchment there are eight sub-catchments, which vary in their aggregate emission rates of nitrogen and phosphorus. Total nitrogen emitted from this sub-catchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001).

The primary sources for nitrogen are:

- grazing (43%)
- state forests (39%), and
- cropping (9%)

The primary sources for phosphorus are:

- grazing (80%)
- cropping (12%), and
- state forests (4%) (Joo 2000).

## 3.2 Comet River Sub-catchment

Cropping dominates land use in the Comet sub-catchment and although grazing is also common. Approximately 12% of the sub-catchment is national park and 9% is state forest (Henderson 2000). Turbidity and suspended solids are very high, as are the concentrations of nutrients. The concentrations of total nitrogen and phosphorus in run-off from cropping are very high (Noble et al. 1996; Henderson 2000), resulting in high cyanobacteria (blue-green algae) densities throughout the sub-catchment at times of low flow (Noble et al. 1996; Henderson 2000). However, high turbidity (which limits light

penetration) limits the growth of cyanobacteria (Henderson 2000). The widespread distribution of herbicides in surface waters of the sub-catchment is a matter of local concern (Noble et al. 1996; Henderson 2000).

Immediately downstream of the sub-catchment, the waters of the Mackenzie River received a report card score of 'D' (poor) for waters above the Isaac River confluence (Meecham 2003). Water quality in this catchment is threatened by:

- increased chemical loads associated with irrigation and grazing
- flow regulation reducing availability of aquatic habitat, and
- increased sediment run-off associated with interactions between grazing, fire, drought and rainfall (Meecham 2003).

These factors are also likely to have a major influence on water quality within the Comet River sub-catchment.

# 4 References

DERM, 2009, Queensland Water Quality Guidelines, version 3. Department of Environment and Resource Management.

DERM 2011a, *Developing Water quality Guidelines for the Protection of the Freshwater Aquatic Ecosystems in the Fitzroy Basin, Phase 1*, Department of Environment and Resource Management, Brisbane.

DERM, 2011b, *Dawson River Sub-basin Environmental Values and Water Quality Objectives*, September 2011, http://www.derm.qld.gov.au/environmental_management/water/environmental_values_environmental_protection_water_policy/schedule_1_of_epp_water_including_plans/fitzroy_scheduled_evs_wqos.html, accessed April 2012.

DERM, 2011c. *Comet River Sub-basin Environmental Values and Water Quality Objectives, Basin No. 130 (part), including all waters of the Comet River Sub-Basin*. Department of Environment and Resource Management, Brisbane.

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frc environmental, 2009, *Santos Coal Seam Gas Fields Aquatic Ecology Impact Assessment*, unpublished report prepared for URS Australia Pty Ltd.

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Joo, M., McNeil, V. H., O'Brien, E. & Fearon, R., 2000, *Nutrient emission modelling in the Dawson River Basin using catchment management support system (CMSS)*, report prepared for Prepared for the Department of Natural Resources.

Meecham, J., 2003, *Developing a Water Quality Policy for Central Queensland: Processes and Information used to Develop the Policy for the Maintenance and Enhancement of Water Quality in central Queensland*, report prepared for Queensland Department of Local Government and Planning.

Noble, R.M., Rummenie, S.K., Long, P.E., Fabbro, L.D. & Duivenvoorden, L.J., 1996 'The Fitzroy River catchment and assessment of the condition of the riverine system', In: Australian Agronomy Conference, Australian Society of Agronomy.

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# Appendix C Aquatic Flora

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Figure 2.3 Eurasian water milfoil at site KP177.7. 7

# 1 Survey Design and Methods

## 1.1 Aquatic Flora Assessment

The aquatic vegetation at each site was assessed along a 100 m reach of the stream and the adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following environmental parameters were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species
- growth form of each species (submerged, floating (free-floating or rooted) and emergent) (Table 1.1)
- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Table 1.1 Aquatic flora growth forms.

| Growth Form | Description |
|---|---|
| submerged | • predominantly grow beneath the surface of the water<br>• flowers may project above the water surface<br>• some leaves may float on the water surface |
| floating | • can be either free-floating or rooted<br>• free-floating species are usually not attached to the substrate<br>• rooted species are attached to the substrate and normally have at least the mature leaves floating on the water surface |
| emergent | • rooted in the substrate<br>• stems, flowers and most of the mature leaves project above the water surface |

source: Sainty & Jacobs 2003

Percent cover of each species was assessed visually and the presence of listed protected species, under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* was determined for each site.

Aquatic flora species were identified in the field, where practical. Representative specimens were collected for identification in the laboratory (or by the Queensland Herbarium, if required). Species were identified as native or exotic according to the *Census of Queensland Flora 2007* (Queensland Herbarium 2007).

## 1.2 Regional and Ecological Perspective

The literature on aquatic vegetation in each catchment was also reviewed, and summarised to provide a context for the results.

# 2 Results

## 2.1 Taxonomic Richness

Taxonomic richness varied between sites, ranging from 0 to 12. The highest taxonomic richness was at site KP177.7 in the Dawson River sub-catchment, which was dominated by giant sedge, and at site KP108.6 in the Comet River sub-catchment, which was dominated by lesser joyweed (Figure 2.1; Table 2.1). No aquatic flora was observed at site KP124.5 in the Comet River sub-catchment and at site KP187.6 in the Dawson River sub-catchment.

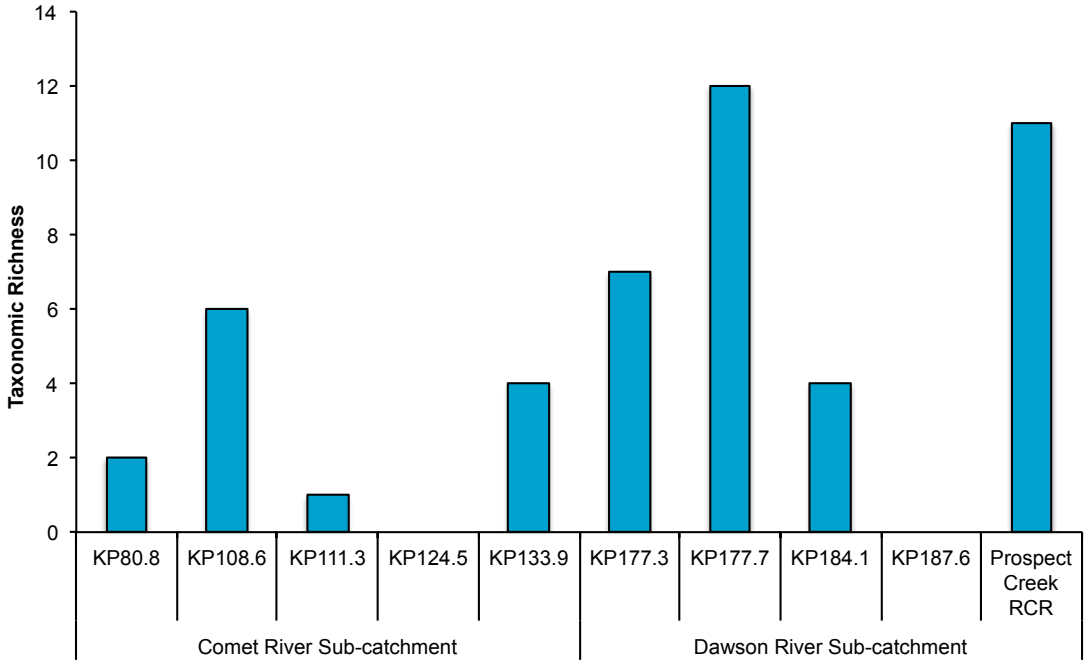


Figure 2.1 Taxonomic richness of aquatic flora at each site along the GLNG pipeline (KP70 to KP200).

## 2.2 Percent Cover

The percent cover of aquatic flora (as a percentage of the total substrate) ranged from 0 to 100% (Figure 2.2; Table 2.1). The highest cover was at site KP177.3 (palustrine wetland in the Dawson River sub-catchment) and the lowest percent cover (of the sites where aquatic flora was found) was at site KP80.8 (in the Comet River sub-catchment). Overall, the percent cover of aquatic flora was higher at sites in the Dawson River sub-catchment than at sites in the Comet River sub-catchment.

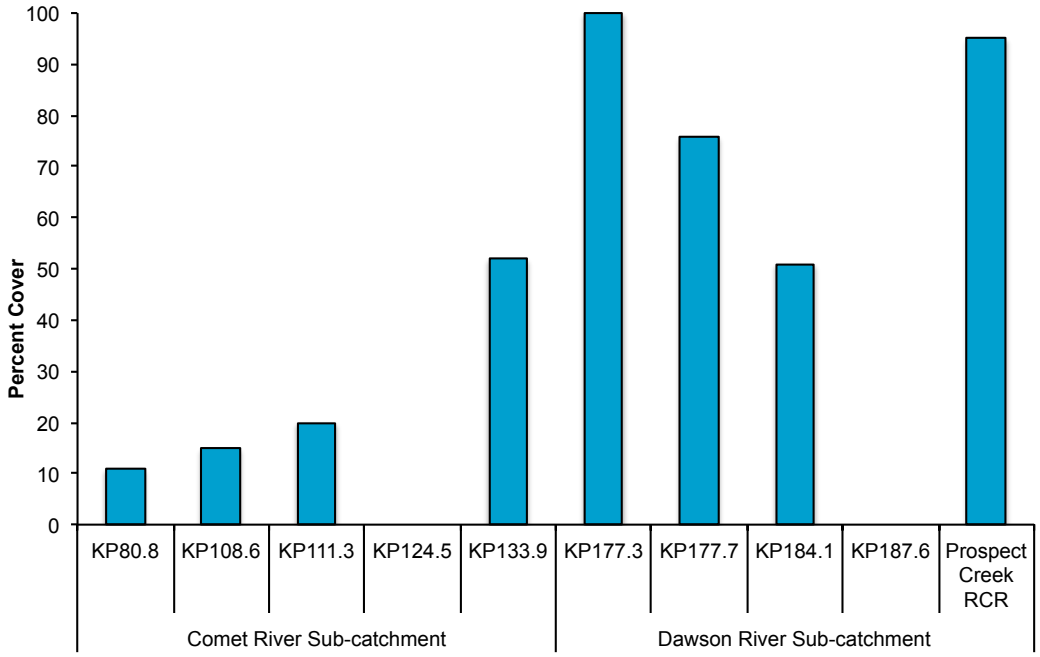


Figure 2.2 Percent cover of aquatic flora at each site along the GLNG pipeline (KP70 to KP200).

Table 2.1 Abundance of each aquatic flora species at each site along the GLNG pipeline (KP70 to KP200).

| Species Name | Common Name | Growth Form | Comet River sub-catchment | | | | | Dawson River sub-catchment | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KP8 1.2 | KP10 8.5 | KP11 1.3 | KP12 4.4 | KP13 3.9 | KP17 7.0 | KP17 7.7 | KP18 3.9 | KP18 7.6 | Prospect Creek RCR | |
| *Alternanthera denticulata* | lesser joyweed | E | 5 | | | | | | | | | | 5 |
| *Aponogeton elongatus* | cape pond lily | FA | | | | | | 0.3 | | | | | 0.3 |
| *Cyperus bifax* | downs nutgrass | E | | | | | 30 | | | | 3 | | 33 |
| *Cyperus concinnus* | trim flat sedge | E | | | | | 0.1 | | | | 8 | | 8.1 |
| *Cyperus difformis* | dirty dora | E | 2 | | | | | | 1 | | | | 3 |
| *Cyperus distans* | flat sedge | E | | | | | | | | | | 20 | 20 |
| *Cyperus exaltatus* | giant sedge | E | | | | | 0.1 | 54.1 | 40 | | | | 94.2 |
| *Cyperus polystachyos* | bunchy sedge | E | | | | 2 | | | | | | | 2 |
| *Cyperus trinervis* | Australian flat sedge | E | 2 | | | | | | | | | | 2 |
| *Eleocharis pallens* | pale spike sedge | E | | | | | 15 | 0.5 | | | | | 15.5 |
| *Glyceria maxima* | reed sweetgrass | E | | 20 | | 30 | | | | | | | 50 |
| *Juncus continuus* | sand rush | E | | | | | 0.1 | | | | | 10 | 10.1 |
| *Juncus sp.* | – | E | 1 | | | 15 | | | | | | | 16 |
| *Leptochloa digitata* | umbrella canegrass | E | | | | | 39.7 | | 5 | | | 10 | 54.7 |
| *Ludwigia peploides ssp. Montevidensis* | water primrose | FA | | | | | | 0.5 | | | | | 0.5 |
| | common | | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Myriophyllum verrucosum* | red milfoil | S | | | | | | | | | | 50 | 50 |
| *Nymphaea caerulea* | cape waterlily | FA | | | | | | 1 | | | | | 1 |
| *Paspalum sp.* | – | E | | | | | | 3 | | | | | 3 |
| *Persicaria decipiens* | slender knotweed | E | 3 | | | 5 | | 0.1 | | | | | 8.1 |
| *Persicaria hydropiper* | water pepper | E | 2 | | | | | | | | | | 2 |
| *Potamogeton crispus* | curly pondweed | S | | | | | | 0.6 | | | | | 0.6 |
| *Potamogeton ochreatus* | blunt pondweed | S | | | | | | | | | | 5 | 5 |
| *Potamogeton sulcatus* | floating pondweed | FA | | | | | | 3.1 | | | | | 3.1 |
| *Triglochin sp.* | water ribbons | S | | | | | | 0.1 | | | | | 0.1 |
| | **% exotic species** | | **–** | **–** | **100** | | **57.7** | **–** | **21.8** | **–** | **–** | **–** | |
| | **Total** | | **11** | **15** | **20** | **0** | **52** | **100** | **75.8** | **51** | **0** | **95** | |

– not present

E – emergent; S – submerged; FA – floating-attached

[1] could not be identified to species level due to a lack of reproductive parts

## 2.3 Growth Form Diversity

Emergent aquatic flora was the only growth form at all sites in the Comet River sub-catchment.

Emergent aquatic flora was the most common growth form at all sites in the Dawson River sub-catchment. There was submerged aquatic flora at site KP177.7 only in the Dawson River sub-catchment. Submerged aquatic flora included Eurasian water milfoil (*Myriophyllum spicatum*) (Figure 2.3), curly pondweed (*Potamogeton crispus*), and water ribbons (*Triglochin* sp.). There were six floating attached species at three sites in Dawson River sub-catchment; four species at site KP177.7 and one each at sites KP177 and KP184.1.

The lack or limited number of submerged and floating attached aquatic flora in the creeks reflected the creek's ephemeral nature. Submerged aquatic flora cannot survive dry periods and high turbidity (high turbidity reduces light in the water column and inhibits photosynthesis); emergent forms are most tolerant of dry conditions.

Figure 2.3

Eurasian water milfoil at site KP177.7.



## 2.4 Exotic Species

Four exotic species were identified along the GLNG Pipeline, including:

- reed sweetgrass
- Eurasian water milfoil
- *Paspalum* sp., and
- cape water lily.

Reed sweetgrass was found at site KP111.3 (comprising 100% aquatic flora) and KP133.9 (comprising 57.7% aquatic flora) in the Comet River sub-catchment. The remaining three exotic species were found at site KP177.7 (comprising 21.8% aquatic flora) (Table 2.1).

Eurasian water milfoil is a declared Class 1 pest under the *Land Protection (Pest and Stock Route Management) Act 2002.* Cape water lily, reed sweetgrass and several species from the genus *Paspalum* sp. are considered to be environmental weeds and one species (*Paspalum mandiocanum*) is a declared pest under local government law in some areas.

## 2.5 Listed Species of Conservational Significance

There were no species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* observed in the surveys.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Duding the GLNG Project Environmental Impact Statement (EIS) surveys, 13 species of emergent aquatic flora were recorded from the upper Dawson River sub-catchment (frc environmental 2009). The most common and abundant species were:

- awnless barnyard grass (*Echinochloa colona*)
- common rush (*Juncus usitatus*), and
- mat rush (*Lomandra longifolia*).

Two exotic species were recorded: reed sweetgrass and curled dock (*Rumex crispus*).

State of the Rivers (Telfer 1995) sites in the sub-catchment were dry at the time of sampling (91%), and sites with water did not support aquatic vegetation. A similar result was obtained during a reconnaissance of the upper Dawson sub-catchment (frc environmental 2007).

frc environmental (2007) reported ten different species of aquatic flora at seven sites, with richness ranging from zero to eight species at any one site. All aquatic floras had an emergent growth form (there were no floating or submerged species). Subsequently, frc environmental (2008) reported nine species with richness ranging from one to six species at any one site and cover of less than or equal to 10%. The most abundant and common aquatic flora was the common rush.

## 3.2 Comet River Sub-catchment

Duding the GLNG Project Environmental Impact Statement (EIS) surveys, 14 species of emergent aquatic flora, on floating attached species and four submerged species were recorded from the Comet River sub-catchment (frc environmental 2009). The most common and abundant species were:

- awnless barnyard grass
- water couch (*Cynodon dactylon*), and
- common rush.

Two exotic species were recorded: reed sweetgrass and curled dock.

The State of the Rivers assessment (Henderson 2000), rated the aquatic vegetation communities of the Comet River sub-catchment mostly as very poor. This was likely to reflect the high turbidity at the time of survey, which prevented an accurate assessment at many sites; turbidity was considered too high to accurately estimate cover at 18% of sites. Aquatic vegetation recorded in the Comet River sub-catchment included:

- common reed (*Phragmites australis*)
- water fern (*Azolla* spp.), and
- *Blyxa* spp.

# 4 References

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# Appendix D Macroinvertebrate Communities

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# 1 Survey Design and Methods

## 1.1 Sample Collection

### Macroinvertebrate Samples

Benthic macroinvertebrates were assessed at each site in bed and edge habitats. Five samples were taken from each habitat type, with each sample consisting of five sweeps of an area of 30 $cm^2$. A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples.

### Macrocrustacean Samples

Macrocrustaceans are not planktonic and include the orders Amphipoda, Isopoda and Decapoda. Macrocrustaceans (e.g. prawns, shrimps and yabbies) were caught as by-catch in fish surveys, using a combination of backpack electrofishing, baited traps and seine nets. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*. Macrocrustaceans were also caught in macroinvertebrate surveys, using a macroinvertebrate sampling net.

Details of fishing methods and survey efforts are presented in Appendix E.

## 1.2 Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003). All macrocrustaceans were identified and counted in the field and specimens were returned to the environment.

## 1.3 Data Analysis

The following indices were calculated for each sample (further information is provided overleaf):

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2 scores.

These indices were used to indicate the current ecological health of surveyed waterways. The mean and standard error was calculated for each habitat type at each site. The total number of species and total abundance for each habitat type at each site were also calculated by pooling the data from the five samples. Results were compared to the relevant biological water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin (DERM 2011) for the Fitzroy River Basin, including the Dawson River catchment (Table 1.1). While the guidelines were developed using macroinvertebrate samples collected using AUSRIVAS sampling methods and are not directly applicable, this comparison was still useful for providing an overall preliminary indication of ecosystem health.

Table 1.1 Fitzroy Basin biological water quality objectives for the Comet River sub-catchment and Dawson River sub-catchment.

| Indicator | Habitat | WQO |
|---|---|---|
| **Comet River and Dawson River Sub-catchment** | | |
| composite [a] | taxonomic richness | 12–21 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.33–3.85 |
| edge | taxonomic richness | 23–33 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.31–4.2 |

source: DERM (2011)

[a] comprises all bed habitat within the site, including sandy pool, rocky pool, riffle, run and cascade

### *Abundance*

Abundance is the total number of macroinvertebrates.

### *Taxonomic Richness*

Taxonomic richness is the number of taxa (in this assessment, families). Taxonomic richness is a basic, unambiguous and effective diversity measure. However, it is affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxon, so rare and common taxa are considered equally.

### *PET Richness*

While some groups of macroinvertebrates are tolerant to pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat condition and water quality than in sites of degraded condition. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score, the greater the inferred degradation.

### *SIGNAL 2 Scores*

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence or absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxon, and
- divided by the total of the weight factors for each taxon.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 1.1). Boundaries based on the Fitzroy Basin biological water quality objectives were used for this study.

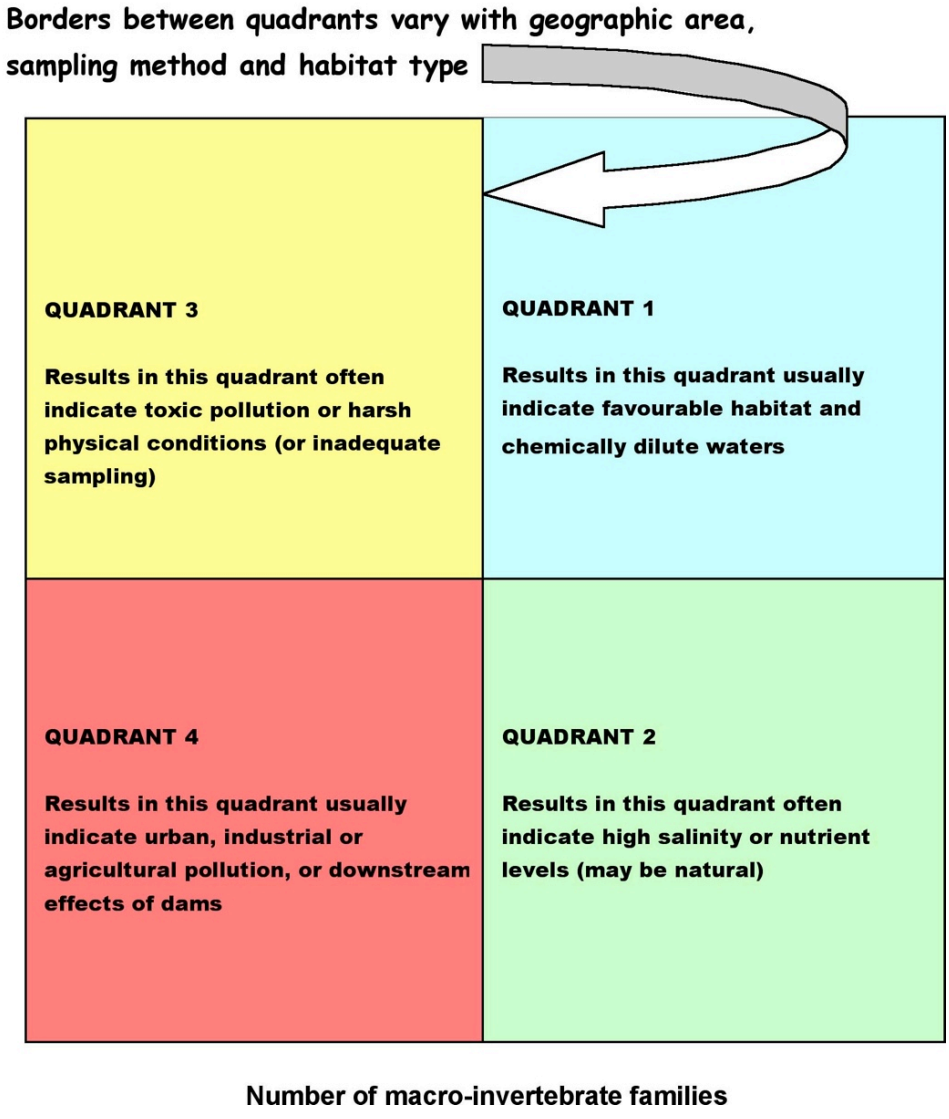


Figure 1.1 Quadrant diagram for SIGNAL 2 / family bi-plot.

### Multivariate Analyses

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or indices (such as richness, PET richness and SIGNAL 2 scores) derived to represent the community (i.e. univariate analyses). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

We examined differences in community composition between sites, using a one-way analysis of similarity (ANOSIM). Before analysis, community data was log-transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, using the averaged data for each habitat at each site, using non-metric multi-dimensional scaling (nMDS) ordinations. Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

## 1.4 Regional and Ecological Perspective

The literature on macroinvertebrate communities in each catchment was also reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

## 2.1 Abundance

### Mean Abundance

Mean abundance (i.e. the average number of individuals of the five samples from each site) varied between sites and between habitats at each site. In both bed and edge habitats, the highest mean abundance was at site KP108.6 (Clematis Creek) in the Comet River sub-catchment, although mean abundance of macroinvertebrates was also high in edge habitat at Prospect Creek RCR (Figure 2.1). The high variation in abundance between sites was likely to be because sites were ephemeral, isolated pools. Mean abundance was higher in edge habitat at each site. This was a common result, and was likely to reflect the habitat structure.

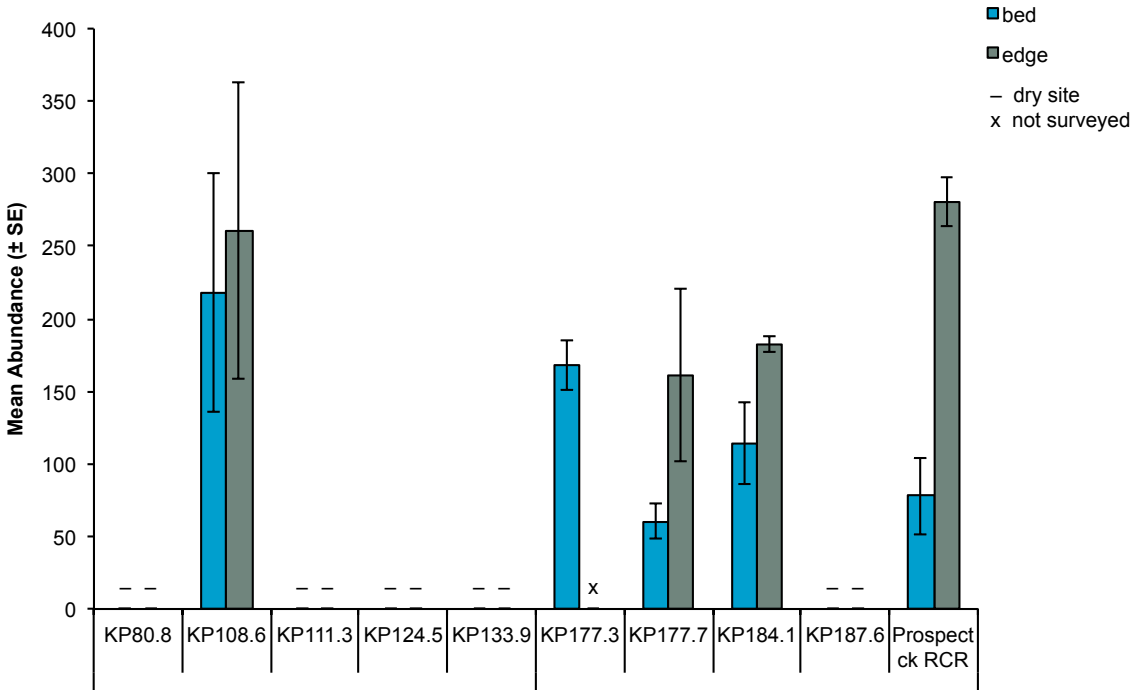


Figure 2.1 Mean abundance of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## Total Abundance

In bed and edge habitat, total abundance (i.e. the total number of individuals in the five samples from each site) was highest at site KP108.6 in the Comet River sub-catchment and lowest at site KP177.7 (Prospect Creek) in the Dawson River sub-catchment, where Cladocera dominated edge habitat and Chironomidae dominated bed habitat (Figure 2.2). The total abundance of macroinvertebrates in edge habitat was also high at Prospect Creek RCR.

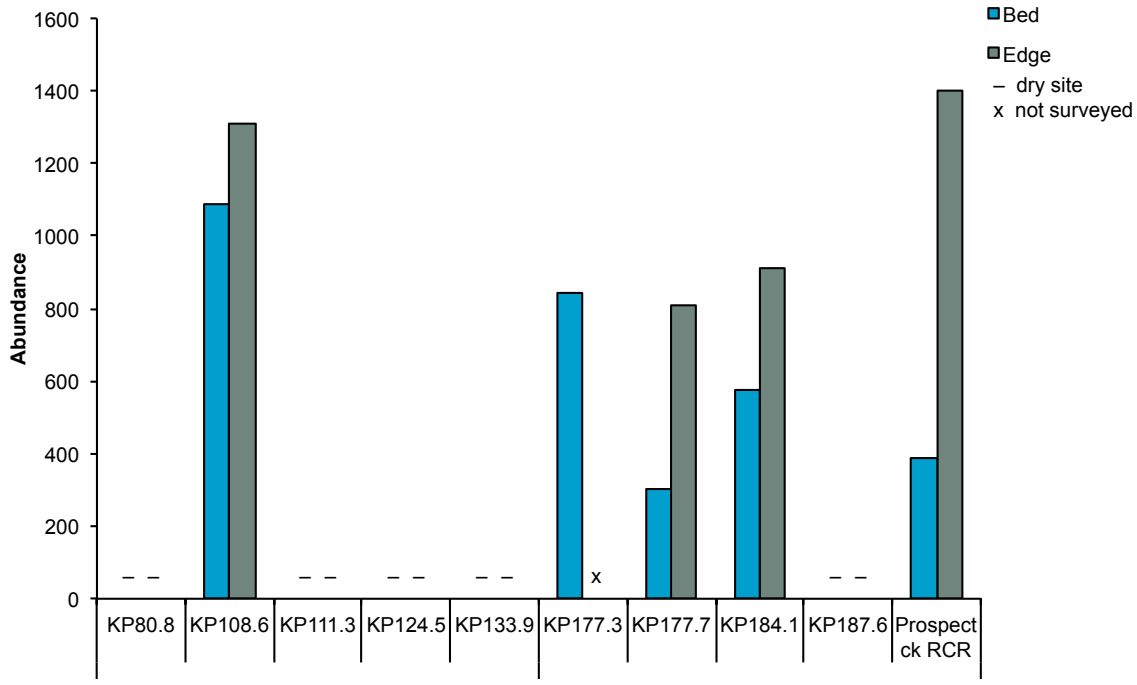


Figure 2.2 Total abundance of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## 2.2 Taxonomic Richness

### Mean Taxonomic Richness

Mean taxonomic richness varied between sites and between habitats at each site. The highest taxonomic richness was at sites KP177.7 (Prospect Creek) and Prospect Creek RCR in edge habitat and at site KP177.3 (palustrine wetland) in bed habitat. In both bed and edge habitat, the lowest taxonomic richness was at site KP184.1 (Unnamed watercourse 5) (Figure 2.3). Overall, taxonomic richness was lower in bed habitat than in edge habitat at each site. Taxonomic richness of macroinvertebrates had no obvious relationship to the overall habitat condition, indicating that changes in community composition were likely to be related to site-specific factors such as habitat availability or patchy recruitment processes of macroinvertebrates.

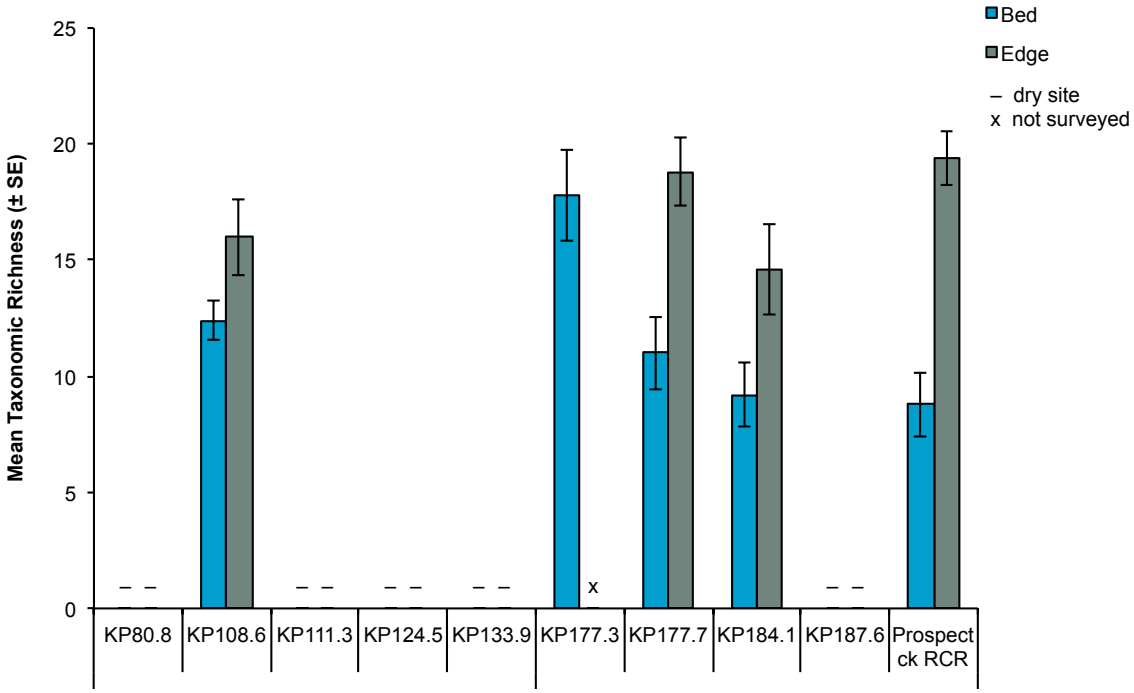


Figure 2.3 Mean taxonomic richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## Total Taxonomic Richness

Total taxonomic richness ranged from 19 to 34 taxa in bed habitat and from 30 to 44 taxa in edge habitat. The highest taxonomic richness was at site KP177.3 (palustrine wetland) in bed habitat and site KP177.7 (Prospect Creek) in edge habitat. Total taxonomic richness was within or above the Fitzroy Basin WQO range for Comet River and Dawson River sub-catchments (Figure 2.4; Figure 2.5).

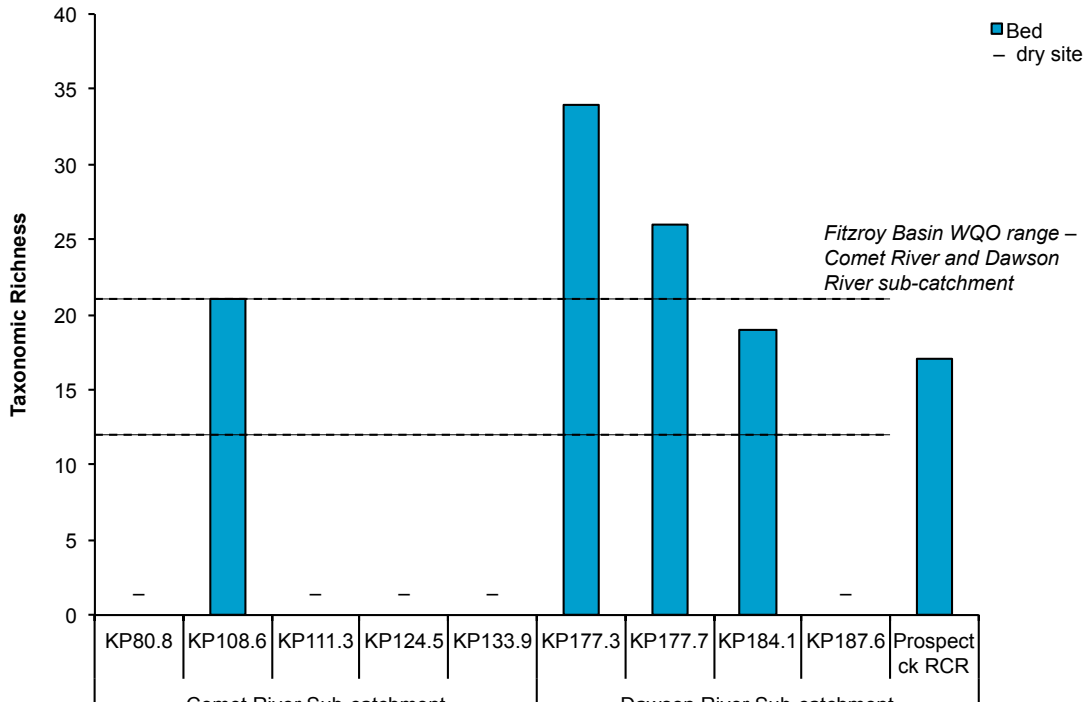


Figure 2.4 Total taxonomic richness of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP70 to KP200).

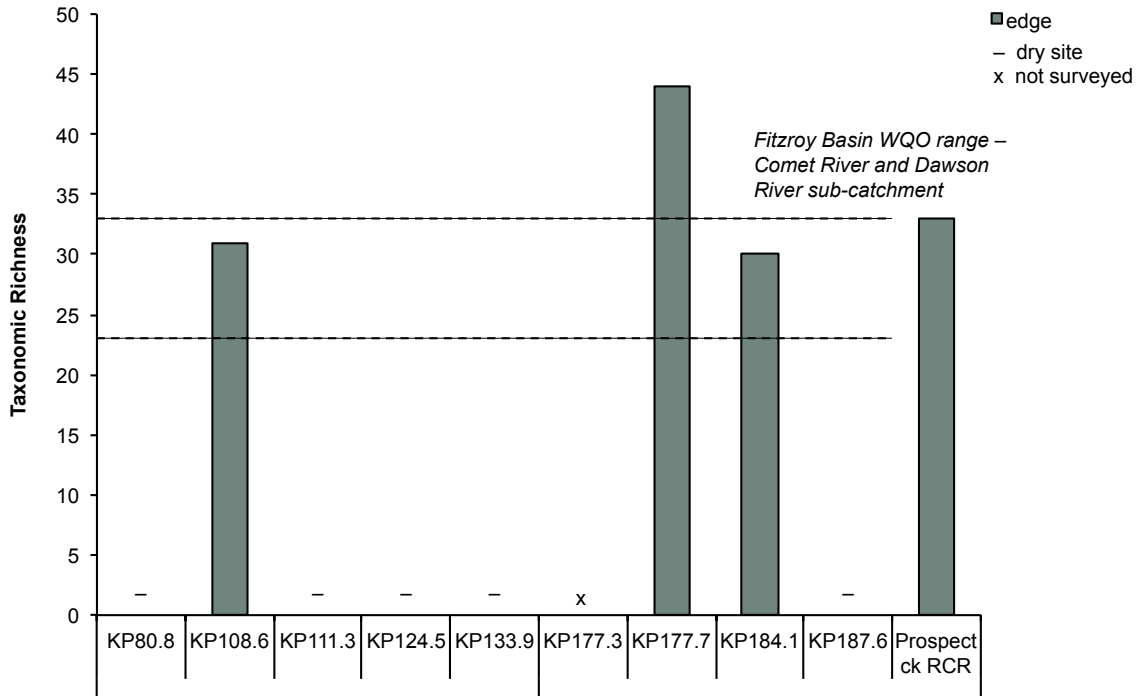


Figure 2.5 Total taxonomic richness of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## 2.3 PET Richness

### Mean PET Richness

PET taxa are sensitive to pollutants and changes in water quality and / or environmental degradation. In both bed and edge habitat, mean PET was highest at site KP108.6 (Clematis Creek). Mean PET richness was lowest at site KP177.3 (palustrine wetland) in bed habitat and at site KP184.1 (Unnamed watercourse 5) in edge habitat (Figure 2.6).

Overall, mean PET richness was higher in edge habitat than in bed habitat. Similar to other indices, PET richness was likely to be related to site-specific habitat availability and condition.

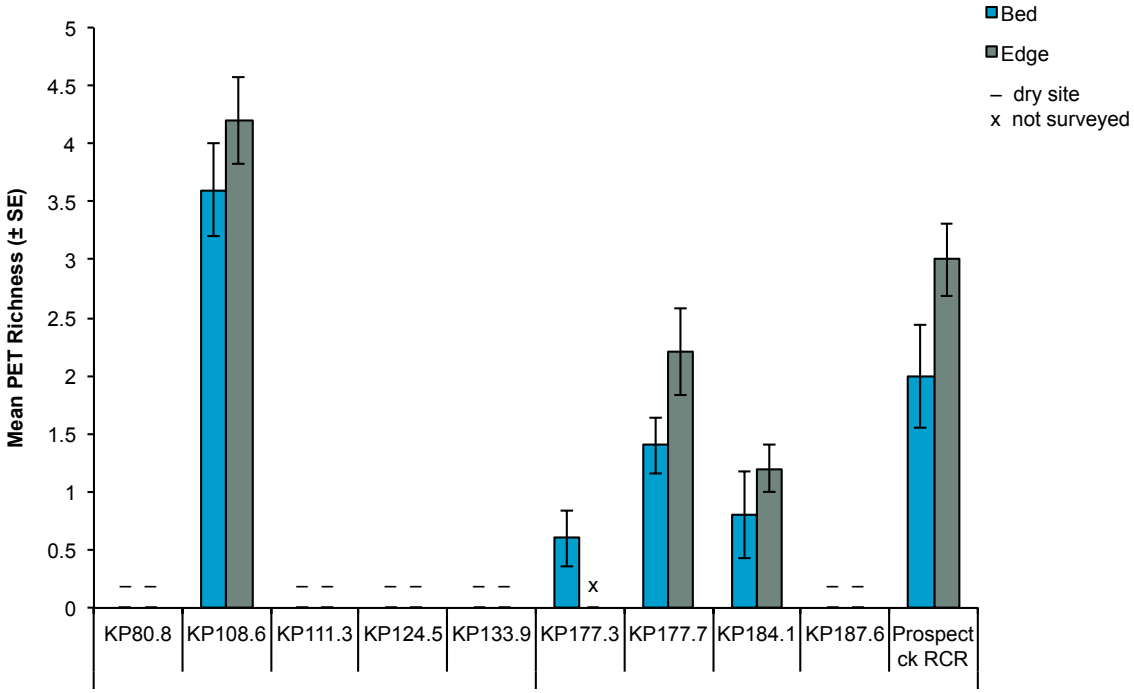


Figure 2.6 Mean PET richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## Total PET Richness

Total PET richness ranged from 1 to 4 taxa in bed habitat and from 3 to 5 taxa in edge habitat. The highest PET richness was at sites 108.6 (Clematis Creek) and 184.1 (Unnamed watercourse 5) in bed habitat and sites 108.6 and KP177.7 (Prospect Creek) in edge habitat. Total PET richness was within or above the Fitzroy Basin WQO range for Comet River and Dawson River sub-catchments at each site, except at site KP177.3 in bed habitat (Figure 2.7). However, site KP177.3 is a wetland, so PET richness is not directly applicable.

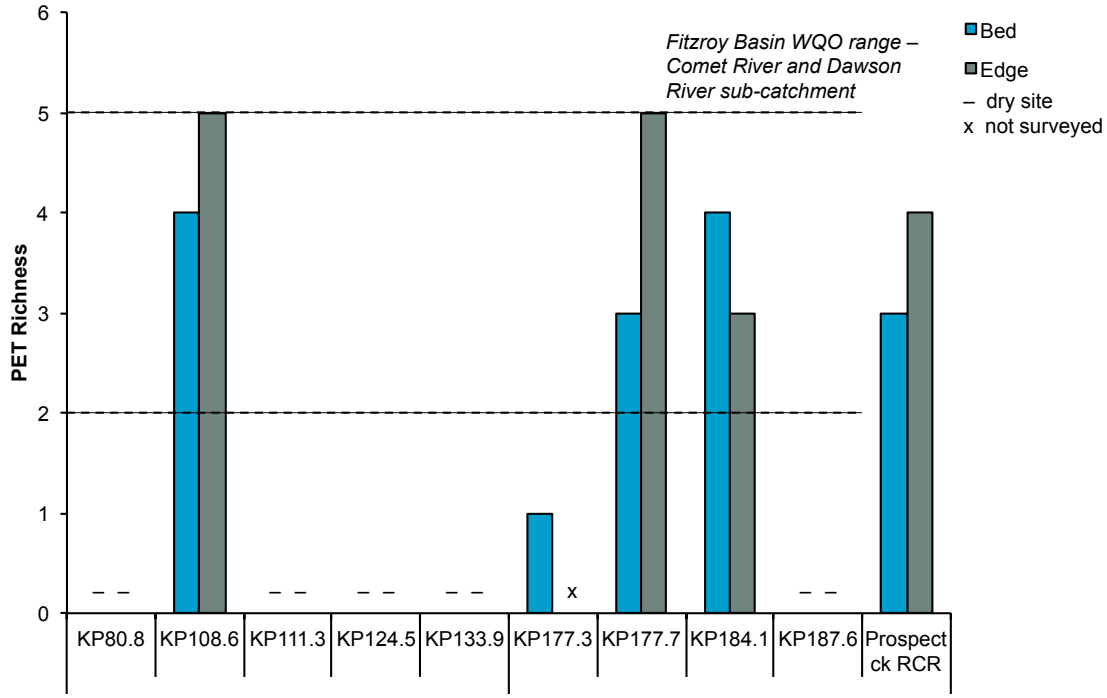


Figure 2.7 Total PET richness of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## 2.4 SIGNAL 2 Scores

### Mean SIGNAL 2 Scores

Mean SIGNAL 2 scores were low (<4) in bed and edge habitat, and at most sites scores were higher in bed habitat than in edge habitat (Figure 2.8).

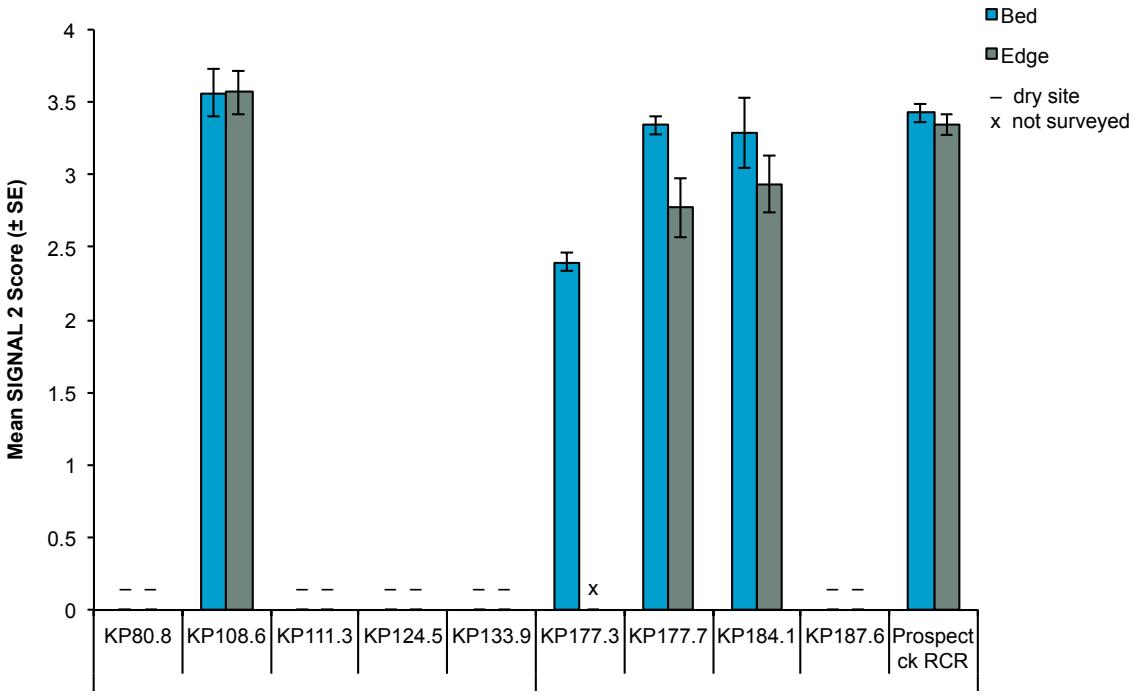


Figure 2.8 Mean SIGNAL 2 scores of macroinvertebrates in bed and edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## Total SIGNAL 2 Scores

Total SIGNAL 2 scores were low (<4) in bed and edge habitat. SIGNAL 2 scores ranged from 2.59 to 3.79 in bed habitat and from 2.91 to 3.42 in edge habitat. Total SIGNAL 2 scores were within the Fitzroy Basin WQO range at only two sites (KP177.7, Prospect Creek, and Prospect Creek RCR) in bed habitat and two sites (KP108.6, Clematis Creek, and Prospect Creek RCR) in edge habitat, and below the WQO range at all other sites (Figure 2.9; Figure 2.10).

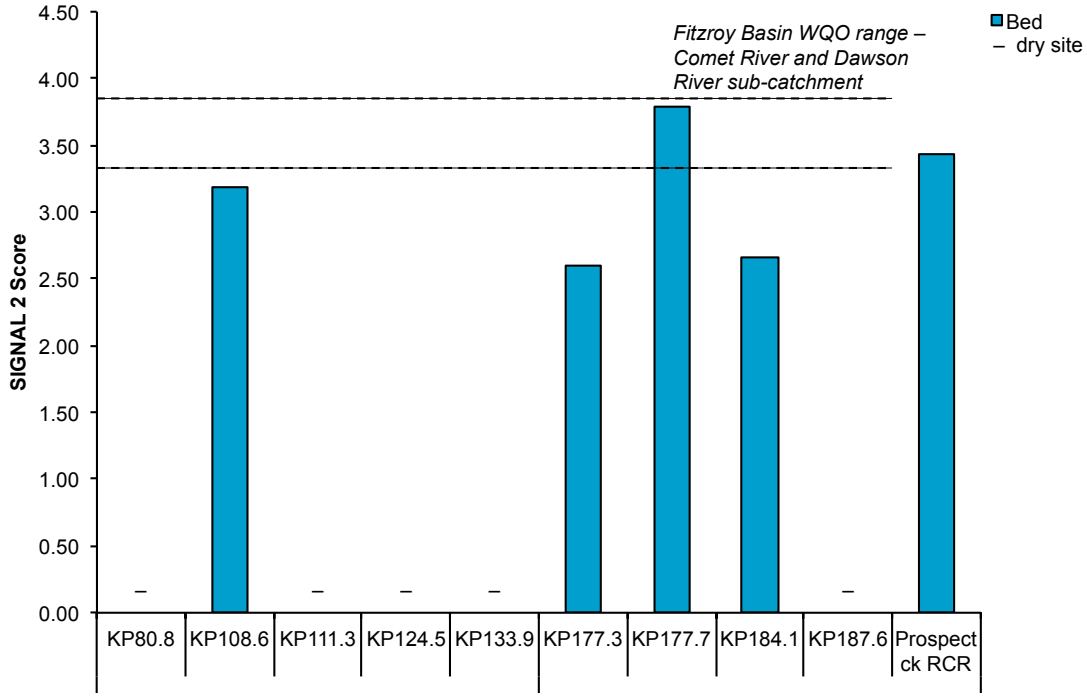


Figure 2.9 Total SIGNAL 2 scores of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP70 to KP200).

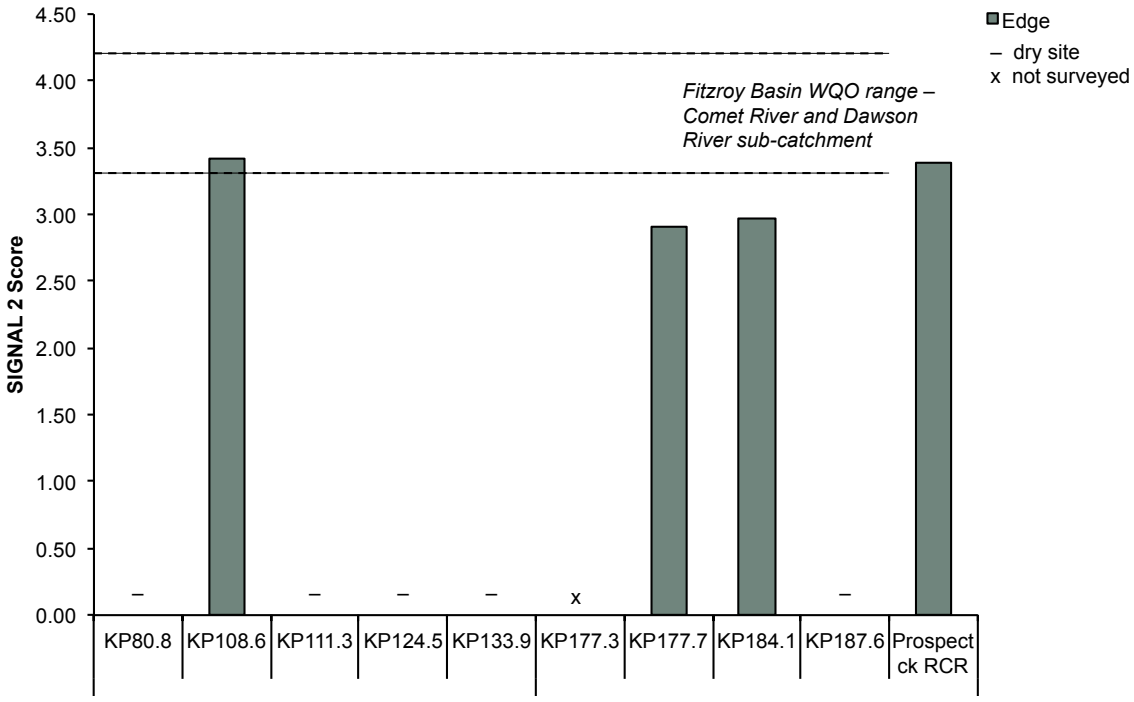


Figure 2.10 Total SIGNAL 2 scores of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## SIGNAL 2 / Family Bi-plots

The SIGNAL 2 / family bi-plot for bed and edge habitat showed that most sites were within quadrant 2, which indicated that the macroinvertebrate community was influenced by high salinity or high concentrations of nutrients (which may be natural). Site KP177.7 (Prospect Creek) and Prospect Creek RCR in bed habitat and KP108.25 (Clematis Creek) and Prospect Creek RCR in edge habitat were within quadrant 1, which indicated favourable habitat and chemically dilute waters (Figure 2.11; Figure 2.12).

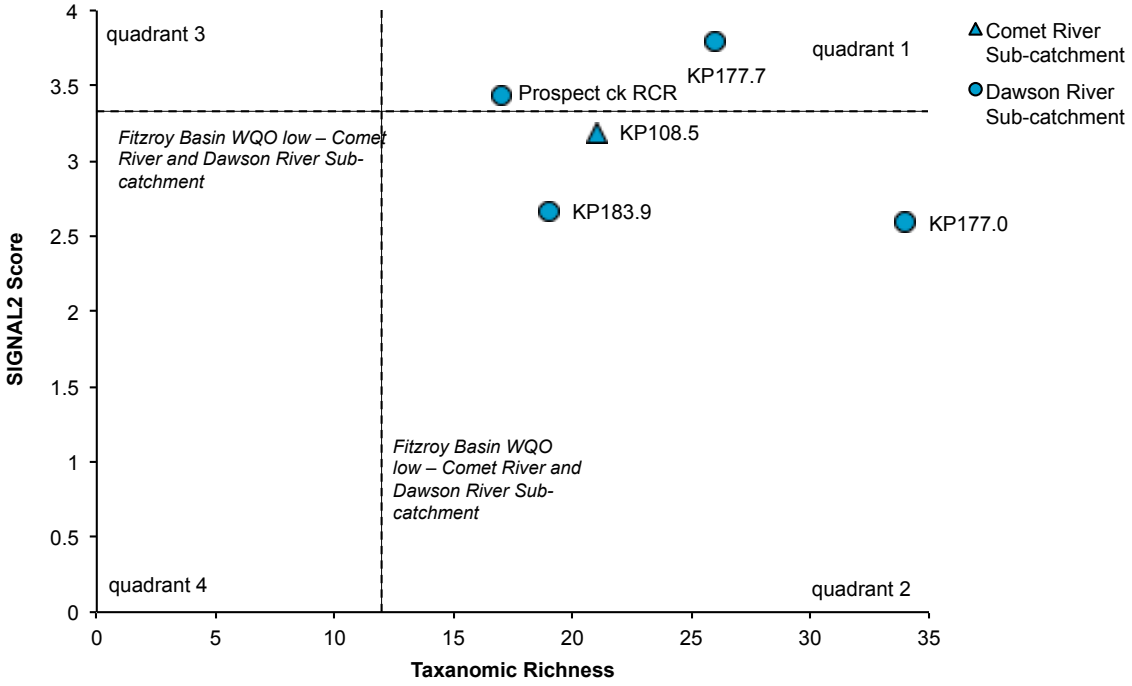


Figure 2.11 SIGNAL 2 / family bi-plot of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP70 to KP200).

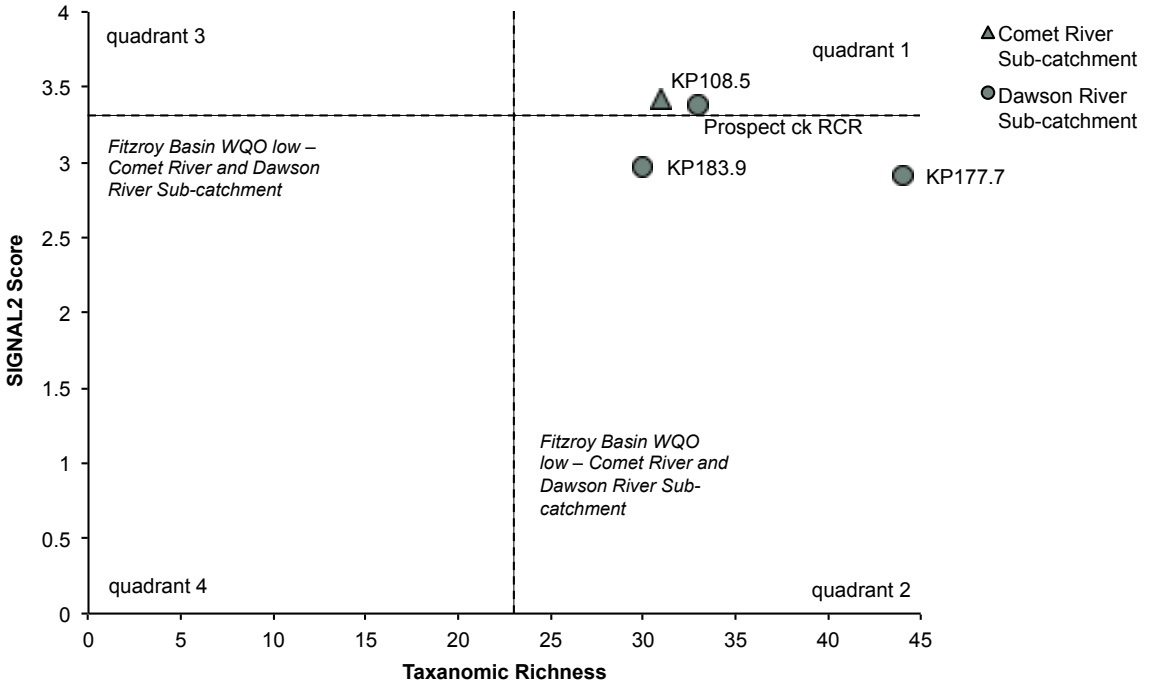


Figure 2.12 SIGNAL 2 / family bi-plot of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP70 to KP200).

## 2.5 Community Composition

### Bed Habitat

Macroinvertebrate community composition in bed habitat varied between sites (ANOSIM Global R statistic=0.897, p<0.001) and was similar within sites, indicated by clustering of samples from each of the sites in the nMDS plot (Figure 2.13). The differences in community structure between sites might be related to site-specific habitat availability and condition and patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between each site (ANOSIM, p<0.05). Communities from the sites closest together (sites KP177.3 and KP177.7) were most different from each other (Global R statistic=1, p<0.05; note large distance between sites on the nMDS plot). This variation in community composition was due to the presence of diving beetle (family Dytiscidae) and biting midge larvae (sub-family Culicidae) at site KP177.3, and the presence of aquatic worms (sub-class Oligochaeta) at site KP177.7 (SIMPER). However, site KP177.3 is a wetland and site KP177.7 is a stream (Prospect Creek), so differences in macroinvertebrate communities over this small geographic scale likely resulted from these habitat differences.

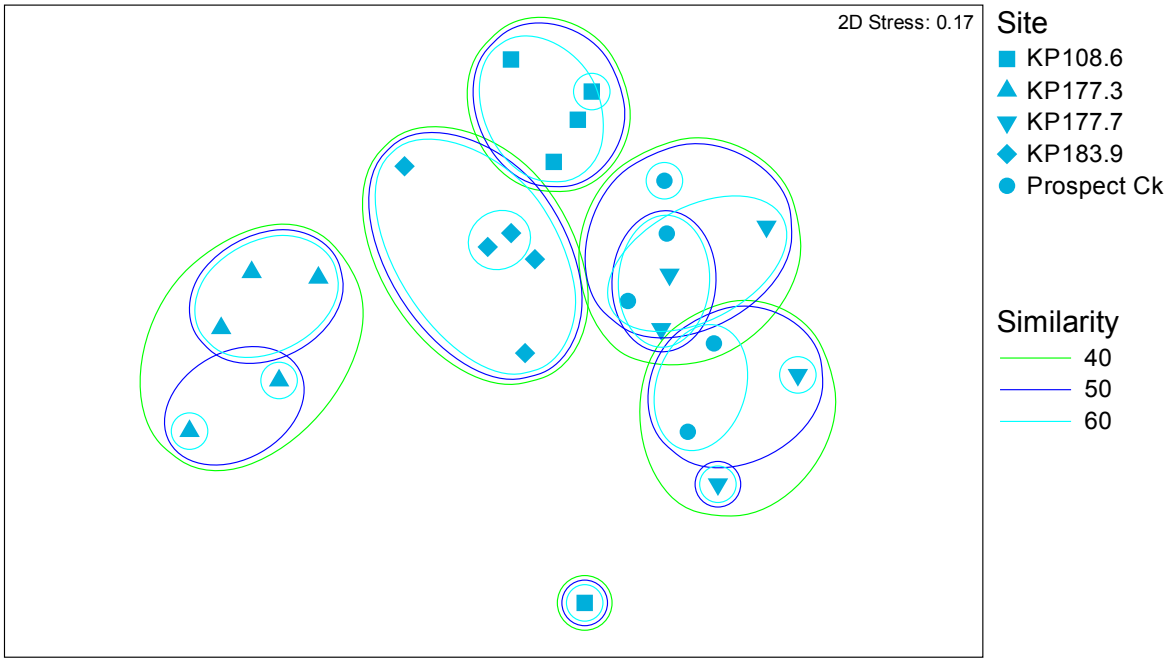


Figure 2.13 Non-metric multidimensional scaling ordination in bed habitat.

## Edge Habitat

Macroinvertebrate community composition in edge habitat varied between sites (ANOSIM Global R statistic=0.780, p<0.001) and was similar within sites, indicated by clustering of samples from each of the sites in the nMDS plot (Figure 2.14). Similar to bed habitat, the differences in community structure between sites might be related to site-specific habitat availability and condition. Pairwise comparisons revealed that there were significant differences between each site (ANOSIM, p<0.05). Communities from sites KP108.6 (Clematis Creek) in the Comet River sub-catchment and KP177.7 (Prospect Creek) in the Dawson River sub-catchment were most different from each other (Global R statistic=0.764, p<0.05). This variation in community composition was due to the high abundance of mayflies (family Caenidae) and caddisflies (family Ecnomidae), which are both PET taxa, at site KP108.6 and the high abundance of damselflies (family Coenagrionidae) at site KP177.7 (SIMPER).

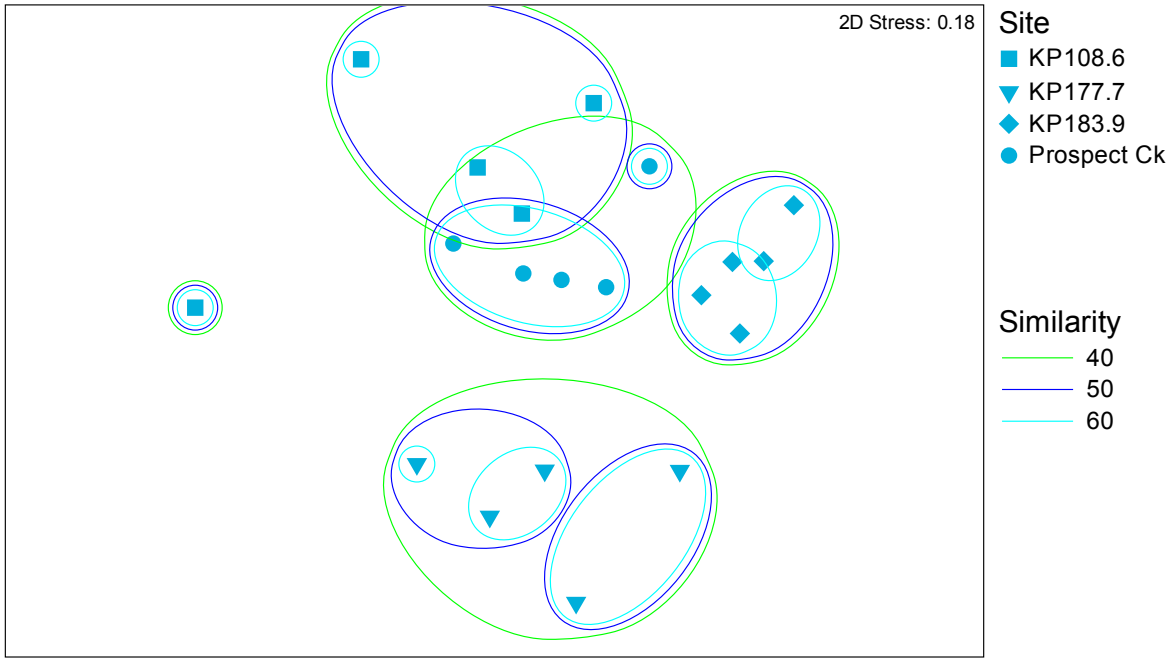


Figure 2.14 Non-metric multidimensional scaling ordination in edge habitat.

## 2.6 Macrocrustaceans

Three taxa of macrocrustaceans were caught:

- freshwater prawn (*Macrobrachium australiense*) (Figure 2.15)
- freshwater shrimp (family Atyidae, genus *Caridina*), and
- yabbies (*Cherax depressus)* (Figure 2.16).

Figure 2.15

Freshwater shrimp caught in the Comet River and Dawson River sub-catchments.



Figure 2.16

Yabby caught in the Comet River and Dawson River sub-catchments.



Overall, the most abundant and widespread species caught were the freshwater shrimp and freshwater prawn, which were caught at three sites. Communities were most diverse at site KP108.6 where three species were caught.

Table 2.1 Abundance of macrocrustaceans at each site along the GLNG pipeline (KP70 to KP200).

| Family<br>Common Name | Comet River Sub-catchment | | | | Dawson River Sub-catchment | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | KP80.8 | KP108.6 | KP111.3 | KP124.5 | KP133.9 | KP177.3 | KP177.7 | KP184.1 | KP187.6 | PC [a] | |
| **Atyidae**<br>freshwater shrimp | – | 8 | – | – | – | 1 | 170 | – | – | **61** | **179** |
| **Palaemonidae**<br>freshwater prawn | – | 30 | – | – | – | – | 72 | 4 | – | **20** | **106** |
| **Parastacidae**<br>yabby | – | 14 | – | – | – | – | – | 9 | – | **-** | **21** |
| **Total** | **–** | **52** | **–** | **–** | **–** | **1** | **242** | **13** | **–** | **81** | **308** |

[a] **Prospect Creek RCR**

The common yabby (*Cherax destructor*) is listed as vulnerable on the International Union for Conservation of Nature and Resources Red List of Threatened Species, but is not listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), or Queensland's *Nature Conservation Act 1992*.

No species, listed under the EPBC Act or Queensland's *Nature Conservation Act 1992,* were caught.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Data on macroinvertebrate communities was obtained from the Department of Environment and Heritage (DEHP) site 130302A (Dawson River at Taroom) from 1994 to 2004. Taxonomic richness was between 17 and 32 individuals in edge habitat and between 7 and 25 individuals in pool habitat (sandy and rocky), which was similar to taxonomic richness in the current wet season survey.

The PET richness in the Dawson River at Taroom was between one and six individuals in edge and pool habitats. This was similar to PET richness in the current survey, indicating that PET richness is similar at other sites throughout the region.

Macroinvertebrate communities in edge habitat in the Dawson River were within quadrants 1 and 2 of the family bi-plot. Macroinvertebrate communities in bed habitat in the Dawson River were within quadrants 2 and 4, indicating that there are potentially large differences in the quality of water and / or habitat condition (e.g. sedimentation of bed habitats). Overall, surrounding land uses are likely to impact macroinvertebrate communities in the catchment.

## 3.2 Comet River Sub-catchment

The former Queensland Department of Natural Resources and Water sampled macroinvertebrates from the Comet River sub-catchment between 1995 and 1998. The richness of macroinvertebrate communities varied over time and between locations, and ranged from 21 to 29 individuals in edge habitat and 15 to 26 individuals in bed habitat, which is consistent with the results of the current study.

The PET richness from bed and edge habitats in the Brown and Comet Rivers are indicative of a healthy habitat and / or water quality. Similar to the current study, macroinvertebrate communities in the Brown and Comet Rivers displayed clustering within quadrants 2, indicating that communities are affected by high nutrients and / or salinity.

# 4 References

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# Appendix E Freshwater Fish

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# 1 Survey Design and Methods

## 1.1 Data Collection

Fish communities were surveyed using a combination of backpack electrofishing, baited traps, and seine and dip nets (Table 1.1). Fish communities were assessed at four of the eight sites, as the following sites were dry:

- KP80.8
- KP111.3
- KP124.5
- KP133.9, and
- KP187.6.

Bait traps were not set at sites KP108.6 and KP177.3, as the water level was too low.

All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root LR-24 backpack electrofisher in shallow water. At sites where the conductivity of the water was too low or too high to effectively electrofish, or the water level was too low, fish communities were surveyed with a seine and dip nets with a 20 to 50 mm mesh size.

Fish communities were also surveyed with five small (2 mm mesh size) baited traps, which were set at each site for approximately a minimum of two hours. Bait traps were not set at sites where water level was too low.

Specimens that were unable to be identified in the field were euthanised and returned to the laboratory for identification.

The sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approval No. CA 2012/02/593 issued to frc environmental.

Table 1.1 Electrofishing and net efforts for fish surveys.

| Site | Method | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|
| **Comet River Sub-catchment** | | | | | | |
| KP108.6 | backpack electrofishing | 2012-03-20 | 1230 | 1245 | 300 V<br>30 Hz<br>12% | 279 s |
| **Dawson River Sub-catchment** | | | | | | |
| KP177.3 | dip net | 2012-02-19 | – | – | – | – |
| KP177.7 | small bait traps (5) | 2012-02-17 | 0900 | 1030 | – | 1.5 h |
| | backpack electrofishing | | 0910 | 1000 | 190 V<br>30 Hz<br>12% | 500 s |
| KP184.1 | small bait traps (5) | 2012-03-29 | 0940 | 1220 | – | 2.7 h |
| | backpack electrofishing | | 1105 | 1205 | 220 V<br>30 Hz<br>12% | 503 s |
| Prospect Creek RCR | small bait traps (5) | 2012-10-08 | 0930 | 1200 | – | 2.5 h |
| | backpack electrofishing | | 1005 | 1100 | 150 V<br>30 Hz<br>12% | 548 s |

## 1.2 Data Analysis

Fish communities at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage

- abundance of exotic species, and
- abundance of listed protected species.

## 1.3 Regional and Ecological Perspective

The literature on fish communities in each catchment was also reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

## 2.1 Abundance

The abundance of fish varied between sites. Fish were most abundant at sites KP184.1 (unnamed watercourse 6) and KP177.7 (Prospect Creek) in the Dawson River sub-catchment, where the catch was dominated by:

- mosquitofish (*Gambusia holbrooki*)
- glassfish (*Ambassis agassizii*), and
- common carp gudgeon (*Hypseleotris* spp.).

Fish abundance was lowest at site KP177.3 (palustrine wetland) in the Dawson River sub-catchment (Figure 2.1; Table 2.1). The composition and abundance of fish communities in ephemeral waterways, such as those in this survey, are known to be highly variable both spatially and temporally.

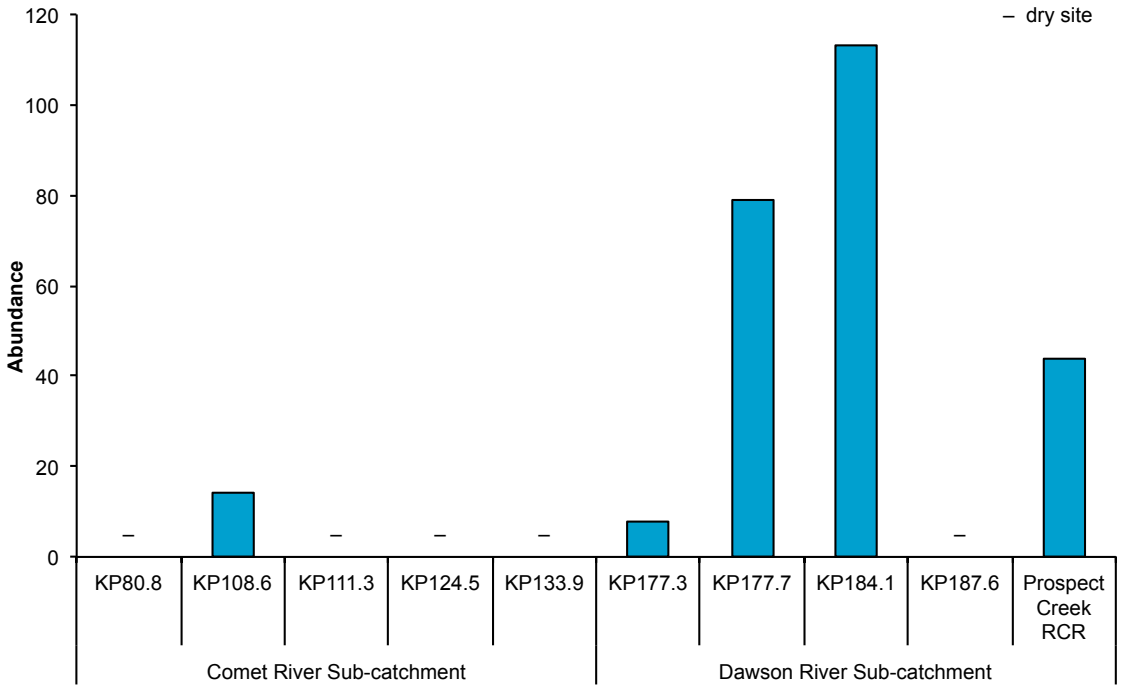


Figure 2.1 Abundance of fish at each site along the GLNG pipeline (KP70 to KP200).

Table 2.1 Abundance of each fish species at each site along the GLNG pipeline (KP70 to KP200).

| Species | Common Name | Comet River Sub-catchment | | | | | Dawson River Sub-catchment | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KP80.8 | KP108.6 | KP111.3 | KP124.5 | KP133.9 | KP177.3 | KP177.7 | KP184.1 | KP187.6 | PCRCR[a] | |
| *Ambassis agassizii* | Agassiz's glassfish | – | 0 | – | – | – | 2 | 28 | 31 | – | 3 | 64 |
| *Gambusia holbrooki* | mosquitofish | – | 0 | – | – | – | 1 | 19 | 59 | – | 0 | 79 |
| *Hypseleotris sp.* | common carp gudgeon | – | 6 | – | – | – | 5 | 25 | 18 | – | 41 | 95 |
| *Leiopotherapon unicolor* | spangled perch | – | 1 | – | – | – | 0 | 0 | 0 | – | 0 | 1 |
| *Melanotaenia splendida* | eastern rainbowfish | – | 1 | – | – | – | 0 | 7 | 1 | – | 0 | 9 |
| *Mogurnda adspersa* | purple spotted gudgeon | – | 6 | – | – | – | 0 | 0 | 0 | – | 0 | 6 |
| *Nematalosa erebi* | bony bream | – | 0 | – | – | – | 0 | 0 | 4 | – | 0 | 4 |
| | **% exotic species** | **–** | **–** | **–** | **–** | **–** | **12.5** | **24.1** | **52.2** | **–** | **–** | |

## 2.2 Taxonomic Richness

Taxonomic richness varied between sites. The fish community was most diverse at site KP184.1 (unnamed watercourse 5) in the Dawson River sub-catchment and KP108.6 (Clematis Creek) in the Comet River sub-catchment. The fish community was least diverse at site KP177.3 (palustrine wetland) in the Dawson River sub-catchment (Figure 2.2). The low number of species at some sites might indicate the ephemeral nature of the wetlands surveyed and the low connectivity to other water bodies (particularly for wetland site KP177.3 in the Dawson River sub-catchment). It is also possible that the high abundance of exotic species at some sites might be competing for resources, limiting the number of native species.

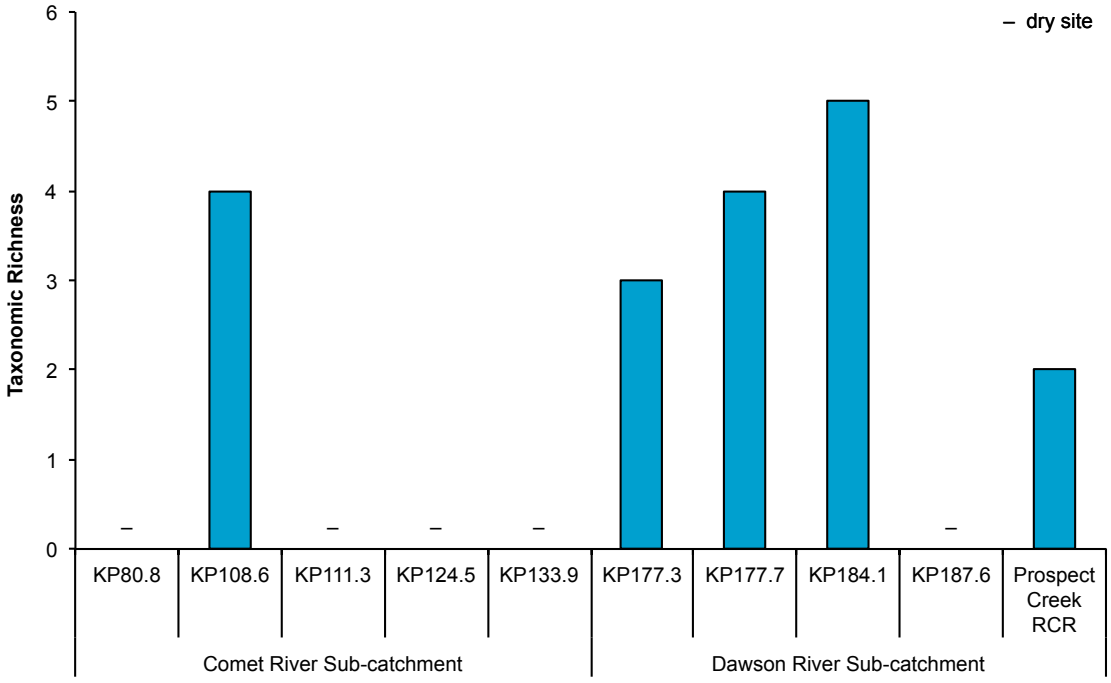


Figure 2.2 Taxonomic richness of fish at each site along the GLNG pipeline (KP70 to KP200).

## 2.3 Life-history Stages

The abundance of each life-history stage varied between sites. The intermediate life-history stage dominated fish communities at sites KP177.3 (palustrine wetland) and KP177.7 (Prospect Creek) in the Dawson River sub-catchment and the adult life-history stage dominated fish communities at site KP108.6 (Clematis Creek). No adults were caught at site KP177.3 (Figure 2.3). Due to the fast growth rates (i.e. maturation periods within 12 months) of most of species in the survey area, this is the expected distribution of life-history stages. That is, most species breed in autumn and summer, so in February / March most juveniles had developed to the intermediate life-history stage.

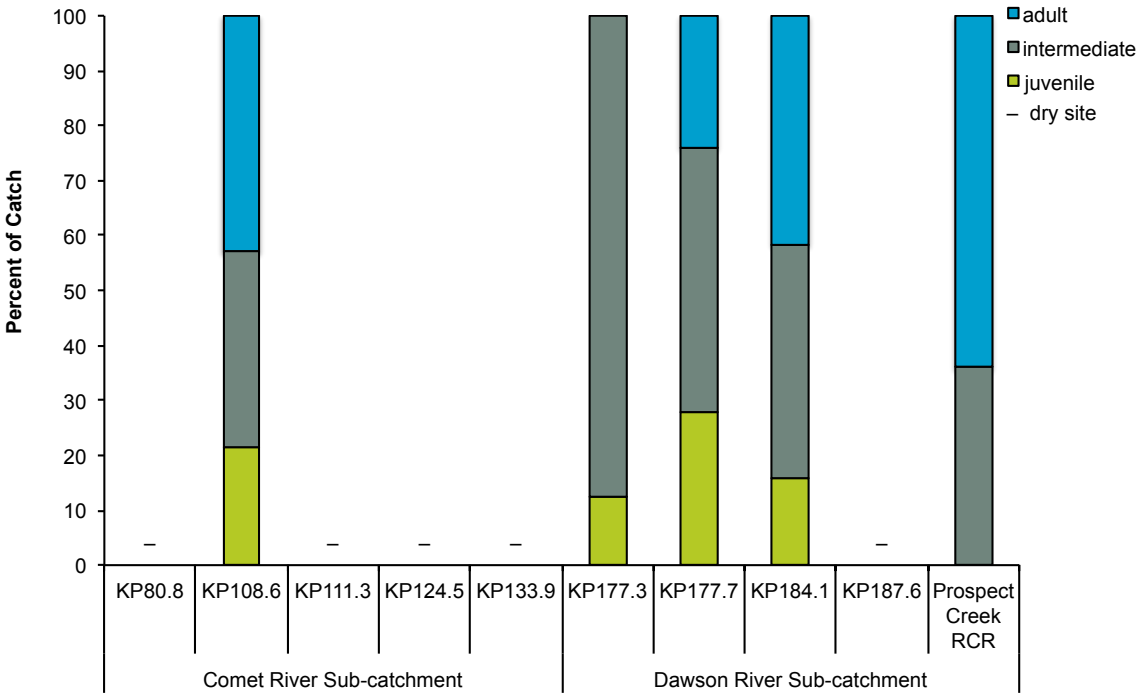


Figure 2.3 Life-history stages of fish at each site along the GLNG pipeline (KP70 to KP200).

## 2.4 Exotic Species

Mosquitofish were caught at these sites in the Dawson River sub-catchment:

- KP177.3 (12.5% of total catch)
- KP177.7 (24.1% of total catch), and
- KP184.1 (52.2% of total catch) (Table 2.1).

Mosquitofish are declared noxious under Queensland's Fisheries Regulation 2008. Overall, exotic mosquitofish accounted for 36.9% of the total catch in the survey area.

## 2.5 Listed Species of Conservation Significance

No species listed under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* were caught in this survey.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Twenty species from 12 families have been recorded in the Dawson River sub-catchment. Berghuis and Long (1999) sampled two sites in the upper Dawson River during surveys of the Fitzroy Basin undertaken between 1994 and 1996, and caught 775 fish comprising ten species. More recently, in a dry season survey of four sites in the Dawson River sub-catchment, 267 fishes comprising eight species were caught (frc environmental 2007); and in a wet season survey of eight sites, a total of 481 fish comprising 20 species were caught. In dry season surveys in the Dawson River sub-catchment, 316 fishes comprising nine species were caught (frc environmental 2008). During the GLNG EIS, 255 species comprising seven species were caught in the upper Dawson River sub-catchment (frc environmental 2009). The species of fish caught in these surveys are listed in Table 3.1.

The most abundant fish species caught in the Dawson River sub-catchment in these surveys were bony bream (*Nematolosa erebi*), carp gudgeons (*Hypseleotris* spp.) and eastern rainbowfish (*Melanotaenia splendida*) (Berghuis & Long 1999; frc environmental 2009). The most abundant fish species caught along the GLNG pipeline were:

- eastern mosquitofish (*Gambusia holbrooki*)
- Agassiz's glassfish (*Ambassis agassizii*), and
- carp gudgeons.

Surveys completed by the Department of Primary Industries and Fisheries (Berghuis & Long 1999) did not report any exotic species in the Dawson River sub-catchment, although they were recorded in the Fitzroy Basin. Guppies were caught in an urban creek near Rockhampton. Goldfish was also seen (but not caught) near Rockhampton (Berghuis & Long 1999). Since then, goldfish have been caught in Juandah Creek and the Dawson River (Ecowise 2008; frc environmental 2008), and mosquitofish were caught in the Dawson River in November 2007 and June 2008 (frc environmental 2007; Ecowise 2008), as well as in the current surveys. Mosquitofish are declared noxious species in Queensland under the Fisheries Regulation 2008. Goldfish and guppies are listed as a non-indigenous fish under the Fisheries Regulation 2008.

No species recorded in the catchment is listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992*.

Table 3.1 Fish species known from the Dawson River sub-catchment, and their presence / abundance in the current survey area.

| **Family**<br>*Species* | **Common Name** | **Dawson River Sub-catchment** | **Current Survey** |
|---|---|---|---|
| **Ambassidae** | | | |
| *Ambassis agassizii* | Agassiz's glassfish | ✓ | ✓ |
| **Antherinidae** | | | |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | ✓ | – |
| **Clupeidae** | | | |
| *Nematolosa erebi* | bony bream | ✓ | ✓ |
| **Cyprinidae** | | | |
| *Carassius auratus* [a] | goldfish | ✓ | – |
| **Eleotridae** | | | |
| *Hypseleotris* spp. | common carp gudgeon | ✓ | ✓ |
| *Mogurnda adspersa* | purple spotted gudgeon | ✓ | ✓ |
| *Oxyeleotris lineolata* | sleepy cod | ✓ | – |
| *Philypnodon grandiceps* | flathead gudgeon | ✓ | – |
| **Melanotaeniidae** | | | |
| *Melanotaenia splendida* | eastern rainbowfish | ✓ | ✓ |
| **Osteoglossidae** | | | |
| *Scleropages leichardti* | southern saratoga | ✓ | – |
| **Percichthyidae** | | | |
| *Macquaria ambigua oriens* | golden perch | ✓ | – |
| **Plotosidae** | | | |
| *Neosilurus hyrtlii* | Hyrtl's tandan | ✓ | – |
| *Porochilus rendahli* | Rendahl's catfish | ✓ | – |
| *Tandanus tandanus* | freshwater catfish | ✓ | – |
| **Poeciliidae** | | | |
| *Gambusia holbrooki* [a] | mosquitofish | ✓ | ✓ |
| *Poecilia reticulata* [b] | guppy | ✓ | – |

| Family<br>*Species* | Common Name | Dawson River Sub-catchment | Current Survey |
|---|---|---|---|
| **Pseudomugilidae** | | | |
| *Pseudomugil signifer* | pacific blue eye | ✓ | – |
| **Terapontidae** | | | |
| *Leiopotherapon unicolor* | spangled perch | ✓ | ✓ |
| *Scortum hillii* | leathery grunter | ✓ | – |

Sources: (Berghuis & Long 1999; frc environmental 2007; Marsden & Power 2007; Ecowise 2008; frc environmental 2008; 2009)

[a] exotic non-indigenous species, declared noxious under the Fisheries Regulation 2008

[b] exotic non-indigenous species

## 3.2 Comet River Sub-catchment

The Queensland Department of Primary Industries and Fisheries (DPI&F) surveyed one site in the Comet River and 207 fishes comprising eight species were caught, all of which were native (Berghuis & Long 1999). Eastern rainbowfish and spangled perch were the most abundant species caught in this study (Berghuis & Long 1999). A survey of eight sites in the Rolleston region by frc environmental (frc environmental 2004) reported spangled perch in Bootes and Meteor Creeks, both tributaries of the Comet River. These species were also recorded in the Comet River sub-catchment during the GLNG EIS (frc environmental 2008), and fly-specked hardyhead and purple spotted gudgeon were also found. None of these studies, nor the current survey, recorded any exotic species in the Comet River sub-catchment. The species of fish caught in these surveys are listed in Table 3.2.

Table 3.2 Fish species known from the Comet River sub-catchment, and their presence / abundance in the current survey area.

| **Family**<br>Species | **Common Name** | **Comet River sub-Catchment** | **Current Survey** |
|---|---|---|---|
| **Ambassidae** | | | |
| *Ambassis agassizii* | Agassiz's glassfish | ✓ | – |
| **Atherinidae** | | | |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | ✓ | – |
| **Clupeidae** | | | |
| *Nematalosa erebi* | bony bream | ✓ | – |
| **Eleotridae** | | | |
| *Hypseleotris compressa* | empire gudgeon | ✓ | – |
| *Hypseleotris* spp. | common carp gudgeon | ✓ | ✓ |
| *Mogurnda adspersa* | purple spotted gudgeon | ✓ | ✓ |
| *Oxyeleotris lineolatus* | sleepy cod | ✓ | – |
| **Melanotaeniidae** | | | |
| *Melanotaenia sp.* | rainbowfish | | |
| *Melanotaenia splendida* | eastern rainbowfish | ✓ | ✓ |
| **Plotosidae** | | | |
| *Tandanus tandanus* | eel-tailed catfish | ✓ | – |
| *Neosilurus hyrtlii* | Hyrtl's tandan | ✓ | – |
| **Terapontidae** | | | |
| *Leiopotherapon unicolor* | spangled perch | ✓ | ✓ |
| *Scortum hillii* | leathery grunter | ✓ | – |

Sources: (Berghuis & Long 1999; frc environmental 2004; 2008; 2009)

# 4 References

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Santos
GLNG Project

**APPENDIX B3 – Aquatic Values Assessment Major Watercourses KP200-406**

# Gladstone Liquefied Natural Gas (GLNG) Pipeline Project

## Aquatic Values Assessment Major Watercourses KP200-KP406

## 3380-GLNG-4-1.3-0084

*Prepared for:*

**GLNG Operations Pty Ltd**

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

frc reference: 111016

**Document Control Summary**

| | |
|---|---|
| Project No.: | 111016 |
| Status: | Issued for use |
| Project Director: | Lauren Thorburn |
| Project Manager: | Ben Cook |
| Title: | Gladstone Liquefied Natural Gas (GLNG) Pipeline Project – Aquatic Values Assessment Major Watercourses KP 200 – 406: 3380-GLNG-4–1.3-0084 |
| Project Team: | B. Cook, S. Walker, D. Holzheimer, L. West, J. Charlish, C. Forward, L. Thorburn |
| Client: | GLNG Operations Pty Ltd |
| Client Contact: | Angela Hampson |
| Date: | October 2012 |
| Edition: | Rev 0 |
| Checked by: | L. Thorburn  |
| Issued by: | B. Cook  |

Distribution Record

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## Summary

Gladstone Liquefied Natural Gas (GLNG) Operations Pty Ltd proposes to construct a high pressure Gas Transmission Pipeline (GTP) to transport Coal Seam Gas (CSG) from the CSG fields at Roma and Fairview to a proposed Liquefied Natural Gas (LNG) facility on Curtis Island. A condition of Environmental Impact Statement (EIS) approval for the Project was the requirement for a detailed Aquatic Values Management Plan (AVMP) to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the right of way (ROW) between sites KP200 and KP406 to support the development of the AVMP. This Aquatic Values Assessment (AVA) presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

Overall results of the detailed field assessments showed that:

- habitat condition of waterways varied from poor to excellent, with most sites having moderate habitat condition; 10 of the 29 sites were dry at the time of survey
- water quality was non-compliant with Water Quality Objectives (WQOs) at some sites for pH, turbidity, electrical conductivity and dissolved oxygen
- aquatic flora diversity and cover varied among sites
- macroinvertebrate taxonomic richness and abundance varied among sites and were characteristic of waterbodies with moderate water and habitat quality
- freshwater fish diversity and abundance reflected expected ranges for ephemeral streams of the region, and
- there were turtles at three sites.

# 1 Introduction

GLNG Operations Pty Ltd proposes to construct a high pressure GTP to transport CSG from the CSG fields at Roma and Fairview to a proposed LNG facility on Curtis Island. The GTP forms one component of the GLNG Project, which includes:

- exploration and production of CSG in the Surat Basin and Bowen Basin gas fields
- construction and operation of the GTP from the CSG fields to the LNG facility on Curtis Island, and
- construction and operation of the LNG facility.

Following the evaluation of an initial EIS and a supplementary EIS, the Coordinator General advised that the GLNG Project could proceed subject to conditions. One of these conditions was the requirement for a detailed AVMP to be prepared for watercourses and wetlands intercepted by the GTP.

GLNG commissioned frc environmental to undertake detailed assessments of aquatic values and aquatic habitat condition at major watercourse crossings (stream order 3 and greater) along the GTP within the ROW between sites KP200 and KP406 to support the development of the AVMP. This AVA presents the methods and results of detailed wet season aquatic assessments at each major watercourse crossing for:

- aquatic habitat condition
- water quality
- aquatic flora
- aquatic macroinvertebrates
- freshwater fish, and
- turtles.

Site assessment sheets for each major watercourse crossing are presented in the AVMP.

Other AVMPs and AVAs present the findings of aquatic ecology assessments for the remaining major watercourse crossings along the GTP ROW (i.e. sites KP0–KP70 and sites KP70–KP200).

# 2 Survey Area

## 2.1 Gas Transmission Pipeline Right of Way

The survey area for this AVA is the GLNG GTP ROW (Figure 2.1) between sites KP200 and KP406 (Figure 2.2). Thirty-two major watercourse crossings (i.e. thirty-one watercourses with third stream order and above, and one palustrine wetland) were identified within the GTP ROW between KP200 and KP406 from Department of Environment and Heritage Protection (DEHP) wetland mapping, and this AVA considers 30 of these (Table 2.1). The two major watercourse crossings that were not directly assessed in this study were:

- Selheim Creek (KP280.2), which was not surved because land access to the site was not granted, and
- Unnamed watercourse 8 (KP303.7), which was considered to have the same aquatic values of unnamed watercourse 8 (KP305.5), as these sites were nearby on the same creek that was dry at the time of survey.

All other minor watercourse crossings between sites KP200 and KP406 (i.e. first and second order streams; 108 crossings in total) were not assessed as part of this AVA, as the aquatic values of these watercourse crossings were assessed by GLNG Operations Pty Ltd. These results are presented in a separate AVA for minor watercourses.

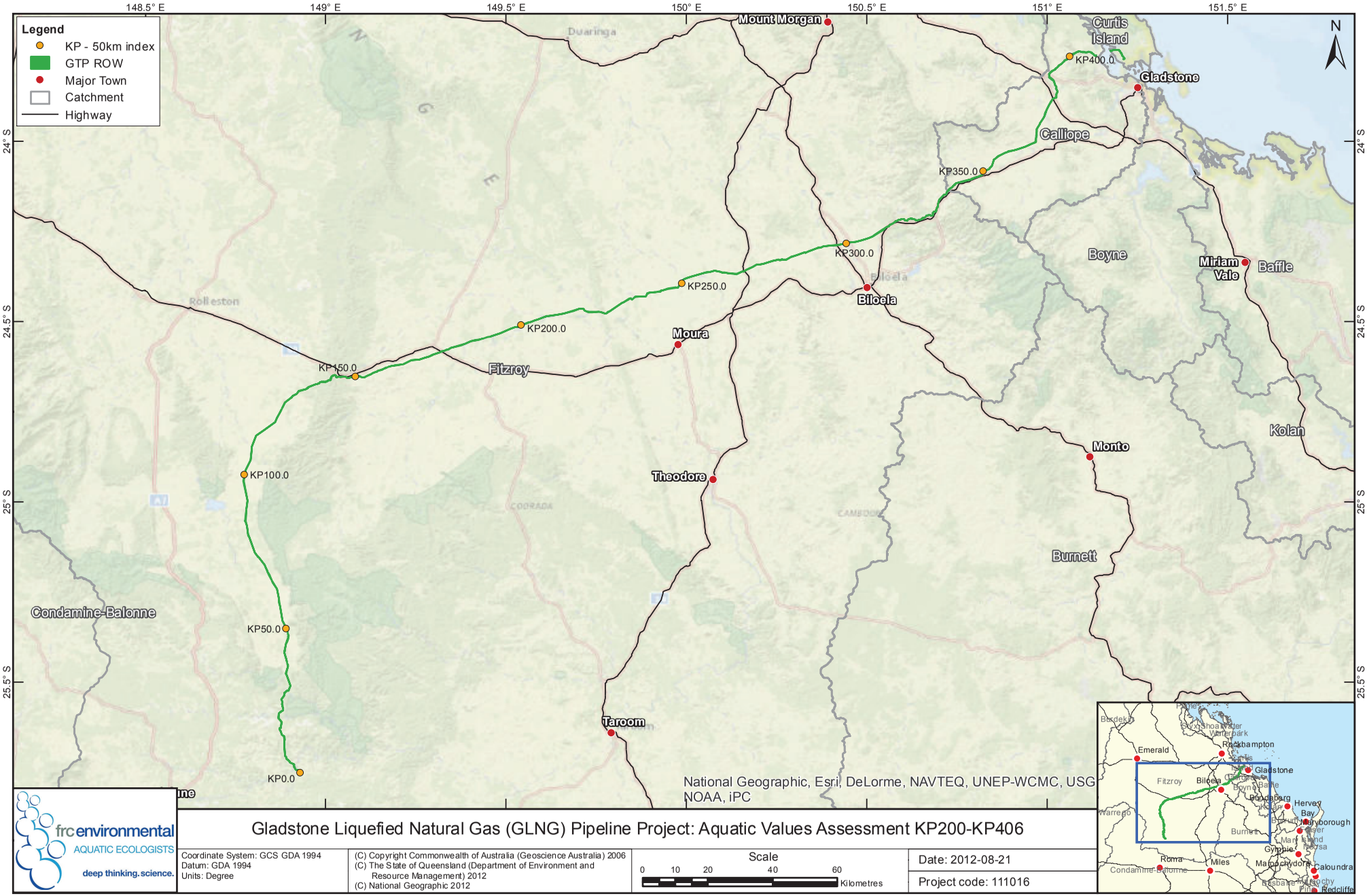


Figure 2.1 Alignment of the Gladstone Liquefied Natural Gas transmission pipeline right of way.

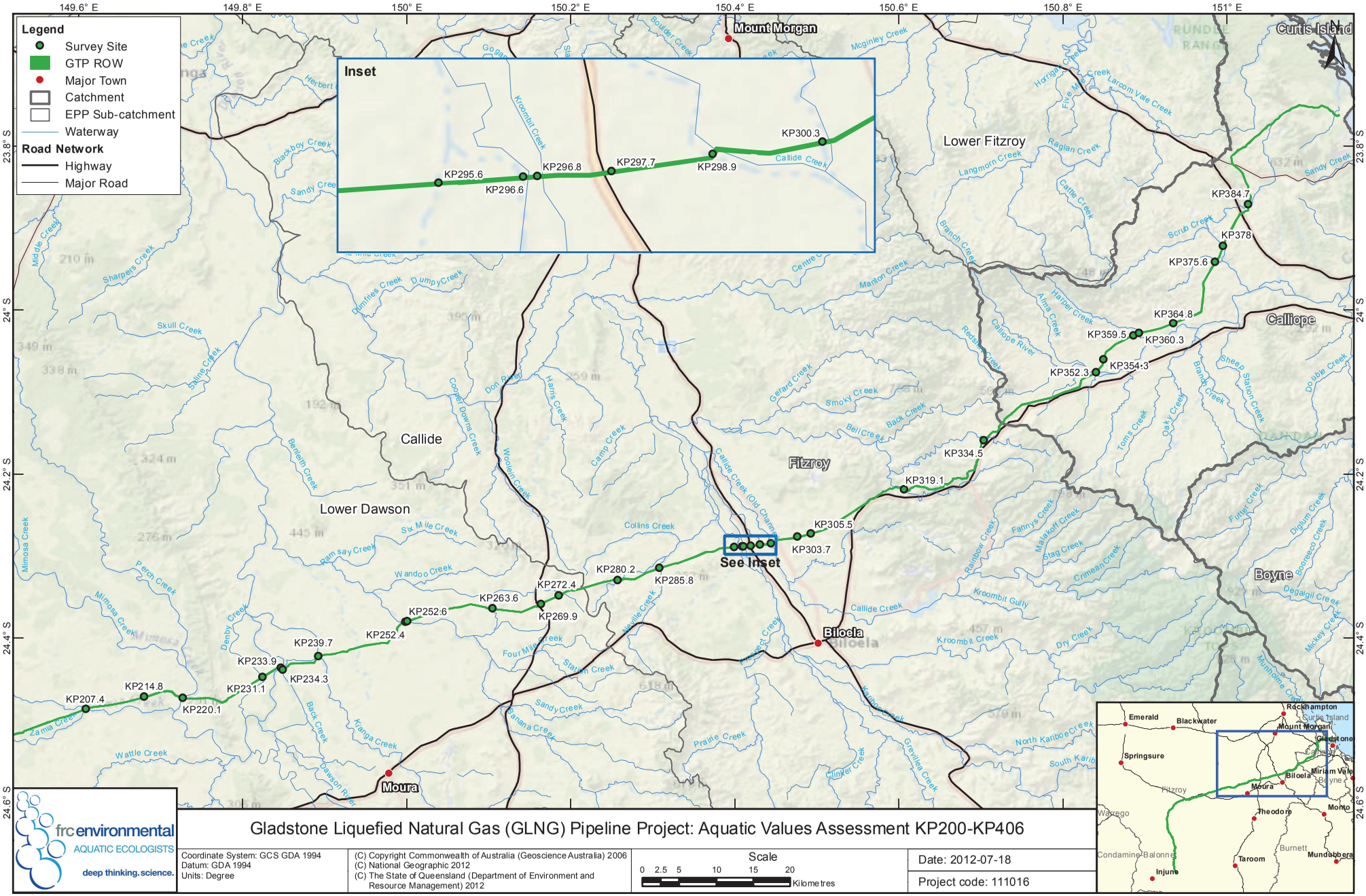


Figure 2.2 Major waterway crossings assessed along the GLNG pipeline (KP200 to KP406).

Table 2.1 Major watercourse crossings along the GTP ROW between sites KP200 and KP406 that were surveyed for aquatic values.

| Watercourse / Wetland | KP | Stream Order | Easting | Northing |
|---|---|---|---|---|
| Conciliation Creek | 207.4 | 5 | 764464.78[1] | 7289412.67 |
| Brolga Gully | 214.8 | 3 | 771697.89[1] | 7290884.68 |
| Mimosa Creek | 220.1 | 6 | 776470.80[1] | 7290638.13 |
| Mimosa RCR | | 6 | 778284.34[1] | 7291589.07 |
| Denby Creek | 231.1 | 3 | 786327.93[1] | 7290629.67 |
| Dawson River | 233.9 | 8 | 788651.15[1] | 7294513.70 |
| Back Creek | 234.3 | 3 | 788870.56[1] | 7294211.21 |
| Kianga Creek | 239.7 | 4 | 793337.72[1] | 7295957.88 |
| Banana Creek | 252.4 | 5 | 804230.94[1] | 7300351.98 |
| Banana Creek | 252.6 | 3 | 195802.94[2] | 7300430.09 |
| Police Camp Creek | 263.6 | 4 | 206303.26[2] | 7302368.13 |
| Police Camp Creek | 269.6 | 3 | 212266.69[2] | 7303141.75 |
| Spring Creek | 272.4 | 3 | 214450.21[2] | 7304324.48 |
| Neville Creek | 285.8 | 3 | 226831.71[2] | 7308280.65 |
| Orange Creek | 295.6 | 4 | 235998.69[2] | 7311276.67 |
| unnamed watercourse 7 | 296.6 | 6 | 237002.11[2] | 7311372.70 |
| Kroombit Creek | 296.8 | 5 | 237168.19[2] | 7311388.58 |
| Unnamed palustrine wetland | 297.7 | – | 238043.24[2] | 7311466.94 |
| Callide Creek | 298.9 | 5 | 239238.17[2] | 7311711.38 |
| Callide Creek (Old Channel) | 300.3 | 3 | 240540.17[2] | 7311892.17 |
| unnamed watercourse 8 | 305.5 | 3 | 245483.63[2] | 7313305.78 |
| Collards Creek | 319.1 | 3 | 256920.60[2] | 7319450.22 |
| Bell Creek | 334.5 | 5 | 266678.28[2] | 7326216.55 |
| Calliope River | 352.3 | 3 | 280475.76[2] | 7335673.07 |
| unnamed watercourse 9 | 354.3 | 3 | 281345.24[2] | 7337398.28 |
| unnamed watercourse 10 | 359.4 | 4 | 285012.79[2] | 7340719.11 |

| Watercourse / Wetland | KP | Stream Order | Easting | Northing |
|---|---|---|---|---|
| Harper Creek | 360.3 | 3 | 299009.04[2] | 7358584.99 |
| Alarm Creek | 364.8 | 3 | 289946.04[2] | 7342432.82 |
| Gravel Creek | 375.6 | 4 | 294998.09[2] | 7350750.23 |
| Larcom Creek | 378.0 | 3 | 295960.58[2] | 7352966.54 |
| Larcom Creek | 384.7 | 3 | 920927.21[2] | 7366399.62 |

[1] Zone 55J WGS 84

[2] Zone 56J WGS 84

## 2.2 Aquatic Values of the Region

The GTP ROW traverses the lower Dawson River sub-catchment and the Callide Creek sub-catchment within the Fitzroy Basin as well as the Calliope Basin (Figure 2.2). The flow regime of these river systems is dominated by unpredictable, highly intermittent summer flow with some reaches having variable, extremely intermittent summer flow (Kennard et al. 2010). So, most stream reaches tend to be dry during winter, and the magnitude, duration and timing of summer flows vary greatly between years. As for other dryland river systems, permanent pools and waterholes are critical habitat areas for aquatic biota (*sensu* Abell et al. 2007) and provide refugia habitat that enable aquatic species to persist during dry periods (Sheldon et al. 2010). Permanent waterbodies in the region therefore have high aquatic ecological values.

Catchment areas in the Fitzroy Basin and Calliope Basin have been extensively cleared for grazing; so, aquatic habitat is typically in a slightly to moderately disturbed condition. However, these catchment areas also have overall high ecological values, in part due to the presence of significant aquatic species and significant aquatic places (URS 2009).

Significant species include those with legislated conservation significance, such as the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Queensland's *Nature Conservation Act 1992* (NCA), and species that are endemic to the Fitzroy Basin.

Aquatic species with legislated conservational significance from the Fitzroy Basin include:

- Murray cod (*Maccullochella peelii*; listed as vulnerable under the Commonwealth's EPBC Act), which is not naturally found in the Fitzroy Basin but has been stocked in reservoirs for recreational fishing. However, this fish has not become established in this river system and is unlikely to occur in the Project area

- Queensland lungfish (*Neoceratodus forsteri;* listed as vulnerable under the Commonwealth's EPBC Act). The record for the lungfish is over 140 years old and there have been no recent sightings
- white-throated snapping turtle (*Elseya albagula*) is listed as least concern under Queensland's NCA but is a priority species under the 'back on track' framework
- the Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the Commonwealth's EPBC Act and Queensland's NCA
- platypus (*Ornithorhynchus anatinus*) is listed as least concern under Queensland's NCA (but it is an iconic Australian species)
- five species of frog are listed under Queensland's NCA and / or the Commonwealth's EPBC Act. Two of these species are endemic to the Fitzroy Basin and are protected within Kroombit Tops National Park: Kroombit tinker frog (*Taudactylus pleione*), and cascade treefrog (*Litoria pearsoniana*). The other three species of threatened frog, including tusked frog (*Adelotus brevis*) and rough-collared frog (*Cyclorana brevipes*), are more widespread in eastern Queensland and may occur in aquatic habitats intercepted by the GTP ROW
- boggomoss snail (*Adclarkia dawsonensis*) is listed as critically endangered under the Commonwealth's EPBC Act. This species is known from two localities in the greater Taroom area within the Dawson River sub-catchment (Stanisic 2008). Identified threats to this species include: land clearing, fire, grazing, weeds, earthworks, and changed hydrology, and
- thirteen species of birds dependent on riverine and wetlands ecosystems that are listed under Queensland's NCA and / or the Commonwealth's EPBC Act. This includes the black-necked stork (*Ephippiorhynchus asiaticus*) and cotton pygmy goose (*Nettapus coromandelianus*) which have been identified in the survey area and are listed as near threatened under Queensland's NCA, and
- several threatened aquatic plants, including the endangered salt pipewort (*Eriocaulon carsonii*) and the near-threatened sedge (*Eleocharis blakeana*).

The Fitzroy Basin also contains several endemic aquatic species:

- Fitzroy River turtle (*Rheodytes leukops*); also listed as vulnerable under the Commonwealth's EPBC Act and Queensland's NCA as described above
- southern saratoga (*Scleropages leichardti*)
- leathery grunter (*Scortum hillii*), and
- freshwater snail (*Larina strangei*), which is endemic to the Dawson River sub-catchment.

Aquatic species with legislated conservational significance from the Calliope Basin include:

- one species of frog, tusked frog (*Adelotus brevis*), listed as vulnerable under Queensland's NCA
- seven species reptiles (e.g. marine turtles and estuarine crocodiles) and marine mammals (e.g. cetaceans and porpoises), which are more likely to be dependant on estuarine or marine habitats that the freshwater habitat in the Project area
- platypus (*Ornithorhynchus anatinus*), which is listed at Least Concern under Queensland's NCA (but it is an iconic Australian species)
- eight species of birds (three shorebird species and five wetland species) listed under Queensland's NCA and / or the Commonwealth's EPBC Act
- three species of threatened aquatic plants (*Maundia triglochinoides*, *Eriocaulon carsonii* and *Thelypteris confluens*); however, recorded distribution of all three species is south of the Project area.

While permanent waterbodies in the region have high aquatic ecology values due to the overall dryland ecology of this river basin, many intermittent and ephemeral systems also have aquatic values, especially ephemeral wetlands and larger ephemeral watercourses (e.g. third stream order and above). These aquatic habitats provide:

- corridors and habitat for upstream migration of endemic species (e.g. southern saratoga and leathery grunter) and other aquatic fauna (e.g. bony bream, spangled perch, glass perchlets, and river prawns) during temporary wet periods, and
- habitat for species dependent on wetland drying, such as various species of aquatic flora that undergo flowering and seed in response to wetland drying.

# 3 Methods and Results

The field assessments were completed at the end of the wet season, from 17 to 29 April 2012. Aquatic habitat, aquatic flora, macroinvertebrates, fish and turtles were assessed, as described below.

## 3.1 Aquatic Habitat Assessment

Aquatic habitat condition was assessed using two approaches:

- the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland AUSRIVAS Sampling and Processing Manual (DNRM 2001), and
- the habitat bioassessment scoring method (DNRM 2001).

Results for the habitat condition assessment showed that:

- grazing was the dominant land use surrounding most sites. There was generally low to moderate erosion at sites, although there was considerable bank erosion at site KP231.1 (Denby Creek) and site KP305.5 (unnamed watercourse 8)
- there was substantial and connected or flowing water at fifteen sites; disconnected pools at four sites; and eleven sites were dry at the time of survey
- the channels of watercourses were generally straight to mildly sinuous
- substrate was dominated by silt and / or clay and sand at most sites
- riparian vegetation was dominated by native trees (e.g. eucalypts, Brigalow, softwood scrub and cypress pine communities) with an understorey of grasses, and
- in-stream habitat was dominated by emergent aquatic vegetation, large woody debris and pools; there were also riffles at some sites.

Results for the habitat bioassessment scores (excluding the palustrine wetland KP297.7) showed that the habitat was in:

- poor condition at five sites in the Fitzroy Basin due to
  - little bottom substrate or habitat
  - poor bank vegetation stability

  - poor habitat diversity, and
  - extensive embeddedness
- moderate condition at twelve sites in the Fitzroy Basin and four sites in the Calliope Basin due to
  - more bottom substrate or available cover
  - better habitat diversity
  - better streamside cover, and
  - better bank vegetation stability
- good to excellent condition at four sites in the Fitzroy Basin and four sites in the Calliope Basin due to
  - high habitat diversity,
  - low embeddedness, and
  - good streamside cover.

Details of aquatic habitat assessment methods and results are presented in Appendix A.

## 3.2 Water Quality

Water quality was measured in situ at sites containing sufficient water at the time of survey. The water quality parameters measured were:

- pH
- electrical conductivity
- dissolved oxygen, and
- turbidity.

The water quality results for sites in the Fitzroy Basin were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 (EPP Water) for waterways in the Fitzroy Basin, including the Lower Dawson River sub-catchment and Callide Creek (DERM 2011). The WQOs for electrical conductivity and pH are based on (DERM 2011a):

- the default Queensland Water Quality Guidelines (QWQG) for the lower Dawson catchment as there was insufficient reference data, and

- reference data at the Don River at Kingsborough and Bell Creek at Craiglands for the Callide catchment.

The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009), and these have been presented as the WQOs scheduled under the EPP Water.

There are no WQOs scheduled under the EPP Water for waterways in the Calliope Basin. Therefore, the water quality results for sites in the Calliope Basin were compared to the Queensland Water Quality Guidelines for slightly to moderately disturbed freshwater watercourses in the Central Coast region (DERM 2009).

There was sufficient water at twelve sites in the Fitzroy Basin and seven sites in the Calliope Basin that enabled water quality to be measured in situ. The results of these assessments showed that:

- pH was within the WQO range at all sites, except two sites in the Calliope Basin
- electrical conductivity was within the WQO range at four sites in the Fitzroy Basin and four sites within the Calliope Basin
- dissolved oxygen was within the WQO range at five sites in both the Fitzroy Basin and four sites within the Calliope Basin, and
- turbidity exceeded the WQO at six sites in the Fitzroy Basin and was below the WQO at all other sites in both the Fitzroy Basin and Calliope Basin.

These results were typical of ephemeral streams and are consistent with the findings from the wider catchments. Details of water quality assessment methods and results are presented in Appendix B.

## 3.3 Aquatic Plants

The aquatic plant community at each site was assessed along a 100 m reach of the stream and adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species)
- growth form of each species (submerged, floating (free-floating or rooted) and emergent)

- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Results of the aquatic plant survey showed that:

- taxonomic richness of aquatic plants ranged from 0 to 12 individuals in the Fitzroy Basin and 4 to 13 individuals in the Calliope Basin
- percent cover of aquatic plants ranged from 0 to 82% in the Fitzroy Basin and 10 to 87% in the Calliope Basin
- most aquatic plants observed were of emergent growth form; however, floating and submerged species were found at five sites in the Fitzroy Basin and at seven sites in the Calliope Basin.
- there were two exotic species of aquatic plant recorded from both the Fitzroy and Calliope Basins: para grass and common starwort, and
- no listed species of conservational significance were found.

Details of macrophyte assessment methods and results are presented in Appendix C.

## 3.4 Macroinvertebrates

Benthic macroinvertebrates were assessed at five sites in bed and edge habitats. Samples were identified to the family level, and the following indices were calculated:

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2 scores.

Taxonomic richness, PET richness and SIGNAL 2 scores were assessed against local Queensland Water Quality Guidelines (QWQGs) for the Fitzroy Basin and Central Coast.

Results of the macroinvertebrate surveys showed that:

- abundance of macroinvertebrates was highest at site KP285.8 (Neville Creek) in bed and edge habitats in the Fitzroy Basin; and at site KP352.3 (Calliope River) in bed habitat and site KP384.7 (Larcom Creek) in edge habitat in the Calliope Basin

- mean taxonomic richness of macroinvertebrates was below the QWQG range in bed and edge habitats at all sites in the Fitzroy Basin, except at site KP239.7 (Kianga Creek) in bed habitat; and was below the QWQG range at three sites in bed habitat and at five sites in the edge habitat in the Calliope Basin
- mean PET richness was within the QWQG range at five sites in bed habitat and at six sites in edge habitat, and was below the QWQG range at all other sites in the Fitzroy Basin; mean PET richness was within the QWQG range at all sites in bed and edge habitats, except at site KP359.4 (unnamed watercourse 10) in bed habitat
- mean SIGNAL 2 scores of macroinvertebrates were low (<4) in bed and edge habitats at most sites. Mean SIGNAL 2 scores were within the QWQG range at five sites in bed habitat and at eight sites in edge habitat in the Fitzroy Basin; and within the QWQG range at three sites in bed habitat and at all sites in edge habitat in the Calliope Basin
- quantitative analyses of macroinvertebrate community composition showed differences between sites. Microcrustaceans and non-biting midge larvae most commonly contributed to the dissimilarity between macroinvertebrate community composition, and
- freshwater shrimp and freshwater prawns were the most commonly found taxa of macrocrustaceans.

Details of macroinvertebrate assessment methods and results are presented in Appendix D.

## 3.5 Freshwater Fish

Freshwater fish communities were surveyed using a combination of electrofishing (backpack and boat), baited traps and seine nets. The following indices were calculated using the fish community data at each site:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage
- proportion and abundance of exotic species, and
- abundance of listed protected species.

Fish surveys were done at only twelve sites in the Fitzroy Basin and at seven sites in the Calliope Basin. Results for these sites showed that:

- eleven native species of fish were caught (twelve species in total, including exotic species) in the Fitzroy Basin, with the most commonly found species being Agassiz's glassfish (*Ambassis agassizii*.) and gudgeon (*Hypseleotris spp.*); twelve native species of fish were caught (no exotic species caught) in the Calliope Basin, with the most commonly found species being fly-specked hardyhead (*Craterocephalus stercusmuscarum*) and eastern rainbowfish (*Melanotaenia splendida.*)
- fish were most abundant at site KP289.9 (Callide Creek) in the Fitzroy Basin and at site KP360.3 (Harper Creek) in the Calliope Basin and were also abundant at site KP214.8 (Brolga Gully)
- taxonomic richness ranged from 1 to 8 species at each site in the Fitzroy Basin and from 2 to 13 species at each site in the Calliope Basin
- intermediate (i.e. sub-adult) life-history stage dominated fish communities at most sites, but juveniles dominated fish communities at site KP360.3 (Harper Creek) and adults dominated fish communities at sites KP298.9 (Callide Creek), KP334.5 (Bell Creek) and KP384.7 (Larcom Creek)
- mosquitofish (*Gambusia holbrooki*) are listed as noxious in Schedule 6 of Queensland's Fisheries Regulation 2008 and were caught at sites
  - KP214.8 (Brolga Valley)
  - KP234.3 (Back Creek)
  - KP239.7 (Kianga Creek)
  - KP252.4 (Banana Creek)
  - KP296.8 (Kroombit Creek)
  - KP298.9 (Callide Creek), and
  - no listed species of conservational significance were found.

Details of freshwater fish assessment methods and results are presented in Appendix E.

## 3.6 Turtles

Turtle traps were set at sites where the water was deep enough to provide suitable turtle habitat and the allow use of cathedral traps. These sites were:

- KP233.9 (Dawson River) in the Fitzroy Basin
- KP360.3 (Harper Creek) in the Calliope Basin, and
- KP384.7 (Larcom River) in the Calliope Basin.

Turtle traps were not set where the site was dry or the water level was too low, or where access was too dangerous to take turtle traps.

Turtles at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site), and
- abundance of listed protected species.

Results for the turtle survey showed that:

- five adult Krefft's river turtle (*Emydura macquarii krefftii*) were caught at sites KP360.3 (Harper Creek) and KP384.7 (Larcom River), and three adult Krefft's river turtles were caught at site KP233.9 (Dawson River)
- two adult saw-shelled turtles (*Wollumbinia latisternum*) were caught at site KP360.3 (Harper Creek), and
- no species, listed under the Commonwealth's EPBC Act or Queensland's NCA were caught at any sites.

Details of turtle assessment methods and results are presented in Appendix F.

## 3.7 Description of Aquatic Values

Wet season field investigations, literature reviews and database searches were used to inform the assignment of overall wet season aquatic value for each watercourse crossing. Four categories of aquatic value were used (High, Moderate, Low, Negligible), based on the following criteria:

### 3.7.1 High Values

Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the *Environment Protection and Biodiversity Conservation Act 1999* and / or the *Nature*

*Conservation Act 1992*, and / or those species listed as priority species in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity document (DERM 2010).

Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species was assessed using a combination of:

- habitat condition [e.g. the Bioassessment scores method (DNRM 2001)
- levels of disturbance (e.g. erosion, riparian vegetation condition),
- likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS), and
- relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River turtle, Tucker et al. 2001; in-stream habitat and connectivity for freshwater fish, including undercut banks, substrate characteristics, large woody debris).

### 3.7.2 Moderate Value

Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.

Aquatic life included:

- submerged and / or floating attached aquatic plants
- native freshwater fish (such as rainbowfish, spangled perch, glass perchlets, purple spotted gudgeons),
- aquatic invertebrates (including crayfish, shrimps, snails, mussels, and insects).

Life history stage (i.e. juvenile, intermediate, adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.

Aquatic habitat was assessed using:

- habitat condition (e.g. the Bioassessment scores method (DNRM 2001))
- levels of disturbance (e.g. erosion, riparian vegetation condition), and

- habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, large woody debris).

### 3.7.3 Low Value

Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.

Emergent aquatic plants, such as sedges and nardoo, may be have been present.

Field investigations also indicated the presence of structural habitat elements, including:

- woody debris
- cobbles and / or
- undercut banks.

Habitat condition was determined using:

- the Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams, and
- levels of disturbance (e.g. erosion, riparian vegetation condition).

### 3.7.4 Negligible Value

Where field investigations indicated:

- an absence of aquatic habitats and
- absence of aquatic life (e.g. no aquatic fauna or aquatic plants, including no sedges).

Habitat condition was typically poor:

- Low Bioassessment Scores (DNRM 2001), and
- High levels of disturbance (e.g. extensive erosion, no riparian vegetation).

### 3.7.5 Dry Season Aquatic Values

Dry season aquatic values were also based on these four criteria, using previous dry season surveys for several sites to inform of permanence of pools / water, and expert judgment regarding permanence of pools / water at sites not visited during the dry season. Sites that were dry during the wet season were considered likely to also be dry during the dry season, as were sites that were previously shown to be dry during the dry season. Sites that contained water during the wet season, even as disconnected pools within the channel, were conservatively assessed as possibly having temporary water that may persist for some time into the dry season. In these cases, dry season aquatic values were assessed as moderate, in accordance with the criteria above.

# 4 Conclusions and Recommendations

## 4.1 Aquatic Values

The aquatic values of major watercourses within the GTP ROW between sites KP200 and KP406 are summarised in Table 4.1.

Table 4.1 Aquatic values of major watercourses along the GLNG pipeline (KP200 to KP406).

| | | Assessment of Watercourse / Wetland | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **Site KP** | **Stream Order** | **Significant Species Habitat (Aquatic)** | **Breeding Place for Significant Species** | **DEHP Regional Ecosystem Mapping** | **Overall Aquatic Value (crossing and reach)[a]** |
| Conciliation Creek | 207.4 | 5 | unlikely | unlikely | non-remnant | moderate |
| Brolga Gully | 214.8 | 3 | unlikely | unlikely | non-remnant | moderate |
| Mimosa Creek | 220.1 | 6 | possible | possible | non-remnant | high |
| Mimosa RCR | | 6 | unlikely | unlikely | Non-remnant | moderate |
| Denby Creek | 231.1 | 3 | unlikely | unlikely | of concern 11.3.2 11.3.4 11.3.25 | moderate |
| Dawson River | 233.9 | 8 | likely | likely | endangered 11.3.2, 11.3.1 | high |
| Back Creek | 234.3 | 3 | unlikely | unlikely | endangered 11.3.2, 11.3.1 | moderate |
| Kianga Creek | 239.7 | 4 | unlikely | unlikely | of concern, 11.3.2, 11.3.1 | moderate |
| Banana Creek | 252.4 | 5 | unlikely | unlikely | non-remnant | moderate |

| Assessment of Watercourse / Wetland | | | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **Site KP** | **Stream Order** | **Significant Species Habitat (Aquatic)** | **Breeding Place for Significant Species** | **DEHP Regional Ecosystem Mapping** | **Overall Aquatic Value (crossing and reach)[a]** |
| Banana Creek | 252.6 | 3 | unlikely | unlikely | non-remnant | low |
| Police Camp Creek | 263.6 | 4 | unlikely | unlikely | non-remnant | low |
| Police Camp Creek | 269.6 | 3 | unlikely | unlikely | non-remnant | low |
| Spring Creek | 272.4 | 3 | unlikely | unlikely | non-remnant | low |
| Neville Creek | 285.8 | 3 | unlikely | unlikely | non-remnant | moderate |
| Orange Creek | 295.6 | 4 | unlikely | unlikely | non-remnant | Low |
| Unnamed watercourse 7 | 296.6 | 6 | unlikely | unlikely | non-remnant | low |
| Kroombit Creek | 296.8 | 5 | unlikely | unlikely | non-remnant | moderate |
| Palustrine Wetland | 297.7 | | unlikely | unlikely | non-remnant | low |
| Callide Creek | 298.9 | 5 | unlikely | unlikely | non-remnant | moderate |
| Callide Creek (Old Channel) | 300.3 | 3 | unlikely | unlikely | non-remnant | low |
| unnamed watercourse 8 | 305.5 | 3 | unlikely | unlikely | non-remnant | low |
| Collards Creek | 319.1 | 3 | unlikely | unlikely | Least concern, 11.11.15, 11.3.25, 11.11.4, 11.11.4a | low |
| Bell Creek | 334.5 | 5 | unlikely | unlikely | non-remnant | moderate |

| Assessment of Watercourse / Wetland | | | | | | |
|---|---|---|---|---|---|---|
| **Watercourse / Wetland** | **Site KP** | **Stream Order** | **Significant Species Habitat (Aquatic)** | **Breeding Place for Significant Species** | **DEHP Regional Ecosystem Mapping** | **Overall Aquatic Value (crossing and reach)[a]** |
| Calliope River | 352.3 | 3 | possible | possible | of concern, 11.3.4, 11.3.25 | high |
| unnamed watercourse 9 | 354.3 | 3 | unlikely | unlikely | non-remnant | low |
| unnamed watercourse 10 | 359.4 | 4 | unlikely | unlikely | non-remnant | moderate |
| Harper Creek | 360.3 | 3 | possible | possible | non-remnant | high |
| Alarm Creek | 364.8 | 3 | unlikely | unlikely | non-remnant | moderate |
| Gravel Creek | 375.6 | 4 | unlikely | unlikely | non-remnant | moderate |
| Larcom Creek | 378.0 | 3 | possible | possible | non-remnant | high |
| Larcom Creek | 384.7 | 3 | possible | possible | non-remnant | high |

a negligible – aquatic habitat and aquatic life not present; low – aquatic habitat present but aquatic life not present, site contains water only during heavy rainfall events, otherwise site is dry; moderate – aquatic habitat and aquatic life present, but conservation significant or endemic species unlikely to occur; high – aquatic habitat and aquatic life present, and conservation significant and endemic species and their breeding places likely to occur.

## 4.2 General Impact Mitigation Measures

Various pipeline crossing methods have the potential to impact aquatic values of watercourses. These broadly include:

- **Fuel and oil spills**, which are toxic to aquatic flora and fauna even in low concentrations. Major spills (i.e. in the order of tens to hundreds of litres) will have a locally significant impact on aquatic ecosystems

- **Introduction of invasive aquatic plant species** on machinery, such as para grass (*Urochloa mutica*), *Hymenachne amplexicaulis*, water hyacinth (*Eichhomia crassipes*) and *Salvinia molesta*. These aquatic weeds are common in parts of Queensland. Para was found at sites 354.3 (unnamed watercourse 9) and KP360.3 (Harper Creek); and common starwort (*Callitriche stagnalis)* was found at sites KP378.0 (Larcom Creek) and KP334.5 (Bell Creek). These aquatic weeds have the potential to choke aquatic habitats, thereby reducing the habitat values of the site and suitability for native aquatic species.
- **Earth works causing erosion and sedimentation**, which can:
  - increase turbidity of water, which reduces respiratory and feeding efficiency of fish and macroinvertebrates, and impacts aquatic plants by reducing light penetration. However, it should be noted that waterways in the area are often naturally turbid and the species that inhabit these watercourses are tolerant of relatively high turbidity. So, slight short-term increases in turbidity would be unlikely to have adverse ecological impacts on aquatic ecosystems. However, significant and / or prolonged increases in turbidity may impact aquatic flora and fauna, and
  - smother habitat for aquatic species and in-fill pools with sediment. Habitats that may potentially be smothered by sediment include large and small woody debris, detritus, tree roots, sand and gravel bars, cobble and riffle habitats, undercut banks, overhanging and trailing bank vegetation. Many of these habitats were found in the local waterways within the survey area.
- **Riparian vegetation clearing,** which can have numerous impacts for aquatic flora and fauna. These include:
  - decreasing bank stability and increasing erosion and sedimentation
  - decreasing the supply of leaves and woody material in the stream that provides food and habitat resources for aquatic species
  - increasing exposure of aquatic fauna to solar radiation (i.e. reduced shading of watercourse), and
  - increasing water temperature due to increased solar radiation of watercourse.
- **Access track crossings**, which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low flow periods, and
  - cause localised loss of in-stream habitat and localised destruction of aquatic biota.

- **Trench construction,** which may:
  - cause erosion and sedimentation
  - alter the profile of the bed, which may be a barrier to water flow and fish dispersal during low-flow periods, and
  - cause localised loss of in-stream habitat and localised destruction of aquatic biota.
- **Site** remediation, which if done poorly, can lead to sustained erosion and sedimentation, and sustained impacts to aquatic ecosystems.

Mitigation measures for these activities are presented in Table 4.2.

Table 4.2 General aquatic environment impact mitigation measures for various watercourse crossing methods

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Fuel and oil spills | • Establish designated vehicle maintenance areas, refuelling stations and fuel storage areas in bunded areas that are more than 30 m from nearby waterways and dams |
| | • Report all spills over 20 litres to an Environmental Officer or delegated person |
| | • Have appropriate spill containment and clean-up kits in the field, with spill kits accessible to construction crews at all times. Kits will contain equipment for clean up of fuel and oil on land or dry creek beds, and spills to water (e.g. floating booms) |
| | • Manage all spills in accordance with Australian Standard 1940-2004 |
| Introduction of invasive aquatic plants | • Weed washdown and inspections, to control the spread of other weeds in the region (e.g. *Parthenium hysterophorus*) |
| Soil erosion and sedimentation | • Implement sediment and stormwater control measures |
| | • Minimize the area of earth that is disturbed |
| | • Operate vehicles and machinery on specified access tracks (i.e. do not make more than one access track) |
| Riparian vegetation clearing | • Minimize the amount of vegetation that needs to be cleared |
| | • Ensure that adjacent riparian vegetation or aquatic habitats are not disturbed by machinery or falling trees |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Access track crossings* | • Implement sediment and stormwater control measures<br>• Move any in-stream habitat structures (e.g. woody debris, boulders) shall be removed and set aside during construction, and shall be reinstated to the watercourse after the conclusion of construction.<br>• Ensure access track is not higher than the bed level of the stream unless box or flume culverts are installed<br>• Maintain fish passage at access tracks, by ensuring that:<br>  • the access track is constructed in the dry season where practical/possible<br>  • the access track is as narrow as reasonably practical<br>  • the flume pipes are as large as reasonably practical in diameter<br>  • the bottom of the flumes are below bed level, and natural bed material and / or rocks and gravel are placed in the bottom of the flumes<br>  • the flumes are maintained so that they remain free of debris, and<br>  • the work area is rehabilitated once the crossing is removed, including re-instatement of the bed and bank shape and revegetation of the banks. |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Trench construction* | • Where feasible, trench during the dry season, when stream bed is dry<br>• Move any in-stream habitat structures (e.g. woody debris, boulders) shall be removed and set aside during construction, and shall be reinstated to the watercourse after the conclusion of construction.<br>• Implement designed in accordance with the Australian Pipeline Industry Association Code of Practice and other relevant standards (AE 2001; APIA 2009), which require that:<br>  • works are completed as soon as reasonably practical, to minimise the impact on aquatic fauna<br>  • upstream and downstream dams are installed on the edge of the temporary workspace, to maximise the area of the workspace. These dams should be constructed of an appropriate material for each creek (e.g. steel plates, flumes, sand bags or aquadam), and<br>  • if there is flowing water is present, an effort will be made to maintain flow, including variations in flow patterns (e.g. increased flow due to increased rainfall), using appropriate pumps (e.g. increased pumping effort in response to increased stream flow)<br>  • pump intakes are to be screened to ensure that no fish are trapped<br>  • fish are salvaged from the isolated workspace and translocated to appropriate waterways (see above)<br>  • the upstream dam is slowly removed, to allow water to flush the sediment from the workspace area where practicale/possible<br>  • sediment-laden water is pumped into sumps or onto vegetation<br>  • operation of the clean-water pump sustains flow below the downstream dams until the downstream dam is removed. |

| Potential impacts of activity | Mitigating Measures |
|---|---|
| Site remediation | • Implement well-designed and high quality site remediation works that include profiling the bed and banks of watercourses and revegetation<br>• Set ecological targets for remediation works and conduct monitoring by qualified aquatic ecologists (e.g. once off during the following wet season) |

* denotes activities that may require waterway barrier works permits from the Department of Agriculture, Fisheries and Forestry; refer to the Project-Specific Self Assessable Code

## Fish Salvage

Once flow is diverted from isolated workspaces (see Table 4.2 – trench construction), stranded fish should be translocated to waterholes downstream of the diversion channel in accordance with the Fisheries Queensland (part of the Department of Agriculture, Fisheries and Forestry) guideline: *Fish Salvage Guidelines*, as summarised below:

- fauna should be captured by suitably-qualified aquatic ecologists during a one-off intense fauna survey approximately one week prior to the commencement of construction
- salvaged fauna should be translocated to suitable waterholes in the same local catchment (to prevent the transfer of exotic fish or aquatic disease and prevent hybridisation between genetically unrelated individuals)
- fish, macrocrustaceans, freshwater mussels, freshwater snails (such as moon snails at KP177.3), and turtles should be captured using gear appropriate to the waterways and species present (at the site, this is likely to include electrofishing, seine nets and set traps), and
- aquatic fauna should be handled, transported and released so as to minimise damage to the fish (e.g. handle with wet hands, hold correctly, transport using aerated water).

Various apparatus used to capture / translocate fish will require a General Fisheries Permit, issued by Fisheries Queensland, and should be operated by appropriately experienced professionals.

## Water Quality Monitoring

Pre-construction baseline water quality monitoring and post-construction monitoring be done in accordance with the methods outlined in the AVMP. During construction, visual monitoring for sediment plumes will be done. If observed, construction works will cease and the erosion and sediment control measures will be inspected and repaired or revised as required.

If plumes are observed, water quality monitoring will also be done at one site upstream of the construction site, and one downstream (where safely accessible) in order to verify that the plume was related to construction activities, and to provide a record of monitoring. Baseline and post-construction monitoring will include three replicate samples of in situ water quality using a water quality probe for:

- water temperature

- dissolved oxygen (% saturation)
- conductivity
- pH, and
- turbidity.

Photographs will also be taken at each site.

The water quality monitoring should also be done according the AVMP by an appropriately qualified professional in accordance with the *Monitoring and Sampling Manual* (DERM 2010).

# 5 References

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# Appendix A Aquatic Habitat Condition

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# 1 Methods

## 1.1 In-stream Habitat Condition

The in-stream habitat condition at each site was assessed using the Australian River Assessment System (AUSRIVAS) protocol described in the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001). The following parameters were assessed:

- adjacent land use
- water velocity and depth
- channel diversity
- substrate composition, including sand bars and substrate compaction
- type and condition of riparian vegetation, and
- in-stream habitat (e.g. log jams, leaf packs, trailing vegetation and undercut banks).

## 1.2 Habitat Bioassessment Scores

A habitat bioassessment score (DNRM 2001) is a numerical index of aquatic habitat condition that enables a direct comparison of habitat quality between sites. The method requires habitat quality to be scored (from zero to twenty) for each of nine criteria:

- substrate or available cover
- embeddedness
- water velocity and depth
- channel alteration
- bed scouring and deposition
- pool:riffle and run:bend ratio
- bank stability
- bank vegetative stability, and
- streamside vegetation cover.

The sum of the scores for each criterion gives the overall habitat score. This is used to allocate sites to one of four categories (Table 1.1):

- excellent habitat condition (overall score >110)
- good habitat condition (overall score 75 to 110)
- moderate habitat condition (overall score 39 to 74), and
- poor habitat condition (overall score ≤38).

Table 1.1 Habitat bioassessment scores used to derive overall condition categories.

| Habitat Category | Category Score Range | | | |
|---|---|---|---|---|
| | **Excellent** | **Good** | **Moderate** | **Poor** |
| Bed substrate or available cover | 16–20 | 11–15 | 6–10 | 0–5 |
| Embeddedness | 16–20 | 11–15 | 6–10 | 0–5 |
| Water velocity and depth | 16–20 | 11–15 | 6–10 | 0–5 |
| Channel alteration | 12–15 | 8–11 | 4–7 | 0–3 |
| Bed scouring & deposition | 12–15 | 8–11 | 4–7 | 0–3 |
| Pool:riffle and run:bend ratio | 12–15 | 8–11 | 4–7 | 0–3 |
| Bank stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Bank vegetative stability | 9–10 | 6–8 | 3–5 | 0–2 |
| Streamside vegetation cover | 9–10 | 6–8 | 3–5 | 0–2 |
| **Total (Habitat Bioassessment Score for the Site)** | **111–135** | **75–110** | **39–74** | **0–38** |

## 1.3 Regional and Ecological Perspective

The condition of aquatic habitat in each catchment was reviewed, based on the *State of the Rivers* surveys for the Fitzroy River Basin (Telfer 1995) and the *Calliope River Basin Draft Water Resource Plan Ecological Assessment Report* (DERM 2005) for the Calliope River Basin, and summarised to provide a context for the results of this survey.

# 2 Results

## 2.1 In-stream Habitat Condition

Site assessment sheets that summarise the aquatic habitat and present photographs of each site are presented as an appendix to the Aquatic Values Management Plan (AVMP).

### Adjacent Land Use

Grazing was the dominant land use surrounding most sites. Sites generally had low to moderate erosion, although Denby Creek (KP231.1) and unnamed watercourse 8 (KP305.5) had considerable bank erosion.

### Water Velocity and Depth

Fourteen sites had substantial and connected or flowing water at the time of survey, including:

- Conciliation Creek (KP207.4)
- Brolga Gully (KP214.8)
- Mimosa Creek RCR
- Mimosa Creek (KP220.1)
- Denby Creek (KP231.1)
- Dawson River (KP233.9)
- Back Creek (KP234.3)
- Kroombit Creek (KP296.8)
- Callide Creek (KP298.9)
- Bell Creek (KP334.5)
- Calliope River (KP352.3)
- Harper Creek (KP360.3)
- Alarm Creek (KP3648)
- Gravel Creek (KP375.6), and
- Larcom Creek (KP378.0 & KP384.7).

Four sites were disconnected pools, including:

- Mimosa Creek RCR
- Kianga Creek (KP239.7)
- Banana Creek (KP252.4)
- Neville Creek (KP285.8), and
- unnamed watercourse 10 (KP359.5).

Eleven sites were dry, including:

- Banana Creek (KP252.6)
- Police Camp Creek (KP263.6 and KP269.6)
- Spring Creek (KP272.4)
- Orange Creek (KP295.6)
- unnamed watercourse 7 (KP296.6)
- Palustrine Wetland (KP297.7)
- Callide Creek (Old Channel) (KP300.3)
- unnamed watercourse 8 (KP305.5)
- Collards Creek (KP319.1), and
- unnamed watercourse 9 (KP354.3).

## Channel Diversity

Channels were generally straight or mildly sinuous, although Gravel Creek (KP375.6) had an anabranching channel pattern. Many sites had moderately sloped to steep banks. The Calliope River (KP352.3) comprised a large high-flow channel that contained two smaller secondary channels; only one of these smaller channels was flowing at the time of survey (Figure 2.1).

Figure 2.1

Looking downstream from the crossing location along the active channel of the Calliope River (KP352.3).



## Substrate Composition

Substrate composition was dominated by silt and / or clay and sand at most sites, although many sites also had gravel, pebble and cobble (Figure 2.2 and Figure 2.3).

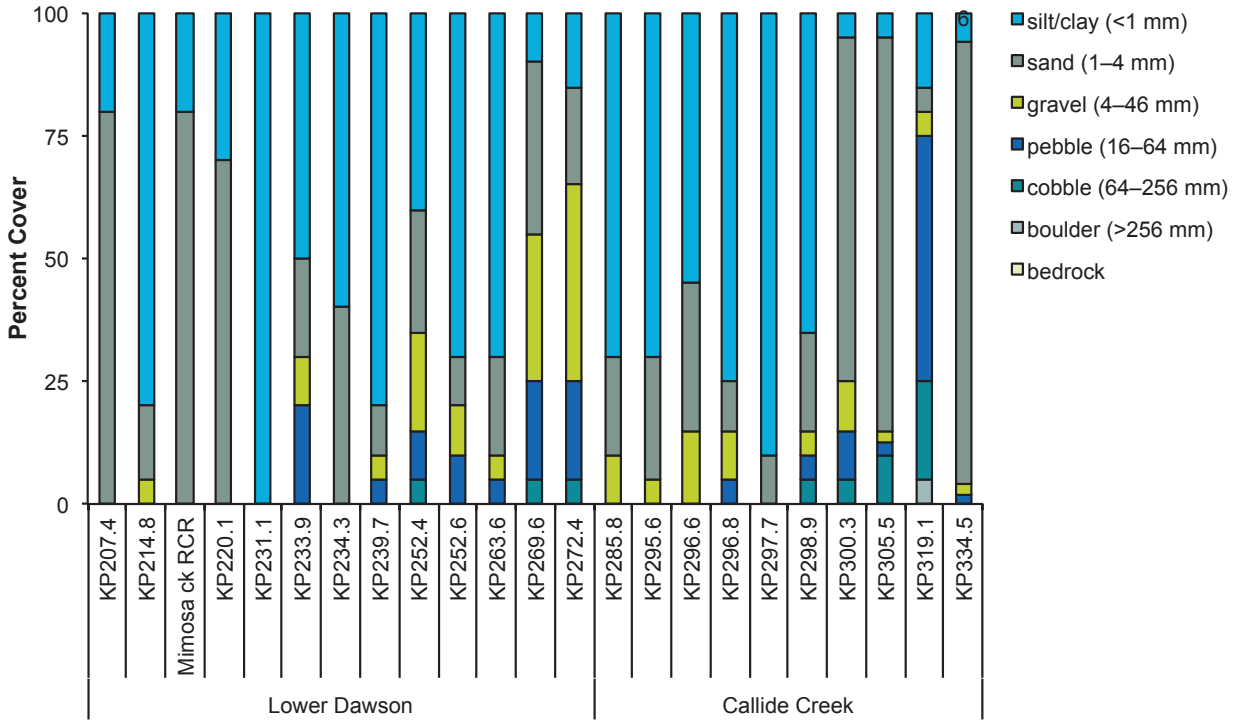


Figure 2.2 Percent cover of substrate types at each site along the GLNG pipeline (KP200 to KP406) within the Fitzroy Basin.

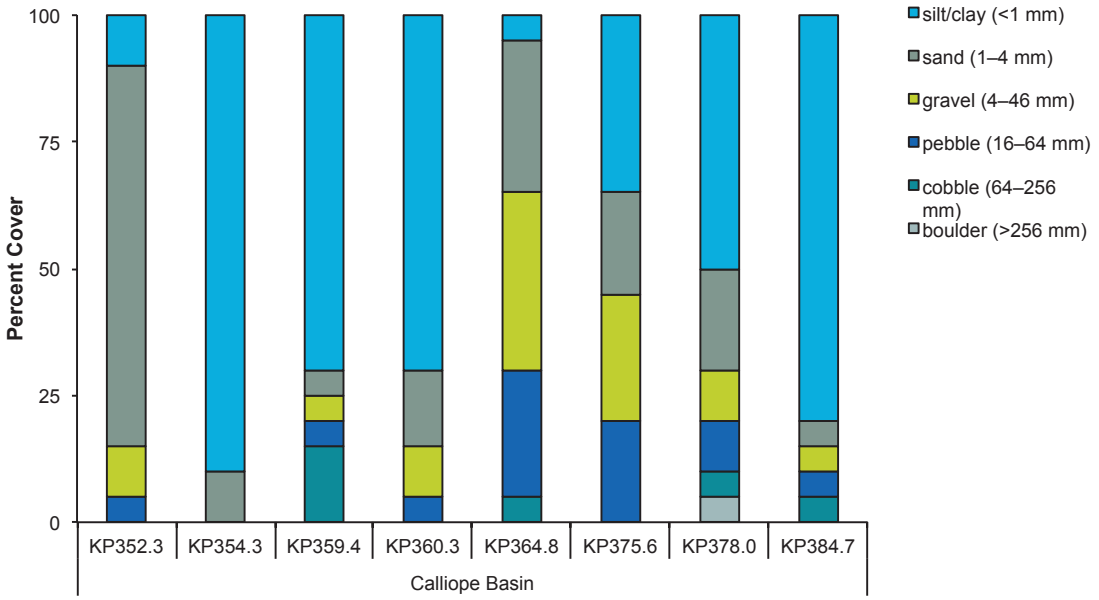


Figure 2.3 Percent cover of substrate types at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## Riparian Vegetation

The canopy riparian vegetation at most sites was native trees with an understorey of grasses (Figure 2.4). Common native tree taxa included eucalypts, melaleucas and bottlebrush trees. Several sites, including Collards Creek (KP319.1), had a thick understorey of *Lantana camara*, a declared pest in Queensland and a weed of national environmental signficance.

Figure 2.4

Riparian vegetation at Harper Creek (KP360.3).



## In-stream Habitat

In-stream habitat provides refuge and food for aquatic fauna (e.g. fish, turtles and macrocrustaceans). Emergent aquatic vegetation, large woody debris and pools dominated the in-stream habitat at most sites (Figure 2.5). There were riffles at:

- Dawson River (KP233.9)
- Back Creek (KP234.3)
- Bell Creek (KP334.5)
- Calliope River (KP352.3), and
- Alarm Creek (KP364.4).

Figure 2.5

In-stream habitat, including start of riffle in foreground, at Alarm Creek (KP364.4).



## 2.2 Habitat Bioassessment Scores

Most sites had moderate habitat condition, a few sites had good habitat condition, and six sites in the Fitzroy Basin had poor habitat condition (Figure 2.6 and Figure 2.7).

The poor habitat scores at these six sites were due to:

- little bottom substrate or habitat (e.g. boulders, woody debris and vegetation)
- poor bank vegetation stability
- poor habitat diversity, and
- extensive embeddedness (as a result of substrate dominated by fine sediment).

Overall, the moderate habitat scores were due to:

- more bottom substrate or available cover (e.g. boulders, woody debris and vegetation)
- better habitat diversity
- better streamside cover, and
- better bank vegetation stability.

Overall, the good habitat scores were due to:

- high habitat diversity
- low embeddedness, and
- good streamside cover.

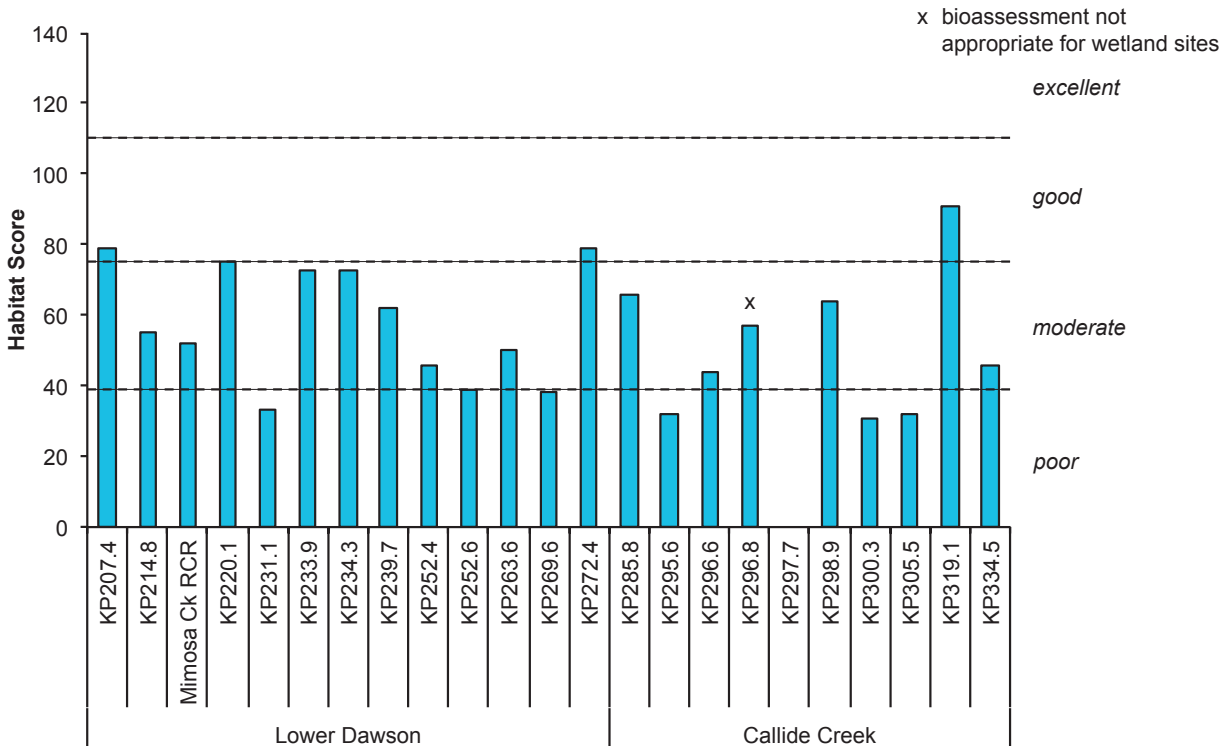


Figure 2.6 Habitat bioassessment score at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

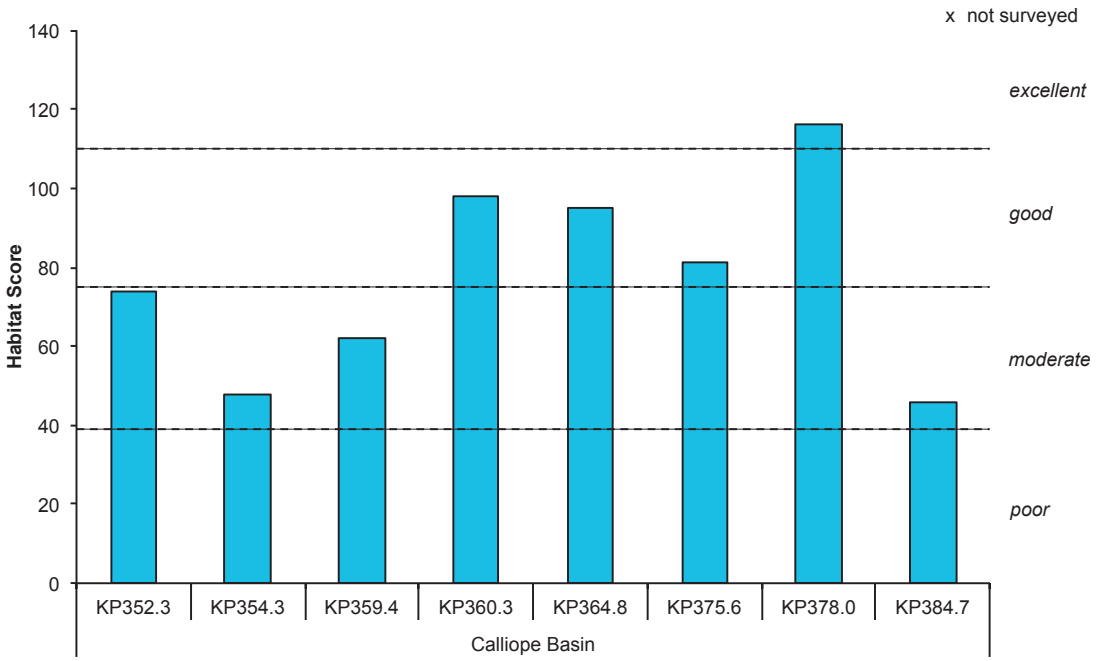


Figure 2.7 Habitat bioassessment score at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

### Reach Environments

In the State of the Rivers survey, the condition of the reach environments varied across the Dawson River sub-catchment, although most stream segments were of moderate condition, as shown at most sites in the current survey. Stream segments with very poor or poor condition were mainly in the western, southern and north-upland tributaries, and in the Don and Callide tributaries of the Dawson River. Stream segments with good to very good ratings were mostly in the upper and regulated Dawson River sub-catchments. Factors that impacted the condition of the reach environments included the extent of vegetation clearing along the stream, for cropping, and exposure to cattle grazing and watering (Telfer 1995).

### Riparian Vegetation and Adjacent Land Use

In the State of the Rivers survey, riparian vegetation throughout the catchment was in very poor to poor condition, although the condition of riparian vegetation in the Upper Dawson River sub-catchment was high (Telfer 1995). The reported impacts to riparian vegetation were clearing, grazing by cattle and invasion of weed species. This is consistent with riparian vegetation condition and land uses observed at sites in the current survey. Eucalypt-dominated communities were the most commonly identified vegetation types within the riparian zones of the catchment, followed by Brigalow, softwood scrub, and cypress pine communities. Grasslands and medium (10 to 30 m) and small (<10 m) trees were the most dominant structural types of vegetation (Telfer 1995). The most extensive adjacent land use in the State of the Rivers survey was the grazing of beef cattle on native pastures (mostly in areas cleared of native timber) (Telfer 1995).

### Bank Stability

In the State of the Rivers survey, the stability of the banks throughout the catchment was generally good, with most banks being stable or very stable. Erosion was the most extensive process occurring throughout the catchment, and was the dominant process in 94% of stream segments. Erosion commonly occurred at bends, at obstacles, and at irregular locations along both the lower and upper banks. The presence of stock and

clearing of vegetation were the major factors contributing to the disturbance of banks (Telfer 1995), as noted at many sites in the current survey.

### Channel Diversity

In the State of the Rivers survey, channel diversity throughout the catchment was mostly low to very low. Generally, channel diversity was highest in the North Upland, and Don and Callide sub-catchments. Run habitat was the most commonly identified channel habitat type throughout the catchment, followed by pools and then riffles (Telfer 1995).

### In-stream Habitat

In the State of the Rivers survey, the condition of in-stream habitat was considered to be generally poor to moderate. Similarly, the overall habitat value for aquatic life was rated at most sites (71%) as very poor to good, which was similar to the habitat value at most sites in the current survey. Sub-catchments that exhibited aquatic habitat in mostly good to very good condition included the upper tributaries sub-catchment and the Upper Dawson River sub-catchment. Individual branches, individual logs, and leaf and twig cover were the most common in-stream habitat. Vegetative debris was the predominant aquatic habitat in this catchment, which highlights the importance of riparian zones to aquatic organisms in the Dawson River sub-catchment (Telfer 1995).

## 3.2 Calliope Basin

The Calliope River Basin encompasses an area of approximately 2 241 $km^2$ and includes four major tributaries, Larcom Creek, Oakey Creek, Paddock Creek and Double Creek. The Calliope River Basin is generally used for agriculture, industry, livestock and residential areas, however most water used by developed areas is obtained from the Awoonga Dam in the Boyne River Basin (DERM 2010).

The Calliope Basin is one of the most extensively cleared basins in south-central Queensland with approximately 66% of the native vegetation removed. Riparian zones within the basin generally consist of thin or altered remnant vegetation structure and composition. Flows from the Calliope River are essential for a number of receiving environments including flow-dependent ecosystems, such as palustrine and intertidal wetlands.

Environmental values for aquatic ecosystems in the Calliope Basin are moderate to high, and include:

- diverse aquatic plant communities
- high integrity fish communities
- diverse macroinvertebrate communities
- habitat diversity
- deep water refuges, and
- floodplain wetlands (DERM 2005).

# 4 References

DERM, 2005, *Calliope River Basin Draft Water Resource Plan Ecological Assessment Report*, report prepared for Department of Natural Resources, Mines by C&R Consulting.

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# Appendix B Water Quality

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Figure 2.3 Electrical conductivity at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO ranges for the Lower Dawson River sub-catchment and Callide Creek. 6

Figure 2.4 Electrical conductivity at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin, and the QWQG range for the Central Coast. 7

Figure 2.5 Percent saturation of dissolved oxygen at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO range for the Lower Dawson River sub-catchment and Callide Creek. 9

Figure 2.6 Percent saturation of dissolved oxygen at each site along the GLNG pipeline (KP200 to KP420) in the Calliope Basin, and the QWQG range for the Central Coast. 10

Figure 2.7 Turbidity at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO for the Lower Dawson River sub-catchment and Callide Creek. 11

Figure 2.8 Turbidity at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin, and the QWQG range for the Central Coast. 12

# 1 Methods

## 1.1 Water Quality Measured In Situ

Water quality was measured in situ at sites containing sufficient water at the time of survey. Water quality was not assessed at sites that were dry or where the water level was too low.

The following water quality parameters were measured using a Hydrolab Quanta water quality meter

- pH
- electrical conductivity, and
- dissolved oxygen.

A Hach 2100Q turbidity meter was used to measure turbidity.

The Hydrolab Quanta water quality meter was calibrated daily and the Hach 2100Q was calibrated at the beginning of the field surveys.

The water quality results for sites in the Fitzroy Basin were compared to the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 (EPP Water) for waterways in the Fitzroy Basin, including the Lower Dawson River sub-catchment and Callide Creek (DERM 2011b) (Table 1.1). The WQOs for electrical conductivity and pH are based on (DERM 2011a):

- the default Queensland Water Quality Guidelines (QWQG) for the lower Dawson catchment as there was insufficient reference data, and
- reference data at the Don River at Kingsborough and Bell Creek at Craiglands for the Callide catchment.

The most relevant guidelines for dissolved oxygen and turbidity are the regional guidelines presented in the Queensland Water Quality Guidelines (DERM 2009), and these have been presented as the WQOs scheduled under the EPP Water.

There are no WQOs scheduled under the EPP Water for waterways in the Calliope Basin. Therefore, the water quality results for sites in the Calliope Basin were compared to the Queensland Water Quality Guidelines for slightly to moderately disturbed freshwater watercourses in the Central Coast region (DERM 2009) (Table 1.2).

Table 1.1 Water quality objectives for the Fitzroy Basin, for the protection of moderately disturbed aquatic ecosystems.

| Parameter | Units | Water Quality Objectives for Fitzroy Basin | |
|---|---|---|---|
| | | Lower Dawson | Callide Creek |
| temperature | °C | – | – |
| pH | pH units | 6.5–8.5 | 6.5–8.5 |
| electrical conductivity | µS/cm | 210–340 | 600–1150 |
| dissolved oxygen [a] | % saturation | 85–110 | 85–110 |
| turbidity | NTU | 50 | 50 |

Source DERM (2011b; a)

µS/cm = microSiemens per centimetre

NTU = nephelometric turbidity unit

– not available

[a] dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth

Table 1.2 Queensland Water Quality Guidelines for the Central Coast, for the protection of moderately disturbed aquatic ecosystems.

| Parameter | Units | Queensland Water Quality Guidelines for Central Coast |
|---|---|---|
| temperature | °C | – |
| pH | pH units | 6.5–8.0 |
| electrical conductivity | µS/cm | 413–1050 |
| dissolved oxygen [a] | % saturation | 90–110 |
| turbidity | NTU | 50 |

Source DERM (2009)

µS/cm = microSiemens per centimetre

NTU = nephelometric turbidity unit

– not available

[a] dissolved oxygen values derived from daytime measurements, and may vary overnight and with depth

## 1.2 Regional and Ecological Perspective

Literature on water quality in each catchment was reviewed, including surveys done for the GLNG EIS, and summarised to provide a context for the results of this survey.

# 2 Results

## 2.1 pH

### Fitzroy Basin

The pH was within the Fitzroy Basin WQO range for the Lower Dawson River sub-catchment and Callide Creek at all sites, and pH varied little between sites within the Fitzroy Basin (Figure 2.1). The exception was at Mimosa RCR (Mimosa Creek revised site) in which the pH was slightly below the WQO range.

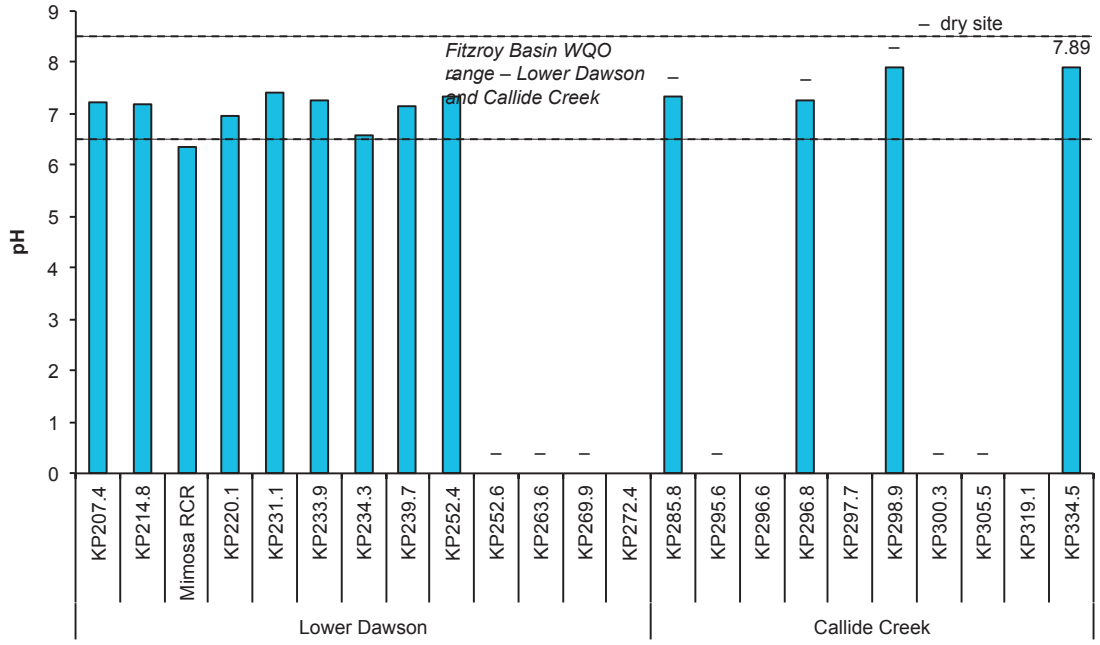


Figure 2.1 The pH at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO for Lower Dawson River sub-catchment and Callide Creek.

## Calliope Basin

The pH at site KP359.5 (unnamed watercourse 10) in the Calliope Catchment was below the QWQG range for the Central Coast, and the pH at site KP375.6 (Gravel Creek) was slightly above the QWQG range for the Central Coast (Figure 2.2).

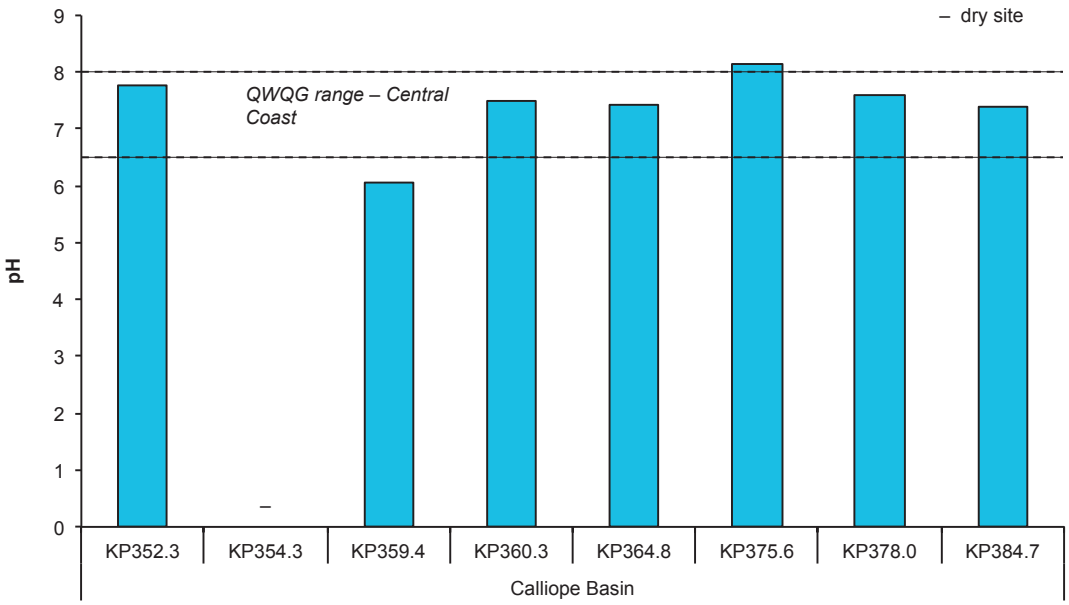


Figure 2.2 The pH at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin, and the QWQG range for the Central Coast.

## 2.2 Electrical Conductivity

### Fitzroy Basin

Electrical conductivity was above the Fitzroy Basin WQO range for the Lower Dawson River sub-catchment at site KP239.7 (Kianga Creek), and above the Fitzroy Basin WQO range for the Callide Creek catchment at site KP285.8 (Neville Creek) (Figure 2.3). Water at these sites was restricted to small isolated pools that would have dried soon after the survey. It was likely that the concentration of salt in the water increased as the pools were contracting.

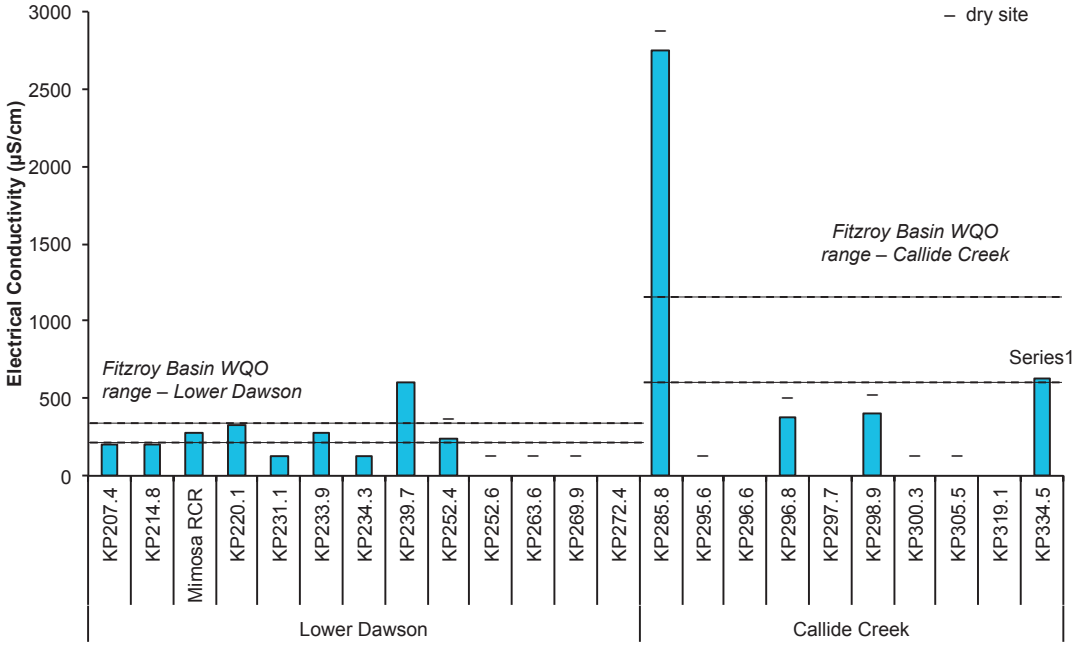


Figure 2.3 Electrical conductivity at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO ranges for the Lower Dawson River sub-catchment and Callide Creek.

## Calliope Basin

Electrical conductivity was above the QWQG range for the Central Coast at site KP375.6 (Gravel Creek) and site KP378.0 (Larcom Creek) in the Calliope Basin (Figure 2.4).

Electrical conductivity depends on a number of factors including catchment run-off and local geology. High electrical conductivity was also likely to be related to evaporation and the subsequent concentration of salts in the remaining isolated pools.

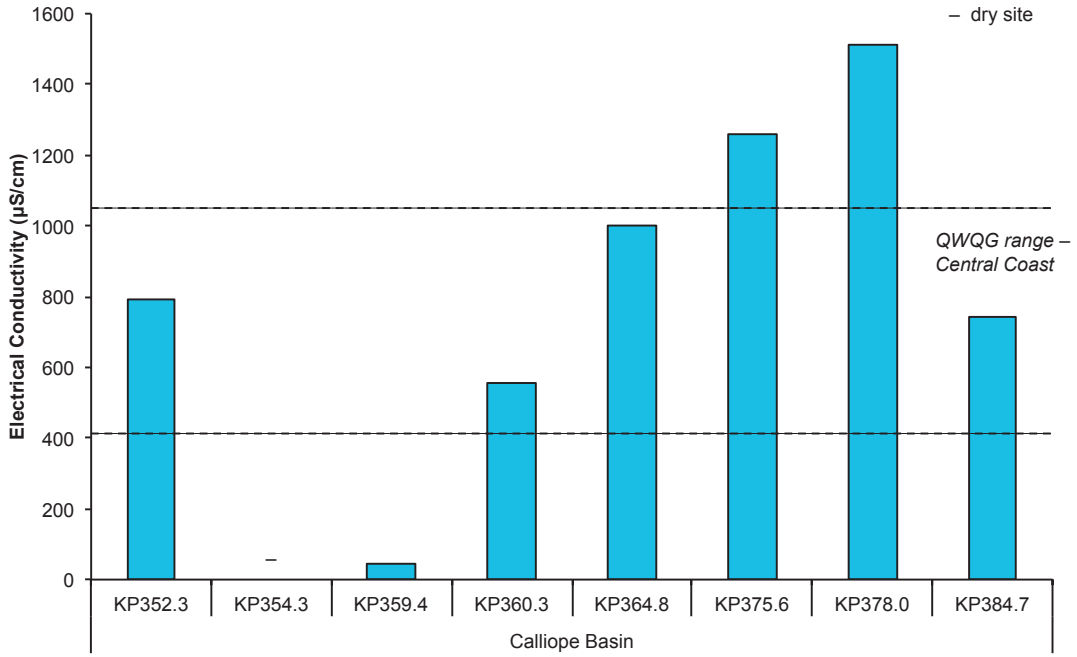


Figure 2.4 Electrical conductivity at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin, and the QWQG range for the Central Coast.

## 2.3 Dissolved Oxygen

### Fitzroy Basin

The percent saturation of dissolved oxygen was below the Fitzroy Basin WQO range for the Lower Dawson River sub-catchment and Callide Creek at a number of sites in the Fitzroy Basin (Figure 2.5).

It should be noted that the WQO for percent saturation dissolved oxygen is considered appropriate for flowing water, not disconnected pools or wetlands. The Queensland Water Quality Guidelines (DERM 2009) recommends adopting local water quality guidelines based on local reference site data. However, reference data for the watercourses assessed in this AVA is not available. As such, the WQO has been applied as a general guide. The saturation of dissolved oxygen was also often low in flowing water, including at sites:

- Conciliation Creek (KP207.4)
- Brolga Gully (KP214.8)
- Mimosa RCR
- Mimosa Creek (KP220.1)
- Back Creek (KP234.3), and
- Kroombit Creek (KP296.8).

The differences in the percent saturation of dissolved oxygen at each site are likely to reflect the:

- time of day measurements were taken (plants photosynthesise during the day, producing oxygen)
- photosynthetic rates of algae and aquatic plants (which are affected by light availability and temperature)
- rate of oxygen uptake by micro-organisms in the waterway associated with decomposing organic matter, and
- amount of surface mixing (caused by wind, water movement and bird activity).

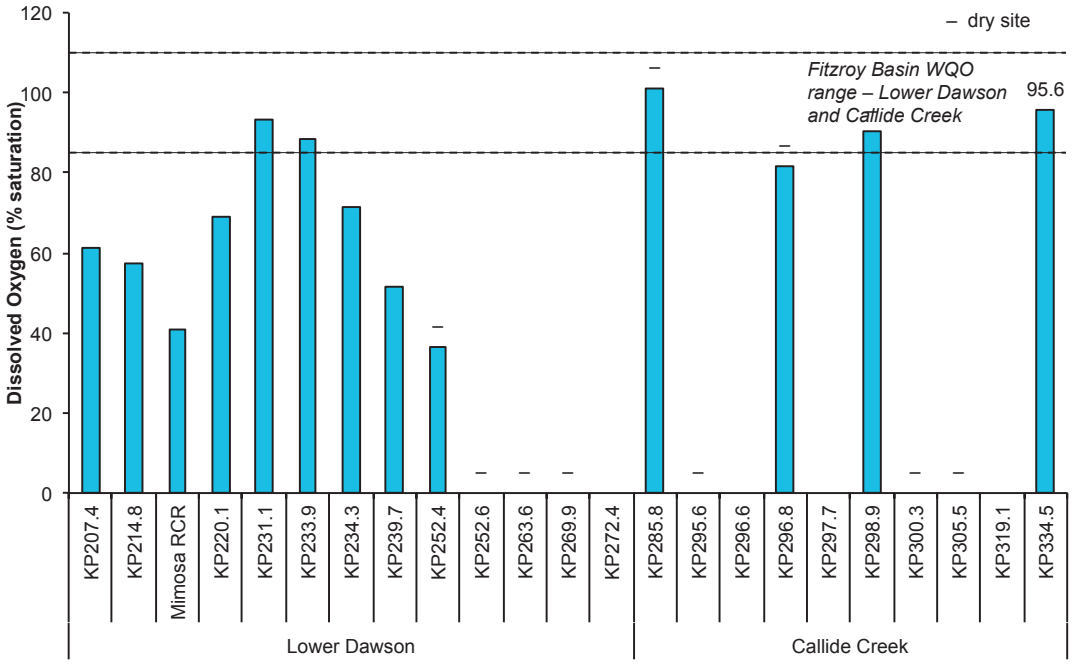


Figure 2.5 Percent saturation of dissolved oxygen at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO range for the Lower Dawson River sub-catchment and Callide Creek.

## Calliope Basin

The percent saturation of dissolved oxygen was below the QWQG range for the Central Coast at a number of sites in the Calliope Basin (Figure 2.6). As discussed above, this is likely to reflect the habitat at each of the sites (isolated pools), though the saturation of dissolved oxygen was also low in flowing water at KP378.0 & KP384.7 on Larcom Creek.

The differences in the percent saturation of dissolved oxygen at each site are likely to reflect the:

- time of day measurements were taken (plants photosynthesise during the day, producing oxygen)
- photosynthetic rates of algae and aquatic plants (which are affected by light availability and temperature)
- rate of oxygen uptake by micro-organisms in the waterway associated with decomposing organic matter, and
- amount of surface mixing (caused by wind, water movement and bird activity).

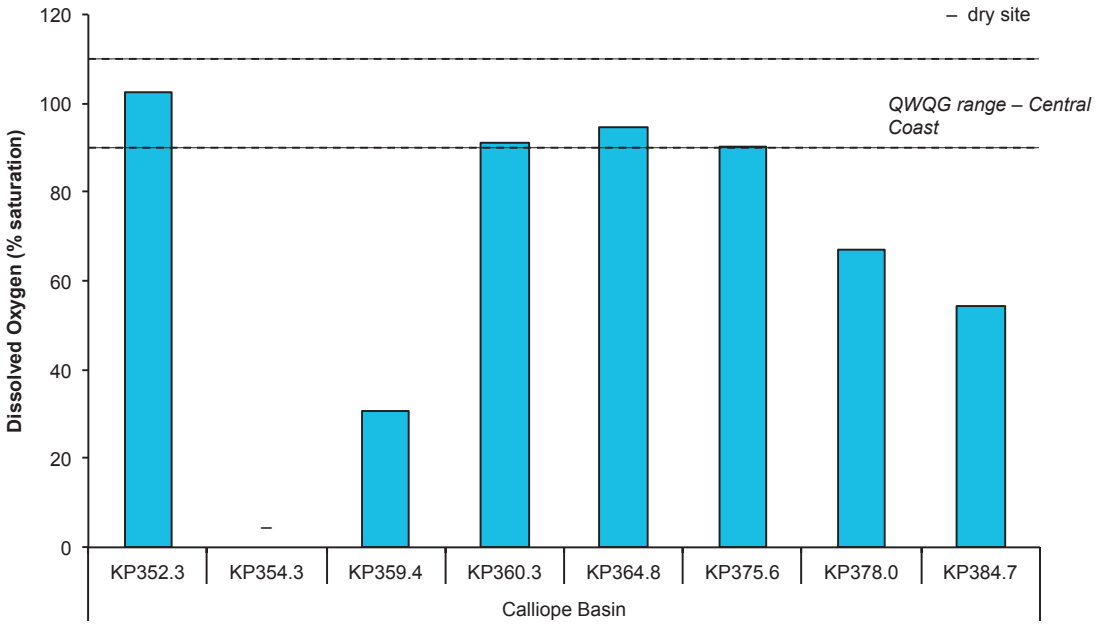


Figure 2.6 Percent saturation of dissolved oxygen at each site along the GLNG pipeline (KP200 to KP420) in the Calliope Basin, and the QWQG range for the Central Coast.

## 2.4 Turbidity

### Fitzroy Basin

Turbidity was above the Fitzroy Basin WQO for the Lower Dawson River sub-catchment and Callide Creek at a number of sites in the Fitzroy Basin (Figure 2.7). No reference data is available for the pipeline. Variation in turbidity between sites was likely to be due to differences in local factors, such as sediment type, aquatic plant cover, and severity of erosion (e.g. erosion associated with cattle access). Turbidity is a potential indicator of sedimentation and erosion.

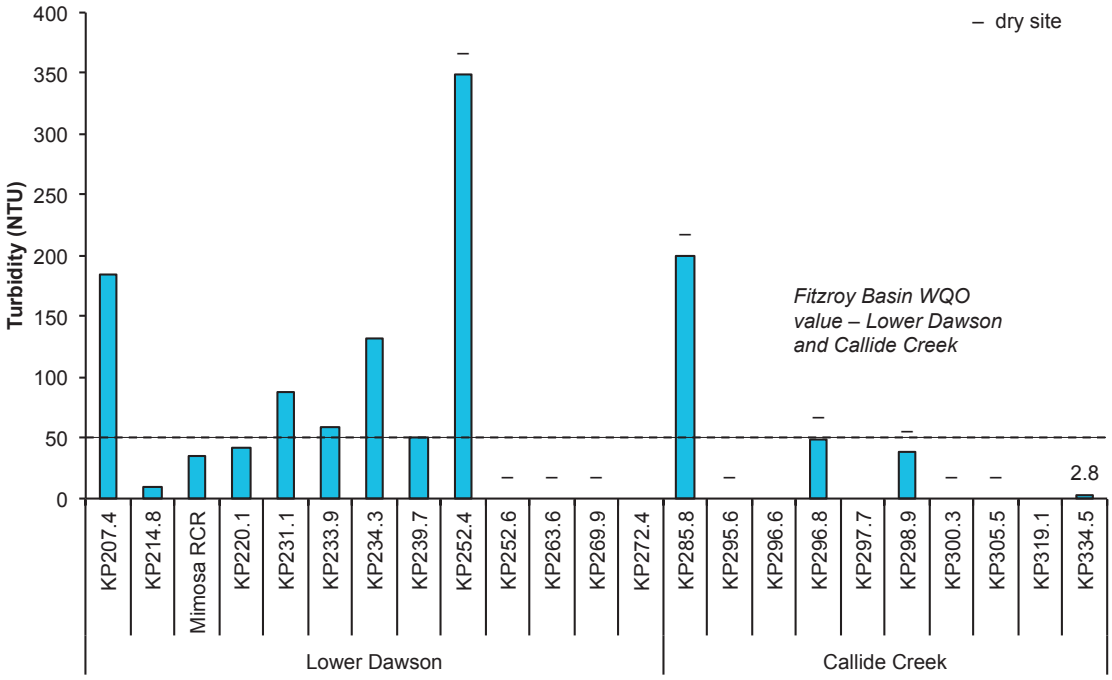


Figure 2.7 Turbidity at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin, and the Fitzroy Basin WQO for the Lower Dawson River sub-catchment and Callide Creek.

## Calliope Basin

Turbidity was low and below the QWQG range for the Central Coast at all sites in the Calliope Basin (Figure 2.8).

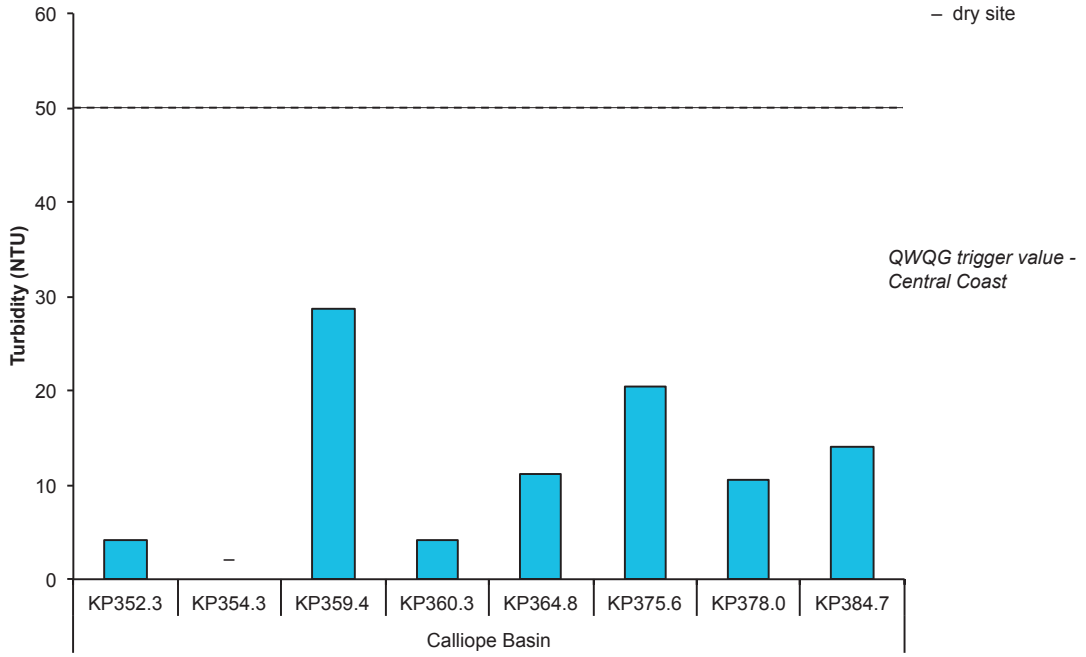


Figure 2.8 Turbidity at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin, and the QWQG range for the Central Coast.

# 3 Regional and Ecological Perspective

## 3.1 Dawson River Sub-catchment

Agricultural land use dominates the Dawson River sub-catchment:

- 77% of the area is grazed
- 12% is state forest
- 7% is cropped, and
- 3% is national park (EPA 2001).

Within the Dawson River sub-catchment there are eight sub-catchments, which vary in their aggregate emission rates of nitrogen and phosphorus. Total nitrogen emitted from this sub-catchment is approximately 0.95 kg/ha/year, and total phosphorus is 0.33 kg/ha/year (EPA 2001).

The primary sources for nitrogen are:

- grazing (43%)
- state forests (39%), and
- cropping (9%)

The primary sources for phosphorus are:

- grazing (80%)
- cropping (12%), and
- state forests (4%) (Joo 2000).

## 3.2 Calliope Basin

The Calliope catchment is generally used for agriculture, industry, livestock and residential areas; however, most water used by developed areas is obtained from the Awoonga Dam in the Boyne River Basin (DERM 2010).

Terrestrial run-off and freshwater from the Calliope River flows into the tidal and coastal areas of Port Curtis and the Port of Gladstone.

# 4 References

DERM, 2009. *Queensland Water Quality Guidelines Version 3 September 2009*. Department of Environment and Resource Management, Brisbane

DERM, 2010. A*nnual Report 2009-10 Queensland's Water Resource Plans*. prepared by Water Quality and Accounting, Department of Environment and Resource Management.

DERM, 2011a. *Developing Water Quality Guidleines for the Protection of the Freshwater Aquatic Ecosystems in the Fotzroy Basin, Phase 1*. Department of Environment and Resource Management, Brisbane.

DERM, 2011b, *Dawson River Sub-basin Environmental Values and Water Quality Objectives*, September 2011, http://www.derm.qld.gov.au/environmental_management/water/environmental_values_environmental_protection_water_policy/schedule_1_of_epp_water_including_plans/fitzroy_scheduled_evs_wqos.html, accessed August 2012.

EPA, 2001, *Nutrient loads from the Dawson River Catchment: National Pollutant Inventory*, http://www.derm.qld.gov.au/register/p00353aa.pdf, accessed April 2001.

Joo, M., McNeil, V. H., O'Brien, E. & Fearon, R., 2000, *Nutrient emission modelling in the Dawson River Basin using catchment management support system (CMSS)*, report prepared for Prepared for the Department of Natural Resources.

# Appendix C Aquatic Flora

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# 1 Survey Design and Methods

## 1.1 Aquatic Plant Assessment

The aquatic plants were assessed at each site along a 100 m reach of the stream and the adjacent bank (50 m upstream and downstream of the pipeline crossing). Plants were identified to species, and the following environmental parameters were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species)
- growth form of each species (submerged, floating (free-floating or rooted) and emergent) (Table 1.1)
- whether the plant was native or introduced to Australia, and
- whether the plant was listed under state or Commonwealth legislation.

Table 1.1 Aquatic plant growth forms.

| Growth Form | Description |
|---|---|
| submerged | • predominantly grow beneath the surface of the water<br>• flowers may project above the water surface<br>• some leaves may float on the water surface |
| floating | • can be either free-floating or rooted<br>• free-floating species are usually not attached to the substrate<br>• rooted species are attached to the substrate and normally have at least the mature leaves floating on the water surface |
| emergent | • rooted in the substrate<br>• stems, flowers and most of the mature leaves project above the water surface |

Source: (Sainty & Jacobs 2003)

Percent cover of each species was assessed visually and the presence of listed protected species, under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992*, was determined at each site.

Aquatic plant species were identified in the field, where practical. Representative specimens were collected for identification in the laboratory (or by the Queensland Herbarium, if required). Species were identified as native or exotic according to the *Census of Queensland Flora 2007* (Queensland Herbarium 2007).

## 1.2 Regional and Ecological Perspective

The literature on aquatic plants in each basin was reviewed, and summarised to provide a context for the results.

# 2 Results

## 2.1 Taxonomic Richness

### Fitzroy Basin

Taxonomic richness of aquatic plants varied between sites and ranged from 0 to 12 species per site in the Fitzroy Basin (Figure 2.1 and Table 2.1). The highest taxonomic richness of aquatic plants was at site KP334.5 (Bell Creek). There were no aquatic plants at sites:

- KP207.4 (Conciliation Creek)
- KP269.9 (Police Camp Creek), or
- KP300.3 (Callide Creek).

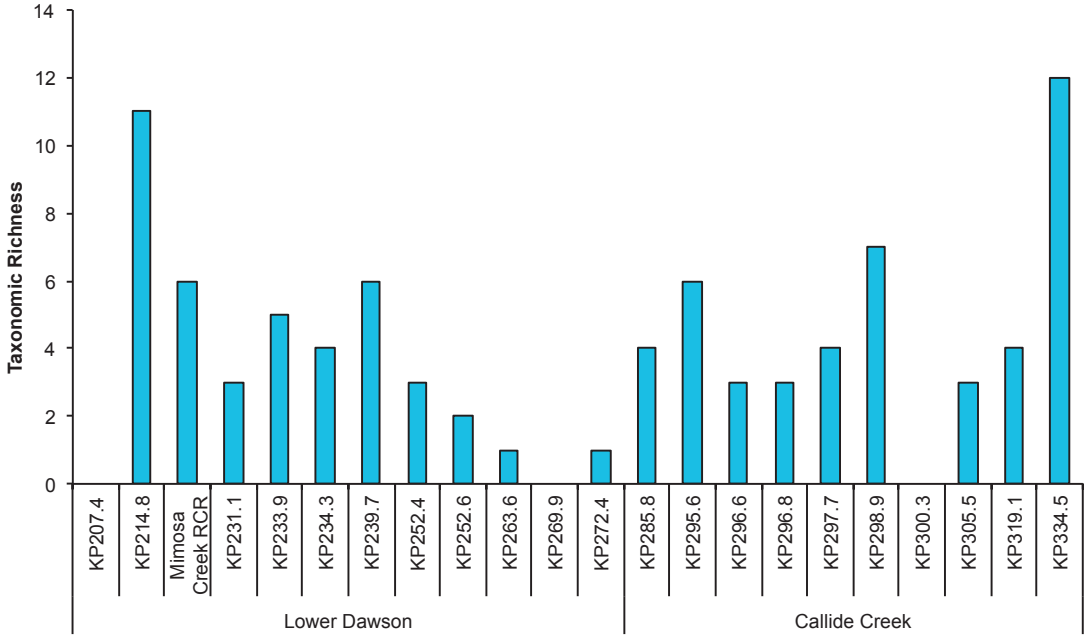


Figure 2.1 Taxonomic richness of aquatic plants at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

Taxonomic richness of aquatic plants varied between sites and ranged from 4 to 13 species per site in the Calliope Basin (Figure 2.2 and Table 2.2). The highest taxonomic richness of aquatic plants was at site KP364.8 (Alarm Creek).

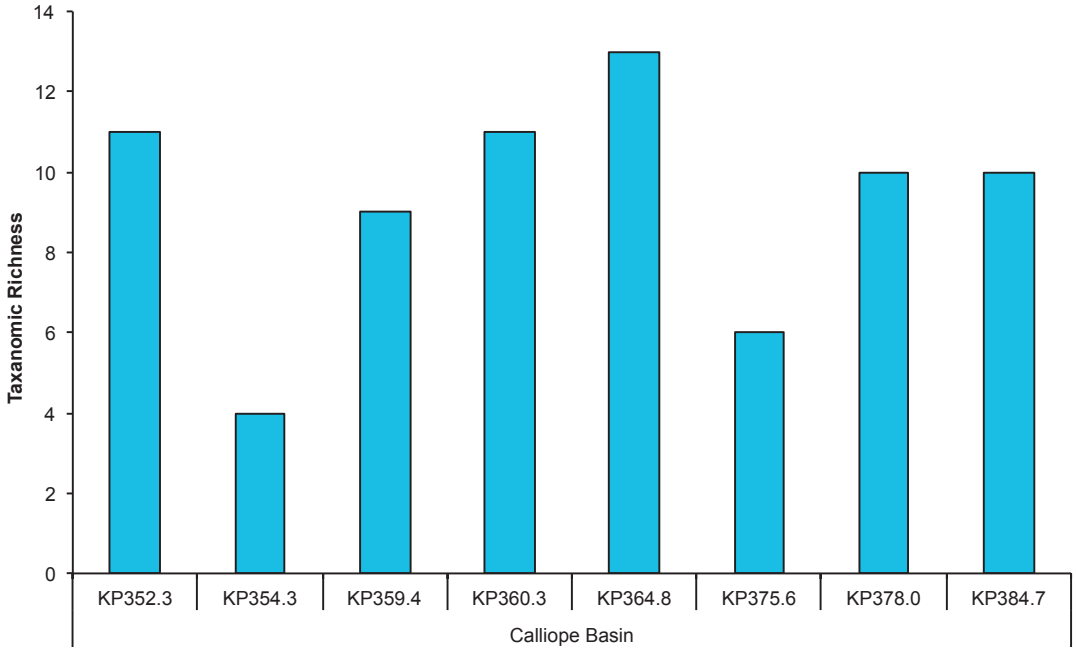


Figure 2.2 Taxonomic richness of aquatic plants at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.2 Percent Cover

### Fitzroy Basin

The percent cover of aquatic plants (as a percentage of the total substrate) ranged from 0 to 82% (Figure 2.3 and Table 2.1). The highest percent cover of aquatic plants was at site KP297.7 (palustrine wetland) and the lowest percent cover (at sites where there were aquatic plants) was at site KP234.3 (Back Creek).

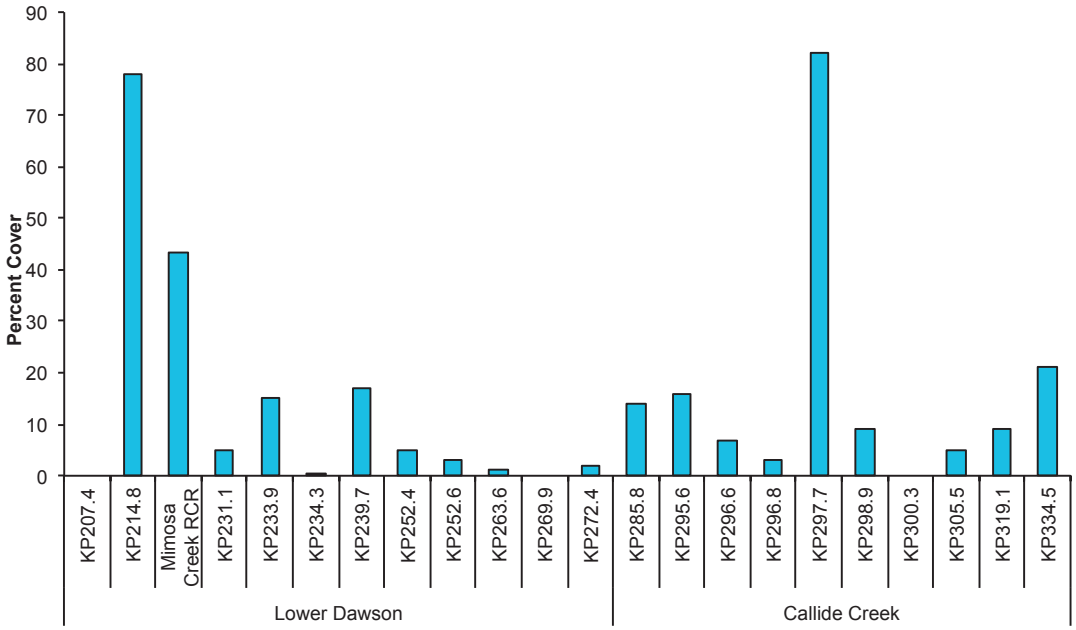


Figure 2.3 Percent cover of aquatic plants at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

The percent cover of aquatic plants (as a percentage of the total substrate) ranged from 10 to 87% (Figure 2.4 and Table 2.2). The highest percent cover was at site KP360.3 (Harper Creek) and the lowest percent cover was at site KP354.3 (unnamed watercourse 9).

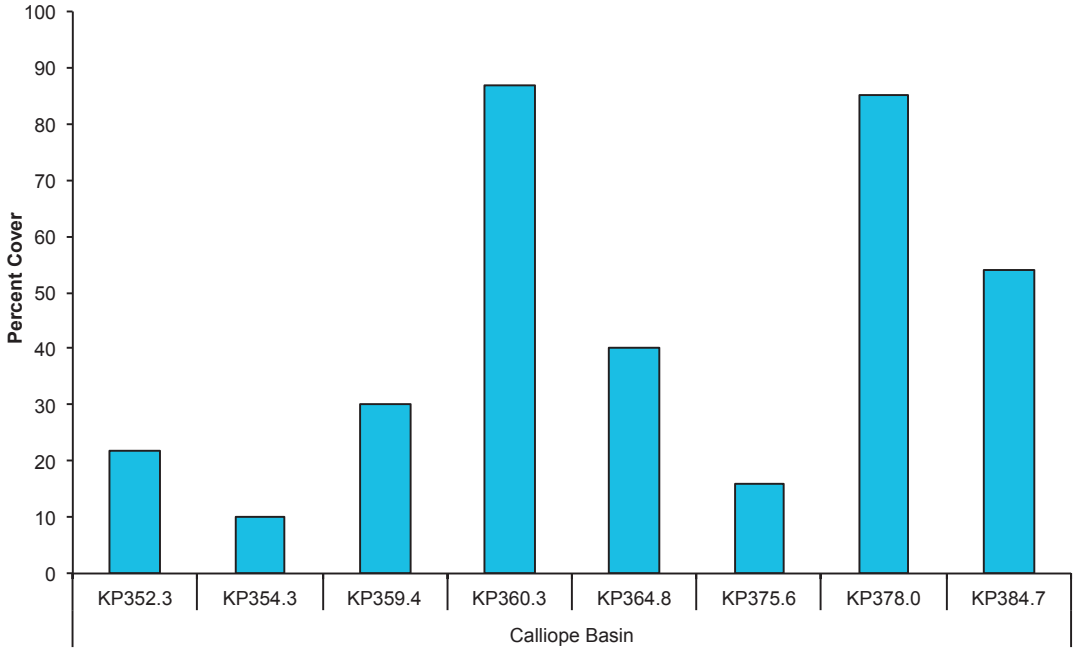


Figure 2.4 Percent cover of aquatic plants at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

Table 2.1 Abundance of aquatic flora species at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

| Species Name | Common Name | Growth Form | Callide Creek | | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KP207.4 | KP214.8 | Mimosa Creek RCR | KP231.1 | KP233.9 | KP234.3 | KP239.7 | KP252.4 | KP252.6 | KP263.6 | KP269.9 | KP272.4 | KP285.8 | KP295.6 | KP296.6 | KP296.8 | KP297.7 | KP298.9 | KP300.3 | KP305.5 | KP319.1 | KP334.5 | |
| *Alternanthera denticulata* | lesser joyweed | E | – | 15 | 2.5 | 2 | 8 | – | 5 | 1 | 1 | 1 | – | – | – | – | 1 | 1 | – | – | – | – | 3 | – | **40.5** |
| *Azolla pinnata* | femy azolla | FF | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | **1** |
| *Blyxa aubertii* | – | S | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **1** |
| *Callitriche muelleri* | – | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | **3** |
| *Centella asiatica* | Asiatic pennywort | E | – | – | 0.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **0.5** |
| *Cyperus bifax* | nutgrass | E | – | 35 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | **36** |
| *Cyperus concinnus* | trim flat-sedge | E | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | – | – | – | – | **1** |
| *Cyperus conicus* | – | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **0.5** |
| *Cyperus difformis* | Dirty Dora | E | – | 3 | – | – | – | – | – | 1 | – | – | – | – | 1 | – | – | – | – | – | – | 1 | – | 1 | **7** |
| *Cyperus distans* | piedmont flatsedge | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **0.5** |
| *Cyperus exaltatus* | tall flatsedge | E | – | 5 | – | 2 | 2 | 0.14 | 5 | – | – | – | – | – | – | 3 | – | – | 15 | – | – | – | – | – | **32.14** |
| *Cyperus flavidus* | yellow flatsedge | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | **1** |
| *Cyperus polystachyos* | bunchy sedge | E | – | – | 5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | 2 | **8** |
| *Cyperus* sp. (cf. *C. lucidus)* | – | E | – | – | – | – | – | – | – | – | – | – | – | – | 8 | – | – | – | – | – | – | – | – | – | **8** |
| *Cyperus* sp. (cf. *C. trinervis)* | – | E | – | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | **2** |
| *Cyperus* sp.1 | – | E | – | – | 5 | – | 1 | – | 2 | 3 | 2 | – | – | – | – | – | – | 1 | – | 1 | – | – | 1 | – | **16** |
| *Cyperus* sp.3 | – | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 4 | 1 | – | 1 | – | – | 2 | 1 | **9** |
| *Cyperus vaginatus* | stiff flat-sedge | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | **3** |
| *Cyperus victoriensis* | flat sedge | E | – | – | – | – | – | – | – | – | – | – | – | – | – | 3 | – | – | – | – | – | 3 | – | – | **6** |
| *Eclipta prostrata* | white eclipta | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | 5 | **7** |
| Floating sp.1 | – | FA | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **2** |
| *Glyceria maxima* | reed sweetgrass | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **0.4** |
| *Juncus continuus* | sand rush | E | – | – | 30 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **31** |
| *Juncus* sp. | – | E | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | 1 | **4** |
| *Lomandra hystrix* | green mat rush | E | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **2** |
| *Lomandra longifolia* | mat rush | E | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | – | – | – | – | – | – | **2** |
| *Ludwigia octovalvis* | willow primrose | E | – | 2 | – | 1 | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **4** |
| *Marsilea hirsuta* | hairy nardoo | FA | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 | 2 | – | – | – | – | – | – | – | **4** |
| *Marsilea mutica* | shiny nardoo | FA | – | 8 | – | – | – | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **11** |
| *Myriophyllum salsugineum* | lake water-milfoil | S | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **3** |
| *Ottelia ovalifolia* | swamp lily | FA | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | – | – | **3** |
| *Paspalum distichum* | water couch | E | – | – | – | – | – | – | – | – | – | – | – | – | 3 | 5 | – | – | 65 | – | – | – | – | 3 | **76** |

| Species Name | Common Name | Growth Form | Callide Creek | | | | | | | | | | | | | | | | Total | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KP207.4 | KP214.8 | Mimosa Creek RCR | KP231.1 | KP233.9 | KP234.3 | KP239.7 | KP252.4 | KP252.6 | KP263.6 | KP269.9 | KP272.4 | KP285.8 | KP295.6 | KP296.6 | KP296.8 | KP297.7 | KP298.9 | KP300.3 | KP305.5 | KP319.1 | KP334.5 | Total |
| *Persicaria attenuata* | smartweed | E | – | – | – | – | – | – | – | – | – | – | – | – | – | 2 | – | – | 1 | – | – | – | – | 1 | **4** |
| *Persicaria decipiens* | slender knotweed | E | – | – | – | – | – | 0.055 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | **1.555** |
| *Persicaria* (cf. *P. subsessilis)* | smartweed | E | – | – | 0.5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **0.5** |
| *Potamogeton crispus* | curly pondweed | S | – | – | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **1** |
| *Potamogeton javanicus* | small pondweed | FA | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **3** |
| *Spirodela* sp. | duckweed | FF | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | – | – | – | – | **1** |
| *Typha* sp. | reed | E | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 | **1** |
| **Total** | | | **0** | **78** | **43.5** | **5** | **15** | **0.4** | **17** | **5** | **3** | **1** | **0** | **2** | **14** | **16** | **7** | **3** | **82** | **9** | **0** | **5** | **9** | **20** | **337.595** |

NA no common name

E – emergent; S – submerged; FA – floating-attached ; FF – free floating

– not present

[a] could not be identified to species level due to a lack of specimens or reproductive parts

Table 2.2 Abundance of aquatic flora species at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

| Species Name | Common Name | Growth Form | Calliope Basin | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KP352.3 | KP354.3 | KP359.4 | KP360.3 | KP364.8 | KP375.6 | KP378.0 | KP384.7 | |
| *Alternanthera denticulata* | lesser joyweed | E | – | – | – | – | 1 | – | 1 | – | **2** |
| *Azolla pinnata* | fern y azolla | FF | – | – | – | 1 | – | – | – | 1 | **2** |
| *Callitriche muelleri* | round water starwort | E | – | – | – | – | – | – | – | 10 | **10** |
| *Callitriche stagnalis* | common starwort | FA | – | – | – | – | – | – | 5 | – | **5** |
| *Centella asiatica* | Indian pennywort | E | – | – | – | – | – | 3 | – | – | **3** |
| *Ceratophyllum demersum* | hornwort | S/E | – | – | – | 50 | – | – | – | – | **50** |
| *Cyperus curvistylis* | – | E | – | – | – | 3 | – | – | – | – | **3** |
| *Cyperus difformis* | rice sedge | E | – | – | 1 | 1 | 1 | 1 | – | – | **4** |
| *Cyperus exaltatus* | tall flatsedge | E | – | 2 | 2 | – | 2 | – | – | 3 | **9** |
| *Cyperus flavidus* | yellow flatsedge | E | 1 | – | – | – | – | – | – | – | **1** |
| *Cyperus polystachyos* | bunchy sedge | E | 3 | – | – | – | 3 | – | – | – | **6** |
| *Cyperus* sp.1 [a] | – | E | 1 | – | – | 10 | 5 | 1 | 10 | 3 | **30** |
| *Cyperus* sp.2 [a] | – | E | – | – | – | 1 | – | – | – | – | **1** |
| *Cyperus sphaeroideus* | globe kyllinga | E | 1 | – | – | – | 3 | – | – | – | **4** |
| *Eclipta prostrata* | white eclipta | E | 1 | – | – | – | – | – | – | – | **1** |
| *Fimbristylis* sp. [a] | fringe-rush | E | 1 | – | – | – | 1 | 1 | – | – | **3** |
| Floating sp.1 [a] | – | FA | – | – | – | – | – | – | 1 | – | **1** |
| *Juncus* sp. [1] | – | E | – | 1 | – | – | 3 | 5 | – | – | **9** |
| *Lomandra hystrix* | green mat rush | E | – | – | – | – | – | – | 3 | – | **3** |
| *Ludwigia octovalvis* | willow primrose | E | – | – | 3 | – | – | – | – | – | **3** |
| *Marsilea mutica* | shiny nardoo | FA | – | – | 3 | – | – | – | – | – | **3** |
| *Monochoria cyanea* | Monochoria | FA | – | – | 1 | – | – | – | – | – | **1** |
| *Myriophyllum salsugineum* | lake water-milfoil | S | – | – | – | – | 5 | 5 | – | – | **10** |
| *Myriophyllum verrucosum* | red water-milfoil | S/E | – | – | – | – | – | – | 5 | – | **5** |
| *Nymphoides* sp. [a] | – | FA | – | – | – | 2 | – | – | – | – | **2** |
| *Ottelia alismoides* | duck lettuce | S | 1 | – | – | 1 | – | – | 10 | – | **12** |
| *Ottelia ovalifolia* | swamp lily | FA | – | – | 2 | 8 | 3 | – | – | 1 | **14** |
| *Pandanus* sp. [a] | – | E | 2 | – | – | – | – | – | – | – | **2** |
| *Paspalum distichum* | water couch | E | – | 2 | 10 | – | – | – | – | 10 | **22** |
| *Persicaria attenuata* | smartweed | E | 1 | – | 5 | – | 4 | – | – | – | **10** |
| *Persicaria decipiens* | slender knotweed | E | 5 | – | 3 | 5 | 8 | – | 30 | 5 | **56** |
| *Potamogeton crispus* | curly pondweed | S | 5 | – | – | – | – | – | 15 | – | **20** |
| *Potamogeton ochreatus* | blunt pondweed | S | – | – | – | – | 1 | – | 5 | – | **6** |

| Species Name | Common Name | Growth Form | Calliope Basin | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | KP352.3 | KP354.3 | KP359.4 | KP360.3 | KP364.8 | KP375.6 | KP378.0 | KP384.7 | |
| *Spirodela* sp. [a] | duckweed | FF | – | – | – | – | – | – | – | 1 | **1** |
| *Urochloa mutica* | para grass | E | – | 5 | – | 5 | – | – | – | – | **10** |
| *Vallisneria nana* | ribbon weed | S | – | – | – | – | – | – | – | 20 | **20** |
| **Total** | | | **22** | **10** | **30** | **87** | **40** | **16** | **85** | **54** | **344** |

NA no common name

E – emergent; S – submerged; FA – floating-attached ; FF – free floating

– not present

[a] could not be identified to species level due to a lack of specimens or reproductive parts

## 2.3 Growth Form Diversity

Most aquatic plants were of emergent growth form (Table 2.1 and Table 2.2). Emergent forms are most tolerant of dry conditions. Floating and submerged species were found at five of the 23 sites in the Fitzroy Basin, and seven of the eight sites in the Calliope Basin. Submerged aquatic flora cannot survive dry periods and high turbidity (high turbidity reduces light in the water column and inhibits photosynthesis), so their presence is likely to be indicative of semi-permanent or permanent pools with relatively good water quality.

## 2.4 Exotic Species

Two exotic species were identified along the GLNG Pipeline:

- para grass at site KP354.3 (unnamed watercourse 9) and at site KP360.3 (Harper Creek), and
- common starwort at site KP378.0 (Larcom Creek) and at site KP334.5 (Bell Creek).

## 2.5 Listed Species of Conservational Significance

There were no species listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* observed in the survey.

# 3 Regional and Ecological Perspective

## 3.1 Fitzroy Basin

During the GLNG Project Environmental Impact Statement (EIS) surveys, 13 species of emergent aquatic plants were recorded from the Upper Dawson River sub-catchment (frc environmental 2009). The most common and abundant species were:

- awnless barnyard grass (*Echinochloa colona*)
- common rush (*Juncus usitatus*), and
- mat rush (*Lomandra longifolia*).

There were two exotic species: reed sweet grass and curled dock (*Rumex crispus*).

There were ten different species of aquatic plants at seven sites, with richness ranging from zero to eight species at any one site (frc environmental 2007). All aquatic plants had an emergent growth form (there were no floating or submerged species). In a subsequent survey, there were nine species with richness ranging from one to six species at any one site and percent cover of less than or equal to 10% (frc environmental 2008). The most abundant and common aquatic plant was the common rush.

## 3.2 Calliope Basin

In the Australia Pacific LNG Project EIS, one site on the Calliope River had a high percent cover and high species richness of submerged, floating and emergent aquatic plants (APLNG 2010). The aquatic plants at this site included:

- aquatic ferns (*Azolla* spp.)
- duckweed (*Lemna* spp.)
- hornwort (*Ceratophyllum demersum*)
- pondweeds (*Potamogeton* spp.)
- water ribbon (*Triglochin procerum*), and
- sedges (*Cyperus* spp.).

An environmental assessment undertaken by DERM (2005) indicated that aquatic plant communities in the Calliope Basin were diverse and of high ecological value.

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# Appendix D Macroinvertebrate Communities

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# 1 Methods

## 1.1 Sample Collection

### Macroinvertebrate Samples

Benthic macroinvertebrates were assessed at each site in bed and edge habitats. Five samples were taken from each habitat type, with each sample consisting of five sweeps of an area of 30 $cm^2$. A standard triangular-framed, macroinvertebrate sampling net with 250 µm mesh was used to collect the samples.

### Macrocrustacean Samples

Macrocrustaceans are not planktonic and include the orders Amphipoda, Isopoda and Decapoda. Macrocrustaceans (e.g. prawns, shrimps and yabbies) were caught using a combination of backpack electrofishing, baited traps and seine nets. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*. Macrocrustaceans were also caught in macroinvertebrate surveys, using a macroinvertebrate sampling net.

Details of fishing methods and survey efforts are presented in Appendix E.

## 1.2 Sample Processing

All samples were preserved in methylated spirits and returned to frc environmental's Brisbane laboratory, where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AUSRIVAS standards and those described by Chessman (2003). All macrocrustaceans were identified and counted in the field and specimens were returned to the environment.

## 1.3 Data Analysis

The following indices were calculated for each sample (further information is provided overleaf):

- abundance
- taxonomic richness
- PET richness, and
- SIGNAL 2 scores.

These metrics were used to indicate the current ecological health of surveyed waterways. The mean and standard error was calculated for each habitat type at each site. The total number of species and total abundance for each habitat type at each site were also calculated by pooling the data from the five samples. Results were compared to the relevant biological water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 for waterways in the Fitzroy Basin, and the Queensland Water Quality Guidelines for the Central Coast Region (DERM 2009; 2011) (Table 1.1). While the guidelines were developed using macroinvertebrate samples collected using AUSRIVAS sampling methods and are not directly applicable, this comparison was still useful for providing an overall preliminary indication of ecosystem health.

Table 1.1 Fitzroy Basin and Central Coast biological water quality objectives.

| Indicator | Habitat | WQO |
|---|---|---|
| composite [a] | taxonomic richness | 12–21 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.33–3.85 |
| edge | taxonomic richness | 23–33 |
| | PET richness | 2–5 |
| | SIGNAL 2 score | 3.31–4.2 |

Source: DERM (2011); DERM (2009)

[a] comprises all bed habitat within the site, including sandy pool, rocky pool, riffle, run and cascade

### *Abundance*

Abundance is the total number of macroinvertebrates.

### *Taxonomic Richness*

Taxonomic richness is the number of taxa (in this assessment, families). Taxonomic richness is a basic, unambiguous and effective diversity measure. However, it is affected by arbitrary choice of sample size. Where all samples are of equal size, taxonomic richness is a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxon, so rare and common taxa are considered equally.

### *PET Richness*

While some groups of macroinvertebrates are tolerant to pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003). Plecoptera (stoneflies), Ephemeroptera (mayflies), and Trichoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families within sites of good habitat condition and water quality than in sites of degraded condition. PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2007). The lower the PET score, the greater the inferred degradation.

### *SIGNAL 2 Scores*

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance. The scores take the relative abundance of tolerant or sensitive taxa into account (instead of only the presence or absence of these taxa). The overall SIGNAL 2 score for a site is based on:

- the total of the SIGNAL grade
- multiplied by the weight factor for each taxon, and
- divided by the total of the weight factors for each taxon.

SIGNAL 2 scores are interpreted in conjunction with the number of families found in the sample. This is achieved using a SIGNAL 2 / family bi-plot (Chessman 2003). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 1.1). Boundaries based on the Fitzroy Basin biological water quality objectives were used for this survey.

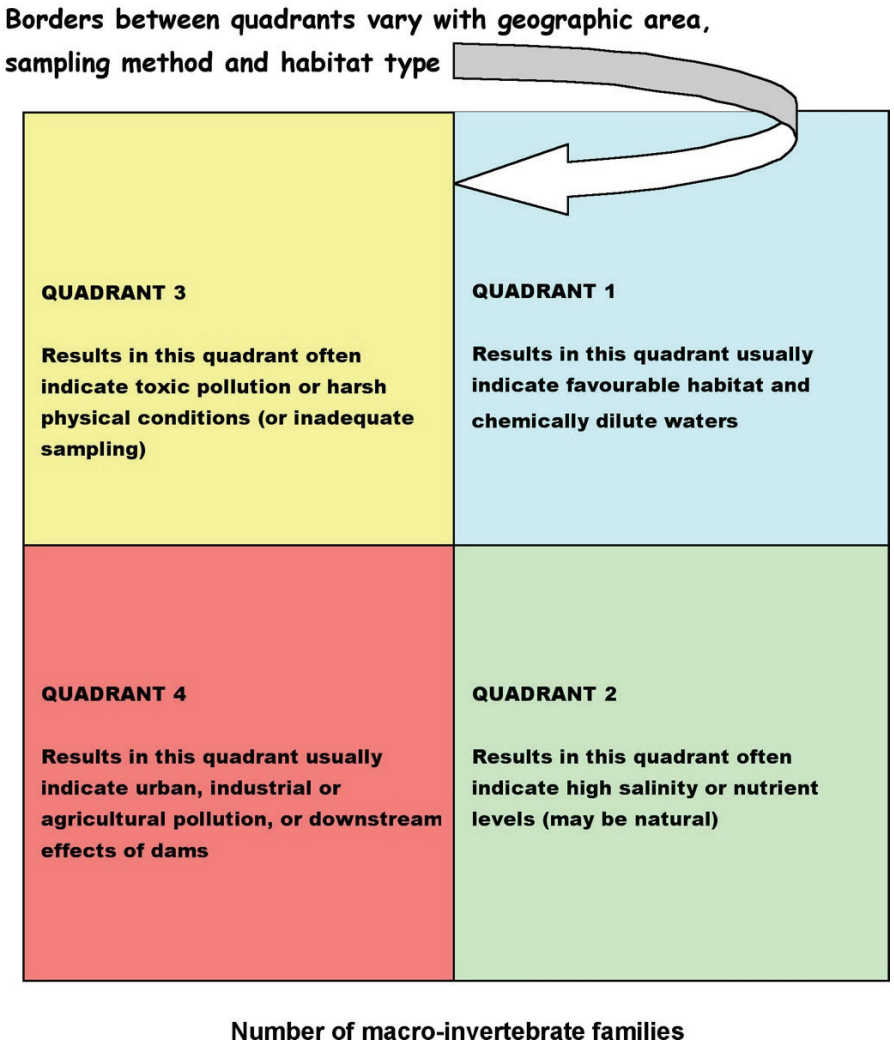


Figure 1.1 Quadrant diagram for SIGNAL 2 / family bi-plot.

### Multivariate Analyses

Multivariate analyses consider changes to the macroinvertebrate community structure as a whole, rather than to a single component of the community (e.g. indicator species) or indices (such as richness, PET richness and SIGNAL 2 scores) derived to represent the community (i.e. univariate analyses). Multivariate analyses provide a powerful tool to determine similarities or dissimilarities in community composition (i.e. type and abundance of each taxon) between pre-determined factors (e.g. sites and impacts).

We examined differences in community composition between sites, using a one-way analysis of similarity (ANOSIM). Before analysis, community data was log-transformed and converted to a Bray-Curtis similarity matrix. Community differences between sites were displayed visually, using the averaged data for each habitat at each site, using non-metric multi-dimensional scaling plots. Individual taxa, that contributed to the differences between sites, were identified using the similarity percentages (SIMPER) species contributions routine (Clarke 1993).

## 1.4 Regional and Ecological Perspective

The literature on macroinvertebrate communities in each catchment was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

## 2.1 Abundance

### Mean Abundance

#### *Fitzroy Basin*

Mean abundance of macroinvertebrates (i.e. the average number of individuals of the five samples from each site) varied between sites, but was relatively similar between bed and edge habitats. Site KP285.8 (Neville Creek) had the highest mean abundance of macroinvertebrates in bed and edge habitats (Figure 2.1 and Figure 2.2). The high mean abundance of macroinvertebrates at site KP285.8 (Neville Creek) was due to the high abundance of non biting midges (s-f Tanypodinae and s-f Chironominae), which are relatively tolerant to disturbance and pollution.

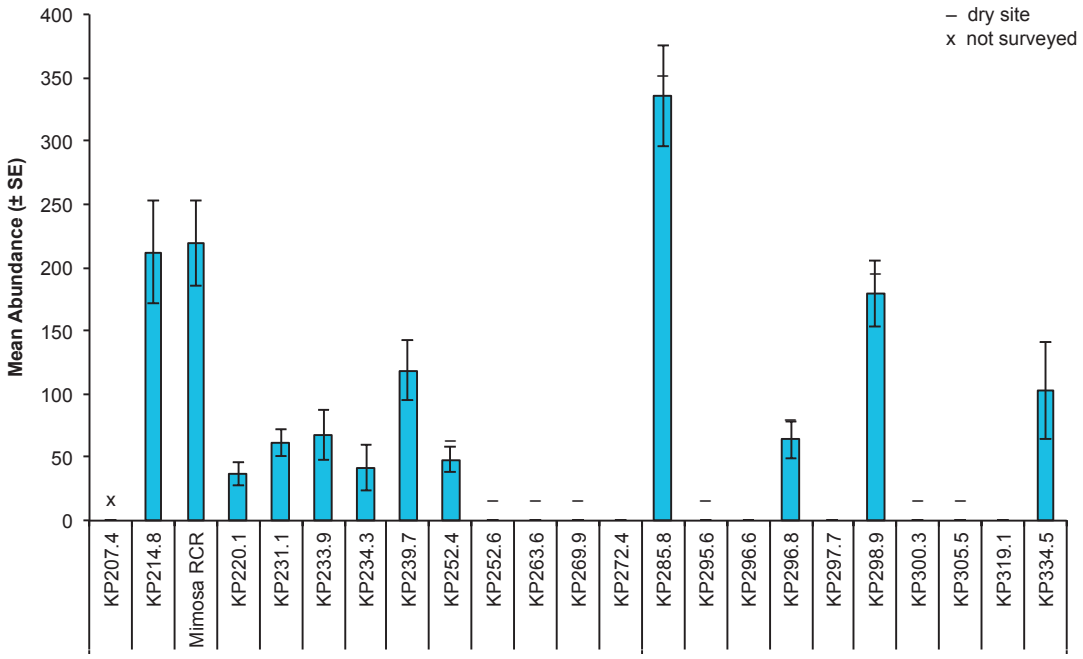


Figure 2.1 Mean abundance of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

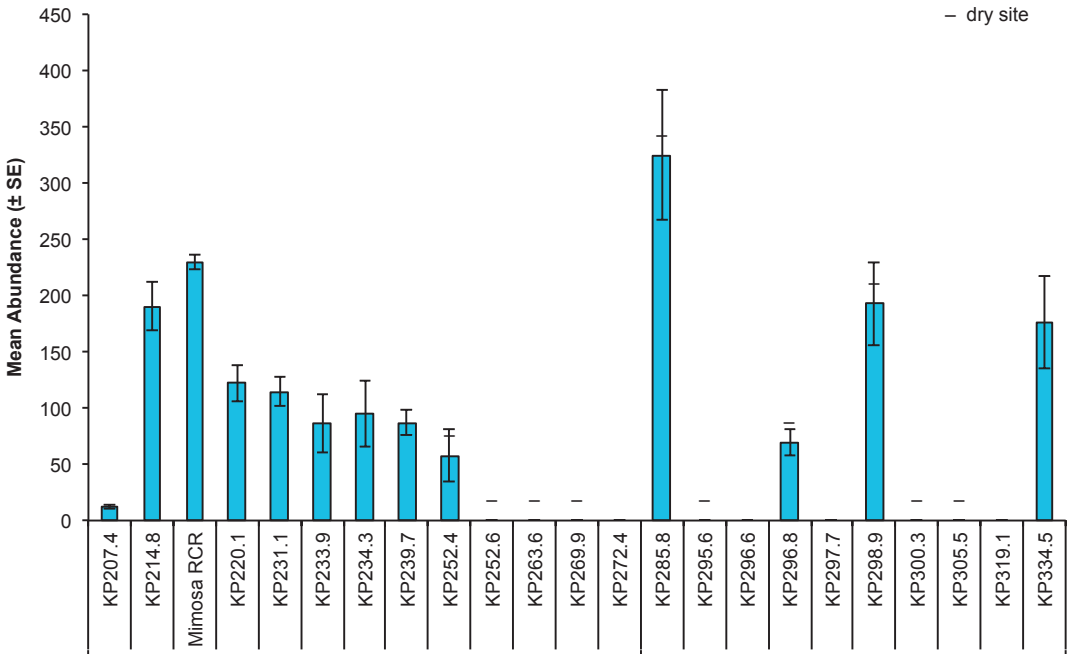


Figure 2.2 Mean abundance of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Mean abundance of macroinvertebrates was relatively similar between most sites, although the variation in the mean abundance of macroinvertebrates in bed habitat was high (note the large error bars) (Figure 2.3 and Figure 2.4). In bed habitat, the highest mean abundance was at site KP352.3 (Calliope River); there was a relatively similar mean abundance at other sites. In edge habitat, the lowest mean abundance was at site KP364.8 (Alarm Creek); there was a relatively similar mean abundance at all other sites.

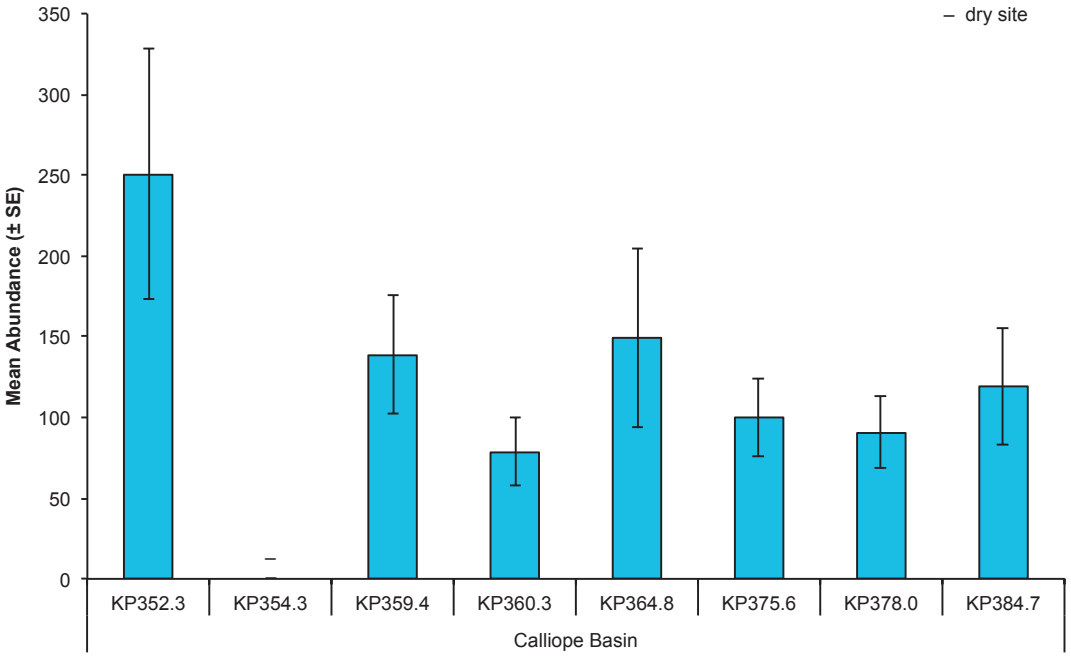


Figure 2.3 Mean abundance of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

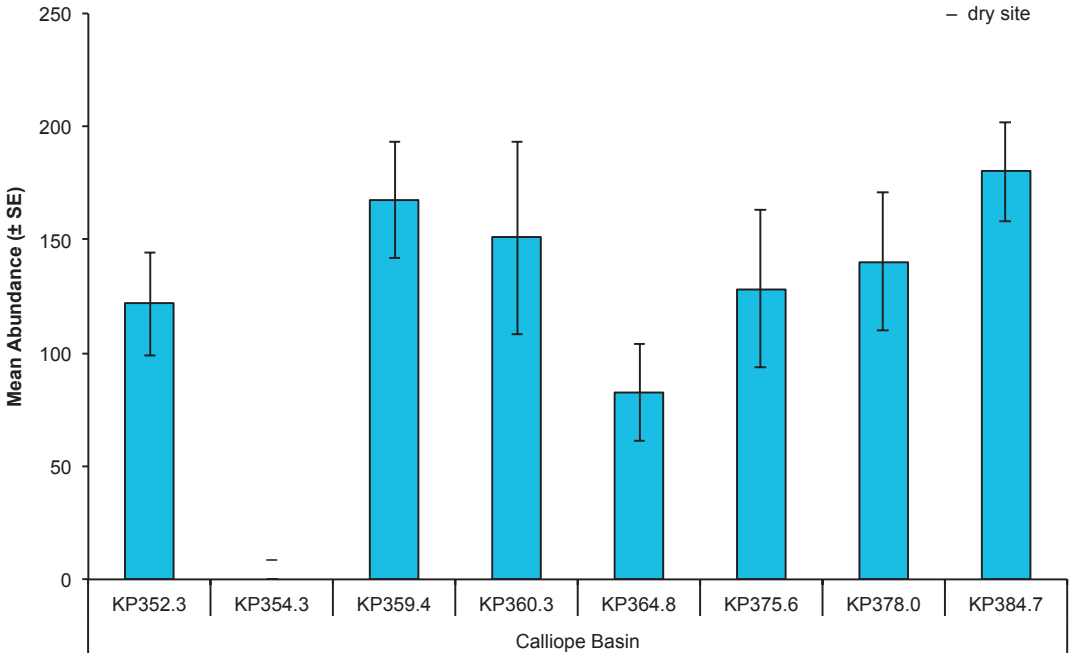


Figure 2.4 Mean abundance of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## Total Abundance

### *Fitzroy Basin*

Similar to mean abundance, total abundance of macroinvertebrates varied between sites, but was relatively similar between bed and edge habitats. The highest total abundance of macroinvertebrates in bed and edge habitats was at site KP285.8 (Neville Creek) (Figure 2.5 and Figure 2.6). Other sites that had a relatively high total abundance of macroinvertebrates included sites:

- KP214.8 (Brolga Gully) in bed and edge habitat
- Mimosa RCR (Mimosa creek revised site location) in bed and edge habitat
- KP298.9 (Callide Creek) in bed and edge habitat, and
- KP334.5 (Bell Creek) in edge habitat.

The high total abundance of macroinvertebrates at site KP285.8 (Neville Creek) was due to the high abundance of non biting midges (s-f Tanypodinae and s-f Chironominae).

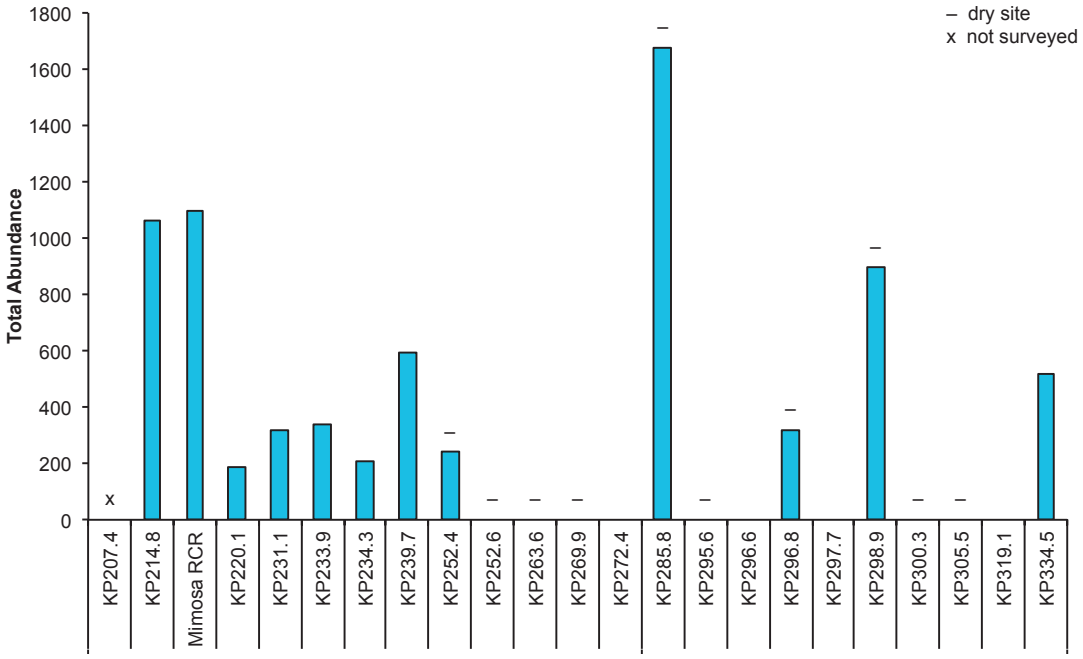


Figure 2.5 Total abundance of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

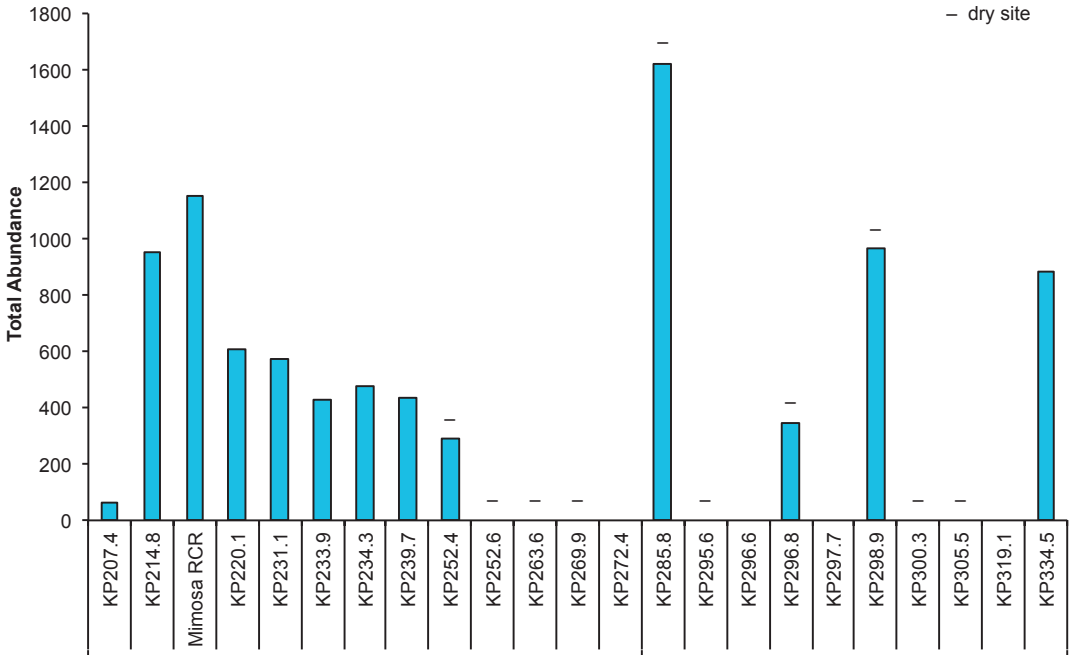


Figure 2.6 Total abundance of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Total abundance of macroinvertebrates varied between sites (Figure 2.7 and Figure 2.8). In bed habitat, the highest total abundance was at site KP352.3 (Calliope River) and the lowest total abundance was at site KP360.3 (Harper Creek). In edge habitat, the highest total abundance was at site KP384.7 (Larcom Creek) and the lowest total abundance was at site KP364.8 (Alarm Creek).

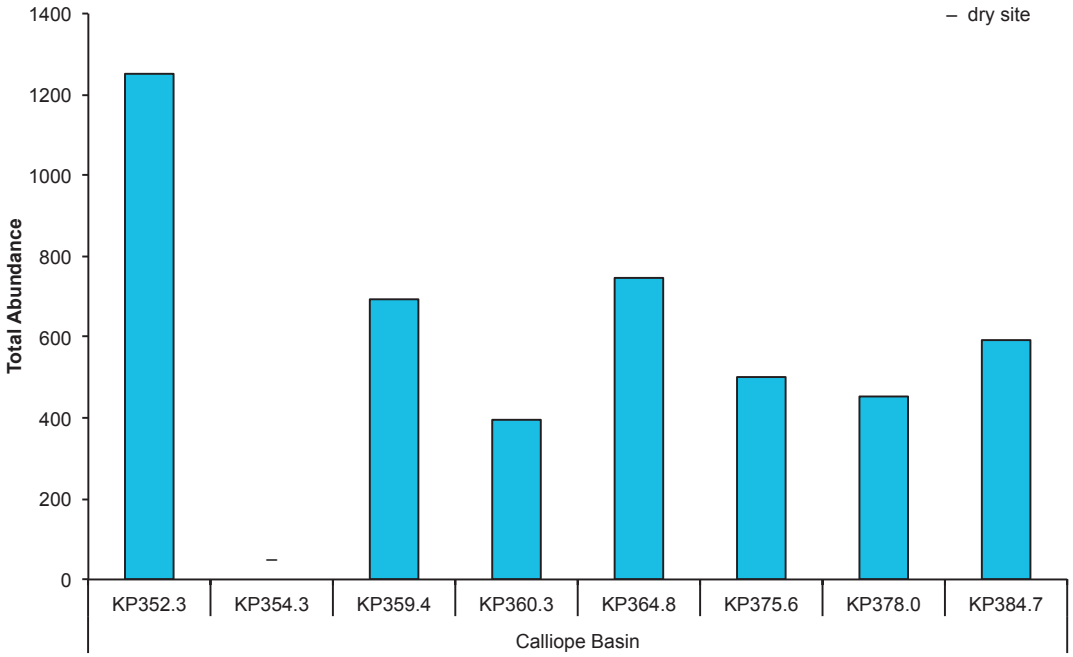


Figure 2.7 Total abundance of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

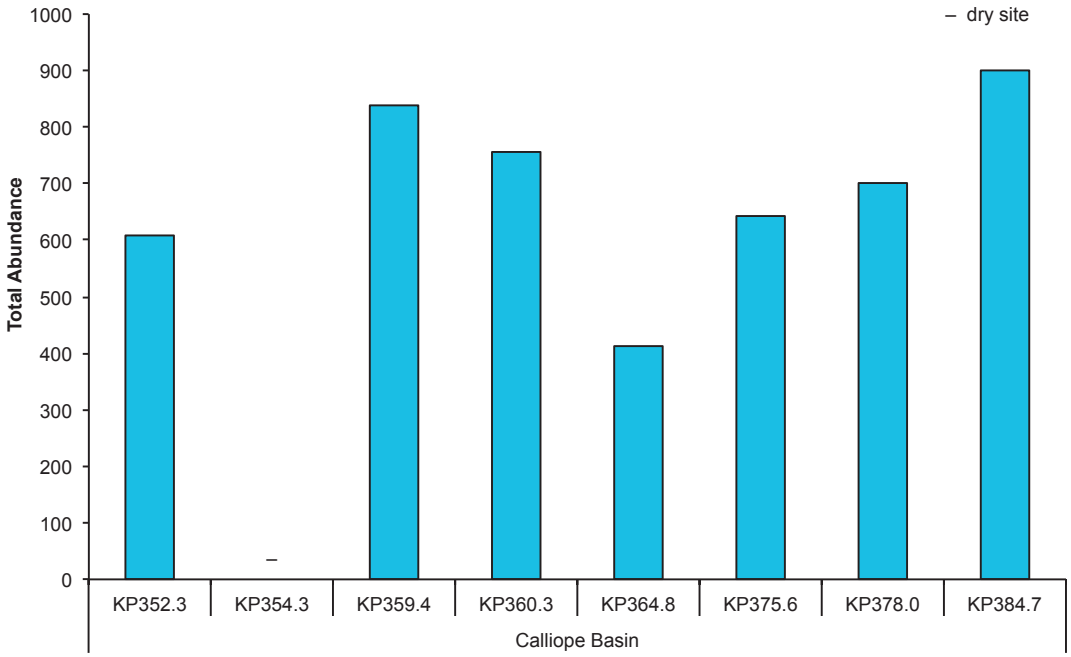


Figure 2.8 Total abundance of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.2 Taxonomic Richness

### Mean Taxonomic Richness

#### *Fitzroy Basin*

Mean taxonomic richness of macroinvertebrates varied between sites and between bed and edge habitats at each site (Figure 2.9 and Figure 2.10). Mean taxonomic richness was below the Queensland Water Quality Guidelines (QWQG) range in bed and edge habitats at all sites, except at sites KP239.7 (Kianga Creek) and Mimosa RCR (Mimosa creek revised site location) in bed habitat where both sites were within the QWQG range. Mean taxonomic richness of macroinvertebrates had no obvious relationship to the overall habitat condition, indicating that changes in community composition were likely to be related to site-specific factors such as habitat availability or the patchy recruitment processes of macroinvertebrates.

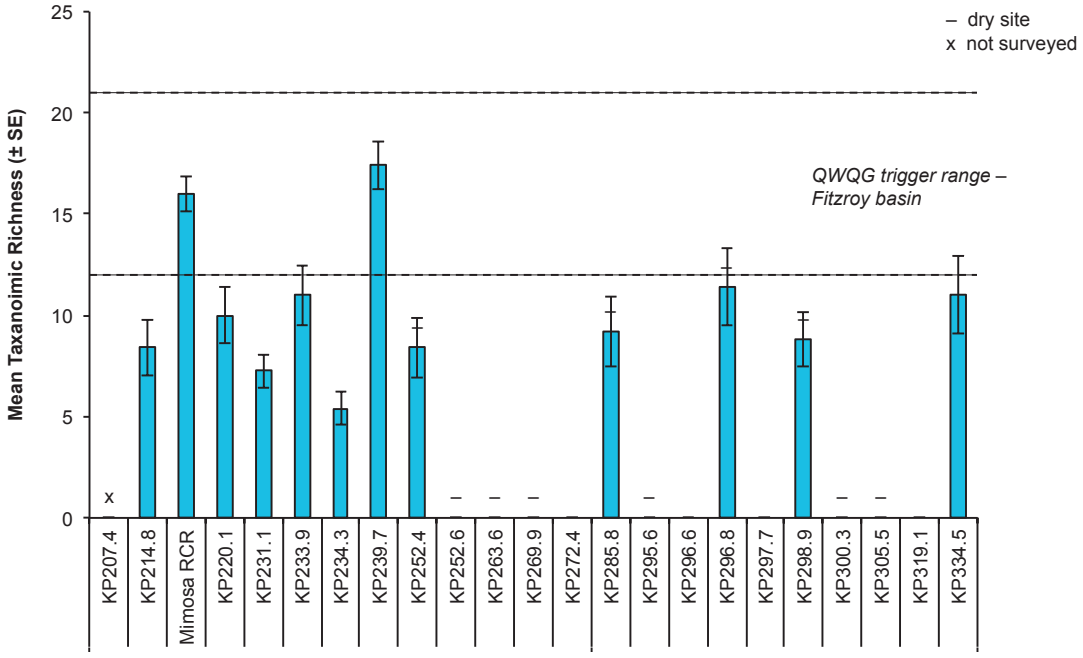


Figure 2.9 Mean taxonomic richness of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

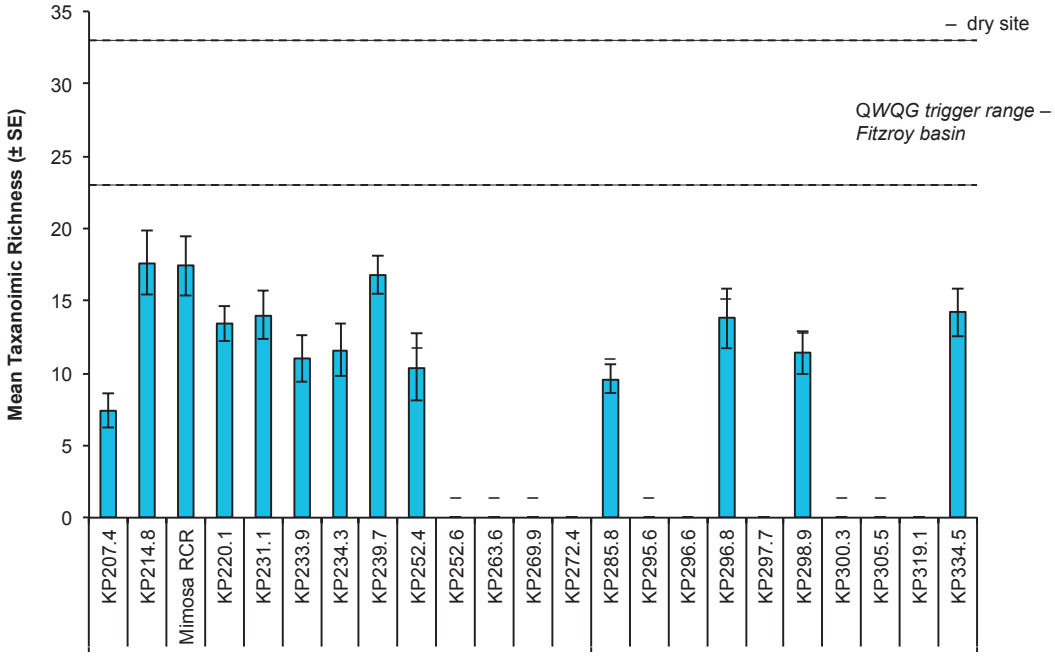


Figure 2.10 Mean taxonomic richness of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Mean taxonomic richness of macroinvertebrates varied between sites and between bed and edge habitats at each site (Figure 2.11 and Figure 2.12). Mean taxonomic richness was within the QWQG range at sites:

- KP352.3 (Calliope River)
- KP359.4 (unnamed watercourse 10)
- KP364.8 (Alarm Creek), and
- KP384.7 (Larcom Creek)

Mean taxonomic richness was below the QWQG range at all other sites in bed and edge habitats. Similar to the Fitzroy Basin, there was no obvious relationship to the overall habitat condition, indicating that changes in community composition were likely to be related to site-specific factors such as habitat availability or the patchy recruitment processes of macroinvertebrates.

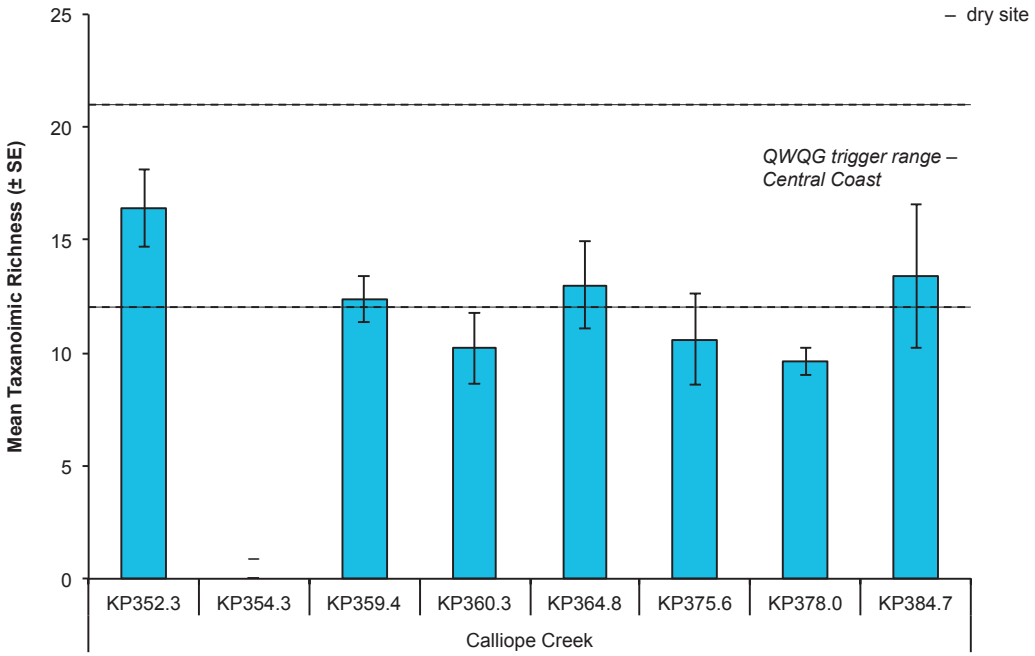


Figure 2.11 Mean taxonomic richness of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

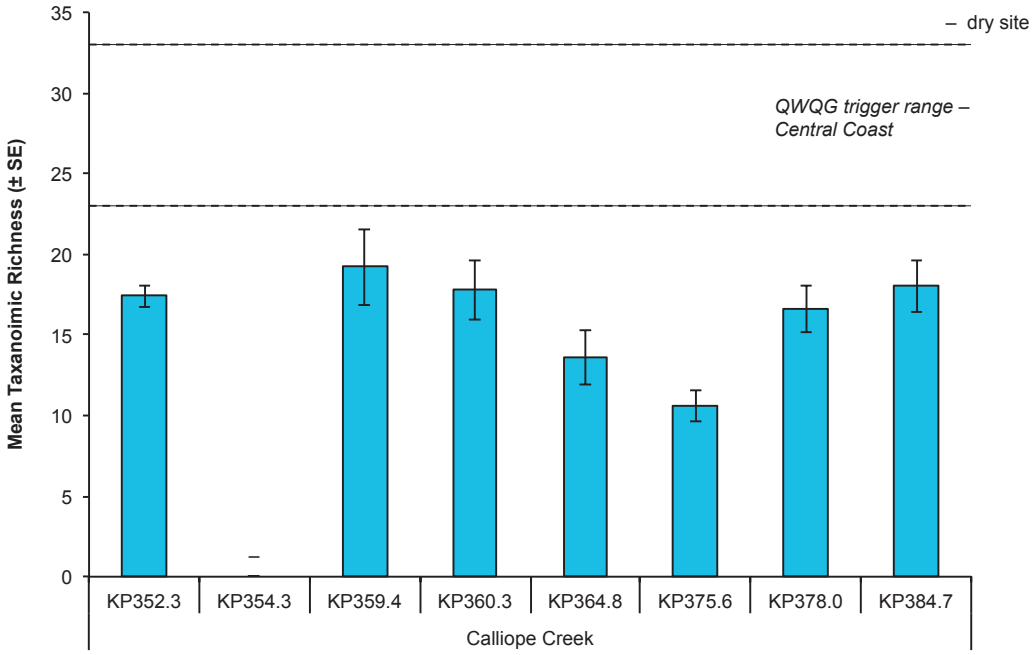


Figure 2.12 Mean taxonomic richness of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## Total Taxonomic Richness

### *Fitzroy Basin*

Total taxonomic richness of macroinvertebrates ranged from 13 to 32 taxa in bed habitat and from 16 to 36 taxa in edge habitat (Figure 2.13 and Figure 2.14). Total taxonomic richness was highest at site KP239.7 (Kianga Creek) in both bed and edge habitat. Total taxonomic richness was within the QWQG range at most sites. However, total taxonomic richness was:

- above the QWQG range at sites:
  - KP329.7 (Kianga Creek) in bed and edge habitats
  - Mimosa RCR (Mimosa creek revised site location) in bed habitat, and
  - KP296.8 (Kroombit Creek) in bed habitat.
- below the QWQG range at sites:
  - KP233.9 (Dawson River) in edge habitat, and
  - KP285.8 (Neville Creek) in edge habitat.

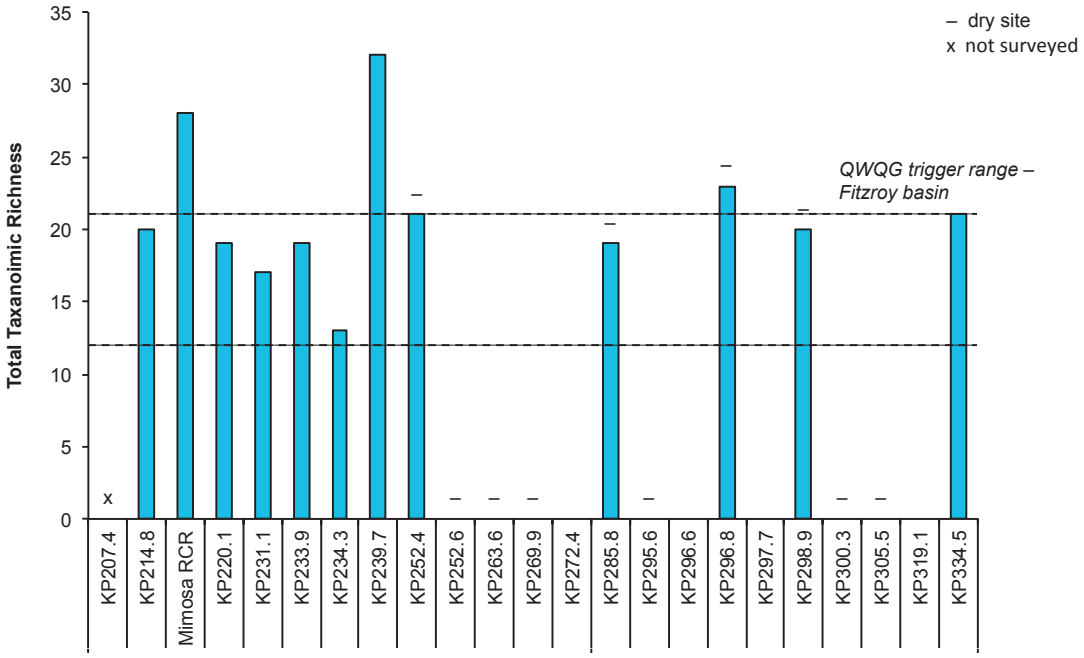


Figure 2.13 Total taxonomic richness of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

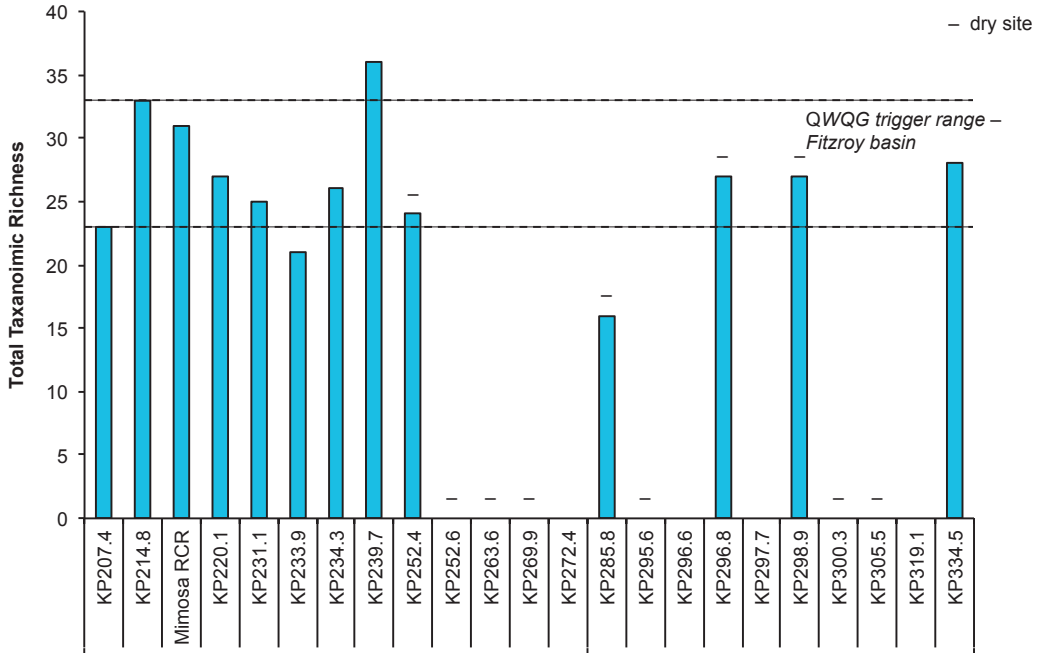


Figure 2.14 Total taxonomic richness of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Total taxonomic richness of macroinvertebrates ranged from 19 to 33 taxa in bed habitat and from 20 to 37 taxa in edge habitat (Figure 2.15 and Figure 2.16). Total taxonomic richness was highest at site KP384.7 (Larcom Creek) in bed habitat and site KP359.4 (unnamed watercourse 10) in edge habitat.

In bed habitat, total taxonomic richness was:

- within the QWQG range at sites
  - KP360.3 (Harper Creek)
  - KP375.6 (Gravel Creek), and
  - KP378.0 (Larcom Creek), and
- above the QWQG range at all other sites.

In edge habitat, total taxonomic richness was:

- within the QWQG range at sites
  - KP352.3 (Calliope River)
  - KP364.8 (Alarm Creek), and
  - KP378.0 (Larcom Creek).
- below the QWQG range at site KP375.6 (Gravel Creek), and
- above the QWQG range at sites
  - KP359.4 (unnamed watercourse 10)
  - KP360.3 (Harper Creek), and
  - KP384.7 (Larcom Creek).

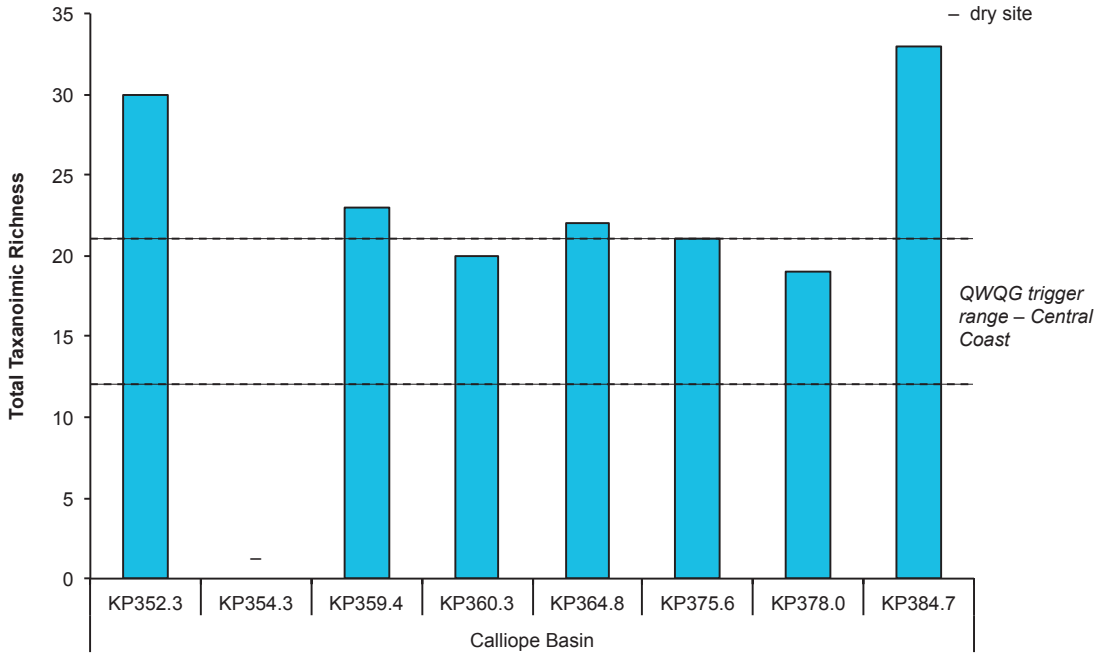


Figure 2.15 Total taxonomic richness of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

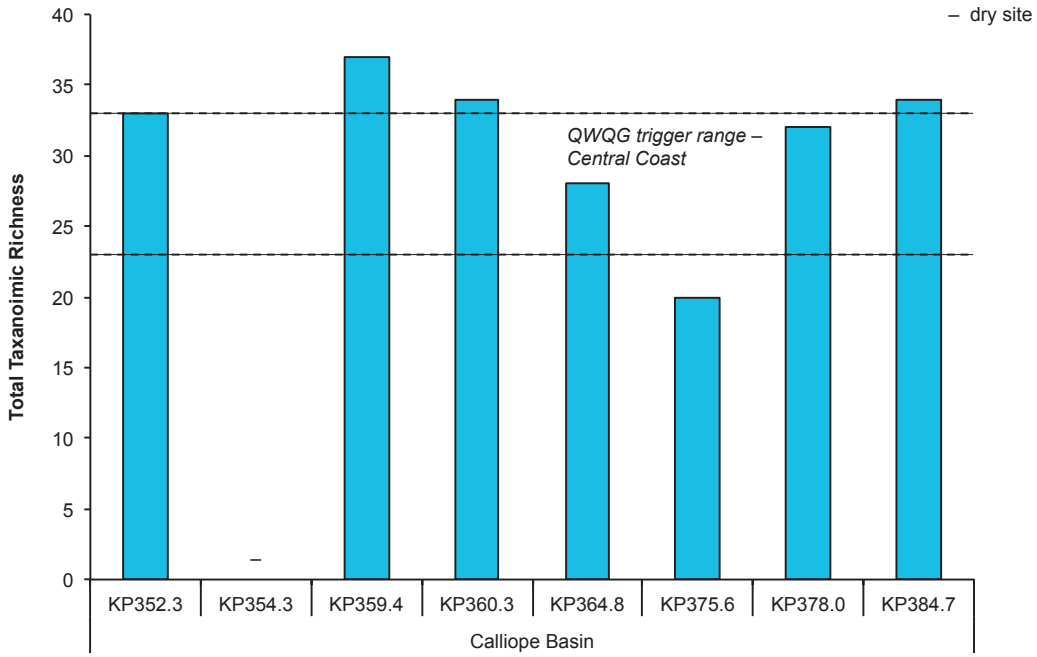


Figure 2.16 Total taxonomic richness of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.3 PET Richness

### Mean PET Richness

#### *Fitzroy Basin*

PET taxa are sensitive to pollutants and changes in water quality, as well as habitat degradation. Mean PET richness was highest at site KP233.9 (Dawson River) in bed habitat and at sites KP334.5 (Bell Creek) and Mimosa RCR (Figure 2.17 and Figure 2.18). In bed habitat, mean PET richness was within the QWQG range at five of the 10 sites surveyed and was below the QWQG range at all other sites. In edge habitat, mean PET richness was within the QWQG range at eight sites, but below the range at three sites. Similar to other indices, PET richness was likely to be related to site-specific habitat availability and condition.

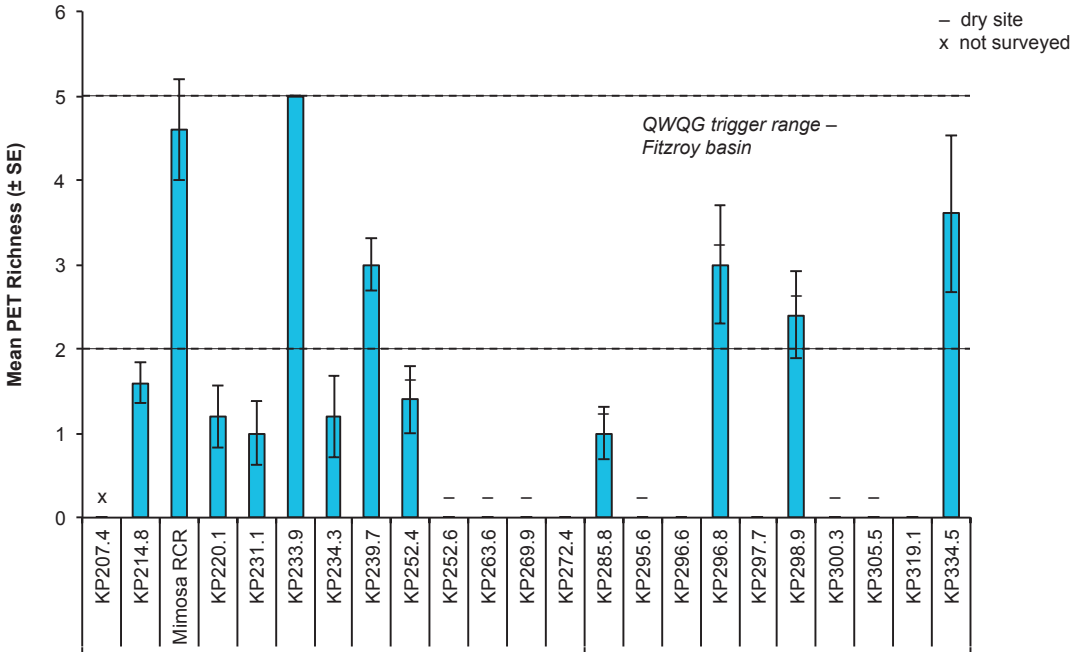


Figure 2.17 Mean PET richness (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

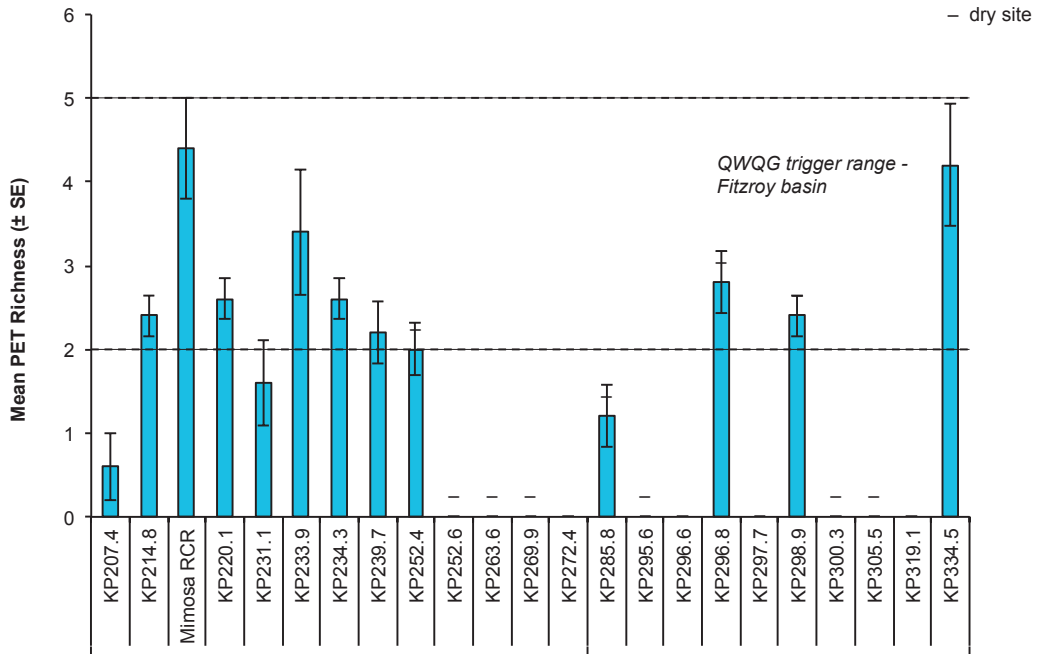


Figure 2.18 Mean PET richness (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Mean PET richness was highest at site KP364.8 (Alarm Creek) in bed habitat and at site KP360.3 (Harper Creek) in edge habitat (Figure 2.19 and Figure 2.20). Mean PET richness was within the QWQG range at all sites in bed and edge habitats, except at site KP359.4 (unnamed watercourse 10) in bed habitat. Similar to other indices, PET richness was likely to be related to site-specific habitat availability and condition.

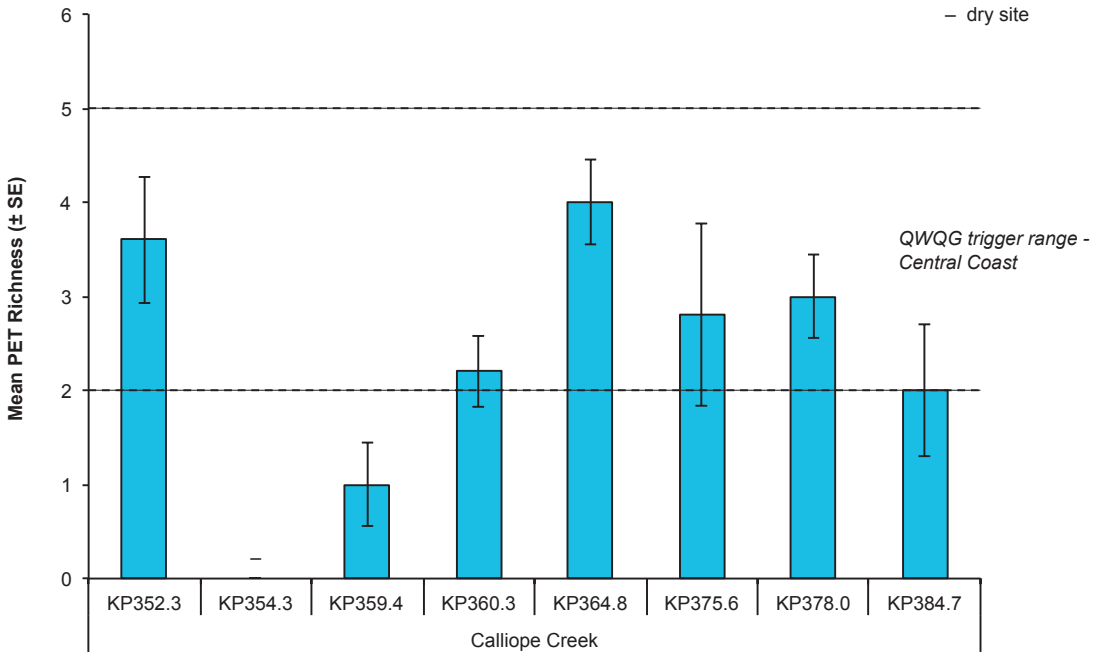


Figure 2.19 Mean PET richness (±SE) of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

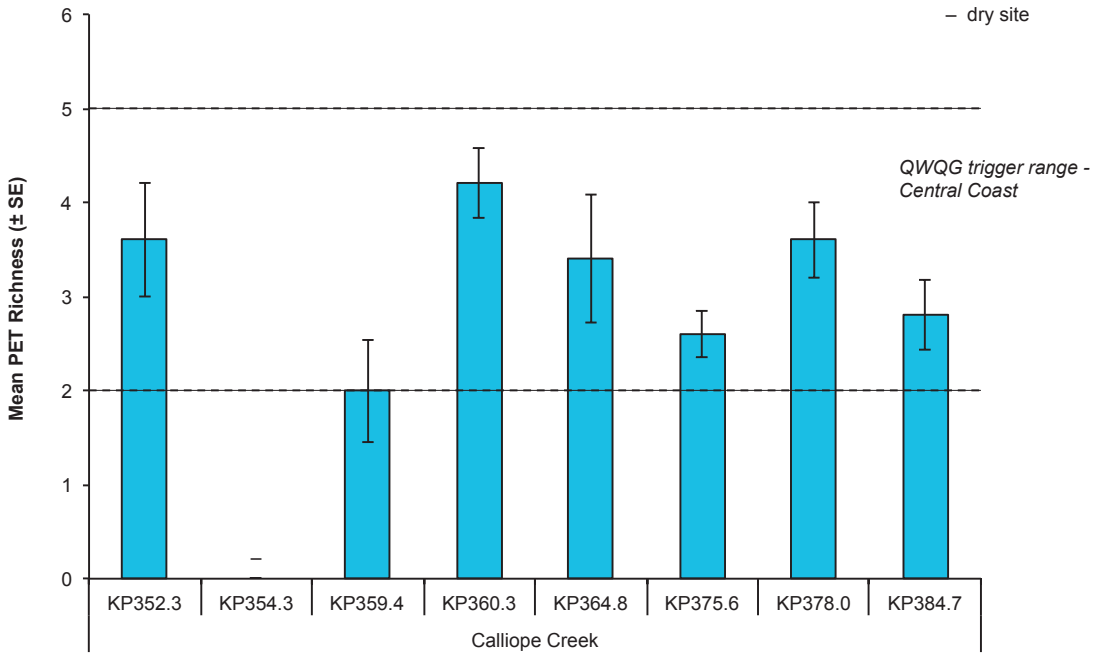


Figure 2.20 Mean PET richness (±SE) of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## Total PET Richness

### *Fitzroy Basin*

Total PET richness ranged from 2 to 7 taxa in bed and edge habitats (Figure 2.21 and Figure 2.22). The highest total PET richness was at sites KP233.9 (Dawson River), Mimosa RCR (Mimosa Creek) and KP334.5 (Bell Creek) in bed habitat and at site KP334.5 (Bell Creek) in edge habitat. Total PET richness was within the QWQG range at most sites; however, there were some exceptions. In bed and edge habitats, total PET richness was above the QWQG range at sites KP233.9 (Dawson River), Mimosa RCR (Mimosa Creek) and KP334.5 (Bell Creek).

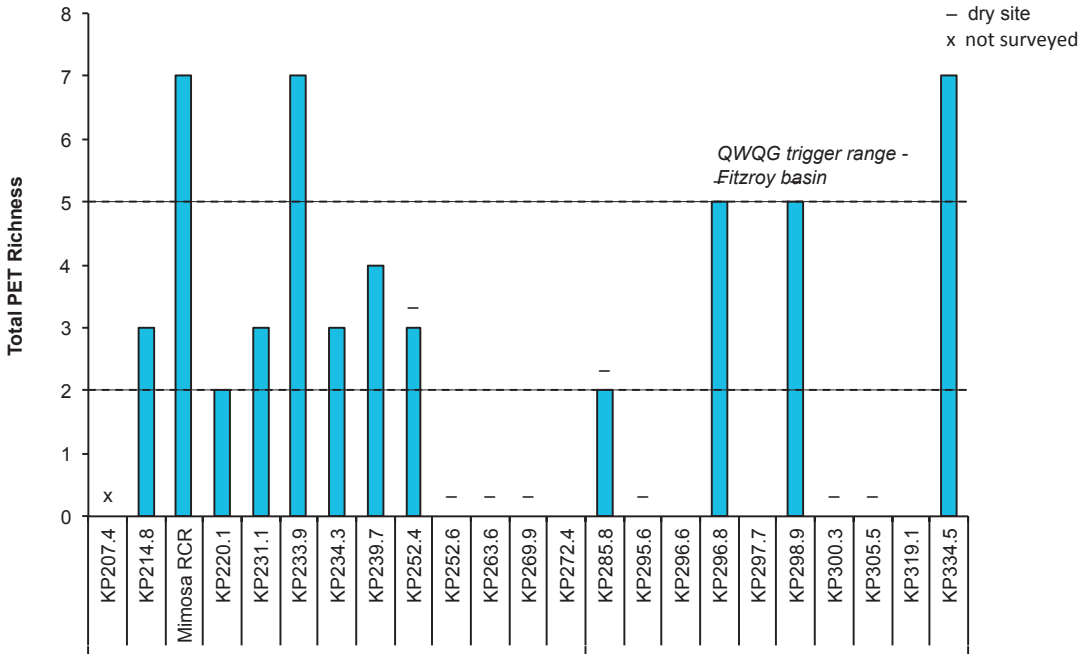


Figure 2.21 Total PET richness in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

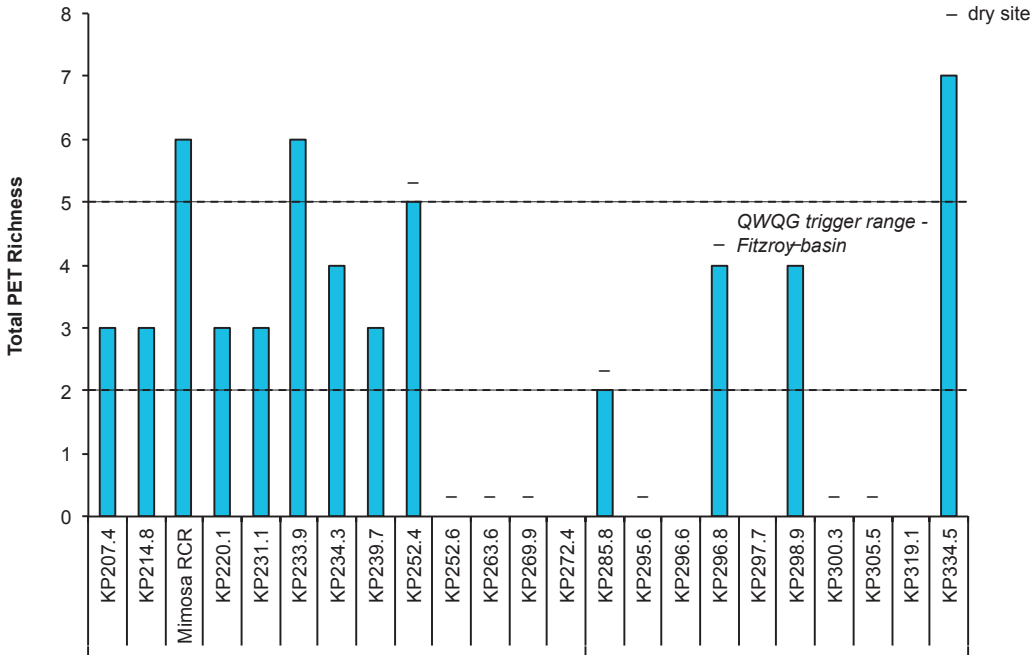


Figure 2.22 Total PET richness in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Total PET richness ranged from 2 to 7 taxa in bed habitat and from 3 to 7 taxa in edge habitat (Figure 2.23 and Figure 2.24). The highest total PET richness was at site KP364.8 (Alarm Creek) in bed habitat and at site KP352.3 (Calliope River) in edge habitat. Total PET richness was within the QWQG range at most sites in bed and edge habitats; but was above the QWQG range at sites:

- KP352.3 (Calliope River) in bed and edge habitats
- KP364.8 (Alarm Creek) in bed and edge habitats, and
- KP375.6 (Gravel Creek) in bed habitat.

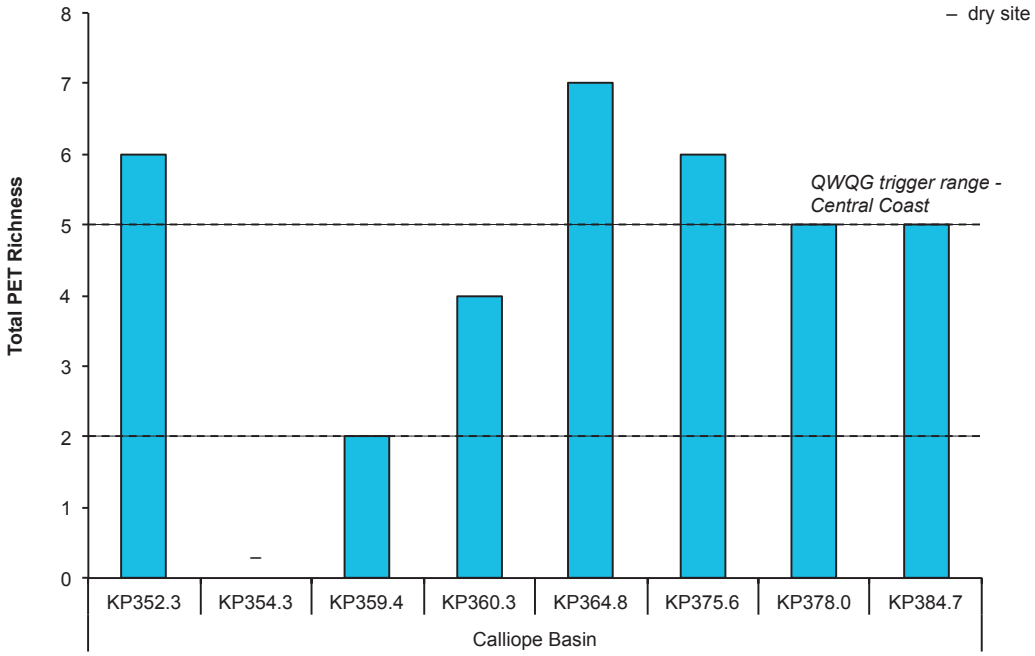


Figure 2.23 Total PET richness of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

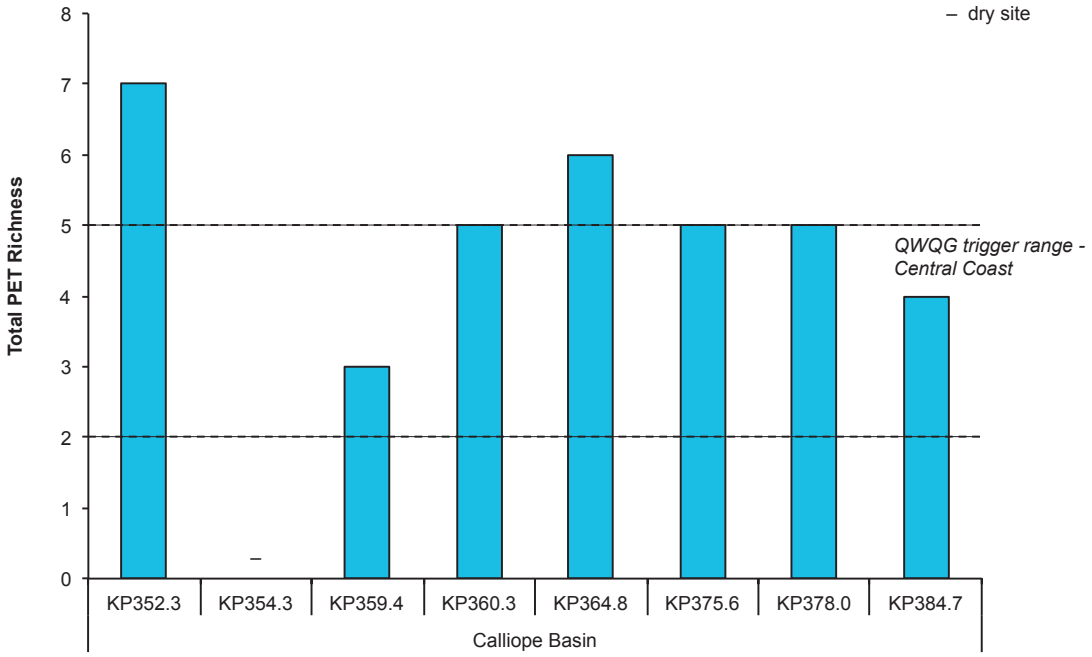


Figure 2.24 Total PET richness of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.4 SIGNAL 2 Scores

### Mean SIGNAL 2 Scores

#### *Fitzroy Basin*

Mean SIGNAL 2 scores were low (<4) in bed and edge habitats at most sites (Figure 2.25 and Figure 2.26). Mean SIGNAL 2 scores were within the QWQG range at most sites in bed and edge habitats; however mean SIGNAL 2 scores in bed habitat, were;

- below the QWQG range at sites
  - KP231.1 (Denby Creek)
  - KP239.7 (Kianga Creek)
  - KP252.4 (Banana Creek), and
  - KP285.8 (Neville Creek);
- above the QWQG range at sites
  - KP233.9 (Dawson River)
  - Mimosa RCR (Mimosa Creek), and
  - KP334.5 (Bell Creek).

Mean SIGNAL 2 scores were below the QWQG range in edge habitat at sites:

- KP207.4 (Conciliation Creek)
- KP231.1 (Denby Creek), and
- KP285.8 (Neville Creek).

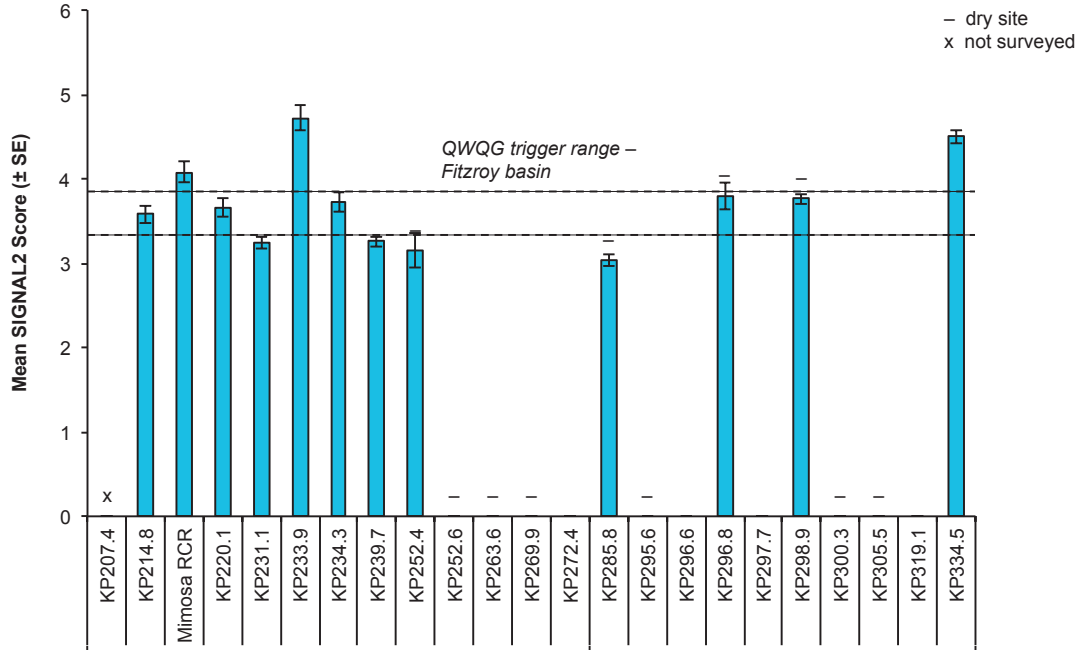


Figure 2.25 Mean SIGNAL 2 scores of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

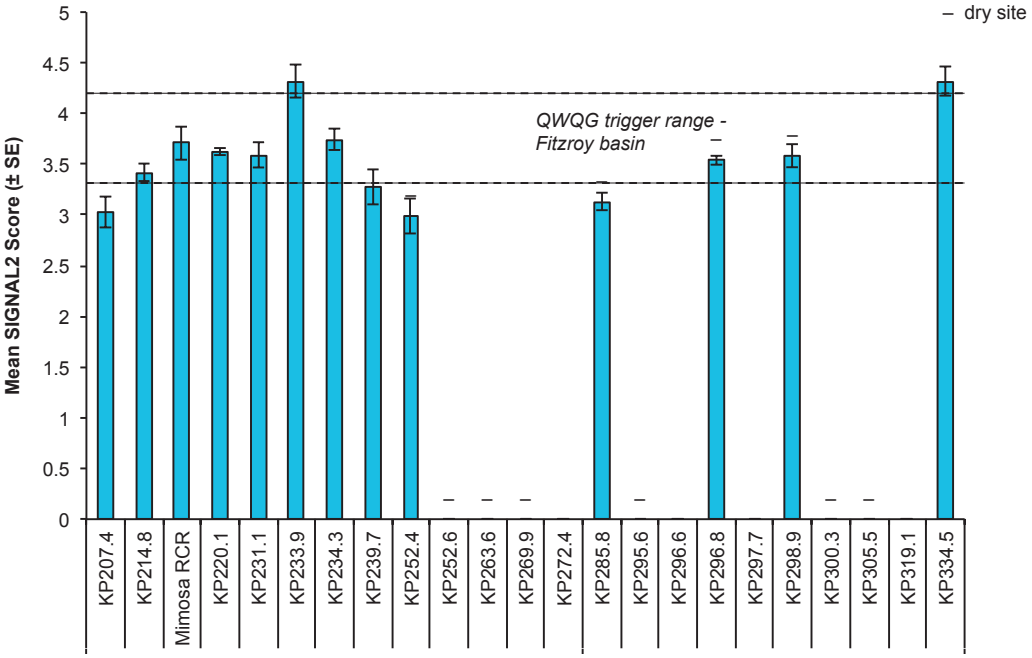


Figure 2.26 Mean SIGNAL 2 scores of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Mean SIGNAL 2 scores were low (<4) in bed and edge habitats at most sites (Figure 2.27 and Figure 2.28). Mean SIGNAL 2 scores were within the QWQG range at three sites in bed habitat and all sites in edge habitat. In bed habitat, mean SIGNAL 2 scores were:

- above the QWQG range at sites
  - KP352.3 (Calliope River),
  - KP364.8 (Alarm Creek), and
  - KP378.0 (Larcom Creek)
- below the QWQG range at site KP359.4 (unnamed watercourse 10).

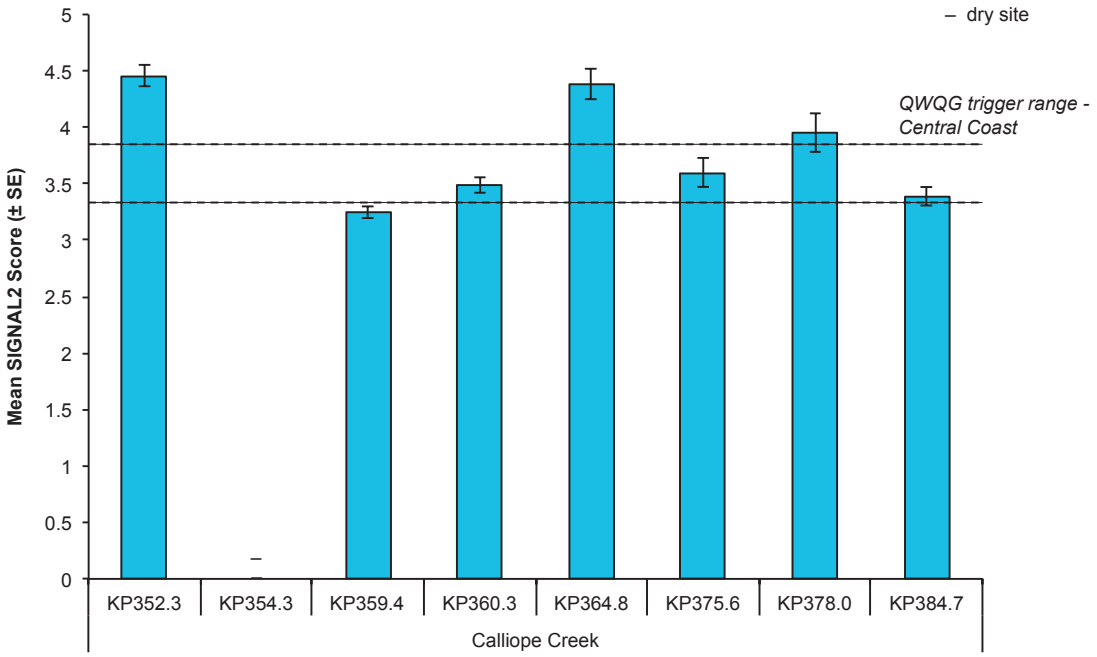


Figure 2.27 Mean SIGNAL 2 scores of macroinvertebrates (±SE) in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

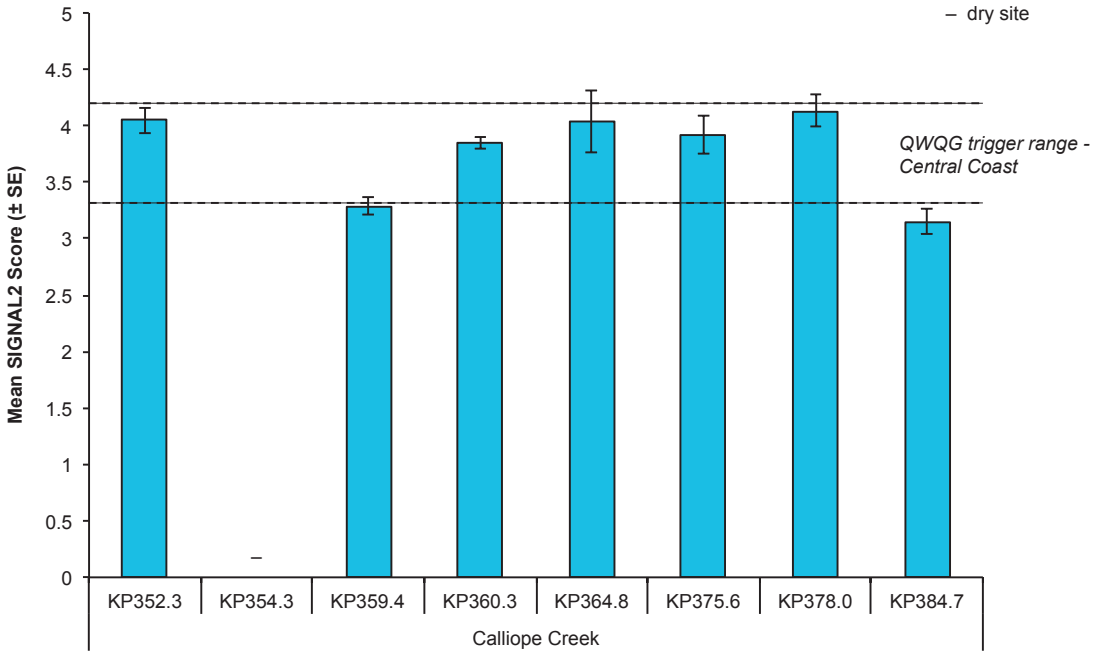


Figure 2.28 Mean SIGNAL 2 scores of macroinvertebrates (±SE) in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## Total SIGNAL 2 Scores

### *Fitzroy Basin*

Total SIGNAL 2 scores ranged from 3.0 to 4.7 in bed habitat and from 3.1 to 4.3 in edge habitat (Figure 2.29 and Figure 2.30). Total SIGNAL 2 scores were within the QWQG range at five sites in bed habitat and at six sites in edge habitat. Total SIGNAL 2 scores were:

- above the QWQG range in bed and edge habitats at sites:
  - KP233.9 (Dawson River) and
  - KP334.5 (Bell Creek)
- above the QWQG range in bed habitat at sites
  - KP296.8 (Kroombit Creek) and
  - Mimosa RCR (Mimosa Creek)
- below the QWQG range in bed habitat at sites
  - KP252.4 (Banana Creek), and
  - KP285.8 (Neville Creek)
- below the QWQG range in edge habitat at sites
  - KP207.4 (Conciliation Creek)
  - KP214.8 (Brolga Gully)
  - KP239.7 (Kianga Creek), and
  - KP285.8 (Neville Creek).

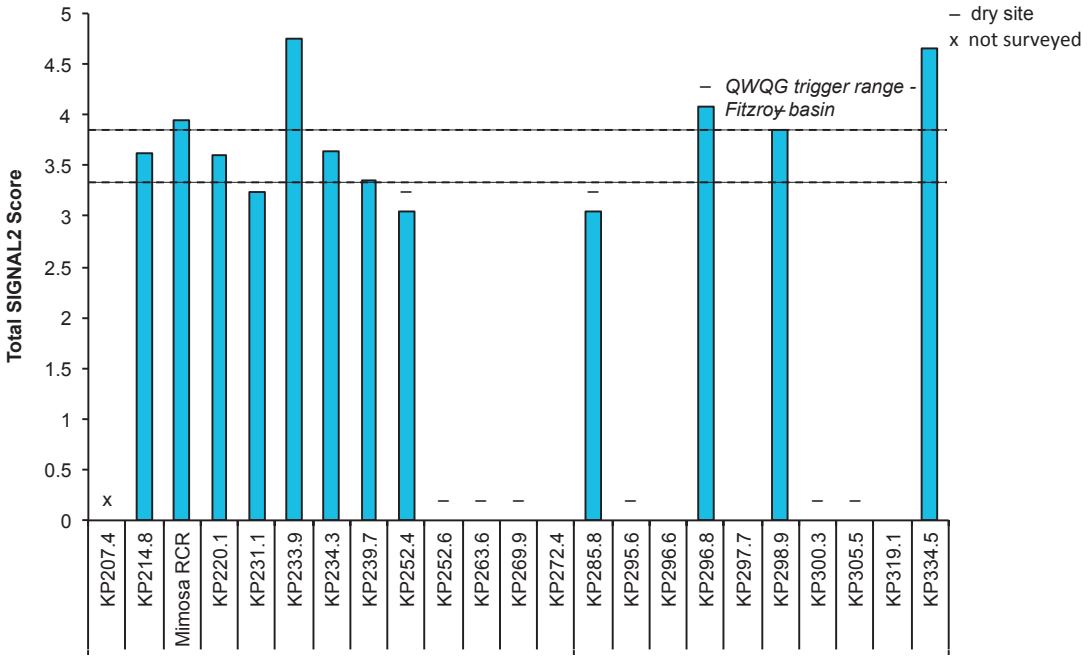


Figure 2.29 Total SIGNAL 2 scores of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

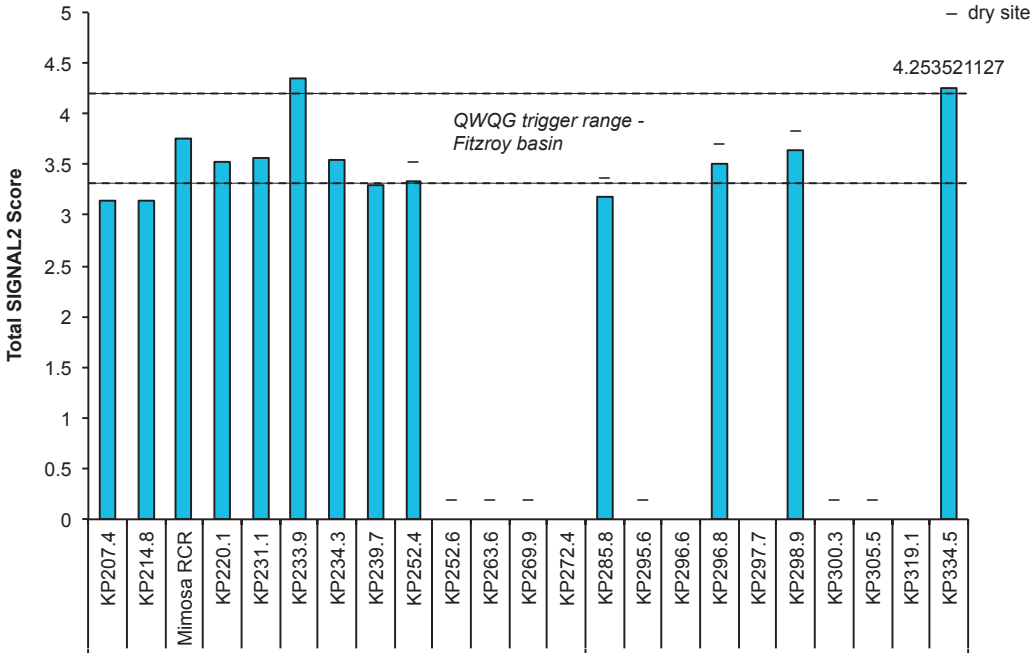


Figure 2.30 Total SIGNAL 2 scores of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

Total SIGNAL 2 scores ranged from 3.2 to 4.5 in bed habitat and from 3.0 to 4.3 in edge habitat (Figure 2.31 and Figure 2.32). Total SIGNAL 2 scores were within the QWQG range at two sites in both bed and edge habitats. Total SIGNAL 2 scores were above the QWQG range at all sites, except at site KP359.4 (unnamed watercourse 10), which was below the QWQG range.

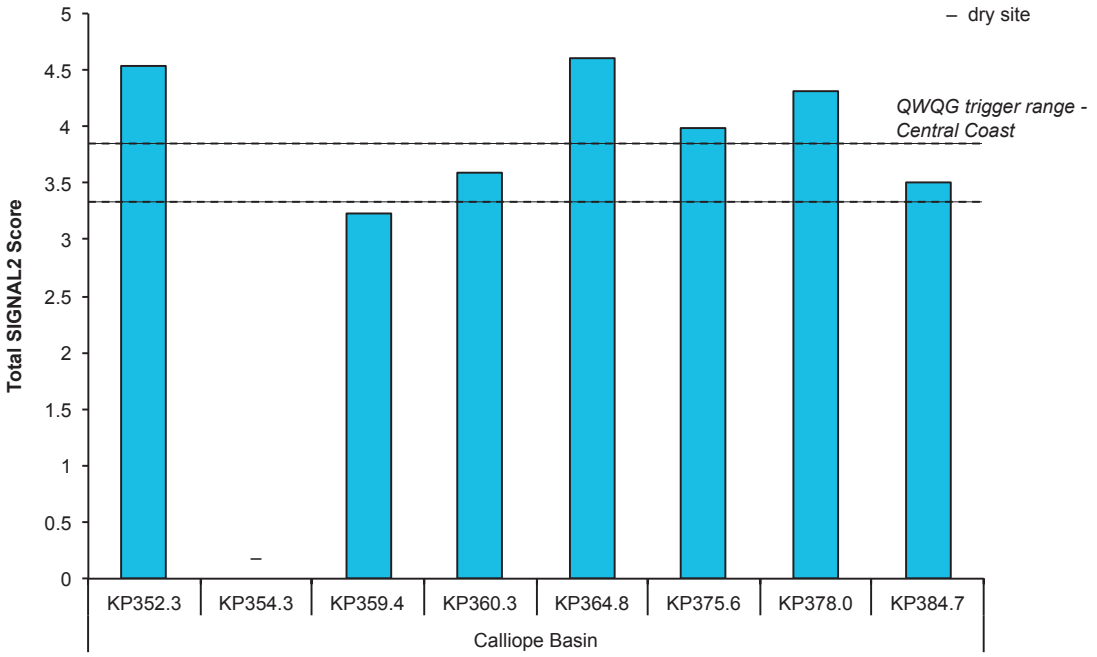


Figure 2.31 Total SIGNAL 2 scores of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

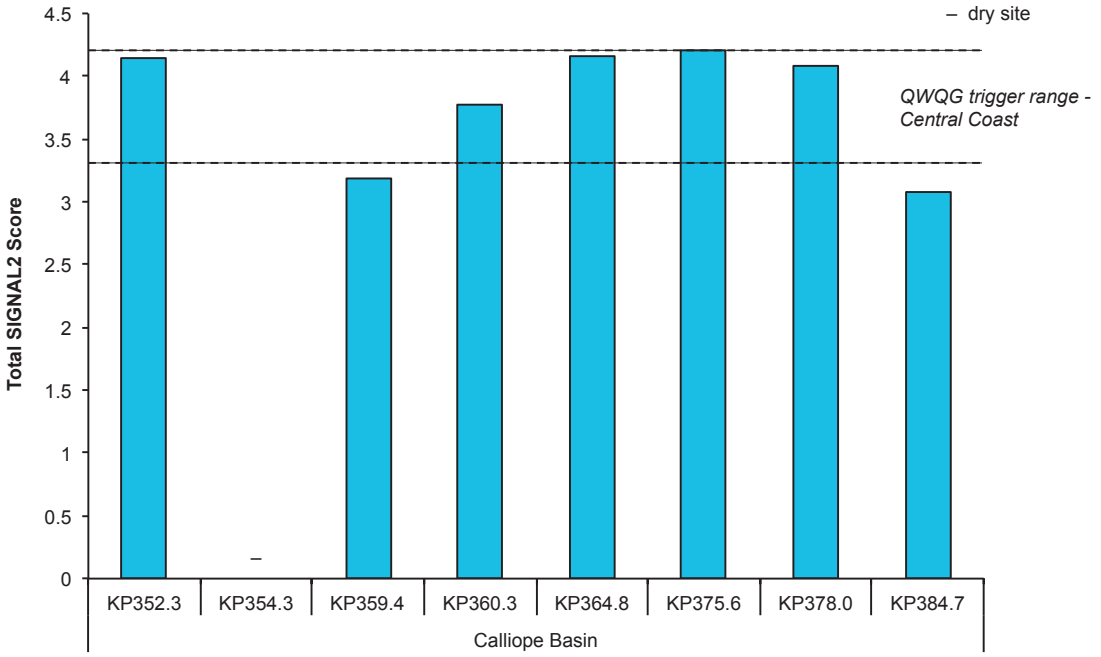


Figure 2.32 Total SIGNAL 2 scores of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## SIGNAL 2 / Family Bi-plots

### *Fitzroy Basin*

The SIGNAL 2 / family bi-plot for bed and edge habitat showed that most sites were within quadrant 3, which suggested that these sites might be influenced by toxic substances or harsh environmental conditions (Figure 2.33 and Figure 2.34). This might be indicative of the ephemeral nature of these waterways. Some sites were also in quadrant 4, which suggested that these sites were influenced by agricultural pollution (given there were no urban and industrial areas or dams upstream of the sites).

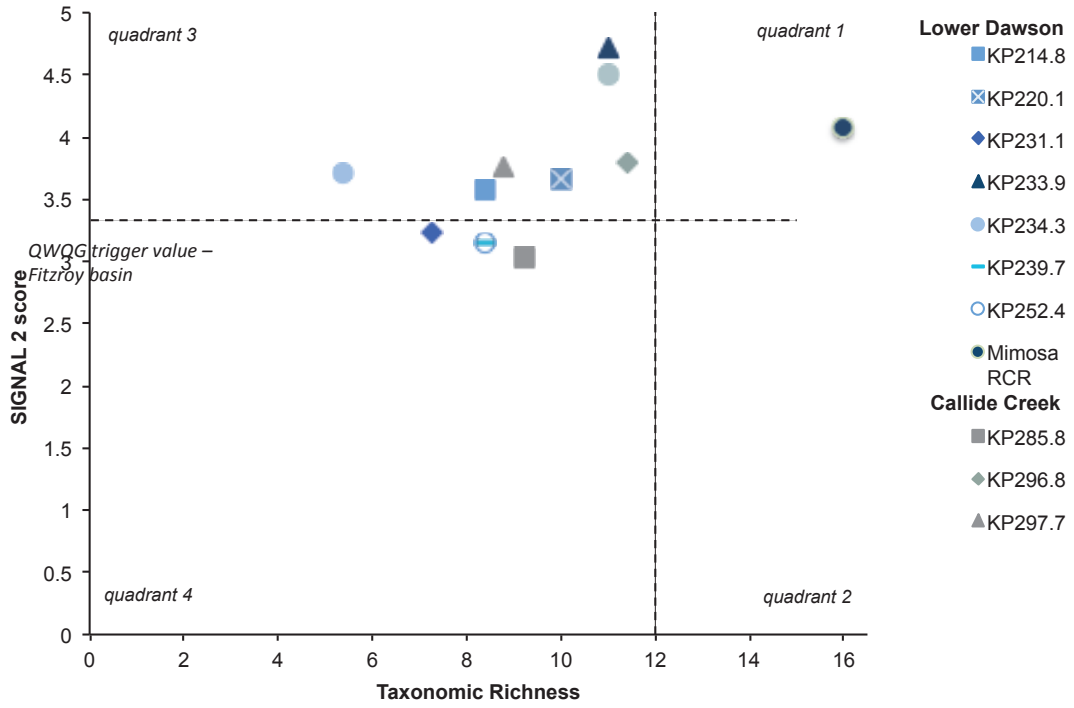


Figure 2.33 SIGNAL 2 / family bi-plot of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

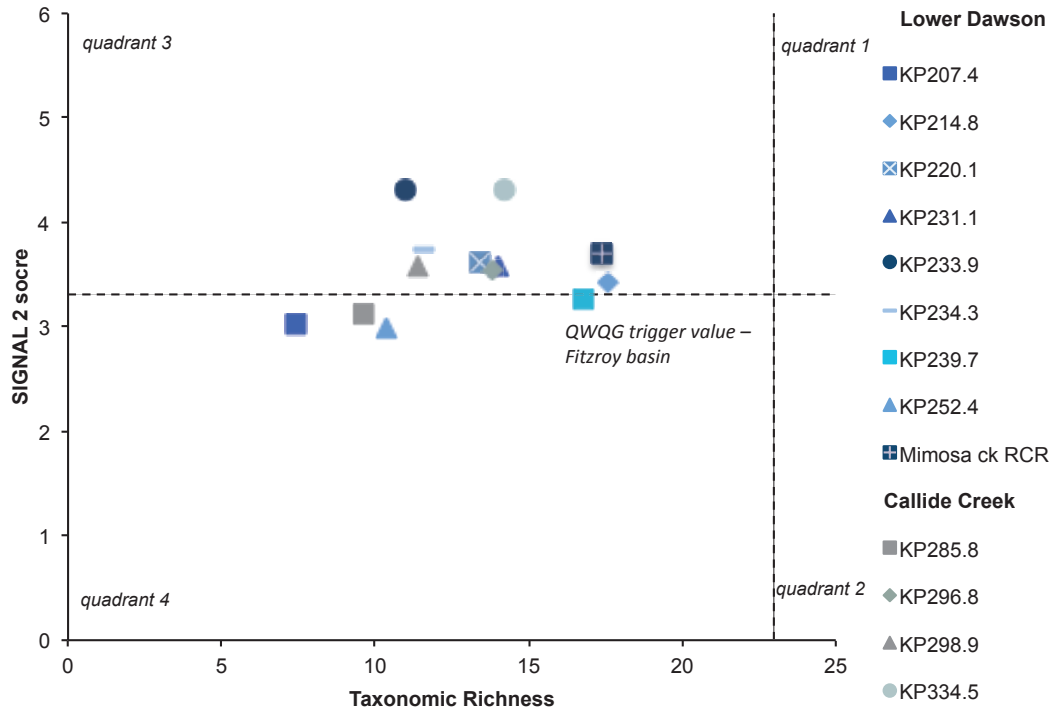


Figure 2.34 SIGNAL 2 / family bi-plot of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Calliope Basin*

The SIGNAL 2 / family bi-plot for bed habitat showed three sites were within quadrant 1, which indicated a favourable habitat condition and chemically dilute waters (Figure 2.35 and Figure 2.36). One site was in quadrant 2 (although this site was close to the boundary of quadrant 1), which suggested that the macroinvertebrate community was influenced by high salinity or high concentrations of nutrients (which may be natural). Three sites in bed habitat and the majority of sites in edge habitat were in quadrant 3, which suggested that these sites might be influenced by toxic substances or harsh environmental conditions. This might be indicative of the ephemeral nature of these waterways. Two sites in edge habitat were in quadrant 4, which suggested that these sites were influenced by agricultural pollution (given there were no urban and industrial areas or dams upstream of the sites).

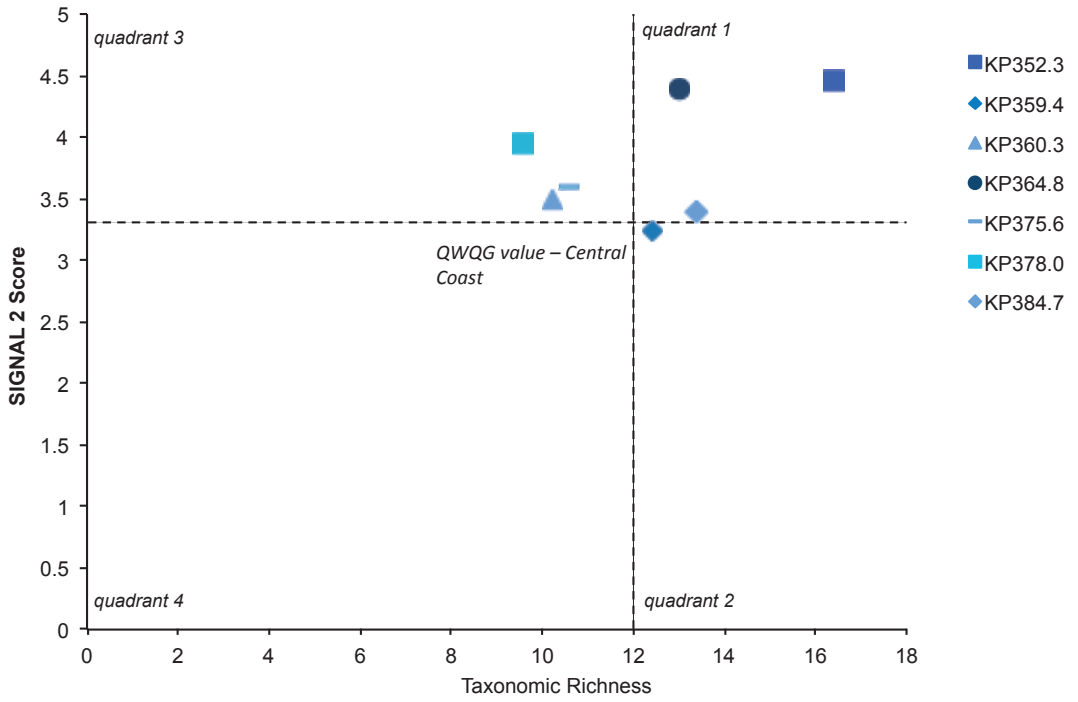


Figure 2.35 SIGNAL 2 / family bi-plot of macroinvertebrates in bed habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

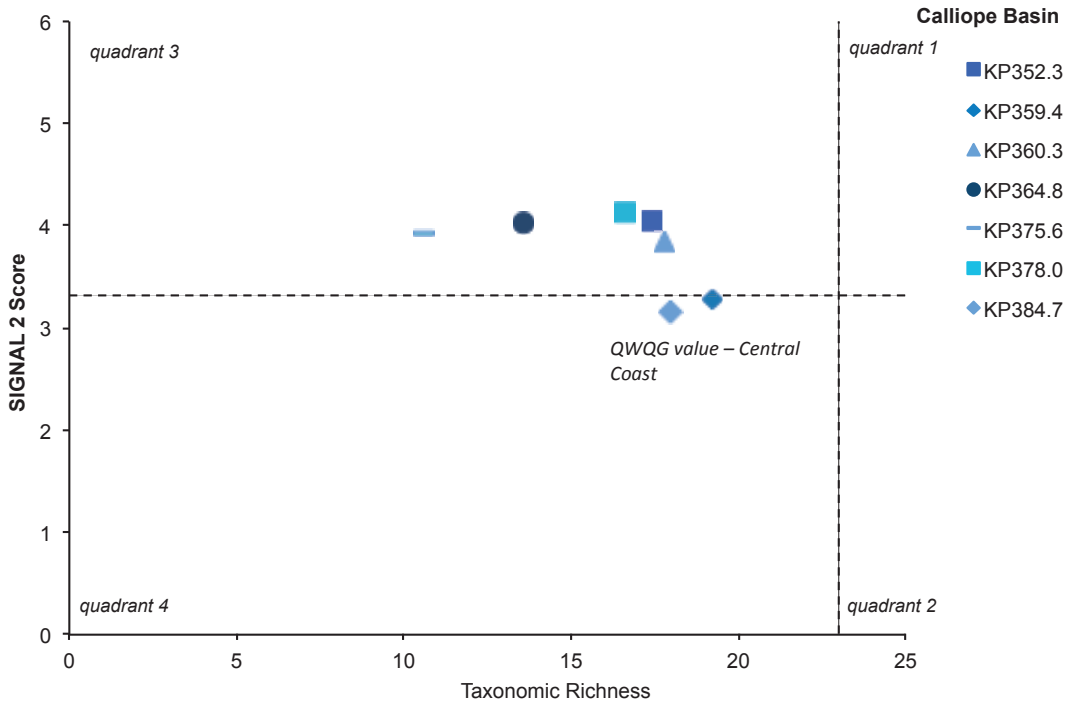


Figure 2.36 SIGNAL 2 / family bi-plot of macroinvertebrates in edge habitat at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.5 Community Composition

### Fitzroy Basin

#### *Bed Habitat*

Macroinvertebrate community composition in bed habitat varied between sites (ANOSIM Global R statistic=0.797, $p<0.001$) (Figure 2.37). However, note that the high stress value indicating that the non-metric multidimensional scaling plot does not closely reflect the relationship between samples. The differences in community structure between sites might be related to site-specific habitat availability and condition, and the patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, $p<0.05$). SIMPER analyses showed that pairwise site combinations had average dissimilarity in macroinvertebrate communities from 46.2 to 85.8%; and was generally greater than 60%. Taxa that most commonly contributed the to dissimilarity in macroinvertebrate communities between sites included:

- sf Tanypodinae
- sf Chironominae
- Caenidae
- Baetidae
- Notonectidae
- Simuliidae
- Dytiscidae, and
- Tipulidae.

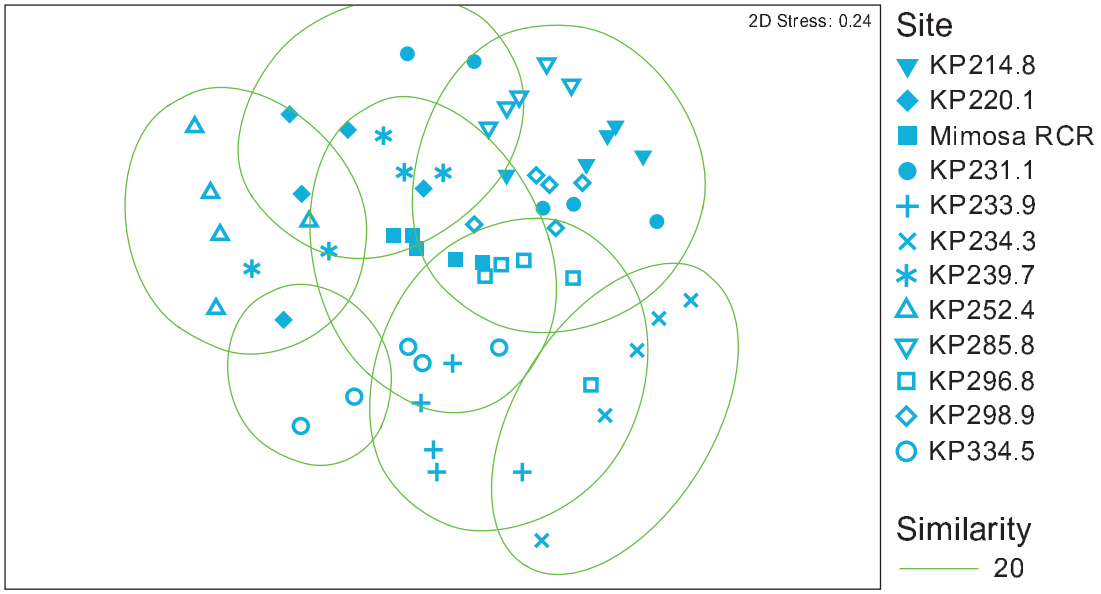


Figure 2.37 Non-metric multidimensional scaling plot for macroinvertebrate community composition in bed habitat for the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

### *Edge Habitat*

Macroinvertebrate community composition in edge habitat varied between sites (ANOSIM Global R statistic=0.721, $p<0.001$) (Figure 2.38). However, note that the high stress value indicating the non-metric multidimensional scaling plot does not closely reflect the relationship between samples. The differences in community structure between sites might be related to site-specific habitat availability and condition, and the patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, $p<0.05$). SIMPER analyses showed that pairwise site combinations had average dissimilarity in macroinvertebrate communities from 46.8 to 85.4%; and was generally greater than 60%. Taxa that most commonly contributed the to dissimilarity in macroinvertebrate communities between sites included:

- sf Tanypodinae
- sf Chironominae
- Caenidae
- Atyidae
- Baetidae
- Corixidae
- Leptoceridae
- Notonectidae, and
- Tipulidae.

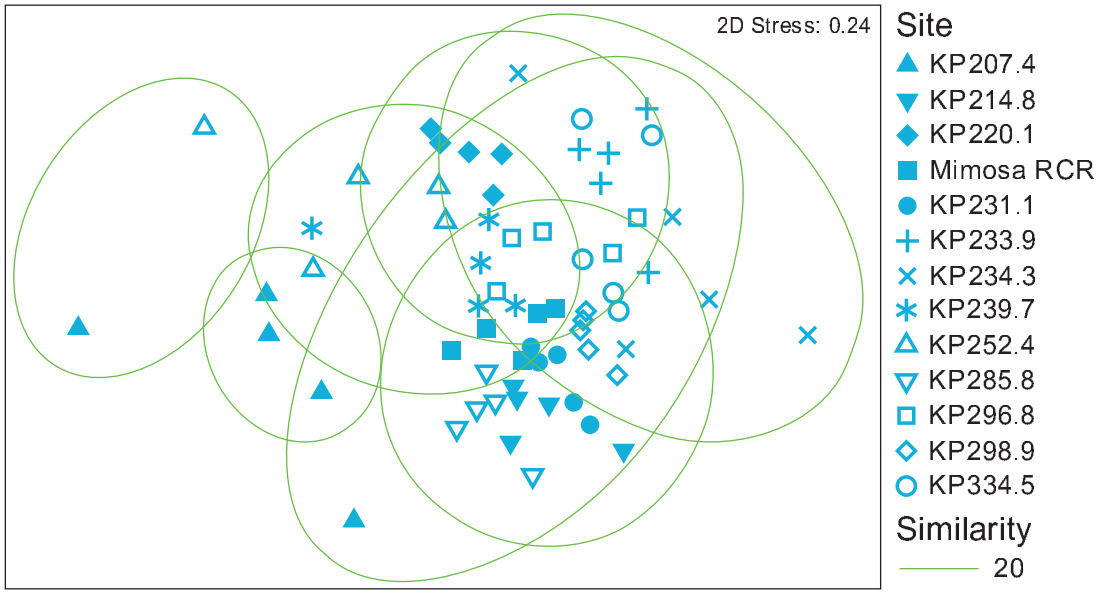


Figure 2.38 Non-metric multidimensional scaling plot for macroinvertebrate community composition in edge habitat for the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

### *Bed Habitat*

Macroinvertebrate community composition in bed habitat varied between sites (ANOSIM Global R statistic=0.608, p<0.001) (Figure 2.39). However, note that the high stress value indicating the non-metric multidimensional scaling plot does not closely reflect the relationship between samples. The differences in community structure between sites might be related to site-specific habitat availability and condition, and the patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, p<0.05); except at sites KP364.8 (Alarm Creek) and KP378.0 (Larcom Creek) (ANOSIM, p>0.05). SIMPER analyses showed that pairwise site combinations had average dissimilarity in macroinvertebrate communities from 48.0 to 74.2%; and was generally greater than 50%. Taxa that most commonly contributed the to dissimilarity in macroinvertebrate communities between sites included:

- Elmidae
- sf Orthocladiinae
- sf Tanypodinae
- Leptophlebiidae
- sf Chironominae
- Caenidae
- sf Tanypodinae
- Atyidae, and
- Oligochaeta.

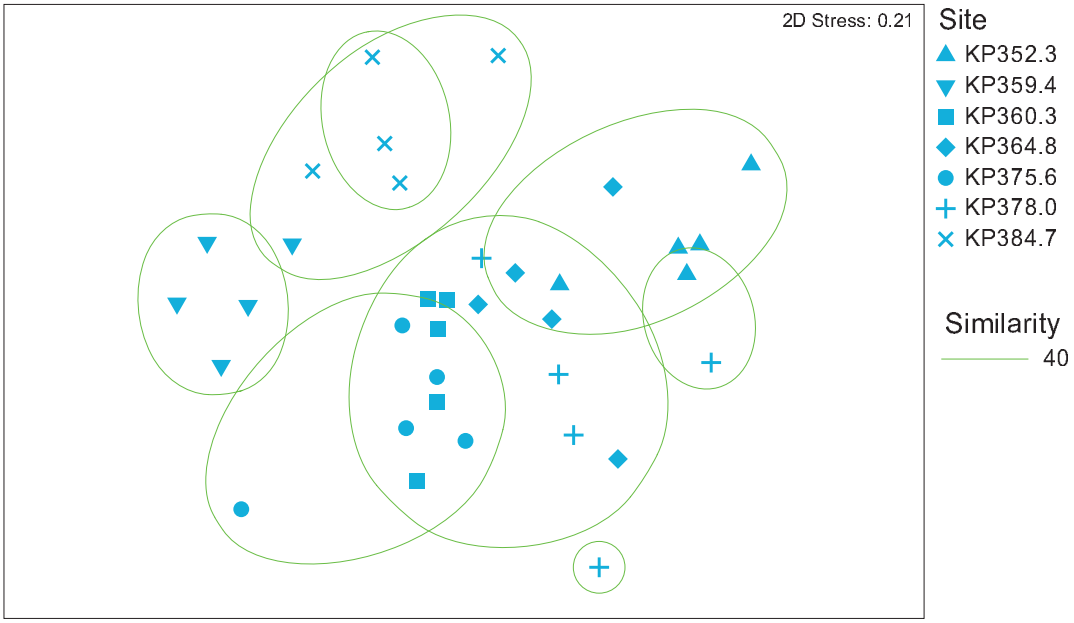


Figure 2.39 Non-metric multidimensional scaling plot for macroinvertebrate community composition in bed habitat for the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

### *Edge Habitat*

Macroinvertebrate community composition in bed habitat varied between sites (ANOSIM Global R statistic=0.627, $p<0.001$) (Figure 2.40). However, note that the high stress value indicating the non-metric multidimensional scaling plot does not closely reflect the relationship between samples. Within-site variation was also commonly high, indicated by the spread of samples from most sites on the non-metric multidimensional scaling plot. The differences in community structure between sites might be related to site-specific habitat availability and condition, and the patchy recruitment processes by macroinvertebrates. Pairwise comparisons revealed that there were significant differences between all sites (ANOSIM, $p<0.05$); except at sites KP360.3 (Harper Creek) and KP375.6 (Gravel Creek) (ANOSIM, $p>0.05$). SIMPER analyses showed that pairwise site combinations had average dissimilarity in macroinvertebrate communities from 46.0 to 64.0. Taxa that most commonly contributed the to dissimilarity in macroinvertebrate communities between sites included:

- Atyidae
- sf Tanypodinae
- sf Chironominae
- Gomphidae
- Caenidae
- Leptoceridae, and
- Baetidae.

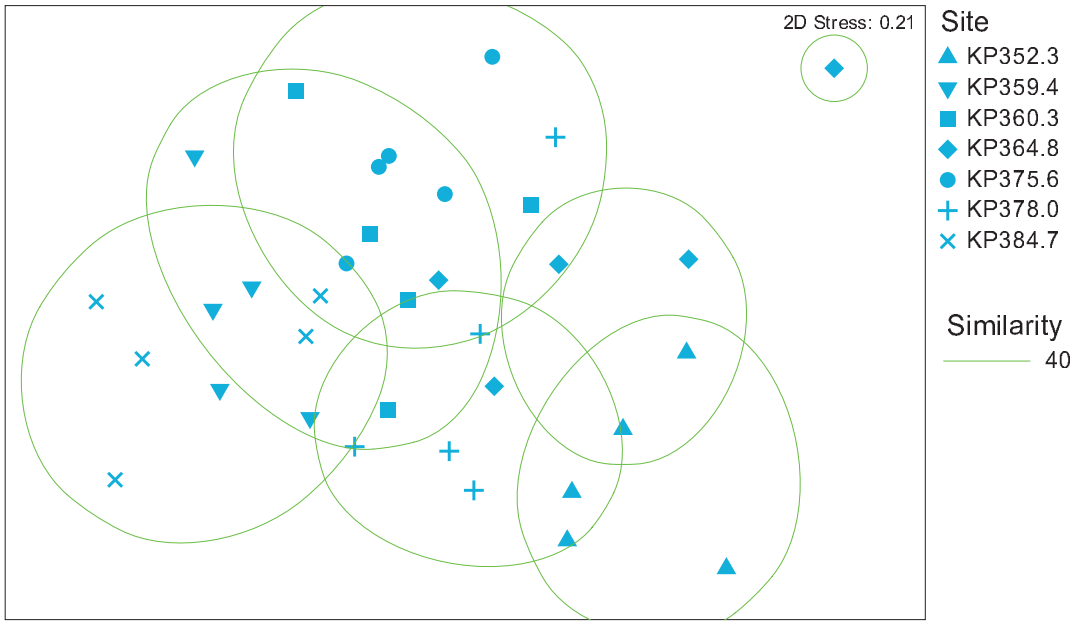


Figure 2.40 Non-metric multidimensional scaling plot for macroinvertebrate community composition in edge habitat for the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.6 Macrocrustaceans

Three macrocrustacean taxa were caught in the Fitzroy and Calliope basins:

- freshwater prawn (*Macrobrachium australiense*)
- freshwater glass shrimp (family Atyidae, genus *Caridina*) (Figure 2.41), and
- yabbies (*Cherax destructor*).

The most abundant and widespread species caught were the freshwater shrimp and freshwater prawn (Table 2.1 and Table 2.2).

Figure 2.41

Freshwater prawn caught at site KP298.6 (Callide Creek).



Table 2.1 Abundance of macrocrustaceans at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

| **Family**<br>*Species* | **Common Name** | **Fitzroy Basin Sites** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **KP214.8** | **Mimosa RCR** | **KP231.1** | **KP233.9** | **KP234.3** | **KP239.7** | **KP252.4** | **KP285.8** | **KP296.8** | **KP298.9** | **KP334.5** | **Total** |
| **Atyidae** | | | | | | | | | | | | | |
| *Caridina* spp. | Freshwater shrimp | 12 | – | 24 | 8 | 10 | 1 | 19 | – | 380 | 142 | 3 | **664** |
| **Palaemonidae** | | | | | | | | | | | | | |
| *Macrobrachium australiense* | Freshwater prawn | – | – | 34 | 357 | 33 | – | 4 | 6 | 40 | 20 | – | **612** |
| **Parastacidae** | | | | | | | | | | | | | |
| *Cherax destructor* | yabby | – | – | – | – | 1 | 32 | 37 | – | 6 | 6 | 10 | **94** |
| **Total** | | **12** | | **58** | **365** | **44** | **33** | **60** | **6** | **426** | **168** | **13** | **1370** |

Table 2.2 Abundance of macrocrustaceans at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

| **Family**<br>*Species* | **Common Name** | **Calliope Basin Sites** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **KP352.3** | **KP359.4** | **KP360.3** | **KP364.8** | **KP375.6** | **KP378.0** | **Total** |
| **Atyidae** | | | | | | | | |
| *Caridina* spp. | freshwater shrimp | 5 | 69 | 51 | 148 | 600 | 53 | **926** |
| **Palaemonidae** | | | | | | | | |
| *Macrobrachium australiense* | freshwater prawn | 18 | 12 | – | 35 | 11 | 13 | **89** |
| **Parastacidae** | | | | | | | | |
| *Cherax destructor* | yabby | – | 1 | – | – | 3 | – | **4** |
| **Total** | | **23** | **82** | **51** | **183** | **614** | **66** | **1019** |

The yabby is listed as vulnerable on the International Union for Conservation of Nature and Resources Red List of Threatened Species, but is not listed under the Commonwealth's EPBC Act, or Queensland's NCA.

No species, listed under the EPBC Act or Queensland's NCA, were caught.

# 3 Regional and Ecological Perspective

## 3.1 Fitzroy Basin

Data on macroinvertebrate communities was obtained from the Department of Environment and Heritage site 130302A (Dawson River at Taroom) in surveys done from 1994 to 2004. Taxonomic richness was between 17 and 32 individuals in edge habitat and between 7 and 25 individuals in pool habitat (sandy and rocky).

The PET richness in the Dawson River at Taroom was between one and six individuals in edge and pool habitats. This was similar to PET richness in the current survey, indicating that PET richness is similar at other sites throughout the region.

Macroinvertebrate communities in edge habitat in the Dawson River were within quadrants 1 and 2 of the family bi-plot. Macroinvertebrate communities in bed habitat in the Dawson River were within quadrants 2 and 4, indicating that there are potentially large differences in the quality of water and / or habitat condition (e.g. sedimentation of bed habitats). Overall, surrounding land uses are likely to impact macroinvertebrate communities in the catchment.

## 3.2 Calliope Basin

There is little information available regarding the aquatic macroinvertebrate communities of the Calliope region; however, frc environmental surveyed four sites on Larcom Creek and Sandy Creek in the north end of the Calliope Basin (frc environmental 2011). Taxonomic richness was between 17 and 27 individuals at each site in edge habitat in the dry season, and between 13 to 16 taxa in bed habitat.

The PET richness in bed and edge habitat was within or above the QWQG range, with more families in edge habitat (frc environmental 2011). The PET richness indicated good water and / or habitat quality, which was similar to PET richness at sites in the current survey along the Mainline Pipeline.

Macroinvertebrate communities in edge habitat in Larcom and Sandy Creek were within quadrants 1 (favourable habitat conditions) and 3 (likely to be influenced by pollution and harsh physical conditions). Communities in edge habitat in the current survey were all within quadrant 1, except for one site that was in quadrant 2. Macroinvertebrate communities in bed habitat in Larcom and Sandy Creek were within quadrants 1 and 2 of

the family bi-plot (frc environmental 2011), while communities in bed habitat in the current survey were within quadrants 1, 3 and 4.

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# Appendix E Freshwater Fish

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# 1 Survey Design and Methods

## 1.1 Data Collection

Fish communities were surveyed using a combination of backpack electrofishing, baited traps, and seine and dip nets (Table 1.1). Fish communities were assessed at 20 of the 31 sites, as the following sites were dry:

- KP252.6
- KP263.6
- KP269.6
- KP272.4
- KP295.6
- KP296.6
- KP297.7
- KP300.3
- KP305.6
- KP319.1, and
- KP354.3.

All available habitats (e.g. pool, riffle, run and bend) were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*, using a Smith-Root LR-24 backpack electrofisher in shallow water or a 2.5GPP boat electrofisher in deep water. At sites where the conductivity of the water was too low or too high to effectively electrofish, or the water level was too low, fish communities were surveyed with a seine and dip nets with a 20 to 50 mm mesh size.

Fish communities were also surveyed with five small (2 mm mesh size) baited box traps and two baited opera house traps, which were set at each site for a minimum of approximately two hours. Bait traps were not set at sites where the water level was too low.

Specimens that were unable to be identified in the field were humanely euthanised and returned to the laboratory for identification.

The sampling of fishes was conducted under General Fisheries Permit No. 153223 and Animal Ethics Approval No. CA 2012/02/593 issued to frc environmental.

Table 1.1 Electrofishing and net efforts for fish surveys in the current survey.

| Site | Method | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|
| **Fitzroy Basin** | | | | | | |
| KP207.4 | box traps (5) | 12/02/18 | 1135 | 1530 | – | 20 h |
| | opera traps (2) | | 1150 | 1535 | – | 8 h |
| | boat electrofishing | | 1310 | 1355 | 50–1000 V | 1000 s |
| | | | | | 80% | |
| | | | | | 60 DC/s | |
| | | | | | 2–3 Amps | |
| KP214.8 | seine net | 12/04/25 | | | | 1 x 15 m |
| | box traps (5) | | 1440 | 1650 | – | 10 h |
| | backpack electrofishing | | 1420 | 1440 | 225 V | 384 s |
| | | | | | 30 Hz | |
| | | | | | 12% | |
| Mimosa Creek RCR | bait traps (5) | 8/10/12 | 1330 | 1530 | | 10 h |
| KP231.1 | small bait traps (5) | 12/04/26 | 1430 | 1545 | – | 6.25 h |
| | backpack electrofishing | | 1505 | 1520 | 400 V | 186 s |
| | | | | | 30 Hz | |
| | | | | | 12% | |
| KP233.9 | seine net | 12/04/26 | | | | 1 x 20 m |
| | small bait traps (5) | | 1040 | 1320 | – | 13.3 h |
| | backpack electrofishing | | 1200 | 1225 | 300 V | 586 s |
| | | | | | 30 Hz | |
| | | | | | 12% | |
| KP234.3 | seine net | 12/02/17 | | | | 2 x 5 m |
| | backpack electrofishing | | 1115 | 1215 | 190 V | 501 s |
| | | | | | 30 Hz | |
| | | | | | 12% | |
| KP239.7 | backpack electrofishing | 12/04/25 | 0935 | 0945 | 155 V | 176 s |
| | | | | | 30 Hz | |
| | | | | | 12% | |

| Site | Method | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|
| KP252.4 | backpack electrofishing | 12/04/24 | 1215 | 1230 | 270 V<br>30 Hz<br>12% | 255 s |
| KP285.8 | seine net | 12/03/21 | | | | 3 x 2 m |
| KP296.8 | seine net | 12/04/23 | | | | 1 x 10 m |
| | box traps (5) | | 0950 | 1205 | – | 11.25 h |
| | backpack electrofishing | | 1025 | 1055 | 200 V<br>30 Hz<br>12% | 538 s |
| KP298.9 | seine net | 12/04/22 | | | | 1 x 15 m |
| | box traps (5) | | 1000 | 1215 | – | 11.25 h |
| | backpack electrofishing | | 1130 | 1145 | 220 V<br>30 Hz<br>12% | 318 s |
| KP334.5 | backpack electrofishing | 12/04/21 | 1350 | 1410 | 255 V<br>30 Hz<br>12% | 411 s |
| **Calliope Basin** | | | | | | |
| KP352.0 | small bait traps (5) | 12/04/19 | 1530 | 1745 | – | 11.25 h |
| | backpack electrofishing | | 1610 | 1640 | 200 V<br>30 Hz<br>12% | 509 s |
| KP359.2 | box traps (5) | 12/04/18 | 1415 | 1615 | – | 10 h |
| | backpack electrofishing | | 1525 | 1555 | 575 V<br>30 Hz<br>12% | 516 s |
| KP360.0 | seine net | 12/04/17 | | | | 1 x 10 m |
| | small bait traps (5) | | 1515 | 1650 | – | 7.9 h |
| | opera traps (2) | | 1045 | 1715 | – | 13 h |

| Site | Method | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|
| KP364.4 | small bait traps (5) | 12/04/17 | 1130 | 1450 | – | 16.7 h |
| | backpack electrofishing | | 1400 | 1425 | 300 V<br>30 Hz<br>12% | 511 s |
| KP375.3 | box traps (5) | 12/04/19 | 1200 | 1410 | – | 10.8 h |
| | backpack electrofishing | | 1300 | 1330 | 160 V<br>30 Hz<br>12% | 506 s |
| KP377.8 | seine net | 12/04/19 | | | | 1 x 10 m |
| | small bait traps (5) | | 0720 | 0940 | – | 11.8 h |
| | backpack electrofishing | | 0745 | 0815 | 150 V<br>30 Hz<br>12% | 503 s |
| KP384.4 | small bait traps (5) | 12/04/20 | 0710 | 0925 | – | 11.25 h |
| | opera traps (2) | | 0710 | 0925 | – | 4.5 h |
| | backpack electrofishing | | 0830 | 0850 | 175 V | 260 s |

## 1.2 Data Analysis

Fish communities at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site)
- abundance at each life-history stage
- abundance of exotic species, and
- abundance of listed protected species.

## 1.3 Regional and Ecological Perspective

The literature on fish communities in each basin was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

## 2.1 Abundance

### Fitzroy Basin

Fish were most abundant at site KP214.8 (Brolga Gully) and at site KP289.9 (Callide Creek) in the Fitzroy Basin (Figure 2.1 and Table 2.1). Fish communities at site KP214.8 (Brolga Gully) were dominated by Agassiz's glassfish (*Ambassis agassizii*) and at site KP289.9 (Callide Creek) were dominated by fly-specked hardyhead (*Craterocephalus stercusmuscarum*) and gudgeons (*Hypseleotris* spp.). The abundance of fish was lowest at site Mimosa Creek RCR. The composition and abundance of fish communities in ephemeral waterways, such as those in this survey, are known to be highly variable both spatially and temporally.

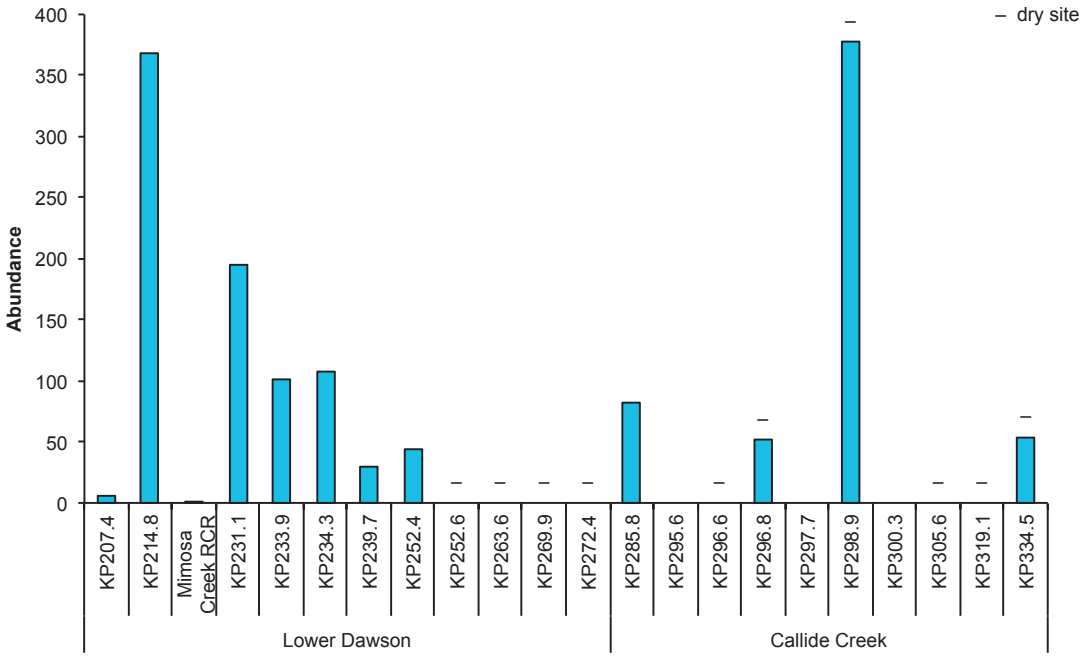


Figure 2.1 Abundance of fish at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

Fish were most abundant at site KP360.3 (Harper Creek) where communities were dominated by fly-specked hardyhead (*Craterocephalus stercusmuscarum*) and gudgeons (*Hypseleotris* spp.) (Figure 2.2 and Table 2.2). The abundance of fish was lowest at site KP384.7 (Larcom Creek). The composition and abundance of fish communities in ephemeral waterways, such as those in this survey, are known to be highly variable both spatially and temporally.

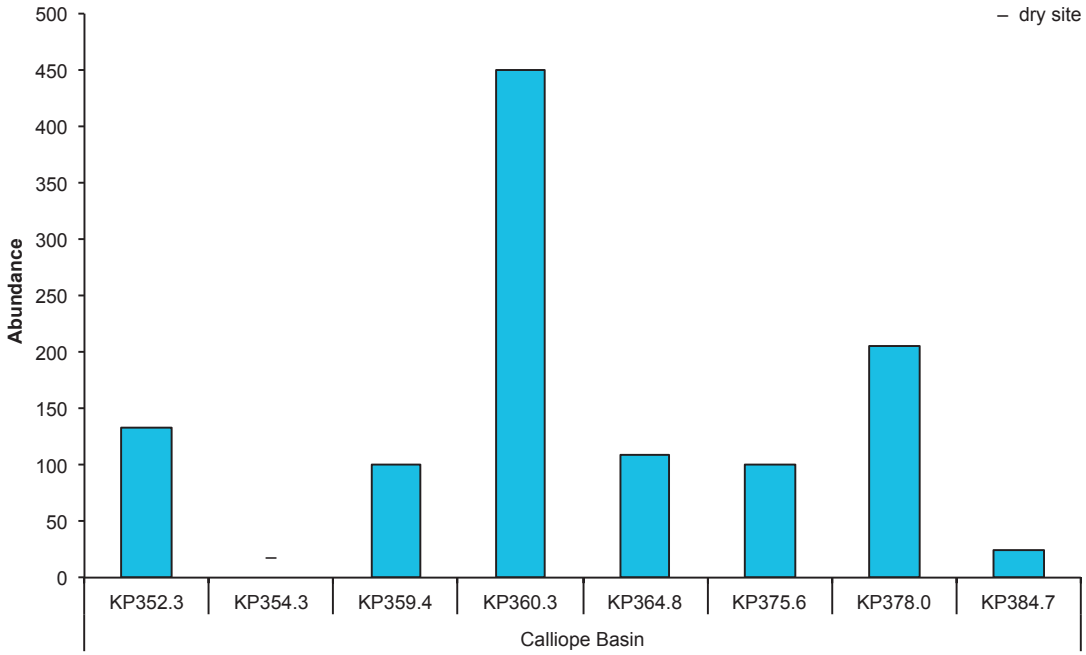


Figure 2.2 Abundance of fish at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

Table 2.1 Abundance of fish species at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

| Species | Common Name | Lower Dawson | | | | | | | | | | | | | | Callide Creek | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KP207.4 | KP214.8 | Mimosa Creek RCR | KP231.1 | KP233.9 | KP234.3 | KP239.7 | KP252.4 | KP252.6 | KP263.6 | KP269.9 | KP272.4 | KP285.8 | KP295.6 | KP296.6 | KP296.8 | KP297.7 | KP298.9 | KP300.3 | KP305.6 | KP319.1 | KP334.5 | |
| *Ambassis agassizii* | Agassiz's glassfish | 1 | 236 | – | – | 33 | 1 | 4 | 1 | – | – | – | – | 66 | – | – | 6 | – | 127 | – | – | – | – | **478** |
| *Amniataba percoides* | barred grunter | – | – | – | – | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **1** |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | – | – | – | – | – | 23 | – | – | – | – | – | – | – | – | – | 9 | – | 76 | – | – | – | – | **108** |
| *Gambusia holbrooki* | mosquitofish [a] | – | 65 | – | – | – | 13 | 23 | 38 | – | – | – | – | – | – | – | 7 | – | 58 | – | – | – | – | **204** |
| *Hypseleotris* spp. | gudgeon | 1 | – | – | 195 | 34 | 38 | 1 | 5 | – | – | – | – | 2 | – | – | 7 | – | 110 | – | – | – | – | **438** |
| *Leiopotherapon unicolor* | spangled perch | – | 4 | – | – | 1 | – | – | – | – | – | – | – | 1 | – | – | 1 | – | 2 | – | – | – | – | **10** |
| *Melanotaenia splendida* | eastern rainbowfish | – | 63 | – | – | 7 | 6 | 2 | – | – | – | – | – | 6 | – | – | 18 | – | – | – | – | – | – | **102** |
| *Mogurnda adspersa* | purple spotted gudgeon | – | – | 1 | – | 6 | – | – | – | – | – | – | – | 1 | – | – | 4 | – | 4 | – | – | – | 21 | **40** |
| *Nematalosa erebi* | bony bream | 3 | – | – | – | 16 | 26 | – | – | – | – | – | – | 6 | – | – | – | – | 1 | – | – | – | – | **52** |
| *Oxyeleotris lineolatus* | sleepy cod | – | – | – | – | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **3** |
| *Pseudomugil signifer* | pacific blue-eye | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 33 | **33** |
| *Scortum hillii* | leathery grunter | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | **1** |
| **Total** | | **6** | **368** | | **1** | **101** | **107** | **30** | **44** | **–** | **–** | **–** | **–** | **82** | **–** | **–** | **52** | **–** | **378** | **–** | **–** | **–** | **54** | **1470** |

[a] exotic non-indigenous species, declared noxious under the Fisheries Regulation 2008

Table 2.2 Abundance of fish species at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

| Species | Common Name | Calliope Basin | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | KP352.3 | KP354.3 | KP359.4 | KP360.3 | KP364.8 | KP375.6 | KP378.0 | KP384.7 | |
| *Ambassis agassizii* | Agassiz's glassfish | 3 | – | 7 | 1 | 14 | 7 | 9 | – | **41** |
| *Amniataba percoides* | barred grunter | 2 | – | – | – | – | – | – | – | **2** |
| *Anguilla reinhardtii* | longfin eel | 6 | – | – | – | 2 | – | 2 | – | **10** |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | 3 | – | 1 | 193 | 3 | – | 83 | 7 | **290** |
| *Glossamia aprion* | mouth almighty | 1 | – | – | 5 | – | – | 1 | – | **7** |
| *Hypseleotris compressa* | empire gudgeon | 37 | – | 1 | 30 | 41 | 16 | 20 | 4 | **149** |
| *Hypseleotris* spp. | gudgeon | – | – | 76 | 172 | 2 | 7 | 1 | 2 | **260** |
| *Leiopotherapon unicolor* | spangled perch | 4 | – | 1 | – | 2 | 1 | – | – | **8** |
| *Melanotaenia splendida* | eastern rainbowfish | 64 | – | 11 | 37 | 19 | 50 | 80 | 10 | **271** |
| *Mogurnda adspersa* | purple spotted gudgeon | 5 | – | 3 | 12 | 17 | 18 | 3 | 1 | **59** |
| *Neosilurus hyrtlii* | Hyrtl's tandan | – | – | – | – | 3 | – | 2 | – | **5** |
| *Pseudomugil signifer* | pacific blue-eye | 8 | – | – | – | 5 | 1 | 4 | – | **18** |
| **Total** | | **133** | **–** | **100** | **450** | **108** | **100** | **205** | **24** | **1120** |

## 2.2 Taxonomic Richness

### Fitzroy Basin

Fish communities were most diverse at site KP233.9 (Dawson River) in the Fitzroy Basin (Figure 2.3 and Table 2.1). The fish community at site KP231.1 (Denby Creek) and Mimosa Creek RCR were the least diverse in the Fitzroy Basin. The leathery grunter (*Scortum hillii*) was only caught at site KP207.4 (Conciliation Creek), where the total taxonomic richness was moderate.

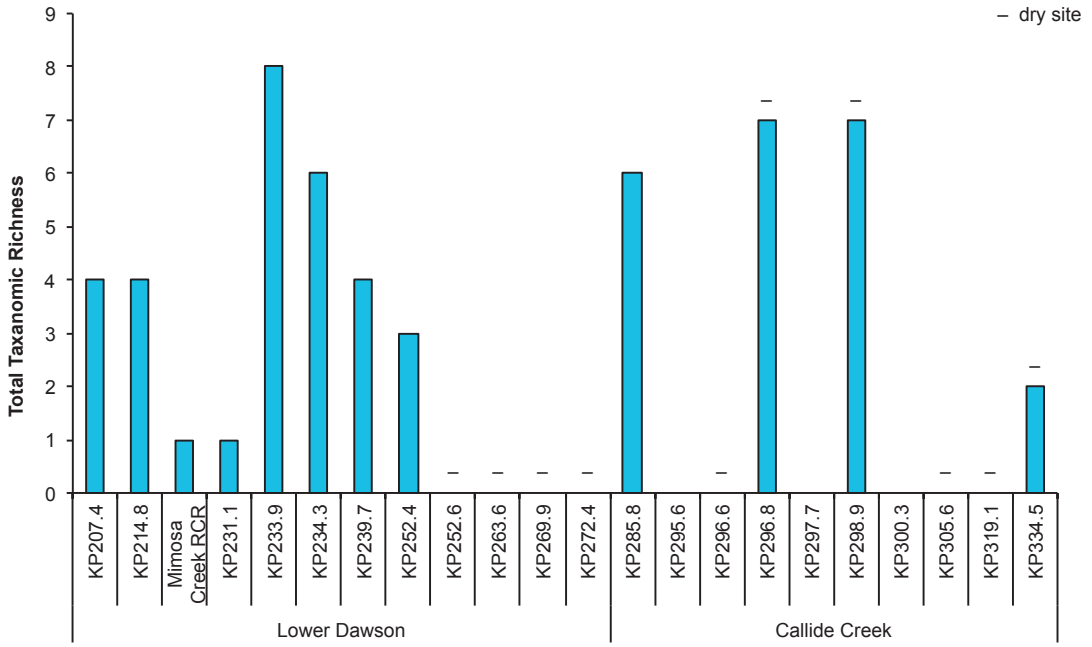


Figure 2.3 Total taxonomic richness of fish at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

Fish communities were most diverse at site KP352.3 (Calliope River), site KP364.8 (Alarm Creek) and site KP378.0 (Larcom Creek) in the Calliope Basin (Figure 2.4 and Table 2.2). The fish community was least diverse at site KP384.7 (Larcom Creek) in the Calliope Basin.

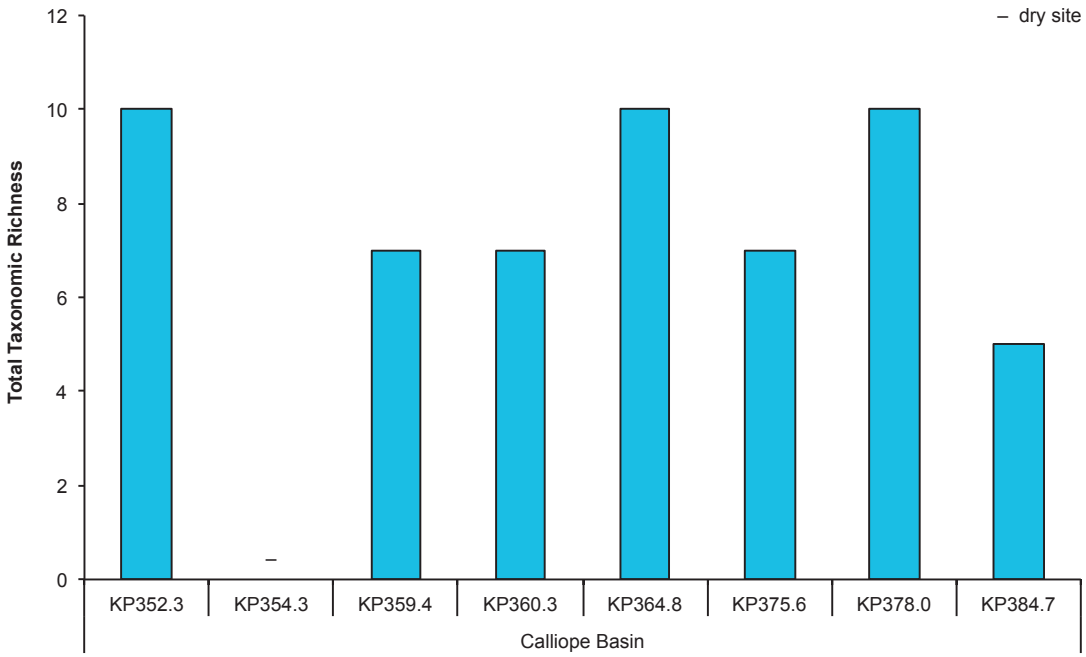


Figure 2.4 Total taxonomic richness of fish at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.3 Life-history Stages

### Fitzroy Basin

The intermediate life-history stages generally dominated fish communities in the Fitzroy Basin (Figure 2.5). Due to the fast growth rates (i.e. maturation periods within 12 months) of most of species in the survey area, this was the expected distribution of life-history stages. That is, most species breed in autumn and summer, so in April most juveniles had developed to the intermediate or adult life-history stage. Adult fish dominated communities at site KP298.9 (Callide Creek) and at site KP334.5 (Bell Creek).

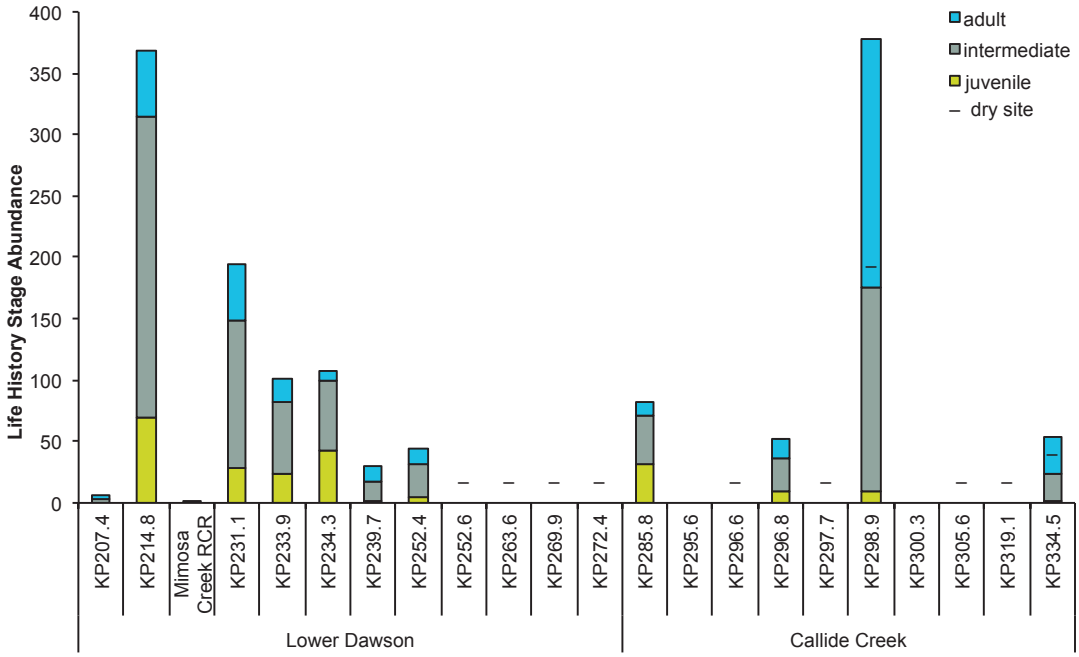


Figure 2.5 Life-history stages of fish at each site along the GLNG pipeline (KP200 to KP406) in the Fitzroy Basin.

## Calliope Basin

The intermediate life-history stages generally dominated fish communities in the Calliope Basin (Figure 2.6). There were some exceptions: juveniles dominated communities at site KP360.3 (Harper Creek) and adults dominated communities at site KP384.7 (Larcom Creek).

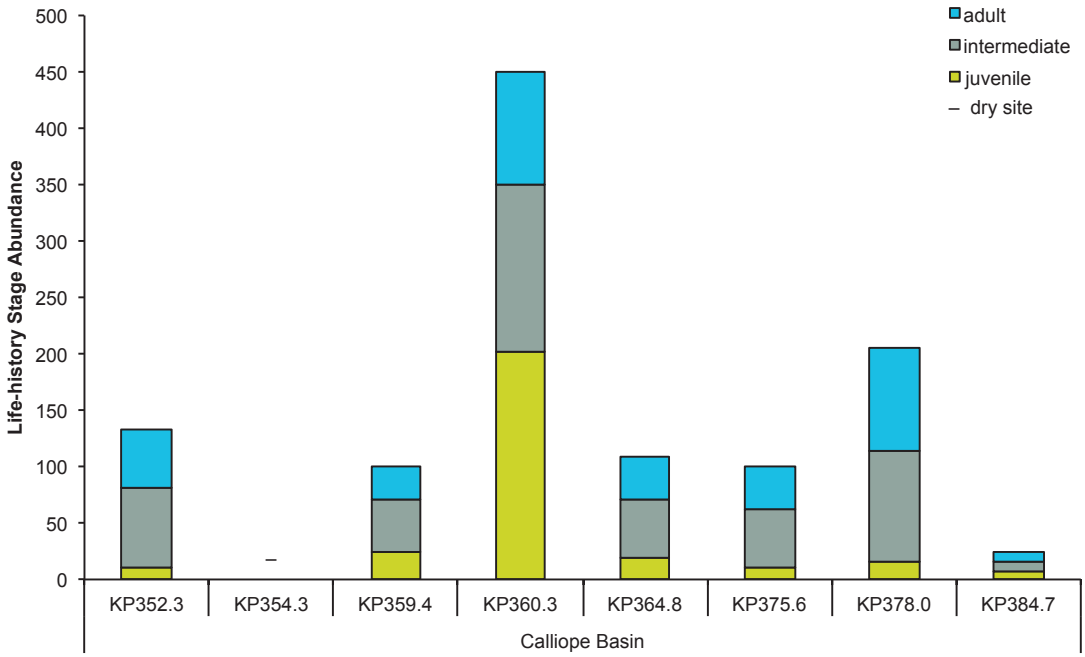


Figure 2.6 Life-history stages of fish at each site along the GLNG pipeline (KP200 to KP406) in the Calliope Basin.

## 2.4 Exotic Species

Mosquitofish (*Gambusia holbrooki*) were caught in the Fitzroy Basin at sites:

- Brolga Valley (KP214.8)
- Back Creek (KP234.3)
- Kianga Creek (KP239.7)
- Banana Creek (KP252.4)
- Kroombit Creek (KP296.8), and
- Callide Creek (KP298.9).

Mosquitofish are listed as noxious in Schedule 6 of Queensland's Fisheries Regulation 2008.

No other exotic species were caught at any other sites.

## 2.5 Listed Species of Conservation Significance

No species listed under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992* were caught in this survey.

# 3 Regional and Ecological Perspective

## 3.1 Fitzroy Basin

Forty-three species from 22 families of native fish have been recorded in the Fitzroy Basin (Table 3.1) (Berghuis & Long 1999; Marsden & Power 2007; Ecowise 2008; frc environmental 2008a; b; 2009; DEHP 2012). The most frequently recorded fish from the DEHP WildNet database are:

- bony bream (*Nematolosa erebi*)
- eastern rainbowfish (*Melanotaenia splendida*)
- Agassiz's glassfish (*Ambassis agassizii*)
- flyspecked hardyhead (*Craterocephalus stercusmuscarum*)
- golden perch (*Macquaria ambigua*), and
- spangled perch (*Leiopotherapon unicolor*).

Three exotic freshwater fish have been recorded in the Fitzroy Basin (Ecowise 2008; frc environmental 2008a; c; DEHP 2012)

- eastern mosquitofish (*Gambusia holbrooki*)
- guppy (*Poecilia reticulata*), and
- goldfish (*Carassius auratus*).

Mosquitofish are a declared noxious species in Queensland under the Fisheries Regulation 2008. Goldfish and guppies are listed as a non-indigenous fish under the Fisheries Regulation 2008.

Two species, listed as vulnerable under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992*, have been recorded in the in the Fitzroy Basin:

- Murray cod (*Maccullochella peelii*), and
- Australian lungfish (*Neoceratodus forsteri*).

The Murray cod has been stocked to the Fitzroy Basin and it is unclear whether it has become established. The last sighting of the Australian lungfish in the Fitzroy Basin was in 1870.

## 3.2 Calliope Basin

Thirty-six species from 21 families of native fish have been recorded in the Calliope Basin (Table 3.1) (APLNG 2010; DEHP 2012). The most frequently recorded fish from the DEHP WildNet database are:

- bony bream (*Nematolosa erebi*), and
- eastern rainbowfish (*Melanotaenia splendida*).

Two exotic freshwater fish have been recorded in the Calliope Basin:

- eastern mosquitofish (*Gambusia holbrooki*), and
- guppy (*Poecilia reticulata*).

No species recorded in the Calliope Basin is listed under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* or Queensland's *Nature Conservation Act 1992*.

Table 3.1 Fish species known from the Fitzroy and Calliope basins, and their presence in the current survey.

| Family<br>*Species* | Common Name | Fitzroy Basin | Calliope Basin | Current Survey |
|---|---|---|---|---|
| **Ambassidae** | | | | |
| *Ambassis agassizii* | Agassiz's glassfish | ✓ | ✓ | ✓ |
| *Ambassis marianus* | estuary glassfish | – | ✓ | – |
| *Ambassis vachellii* | Vachelli's perchlet | | ✓ | |
| **Anguillidae** | | | | |
| *Anguilla obscura* | Pacific shortfin eel | ✓ | – | – |
| *Anguilla reinhardtii* | longfin eel | ✓ | ✓ | ✓ |
| **Apogonidae** | | | | |
| *Glossamia aprion* | mouth almighty | ✓ | ✓ | ✓ |
| **Ariidae** | | | | |
| *Neoarius graeffei* | blue catfish | ✓ | ✓ | – |
| **Antherinidae** | | | | |
| *Craterocephalus marjoriae* | silverstreak hardyhead | ✓ | – | – |
| *Craterocephalus stercusmuscarum* | fly-specked hardyhead | ✓ | ✓ | ✓ |
| **Belonidae** | | | | |
| *Strongylura krefftii* | freshwater longtom | ✓ | ✓ | – |
| **Centropomidae** | | | | |
| *Lates calcarifer* | barramundi | ✓ | ✓ | – |
| **Ceratodontidae** | | | | |
| *Neoceratodus forsteri* [a] | Australian lungfish | ✓ | – | – |
| **Clupeidae** | | | | |
| *Nematolosa erebi* | bony bream | ✓ | ✓ | ✓ |
| *Herklotsichthys castelnaui* | southern herring | – | ✓ | – |
| **Cyprinidae** | | | | |
| *Carassius auratus* [b] | goldfish | ✓ | – | – |

| Family<br>*Species* | Common Name | Fitzroy Basin | Calliope Basin | Current Survey |
|---|---|---|---|---|
| **Eleotridae** | | | | |
| *Giurus margaritacea* | snakehead gudgeon | ✓ | – | – |
| *Gobiomorphus australis* | striped gudgeon | ✓ | ✓ | – |
| *Hypseleotris compressa* | empire gudgeon | ✓ | ✓ | ✓ |
| *Hypseleotris galii* | firetail gudgeon | ✓ | ✓ | – |
| *Hypseleotris klunzingeri*. | western carp gudgeon | ✓ | – | – |
| *Hypseleotris* sp. | Midgley's carp gudgeon | ✓ | ✓ | ✓ |
| *Mogurnda adspersa* | purple spotted gudgeon | ✓ | ✓ | ✓ |
| *Oxyeleotris lineolata* | sleepy cod | ✓ | – | ✓ |
| *Philypnodon grandiceps* | flathead gudgeon | ✓ | – | – |
| **Gobiidae** | | | | |
| *Glossogobius giuris* | tank goby | ✓ | ✓ | – |
| *Redigobius bikolanus* | speckled goby | ✓ | ✓ | – |
| **Hemiramphidae** | | | | |
| *Arrhamphus sclerolepis* | snubnose garfish | ✓ | ✓ | – |
| **Kuhliidae** | | | | |
| *Kuhlia rupestris* | jungle perch | ✓ | ✓ | – |
| **Lutjanidae** | | | | |
| *Lutjanus argentimaculatus* | mangrove jack | – | ✓ | – |
| **Megalopidae** | | | | |
| *Megalops cyprinoides* | oxeye herring | ✓ | ✓ | – |
| **Melanotaeniidae** | | | | |
| *Melanotaenia fluviatilis* | Murray River rainbowfish | – | ✓ | – |

| Family<br>*Species* | Common Name | Fitzroy Basin | Calliope Basin | Current Survey |
|---|---|---|---|---|
| *Melanotaenia splendida* | eastern rainbowfish | ✓ | ✓ | ✓ |
| *Melanotaenia splendida tatei* | desert rainbowfish | ✓ | ✓ | – |
| *Rhadinocentrus ornatus* | ornate rainbowfish | ✓ | – | – |
| **Monodactylidae** | | | | |
| *Monodactylus argenteus* | diamondfish | – | ✓ | – |
| **Mugilidae** | | | | |
| *Myxus petardi* | pinkeye mullet | ✓ | – | – |
| **Osteoglossidae** | | | | |
| *Scleropages leichardti* | southern saratoga | ✓ | – | – |
| **Percichthyidae** | | | | |
| *Maccullochella peelii* [a] | Murray cod | ✓ | – | – |
| *Macquaria ambigua oriens* | golden perch | ✓ | – | – |
| **Plotosidae** | | | | |
| *Neosilurus hyrtlii* | Hyrtl's tandan | ✓ | ✓ | ✓ |
| *Porochilus rendahli* | Rendahl's catfish | ✓ | – | – |
| *Tandanus tandanus* | freshwater catfish | ✓ | ✓ | – |
| **Poeciliidae** | | | | |
| *Gambusia holbrooki* [b] | mosquitofish | ✓ | ✓ | ✓ |
| *Poecilia reticulata* [c] | guppy | ✓ | ✓ | – |
| **Pseudomugilidae** | | | | |
| *Pseudomugil signifer* | pacific blue eye | ✓ | ✓ | ✓ |
| **Retropinnidae** | | | | |
| *Retropinna semoni* | Australian smelt | ✓ | – | – |
| **Scatophagidae** | | | | |
| *Scatophagus argus* | spotted scat | – | ✓ | – |
| *Selenotoca multifasciata* | striped scat | – | ✓ | – |

| Family<br>*Species* | Common Name | Fitzroy Basin | Calliope Basin | Current Survey |
|---|---|---|---|---|
| **Scorpaenidae** | | | | |
| *Notesthes robusta* | bullrout | ✓ | ✓ | – |
| **Terapontidae** | | | | |
| *Amniataba percoides* | barred grunter | ✓ | ✓ | ✓ |
| *Bidyanus bidyanus* | silver perch | ✓ | – | – |
| *Hephaestus fuliginosus* | sooty grunter | ✓ | – | – |
| *Leiopotherapon unicolor* | spangled perch | ✓ | ✓ | ✓ |
| *Terapon jarbua* | crescent grunter | – | ✓ | – |
| *Scortum hillii* | leathery grunter | ✓ | – | ✓ |

Sources: (Berghuis & Long 1999; Marsden & Power 2007; Ecowise 2008; frc environmental 2008a; b; 2009; DEHP 2012)

– not caught

[a] listed as vulnerable under the EPBC Act

[b] exotic non-indigenous species, declared noxious under the Fisheries Regulation 2008

[c] exotic non-indigenous species

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# Appendix F Freshwater Turtles

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Figure 2.2 Saw-shelled turtle caught at site KP360.3 (Harper Creek). 3

# 1 Survey Design and Methods

## 1.1 Field Sampling

Turtle traps were set at sites where the water was deep enough to provide suitable turtle habitat and the allow use of cathedral traps. Four baited cathedral traps were set along the bank and next to cover (e.g. vegetation and snags) for:

- 2.7 hours at site KP233.9 (Dawson River)
- 6.5 hours at site KP360.3 (Harper Creek), and
- 2.5 hours at site KP384.7 (Larcom Creek).

Turtle traps were not set where the site was dry or the water level was too low, or where access was too dangerous to take turtle traps.

The design of the traps was similar to traps used by the Department Environment and Heritage Protection's (DEHP's) turtle research group. The traps had a series of collapsible chambers (approximately 3.5 m in height and 0.7 m in diameter) and two, one-way entrances in the lower baited chamber. Traps were set so that the top of the chamber allowed turtles access to the surface to breathe. Traps were closely monitored to ensure that no turtles or other air-breathing species were entangled or trapped below the surface. The sampling of turtles was conducted under Animal Ethics Approval No. CA 2012/02/593 and QLD Scientific Purposes Permit WISP05080608 issued to frc environmental. Observations for turtles were made at all sites while electrofishing.

## 1.2 Data Analysis

Turtles at each site were assessed for:

- total abundance (total number of individuals caught at a site)
- taxonomic richness (total number of species caught at a site), and
- abundance of listed protected species.

## 1.3 Regional and Ecological Perspective

The literature on turtles in the basins was reviewed, and summarised to provide a context for the results of these surveys.

# 2 Results

Five adult Krefft's river turtles (*Emydura macquarii krefftii*) were caught at Harper Creek (KP360.3) and Larcom Creek (KP384.7) and three adults were caught at the Dawson River (KP233.9) (Table 2.1 and Figure 2.1). Two adult saw-shelled turtles (*Wollumbinia latisternum*) were also caught at Harper Creek (KP360.3) (Table 2.1 and Figure 2.2). These species are not listed under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* or Queensland's Nature Conservation (Wildlife) Regulation 2006.

Table 2.1 Freshwater turtles at each site in the Fitzroy and Calliope basins.

| Species | Common Name | Lower Dawson | Calliope Basin | |
|---|---|---|---|---|
| | | **Site KP233.9 (Dawson River)** | **Site KP360.3 (Harper Creek)** | **Site KP384.7 (Larcom Creek)** |
| *Emydura macquarii krefftii* | Krefft's river turtle | 3 | 5 | 5 |
| *Wollumbinia latisternum* | saw-shelled turtle | 0 | 2 | 0 |

Figure 2.1

Krefft's river turtle caught at site KP233.9 (Dawson River).



Figure 2.2

Saw-shelled turtle caught at site KP360.3 (Harper Creek).



# 3 Regional and Ecological Perspective

## 3.1 Fitzroy Basin

The Fitzroy Basin has a high conservation value with respect to freshwater turtles, as there are several species endemic to the region. Eight species have been recorded in the Fitzroy Basin (DEHP 2012a):

- Krefft's river turtle (*Emydura macquarii krefftii*)
- Murray turtle (*Emydura macquarii macquarii*)
- Fitzroy River turtle (*Rheodytes leukops*)
- white-throated snapping turtle (*Elseya albagula*)
- short-necked turtle (*Emydura* sp.)
- broad-shelled river turtle (*Chelodina expansa*)
- snake-necked turtle (*Chelodina longicollis*), and
- saw-shelled turtle (*Wollumbinia latisternum*).

The Fitzroy river turtle is listed as Vulnerable under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* and Queensland's Nature Conservation (Wildlife) Regulation 2006. The white-throated snapping turtle is not listed as a threatened species, but it is ranked as a high priority species under the Department of Environment and Heritage Protection's *Back on Track* species prioritisation framework.

The Fitzroy River turtle is endemic to the natural permanent riverine habitats of the Fitzroy Basin, although it has not been recorded in the Upper Dawson River sub-catchment (Limpus et al. 2007). However, DEHP's turtle group suggest that Fitzroy River turtle likely occurs further upstream in the Dawson River, where it would inhabit reaches with deep pools, riffles and sandy banks (Tucker et al. 2001; Limpus et al. 2007).

The white-throated snapping turtle was only described in 2006 (Thomson et al. 2006); previously it had been regarded as part of the more common and widely distributed northern snapping turtle (*Elseya dentata*). Within the Fitzroy Basin, this species occurs from the barrage on the lower Fitzroy River to the uppermost spring fed pools in the Upper Dawson, Mackenzie and Comet catchments (Limpus et al. 2007; frc environmental 2009). The white-throated snapping turtle has been recorded almost exclusively in close association with permanent flowing stream reaches, typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and / or submerged logs and fallen trees (Haman et al. 2007).

## 3.2 Calliope Basin

Within the Calliope Basin, only four species of freshwater turtle have been recorded (DEHP 2012b):

- Krefft's river turtle (*Emydura macquarii krefftii*)
- short-necked turtle (*Emydura* sp.)
- white-throated snapping turtle (*Elseya albagula*), and
- saw-shelled turtle (*Wollumbinia latisternum*).

# 4 References

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**APPENDIX B4 – Humpy Creek (KP407), Field Data Sheets, Photographs, Laboratory Results and Herbarium Results**

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# GLNG

## Gas Transmission Pipeline

## Field Data Sheet for Watercourse Assessments

Document Number: 3380-GLNG-4-1.3-0047

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A.Hampson | | |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Coordinator | B.Angus | | |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | I.Bridge | | |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 4/01/12 | A | For Review | | | |
| | | | | | |
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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 30/3/12 KP Point 407.87 Eastings 309234 Northings 7371274
Watercourse Name Hungry Creek Distance from Source 2.7km AMTD 1-3km
Stream Order 3 Photo taken of access track Y/N
Catchment Area Mosquito Weather Fine.
Rain in the Past week _____ Time of Day 2pm Cloud Cover (%) 20.
HTide 2.13.

---

**OBSERVATIONS**

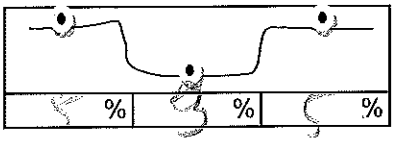
Mean Channel width (m) 10m.
Height of Banks  Left 4 Right 2

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 50 Shrubs % _____
Trees < 10m % 40 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)
  - crops, scattered mangroves.

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Eucalypts, Narrow leaved ironbark.

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % | |
| Boulder (>256mm) | % | Gravel (4-16mm) | % | /100 |
| Cobble (64-256mm) | % | Sand (1-4mm) | % | |
| | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

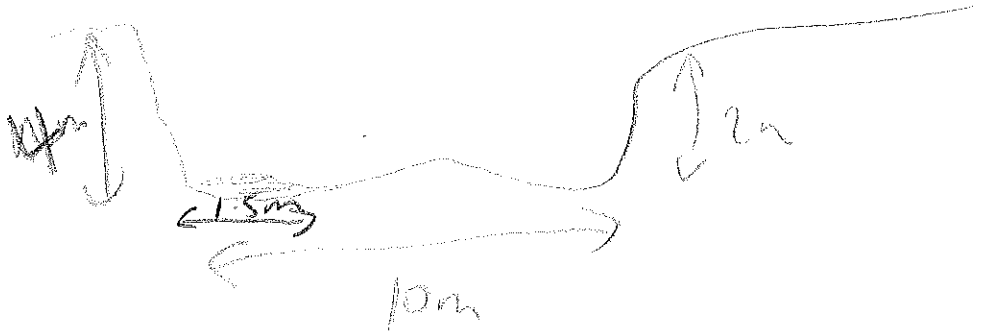
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

**General Comments / Reach Description:**

Straight winding channel, steep banks. Moderate level of erosion.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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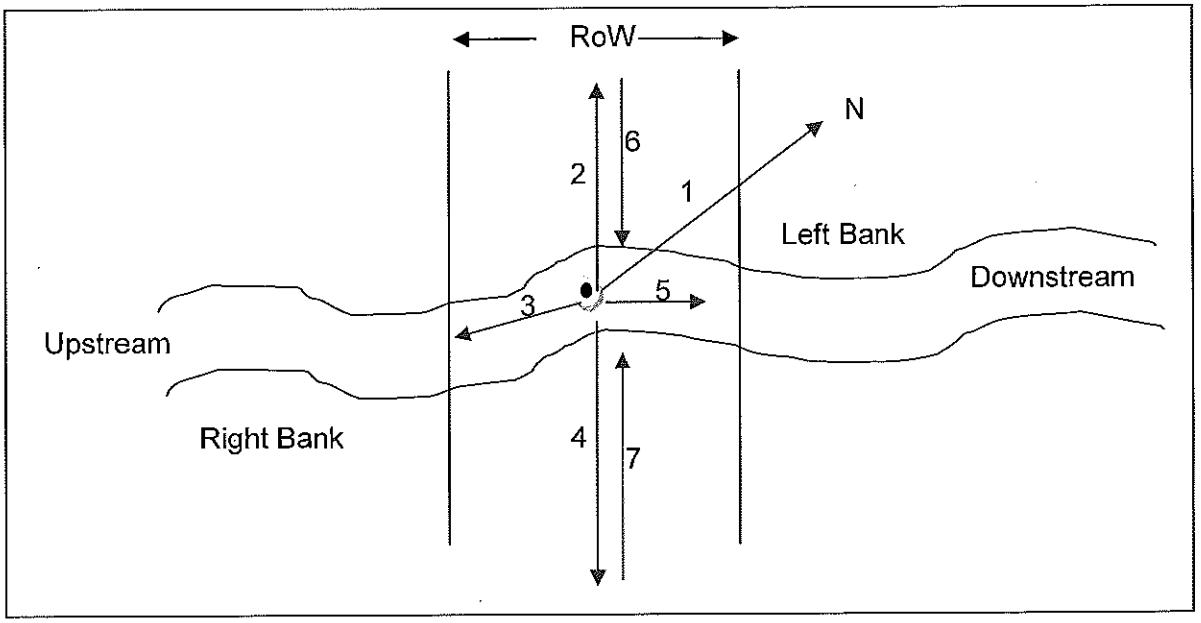
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Winding channel, limited riparian veg. scattered Ceriops ~ 20 individuals in crossing location scattered both upstream & d/stream of crossing. Other mangrove species also present. Watercourse moderately flowing, well below watermark, moderately saline. Evidence of saltwater intrusion.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 31·31 | 31·26 | | 31·23 |
| Conductivity (µS/cm) | 6267 | 6363 | | 6315 |
| pH | 7·86 | 7·87 | | 7·865 |
| Dissolved $O_2$ (mg/L) | 9·05 | 8·95 | | 9·0 |
| Turbidity (NTU) | 7·8 | 8·1 | | 7·95 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**4**

- *Aegialitis annulata*
- **Ceriops tagal*
- **Lumnitzera racemosa*
- **Myrsine crassifolia*
- rr d r r

d d d r r M

# Certificate of Analysis

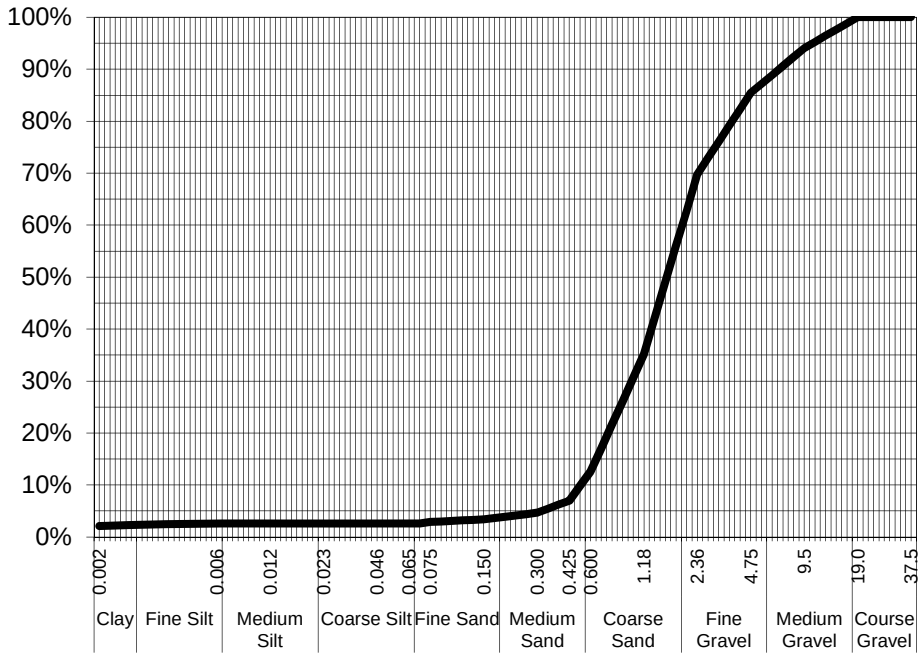
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-001 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP407.87 - Bottom |

### Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 94% |
| 4.75 | 85% |
| 2.36 | 70% |
| 1.18 | 35% |
| 0.600 | 13% |
| 0.425 | 7% |
| 0.300 | 5% |
| 0.150 | 3% |
| 0.075 | 3% |
| Particle Size (microns) | |
| 65 | 3% |
| 46 | 3% |
| 23 | 3% |
| 12 | 3% |
| 6 | 3% |
| 4 | 3% |
| 2 | 2% |

| | |
|---|---|
| Median Particle Size (mm) | 1.180 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Sample Comments:**

**Analysed:** 15-May-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium coarse sand and gravel

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.1/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

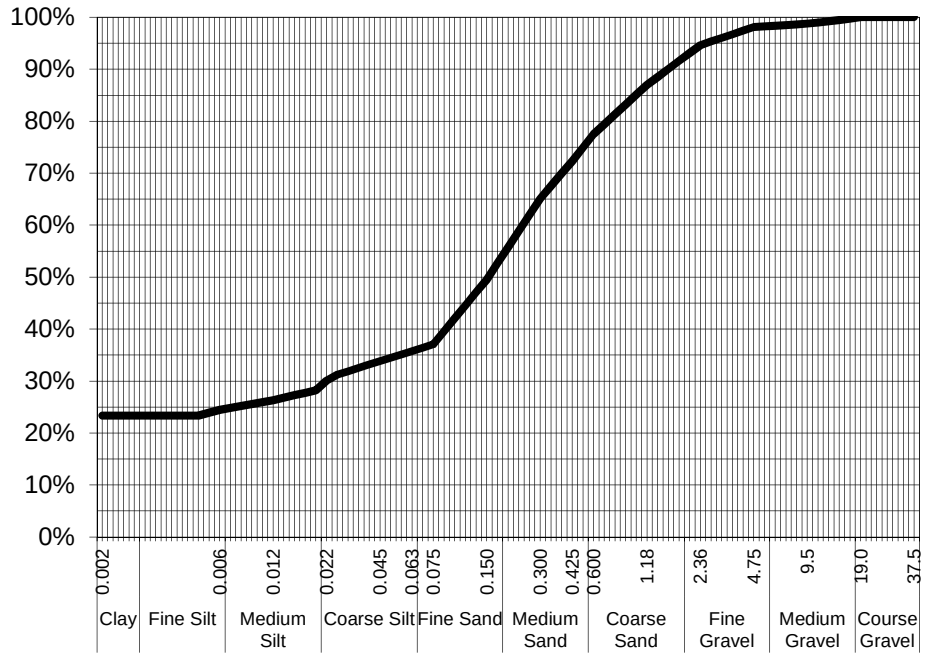
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-002 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP407.87 - Bank |

### Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 99% |
| 4.75 | 98% |
| 2.36 | 95% |
| 1.18 | 87% |
| 0.600 | 77% |
| 0.425 | 72% |
| 0.300 | 65% |
| 0.150 | 50% |
| 0.075 | 37% |
| Particle Size (microns) | |
| 63 | 36% |
| 45 | 34% |
| 22 | 30% |
| 12 | 26% |
| 6 | 24% |
| 4 | 23% |
| 2 | 23% |

| | |
|---|---|
| Median Particle Size (mm) | 0.150 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

| | | | |
|---|---|---|---|
| **Sample Comments:** | | **Analysed:** | 15-May-12 |
| **Loss on Pretreatment** | NA | **Limit of Reporting:** | 1% |
| **Sample Description:** | Sand and silty clay | **Dispersion Method** | Shaker |
| **Test Method:** | AS1289.3.6.1/AS1289.3.6.3 | **Hydrometer Type** | ASTM E100 |

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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NATA
WORLD RECOGNISED ACCREDITATION

**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***











**REFERENCE GUIDES**

**Categories of Bank erosion:**

| | |
|---|---|
| None: | *Typical Features* – good vegetation cover, no significant damage to bank structure, no exposed roots |
| Limited Erosion: | *Typical Features* – good vegetation cover, minor isolated erosion, no continuous damage to bank, some exposed roots |
| Moderate Erosion: | *Typical Features* – discontinuous vegetation, obvious damage to bank structure, moderate exposure of roots |
| Extensive Erosion: | *Typical Features* – little effective vegetation, recent bank movement, large amounts of exposed roots |
| Extreme Erosion: | *Typical Features* – evidence of rapid unchecked erosion, little effective vegetation, abundant exposure of roots |

Environment Australia, *National River Health Program: South Australian Sampling and Processing Manual* Accessed: December 2011, Available http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/manual-sa/pubs/manual-sa.pdf

**Plant specimen collection method:**

Queensland Herbarium, 2010, *Collecting and preserving plant specimens, a manual.* Accessed: December 2011, available: http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/publications/pdf/collecting_manual_v5.pdf

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**APPENDIX C – Site Assessment Sheets Major Watercourses**

| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP2.1 Hutton Creek**<br>Catchment: Dawson River | **Easting**<br>692134.34 | **Northing**<br>7151525.58 |

*Stream Order and Geomorphology*
Stream Order 6
Relatively wide (20 m) creek with grazing being the dominant surrounding land use. Flow is intermittent, although water level was above the watermark at time of survey, and a large permanent pool occurs at the crossing location. The left bank was 15 m with a steep gradient; the right bank was 25 m with a steep gradient. Channel substrate had low compaction and was composed of sand and silt / clay.

*Erosion Risk*
Moderate - high. High levels of erosion on right bank due to displaced and fallen trees. High channel disturbance, high local catchment erosion and gully erosion. Erosion present due to unconsolidated sandy sediments and clearing for grazing.

*Riparian Vegetation*
Relatively wide riparian zone, 20 m on the left bank and 10m on right bank, composed of small and large native trees (eucalypt, *Casuarina* sp. and *Callistemon* sp.) with moderate grass. Some trailing bank vegetation and moderate shading of the river.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora including *Rumex crispus* (curled dock), *Marsilea* sp. (nardoo) and *Cyperus distans* (slender flatsedge). High abundance of native fish, including *Ambassis agassizii*, *Hypseleotris* spp., and *Melanotaenia splendida*, and two exotic species present – goldfish (*Carassius auratus*) and mosquitofish (*Gambusia holbrooki*). Freshwater shrimps and prawns were abundant. Site provides dispersal and breeding habitat for aquatic species. Krefft's river turtle (*Emydura macquarii krefftii*) and saw-shelled turtle (*Wollumbinia latisternum*) were caught during the field survey, and platypus burrows observed in the vicinity of the crossing location. Structural habitat included deep pools, undercut banks, trailing roots, large woody debris and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Likely habitat for platypus
Possible habitat for white-throated snapping turtle (*Elseya albagula*)
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 71(Moderate)
Macroinvertebrate Richness: 20 (bed); 29 (edge)
Macroinvertebrate PET Richness: 4 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.02 (bed); 3.41 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Implement works during the dry season as EVR species could be present.

*Site-specific Mitigation Measures*
If open cut construction during wet conditions, fish salvage required. Isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DEEDI (does not meet requirements of self-assessable code due to large bankfull width). Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

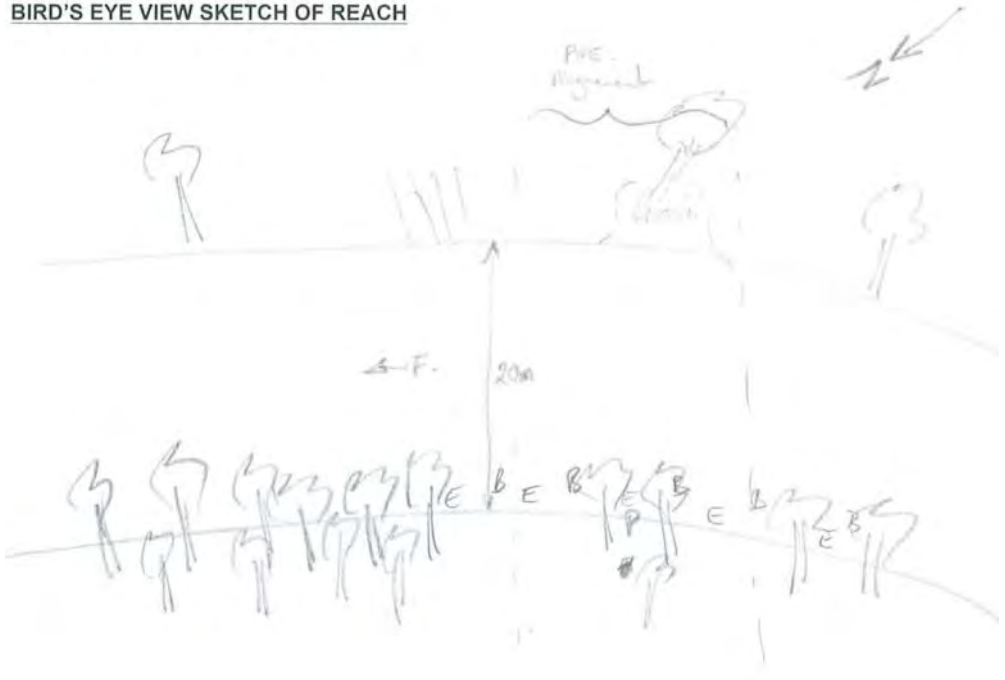
Additional mitigation If construction is in wet season: HDD recommended.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culvert. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**



| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  | |
| **Right Bank** | |
|  | |

| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP2.6 Christmas Creek**<br>Catchment: Dawson River | **Easting**<br>691931.50 | **Northing**<br>7152026.24 |

*Stream Order and Geomorphology*
Stream Order 4

Narrow (2 m), ephemeral water body, slow flowing at the time of survey. Site characterised by disconnected shallow pools and riffles. Left and right banks with moderate slope. Overall bank stability was affected by runoff, stock access, recent high flow, road culvert and vegetation clearing. A water pipeline crossed the creek in the vicinity of the GTP ROW. Channel substrate had low compaction and was comprised of silt / clay and sand. Vegetated side and point bars were present (50%). Grazing was the surrounding land use.

*Erosion Risk*
High. Small stream severely eroded due to construction of road and recent high flows. Very high disturbance in the channel and heavy local catchment erosion.

*Riparian Vegetation*
Riparian zone comprised of grass, some native large trees (eucalypt and *Casuarina* sp.) on the left bank and some bare ground due to road clearing. Moderate trailing bank vegetation, mostly due to aquatic plants (predominantly on the right bank). Riparian vegetation extended 20 m on the left bank and 10 m on the right bank. Riparian vegetation provided shading to 15% of the watercourse.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora was composed of *Persicaria decipiens* (slender knotweed), *Cyperus distans* (slender flatsedge) and *Lomandra longifolia* (mat rush). There were diverse fish species at the site including *Ambassis* agassizii (glassfish), *Hypseleotris* spp. (carp gudgeon), *Leiopotherapon unicolor* (spangled perch) and *Melanotaenia splendida* (eastern rainbow fish). Freshwater shrimps, river prawns and crayfish were caught during the survey. Structural habitat included shallow poorly connected pools and riffles, undercut banks on both sides and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 50 (moderate)
Macroinvertebrate Richness: 18 (bed); 27 (edge)
Macroinvertebrate PET Richness: 3 (bed); 2 (edge)
Macroinvertebrate SIGNAL 2 Score: 2.35 (bed); 2.80 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

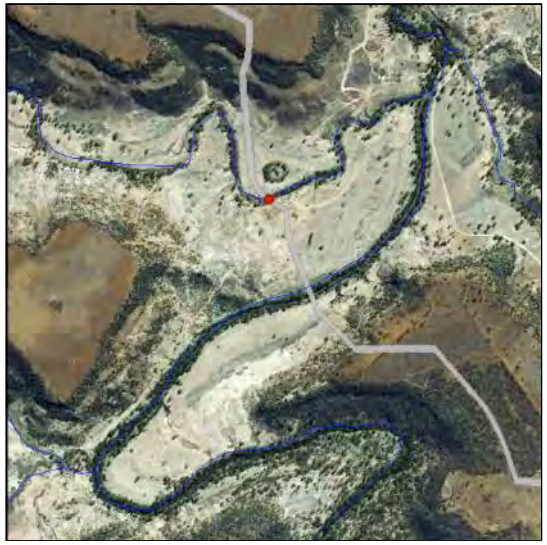
Apply the following specific management measures:

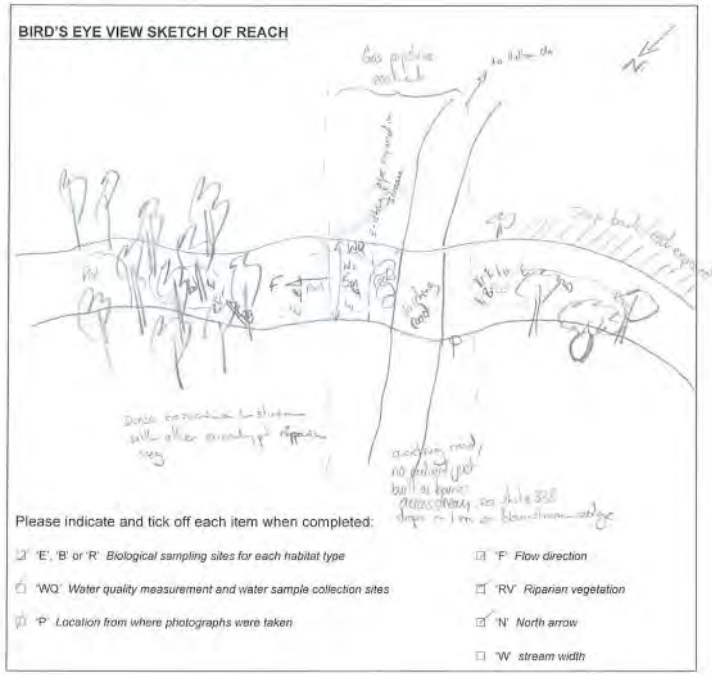
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Ensure pipeline crossing is as close as possible to existing gas pipe corridor to reduce disturbance. If workspace is isolated and there is water present, fish salvage required. Isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use or upgrade existing crossing if possible. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  | |
| **Right Bank** | |
|  | |

| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP20.4 Baffle Creek**<br>Catchment: Dawson River | **Easting**<br>687717.51 | **Northing**<br>7167722.81 |

*Stream Order and Geomorphology*
Stream Order 4
Narrow (3 m), moderately flowing perennial creek with shallow and deep pools present; a riffle was located approximately 50 m upstream of the crossing location. Situated within a sandstone gorge with steep sandy banks about 3 m high. Channel substrate had low compaction and was composed predominantly of sand with boulders (25%). Vegetated side and point bars were present.

*Erosion Risk*
Moderate. Low channel disturbance with some local bank erosion. Recent evidence of very high flows during the wet season survey; water was relatively turbid. Some local erosion present, indicated by poor water clarity and presence of suspended sediment.

*Riparian Vegetation*
Wide intact riparian zone of the right bank (25 m) and 10 m on the left bank. Riparian zone composed of bare ground and shrubs with some native small and large trees (eucalypt and callistemon) and some exotic species. Light shading of the river (10%) and little trailing bank vegetation (5%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Diverse aquatic flora including *Cyperus trinervis* (Australian flatsedge), *Juncus continuus* (sand rush), *Lomandra longifolia* (mat rush) and *Persicaria decipiens* (slender knotweed) was present at the site. Two species of native fish were caught: *Melanotaenia splendida* (eastern rainbowfish) and *Nematalosa erebi* (bony bream); no exotic fish species were present. Mussels and crayfish were present at the site. Fish habitat at the site included run and glide; structural habitat included large boulders, deep and shallow pools, trailing vegetation and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Possible habitat for white-throated snapping turtle (*Elseya albagula*)
Possible (but not preferred) habitat for Fitzroy River turtle (*Rheodytes leukops*)
Possible (but not preferred) habitat for platypus (*Ornithorhynchus anatinus*)

*Aquatic Values*
Habitat Bioassessment Score: 95 (Good)
Macroinvertebrate Richness: 10 (bed); 21 (edge)
Macroinvertebrate PET Richness: 2 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.12 (bed); 3.63 (edge)
Level of Disturbance: low

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

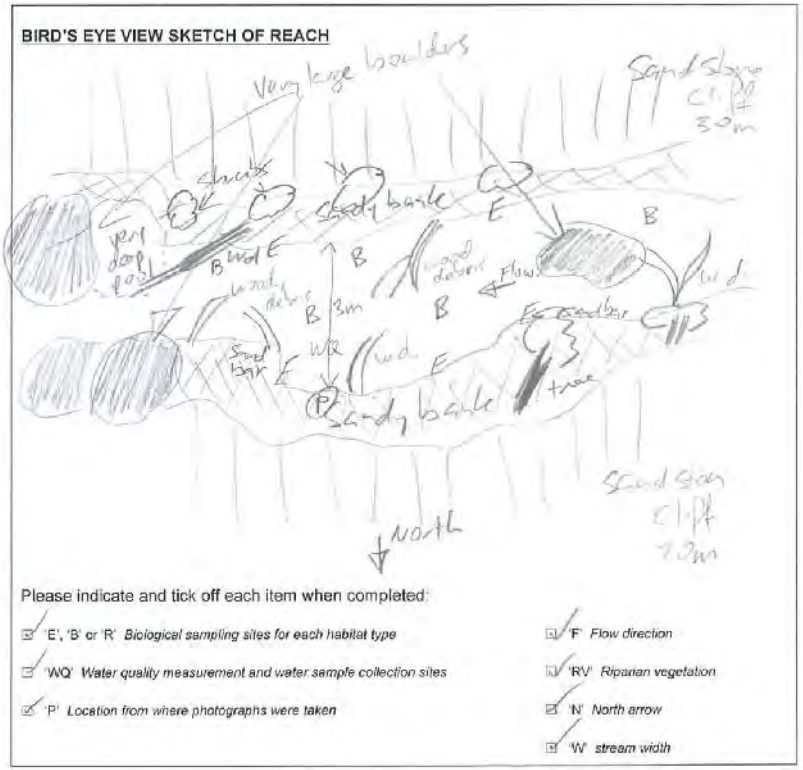
*Timing Constraints*
Dry season; avoid turtle and platypus breeding seasons

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Horizontal directional drilling (HDD) recommended. Open cut not feasible due to steep escarpment.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Construction of an access track crossing not feasible at this location due to steep escarpment.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  | |
| **Right Bank** | |
|  | |

| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **RCR47 Baffle Creek – Western crossing**<br>Catchment: Dawson River | **Easting**<br>687364.88 | **Northing**<br>7167681.78 |

*Stream Order and Geomorphology*
Stream Order 4
Narrow (5 m), incised stream within a high sandstone gorge (50 m cliffs). Stepped stream banks (10 m) were moderately steep and formed by sandstone bedrock. Vegetated point bars were present in the channel, forming 60% of the stream reach. Site characterised by a perennial water body present on a slow flowing intermittent stream. No evidence of high flows for an extended period of time. Channel substrate was stable with moderate compaction and comprised of gravel, pebbles and bedrock. The channel was in a natural state with very low disturbance.

*Erosion Risk*
Moderate. Some local catchment erosion evident, where upstream land use a likely factor. Sand and sediment deposits present on bends and behind obstructions. Sediment deposits at high risk of erosion in the event of high flows. Presence of bedrock component in channel substrate reduces risk of severe erosion.

*Riparian Vegetation*
Due to the cliffs, riparian zone was wider on the left bank (15 m), than on the right bank (5 m). Small trees (<10 m) dominated riparian vegetation with moderate presence of large trees and shrubs. Patches of grass and bare bedrock was also present. Species observed included native pine, eucalypt and callistemon; the exotic Noogoora burr (*Xanthium pungens*) was also present, but not in high numbers. Riparian vegetation provided stream shading (75%) and trailing bank vegetation (25%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Diverse aquatic flora including *Cyperus* sp., *Juncus* sp., *Lomandra* sp., *Carex* sp. and *Potamogeton* sp. was present at the site. Freshwater turtle were present; one adult *Wollumbinia latisternum* (saw-shelled turtle) was caught at this site. Two species of native fish were caught: *Melanotaenia splendida* (eastern rainbowfish) and *Hypseleotris* sp. (carp gudgeon); no exotic fish species were present. Freshwater shrimp (*Macrobrachium* sp.) were present at the site. Fish habitat at the site included riffle and pool; structural habitat included large boulders, deep and shallow pools, trailing vegetation and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Possible habitat for white-throated snapping turtle (*Elseya albagula*)
Possible habitat for Fitzroy River turtle (*Rheodytes leukops*)
Possible (but not preferred) habitat for platypus (*Ornithorhynchus anatinus*)

*Aquatic Values*
Habitat Bioassessment Score: 106 (Good)
Macroinvertebrate Richness: 27 (bed); 29 (edge); 34 (riffle)
Macroinvertebrate PET Richness: 6 (bed); 5 (edge); 8 (riffle)
Macroinvertebrate SIGNAL 2 Score: 4.13 (bed); 3.73 (edge); 4.71 (riffle)
Level of Disturbance: low

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Dry season; avoid turtle and platypus breeding seasons

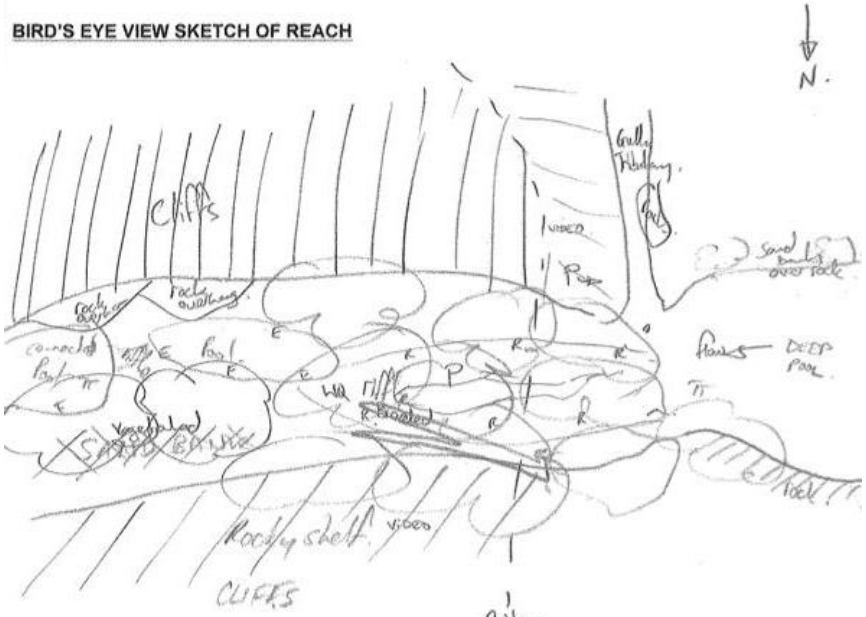
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Horizontal directional drilling (HDD) not feasible. Open trench in dry to low flow conditions. Isolate workspace, divert flows and implement fish salvage and water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete. Construction not recommended in moderate to high flow conditions.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Construction of an access track crossing not recommended at this location due to steep escarpment.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**




Please indicate and tick off each item when completed:

| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  | |
| **Right Bank** | |
|  | |

| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP25.3 Edwards Creek**<br>Catchment: Dawson River | **Easting**<br>688763.07 | **Northing**<br>7171730.48 |

*Stream Order and Geomorphology*
Stream Order 2
Ephemeral watercourse with moderate isolated temporary pool present; otherwise dry. Surrounding land use was native forest with light grazing. Left and right banks of moderate gradient, about 1 m high. Recent high flow was a factor affecting bank stability. Packed and unarmoured channel substrate, dominated by bedrock, cobble and pebbles.

*Erosion Risk*
Low. Low disturbance within catchment.

*Riparian Vegetation*
Riparian vegetation was semi-continuous and extensive on both the left and right banks, characterised by large and small native trees (eucalypt and Cyprus pines), shrubs and grasses. Patches of bedrock were also present in the riparian zone. Light shading of the river (10%) and trailing bank vegetation (15%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Five macrophyte species were present at the time of survey, including *Eleocharis cylindrostachys* (spikerush), *Juncus continuus* (sand rush), *Fimbristylis dichotoma* (common fingerush), *Glyceria maxima* (reed sweetgrass) and *Lomandra longifolia* (mat rush). Freshwater prawns were very abundant. Riffle and cascade habitat would exist during high flows. Undercut banks and boulders provided in-stream habitat within the isolated pool.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is highly unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 67 (moderate)
Macroinvertebrate Richness: 18 (bed),26 (edge)
Macroinvertebrate PET Richness: 4 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 2.54 (bed); 3.25 (edge)
Level of Disturbance: low

Overall Aquatic Values:
Dry Season: Low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

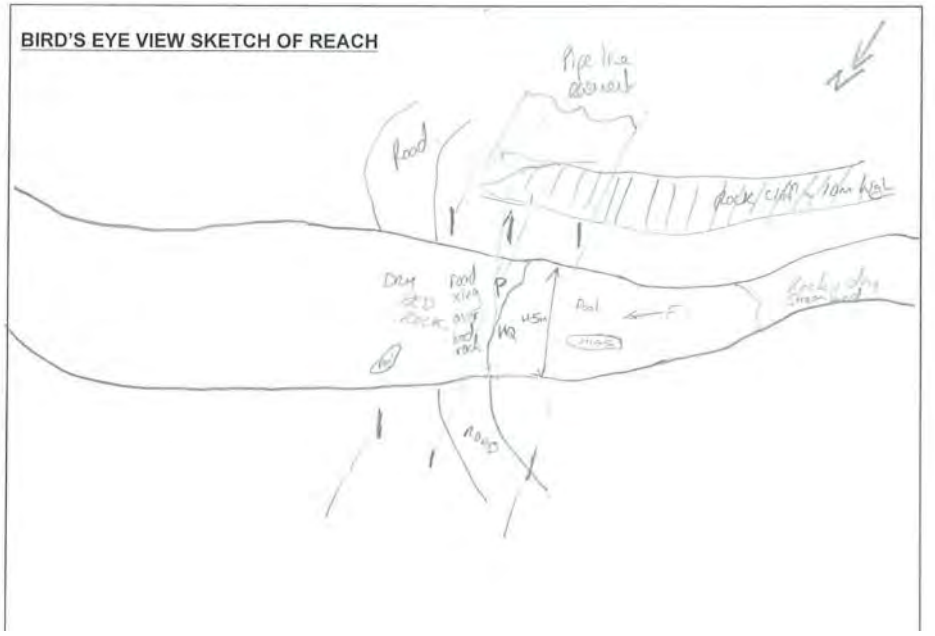
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If wet and workspace is isolated, fish salvage required. If flowing, isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAAF (does not meet requirements of self-assessable code due to large bankfull width). Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete. Any disturbance to bedrock will need to be rehabilitated and sealed so that it is not permeable to water.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP28.7 unnamed watercourse 1**<br>Catchment: Dawson River | **Easting**<br>689498.53 | **Northing**<br>7174788.03 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse. Native forest and light grazing was the surrounding land use. Wide and shallow valley with moderately sloping banks >20 m high; channel was narrow (< 2 m) and dry with a stable substrate comprised of hard dry and compacted red clay; substrate particle size was dominated by silt / clay and some sand. A grassed overflow channel was found adjacent to this channel. A few native emergent aquatic plants were located near the channel, but the site was mostly overgrown by tall grass and weeds.

*Erosion Risk*
Moderate channel disturbance with some local catchment erosion. Minor erosion at hole/dry pool in the main channel.

*Riparian Vegetation*
Semi-continuous riparian vegetation present on left and right banks of the valley, stretching over 100 m into eucalypt woodland and grassland. Large native trees and grasses surrounded the site; moderate shrubs and small trees were present. Weed species present within channel.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, some macrophytes including *Carex, Lomandra*, *Juncus* and *Cyperus* species. No aquatic fauna present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is highly unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 55 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

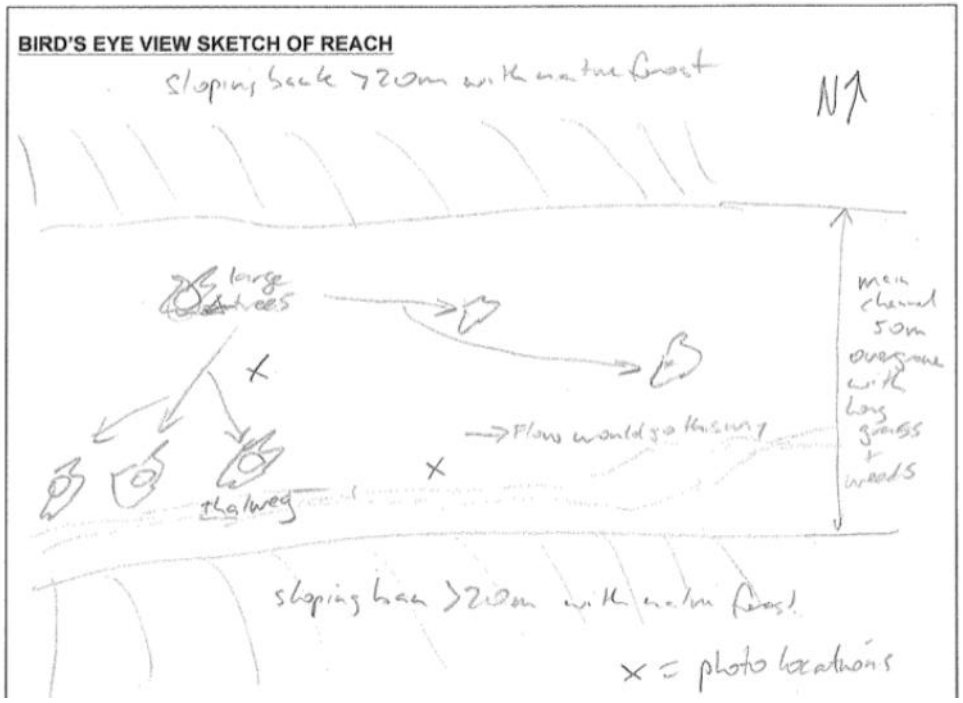
*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

**Aerial Photograph of KP**





| Downstream | Upstream |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP29.8 Dawson River (southern)**<br>Catchment: Dawson River | **Easting**<br>690146.74 | **Northing**<br>7175586.98 |

*Stream Order and Geomorphology*
Stream Order 5
Relatively wide (7 m), very slow flowing turbid water. Site characterised by an intermittent water body with intermittent flows with a mildly sinuous channel pattern. Large deep pool at downstream end and some woody debris present, especially upstream of the crossing location. Left and right banks steep, 12–15m high. Stock, clearing of vegetation and vehicle tracks were factors affecting bank stability. Channel substrate had low compaction and was composed predominantly of silt / clay with some sand deposits.

*Erosion Risk*
Bed stable. Moderate disturbance within catchment with some erosion.

*Riparian Vegetation*
Relatively wide semi-continuous riparian zone (20 m) composed of grass with large native trees (eucalypt, casuarina and callistemon) with some smaller native trees and shrubs also present. Moderate presence of weeds and moderate amount of trailing vegetation along the banks.

*Aquatic Flora and Fauna, Including Breeding Habitat*

Scattered aquatic flora included *Carex inversa* (knob sedge), *Cyperus gracilis* (gracile flatsedge), *Juncus usitatus* (common rush), *Paspalum distichum* (water couch) *and Persicaria hydropiper* (water pepper). In-stream habitat included shallow and deep connected runs and pools with large woody debris, undercut banks, aquatic plants and trailing vegetation. The site provides dispersal and breeding habitat for aquatic species. Fauna included native freshwater fish such as *Hypseleotris* spp. (carp gudgeon), *Melanotaenia splendida* (eastern rainbowfish) and *Nematalosa erebi* (bony bream), and freshwater shrimps and prawns. No turtles were caught during the survey.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
Unlikely preferred habitat for Fitzroy River turtle (*Rheodytes leukops*), but possible habitat for white-throated snapping turtle (*Elseya albagula*)

*Aquatic Values*
Habitat Bioassessment Score: 66 (Moderate)
Macroinvertebrate Richness: 11 (bed); 25 (edge)
Macroinvertebrate PET Richness: 2 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.68 (bed); 3.52 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate to High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

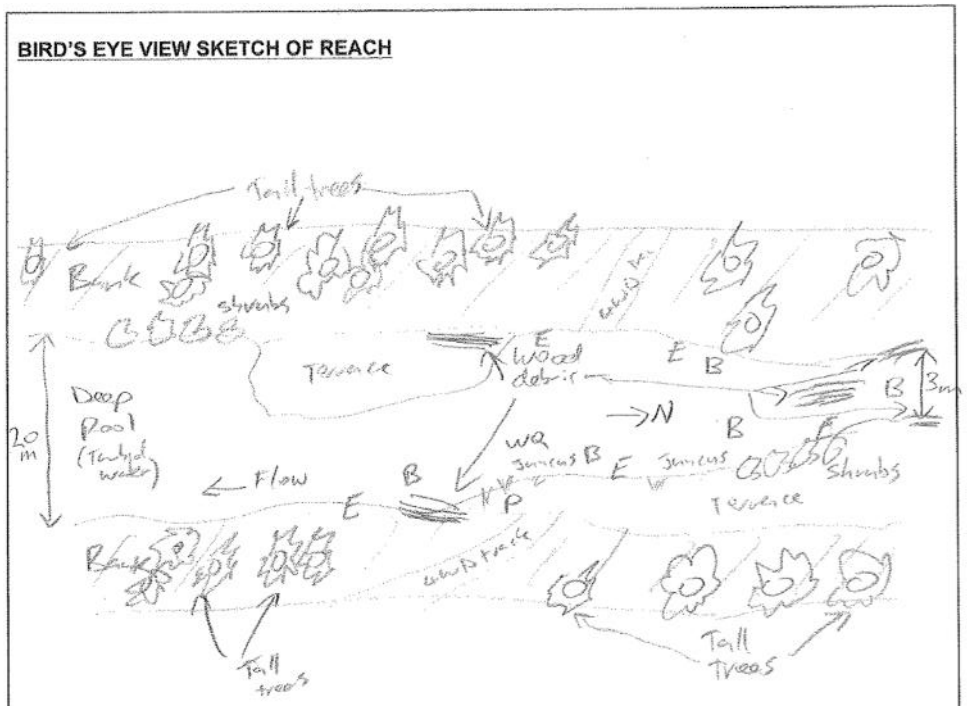
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Otherwise, construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP45.9 Bully Frog Creek**<br>Catchment: Comet River | **Easting**<br>690349.36 | **Northing**<br>7190703.81 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse with grazing as the dominant surround land use. Channel substrate dominated by silt / clay, with evidence of localised sand deposition and moderate compaction. Vegetated side bars present in the channel and a sand bar on right bank upstream of crossing. Right bank is steep (1.5 m) and the left bank vertical (2.5 m); both banks with moderate bank stability. Stock access and vegetation clearing were affecting bank stability.

*Erosion Risk*
Moderate. Very high disturbance throughout the catchment, with heavy erosion upstream and 100 m downstream of crossing. Bank erosion present due to high bank slope.

*Riparian Vegetation*
Many dead trees present and the bed and banks had moderate grass cover. The riparian zone was relatively narrow, with moderate presence of exotic species extending 1 m only on the left bank. Dominated by native and exotic grasses, with occasional clumps of vegetation, mainly Brigalow. There were also moderate amounts of bare ground.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, no aquatic flora or fauna present. Structural habitat composed of logs, branches and terrestrial leaves and twigs.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 23 (poor).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Negligible
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

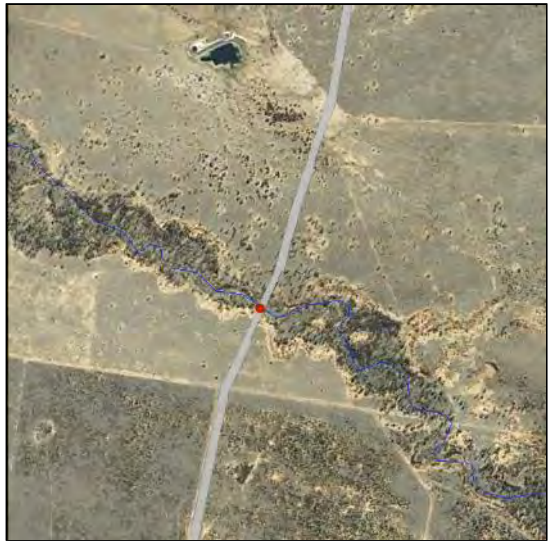
*Timing Constraints*
Nil (no EVR species likely to be present).

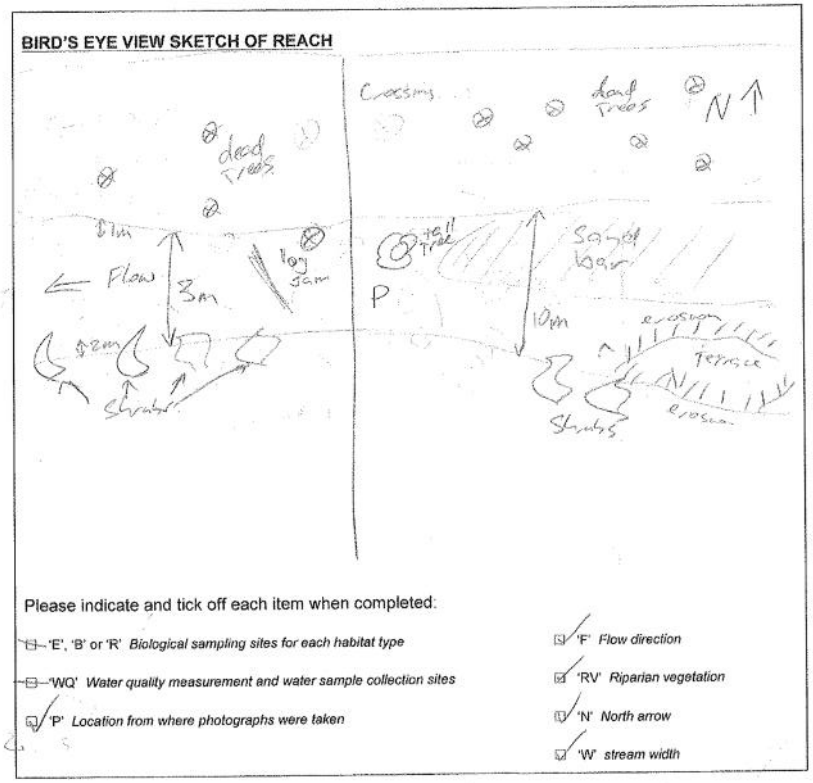
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Revegetate and re-profile banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity at a minimum).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford or causeway. Revegetate and re-profile banks and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP57.4 Unnamed watercourse 2**<br>Catchment: Comet River | **Easting**<br>688604.13 | **Northing**<br>7201768.53 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse. Grazing was the dominant surrounding land use. Channel substrate dominated by silt / clay, with evidence of heavy erosion and low compaction. Left and right banks were very steep (1.5 m) with poor bank stability. Stock access and vegetation clearing were affecting bank stability.

*Erosion Risk*
Moderate. Very high disturbance throughout the catchment, with significant erosion. Bank erosion present due to high bank slope and clearing of native vegetation.

*Riparian Vegetation*
Isolated to no riparian zone on both banks; only very isolated Brigalow. Extensive bare ground with moderate grass and weed species present.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, no aquatic flora or fauna present; no in-stream habitat present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 7 (poor).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Negligible
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

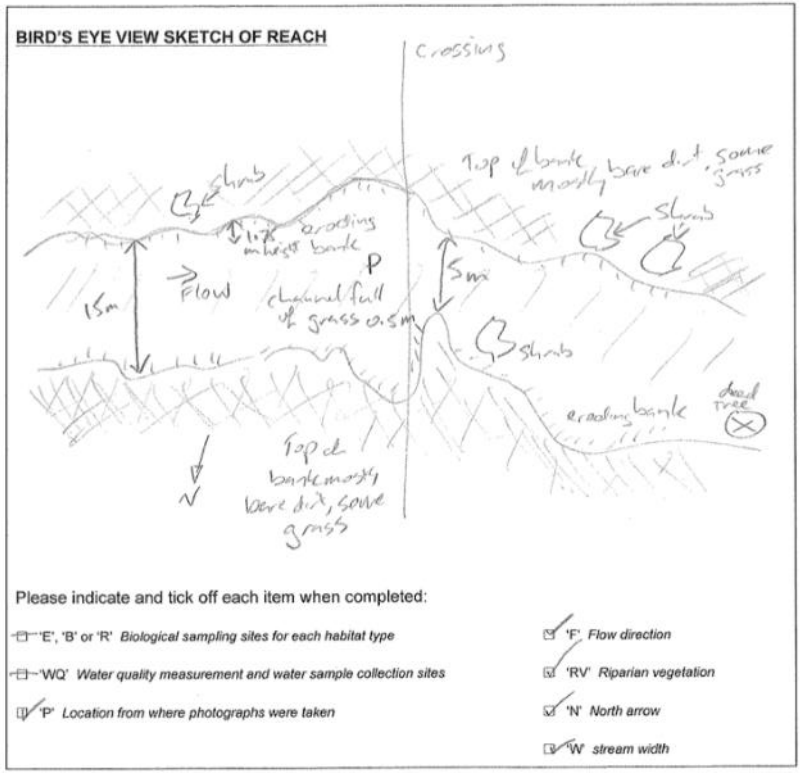
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Revegetate and re-profile banks.

If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity at a minimum).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford or causeway. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP62.3 Ironbark Creek**<br>Catchment: Comet River | **Easting**<br>687904.12 | **Northing**<br>7206559.27 |

*Stream Order and Geomorphology*
Stream Order – 3
Dry, ephemeral watercourse with a relatively narrow deep stream. Several very shallow turbid pools present that would have dried completely shortly after the survey. Considerable sandy deposits, some vegetated mid-channel bars (15%). Vertical slopes on both banks; stability could be affected by the clearing of vegetation. Substrate moderately compacted and composed primarily of silt / clay and sand, with some gravel.

*Erosion Risk*
Moderate. High disturbance and minor erosion within channel and some local catchment erosion.

*Riparian Vegetation*
The riparian zone was characterised by exotic grasses and large native trees (eucalypt) and regularly spaced along both banks (width 20m). Cover of trailing bank vegetation was high (50%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic plants present include *Juncus usitatus* (common rush), *Cyperus difformis* (dirty dora), *Persicaria decipiens* (slender knotweed), *Lomandra longifolia* (mat rush). Structural habitat consisted of very small pools due to overnight rain and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 61 (Moderate)
Macroinvertebrate Richness:
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low, possibly Moderate in an above average wet season

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

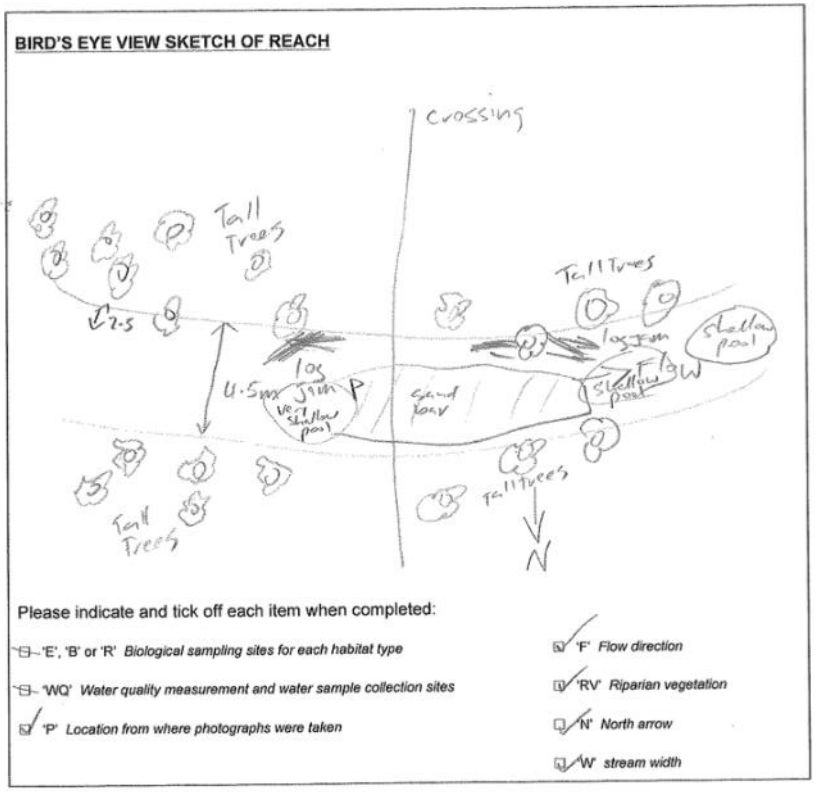
If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity at a minimum). Access may be difficult in wet season.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford or causeway. Re-profile and revegetate banks as they are quite steep. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**




Please indicate and tick off each item when completed:

- ☐ 'E', 'B' or 'R' *Biological sampling sites for each habitat type*
- ☐ 'WQ' *Water quality measurement and water sample collection sites*
- ☑ 'P' *Location from where photographs were taken*
- ☑ 'F' *Flow direction*
- ☑ 'RV' *Riparian vegetation*
- ☑ 'N' *North arrow*
- ☑ 'W' *stream width*

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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
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| **KP80.8 unnamed watercourse 3**<br>Catchment: Fitzroy River | **Easting**<br>680406.00 | **Northing**<br>7222494.00 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, located within a paddock. Channel substrate dominated by silt and clay, characterised by low compaction of sediment.

*Erosion Risk*
Low

*Riparian Vegetation*
The riparian zone was relatively narrow, but extended further on the left bank (1.5 m) than on the right bank (0.5 m). Occasional clumps of vegetation were present along the bank, dominated by native and exotic grasses. There were also moderate amounts of bare ground with a few shrubs and small trees.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Two macrophyte species, both *Cyperus*, were present at the time of survey, with coverage of 11%. No aquatic fauna was present as the site was dry. There was limited structural habitat at the site.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 29 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Negligible – Low
Wet Season: Negligible – Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

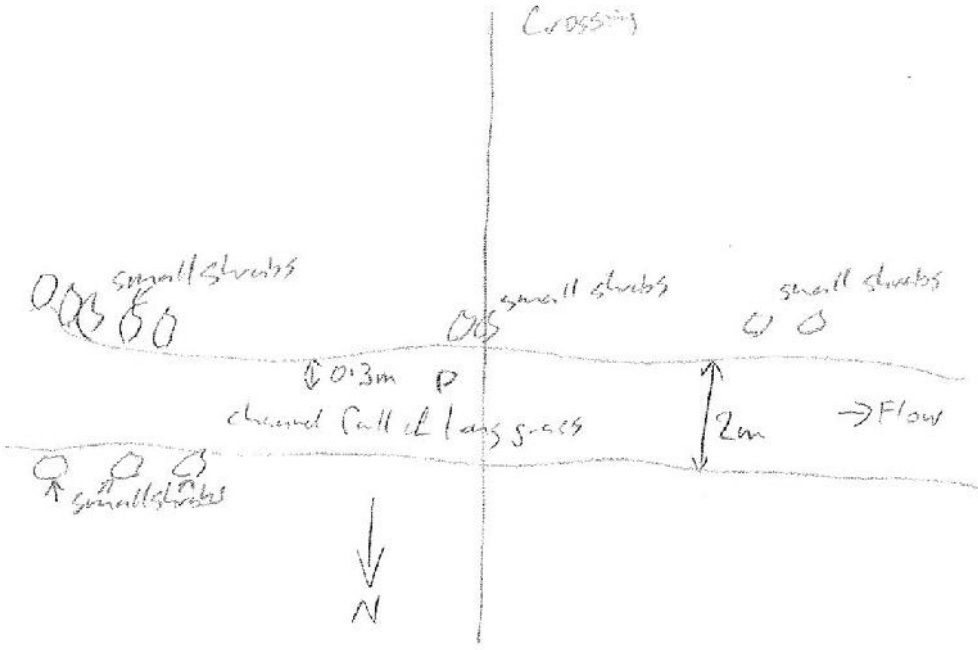
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation If construction is in wet season: Open trench. If water present, implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



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| | Coordinates (Zone 55J, WGS 84) | |
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| **KP108.6 Clematis Creek**<br>Catchment: Fitzroy River | **Easting**<br>681340.08 | **Northing**<br>7250438.74 |

*Stream Order and Geomorphology*
Stream Order 5
Intermittent watercourse, not flowing at the time of survey. Relatively wide, deep channel. Watercourse mostly dry, with some shallow pools (0.4 m) approximately 40 m upstream of crossing location. Left and right banks steep and relatively high (10 m). In-channel bars common covering 85% of streambed; side and point bars present with vegetation on some bars. Moderately compacted channel substrate dominated by sand and gravel.

*Erosion Risk*
Low to moderate. Moderate disturbance within catchment. Erosion present on right bank.

*Riparian Vegetation*
The riparian zone was similar on each bank being approximately 20 m wide and characterised by regularly spaced vegetation along the watercourse. Native and exotic grasses dominated riparian vegetation; there was moderate coverage of large native trees. Some small trees and weeds were also present at time of survey.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Six macrophyte species were present at the time of survey, including *Cyperus, Juncus, and Persicaria* species, covering 15% of the total area. Four native fish species were caught, including spangled perch (*Leiopotherapon unicolor)* and purple spotted gudgeon (*Mogurnda adspersa*); these species are adapted to living in ephemeral watercourses.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is highly unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 71 (moderate).
Macroinvertebrate Richness: 21 (bed), 31 (edge)
Macroinvertebrate PET Richness: 4 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.19 (bed); 3.42 (edge)
Level of Disturbance: moderately disturbed

Overall Aquatic Values:
Dry Season: Low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

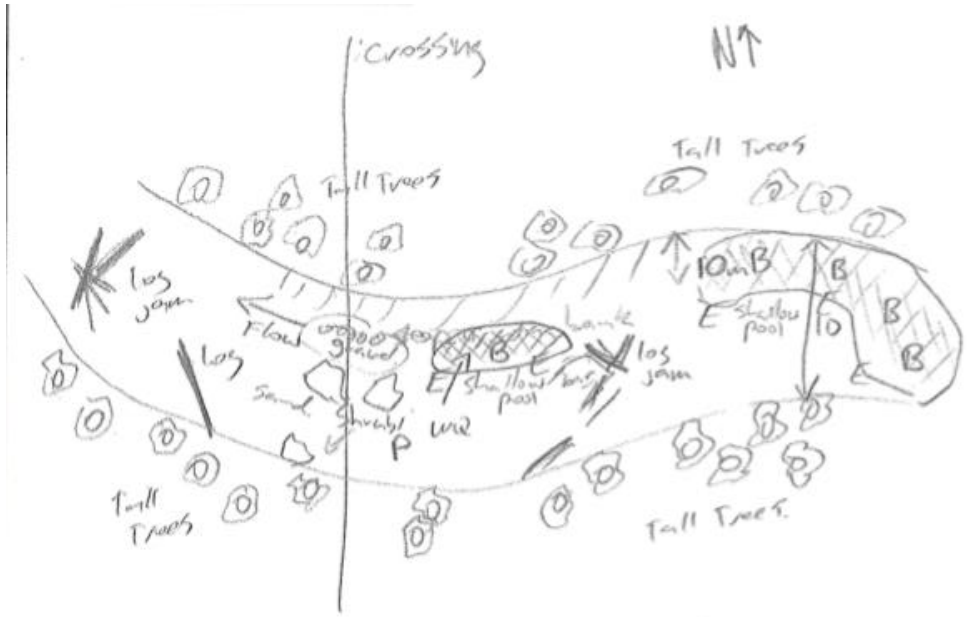
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench recommended in dry season. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If wet, fish salvage required. If flowing, isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DEEDI (does not meet requirements of self-assessable code due to large bankfull width).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culvert. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





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| | Coordinates (Zone 55J, WGS 84) | |
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| **KP111.3 May Creek**<br>Catchment: Fitzroy River | **Easting**<br>682201.00 | **Northing**<br>7253013.00 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, intermittent watercourse, located within a paddock. Channel substrate dominated by sand, characterised by low compaction and moderate aggradation of sediment, namely sand. Mid-channel vegetated bars present, with 70% of streambed forming a bar. Left and right banks were 2 m high and steep. Overall bank stability rated low, affected by vegetation clearing and stock access.

*Erosion Risk*
Moderate. Very high disturbance throughout the catchment. Evidence of eroding banks and sand deposition on channel bed.

*Riparian Vegetation*
The riparian zone was relatively narrow, but extended further on the left bank (0.5 m) than on the right bank (0.2 m). Occasional clumps of vegetation were present along the bank, dominated by native and exotic grasses. There were also moderate amounts of bare ground with a few shrubs and small trees.

*Aquatic Flora and Fauna, Including Breeding Habitat*
One macrophyte species was present at the time of survey, *Glyceria maxima* with a coverage of 20%. No aquatic fauna was present as the site was dry. Structural habitat included undercut banks, large woody debris (logs, branches and leaves) and tree roots.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 16 (poor).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

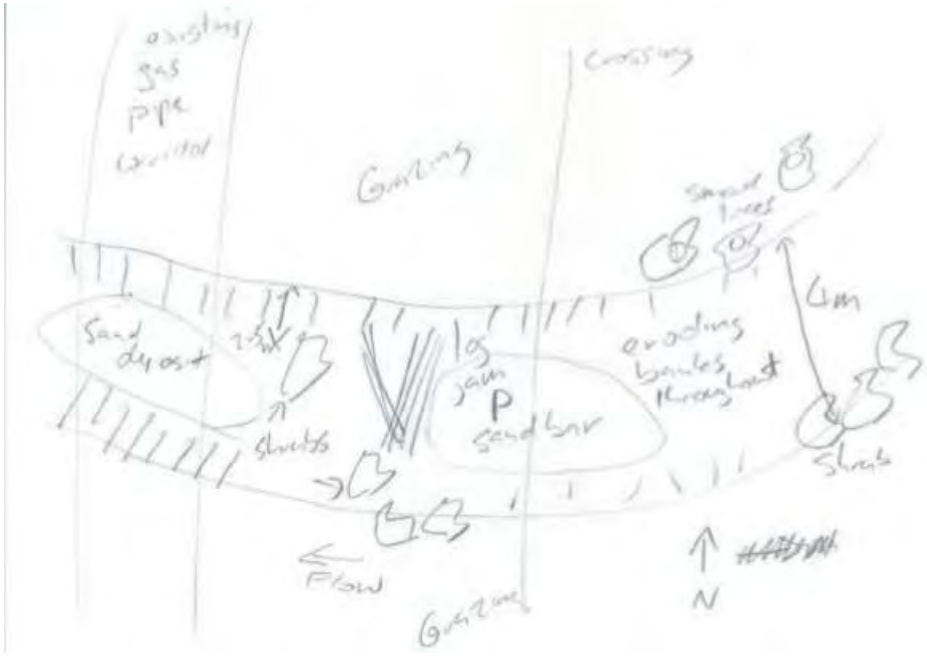
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If construction is in wet season: Open trench. If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitation as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP124.5 Deep Creek**<br>Catchment: Fitzroy River | **Easting**<br>690237.00 | **Northing**<br>7262886.00 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Channel substrate dominated by sand, with evidence of moderate erosion and localised sand deposition. Vegetated bars present in the channel. Left and right banks steep (2 m) with poor bank stability. Stock access, tracks, vegetation clearing and water factors were affecting bank stability.

*Erosion Risk*
Moderate. Very high disturbance throughout the catchment, with moderate levels of erosion. Bank erosion present due to high bank slope.

*Riparian Vegetation*
The riparian zone was relatively narrow, extending 0.5 m on the left bank and 1.0 m on the right bank. Occasional clumps of vegetation were present along the bank, mainly native and exotic grasses. There were also moderate amounts of bare ground and some large trees. Some stream cover and trailing vegetation was provided by the riparian vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, no aquatic flora or fauna present. Structural habitat composed of logs, branches and undercut banks (10% on right bank).

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 24 (poor).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If construction is in wet season: Open trench. If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**



| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP133.9 unnamed watercourse 4**<br>Catchment: Fitzroy River | **Easting**<br>697375.00 | **Northing**<br>7268652.00 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by light grazing land. Shallow, irregular channel with moderately sloping banks 0.5 m high. A grassed overflow channel was found adjacent to the main channel. The main channel had a stable substrate with low compaction; substrate particle size was dominated by sand and silt / clay. Point bars present, forming 25% of streambed.

*Erosion Risk*
Low to Moderate. Low disturbance throughout the catchment, with some local catchment erosion. Bank erosion present on right bank.

*Riparian Vegetation*
Semi-continuous riparian vegetation present on left and right banks, stretching over 100 m into Eucalypt woodland. Large native trees and grasses surrounded the site; few shrubs or small trees were present.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, some macrophytes including *Juncus* and *Cyperus* species. No aquatic fauna present. Structural habitat composed of large woody debris, roots and undercut banks (5% on both banks).

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: 49 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: low

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation If construction is in wet season: Open trench. If water present, isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring if flowing (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP177.3 unnamed palustrine wetland**<br>Catchment: Fitzroy River | **Easting**<br>735988.63 | **Northing**<br>7279484.82 |

*Stream Order and Geomorphology*
Stream Order –
Palustrine wetland of moderate size, spanning approximately 100m from east to west. Site surrounded by grazing land where a wetland has formed at the base of a gradual slope. Wetland drains into an anabranch of Prospect Creek. Substrate composed primarily of silt with some sand.

*Erosion Risk*
Moderate. High disturbance within catchment. Obvious evidence of clearing for existing gas line.

*Riparian Vegetation*
The riparian zone was characterised by large native trees (eucalypt and brigalow) and grasses with some small trees and shrubs. Riparian vegetation was not present on the right bank, however it extended 30 m on the left bank.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Dense (100%) coverage of macrophytes with high species diversity, including *Cyperus bifax* (downs nutgrass), *Cyperus concinnus* (trim flat sedge), *Eleocharis pallens* (pale spike sedge) *and Leptochloa digitata* (umbrella canegrass). Exotic and native species of fish were present. *Ambassis agassizii*., *Hypseleotris* spp. and *Gambusia holbrooki* (eastern gambusia) were caught during the field survey. Structural habitat consisted of a pools, floating macrophytes and emergent macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
The Fitzroy River turtle (*Rheodytes leukops*) is highly unlikely to occur at the crossing location due to lack of suitable habitat.

*Aquatic Values*
Habitat Bioassessment Score: not applicable
Macroinvertebrate Richness: 34
Macroinvertebrate PET Richness: 1
Macroinvertebrate SIGNAL 2 Score: 2.59
Level of Disturbance: moderate - high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: High (due to the potential habitat for listed frogs)

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

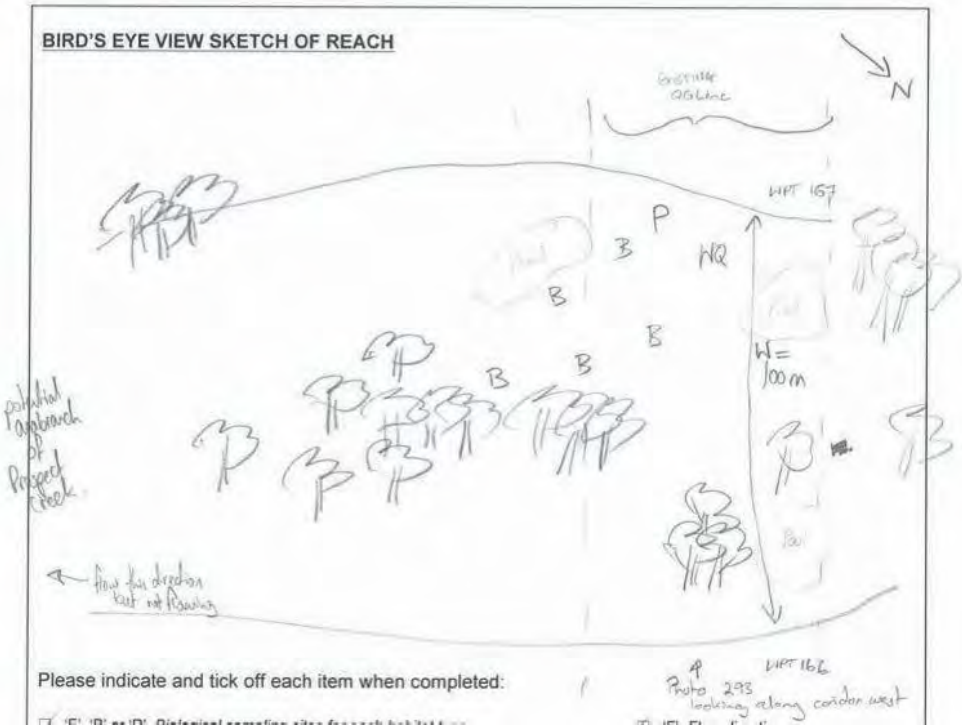
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench recommended in dry season. Revegetate wetland and replace other habitat elements (e.g. large woody debris) when construction complete.

Additional mitigation: Implement frog survey using qualified ecologists prior to construction. Fish, frog and other aquatic fauna salvage necessary if wet. Retain topsoil for use in rehabilitation works. Isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DEEDI (does not meet requirements of self-assessable code due to large bankfull width).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP177.7 Prospect Creek**<br>Catchment: Fitzroy River | **Easting**<br>736562.00 | **Northing**<br>7279705.00 |

*Stream Order and Geomorphology*
Stream Order 4
Relatively wide (20 m), slow flowing creek. Site characterised by a perennial water body with intermittent flows; water level was above the watermark at the time of survey. The left bank was 2 m with a low gradient; the right bank was 1 m with a low gradient. Stock and runoff were factors affecting bank stability. Channel substrate had low compaction and was composed predominantly of silt / clay with some sand. Although no bars were present there was a moderate build up of sediment in the shallow channel.

*Erosion Risk*
Moderate. Moderate disturbance within catchment with some erosion. Recent evidence of high flows due to flooding. Some local erosion present, indicated by poor water clarity and presence of suspended sediment.

*Riparian Vegetation*
Relatively wide riparian zone (20 m) composed of small and large native trees (eucalypt and acacia) with some grass and shrubs also present. Moderate amounts of trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic flora including *Cyperus exaltatus* (giant sedge), *Myriophyllum spicatum* (spike water-milfoil) *Potamogeton sulcatus* (floating pondweed) and *Paspalum* sp. Relatively high diversity and abundance of native and exotic fish, including *Ambassis agassizii*, *Hypseleotris* spp. and *Gambusia holbrooki* (eastern gambusia). Site provides dispersal and breeding habitat for aquatic species. It is unlikely that the Fitzroy River turtle (*Rheodytes leukops*) occurs at this location. Structural habitat was composed of pools (80%), run glide (20%), large woody debris and macrophytes (fragments and large patches of floating vegetation).

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 50 (Moderate)
Macroinvertebrate Richness: 26 (bed); 44 (edge)
Macroinvertebrate PET Richness: 3 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.79 (bed); 2.91 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

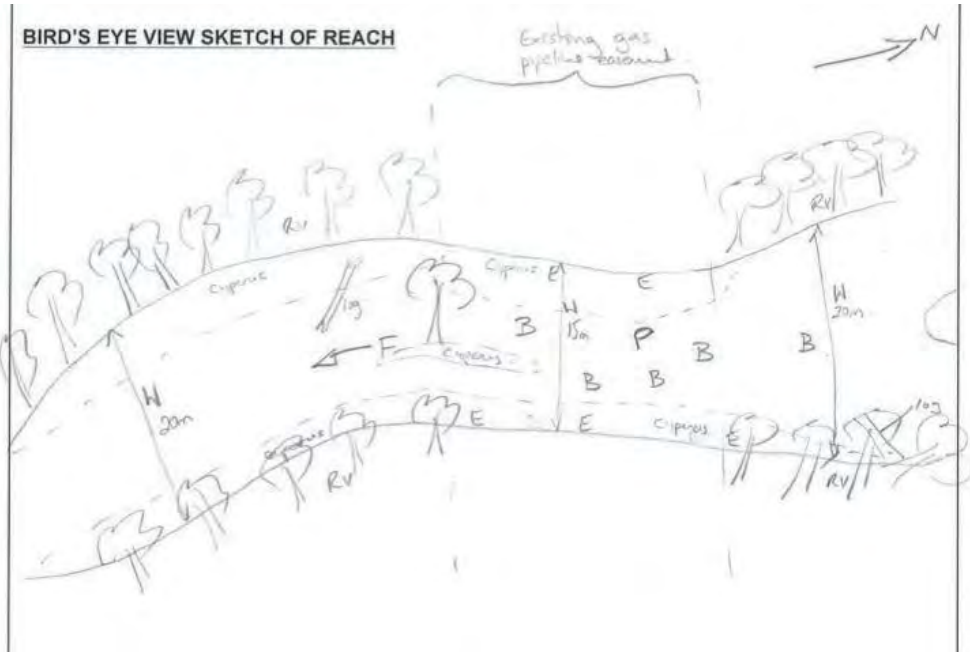
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench recommended in dry season. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If wet, fish salvage required. Isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DEEDI (does not meet requirements of self-assessable code due to large bankfull width).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culverts. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **Prospect Creek RCR**<br>Catchment: Fitzroy River | **Easting**<br>735883.99 | **Northing**<br>7280331.29 |

*Stream Order and Geomorphology*
Stream Order 4
Relatively narrow (3 m), slow flowing creek. Site characterised by dry section of streawith drying pools both upstream and downstream of the crossing locations. The left bank was 2 m with a steep gradient; the right bank was 3 m with a moderate gradient. Stock and vegetation clearing were factors affecting bank stability. Channel substrate had low compaction and was composed predominantly of silt / clay with some sand. There was a small amount of bar development.

*Erosion Risk*
Moderate. Moderate disturbance within catchment with some erosion. Recent evidence of high flows due to flooding. Some local erosion present, indicated by poor water clarity and presence of suspended sediment.

*Riparian Vegetation*
Scattered riparian vegetation (5-10 m) composed of small and large native trees (eucalypt and acacia) with some grass and shrubs also present. Moderate amounts of trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic flora including *Cyperus exaltatus* (giant sedge), *Juncus* sp., *Myriophyllum spicatum* (spike water-milfoil) and *Potamogeton sulcatus* (floating pondweed). Relatively high diversity and abundance of native and exotic fish, including *Ambassis agassizii*, *Hypseleotris* spp. and *Gambusia holbrooki* (eastern gambusia). Site provides dispersal and breeding habitat for aquatic species. It is unlikely that the Fitzroy River turtle (*Rheodytes leukops*) occurs at this location. Structural habitat was composed of dry stream bed and isolated pools both upstream and downstream of the crossing location.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 55 (Moderate)
Macroinvertebrate Richness: 17 (bed); 33 (edge)
Macroinvertebrate PET Richness: 3 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.43 (bed); 3.38 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

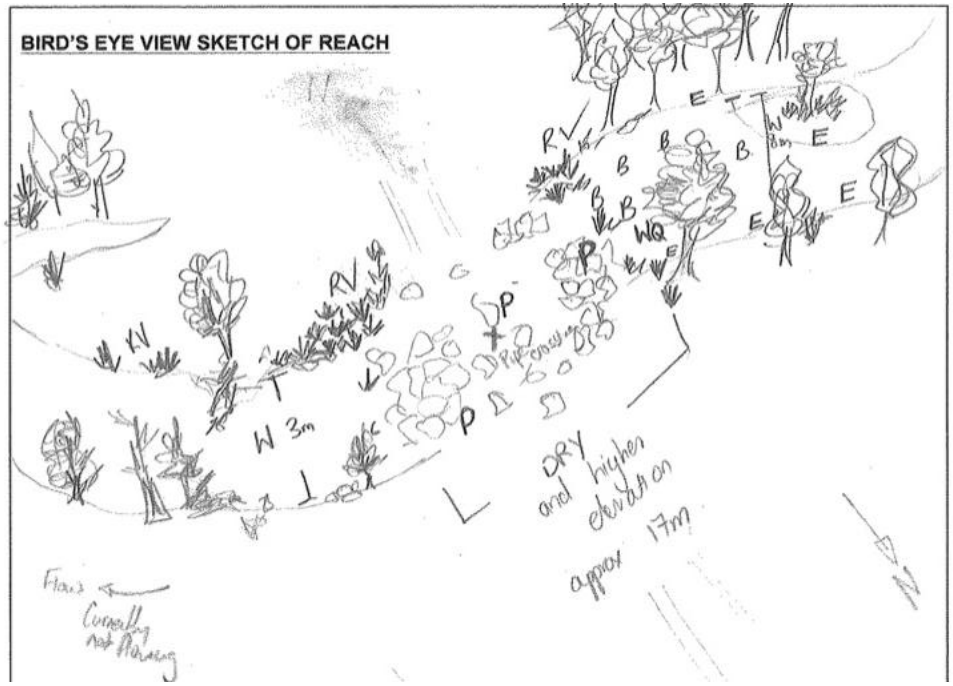
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench recommended in dry season. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If wet, fish salvage required. Isolate workspace, divert flows and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DEEDI (does not meet requirements of self-assessable code due to large bankfull width).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culverts. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| Right Bank | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP184.1 unnamed watercourse 5**<br>Catchment: Fitzroy River | **Easting**<br>742472.00 | **Northing**<br>7281878.00 |

*Stream Order and Geomorphology*
Stream Order 3
Moderately wide (10 m), ephemeral watebody, not flowing at the time of survey. Site characterised by an isolated shallow pool. Left and right banks were low (1.5 m) with low slope. Overall bank stability was low, affected by runoff, floodplain scours, stock access and vegetation clearing (existing pipeline also present). Channel substrate had low compaction and was comprised of silt / clay with a small component of sand; no bars were present. Grazing was the adjacent land use.

*Erosion Risk*
High. Pre-existing disturbance and rehabilitation along pipeline alignment. Sedimentation high within the channel. Stock access causing extensive damage to bank stability.

*Riparian Vegetation*
Riparian zone comprised of large Eucalypt trees and grass with some bare ground. Riparian vegetation had good coverage, extending 10 m on the left bank and 5 m on the right bank. Riparian vegetation provided shading to 15% of the watercourse.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora was composed of native macrophyte species including *Marsilea mutica* (nardoo) and *Cyperus difformis* (dirty dora). There was high abundance of fish at the site, where exotic and native fish species were caught, including *Gambusia holbrooki* (eastern gambusia) and *Ambassis agassizii*. These species are adapted to living in harsh ephemeral environments. Structural habitat was comprised of macrophytes (emergent), shallows, pools and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 42
Macroinvertebrate Richness: 19 (bed); 30 (edge)
Macroinvertebrate PET Richness: 4 (bed); 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 2.67 (bed); 2.97 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

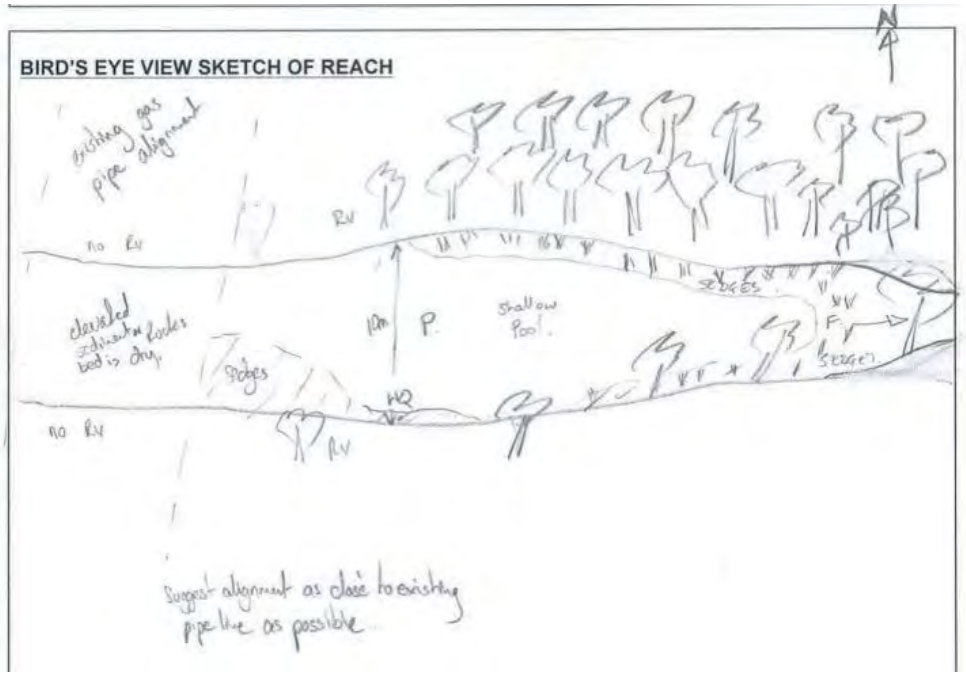
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench recommended in dry season. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: Ensure pipeline crossing is as close as possible to existing gas pipe corridor. Fish salvage required if wet. Isolate workspace and divert flows in accordance with self-assessable code for temporary waterway barrier works. Implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity).

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP207.4 Conciliation Creek**<br>Catchment: Dawson River | **Easting**<br>764464.78 | **Northing**<br>7289412.67 |

*Stream Order and Geomorphology*
Stream Order 5
Stream width 30 m; surrounding land use was grazing on both banks and some native forest on the left bank. Slow water flow and the water level was above the watermark at time of survey (>2.5 m deep). The left bank was 4 m with a moderate gradient; the right bank was 5 m with a steep gradient. Runoff and flow were factors that were affecting channel stability. Channel substrate had low compaction and was composed of sand and silt / clay.

*Erosion Risk*
Moderate. Some local catchment erosion from grazing present.

*Riparian Vegetation*
Riparian zone was 10 m on the left and 5 m on the right; consisting of grass and large native tree species (eucalypt) and some exotic riparian species. Some trailing bank vegetation and moderate shading of the river.

*Aquatic Flora and Fauna, Including Breeding Habitat*
No aquatic flora as this ephemeral watercourse is likely dry for most months. Fish were caught, including *Ambassis agassizii*, *Hypseleotris* spp. and *Scortum hillii*. Structural habitat was composed of deep pools due to high flows associated with recent heavy rainfall; undercut banks, trailing roots and large woody debris. Site provides dispersal habitat for aquatic species, but is unlikely to provide key breeding habitat.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 79 (Good)
Macroinvertebrate Richness: 23 (edge)
Macroinvertebrate PET Richness: 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.15 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

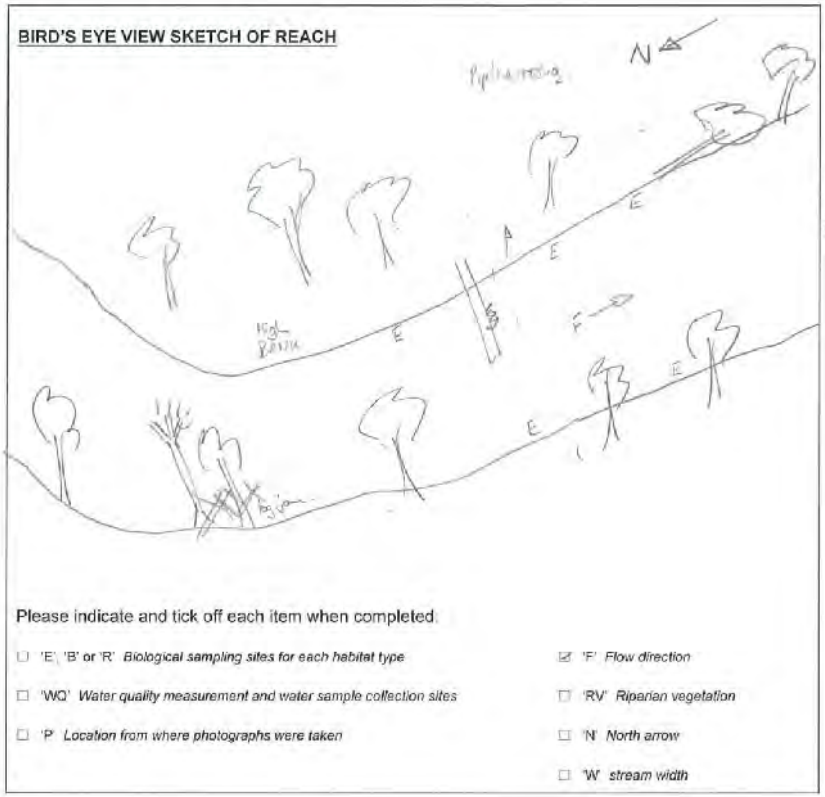
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Otherwise, construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP214.8 Brolga gully**<br>Catchment: Dawson River | **Easting**<br>771697.89 | **Northing**<br>7290884.68 |

*Stream Order and Geomorphology*
Stream Order 3
Moderate stream width (10 m); surrounding land use was grazing. Intermittent flow regime and water body; water level was above the watermark at time of survey. Both banks were relatively flat and 0.5 m high. Channel substrate had low compaction and was composed mostly of silt / clay with some sand and lots of organic matter due to grass that has been inundated.

*Erosion Risk*
Low. Dam / weir downstream. No local catchment or channel erosion. Factors that were affecting stability include flow, vegetation clearing and stock.

*Riparian Vegetation*
Mostly exotic riparian vegetation present consisting of mainly grasses and parthenium with little shrub cover. Little shading of the river and trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora including *Cyperus* spp., *Marsilea mutica*, *Blyxa auberti*, *Alternanthera denticulata*, *Potamogeton javanicus*, *Myriophyllum salsugineum* and *Ludwigia* sp.. *Caradina* sp. (freshwater shrimp) was caught as were several fish species; *Ambassis agassizii*, *Melanotaenia splendida* and *Leiopotherapon unicolour*. Structural habitat was composed of shallow and deep pools, aquatic flora, filamentous algae and some large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 55 (Moderate)
Macroinvertebrate Richness: 20 (bed); 33 (edge)
Macroinvertebrate PET Richness: 3 (bed); 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.61 (bed); 3.14 (edge)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

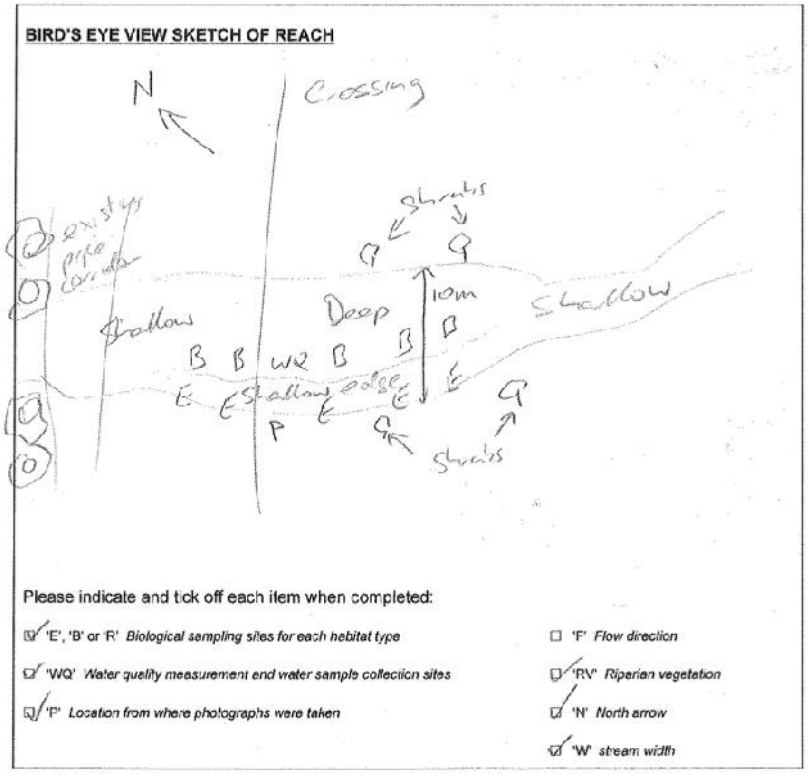
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP220.1 Mimosa Creek**<br>Catchment: Dawson River | **Easting**<br>776470.80 | **Northing**<br>7290629.67 |

*Stream Order and Geomorphology*
Stream Order 6
Relatively wide stream (30 m), slow flowing creek that was characterised by an intermittent flow regime and water body. Water level was above the watermark and grazing land surrounded creek. Both banks had moderate slope gradients (10 m high). Stock, flow and runoff were factors that affected bank stability. Channel substrate was composed of sand with some silt / clay and had low compaction. There was a small road culvert 0.5 km upstream of surveyed site.

*Erosion Risk*
Moderate. Moderate local catchment erosion due to cattle access to water.

*Riparian Vegetation*
Relatively wide riparian zone spanning both the left (30 m) bank and right (20 m) bank. Riparian vegetation was mainly composed of bare ground, grass and tall native trees (eucalypt). Some small native trees and exotic species were present (Parthenium and Cobblers pegs). Moderate shading of the river (50%) by riparian vegetation and some trailing bank vegetation (15%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora was present including *Cyperus* sp., *Persicaria decipiens* (slender knotweed), *Glyceria maxima* (reed sweet grass) and *Juncus* sp. Aquatic fauna species present included *Ambassis agassizii* (Agassiz's glassfish), *Hypseleotris* sp., *Mogurnda adspersa* (purple-spotted gudgeon) and *Leiopotherapon unicolor* (spangled perch). Freshwater shrimp, crayfish and prawn were caught. Habitat structure was characterised by shallow runs with a higher than usual water level due to recent heavy rainfall.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
Possible preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 75 (Moderate)
Macroinvertebrate Richness: 26 (bed); 44 (edge)
Macroinvertebrate PET Richness: 3 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.79 (bed); 2.91 (edge)
Level of Disturbance: low

Overall Aquatic Values:
Dry Season: high
Wet Season: high

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

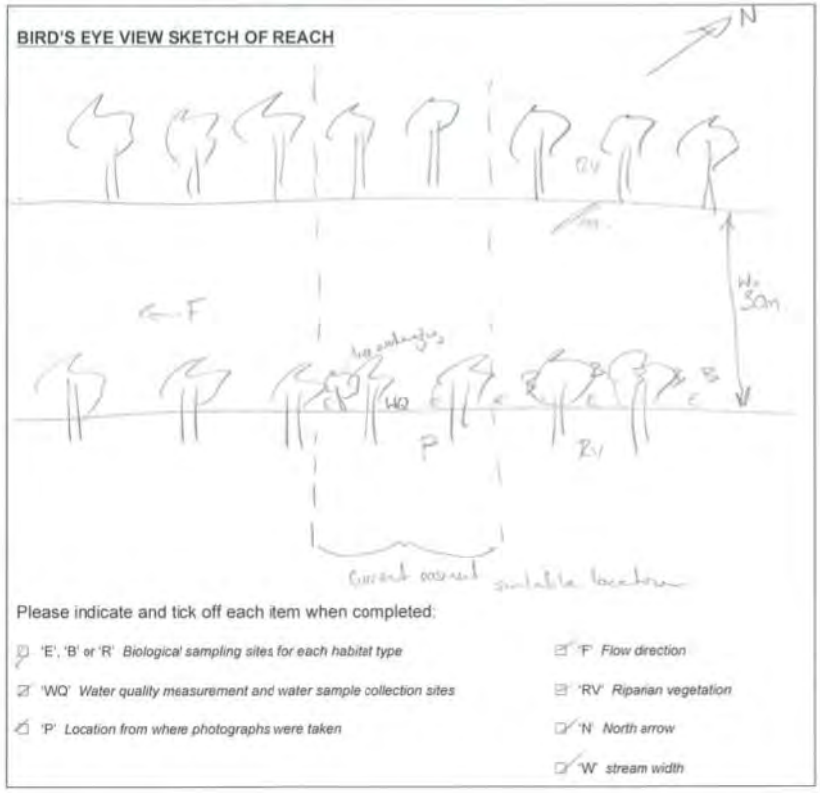
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Otherwise, construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **Mimosa Creek RCR**<br>Catchment: Dawson River | **Easting**<br>778284.34 | **Northing**<br>**7291589.07** |

*Stream Order and Geomorphology*
Stream Order 6
Relatively wide stream (30 m), with almost dry creek bed. Several isolated pools were located upstream of the crossing location. It is likely the site will dry completely over summer. Grazing land surrounded creek. Both banks had moderate slope gradients (6 m high). Stock, flow and runoff were factors that affected bank stability. Channel substrate was composed of sand with some silt / clay and had low compaction..

*Erosion Risk*
Moderate. Moderate local catchment erosion due to cattle access to water.

*Riparian Vegetation*
Relatively wide riparian zone spanning the right (12 m) bank; the left bank had more fragmented riparian vegetation (5 m). Riparian vegetation was mainly composed of grass and tall native trees (eucalypt). Some small native trees and exotic species were present (lantana). Moderate shading of the river (25%) by riparian vegetation and some trailing bank vegetation (10%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora was present including *Cyperus* spp., *Persicaria* sp. (knotweed), and *Juncus* sp. The only aquatic fauna species present was *Mogurnda adspersa* (purple-spotted gudgeon). Habitat structure was limited within the ROW and the site contained little water.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 52 (Moderate)
Macroinvertebrate Richness: 28 (bed); 31 (edge)
Macroinvertebrate PET Richness: 7 (bed); 6 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.95 (bed); 3.76 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

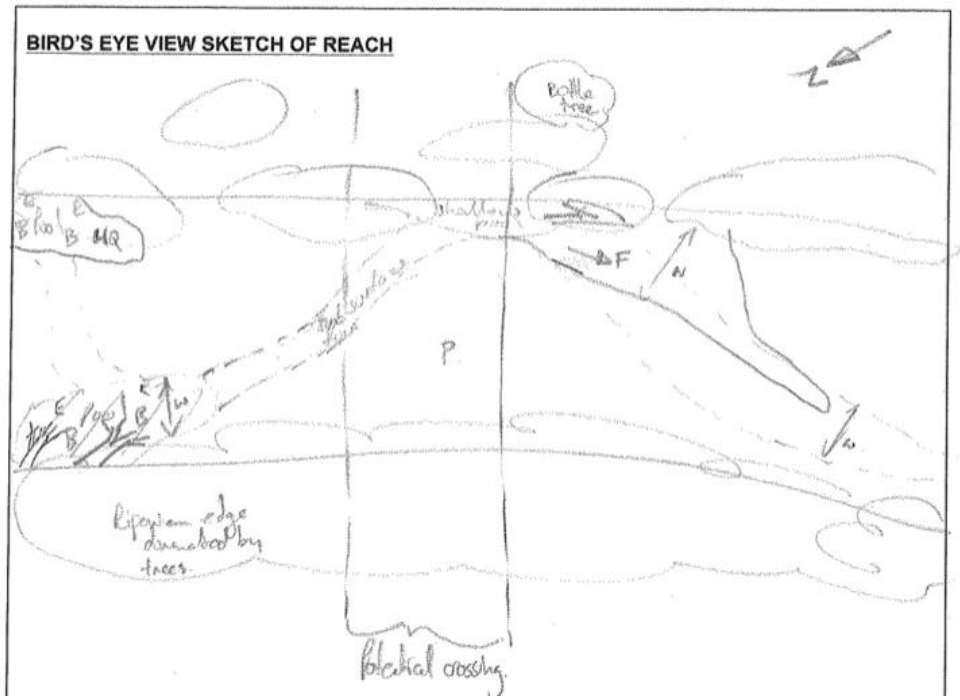
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culvert. Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP231.1 Denby Creek**<br>Catchment: Dawson River | **Easting**<br>786327.93 | **Northing**<br>7293279.93 |

*Stream Order and Geomorphology*
Stream Order 3
Average stream width 10 m; surrounding land use was grazing. Flow regime and water body were perennial; water level was above the watermark at time of survey and water was flowing slowly. The left bank was moderately steep (2.5 m) and the right bank had a low gradient slope (1 m). Overall bank stability was low. Stock, flow and vegetation clearing were factors affecting stability. Channel substrate had low compaction and was composed of silt /clay.

*Erosion Risk*
Moderate. Moderate local catchment erosion was present. Left bank with moderate erosion.

*Riparian Vegetation*
Relatively narrow riparian zone spanning the left (4 m) and right (6 m) banks. Riparian zone dominated by bare ground with some small native trees (melaleuca) and grass. Few large native trees and shrubs were present. Moderate shading of river (50%) and some trailing bank vegetation (15%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Few aquatic plants were present including *Alternanthera denticulata* (lesser joyweed), *Cyperus* sp. and *Ludwigia* sp. Little aquatic fauna was present, only carp gudgeons (*Hypseleotris* sp.), freshwater shrimp and freshwater prawns. Structural habitat was composed of shallow and deep pools and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 33 (poor)
Macroinvertebrate Richness: 17 (bed); 25 (edge)
Macroinvertebrate PET Richness: 3 (bed); 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.20 (bed); 3.50 (edge)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

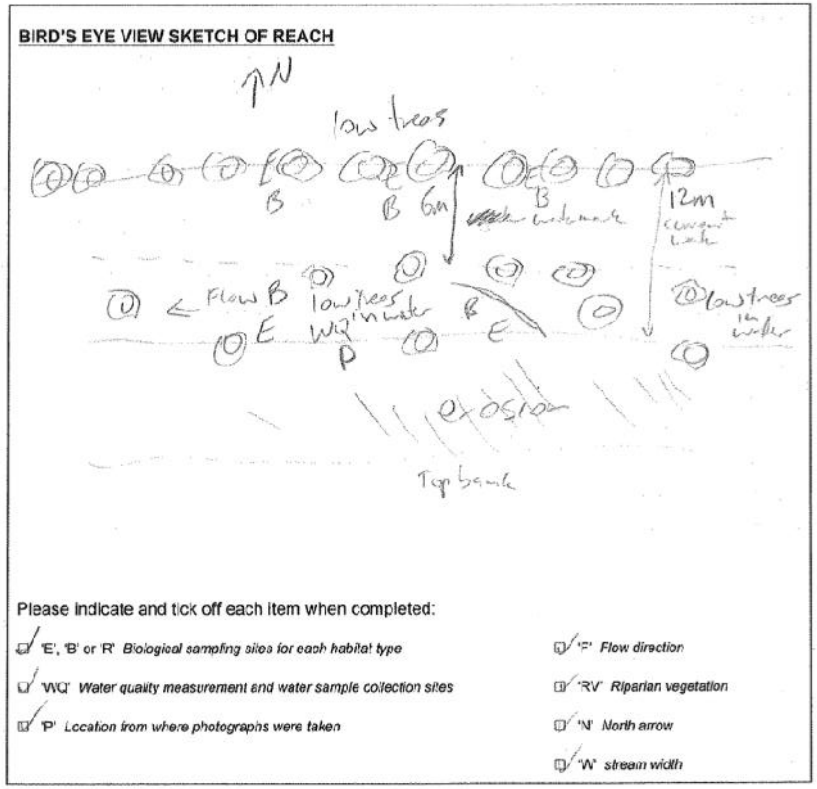
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Otherwise, construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP233.9 Dawson River downstream**<br>Catchment: Dawson River | **Easting**<br>788651.15 | **Northing**<br>7294513.70 |

*Stream Order and Geomorphology*
Stream Order 8
Wide river (60 m), with with grazing on the left bank and native forest on the right bank. Flow regime and water body were perennial; water level was above the watermark and there was a high diversity of flow types at time of survey, including slow flowing pools, riffles and backwaters. Vegetated side and mid channel bars were present in irregular patterned channel. The left bank was 10 m with a steep gradient; the right bank was 8 m with a steep gradient. Channel substrate had moderate compaction and was composed of silt / clay, sand, pebble and some gravel. A dam is located approximately 20 km upstream.

*Erosion Risk*
Low - moderate. Little local catchment erosion. Water flow was a factor affecting stability.

*Riparian Vegetation*
The width of the riparian zone on the left bank was 20 m and >50 m on the right bank. Riparian zone dominated with small and large native trees (eucalypt and melaleuca), bare ground, parthenium weed and grasses. Some trailing bank vegetation was present and there was moderate shading of river.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora present included of *Cyperus exaltatus*, *Persicaria decipiens*, *Paspalum* sp. and *Portulaca oleracea*. High diversity of aquatic fauna; glass perchlet (*Ambassis agassizii*), bony bream (*Nematalosa erebi*), purple spotted gudgeon (*Mogurnda adspersa*), sleepy cod (*Oxyeleotris lineolata*), carp gudgeons (*Hypseleotris* spp.) and fly-specked hardyheads (*Craterocephalus stercusmuscarum*). The exotic mosquitofish (Gambusia holbrooki) was also present. Freshwater shrimp, crayfish and prawn were abundant. Structural habitat was composed of deep and shallow pools, undercut banks, backwater, large woody debris, riffles and runs, gravel substrates, and connected pools in channel.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Fitzroy River turtle, lungfish and saltwater crocodile in EPBC search
Likely preferred habitat for EVR species.
Likely habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 73 (moderate)
Macroinvertebrate Richness: 11 (bed); 11 (edge)
Macroinvertebrate PET Richness: 5.0 (bed); 3.4 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.72 (bed); 4.32 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

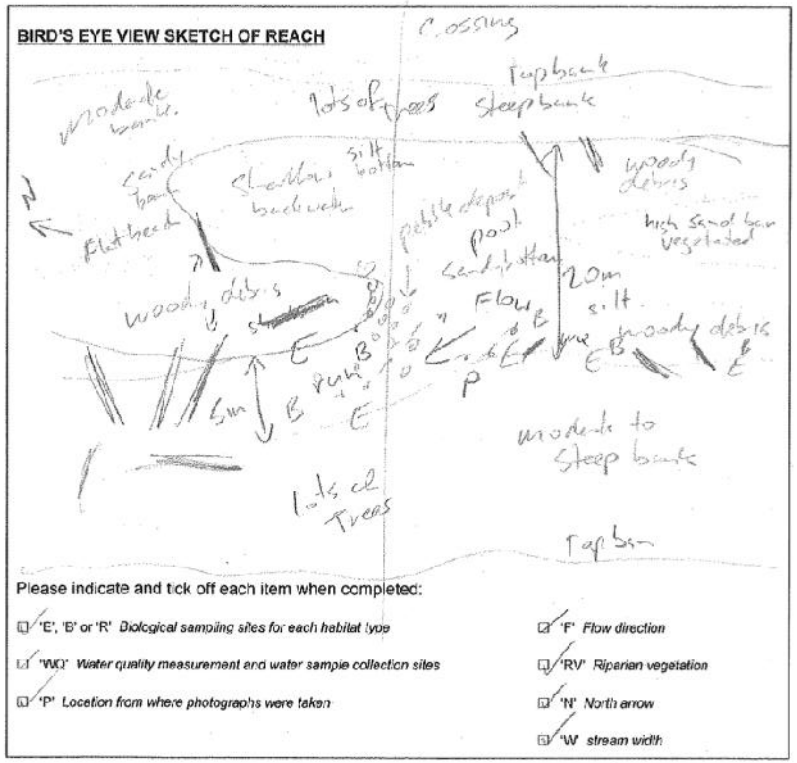
*Timing Constraints*
Dry season works (EVR species likely present)

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish and other aquatic fauna salvage required . Implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Multi-span bridge or large box culverts. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP234.3 Back Creek**<br>Catchment: Fitzroy River | **Easting**<br>788870.56 | **Northing**<br>7294211.21 |

*Stream Order and Geomorphology*
Stream Order 3
Narrow creek (< 10 m) with grazing land surrounding. Creek characterised by ephemeral water body and flow regime. Moderate water flow due to recent heavy rainfall; water relatively turbid. The left bank had a moderate slope (3 m) and the right bank had a step slope (5 m). Flow, runoff and floodplain scours were factors that affected the bank stability. Channel substrate was composed of silt / clay and sand and had low compaction. Vegetated side bars were present in the channel.

*Erosion Risk*
Low – Moderate. Some local catchment erosion.

*Riparian Vegetation*
Relatively wide riparian zone; 20 m on the left and 10 m on the right. Dominant vegetation was grass and sedges. Moderate abundance of large native trees present (eucalypt), some bare ground and few shrubs. Some shading of the stream (25%) and moderate trailing bank vegetation (50%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora was present, including *Cyperus* sp., *Persicaria decipiens* (slender knotweed), *Paspalum* sp. and *Portulaca oleracea* (purslane). A diverse range of fish species was caught, including glass perchlets (*Ambassis agassizii*), bony bream (*Nematalosa erebi*), fly-specked hardyheads (*Craterocephalus stercusmuscarum*), eastern rainbowfish (*Melanotaenia splendida*), carp gudgeons (*Hypseleotris* spp.) and the exotic mosquitofish (*Gambisua holbrooki*). Freshwater shrimp (*Caridina* spp.), rivers prawns (*Macrobrachium australiense*) and crayfish (*Cherax destructor*) were caught. Structural habitat was composed of shall pools, runs, undercut banks and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 73 (Moderate)
Macroinvertebrate Richness: 13 (bed); 26 (edge)
Macroinvertebrate PET Richness: 3 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.72 (bed); 3.64 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

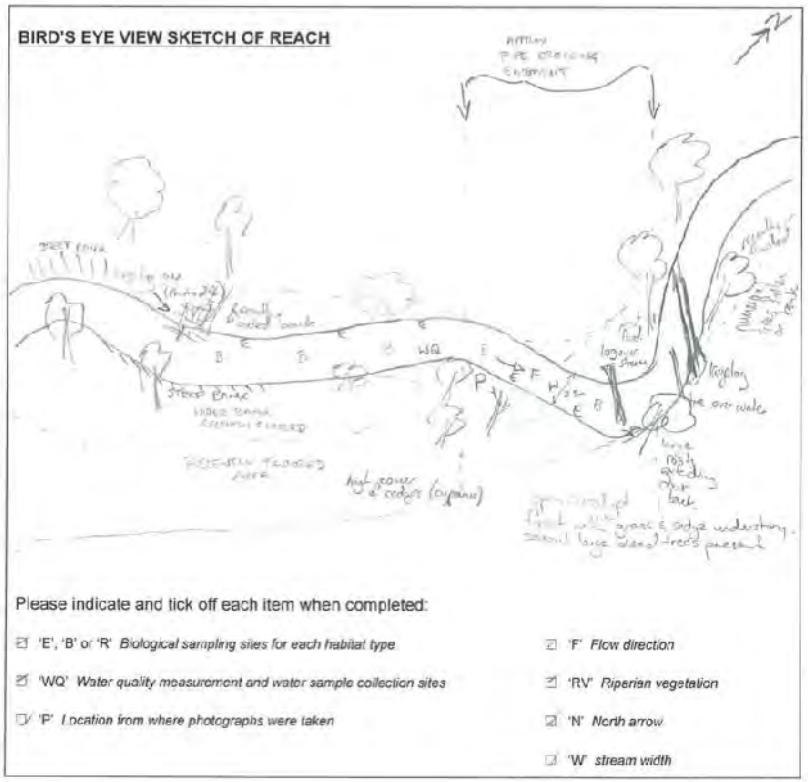
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP239.7 Kianga Creek**<br>Catchment: Dawson River | **Easting**<br>793337.72 | **Northing**<br>7295957.88 |

*Stream Order and Geomorphology*
Stream Order 4
Narrow creek (< 10 m) surrounded by grazing land. Site characterised by temporary water body and ephemeral flow regime. Water was not flowing; reduced to several small isolated pools. The left bank and right bank (1 m) had low gradients and had high overall bank stability. Stock, flow and vegetation clearing were factors affecting bank stability. Channel was braided and had unvegetated mid-channel bars. Channel substrate had moderate compaction and was composed predominantly of silt / clay with some sand.

*Erosion Risk*
Some local catchment erosion on banks.

*Riparian Vegetation*
Relatively wide riparian zone (15 to 20 m) dominated by grass and shrubs. Some small and large native trees (eucalypt and melaleuca). Weed species were present mainly grasses, rubber vine and herbaceous species. Light shading of the river (15%) and some trailing bank vegetation (10%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Some aquatic flora present including *Cyperus sp., Potamogeton crispus* (curly pondweed), *Alternanthera denticulata* (lesser joyweed) and *Ludwig* sp. Several freshwater species were caught, including glass perchlets (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*), carp gudgeons (*Hypseleotris* spp.) and the exotic moaquitofish (*Gambusia holbrooki*). Freshwater shrimp (*Caridina* spp.) and crayfish (*Cherax destructor*), and freshwater moon snails (*Notopala sublineata*) were present. Structural habitat was composed of shallow pools, undercut banks and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 62 (moderate)
Macroinvertebrate Richness: 32 (bed); 36 (edge)
Macroinvertebrate PET Richness: 4 (bed); 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.35 (bed); 3.29 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

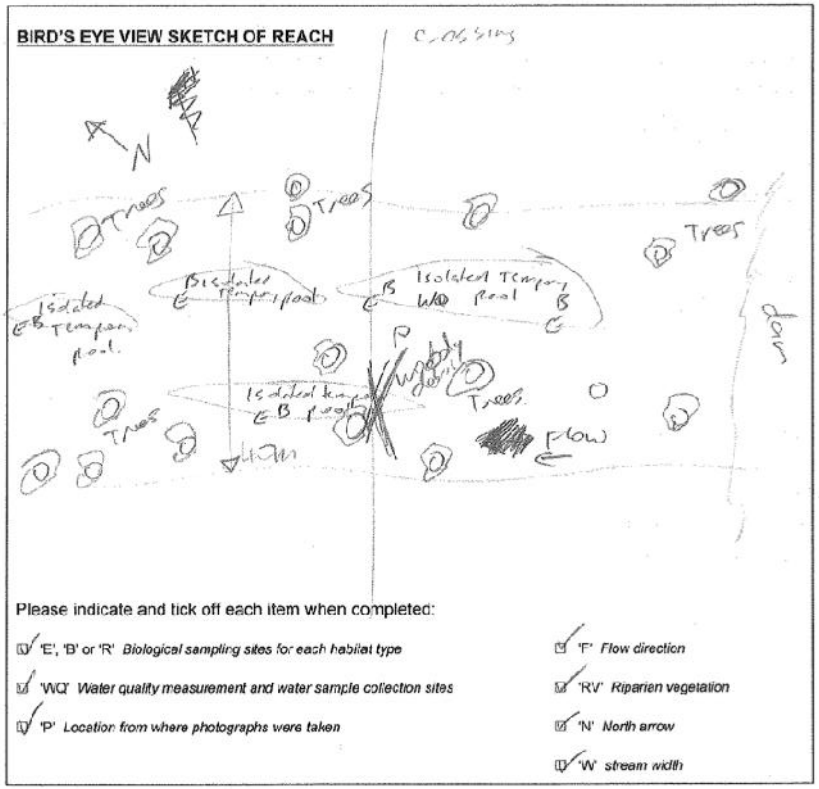
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 55J, WGS 84) | |
|---|---|---|
| **KP252.4 Banana Creek**<br>Catchment: Dawson River | **Easting**<br>804230.94 | **Northing**<br>7300351.98 |

*Stream Order and Geomorphology*
Stream Order 5
Narrow stream width (2.5 m), temporary system with isolated pools and no flow. Left bank had low gradient (1 m) and right bank was steep (2.5 m). Both banks had moderate stability, with and flow, stock and vegetation clearing being factors that affected bank stability. Channel substrate had moderate compaction and was composed predominantly of silt / clay, sand and gravel. Unvegetated mid-channel bars present.

*Erosion Risk*
Moderate. Some local catchment erosion.

*Riparian Vegetation*
Narrow riparian zone 5 m on left bank and 8 m on right bank. Composed of predominantly bare ground and come grasses, shrubs, small and tall native trees (eucalypt and melaleuca). Moderate to dense shading of the river and some trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora included *Cyperus distans, Cyperus difformis* and *Alternanthera denticulata*. Aquatic fauna included glass perchlets (*Ambassis agassizii*), carp gudgeons (*Hypseleotris* spp.), the exotic mosquitofish (*Gambusia holbrooki*), freshwater moon snails (*Notopala sublineata*), and freshwater shrimps (*Caridina* spp.). Structural habitat consists of shallow and deep pools, undercut banks and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 46 (moderate)
Macroinvertebrate Richness: 21 (bed); 24 (edge)
Macroinvertebrate PET Richness: 3 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.04 (bed); 3.33 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

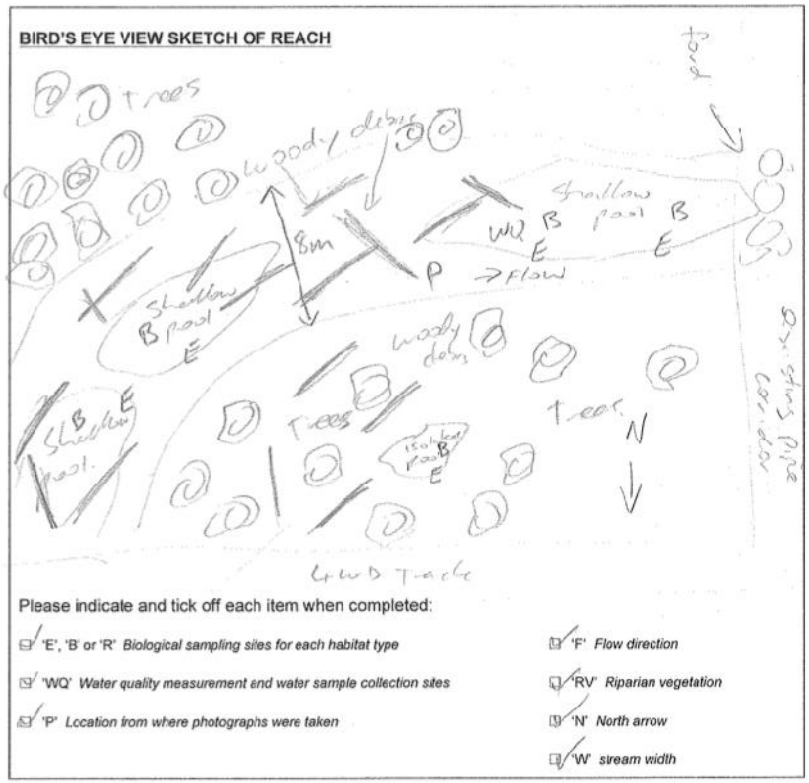
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP252.6 Banana Creek**<br>Catchment: Dawson River | **Easting**<br>195802.94 | **Northing**<br>7300430.09 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Dam upstream (0.1 km) significantly affects flows at the site. Mildly sinuous and braided channel, that was composed of silt /clay and some sand, gravel and pebble. Channel bed was moderately compacted. The left and right bank had low gradient slopes of 1 m and 1.2 m respectively. Moderate overall bank stability. Stock was a factor affecting overall bank stability.

*Erosion Risk*
Low. Some local catchment erosion.

*Riparian Vegetation*
Riparian zone spanned 15 m on the left bank and 5 m on the right bank. Riparian zone was dominated by grass species. Some bare ground, shrubs and small and large native trees (eucalypt, acacia). Limited shading of the river (25%) by riparian vegetation and some trailing bank vegetation (10%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, aquatic flora including *Cyperus* sp. and *Alternanthera denticulata.* No aquatic fauna present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 39 (poor)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

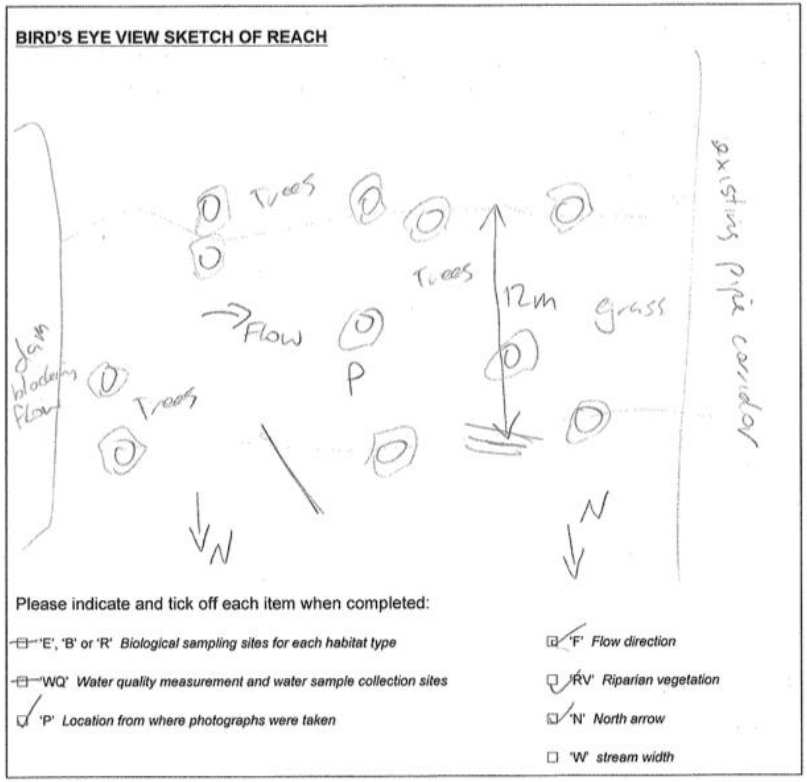
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Nil. Site unlikely to contain water

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing road if possible.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP263.6 Police Camp Creek**<br>Catchment: Dawson River | **Easting**<br>206303.26 | **Northing**<br>7302368.13 |

*Stream Order and Geomorphology*
Stream Order 4
Dry, ephemeral watercourse, adjoined by grazing land. Channel substrate dominated by silt / clay, with evidence of localised sand deposition and moderate compaction. Unvegetated mid-channel bars present. Right bank is steep (2 m) and the left vertical (2 m) both banks with stable banks. Stock access affected bank stability.

*Erosion Risk*
Low - moderate. Erosion on banks with some local catchment erosion.

*Riparian Vegetation*
Riparian vegetation narrow on the left bank (5 m) and relatively wide on the right bank (20 m), consisting mainly of native large trees (eucalypt) and exotic grasses. Some shrubs and smaller trees present. Moderate shading of the channel and some trailing vegetation present.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora was limited to *Alternanthera denticulata*. Site dry at time of survey, no fauna present. Structural habitat comprised of logs, branches and terrestrial leaves and twigs. Unlikely to be breeding habitat for significant aquatic species.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 50 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

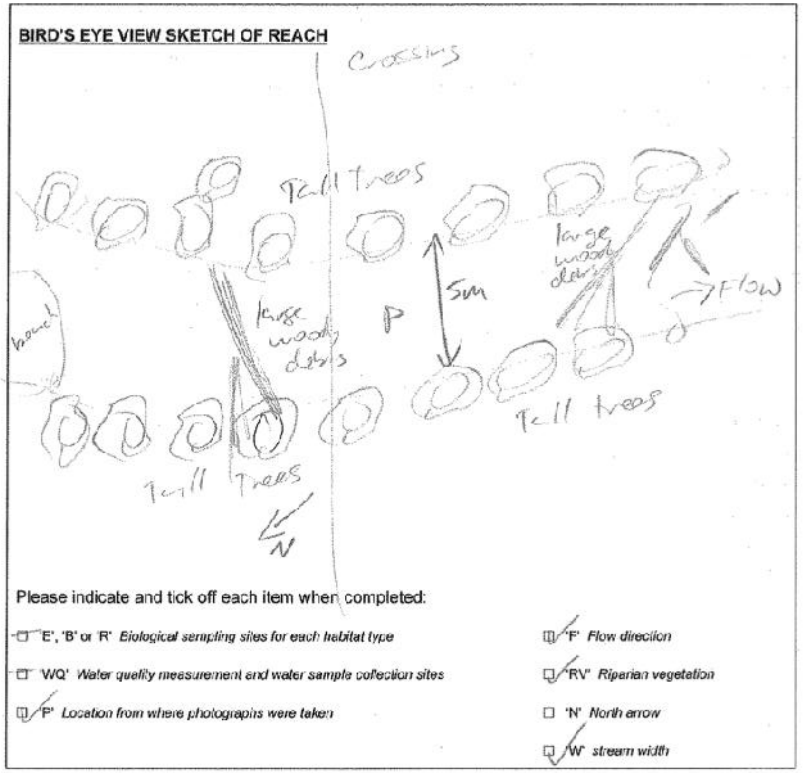
*Site-specific Pipeline Construction Methods and Mitigation Measures*
If open trench, revegetate and re-profile banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation:
Nil

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Revegetate and re-profile banks and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP269.9 Police Camp Creek**<br>Catchment: Dawson River | **Easting**<br>212266.69 | **Northing**<br>7303141.75 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Narrow, shallow channel a steep left bank (0.5 m) and a vertical gradient right bank (1.2 m). Unvegetated mid-channel bars present (70%). The channel was composed of sand, gravel and pebbles with low compaction and moderate aggradation.

*Erosion Risk*
Moderate overall bank stability with some local catchment erosion on both banks. High levels of disturbance; flow, stock and vegetation clearing were factors affecting stability.

*Riparian Vegetation*
Virtually no riparian vegetation zone; right bank had 0.5 m and consisted of grasses, some bare-ground, shrubs and small trees (*Acacia* sp.). Little shading of the river and very little trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, no aquatic flora or fauna present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 38 (poor)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

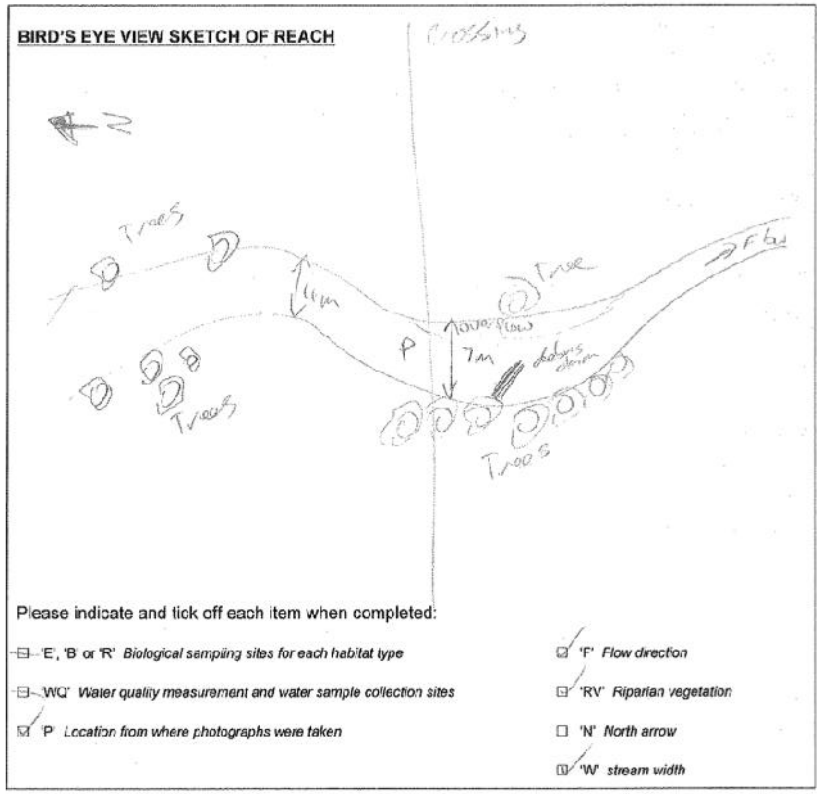
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

*Additional mitigation if construction is in wet season*:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP272.4 Spring Creek**<br>Catchment: Dawson River | **Easting**<br>214450.21 | **Northing**<br>7304324.48 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Mildly sinuous channel pattern that was composed of gravel, pebbles and sand. Unvegetated side / point bars and mid-channel bars were present. The left (1 m) and right (1 m) bank had vertical slope gradients. Stock and vegetation clearing were factors affecting channel stability.

*Erosion Risk*
Low. Some local catchment erosion, the left bank had slight erosion.

*Riparian Vegetation*
Narrow riparian vegetation zone spanning the left (3 m) and right (3 m) banks. Vegetation was dominated by grass. Some bare ground, few shrubs and some small and large native trees (casuarina) were present. Herbaceous weed species were also present. Moderate shading of the river by riparian vegetation (50%) and some trailing bank vegetation (25%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey. Only *Lomandra longifolia* (Spiny-head Mat-rush) was present and no aquatic fauna present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 79 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

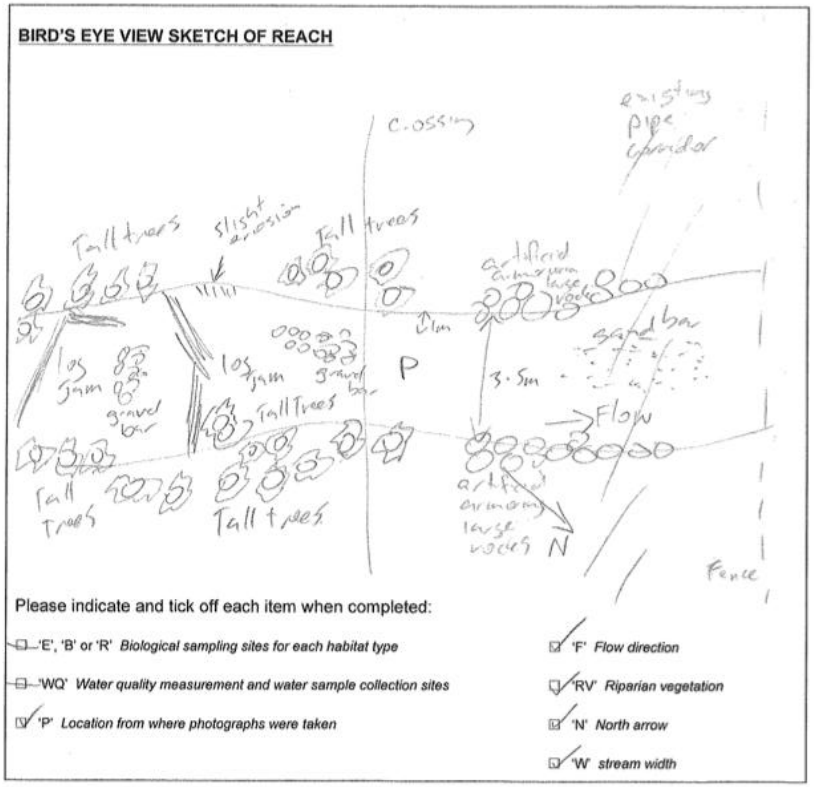
*Additional mitigation If construction is in wet season*:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**




Please indicate and tick off each item when completed:

- ☐ 'E', 'B' or 'R' *Biological sampling sites for each habitat type*
- ☐ 'WQ' *Water quality measurement and water sample collection sites*
- ☑ 'P' *Location from where photographs were taken*
- ☑ 'F' *Flow direction*
- ☑ 'RV' *Riparian vegetation*
- ☑ 'N' *North arrow*
- ☑ 'W' *stream width*

| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP285.8 Neville Creek**<br>Catchment: Callide Creek | **Easting**<br>226831.71 | **Northing**<br>7308280.65 |

*Stream Order and Geomorphology*
Stream Order 3
Bankfull width was 18 m, with grazing being the dominant surrounding land use. Temporary watercourse that contained several shallow, isolated pools. Channel substrate composed of silt /clay and some sand. Channel had low compaction and unvegetated side and mid-channel bars were present. Left bank (2.5 m) was steep and the right bank (1.5 m) had a vertical slope. Overall bank stability was moderate. Stock, flow and vegetation clearing were factors affecting stability.

*Erosion Risk*
Low. Some local catchment erosion; the left upper bank and on the lower bank of both sides had slight erosion.

*Riparian Vegetation*
Riparian zone on the left bank spanned 4 m and on the right bank 0.5 m. The vegetation was dominated by grass and bare ground. Some large and small native trees were present (eucalypt and melaleuca) and few shrubs. Some shading of the river (15%) and moderate trailing bank vegetation (25%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora was found including *Cyperus* spp. and *Paspalum distichum* (water couch). Freshwater fish caught included glass perchlets (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*), bony bream (*Nematolosa erebi*), purple spotted gudgeons (*Mogurnda adspersa*) and spangled perch (*Leiopotherapon unicolour*). Freshwater shrimp (*Caridina* spp) and freshwater moon snails (*Notopala sublineata*) were caught, and crayfish burrows were abundant on banks. Habitat structure was composed of shallow pools and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 66 (moderate)
Macroinvertebrate Richness: 19 (bed); 16 (edge)
Macroinvertebrate PET Richness: 2.0 (bed); 2.0 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.04 (bed); 3.18 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

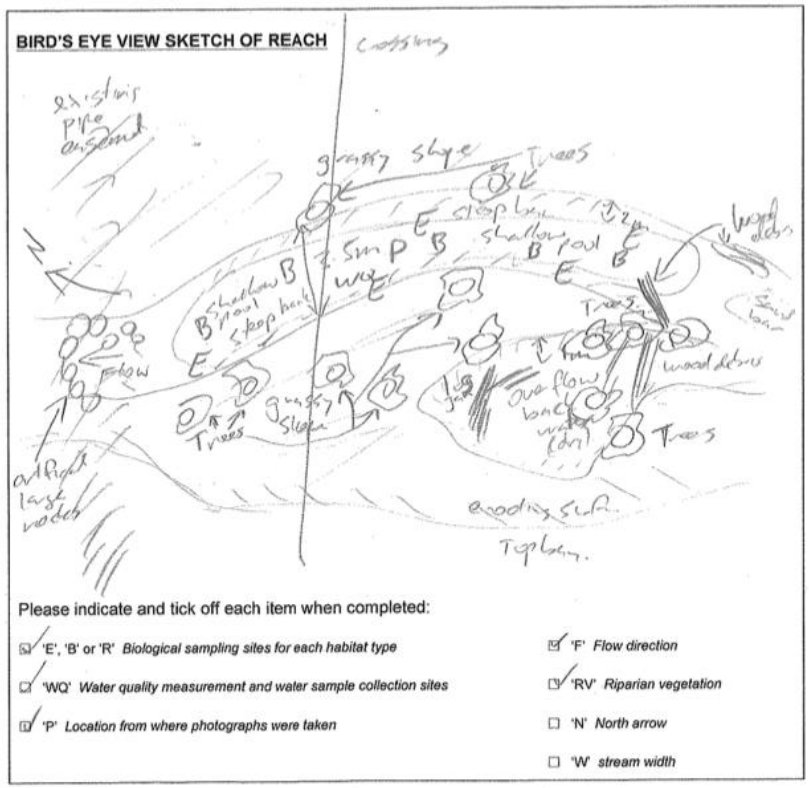
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

Additional mitigation If construction is in wet season:
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing pipe corridor if possible. Otherwise gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP295.6 Orange Creek**<br>Catchment: Callide Creek | **Easting**<br>235998.69 | **Northing**<br>7311276.67 |

*Stream Order and Geomorphology*
Stream Order 6
Dry, ephemeral watercourse, adjoined by some native forest and grazing on the left bank and cropping right bank cropping. Channel pattern is braided with substrate dominated by silt / clay and some sand. Evidence of moderate channel disturbance and some local catchment erosion. Unvegetated side bars present in the channel. Left and right banks low gradient (0.6 m) with moderate bank stability. Stock access, flow and vegetation clearing were affecting bank stability.

*Erosion Risk*
Moderate. Some local catchment erosion and moderate channel disturbance. Clear evidence of channel erosion from recent flows.

*Riparian Vegetation*
Wide riparian vegetation zone, extending 30 m on the left bank and 20 m on the right; consisting of native large trees (eucalypt and casuarina) and some smaller trees, grasses, shrub and bare ground. There was some shading of the river and trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic plants present consisting of *Marsilea hirsute, Cyperus exaltatus*, *Cyperus concinnus*, *Paspalum distichum* and *Persicaria attenuata.* Site dry at time of survey, no aquatic fauna present. Structural habitat comprised of large woody debris and some trailing roots.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 32 (poor).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

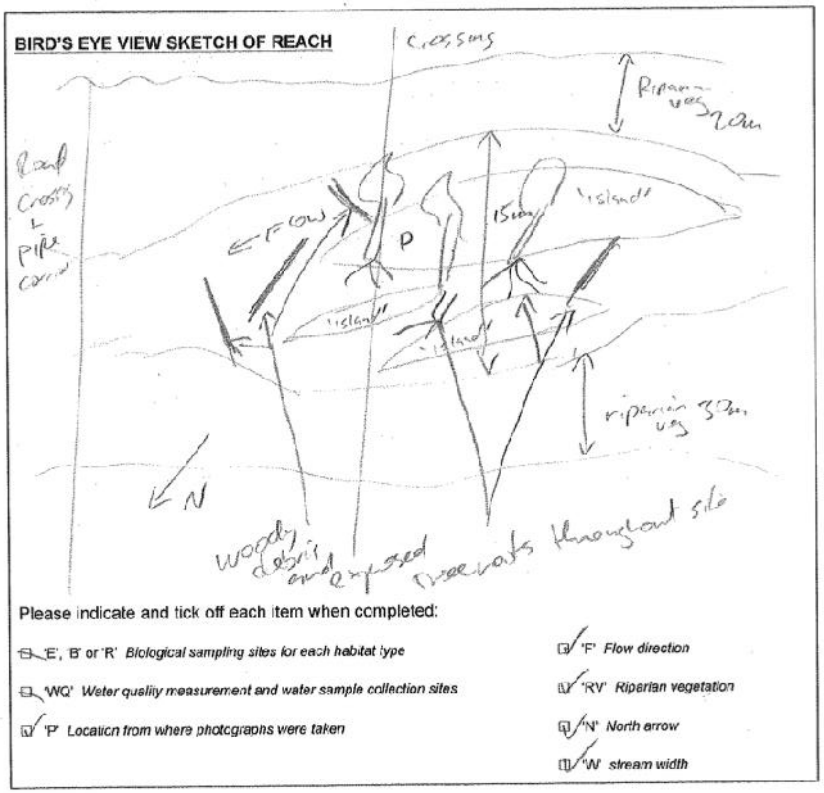
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If construction is in wet season:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing ford if possible.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP296.6 Unnamed Watercourse 7**<br>Catchment: Fitzroy River | **Easting**<br>237002.11 | **Northing**<br>7311372.70 |

*Stream Order and Geomorphology*
Stream Order 4
Dry, ephemeral watercourse, adjoined by cropping land. Channel was composed of silt /clay, sand some gravel. Channel substrate compaction was moderate and unvegetated mid-channel bars were present. Flow and vegetation clearing were factors affecting stability.

*Erosion Risk*
Low. No local catchment erosion.

*Riparian Vegetation*
Regularly spaced riparian vegetation dominating by grass. Some tall and small native trees (eucalypt), shrubs and bare ground were present. There were some exotic species present. Some shading of the river by riparian vegetation (15%) and trailing bank vegetation (10%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, some macrophytes were found including *Cyperus* sp., *Marsilea hirsuta* (hairy nardoo) and *Alternanthera denticulata* (lesser joyweed). No aquatic fauna present.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 38 (poor)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

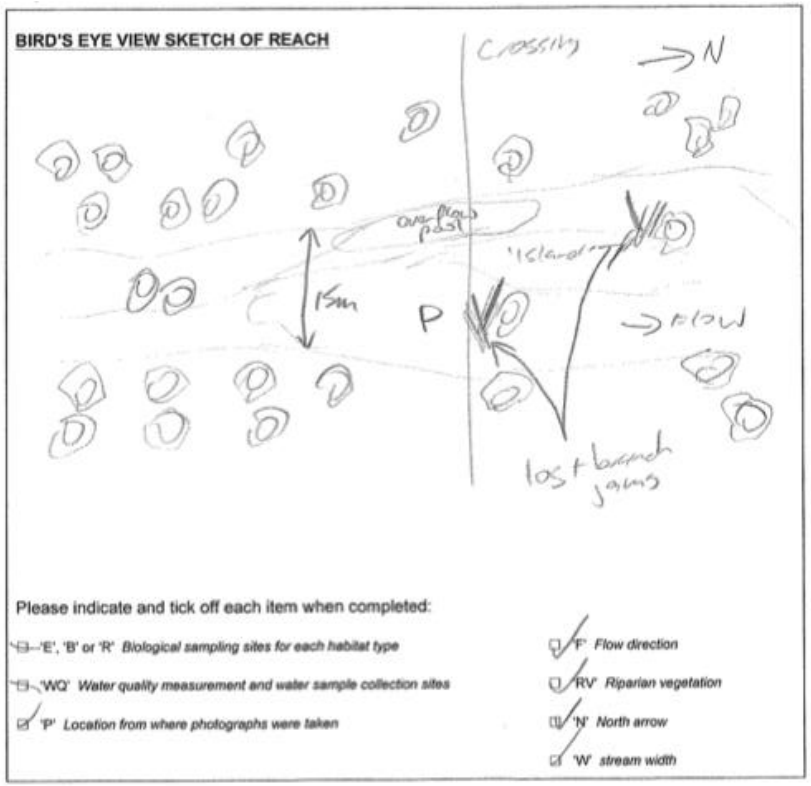
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

Additional mitigation If construction is in wet season:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing road if possible.

**Aerial Photograph of KP**



| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP296.8 Kroombit Creek**<br>Catchment: Callide Creek | **Easting**<br>237168.19 | **Northing**<br>7311388.58 |

*Stream Order and Geomorphology*
Stream Order 6
Narrow (4.5 m) creek surrounded by cropping land. Perennial watercourse with perennial flow regime, water level higher than the water mark at time of survey. The both banks were steep (3 m) with moderate overall bank stability. Flow and vegetation clearing were factors affecting stability. Unvegetated side bars present. Channel substrate had moderate compaction and was composed of silt / clay and some sand and gravel.

*Erosion Risk*
Moderate. Some local catchment erosion; small patches of erosion on both banks.

*Riparian Vegetation*
Narrow riparian zone; 5 m on left bank and 8 m on right bank. Riparian zone dominated by native large trees (eucalypt, melaleuca, casuarina) with an understory of grasses. Some bare ground, small trees and few shrubs. Moderate shading of the river (50%) and some trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Few species of aquatic flora found including *Cyperus* sp., *Marsilea hirsuta* (hairy nardoo) and *Alternanthera* sp.. High diversity of fish species were present, including glass perchlets (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), purple spotted gudgeon (Mogurnda adspersa), spangled perch (*Leiopotherapon unicolor*), carp gudgenos (*Hypseleotris* spp.), and exotic mosquitofish (*Gambusia holbrooki*). Freshwater prawns (Macrobrachium australiense) were very abundant, and crayfish (*Cherax destructor*) and shrimp (*Caridina* spp.) were also caught. Structural habitat was comprised of shallow and deep pools, undercut banks and large woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 57 (Moderate)
Macroinvertebrate Richness: 23 (bed); 27 (edge)
Macroinvertebrate PET Richness: 5 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.08 (bed); 3.63 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

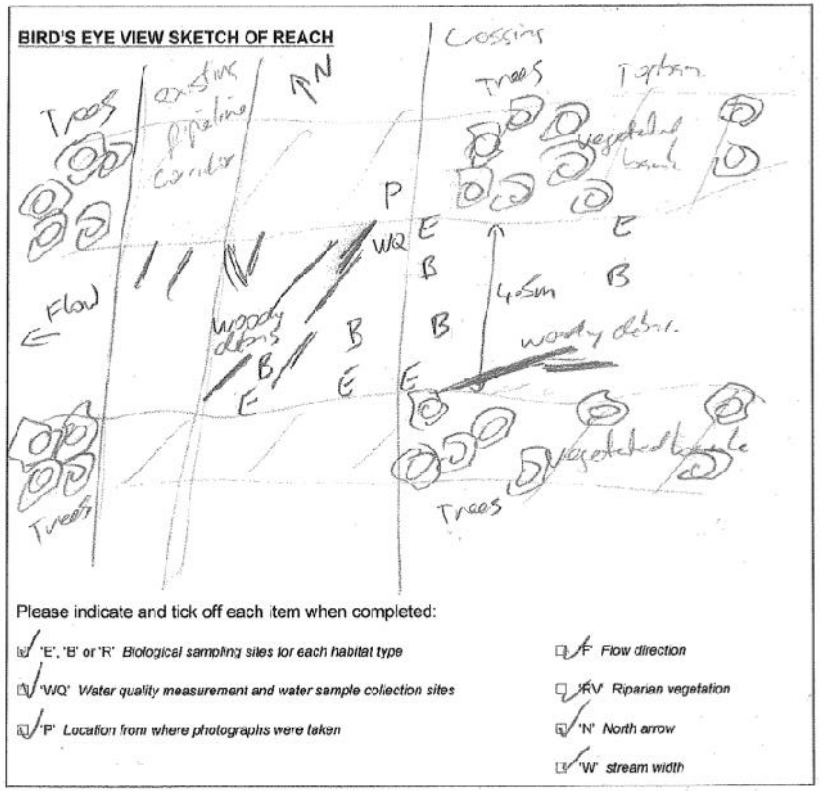
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP297.7 Palustrine Wetland**<br>Catchment: Callide Creek | **Easting**<br>238043.24 | **Northing**<br>7311466.94 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral wetland, located within a grassy paddock. Shallow depression present. The substrate is dominated by silt and clay and characterised by moderate compaction of sediment.

*Erosion Risk*
Low.

*Riparian Vegetation*
No riparian zone. Occasional large trees (eucalypt) and bare ground, dominated by exotic grasses.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora present; *Cyperus exaltatus* (tall flatsedge), *Paspalum distichum* (water couch), *Juncus* sp., *Persicaria attenuate* (polygonaceae). No aquatic fauna was present as the site was dry. There was limited structural habitat at the site.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score:
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Negligible – Low
Wet Season: Negligible – Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

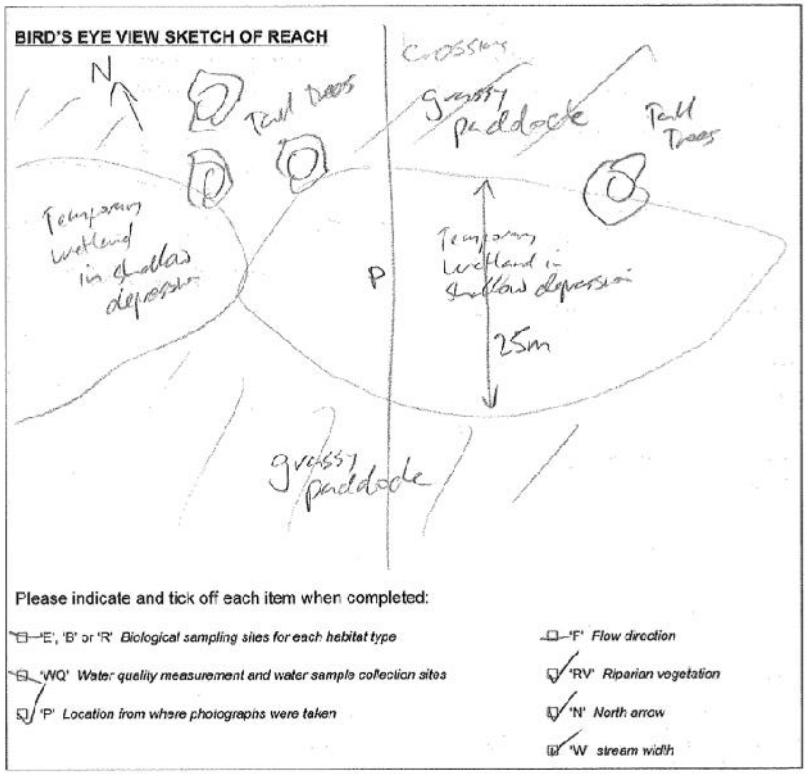
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation If construction is in wet season:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing pipeline corridor/road if possible.

**Aerial Photograph of KP**





| Wetland photo 1 | Wetland photo 2 |
| --- | --- |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP298.9 Callide Creek**<br>Catchment: Callide Creek | **Easting**<br>239238.17 | **Northing**<br>7311711.38 |

*Stream Order and Geomorphology*
Stream Order 5
Narrow (3 m) mildly sinuous creek with grazing being the dominant surrounding land use. Water body and flow regime characterised as intermittent. Water level above watermark and water not flowing. The left bank was steep (10 m) and the right bank was vertical (3 m). Moderate overall bank stability. Stock, flow, vegetation clearing and a pipe crossing were factors affecting stability. Unvegetated side bars were present in channel. Channel substrate had moderate compaction and was composed of silt / clay and some sand.

*Erosion Risk*
Low. Some local catchment erosion at point of existing pipe and on right bank.

*Riparian Vegetation*
The riparian zone spanned 8 m on the left bank and 3 m on the right bank. The dominant vegetation type was grass with come large and small native trees (eucalypt and melaleuca), shrubs and bare ground. Moderate shading of the river (50%) and some trailing bank vegetation (15%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora species include *Cyperus* sp., *Azolla pinnata* (water velvet), *Spirodela* sp., *Ottelia ovalifolia* (swamp lily) and *Eclipta prostrata* (false daisy). Aquatic fauna included glass perchlets (*Ambassis agassizi*), bony bream (*Nematalosa erebi*), fly-specked hardyhead (*Craterocephalus stercusmuscarum*), carp gudgeons (*Hypseleotris* spp.), spangled perch (*Leiopotherapon unicolor*), purple spotted gudgeons (*Mogurnda adspersa*), and the exotic mosquitofish (*Gambusia holbrooki*). Freshwater shrimp, crayfish and prawns were present, and mussel shells were on the bank. Structural habitat was composed of deep and shallow pools, undercut banks, large woody debris and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 64 (Moderate)
Macroinvertebrate Richness: 20 (bed); 27 (edge)
Macroinvertebrate PET Richness: 5 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.84 (bed); 3.63 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

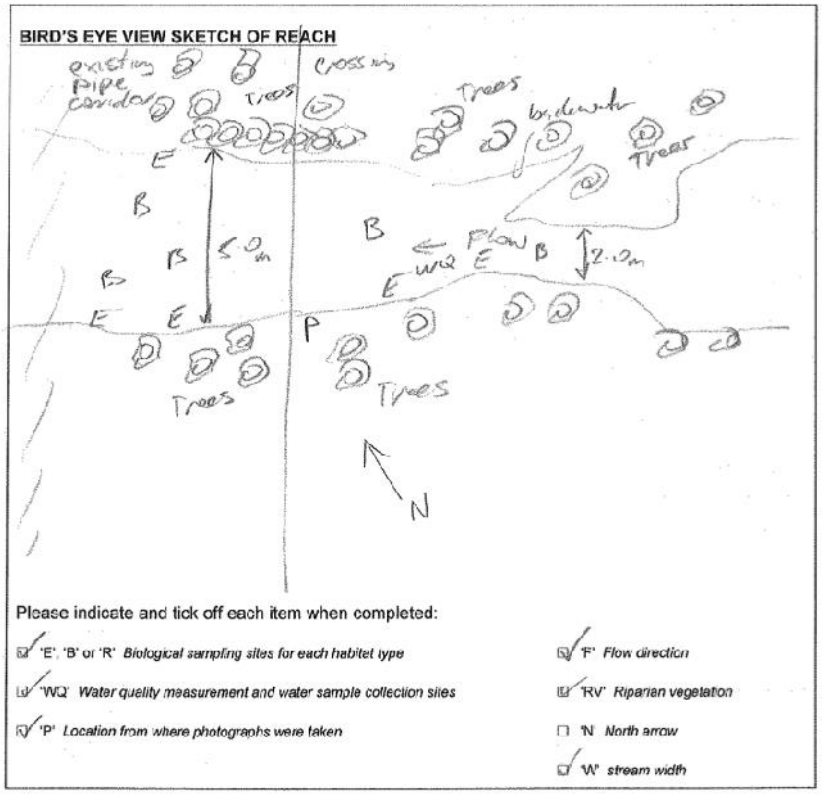
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP300.3 Callide Creek (Old Channel)**<br>Catchment: Callide Creek | **Easting**<br>240540.17 | **Northing**<br>7311892.17 |

*Stream Order and Geomorphology*
Stream Order 5
Dry, ephemeral watercourse, adjoined by cropping. Moderately wide (12 m) with a 2.5 m vertical left bank and steep gradient right bank of 2.5 m. Vegetated mid-channel bars present (60%) and sand deposits. Channel bed compaction was low and of a moderate aggradation. Channel bed substrate composition consisted of sand and some gravel and pebbles.

*Erosion Risk*
Low. Some local catchment erosion.

*Riparian Vegetation*
Riparian zone extends 8 m on the left bank and 3 m on the right bank. Riparian vegetation composed of large native trees (eucalypt) and grasses, some shrubs, small trees and bare ground present. Small amounts of shading of the river and trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, no aquatic fauna or flora.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 31 (moderate)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

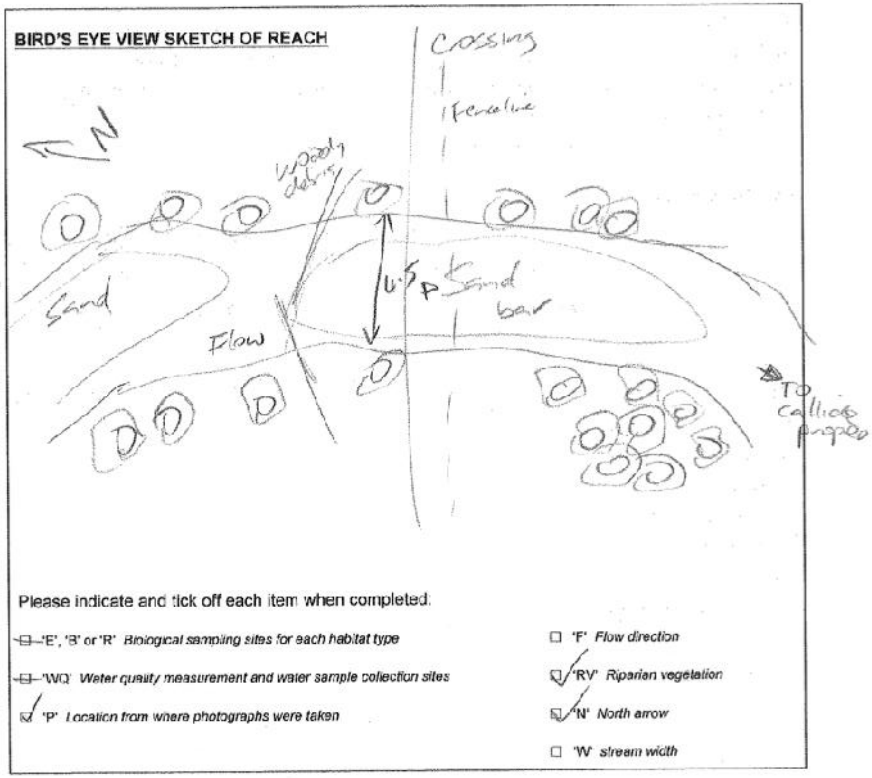
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

Additional mitigation If construction is in wet season:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP305.5 Unnamed Watercourse 8**<br>Catchment: Callide Creek | **Easting**<br>245483.63 | **Northing**<br>7313305.78 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Low gradient left bank and vertical right bank with low overall bank stability. Stock, flow and vegetation clearing were factors affecting stability. Channel had low compaction and was composed of sand with some cobble. Channel dominated by vegetated and unvegetated side and mid-channel bars (75%).

*Erosion Risk*
Right bank eroding at crossing point and some local catchment erosion.

*Riparian Vegetation*
Semi-continuous riparian vegetation present on right bank dominated by grass, moderate coverage by large native trees (eucalypt) and some smaller trees, bare ground and shrubs. Light shading of the river by riparian vegetation and small amounts of trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Aquatic flora consisted of only *Cyperus* spp. There was no aquatic fauna as the site was dry at the time of survey.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 32 (low)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

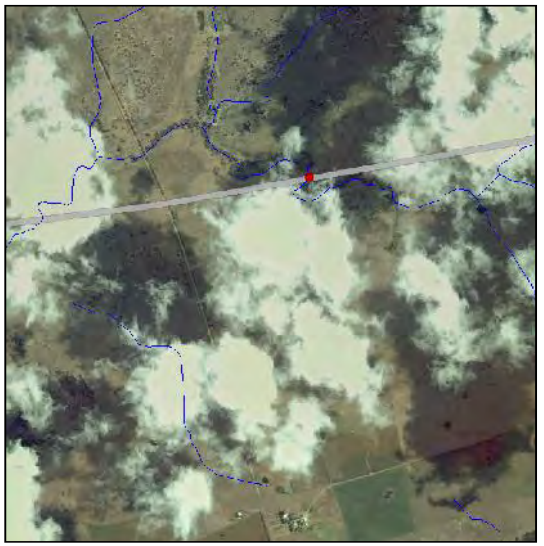
Apply the following specific management measures:

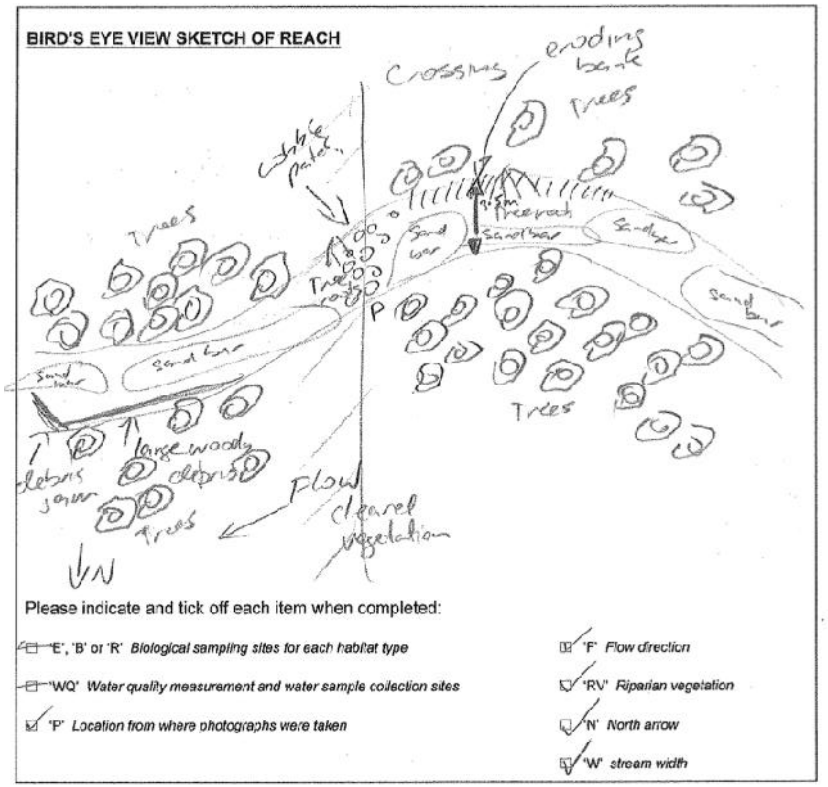
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

Additional mitigation If construction is in wet season:
Nil.
*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP319.1 Collards Creek**<br>Catchment: Callide Creek | **Easting**<br>256920.60 | **Northing**<br>7319450.22 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by native forest and grazing land uses. Moderate gradient left bank slope (1 m) and low gradient right bank slope (1 m). Flow was a factor affecting bank stability. No bars present in channel. Some spotty cover of silt sediment was present covering very armoured cobble and pebbled channel bed.

*Erosion Risk*
Low. Limited local catchment erosion.

*Riparian Vegetation*
Wide riparian vegetation zone (20 m) on both banks dominated by small native trees (eucalypt, melaleuca, casuarina, callistemon) and shrubs. Some larger trees, grass and bare ground. Extensive amounts of *Lantana* sp. were present. Moderate shading of the river by riparian vegetation and some trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Few aquatic flora species present, which included *Cyperus* sp. and *Alternanthera denticulata* (lesser joyweed). No aquatic fauna as site was dry at time of survey.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 91 (good)
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

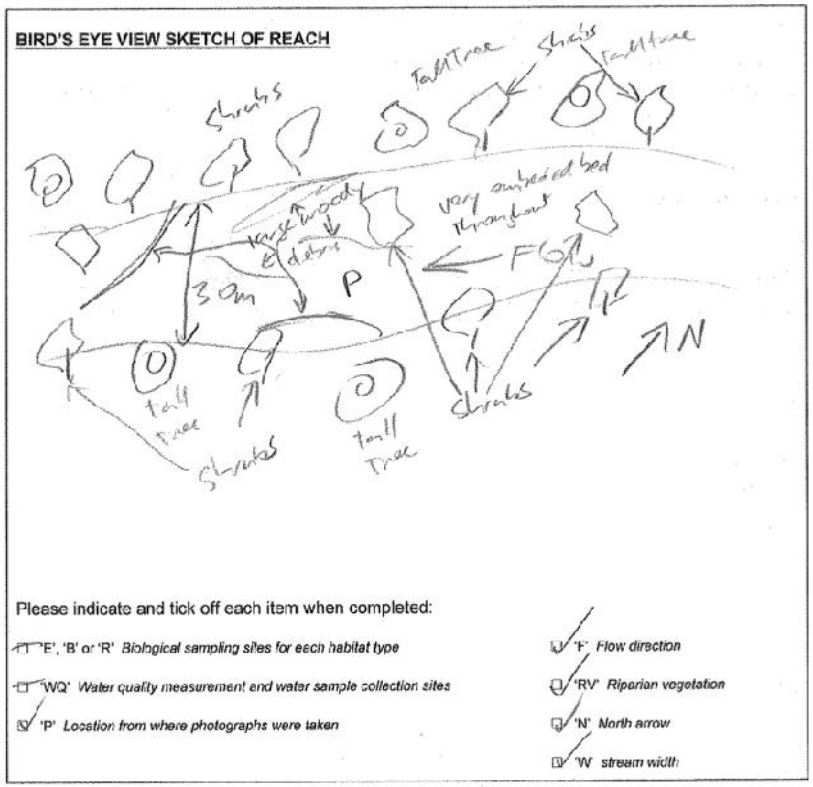
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks.

Additional mitigation If construction is in wet season:
Nil. Access may be difficult if roads are wet.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP334.5 Bell Creek**<br>Catchment: Callide Creek | **Easting**<br>266678.28 | **Northing**<br>7326216.55 |

*Stream Order and Geomorphology*
Stream Order 3
Narrow (2.5 m), shallow creek, characterised as a perennial water body and flow regime. Channel surrounded by grazing pastures. Moderate water flow, the water level was at the water mark. Low gradient left bank (1 m) and steep right bank (2.5 m). Stock and vegetation clearing were factors affecting stability. Braided channel that had vegetated and unvegetated side and mid-channel bars and bars around obstructions. Channel substrate had low compaction and was composed of significant aggregation of sand.

*Erosion Risk*
Moderate. Moderate local catchment erosion on right bank. Heavy sand deposits suggested erosion in upper catchment.

*Riparian Vegetation*
Riparian zone was 10 m on the left bank and 5 m on the right. Riparian zone was dominated by large native trees (e.g. melaleuca, casuarina, callistemon) and grass species. Lantana was present. Some small trees, shrubs and bare ground was also present. Moderate shading of the watercourse (50%) and very little trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Diverse aquatic flora was present including; *Callitriche muelleri* (starwort), *Eclipta prostrata* (false daisy), *Cyperus* spp., *Juncus* sp., *Persicaria decipiens*(slender knotweed) and *Persicaria attenuata* (polygonaceae). Fish species present were purple spotted gudgeons (*Morgunda adspersa*) and Pacific blue-eyes (*Pseudomugil signifier*). Crayfish (*Cherax destructor*) and freshwater shrimp (*Caridina* spp.) were present. Structural habitat was comprised of shallow poorly connected pools, riffle, undercut bank on both sides and large woody debris. In-stream cover consisted of tree roots and algal clumps.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 46 (moderate)
Macroinvertebrate Richness: 21 (bed); 28 (edge)
Macroinvertebrate PET Richness: 7 (bed); 7 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.66 (bed); 4.25 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP352.3 Calliope River**<br>Catchment: Calliope River | **Easting**<br>280475.76 | **Northing**<br>7335673.07 |

*Stream Order and Geomorphology*
Stream Order 5
Narrow (3.5 m), relatively deep (8 m) principal channel that contained two smaller channels. Only one of these small channels contained water, and it had perennial, moderate flow, shallow and depp pools, riffles and backwaters. Native forest and grazing were the surrounding land uses. Steep left bank (15 m) and low gradient right bank (6 m). Flow and stock were factors affecting stability. Unvegetated side / point bars and bars around obstructions in channel. Channel substrate had low compaction and consisted of sand with some gravel and silt/ clay.

*Erosion Risk*
Moderate. Moderate local catchment erosion. A large amount of sand in channel suggests upstream erosion.

*Riparian Vegetation*
Wide intact riparian zone of the right bank (80 m) and left bank (20 m). Riparian zone composed predominantly of large native trees (eucalypt, melaleuca and callistemon). Native and exotic smaller trees, shrubs and grasses were present. Heavy shading of the river (75%) and moderate trailing bank vegetation (25%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Diverse aquatic flora including *Cyperus sp., Potamogeton crispus* (curly pondweed), *Persicaria attenuate* (polygonaceae), *Ottelia alismoides* (hydrocharitaceae), *Eclipta prostrata* (false daisy) and *Persicaria decipiens* (slender knotweed). Native fish found, including eastern rainbowfish (*Melanotaenia splendida*), glass perchlets (*Ambassis agassizii*), marbled eel (*Anguilla reinhardtii*), empire gudgeons (*Hypseleotris compressa*), Pacific blue-eyes (*Pseudomugil signifier*), southern mouth almighty (*Glossamia aprion gillii*), banded grunter (*Amniataba percoides*), and spangled perch (*Leiopotherapon unicolour*). Freshwater prawns (*Macrobrachium australiense*) and shrimp (*Caridina* spp.) were present. Structural habitat categorised as shallow runs and riffles, shallow and deep pools, undercut banks, large woody debris and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Possible preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 74 (Moderate)
Macroinvertebrate Richness: 30 (bed); 33 (edge)
Macroinvertebrate PET Richness: 6 (bed); 7 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.50 (bed); 4.13 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

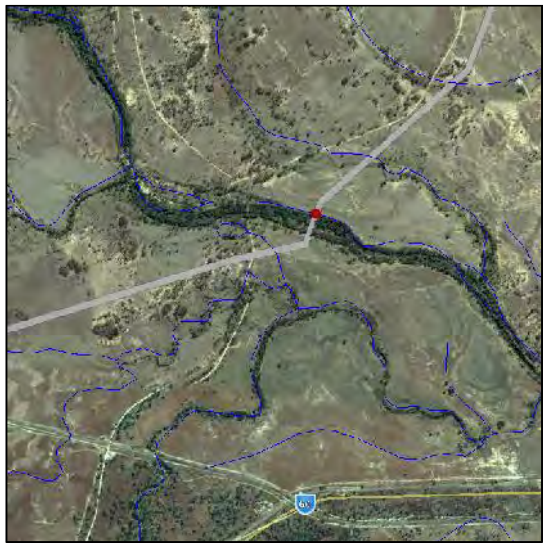
Apply the following specific management measures:

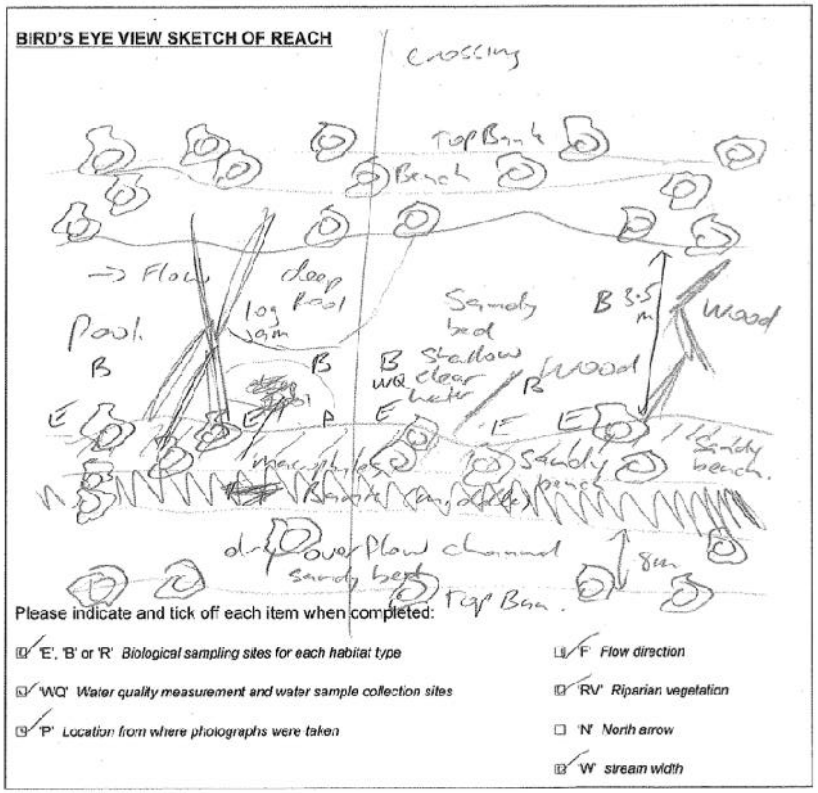
*Timing Constraints*
Works should be implemented in the dry season where possible, but avoid the months May to September when white throated snapping turtles are breeding.

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP354.3 Unnamed watercourse 9**<br>Catchment: Calliope River | **Easting**<br>281345.24 | **Northing**<br>7337398.28 |

*Stream Order and Geomorphology*
Stream Order 3
Dry, ephemeral watercourse, adjoined by grazing land. Channel substrate dominated by silt / clay, with low compaction. Both banks had moderate slope gradients and a bank height of 0.7 m. The overall stability of the banks was moderate. Stock and vegetation clearing were factors affecting stability.

*Erosion Risk*
Low. No local catchment erosion present.

*Riparian Vegetation*
No riparian vegetation, only grasses. Bank vegetation is exclusively long (>1 m) exotic grass species, including paragrass. The channel had shorter grass and paragrass in places.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Site dry at time of survey, limited aquatic flora (e.g. isolated *Cyperus* spp.) and not aquatic fauna present. Structural habitat composed of grass and some woody debris.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*).

*Aquatic Values*
Habitat Bioassessment Score: 48 (moderate).
Macroinvertebrate Richness: zero (dry site)
Macroinvertebrate PET Richness: zero (dry site)
Macroinvertebrate SIGNAL 2 Score: zero (dry site)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Low
Wet Season: Low

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

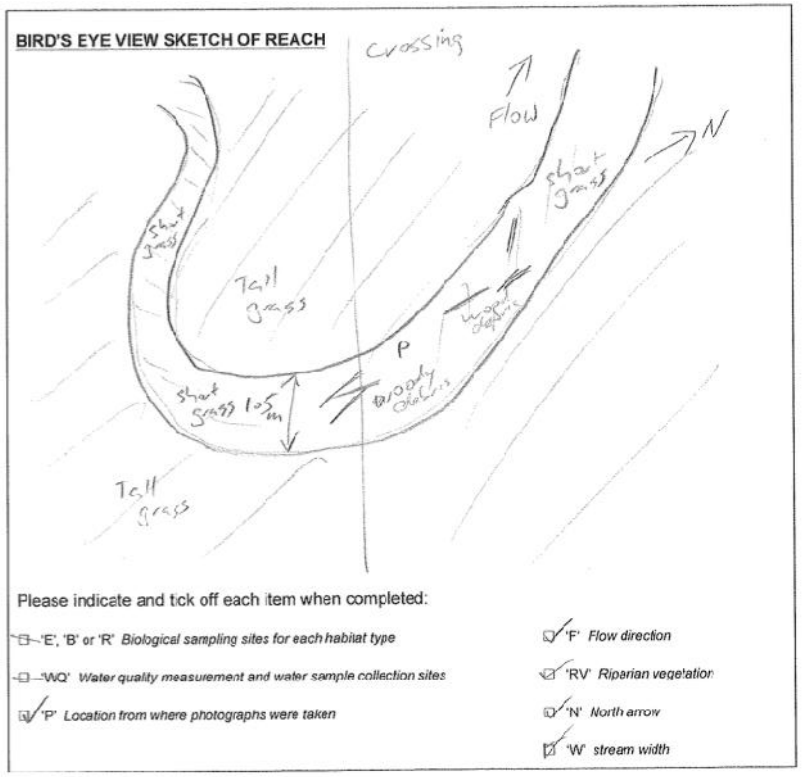
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Revegetate and re-profile banks and replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

Additional mitigation: If construction is in wet season:
Nil.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford. Revegetate and re-profile banks and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP359.5 Unnamed Watercourse 10**<br>Catchment: Calliope River | **Easting**<br>285012.79 | **Northing**<br>7340719.11 |

*Stream Order and Geomorphology*
Stream Order 3
Narrow waterbody similar to a billabong; upstream and downstream of the billabong was dry at time of survey. Waterbody was characterised as intermittent and was without flow. The left bank was steep (1.5 m) and the right bank vertical (1.5 m). Overall bank stability was moderate. Stock and vegetation clearing were factors affecting bank stability. Creek substrate had low compaction and was composed of silt / clay and some cobble.

*Erosion Risk*
Moderate. Moderate local catchment erosion was present. Left bank with moderate erosion.

*Riparian Vegetation*
Riparian zone spanned 10 m on both banks and was dominated by grass and tall native trees (eucalypt and melaleuca). Some small native trees, shrubs and bare ground were also present. Some shading of the river by vegetation (15%) and some trailing bank vegetation (10%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic flora was present including *Persicaria attenuata* (polygonaceae), *Ottelia ovalifolia* (swamp lily), *Ludwigia* sp., *Paspalum distichum* (water Couch), *Cyperus* sp., *Marsilea* sp., *Persicaria decipiens* (slender knotweed) and *Monochoria* sp. Aquatic fauna included glass perchlets (*Ambassis agassizi*), eastern rainbowfish (*Melanotaenia splendida*), empire gudgeons (*Hypseleotris compressa),* fly-specked hardyhead (*Craterocephalus stercusmuscarum*), purple spotted gudgeons (*Mogurnda adspersa*), spangled perch (*Leiopotherapon unicolor*), and carp gudgeons (*Hypseleotris* spp.). Freshwater prawns (*Macrobrachium australiense*) and crayfish (*Cherax destructor*) were caught. Structural habitat was composed of pools, undercut banks, large woody debris and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 62 (moderate)
Macroinvertebrate Richness: 23 (bed); 37 (edge)
Macroinvertebrate PET Richness: 2 (bed); 3 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.22 (bed); 3.18 (edge)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Re-align the GTP ROW to 50 m to the north of the current alignment. Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

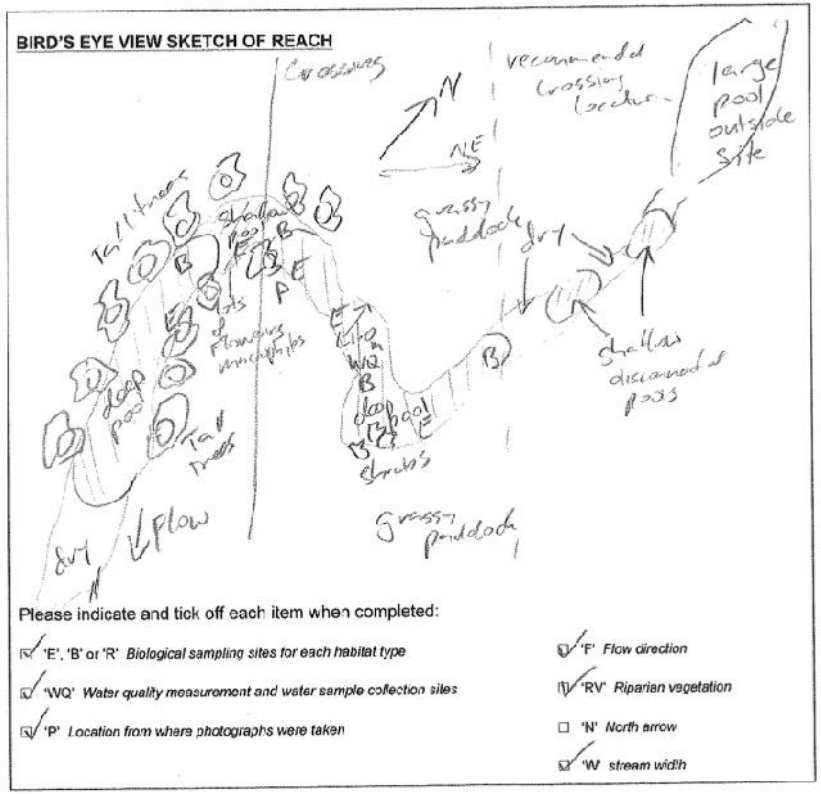
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Realignment of the GTP ROW to 50 m to the north of the current alignment.

Additional mitigation If construction is in wet season:
Nil

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford (50 m to the north of the current alignment). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
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| **Left Bank** | |
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| **Right Bank** | |
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| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP360.3 Harper Creek**<br>Catchment: Calliope Creek | **Easting**<br>285715.11 | **Northing**<br>7341058.56 |

*Stream Order and Geomorphology*
Stream Order 4
Wide bank-full width (75 m) with a mildly sinuous channel. Site characterised by a perennial water body and flow regime, with a moderate water level that was not flowing. Both banks had steep gradients (12 m) with high overall bank stability. Clearing of vegetation was a factor affecting bank stability. Channel substrate too deep to asses.

*Erosion Risk*
Bed stable. High overall bank stability.

*Riparian Vegetation*
Wide riparian vegetation zone on both banks (30 m) dominated by an understory of exotic grasses and to a lesser extent, native large trees (eucalypt, melaleuca and callistemon) and shrubs. Some smaller native trees present and little bare ground. High coverage of shading of the river and trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic flora found consisting of *Cyperus* spp., *Ceratophyllum demersum, Persicaria decipiens, Ottelia ovalifolia, Nymphoides sp. Urochloa mutica* and *Azolla pinnata*. Fauna included freshwater shrimp (Caridina spp.), glass perchlets (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*), empire gudgeons (*Hypseleotris compressa*), carp gudgeons (*Hypseleotris* spp.), purple spotted gudgeons (*Mogurnda adspersa*) and southern mouth almighty (*Glossamia aprion gillii*). Habitat variety consists of deep pools, undercut banks, large woody debris and aquatic flora. Edge habitat substrate composition was comprised of silt / clay and some sand.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Potential preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 98 (Good)
Macroinvertebrate Richness: 20 (bed); 34 (edge)
Macroinvertebrate PET Richness: 4 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.59 (bed); 3.77 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Use trenchless crossing method. Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

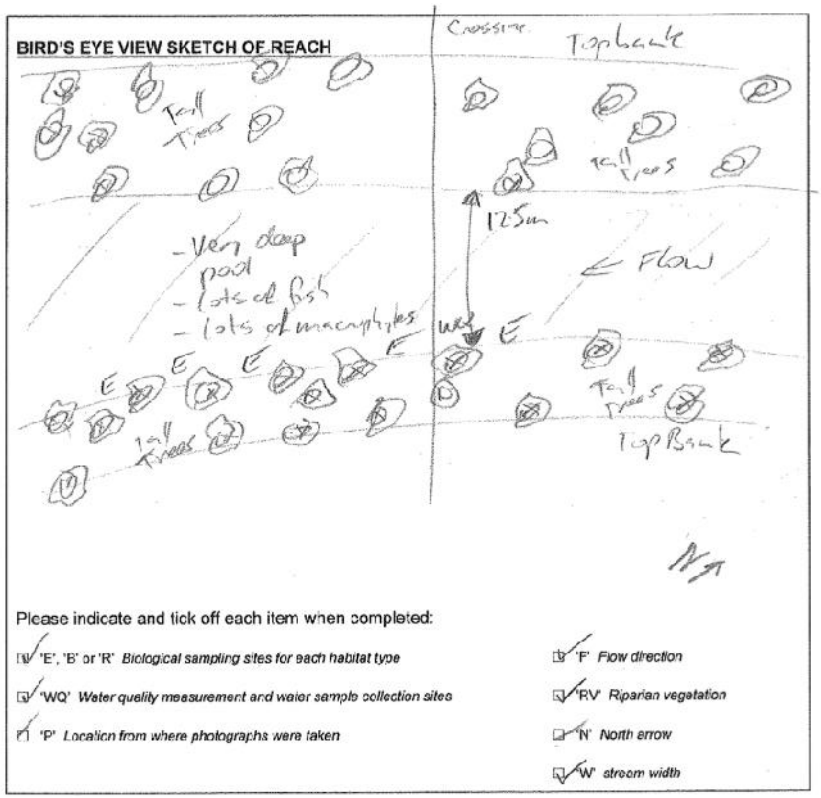
*Timing Constraints*
Works should be implemented in the dry season where possible, but avoid the months May to September when white throated snapping turtles are breeding.

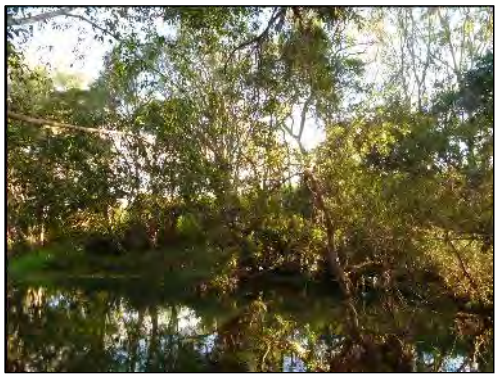
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Trenchless construction

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing road if possible.

**Aerial Photograph of KP**



| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  |  |
| **Right Bank** | |
|  |  |

| | Coordinates (Zone 56J, WGS 84) | |
|---|---|---|
| **KP364.8 Alarm Creek**<br>Catchment: Calliope Creek | **Easting**<br>289946.04 | **Northing**<br>7342432.82 |

*Stream Order and Geomorphology*
Stream Order 3
Relatively wide bank-full width (18 m), with a perennial water body and flow regime. Water very clear and multiple flow types were present, including pools and riffles. Moderate flowing water and water level was moderate at time of survey. Aquatic habitats included connected pools and riffles, undercut banks, large woody debris and aquatic flora. Left bank was moderately steep (5 m) and right bank very steep (5 m). Overall bank stability was high. Stock and flow were factors affecting bank stability. Few vegetated side / point bars and bars around obstructions were present. Channel substrate was packed gravel, sand and pebbles with some silt sediment deposition.

*Erosion Risk*
Low. Some local catchment erosion.

*Riparian Vegetation*
Riparian vegetation zone was narrow; left bank was 3 m and right bank was 4.5 m. Exotic shrubs and grasses dominated riparian vegetation. Some small native trees (callistemon) and bare ground. Moderate shading of the river and some trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic flora found consisting of *Cyperus* spp., *Persicaria decipiens, Juncus* sp., *Potamogeton ochreatus, Alternanthera denticulata, Persicaria* sp., *Ottelia alismoides,* and *Fimbristylis* sp. Aquatic fauna consisted of freshwater shrimps (*Caridina* spp.) and prawns (*Macrobrachium australiense*), and freshwater fish, including glass perchlets (*Ambassis agassizii*), marbled eels (*Anguilla reinhardtii*), eastern rainbowfish (*Melanotaenia splendida*), *empire gudgeons (Hypseleotris compressa*), *Pacific blue-eyes (Pseudomugil signifier*), *purple spotted gudgeons (Mogurnda adspersa*), and spangled perch (*Leiopotherapon unicolour*). Structural habitat was composed of shallow and deep pools, riffle, undercut banks and trailing roots on both banks, large woody debris and aquatic flora.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 95 (Good)
Macroinvertebrate Richness: 22 (bed); 28 (edge)
Macroinvertebrate PET Richness: 7 (bed); 6 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.60 (bed); 4.16 (edge)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

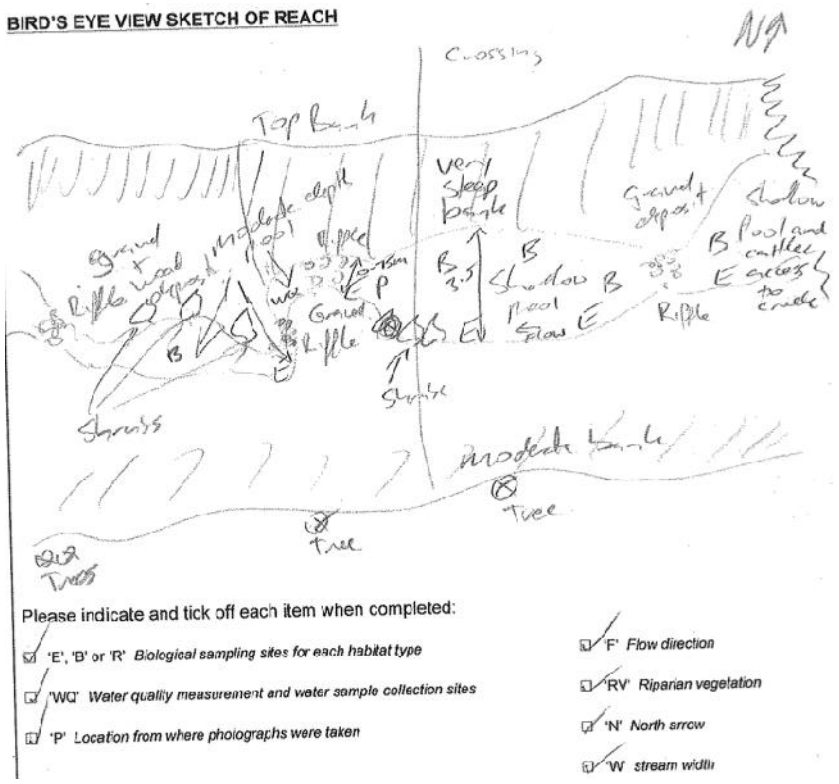
*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Upgrade existing crossing if possible - gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**



**BIRD'S EYE VIEW SKETCH OF REACH**



| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  |  |
| **Right Bank** | |
|  |  |

| | Coordinates (Zone 56K, WGS 84) | |
|---|---|---|
| **KP375.6 Gravel Creek**<br>Catchment: Calliope River | **Easting**<br>294998.09 | **Northing**<br>7350750.23 |

*Stream Order and Geomorphology*
Stream Order 3
Relatively wide (16 m) creek with grazing being the dominant surrounding land use. Perennial water body and flow regime with moderate water flow and water level. Low gradient left bank (1.5 m) and moderately steep right bank (1.5 m). Channel substrate had low compaction and consisted of silt / clay, sand, gravel and pebbles. Vegetated and unvegetated side and mid bars, bars around obstructions and sections of braided channel present.

*Erosion Risk*
Moderate. Some local catchment erosion mainly due to cattle crossing channel. The overall bank stability was moderate. Flow, stock crossing and vegetation clearing were factors affecting stability.

*Riparian Vegetation*
Narrow riparian zone (1 – 1.5 m) dominated by native small trees (*Melaleuca* sp., *Casuarina* sp. and *Callistemon* sp.), shrubs, grasses (exotic species) and bare ground. Few large native trees present. Heavy shading of the river and moderate trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora including *Myriophyllum salsugineum* (watermilfoil), *Cyperus difformis* (rice sedge), *Juncus* sp., *Fimbristylis* sp. and *Centella asiatica* (centella). High diversity of fish present, including glass perchlets (*Ambassis agassizii*), empire gudgeons (*Hypseleotris compressa*), carp gudgeons (*Hypseleotris* spp.), eastern rainbowfish (*Melanotaenia splendida*), purple spotted gudgeons (*Mogurnda adspersa*), and spangled perch (*Leiopotherapon unicolor*). Freshwater shrimp (*Caridina* spp.), prawns (*Macrobrachium australiense*) and crayfish (*Cherax destructor*) present. Structural habitat was composed of shallow and deep pools, undercut banks, trailing roots, large woody debris, backwater and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 81(Moderate)
Macroinvertebrate Richness: 21 (bed); 20 (edge)
Macroinvertebrate PET Richness: 6 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.98 (bed); 4.20 (edge)
Level of Disturbance: very high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

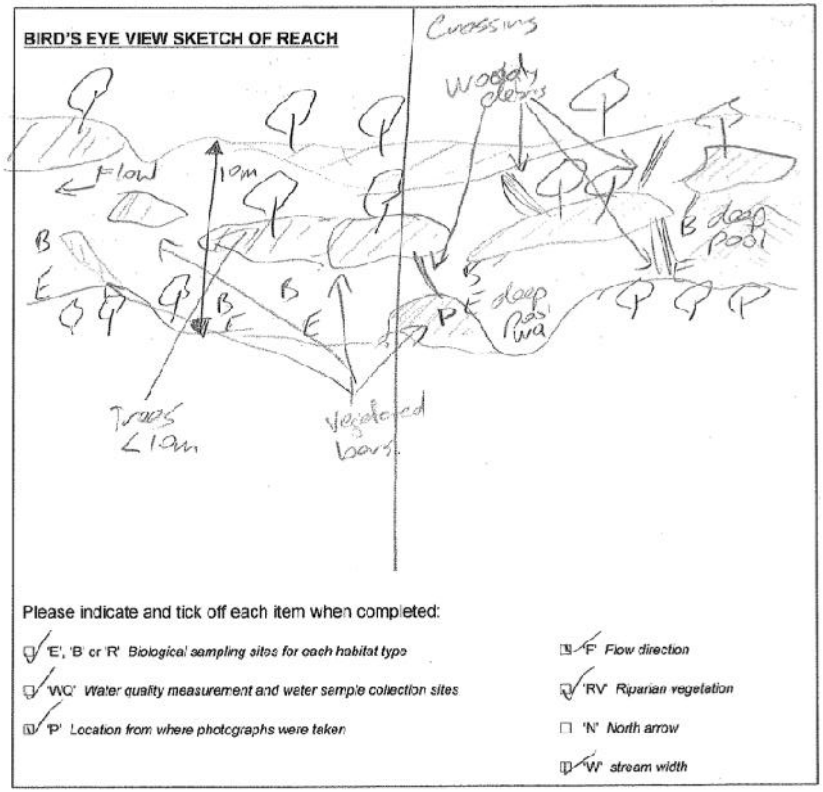
*Timing Constraints*
Nil (no EVR species likely to be present).

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Gravel ford, although construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  |  |
| **Right Bank** | |
|  |  |

| | Coordinates (Zone 56K, WGS 84) | |
|---|---|---|
| **KP378.0 Larcom Creek**<br>Catchment: Calliope River | **Easting**<br>295960.58 | **Northing**<br>7352966.54 |

*Stream Order and Geomorphology*
Stream Order 4
Banfull width 50 m, active channel approximately 6 m wide. Native forest and grazing were the surrounding landuses. Perennial flow regime, with moderate flow at time of survey. The left bank (5 m) and right bank (2 m) had moderate slope gradients with high overall bank stability. Stock and vegetation clearing were factors affecting stability. Channel substrate was composed of silt /clay, sand and some gravel and pebble. Channel bed compaction was moderate and there were vegetated and unvegetated mid-channel bars present. Aquatic habitat included riffles, runs, shallow and deep pools, undercut banks, backwaters, connected and isolated pools, large woody debris and aquatic plants

*Erosion Risk*
Low - moderate. Some local catchment erosion was present on the right bank near the culvert.

*Riparian Vegetation*
Riparian zone was 10 m on the left and 8 m on the right and was dominated by grass, shrubs and small native trees (eucalypt, melaleuca, callistemon). Some large native trees were present and little bare ground. Heavy shading of the river by the riparian zone (75%) and moderate trailing bank vegetation (50%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
High diversity of aquatic plants were present including *Ottelia alismoides*, *Lomandra hystrix*, *Potamogeton ochreatus* (blunt pondweed), *Potamogeton crispus* (curly pondweed), *Myriophyllum verrucosum* (watermilfoil), *Cyperus* sp., *Callitriche muelleri* (starwort) and *Persicaria decipiens* (slender knotweed). High diversity and abundance of aquatic fauna were present, including glass perchlets (*Ambassis agassizi*), marbled eel (*Anguilla reinhardtii*), eastern rainbowfish (*Melanotaenia splendida*), Empire gudgeons (*Hypseleotris compressa*), fly-specked hardyheads (*Craterocephalus stercusmuscarum*), carp gudgeons (*Hypseleotris* spp.), southern mouth almighty (*Glossamia aprion gillii*), Pacific blue-eyes (*Pseudomugil signifier*), and purple spotted gudgeons (*Morgunda adspersa*). Freshwater prawns (*Macrobrachium australiense*) and shrimp (*Caridina* spp.) were caught. Structural habitat was composed of deep and shallow pools, runs, riffle, undercut bank, large woody debris, macrophytes and backwaters.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Potential preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 71(Moderate)
Macroinvertebrate Richness: 19 (bed); 32 (edge)
Macroinvertebrate PET Richness: 5 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.13 (bed); 4.08 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

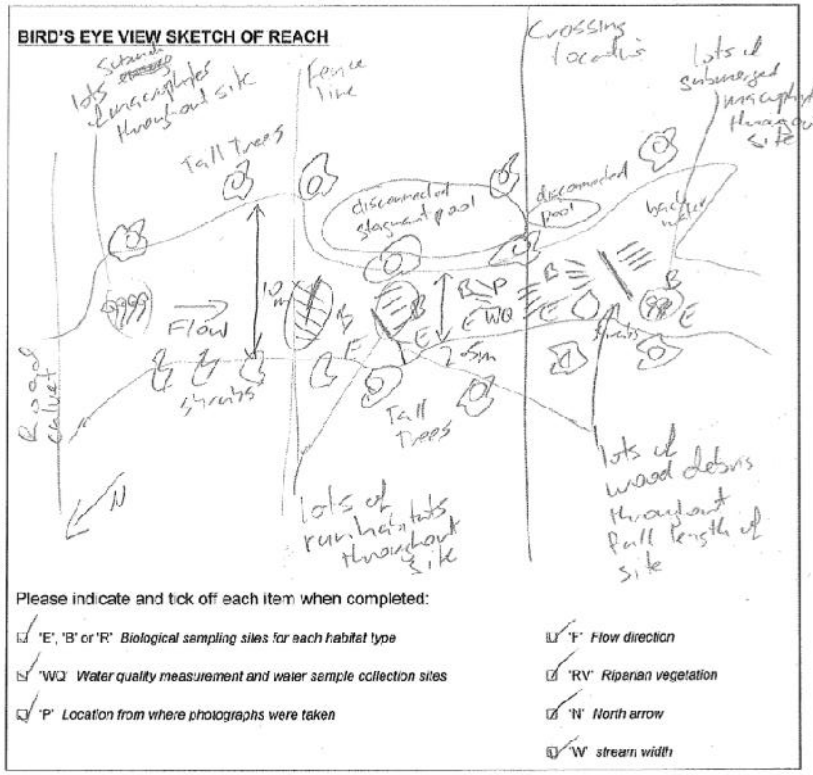
*Timing Constraints*
Works should be implemented in the dry season where possible, but avoid the months May to September when white throated snapping turtles are breeding.

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (meets requirements of self-assessable code due to relatively small bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Use existing road if possible.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  |  |
| **Right Bank** | |
|  |  |

| | Coordinates (Zone 56K, WGS 84) | |
|---|---|---|
| **KP384.7 Larcom Creek**<br>Catchment: Calliope River | **Easting**<br>299009.04 | **Northing**<br>7358584.99 |

*Stream Order and Geomorphology*
Stream Order 3
Relatively narrow (7 m) creek with grazing being the dominant land use. The water body is perennial and water at the time of the survey was above the water mark. The left bank had a low gradient (2 m) and the right bank had a moderate gradient (1.5 m). High overall bank stability. Stock and vegetation clearing were factors affecting bank stability. Channel substrate had low compaction and was composed of silt / clay. Blanket covering of silt and organic matter was present.

*Erosion Risk*
Low. No catchment erosion was present.

*Riparian Vegetation*
Relatively narrow riparian zone spanning both banks (5 m). Riparian zone was composed of grasses (some exotic) and shrubs. Some native large and small trees (eucalypt, casuarina and callistemon) were present and some bare ground. Riparian zone was semi continuous. Moderate shading of river (50%) and some trailing bank vegetation (25%).

*Aquatic Flora and Fauna, Including Breeding Habitat*
Relatively high diversity of aquatic flora including *Cyperus* spp., Spirodela sp., *Paspalum distichum* (water couch), *Callitriche muelleri* (starwort), *Ottelia ovalifolia* (swamp lily), *Vallisneria* sp. and *Azolla* sp. Moderate diversity of fish caught, including glass perchlets (*Ambassis agassizii*), eastern rainbowfish (*Melanotaenia splendida*), carp gudgeons (*Hypseleotris* spp.), Empire gudgeons (*Hypseleotris compressa*), fly-specked hardyheads (*Craterocephalus stercusmuscarum*), Pacific blue-eyes (*Pseudomugil signifier*), and purple spotted gudgeons (*Morgunda adspersa*). Krefft's river turtle (*Emydura macquarii krefftii*) was caught and the site had potential platypus habitat. Freshwater mussel shells were present on banks. Structural habitat was composed of deep pools, undercut banks, large woody debris and macrophytes.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
Potential preferred habitat for EVR species.
No preferred habitat for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 71 (Moderate)
Macroinvertebrate Richness: 33 (bed); 34 (edge)
Macroinvertebrate PET Richness: 5 (bed); 4 (edge)
Macroinvertebrate SIGNAL 2 Score: 3.50 (bed); 3.08 (edge)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: High
Wet Season: High

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

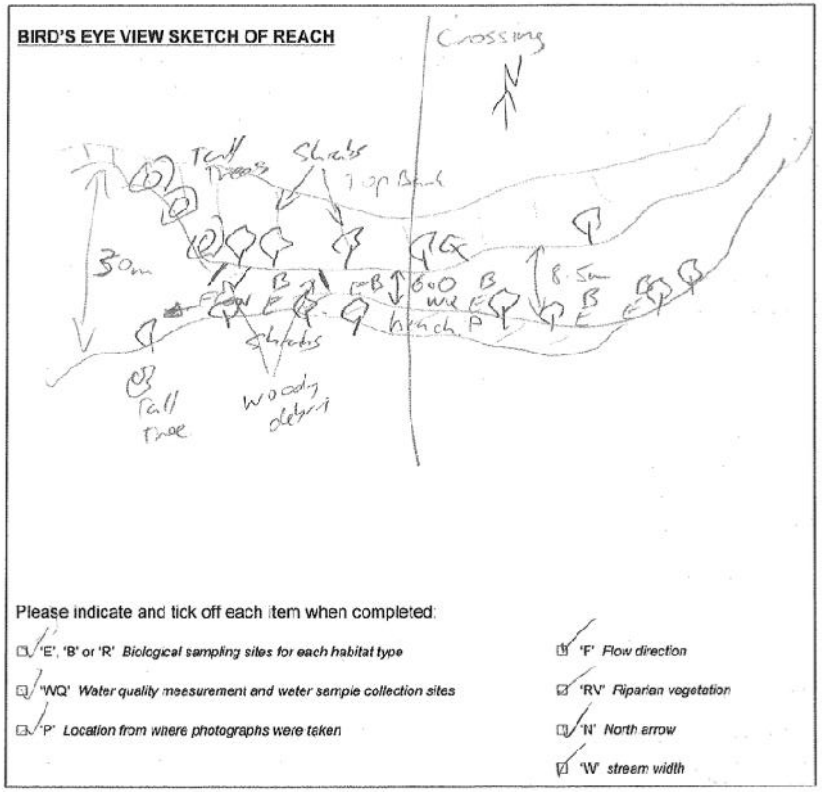
*Timing Constraints*
Works should be implemented in the dry season where possible, but avoid the months May to September when white throated snapping turtles are breeding.

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish salvage required and implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval from DAFF (does not meet the requirements of self-assessable code due to large bankfull width). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culverts; construction must be done to maintain flows. Will require a temporary waterway barrier works approval from DAFF (does not meet the requirements of self-assessable code due to large bankfull width). Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  |  |
| **Right Bank** | |
|  |  |

| | Coordinates (Zone 56K, WGS 84) | |
|---|---|---|
| **KP407.8 Humpy Creek**<br>Catchment: Calliope River | **Easting**<br>309240.2 | **Northing**<br>7371287 |

*Stream Order and Geomorphology*
Stream Order 3
Diverse range of substrates and habitats. Both sand and gravel bars were present at time of survey, where 80% of the streambed formed bars. Channel substrate was an array of sediment sizes, including gravel and sand. Substrate had moderate compaction. The left bank (1.5 m) had a gentle slope and was showing signs of erosion. The right bank had high slope and was 2 m.

*Erosion Risk*
Moderate. Some local catchment erosion present. Overall bank stability was low; affected by flow, stock access and vegetation clearing.

*Riparian Vegetation*
Marine aquatic plants were present on both banks, with high overall cover across the site (90%). Aquatic plant species were dominated by marine couch (*Sporobolus virginicus*). Mangrove species (*Aegialitis annulata, Ceriops tagal* and *Lumnitzera racemosa*) were also present.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Estuarine tidal creek, surveyed during outgoing tide. Both pool and riffle habitats were present. Site characterised by an abundance of aquatic fauna including estuarine fish and crab species. Fish species dominated by greenback mullet (*Liza subviridis*) and estuary glassfish (*Ambassis marianus*).

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Nil recorded during data searches.
No preferred habitat for EVR species.

*Aquatic Values*
Habitat Bioassessment Score: *not applicable*.
Macroinvertebrate Richness: 2 (estuarine); 3 (freshwater)
Level of Disturbance: high

Overall Aquatic Values:
Dry Season: Moderate
Wet Season: Moderate

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

*Timing Constraints*
Nil (no EVR species likely to be present).

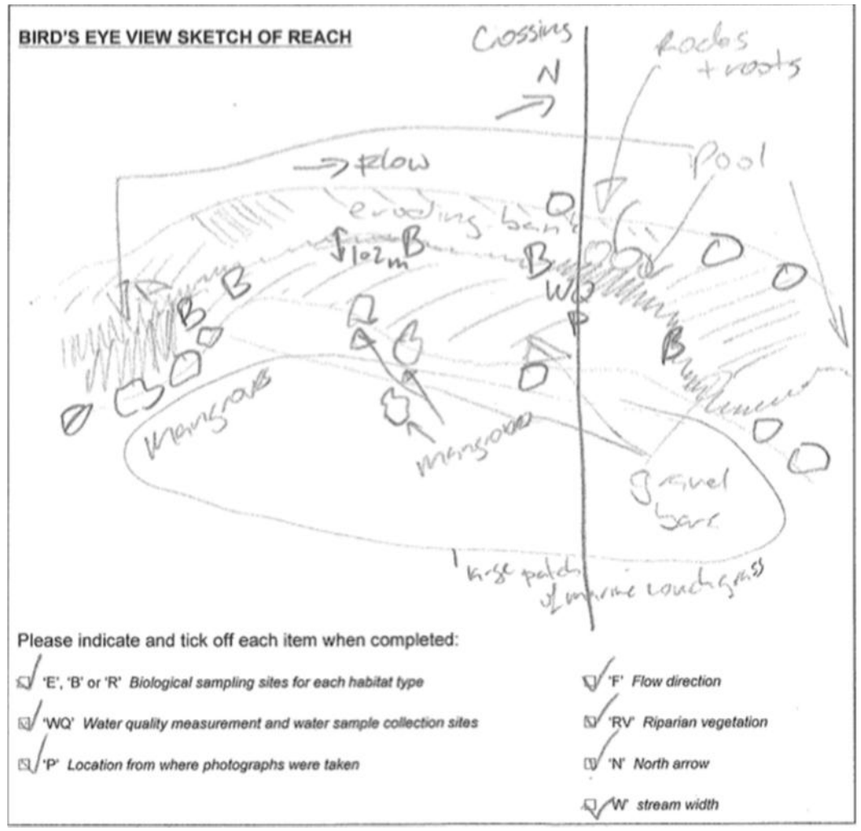
*Site-specific Pipeline Construction Methods and Mitigation Measures*
Open trench. Isolate workspace and divert flows. Fish salvage and water quality monitoring required (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Will require a temporary waterway barrier works approval and disturbance of marine plant from Fisheries Queensland. Reprofile and revegetate banks, replace bed material and in-stream habitat (in particular, large woody debris) when construction complete.

Additional mitigation If construction is in wet season: not recommended in high flow, as above if water present.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Box culvert. Isolate workspace and divert flows. Fish salvage and water quality monitoring required (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Reprofile and revegetate banks, replace bed material and in-stream habitat. Implement temporary and permanent erosion control measures as per the AVMP. Not recommended in high flow.

**Aerial Photograph of KP**





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# APPENDIX D1 – Aquatic Values Assessment for Minor Watercourses KP0-70, 200-406 and Curtis Island

Santos
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# GLNG

## Aquatic Values Assessment for Minor Watercourses KP0 – KP70, KP200 – KP406 and Curtis Island

Document Number: 3380-GLNG-4-1.3-0081

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A. Hampson | | |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| FRC Aquatic Ecologists | B. Cook | | |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Approvals Manager | C. Moore | | |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 16/6/12 | A | For review | AH | AW | CM |
| | | | | | |
| 02/08/12 | 0 | For information | AH | BC | CM |
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# 1 INTRODUCTION

GLNG Operations, a joint venture between Santos GLNG Pty Ltd (Santos), PAPL (Downstream) Pty Ltd (PETRONAS) and Total GLNG Australia (TOTAL) (herein after referred to as "the Proponent") propose to construct a high pressure Gas Transmission Pipeline (GTP) to transport coal seam gas (CSG) from the CSG fields at Roma and Fairview to a proposed liquefied natural gas (LNG) facility on Curtis Island. The GTP forms one component of the Gladstone LNG (GLNG) Project (the Project), which includes the following:

- Exploration and production of CSG in the Surat and Bowen Basin gas fields
- Construction and operation of an approximate 420 km GTP from the CSG fields in Roma and Fairview to the LNG Facility on Curtis Island
- Construction and operation of a gas liquefaction and export facility on Curtis Island and associated infrastructure

## 1.1 State Legislation and Approval

On 16 July 2007, the Queensland Government declared the Project to be a 'significant project requiring an Environmental Impact Statement'. Throughout 2008 and 2009 an environmental impact statement (EIS) was prepared for the proposed Project. The EIS report was approved by the Coordinator-General (CG) for release for public and advisory agency comment from 20 June to 17 August 2009. Submissions covered a broad range of environmental, social, accommodation, materials and employee transport, infrastructure location and regulatory approval matters.

The CG requested additional information about the EIS and the project in the form of a supplementary EIS (SEIS). A SEIS was subsequently prepared and provided to the Department of Infrastructure and Planning (now the Department of Local Government and Planning (DLGP)) in December 2009. The SEIS provided additional information to address the EIS submissions received, and identified refinements to project design.

A CG Report was released in May 2010, which allowed the Project to proceed, subject to Federal and other relevant State approvals.

As part of the conditions imposed on the GLNG project by State and Commonwealth an Aquatic Values Assessment of the watercourses and wetlands intercepted by Project is required. This data needs to be sufficiently robust so as to inform the design and construction phases, in addition to identifying strategies to avoid, minimise and mitigate potential impacts.

This report (Aquatic Values Assessment (AVA)) outlines the aquatic values of the local basins in which the works are to occur, in addition to highlighting the values at each of the minor watercourse crossing locations (stream order of 1 and 2) within the study area. It should be noted separate management plans have been developed to manage specifically with local faunal assemblages, including breeding places (Species Management Plan 3380-GLNG-3-1.3-0036), threatened and conservation significant species (Significant Species Management Plan 3380-GLNG-3-1.3-0031) and soils (Erosion and Sediment Control Plan).

### 1.2 Scope of Works

As stipulated in the Coordinator General's Report (CG Report) Conditions, prior to the commencement of petroleum activities, a review of aquatic values within the project footprint is to be undertaken, in order to recognise where environmental protection of such values will be necessary during the construction and operational phases of the Project. Specifically this AVA will include:

- A detailed assessment of the aquatic values (including animal breeding places) within the minor watercourses along the Project alignment between KP0-70, KP200-406 and Curtis Island. This includes an accurate and comprehensive description of the location, environmental values and ecological condition at a representative sample of minor watercourses in which the Project traverses, in addition to the provision of site specific mitigation measures to protect the aquatic values identified.
- Mitigation measures for permanent watercourse crossings that are consistent with AS2885 – *Pipelines – Gas, Liquid and Petroleum* (Standards Australia 2008; AS2885) and the *Australian Pipeline Industry Association Code of Environmental Practice* (APIS 2009; the Code), which indicate the engineering standards that must be applied during the construction phase of the Project, i.e.:
    - Minimisation of adverse impacts on fauna and significant habitat areas.
    - Minimisation of impacts on riparian, aquatic and water dependent flora and fauna.
    - Minimise erosion and sediment impacts.
    - Maintain water quality and water flow requirements.
    - Maximise rehabilitation success of achieving long term site stability.
- Assessment of the design of all watercourse crossings and waterway barrier works with consideration of the matters discussed in *Waterway barrier works development approvals* (Fish Habitat Management Operational Policy FHMOP 008; Queensland Primary Industries and Fisheries (QPIF) 2009), including:
    - Protection of flora and fauna during construction and operation, including reduction or disruption to habitat, and with particular mention of potential disruption to conservation significant species habitats.
    - Scheduling of construction to protect the breeding and nesting seasons of the endangered Fitzroy River turtle (*Rheodytes leukops*) and white throated snapping turtle (*Elseya albagula),* where applicable.
- Recommendations of rehabilitation of disturbed riparian areas, including commitments to maximising the use of locally sourced species and intensive planting.

It must be noted that separate management plans (i.e. Species Management Plan and Significant Species Management Plan (Ecologica Consulting 2010a and 2010b) have been prepared for aquatic and terrestrial fauna that occur or are expected to occur within the project area. Previous studies have identified the likely impact to three aquatic and semi-aquatic species, namely the Fitzroy River turtle (*Rheodytes leukops*), white throated snapping turtle *(Elseya albagula*) and platypus (*Ornithoryncus anatinus*).

As a result, the scope of this AVA for minor watercourses will focus predominately on identifying potentially suitable habitat for these species within the proposed Watercourse crossings. The proposed mitigation measures are outlined in the Aquatic Values Management Plan. In addition, separate Erosion and Sediment Control Plans, Significant

Species Management Plan and Species Management Plan have been developed for the Project.

# 2 LEGISLATIVE FRAMEWORK

## 2.1 Legislation and Permits

The following legislative documents and approvals have been considered during the preparation of this AVA:

- *Water Act 2000* (Water Act; Queensland Government (Qld Govt.) 2000).
- *Water Regulation 2002* (Water Reg.; Qld Govt. 2002).
- Vegetation Management Act 1999 (VM Act; Qld Govt. 1999).
- Nature Conservation Act 1992 (NC Act; Qld Govt. 1992).
- Land Protection (Pest and Stock Route Management) Act 2002 (LPA; Qld Govt. 2002).
- Sustainable Planning Act 2009 (SPA; Qld Govt. 2009).
- Environmental Protection Act 1994 (EP Act; Qld Govt. 1994).
- Environmental Protection (Water) Policy 2009 (EPP (Water); Qld Govt. 2009).
- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act; Commonwealth Govt. 1999).
- Fisheries Act 1994 (Qld Govt. 1994).
- Environmental Authority approval.
- Riverine Protection Permit.
- Waterway Barrier Approvals.
- Clearing approvals under the NC Act and the VM Act.

## 2.2 Guidelines, Policies and Plans

The following guidelines and policies have been considered during the preparation of this AVA:

- Australian Standard AS2885 – Pipelines – Gas, Liquid and Petroleum (Australian Standards (AS) 2008).
- Australian Standard AS2885.1 - Pipelines - Gas and Liquid Petroleum Part 1: Design and Construction (AS 1997).
- Australian Pipeline Industry Association Code of Environmental Practice (Australian Pipeline Industry Association Ltd (APIA) 2009).
- Fish Habitat Management Operational Policy FHMOP 008 Waterway barrier works development approvals (DPIF 2009).
- Activities in a watercourse, lake or spring associated with mining operations WAM/2008/3435 (DERM 2010a).
- Fish salvage guidelines (QPIF 2004).
- Santos Environment, Health and Safety Management System (EHSMS; Santos 2009).
- Code for Self-assessable Development. Minor Waterway Barrier Works. Code no. WWBW01 (DEEDI 2011).
- Code for Self-assessable Development. Temporary Waterway Barrier Works. Code no. WWBW02 (DEEDI 2010).

The following management/recovery plans have been reviewed and incorporated into this AVA, where applicable:

- Management plan for the conservation of Elseya sp. [Burnett River] in the Burnett River Catchment (Hamann et al 2007).
- GLNG Environmental Management Plan – 3380-GLNG-3-8.2-0027.
- GLNG Construction Environmental Management Plan – 3380-SAIP-4-1.3-1814.
- GLNG Species Management Plan – 3380-GLNG-3-1.3-0036.
- GLNG Significant Species Management Plan – 3380-GLNG-3-1.3-0031.
- GLNG Landscape and Rehabilitation Management Plan – 3380-GLNG-3-1.3-0037.
- GLNG Erosion and Sediment Control Management Plan – Pipeline Construction KP0-70 – 3380-SAIP-4-1.3- 7038 and GLNG Erosion and Sediment Control Management Plan – Pipeline Construction KP200-420 – 3380-SAIP-4-1.3- 7039.

# 3 PROJECT DESCRIPTION

GLNG is proposing the development of coal seam gas (CSG) resources in the Surat and Bowen Basins, between Roma and Emerald, in western Queensland. The CSG fields are intended to supply gas for the proposed liquefied natural gas (LNG) liquefaction and export facility (LNG facility) on Curtis Island, near Gladstone, Queensland. A high pressure gas transmission pipeline (for which this AVA relates) is proposed to be constructed to link the CGS fields to the LNG facility (refer AVMP, Figure 1).

## 3.1 Study Area Description

For the purposes of this report, the study area has been defined 286 km in length and a 30 m Right of Way (ROW) and a 10 m work area covering the following sections of the GTP between:

- KP 0 and KP 70.
- KP 200 and KP 406.
- KP 410 and KP 420 (Curtis Island).

The entire GTP originates approximately 90 km north of Roma and 37 km north east of Injune, within the Fairview Coal Seam Gas Fields extends north through Arcadia Valley to the Dawson Highway before travelling primarily east prior to terminating within the south-western extremity of Curtis Island (refer AVMP, Figure 1).

The project alignment traverses the following local authority areas:

- Maranoa Regional Council.
- Central Highlands Regional Council.
- Banana Shire Council.
- Gladstone Regional Council.

The section of the project referred to in this report traverses the Fitzroy (Dawson and comet sub-catchments) and Calliope Basin. The Fitzroy Basin is the largest basin on Australia's east coast.

The study area is typically characterised by cleared agricultural land which supports grazing and cropping activities. Isolated patches of bushland typically exist as open woodland, often along and adjacent to the watercourses.

## 3.2 Pipeline Alignment

The Gladstone transmission pipeline (GTP) ROW has been positioned closely aligning the existing Queensland Gas (QG) Pipeline for the majority of its length (approximately 300 km). A segment of the alignment to the north of Injune deviates from the QG Pipeline, traversing the eastern side of the Arcadia Valley. The GTP ROW advances towards Gladstone from the south-west and continues on to Port Curtis between Friend Point and Laird Point. The proposed GTP ROW and the section referred to in this document are illustrated in the AVMP's Figure 1.

# 4 METHODOLOGY

## 4.1 Desktop Analysis

The assessment of aquatic values for minor watercourse crossings (stream order 1 and 2) has been conducted in a two stage process beginning with a desktop analysis. From this desktop analysis a representative sample was selected in order to conduct field investigations. The desktop analysis involved the following actions:

- Review of aerial photography.
- GIS analysis to determine an accurate watershed and stream network within the project area.
- GIS analysis to identify the location of the crossings, the stream order of each of the watercourses intercepted and the health of the local catchment (e.g. land use and clearing). GIS data sources included, but was not limited to DERMs Regional Ecosystem (RE) (2010b) and Regrowth Mapping (2010b) and DERM's Wetland Mapping (2010c).
- Review of relevant environmental databases (DERMs Wildlife Online (2010d), *Census of Queensland Flora* (2010)) to identify records of significant aquatic and semi-aquatic plant species known from the locality.
- Review of Queensland Herbariums Regional Ecosystem Description Database (2011).
- Review of the GTP and Coal Seam Gas Fields EIS and SEIS.
- Review of The State of the Rivers reports for the Dawson River and major tributaries (DPI 1995) and the Comet, Nogoa and Mackenzie Rivers (DPI 2000) which provide an assessment of aquatic values through the evaluation of key components, including:
  - Reach environs.
  - Channel habitat diversity.
  - Channel form and dimensions.
  - Bed and bank sediments.
  - Bank stability.
  - Bed and bar stability.
  - Riparian and aquatic vegetation.
  - Aquatic habitat.
  - Scenic recreational and conservation values.
  - Overall condition rating.
- Review of previous ecological and aquatic assessments of the various watercourses within the Fitzroy Basin.

## 4.2 Representative Sample

A representative sample of minor watercourses (stream order 1 and 2) was chosen based on the desktop analysis. An estimated 24 percent sample was selected capturing watercourses that are representative of the various conditions encountered along the GTP ROW. Consideration was given to the following factors:

- Catchment / subcatchment.
- Regional Ecosystem status.
- Vegetation density.
- Land use.
- Terrain.
- Spatial characteristics.

The selected sample is representative of highly disturbed and relatively undisturbed watercourses within the 286km study area. A total of 32 from 134 minor watercourses were assessed for aquatic value. The locations of these minor watercourses are listed in Appendix B and shown in the AVMP's Figure 2. Table 4-1 depicts the representative samples. . For the purposes of this AVA, the minor watercourse crossing at KP25.3 (Edwards Creek, stream order 2) has been removed and is being assessed in detail along with the major watercourses, as preliminary investigations revealed that this location may have high aquatic ecological values and is therefore not included in this AVA.

**Table 4-1 Representative sample of Minor Watercourses**

| Watercourse Name | KP | SO | Eastings | Northings |
|---|---|---|---|---|
| Unnamed Minor watercourse 4 | 18.969 | 2 | 688203.144 | 7166412.517 |
| Gratz Gully | 32.499 | 2 | 690946.081 | 7177671.350 |
| Unnamed Minor watercourse 13 | 39.256 | 1 | 690397.602 | 7184158.863 |
| Unnamed Minor watercourse 21 | 65.647 | 2 | 686445.504 | 7209513.642 |
| Unnamed Minor watercourse 24 | 69.224 | 1 | 685033.621 | 7212799.162 |
| Unnamed Minor watercourse 100 | 221.390 | 1 | 777716.656 | 7290542.240 |
| Unnamed Minor watercourse 101 | 224.968 | 1 | 781177.035 | 7290008.247 |
| Unnamed Minor watercourse 103 | 238.013 | 1 | 792109.139 | 7295098.736 |
| Unnamed Minor watercourse 104 | 238.312 | 1 | 792409.388 | 7295094.015 |
| Unnamed Minor watercourse 110 | 258.240 | 1 | 201047.407 | 7302284.536 |
| Unnamed Minor watercourse 111 | 258.740 | 1 | 201531.842 | 7302405.036 |
| Unnamed Minor watercourse 126 | 307.168 | 2 | 247047.326 | 7313854.935 |
| Unnamed Minor watercourse 133 | 320.524 | 2 | 257976.049 | 7319734.756 |
| Unnamed Minor watercourse 134 | 320.639 | 2 | 258052.595 | 7319821.134 |
| Unnamed Minor watercourse 136 | 328.370 | 1 | 264606.610 | 7321100.907 |
| Unnamed Minor watercourse 144 | 345.586 | 2 | 275079.892 | 7332234.414 |
| Unnamed Minor watercourse 152 | 352.059 | 1 | 280279.389 | 7335478.133 |
| Unnamed Minor watercourse 154 | 353.406 | 1 | 281077.612 | 7336496.002 |
| Unnamed Minor watercourse 161 | 365.713 | 2 | 290778.378 | 7342801.949 |
| Unnamed Minor watercourse 164 | 366.269 | 1 | 291286.630 | 7343028.096 |
| Unnamed Minor watercourse 171 | 374.394 | 1 | 294400.832 | 7349666.171 |
| Unnamed Minor watercourse 172 | 375.699 | 1 | 295030.111 | 7350806.695 |
| Unnamed Minor watercourse 175 | 380.730 | 1 | 297002.425 | 7355408.248 |
| Unnamed Minor watercourse 182 | 391.096 | 1 | 296905.366 | 7364069.257 |
| Unnamed Minor watercourse 184 | 396.757 | 1 | 300193.223 | 7368115.816 |
| Unnamed Minor watercourse 190 | 399.211 | 1 | 301970.019 | 7369677.027 |
| Unnamed Minor watercourse 193 | 399.682 | 1 | 302215.295 | 7370063.381 |
| Unnamed Minor watercourse 195 | 400.028 | 1 | 302507.211 | 7370232.086 |

| Watercourse Name | KP | SO | Eastings | Northings |
|---|---|---|---|---|
| Unnamed Minor watercourse 196 | 400.134 | 1 | 302584.911 | 7370297.987 |
| Unnamed Minor watercourse 198 | 400.797 | 1 | 302989.857 | 7370815.019 |
| Unnamed Minor watercourse 205 | 416.137 | 1 | 316529.995 | 7372579.587 |
| Unnamed Minor watercourse 206 | 418.172 | 1 | 317560.764 | 7370883.328 |

### 4.3 Field Investigations

Field investigations were carried out in accordance with AUSRIVAS's Sampling and Processing Manual (DNRM 2001). At each of the watercourses inspected information was collated on the following:

- Whether the GTP ROW intercepts a permanent pool, wetland area or ephemeral reachInstream habitat complexity (e.g. undercuts, woody debris, macrophyte beds etc.).
- Riparian structure and composition, especially with regard to DERMs RE mapping (2010b).
- Habitat potential for threatened fauna species, Fitzroy River turtle, platypus and white-throated snapping turtle. In addition, to noting down nests and habitat trees and opportunistic sightings of animals.
- Physical water quality sampling – including pH, dissolved oxygen, temperature, conductivity and turbidity of water.
- Vegetation sampling – collection and preservation of riparian and aquatic specimens to be identified by the Queensland Herbarium.
- Threatening processes (e.g. weeds, erosion, cattle roads, other linear infrastructure).
- Photo reference points – crossing location, looking upstream and downstream of the crossing.
- Substrate sampling (of watercourse bank and bed) for particle size distribution.
- Macroinvertebrate sampling where possible.

### 4.4 Methodology for Assigning Overall Aquatic Value to Watercourses

Wet season field investigations, literature reviews and database searches were used to inform the assignment of overall wet season aquatic value for each watercourse crossing. Four categories of aquatic value were used (High, Moderate, Low, Negligible), based on the following criteria:

#### 4.4.1 High Value

- Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the Environment Protection and Biodiversity Conservation Act 1999 and / or the Nature Conservation Act 1992, and / or those species listed as priority species in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity document (DERM 2010).
- Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species was assessed using a combination of:

- Habitat condition [e.g. the Bioassessment scores method (DNRM 2001).
- Levels of disturbance (e.g. erosion, riparian vegetation condition).
- Likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS).
- Relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River Turtle, Tucker et al. 2001; in-stream habitat and connectivity for freshwater fish, including undercut banks, substrate characteristics and large woody debris).

### 4.4.2 Moderate Value

- Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.
- Aquatic life included:
  - Submerged and / or floating attached aquatic plants.
  - Native freshwater fish (such as rainbowfish, spangled perch, glass perchlets and purple spotted gudgeons),
  - Aquatic invertebrates (including crayfish, shrimps, snails, mussels, and insects).
- Life history stage (i.e. juvenile, intermediate, and adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.
- Aquatic habitat was assessed using:
- Habitat condition [e.g. the Bioassessment scores method (DNRM 2001).
- Levels of disturbance (e.g. erosion, riparian vegetation condition).
- Habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, and large woody debris).

### 4.4.3 Low Value

- Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.
- Emergent aquatic plants, such as sedges and nardoo, may be have been present.
- Field investigations also indicated the presence of structural habitat elements, including:
  - Woody debris.
  - Cobbles.
  - Undercut banks.
- Habitat condition was determined using:
  - The Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams.
  - Levels of disturbance (e.g. erosion, riparian vegetation condition).

### 4.4.4 Negligible Value

- Where field investigations indicated:
  - An absence of aquatic habitats.

  - Absence of aquatic life (e.g. no aquatic fauna or aquatic plants and including no sedges).
- Habitat condition was typically poor:
  - Low Bioassessment Scores (DNRM 2001).
  - High levels of disturbance (e.g. extensive erosion and no riparian vegetation).

### 4.4.5 Dry Season Aquatic Values

Dry season aquatic values were also based on these four criteria, using previous dry season surveys for several sites to inform of permanence of pools / water, and expert judgment regarding permanence of pools / water at sites not visited during the dry season. Sites that were dry during the wet season were considered likely to also be dry during the dry season, as were sites that were previously shown to be dry during the dry season. Sites that contained water during the wet season, even as disconnected pools within the channel, were conservatively assessed as possibly having temporary water that may persist for some time into the dry season. In these cases, dry season aquatic values were assessed as moderate, in accordance with the criteria above.

## 5 AQUATIC VALUES OF MINOR WATERCOURSES

This section provides an assessment of the aquatic values of a representative sample of watercourses with a stream order value of 1 or 2 (minor watercourses) between:

- KP 0 and 70.
- KP 200 and 406.
- KP 410 and 420 (Curtis Island).

This includes 32 watercourses out of a total of 134 from within 2 catchment areas (Fitzroy River and Calliope River) which are traversed by the GTP ROW. A summary of the representative watercourses and their locations is provided in Table 1, while Table 5-1 presents the overall aquatic value and mapped vegetation code.

**Table 5-1**

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Overall Aquatic Value |
|---|---|---|---|---|---|
| Unnamed Minor watercourse 4 | 18.969 | 2 | | Non-remnant | Negligible |
| Gratz Gully | 32.499 | 2 | Of concern | 11.3.17 | Negligible |
| Unnamed Minor watercourse 13 | 39.256 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 21 | 65.647 | 2 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 24 | 69.224 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 100 | 221.39 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 101 | 224.97 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 103 | 238.01 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 104 | 238.31 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 110 | 258.24 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 111 | 258.74 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 126 | 307.17 | 2 | | Non-remnant | Low to Moderate |
| Unnamed Minor watercourse 133 | 320.52 | 2 | Least concern | 11.11.15/11.11.4 | Low |
| Unnamed Minor watercourse 134 | 320.64 | 2 | Least concern | 11.11.15/11.11.4 | Negligible |
| Unnamed Minor watercourse 136 | 328.37 | 1 | Least concern | 11.11.15//11.11.4 | Negligible |
| Unnamed Minor watercourse 144 | 345.59 | 2 | | Non-remnant | Low to Moderate |
| Unnamed Minor watercourse 152 | 352.06 | 1 | Of concern | 11.3.4/11.3.25 | Negligible |
| Unnamed Minor watercourse 154 | 353.41 | 1 | | Non-remnant | Low to Moderate |
| Unnamed Minor watercourse 161 | 365.71 | 2 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 164 | 366.27 | 1 | | Non-remnant | Negligible |

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Overall Aquatic Value |
|---|---|---|---|---|---|
| Unnamed Minor watercourse 171 | 374.39 | 1 | | Non-remnant | Moderate |
| Unnamed Minor watercourse 172 | 375.7 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 175 | 380.73 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 182 | 391.1 | 1 | | Non-remnant | Moderate |
| Unnamed Minor watercourse 184 | 396.76 | 1 | | Non-remnant | Moderate |
| Unnamed Minor watercourse 190 | 399.21 | 1 | Endangered | 11.11.15/11.11.18 | Negligible |
| Unnamed Minor watercourse 193 | 399.68 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 195 | 400.03 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 196 | 400.13 | 1 | | Non-remnant | Negligible |
| Unnamed Minor watercourse 198 | 400.8 | 1 | Endangered | 11.11.15/11.11.18 /11.11.3 | Negligible |
| Unnamed Minor watercourse 205 | 416.14 | 1 | Endangered | 12.3.3/12.3.7 | Negligible |
| Unnamed Minor watercourse 206 | 418.17 | 1 | Of concern | 12.11.6/12.11.14 | Negligible |

For ease of reference, watercourse crossings have been assessed and presented in the order of which the pipeline traverses, beginning in the south-west. Data sheets and photographs from field assessments are shown in Appendix A.

### 5.1 Unnamed Minor Watercourse 4 (KP18.9)

The Unnamed minor watercourse at KP18.9 is an ephemeral watercourse which is a tributary of Baffle Creek within the upper Dawson River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land where the area is primarily suited to grazing of native pastures with or without the addition of improved pasture species, but without ground disturbance (DPI/DHLGP 1993). As a result, the watercourse is devoid of riparian and trailing vegetation which consists solely of grasses with scattered shrubs and trees such as *Callitris glaucophylla* and *Indigofera australis*. This is evident in Illustration 1.

The soils in the area have a high erosion potential and the substrate of the watercourse at the crossing location consists of approximately 70 % boulders. At the GTP crossing location the watercourse consists of approximately a 4 m active channel, with high banks at an approximate 15 degree incline forming a wide grassed high flow channel of about 70 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 1: Facing upstream from proposed crossing location at KP18.9 (Wet season 2012)**

### 5.2 Gratz Gully (KP32.4)

Gratz gully at KP32.4 is an ephemeral watercourse which is a tributary of the Dawson River. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped by DERM (2010b) as Of Concern Dominant RE11.3.17. The local catchment of the watercourse contains moderate to extensive trailing vegetation dominated by grasses and Brigalow and Ironbark species. The area is mapped as pasture land suitable for native pastures with some areas tolerating occasional cultivation for improved pasture (DPI/DHLGP 1993). The riparian zone of the watercourse is greater than 10 m wide on the left bank and 2 m on the right bank with an approximate 70 to 80 % canopy cover and consists mainly of Brigalow, *Geijera parviflora* and *Eremophila mitchellii.*

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists of silty loam materials. Extensive bank erosion in the watercourse infers extensive flooding occurred during the 2010/2011 wet season. At the

GTP crossing location the watercourse consists of approximately a 1 m wide active channel, with a non evident high flow channel. Illustration 2 shows the crossing point at this location.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 2: Facing downstream from proposed crossing location at Gratz Gully (KP32.4) (Wet season 2012)**

### 5.3 Unnamed Minor Watercourse 13 (KP39.25)

The Unnamed minor watercourse at KP39.25 is an ephemeral watercourse within the Comet River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry with approximately 40 mm of rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use and is classed as Strategic Cropping Land (SCL). Riparian vegetation consists mainly of trees and scattered shrubs including *Eucalyptus melanophloia, Alectryon oleifolius, Lysiphyllum carronii* and *Parsonsia lanceolata*. The surrounding area has been cleared for agricultural land use, and as a result trailing vegetation consists mainly of grasses with few scattered shrubs and small trees. This is evident in Illustration 3.

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists of silt and clay. At the GTP crossing location the watercourse consists of approximately a 3 m active channel with banks approximately 1 m high.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 3: Facing downstream from proposed crossing location at KP39.25 (Wet season 2012)**

### 5.4 Unnamed Minor Watercourse 21 (KP65.6)

The Unnamed minor watercourse at KP65.6 is an ephemeral watercourse which is a tributary of Ironbark Creek within the Comet River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use and is classed as Strategic Cropping Land (SCL). The area is mapped as Limited Crop Land where the area is primarily suited to cropping and cultivation of pastures, however it may require engineering and/or agronomic improvements (DPI/DHLGP 1993). As a result, the watercourse is largely devoid of riparian and trailing

vegetation which consists solely of grasses with scattered shrubs and few small Brigalow trees which is evident in Illustration 4.

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists of approximately 70 % silt and clay. At the GTP crossing location the watercourse consists of approximately a 1.5 m active channel, with high banks at an approximate half a metre high forming a wide grassed high flow channel of about 12 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 4: Facing downstream from proposed crossing location at KP65.6 (Wet season 2012)**

### 5.5 Unnamed Minor Watercourse 24 (KP69.2)

The Unnamed minor watercourse at KP69.2 is an ephemeral watercourse which is a tributary of the Brown River within the Comet River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use and is classed as SCL. The area is mapped as Limited Crop Land where the area is primarily suited to cropping and cultivation of pastures,

however it may require engineering and/or agronomic improvements (DPI/DHLGP 1993). As a result, the watercourse is largely devoid of riparian and trailing vegetation which consists solely of grasses with few scattered trees which is evident in Illustration 5. Due to the agricultural land use (i.e. grazing) there are compacted stock routes with no vegetative cover on the northern bank.

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists of silt and clay. At the GTP crossing location the watercourse has been heavily altered and consists of an extremely shallow depression less than half a metre deep (evident Illustration 5), however 30 m upstream of the crossing location is a 2 m deep extensively eroded channel, evidently a result from previous flooding.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 5: Facing upstream from proposed crossing location at KP69.2 (Wet season 2012)**

### 5.6 Unnamed Minor Watercourse 100 (KP221.3)

This Unnamed minor watercourse at KP221.3 is an ephemeral watercourse which is a tributary of the Mimosa Creek in the Dawson River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped by DERM (2010b) as non remnant. The local catchment of the watercourse contains limited trailing vegetation consisting of mainly grasses and sparsely distributed silver leaved Ironbark and Eucalypts. The area is classed as SCL and is mapped as Pasture Land suitable for native pastures and occasional cultivation of improved pasture (DPI/DHLGP 1993). The riparian zone of the watercourse is approximately 5 m wide with an approximate 5 % canopy cover on both banks evident in Illustration 6. The main channel is grassed and contains scattered sedges (*Cyperus betchei*).

The soils in the area have a moderate erosion potential and the watercourse at the crossing location consists of a silt/clay substrate. At the GTP crossing location the watercourse consists of a 25 m wide active channel with no evident high flow channel.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 6: Facing upstream at proposed crossing location at KP221.3 (Wet season 2012)**

### 5.7 Unnamed Minor Watercourse 101 (KP224.97)

This Unnamed minor watercourse at KP224.97 is an ephemeral watercourse which is a tributary of the Mimosa Creek in the Dawson River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall.

At the time of assessment, this watercourse was dry with approximately 30 mm of rainfall occurring in the last week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped by DERM (2010b) as non remnant. The local catchment of the watercourse contains limited trailing vegetation consisting of mainly grasses and sparsely distributed silver leaved Ironbark and Eucalypts. The area is mapped as Pasture Land suitable for native pastures without ground disturbance (DPI/DHLGP 1993). The riparian zone of the watercourse is approximately 1-2 m wide with limited canopy cover on both banks. Species present consist of *Acacia fasciculifera*, *Apophyllum anomalum*, *Alectryon diversifolius* and *Carissa ovate* which is evident in Illustration 7.

The soils in the area have a moderate erosion potential and the watercourse at the crossing location consists of a silt/clay substrate. At the GTP crossing location the watercourse consists of a 25 m wide active channel with no evident high flow channel.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 7: Facing downstream at proposed crossing location at KP224.97 (Wet season 2012)**

## 5.8 Unnamed Minor Watercourse 103 and 104 (KP238.013 and KP238.312)

Unnamed minor watercourses 103 and 104 are ephemeral watercourses which are tributaries of the Dawson River. These watercourses are mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, both watercourses were dry.

The GTP traverses perpendicular to these watercourses where the vegetation is mapped by DERM (2010b) as non remnant. The local catchment of the watercourses contains limited trailing vegetation consisting of mainly grasses and sparsely distributed silver leaved Ironbark and Eucalypts. The surrounding area is classed as SCL. The riparian zone of both these watercourses is less than 1 m wide with limited canopy cover on both banks. This is evident in Illustrations 8 and 9.

The soils in the area have a moderate erosion potential and the watercourse at the crossing location consists of a silt/clay substrate. Limited to moderate erosion was present at both sites, which is primarily a result of cattle movement. At the GTP crossing location of Unnamed minor watercourse 104, the watercourse consists of a 10 m wide active channel and a wider high flow channel of 42.5 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 8: Facing upstream at proposed crossing location at KP238.31 (Dry season 2012)**



**Illustration 9: Facing downstream at proposed crossing location at KP238.31 (Dry season 2012)**

### 5.9 Unnamed Minor Watercourse 110 and 111 (KP258.24 and KP258.74)

Unnamed minor watercourses 110 and 111 are ephemeral watercourses which are tributaries of the Dawson River. These watercourses are mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, both watercourses were dry.

The GTP traverses perpendicular to these watercourses where the vegetation is mapped by DERM (2010b) as non remnant. The local catchment of the watercourses contains limited trailing vegetation consisting of mainly grasses and sparsely distributed Eucalypts. The surrounding area is mapped as pasture land suitable for cultivation of native pastures (DPI/DHLGP 1993). The riparian zone of both these watercourses is less than 1 m wide with limited canopy cover on both banks. Plant species present include *Leucaena leucocephala*, *Lysiphyllum carronii* and *Psydrax oleifolium*. This is evident in Illustrations 10 and 11.

The soils in the area have a moderate erosion potential and the watercourse at the crossing location consists of a silt/clay and sand substrate. Moderate to extensive erosion was present at both sites. At the GTP crossing location of Unnamed minor watercourse 104, the watercourse consists of a 3 m wide active channel.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 10: Facing upstream at proposed crossing location at KP258.74 (Dry season 2012)**



**Illustration 11: Facing downstream at proposed crossing location at KP258.74 (Dry season 2012)**

### 5.10 Unnamed Minor Watercourse 126 (KP307.1)

The Unnamed minor watercourse at KP307.1 is an ephemeral watercourse which is a tributary of Callide Creek within the Dawson River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse had a highly turbid low flow after approximately 51 mm of rainfall in the previous week and a further 70 mm falling the previous evening.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped Crop Land suitable for current and potential crops with nil to moderate limitations to production (DPI/DHLGP 1993). As a result, the watercourse is devoid of riparian and trailing vegetation which consists solely of grasses which is evident in Illustration 12. Semi aquatic sedges such as *Fimbristylis ferruginea* and *Cyperaceae sp.* were present throughout the watercourse.

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists of sand and silt particles. At the GTP crossing location the watercourse consists of approximately a 6 m active channel, with low banks of approximately half a metre which form a grassed high flow channel of about 10 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 12: Facing downstream at proposed crossing location at KP307.1 (Wet season 2012)**

### 5.11 Unnamed Minor Watercourse 133 and Unnamed Watercourse 134 (KP320.5 and KP320.6)

This Unnamed minor watercourse at KP320.2 is an ephemeral watercourse which is a tributary of Bell Creek in the Dawson River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry however a small stagnant pool approximately 1 m in diameter was present.

The GTP traverses this watercourse on two occasions where the vegetation is mapped by DERM (2010b) as Not of Concern RE11.11.15/11.11.4. The local catchment at both crossings contains moderate trailing vegetation consisting of mainly *Maleleuca* sp., Thin Leaved Ironbark, Bottle trees and *Cycas megacarpa*. The area also has a widespread infestation of *Lantana camara* and *Xanthium occidentale* (Noogoora Burr). The area is mapped as Pasture Land suitable for light grazing in accessible areas (DPI/DHLGP 1993). The riparian zone of the watercourse is approximately 10 m on the right bank wide with an approximate 5 to 10 % canopy cover on both banks consisting mainly of *Maleleuca* sp. and *Cyperaceae* sp. The left bank has limited riparian vegetation due to the steepness of the rocky terrain.

The soils in the area have a moderate to high erosion potential and the watercourse at the crossing location consists of a rocky substrate. At the first GTP crossing location the watercourse consists of a 15 m wide active channel reducing to approximately 1 m wide at the second crossing. Illustration 13 and 14 show the first and second crossing points respectively.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 13: Facing upstream at proposed crossing location at KP320.5 (Wet season 2012)**



**Illustration 14: Facing upstream at proposed crossing location at KP320.6 (Wet season 2012)**

### 5.12 Unnamed Minor Watercourse 136 (KP328.37)

The Unnamed minor watercourse at KP328.37 is an ephemeral watercourse which is a tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped by DERM (2010b) as Not of Concern RE11.11.15/11.11.4. The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). The surrounding area has moderate to extensive trailing vegetation, consisting of scattered Ironbarks, Eucalyptus and *Xanthorrea* sp. with extensive grass cover. Riparian vegetation is approximately 1 m wide and consists of mainly grasses and trees forming an approximate 10 % canopy cover. This is depicted in Illustration 15.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of gravel with some sand and silty clay. At the GTP crossing location the watercourse consists of approximately a 7.5 m active channel, with steep banks of approximately 2 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 15: Facing upstream at proposed crossing location at KP328.37 (Dry season 2012)**

### 5.13 Unnamed Minor Watercourse 144 (KP345.5)

The Unnamed minor watercourse at KP345.5 is an ephemeral watercourse which flows directly into the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse had a low flow after approximately 51 mm of rainfall in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for native pastures with some areas tolerating occasional cultivation for improved pasture (DPI/DHLGP 1993). As a result, the watercourse is devoid of trailing vegetation which consists solely of grasses. Riparian vegetation is between 5 and 10 metres wide and consists of mainly grasses, *Malelueca* sp. *Eustraphus latifolius* and *Eurythrina vespertilio* which form an approximate 40 % canopy cover. This is depicted in Illustration 16.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of sand and coarse particles. At the GTP crossing location the watercourse consists of approximately a 3 m active channel, with steep banks of approximately 10 m which form a grassed high flow channel of about 10 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 16: Facing upstream from the proposed crossing location at KP345.5 (Wet season 2012)**

### 5.14 Unnamed Minor Watercourse 152 (KP352.06)

The Unnamed minor watercourse at KP352.06 is an ephemeral watercourse which flows directly into the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry, with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as Of Concern dominant 11.3.4/11.3.4/11.3.25 (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures with some improved pasture (DPI/DHLGP 1993). As a result, the watercourse is devoid of riparian and trailing vegetation which consists solely of grasses which is evident in Illustration 17.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles with some sand. At the GTP crossing location the watercourse consists of approximately a 1 m active channel with very small banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 17: Facing downstream from the proposed crossing location at KP352.06 (Dry season 2012)**

### 5.15 Unnamed Minor Watercourse 154 (KP353.4)

The Unnamed minor watercourse at KP353.4 is an ephemeral watercourse which flows directly into the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse had a low flow after approximately 51 mm of rainfall in the previous week and a further 70 mm falling the previous evening.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, the watercourse is devoid of trailing vegetation which consists solely of grasses with scattered Ironbark species. Riparian vegetation is less than 1 m wide and consists of mainly grasses, *Eclipta prostrate*, *Persicaria attenuate* and *Ludwigia* sp. producing about a 5 % canopy cover which is evident in Illustration 18. Few semi aquatic species, *Cyperus exaltatus*, were present in the watercourse as was floating macrophyte *Ottelia ovalifolia*.

The soils in the area have a high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles. At the GTP crossing location the watercourse consists of approximately a 1 m active channel with very small banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 18: Facing downstream at proposed crossing location at KP353.4 (Wet season 2012)**

### 5.16 Unnamed Minor Watercourse 161 (KP365.7)

The Unnamed minor watercourse at KP365.7 is an ephemeral watercourse which is a tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 2, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was completely dry, with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, the watercourse is devoid of riparian and trailing vegetation which consists solely of grasses which is evident in Illustration 19.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles with some fine sand. At the GTP crossing location the watercourse consists of approximately a 3 m active channel with gradually sloping banks approximately 5 m high forming a high flow channel of about 17.5 m.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 19: Facing upstream at proposed crossing location at KP365.71 (Dry season 2012)**

### 5.17 Unnamed Minor Watercourse 164 (KP366.2)

The Unnamed minor watercourse at KP366.2 is an ephemeral watercourse which flows directly into the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse had a low flow after approximately 38 mm of rainfall in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, trailing vegetation in the area is patchy and consists mainly of Eucalypts and Silver leaved ironbark. Riparian vegetation consisted mainly of grasses and tall trees including

*Lophostemon suaveolens* producing a 10 % canopy cover over the watercourse, as evident in Illustration 20. Scattered *Lantana camara* existed in the riparian zone.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of sand and gravel particles. At the GTP crossing location the watercourse consists of approximately a 2 m active channel with 2 m extensively eroded banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 20: Facing upstream at proposed crossing location at KP366.2 (Wet season 2012)**

### 5.18 Unnamed Minor Watercourse 171 (KP374.4)

The Unnamed minor watercourse at KP374.1 is an ephemeral watercourse which is a tributary of Gravel Creek within the Calliope River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse had a moderate flow with approximately 38 mm of rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, the

area is largely devoid of trailing vegetation which consists mainly of grasses and scattered Eucalypts. Riparian vegetation consists of mainly grasses and small Maleleuca trees forming a canopy cover of approximately 50 % which is evident in Illustration 21. At the GTP crossing location, a large permanent pool approximately 1.5 m deep exists with heavy beds of *Chara* sp. and other semi aquatic species such as *Crinum* sp. and *Cyperaceae* sp..

The soils in the area have a high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles. At the GTP crossing location the watercourse consists of approximately a 10 m active channel with 1 – 2 m banks on either side.

Due to the ephemeral nature of this watercourse it is unlikely that this watercourse will support populations of threatened aquatic fauna, however it is a likely refugial habitat for other fauna.



**Illustration 21: Facing downstream at proposed crossing location at KP374.4 (Wet season 2012)**

### 5.19 Unnamed Minor Watercourse 172 (KP375.7)

The Unnamed minor watercourse at KP375.7 is an ephemeral watercourse which is an anabranch of Gravel Creek within the Calliope River catchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily

cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures with some improved pasture (DPI/DHLGP 1993). As a result, trailing vegetation in the area is patchy and consists mainly of grasses. Riparian vegetation consisted mainly of grasses and trees such as *Melaleuca* sp., producing an approximate 40 % canopy cover over the watercourse, as evident in Illustration 22.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of sand and silty clay. At the GTP crossing location the watercourse consists of approximately a 5 m active channel with 1 m shallow banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 22: Facing downstream at proposed crossing location at KP375.7 (Dry season 2012)**

### 5.20 Unnamed Minor Watercourse 175 (KP380.7)

The Unnamed minor watercourse at KP380.7 is an ephemeral watercourse which is tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily

cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, trailing vegetation in the area is limited and consists mainly of grasses. Riparian vegetation consisted mainly of grasses, scattered Ironbarks and Eucalypts producing an approximate 20 % canopy cover over the watercourse, as evident in Illustration 23. Plant species present include *Eleocharis cylindrostachys*. Scattered emergent macrophytes such as *Cyperus* sp. and *Juncus* sp. were also present.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silty clay and fine sand. At the GTP crossing location the watercourse consists of approximately a 2 m active channel with 1 m shallow banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 23: Facing downstream at proposed crossing location at KP380.7 (Dry season 2012)**

### 5.21 Unnamed Minor Watercourse 182 (KP391.1)

The Unnamed minor watercourse at KP391.1 is an ephemeral watercourse within the Calliope River subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse consisted several large permanent non flowing pools, in which moderate rainfall would promote flow.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). As a result, the area is largely devoid of trailing vegetation which consists mainly of grasses and scattered Eucalypts. Riparian vegetation consists of mainly grasses, which is evident in illustration 24. At the GTP crossing location, a large permanent pool with island features approximately 1.5 m deep exists. Heavy beds of *Typha* sp. were present as were emergent macrophytes.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silty clay and fine sand. At the GTP crossing location the watercourse consists of a large pool approximately 25 m wide.

Due to the ephemeral nature of this watercourse it is unlikely that this watercourse will support populations of threatened aquatic fauna, however it is a likely refugial habitat for other fauna.



**Illustration 24: Facing downstream at proposed crossing location at KP391.1 (Dry season 2012)**

### 5.22 Unnamed Minor Watercourse 184 (KP396.75)

The Unnamed minor watercourse at KP396.75 is an ephemeral watercourse which flows directly into the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this

watercourse consisted of several pools which were not connected by flow. The area had approximately 38 mm of rainfall in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The local catchment of the watercourse has been heavily cleared as a result of agricultural land use. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). Trailing vegetation in the area is patchy and consists mainly of grasses and scattered trees. Riparian vegetation consisted mainly of grasses and small Maleleuca trees which is evident in Illustration 25. Few emergent macrophytes such as *Cyperaceae* spp. were present and heavy beds of *Chara* spp. were present in the pool.

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles. At the GTP crossing location the watercourse consists of a 7 m wide permanent pool with shallow banks.

Due to the ephemeral nature of this watercourse it is unlikely that this watercourse will support populations of threatened aquatic fauna, however it is a likely refugial habitat for other fauna.



**Illustration 25: Facing upstream from proposed crossing location at KP396.75 (Wet season 2012)**

### 5.23 Unnamed Minor Watercourse 190 (KP399.2)

The Unnamed minor watercourse at KP399.2 is an ephemeral watercourse which is tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1,

which flows during periods of rainfall. At the time of assessment, this watercourse had a low flow with no rainfall occurring in the past week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as Endangered sub dominant RE 11.11.15/11.11.18 (DERM 2010b). The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). As a result, trailing vegetation in the area is moderate and consists of grasses, trees and shrubs. Riparian vegetation consisted mainly of grasses and trees producing an approximate 50 % canopy cover over the watercourse, as evident in Illustration 26. Identified plant species included *Acacia fasciculifera*, *Acacia disparrima*, *Jasminum simplicifolium*, *Mallotus claoxyloides*, *Mallotus philippensis* and *Coatesia paniculata*. A small amount of algae was present on the surface of the pools.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of gravel and sand. The watercourse banks are extremely eroded and a significant amount of fallen timber and woody debris is indicative of heavy flows occurring during major rain events. At the GTP crossing location the watercourse consists of approximately an 11 m active channel with 5 m banks, with several temporary pools.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 26: Facing downstream at proposed crossing location at KP399.21 (Dry season 2012)**

### 5.24 Unnamed Minor Watercourse 193 (KP399.7)

The Unnamed minor watercourse at KP399.7 is an ephemeral watercourse which is tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the past week.

The GTP traverses perpendicular to this watercourse on 3 occasions where the vegetation is mapped as non-remnant (DERM 2010b). The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). As a result, trailing vegetation in the area is moderate and consists of grasses, trees and shrubs, however relatively cleared in the crossing location. Riparian vegetation consisted solely of grasses with few semi aquatic emergent species present and is evident in Illustration 27. *Cyperus javanicus* was identified as present at the site, as well as macrophyte *Typha* sp..

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists of gravel, silty clay and sand. At the GTP crossing location the watercourse consists of approximately a 4 m active channel with shallow banks. Several temporary pools were located upstream and downstream of the crossing location.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 27: Facing upstream at proposed crossing location at KP399.68 (Dry season 2012)**

### 5.25 Unnamed Minor Watercourse 195 (KP400.03)

The Unnamed minor watercourse at KP400.3 is an ephemeral watercourse which is tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the past week.

The GTP traverses this perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). As a result, trailing vegetation in the area is moderate and consists of grasses, trees and shrubs. Riparian vegetation is moderate and consists of grasses and tress producing an approximate 50 % canopy cover and is evident in Illustration 28. Identified plant species consisted of *Notelaea microphyll*, *Passiflora suberosa*, *Jasminum simplicifolium*, *Acacia disparrima* and *Hibiscus heterophyllu*.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of gravel and sand with some silty clay. The watercourse has a moderate amount of erosion on the banks and a significant amount of woody debris and fallen timber indicates heavy flows during large rain events. At the GTP crossing location the watercourse consists of approximately a 5 m active channel with 2 m high banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 28: Facing upstream at proposed crossing location at KP400.03 (Dry season 2012)**

### 5.26 Unnamed Minor Watercourse 196 (KP400.13)

The Unnamed minor watercourse at KP400.13 is an ephemeral watercourse which is tributary of the Calliope River. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the past week.

The GTP traverses this perpendicular to this watercourse where the vegetation is mapped as non-remnant (DERM 2010b). The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). As a result, trailing vegetation in the area is moderate and consists of grasses, trees and shrubs. Riparian vegetation is extensive, extending approximately 10 m on both banks. Riparian vegetation consists of grasses, shrubs and trees producing an approximate 70 % canopy cover. This is depicted in Illustration 29. Identified species include *Lophostemon confertus, Turraea pubescens, Glochidion ferdinandi, Diospyros geminata, Lantana camara, Acacia maidenii* and *Cupaniopsis wadsworthii.*

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of gravel with some silty clay. The watercourse has a moderate amount of erosion on the banks and a significant amount of woody debris and fallen timber indicates heavy flows during large rain events. At the GTP crossing location the watercourse consists of approximately a 7 m active channel with steep banks approximately 3 m high.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 29: Facing upstream at proposed crossing location at KP400.13 (Dry season 2012)**

### 5.27 Unnamed Minor Watercourse 198 (KP400.8)

The Unnamed minor watercourse at KP400.8 is an ephemeral watercourse which flows into a large lake immediately adjacent to the ROW. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of rainfall. At the time of assessment, this watercourse was dry with no rainfall occurring in the past week.

The GTP traverses this perpendicular to this watercourse where the vegetation is mapped as endangered sub dominant 11.11.15/11.11.18/11.11.3 (DERM 2010b). The area is mapped as pasture land suitable for light grazing of native pastures due to the steepness of the terrain (DPI/DHLGP 1993). As a result, trailing vegetation in the area is moderate and consists of grasses, trees and shrubs. Riparian vegetation consists of grasses and trees producing an approximate 70 % canopy cover, which is evident in Illustration 30 and 31. Species of plant that were identified include *Acacia fasciculifera, Lantana camara and Ehretia membranifolia.*

The soils in the area have a moderate erosion potential and the substrate of the watercourse at the crossing location consists mainly of sand and silty clay with some gravel. At the GTP crossing location the watercourse consists of approximately a 12.5 m active channel with banks approximately 4 m high. At the time of survey, this watercourse was dry, however

after wet weather the water level in the lake would increase. Rises in the water level of the lake may see it encroaching on the ROW.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. Refugia habitat is present immediately downstream of the ROW within the proximately of the lake.



**Illustration 30: Facing upstream at proposed crossing location at KP400.8 (Dry season 2012)**



**Illustration 31: Facing downstream at proposed crossing location at KP400.8 (Dry season 2012)**

### 5.28 Unnamed Minor Watercourse 205 (KP416.1)

The Unnamed minor watercourse at KP416.0 is an ephemeral watercourse which flows directly into the Graham Creek in the Curtis Island subcatchment. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry after approximately 25 mm of rainfall in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as Endangered dominant RE12.3.3/12.3.7 (DERM 2010b). The local catchment of the watercourse is heavily vegetated which is evident in Illustration 32. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). Extensive trailing vegetation consists mainly of grasses, shrubs and trees including *Alphitonia excels*, *Breynia oblongifolia, Gomphocarpus physocarpus*, Eucalypts and Acacias. Several exotic species were located within the ROW including *Lantana camara, Passiflora suberosa, Urena lobata, Praxelis clematidea* and *Asclepias curassavica*. Riparian vegetation consisted of similar species producing a 40 % canopy cover.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists mainly of silt and clay particles. At the GTP crossing location the watercourse consists of approximately a 1 m active channel with shallow banks.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 32: Facing downstream from proposed crossing location at KP416.1 (Wet season 2012)**

### 5.29 Unnamed Minor Watercourse 206 (KP418.1)

The Unnamed minor watercourse at KP418.1 is an ephemeral watercourse which flows directly into Port Curtis. This watercourse is mapped by DERM (2010b) as a stream order 1, which flows during periods of heavy rainfall. At the time of assessment, this watercourse was dry after approximately 25 mm of rainfall in the previous week.

The GTP traverses perpendicular to this watercourse where the vegetation is mapped as Of Concern subdominant RE12.11.6/12/11/14 (DERM 2010b). The local catchment of the watercourse is heavily vegetated which is evident in Illustration 33. The area is mapped as pasture land suitable for grazing of native pastures without ground disturbance (DPI/DHLGP 1993). Extensive trailing vegetation consists mainly of grasses, shrubs and trees including *Xanthorrheas* sp., *Timonius timon*, *Lomandra* sp., Eucalypts and Acacias. Riparian vegetation included species such as *Glochidion lobocarpum*, *Breynia oblongifolia*, *Stephania japonica* and *Dodonaea lanceolata* producing a 40 % canopy cover. Exotic species such as *Passiflora suberosa* and *Conzya sumatrensis* were also present.

The soils in the area have a moderate to high erosion potential and the substrate of the watercourse at the crossing location consists of gravel and courser particles. At the GTP

crossing location the watercourse consists of a 1.5 m channel with steep eroded banks approximately 80 cm high.

Due to the ephemeral nature of this watercourse it is highly unlikely that this watercourse will support populations of threatened aquatic fauna. In addition, no refugia habitat was identified within close proximity to the proposed GTP crossing.



**Illustration 33: Facing downstream from proposed crossing location at KP418.1 (Wet season 2012)**

# 6 POTENTIAL IMPACTS ON MINOR WATERCOURSES

The GLNG EIS (URS 2009) initially assessed the potential impacts of the proposed gas transmission pipeline within a 5 km wide corridor for the majority of the Project's length. The impact assessment of the Curtis Island portion of the GTP ROW was reduced to a width of 100 m. Detailed studies were then undertaken within 30 m of the identified preferred alignment (URS 2009). Potential impacts on the local aquatic values as a result of the construction of the GTP ROW (as determined through a review of the GLNG EIS, in addition to a number of related studies within the area) include:

- Water quality and hydrology:
  - Erosion and sedimentation.
  - Modification of riparian zones, floodplains and wetlands.
  - Temporary and permanent alterations to instream and/or overland flow.
- Vegetation:
  - Introduction and proliferation of weed species.
  - Fragmentation and loss of movement opportunities.
  - Edge effects.
  - Loss of riparian vegetation and other sensitive habitats.
  - Disturbance of threatened and/or conservation significant flora species and communities.
- Fauna:
  - Disturbance to threatened and/or conservation significant species.
  - Loss of habitat and/or breeding places (including threatened and/or conservation listed species).
  - Death/injury of fauna (including threatened species).
  - Introduction of pest species.
  - Temporary obstruction to fish movement.
  - Loss of instream complexity.
- Dust pollution.
- Noise and vibration generation.
- Waste generation and introduction into surrounding environment.

# 7 MITIGATION MEASURES

The mitigation measures for permanent watercourse crossings have been developed in accordance with the following:

- Australian Pipeline Industry Association's (APIA) Code of Environmental Practice: Onshore Pipelines (the Code; March 2009), and are consistent with the AS2885 – *Pipelines – Gas, Liquid and Petroleum*.
- *Code for Self-Assessable Development. Minor Waterway Barrier Works.* Code No. WWBW01 (Qld Govt. 2011).
- *Code for Self-assessable Development: Temporary Waterway Barrier Works* Code No. WWBW02 (Qld Govt. 2010).
- Commonwealth Approval Conditions.
- Co-ordinator General's Conditions.
- GTP EIS and SEIS.
- *Water Act 2000* (Water Act; Queensland Government (Qld Govt.) 2000).

Detailed mitigation measures for each type proposed construction methodologies are outlined in the Aquatic Values Management Plan 3380-GLNG-4-1.3-0012. It should be noted separate management plans have been developed to manage specifically with local fauna and flora assemblages, including breeding places (Species Management Plan 3380-GLNG-3-1.3-0036), protected, threatened and conservation significant species (Significant Species Management Plan 3380-GLNG-3-1.3-0031) and soils (Erosion and Sediment Control Plan 3380-SAIP-4-1.3- 7038 and 3380-SAIP-4-1.3- 7039). Exemption under the *NC Act 1992* for the clearing of least concern plants has also been granted. Management of protected species such as *Cycas megacarpa* will be detailed in the Significant Species Management Plan.

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# APPENDIX A – FIELD DATA SHEETS, HERBARIUM RESULTS, LABORATORY RESULTS AND PHOTOGRAPHS

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# GLNG
## Gas Transmission Pipeline

## Field Data Sheet for Watercourse Assessments

Document Number: 3380-GLNG-4-1.3-0047

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A.Hampson | | |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Coordinator | B.Angus | | |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | I.Bridge | | |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 4/01/12 | A | For Review | | | |
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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 11/1/12 KP Point 18.9 Eastings 688334.2 Northings 7166380
Watercourse Name un-named Distance from Source 2.2 km AMTD 2.2 km
Stream Order 2 Photo taken of access track Y/N
Catchment Area [illegible] Weather Fine
Rain in the Past week NIL Time of Day 11:30a Cloud Cover (%) 10

---

**OBSERVATIONS**

Mean Channel width (m) 4

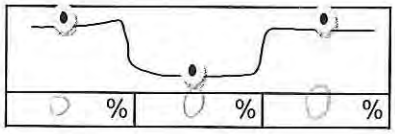
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % 0 Width of riparian Zone (m): LB N/A RB

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**Riparian vegetation**: Grass % 95 Shrubs % 5

Trees < 10m % Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

All grass and shrubs.

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % 70 | Pebble (16-64mm) | % 3 | |
| Boulder (>256mm) | % 20 | Gravel (4-16mm) | % 2 | |
| Cobble (64-256mm) | % 5 | Sand (1-4mm) | % | |
| | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

4m active channel with steep high banks

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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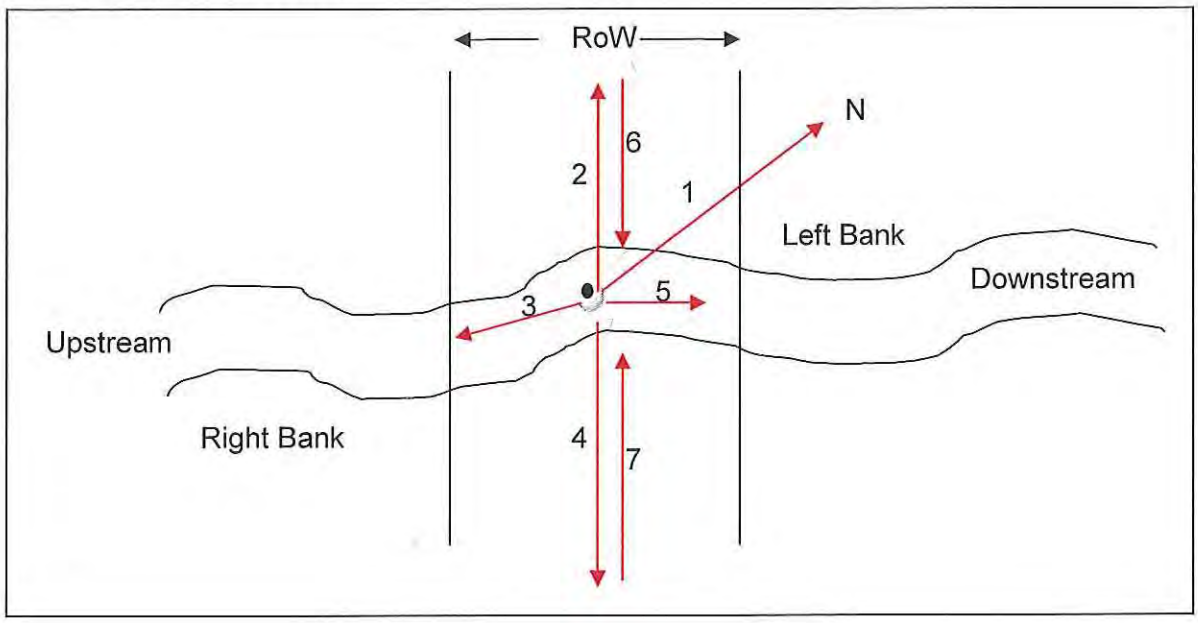
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 055 – |
| Facing left bank (2) | 056 – |
| Facing Upstream (3) | 057 – |
| Facing Right Bank (4) | 058 – |
| Facing Downstream (5) | 059 – |
| From edge of Riparian on left (6) | 060 |
| From edge of Riparian on right (7) | 061 |

**General Comments:**

Dry creek with rocky gravel substrate
Non existant riparian zone
Trailing veg consists of grasses + shrubs only.

Un-named trib of Baffle Creek.

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**Is water present? Yes (No)**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

- *Lophostemon suaveolens*
- *Eucalyptus sp., E. melanophloia*
- *Callitris glaucophylla*
- *Dianella sp.,*
- *Polianthion minutiflorum*
- *Indigofera australis*

# Certificate of Analysis


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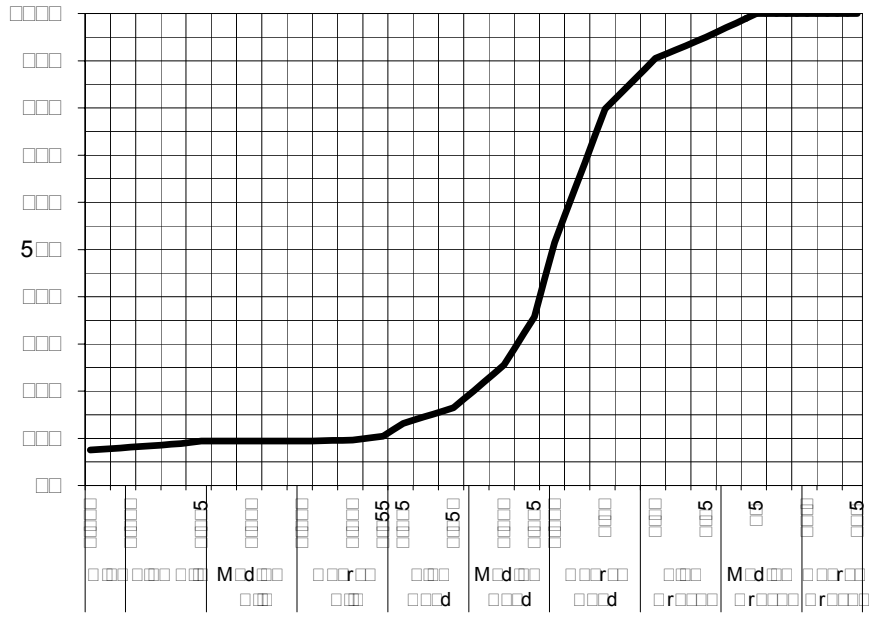
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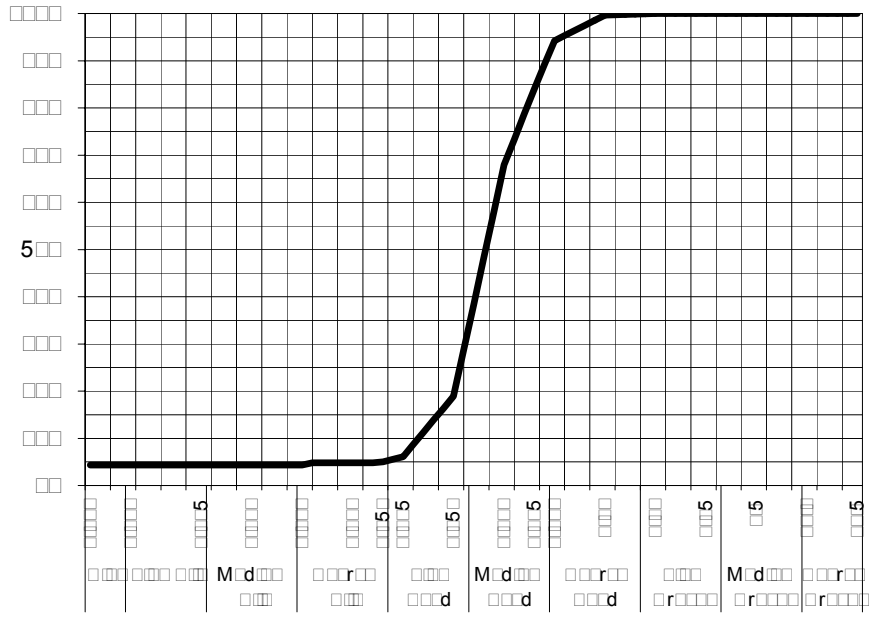
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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

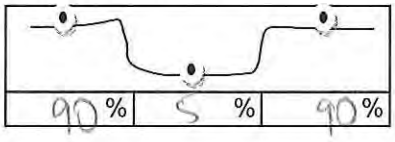
Date 11/1/12 KP Point 25.3 Eastings 688769 Northings 7171732
Watercourse Name Edwards Distance from Source 2.67 AMTD 5.1
Stream Order 2 Photo taken of access track Y/N
Catchment Area Dawson Weather Fine
Rain in the Past week NIL Time of Day _____ Cloud Cover (%) 10

---

**OBSERVATIONS**

Mean Channel width (m) 20
Height of Banks  Left 2 Right 2

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)
Canopy cover % Width of riparian Zone (m): LB 18 RB 11

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**Riparian vegetation**: Grass % 20 Shrubs % 10
Trees < 10m % 30 Trees > 10m % 40

- Collect samples and produce species list after identification (refer to guide)

Notes: _____

**Trailing Vegetation:**

| (Extensive) | Moderate | Slight | Nil |
|---|---|---|---|

Notes:
Extensive Cypress Pine species + Iron bark species.

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | 99 % | Pebble (16-64mm) | 1 % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

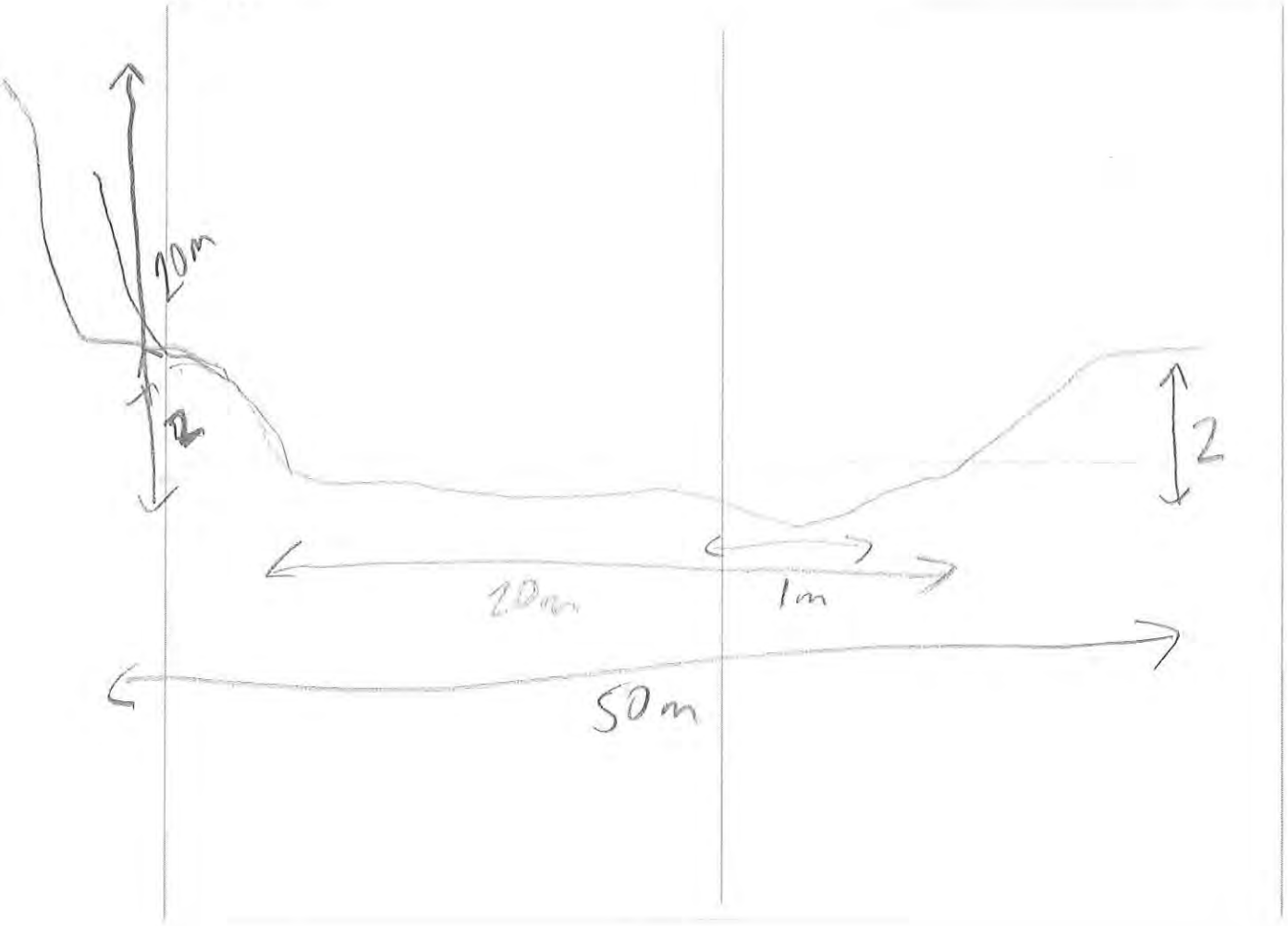
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Very rocky wide active channel

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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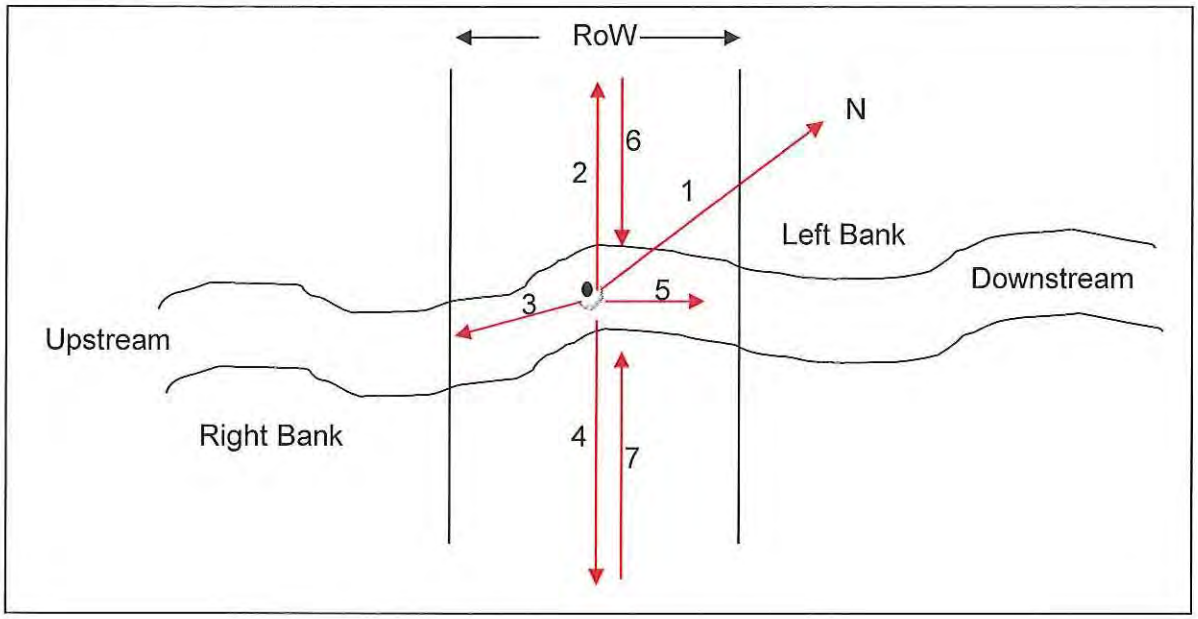
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 062. |
| Facing left bank (2) | 063 |
| Facing Upstream (3) | 064 |
| Facing Right Bank (4) | 065 |
| Facing Downstream (5) | 066 |
| From edge of Riparian on left (6) | 067 |
| From edge of Riparian on right (7) | 068 |

**General Comments:**

Dry in RoW & very rocky however stagnant pool immediately upstream of RoW. Extensive fringing veg

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**Is water present?** (Y)/ N - If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 34.1 | 34.3 | 33.2 | 33.87 |
| Conductivity (µS/cm) | 599 | 595 | 575 | 589.67 |
| pH | 8.6 | 8.3 | 8.6 | 8.5 |
| Dissolved $O_2$ (mg/L) | 8.5 | 8.1 | 8.9 | 8.5 |
| Turbidity (NTU) | 90.8 | 121 | 136 | 115.93 |

Notes: TDS 389 mg/L 382 mg/L

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | (Moderate) | Lot |
| In Water Column: | None | (Little) | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes: filamentous algae

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | (Little) | Moderate | Lot |
| Submerged: | (None) | Little | Moderate | Lot |
| Floating: | (None) | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes: Reeds, Sedges

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- **Ehretia membranifolia*
- **Eustrephus latifolius*
- **Alphitonia excelsa*
- **Eucalyptus sp.,* □□d□□□□□□d
- **Acacia sp.,* □□d□□□□□□d
- **Callitris endlicheri*
- **Psydrax sp.,* □r□□□□□□ *P. odorata*
- **Alphitonia excelsa*
- **Eleocharis cylindrostachys*
- **Dodonaea sp.,* □□□□□□□□ *D. triangularis*
- **Cyperus difformis*
- **Lomandra sp.,* □□d□□□□□□d
- **Juncus usitatus*
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# Certificate of Analysis


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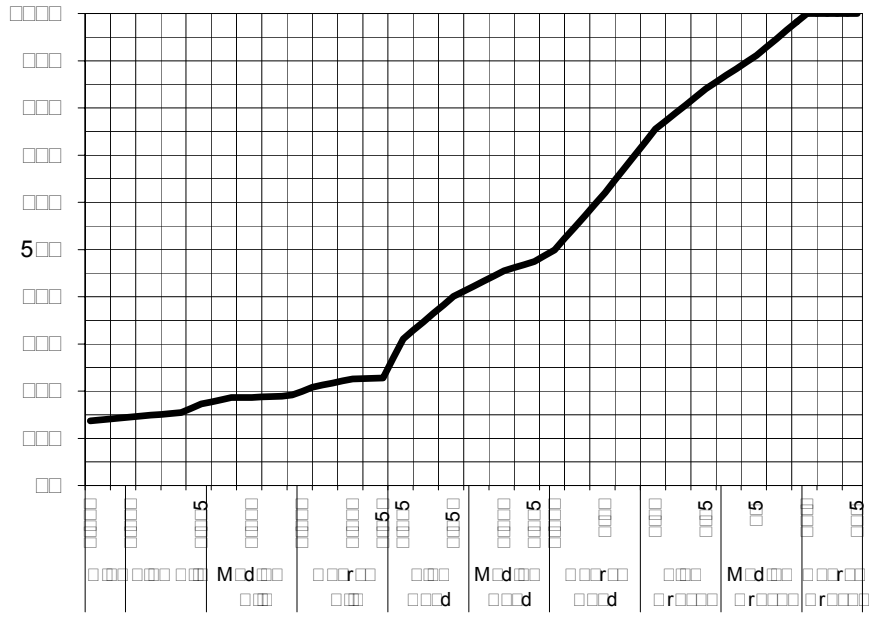
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# Certificate of Analysis

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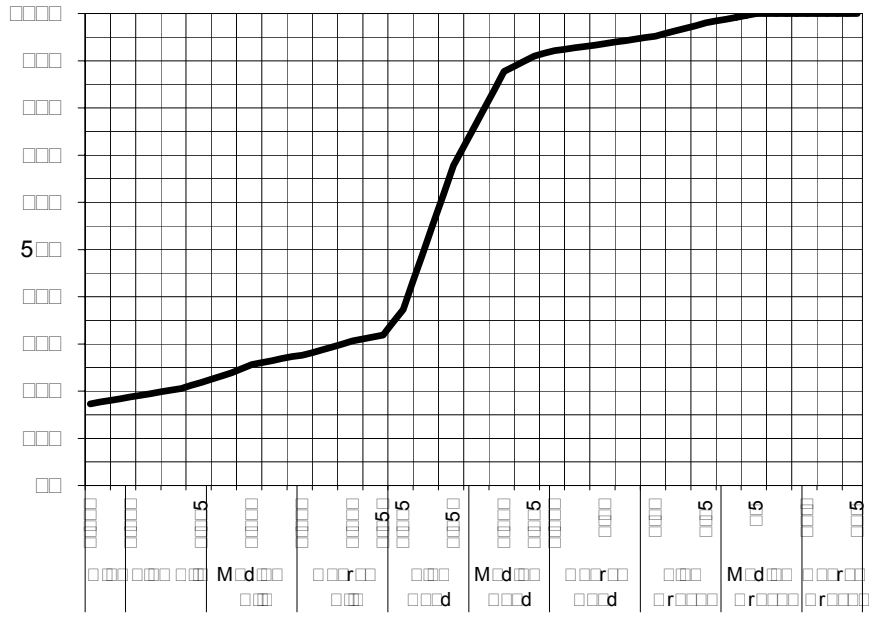


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 11/1/17 KP Point 32.4 Eastings 690958.3 Northings 7177648
Watercourse Name Grats Gully Distance from Source 2.45 AMTD 3.89
Stream Order 2 Photo taken of access track Y/N
Catchment Area Dawson Weather Fine
Rain in the Past week NIL Time of Day 3pm Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 1

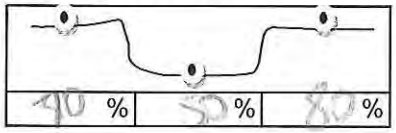
Height of Banks  Left 1 Right 1

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB 10 RB 2

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**Riparian vegetation**: Grass % 40 Shrubs % 10
Trees < 10m % 20 Trees > 10m % 30

- Collect samples and produce species list after identification (refer to guide)

Notes: _____

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Notes: Broad Leaved Iron bark
Silver Leaved Iron bark
Brigalow

Santos
GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | | Silt/clay (<1mm) | % 50 |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

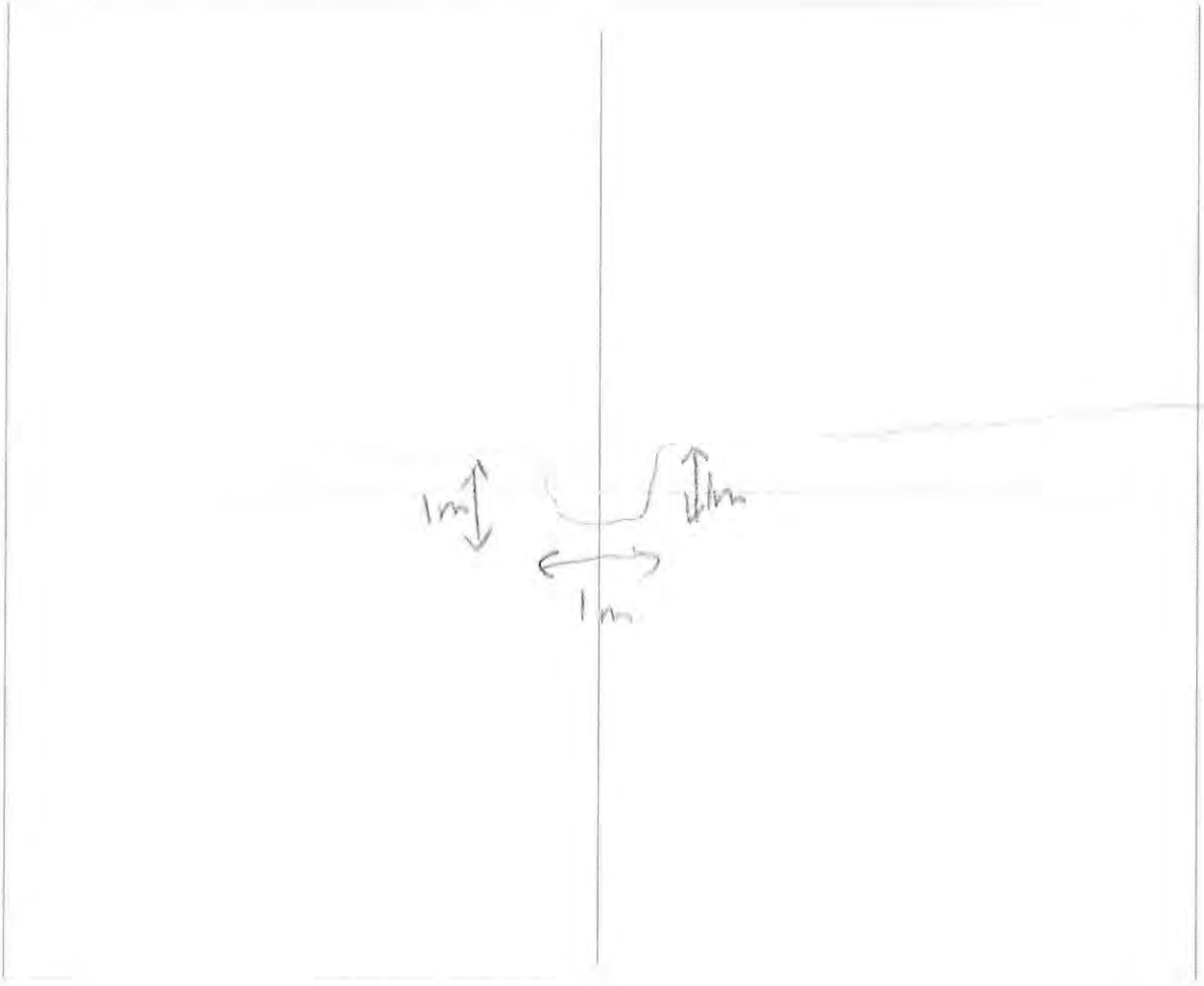
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Small dry channel, steep eroded banks

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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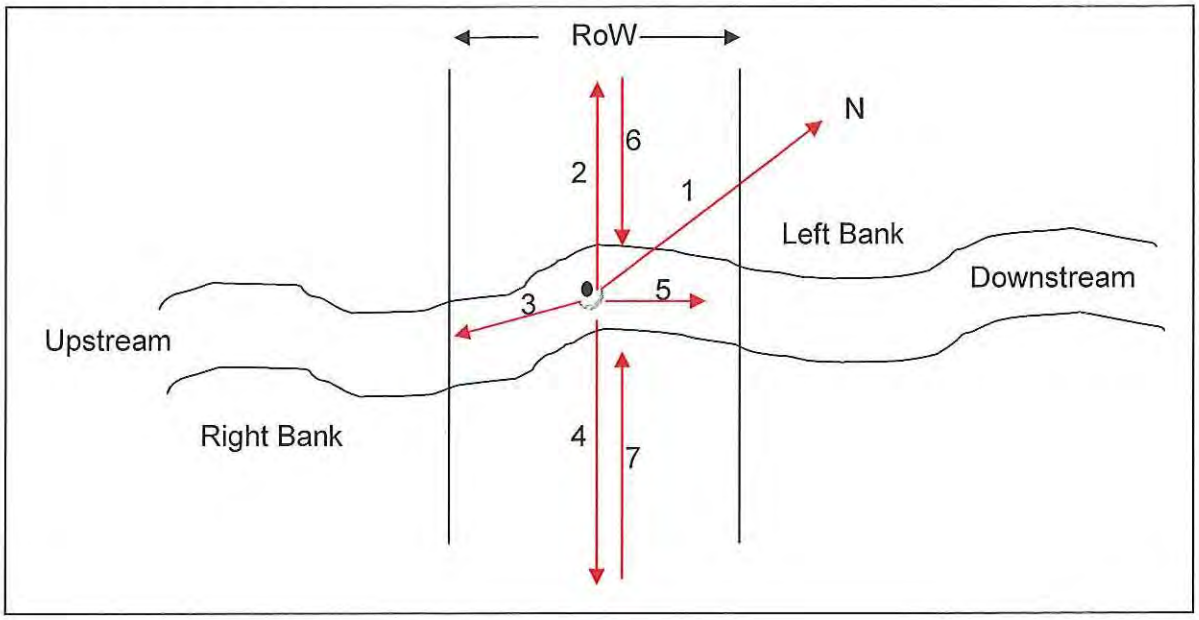
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 071 |
| Facing left bank (2) | 072 |
| Facing Upstream (3) | 073 |
| Facing Right Bank (4) | 074 |
| Facing Downstream (5) | 075 |
| From edge of Riparian on left (6) | 076 |
| From edge of Riparian on right (7) | 077 |

**General Comments:**

Dry watercourse, Steep eroded banks around 1 metre high Extensive trampling veg with bryalow & good veg cover

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**Is water present?** Y/N - If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**4**

- **Acacia sp.,* d d
- **Geijera parviflora*
- **Eremophila mitchellii*
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# Certificate of Analysis


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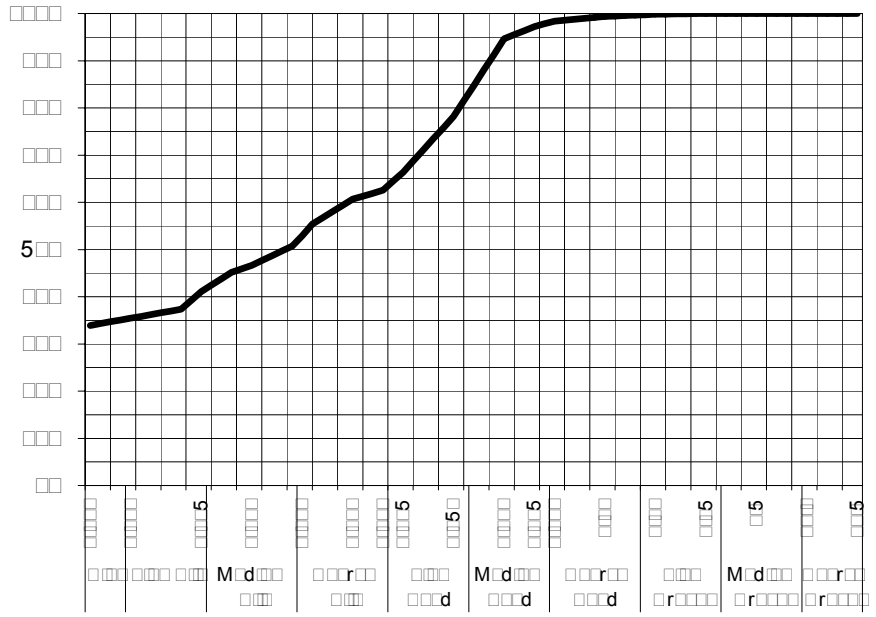
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# Certificate of Analysis


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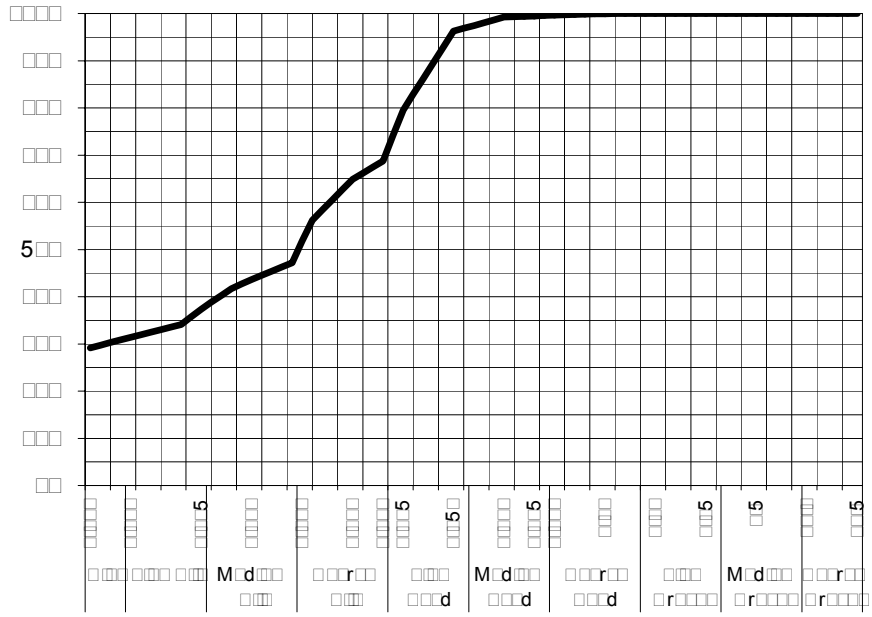


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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**Dianne Blane**
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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 16/3/12 KP Point 39.25 Eastings 690397 Northings 7184158
Watercourse Name Unnamed Distance from Source 600m AMTD
Stream Order 1 Photo taken of access track Y/N
Catchment Area 60m² Weather Overcast
Rain in the Past week 40mL Time of Day 8.30 Cloud Cover (%) 100

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**OBSERVATIONS**

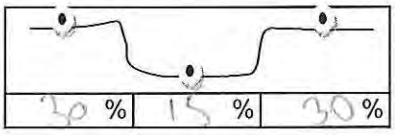
Mean Channel width (m) 3
Height of Banks  Left 1 Right 1

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % Width of riparian Zone (m): LB 5 RB 10

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**Riparian vegetation**: Grass % 60 Shrubs % 10
Trees < 10m % 20 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | (Moderate) | Slight | Nil |
|---|---|---|---|

Extensive grasses & small trees/shrubs

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

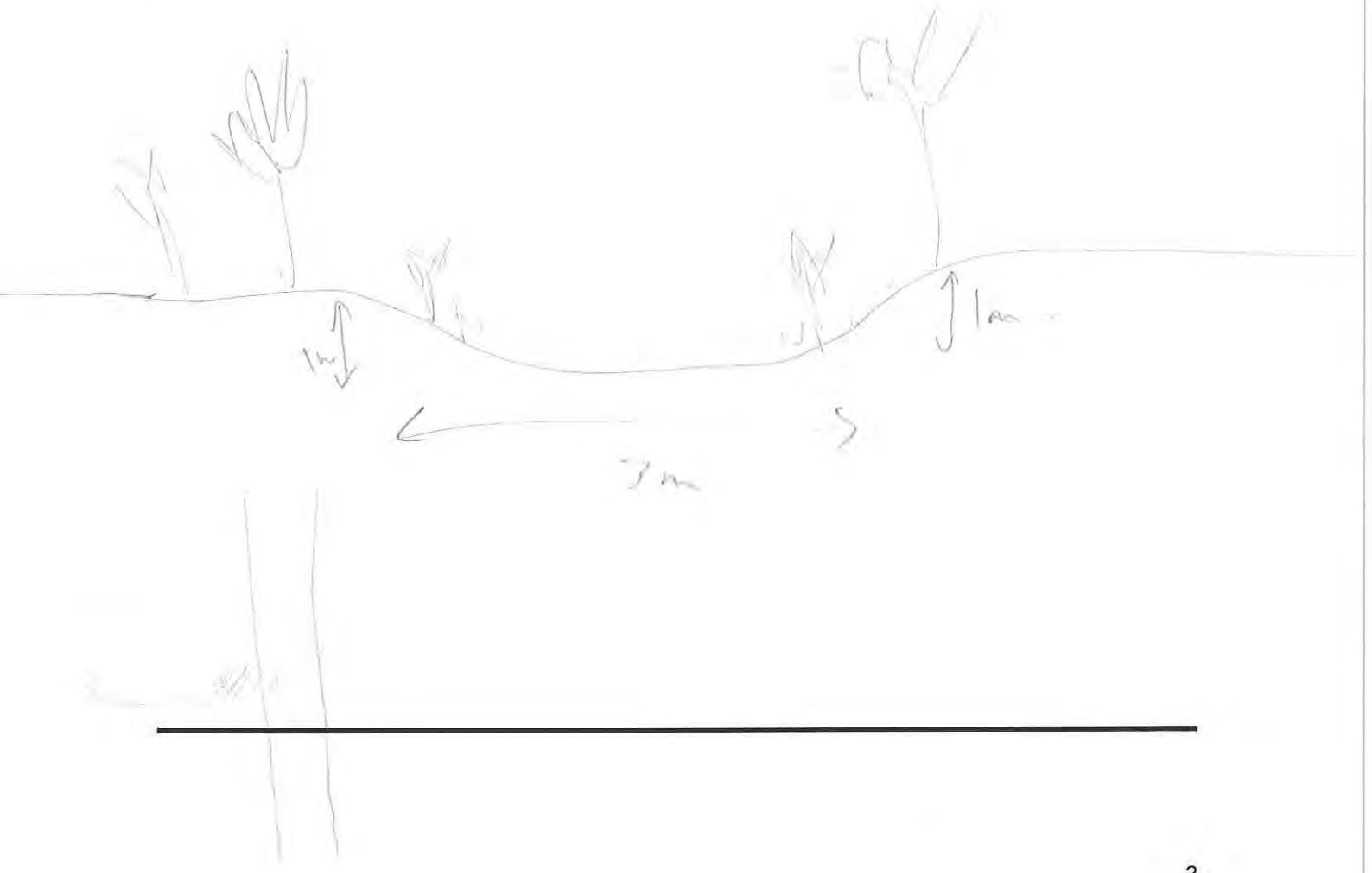
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

windy channel, small dry pool area

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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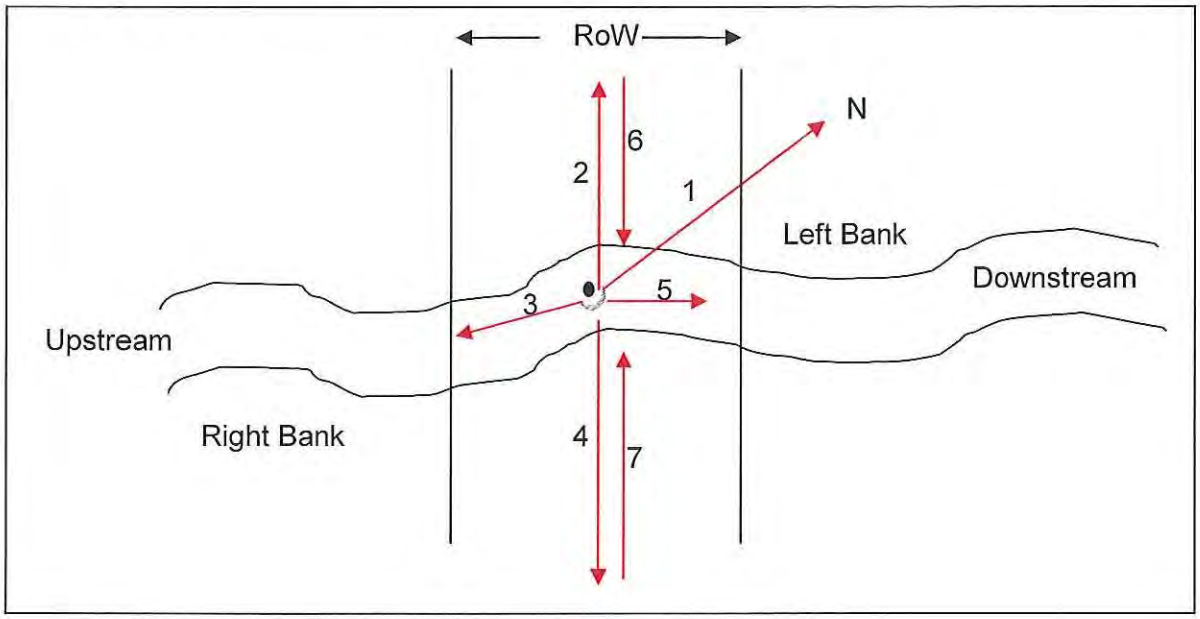
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 39_1 |
| Facing left bank (2) | 39_2 |
| Facing Upstream (3) | 39_3 |
| Facing Right Bank (4) | 39_4 |
| Facing Downstream (5) | 39_5 |
| From edge of Riparian on left (6) | 39_7 |
| From edge of Riparian on right (7) | 39_6 |

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**General Comments:**

Mod - Riparian vegetation consisting mainly ironbark and small shrubs. Dry channel, veg overgrown. Large pool to the right of RoW → dry. Small anabranch to the south, 2nd crossing, very small channel.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**5**

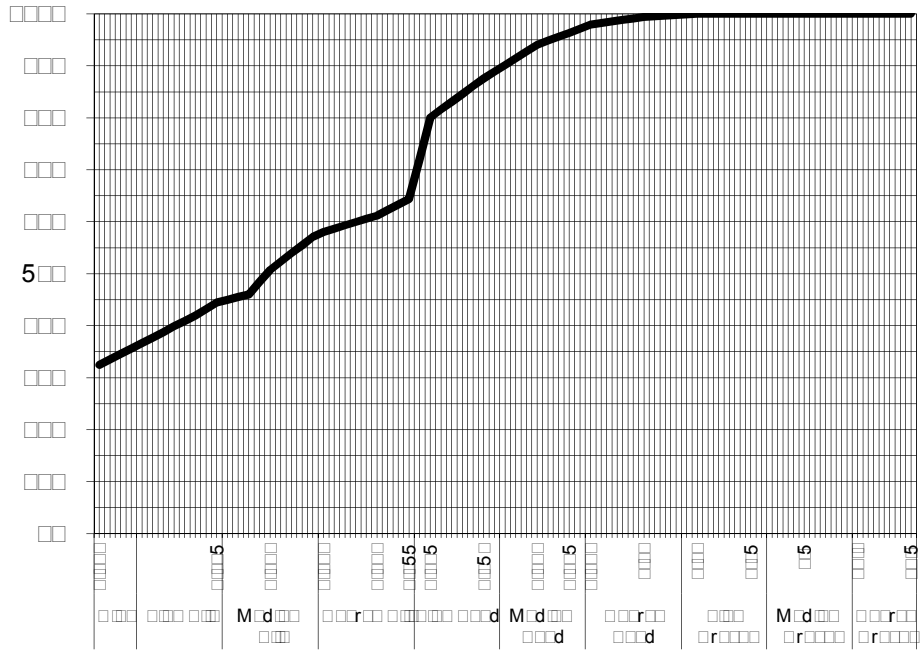
- *Alectryon diversifolius*
- *Alectryon oleifolius*
- *Eucalyptus melanophloia* *melanophloia*
- *Lysiphyllum carronii*
- *Parsonsia lanceolata*

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


5 NATA WORLD RECOGNISED ACCREDITATION


**Dianne Blane**
*Authorised Signatory*

# Certificate of Analysis

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**ALS Environmental**

**Newcastle, NSW**

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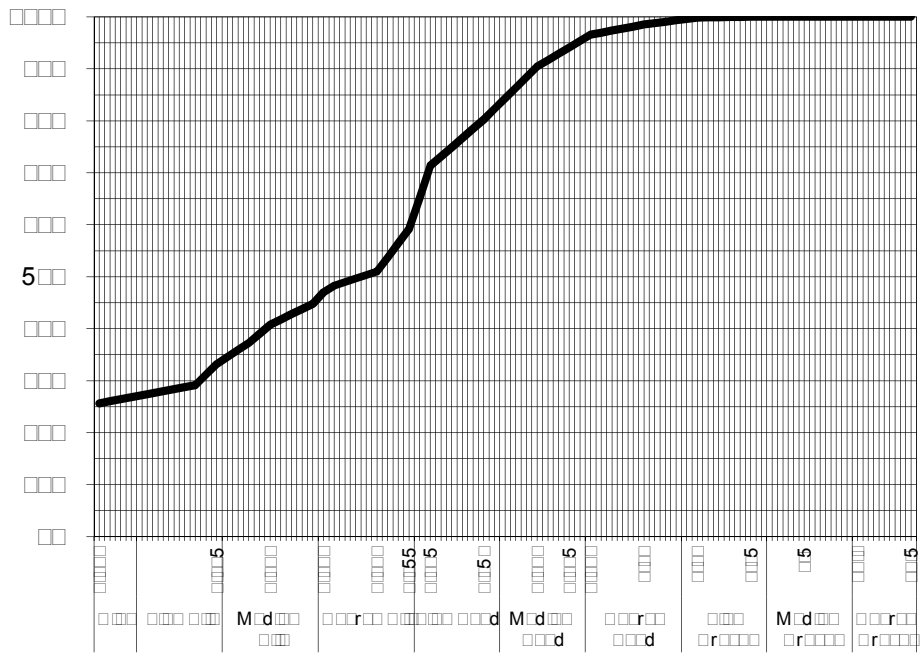

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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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**Dianne Blane**

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***Authorised Signatory***

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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 14/1/12 KP Point 65.6 Eastings 686427.1 Northings 7209571
Watercourse Name un-named Distance from Source 1.3 AMTD 3.1
Stream Order 2 Photo taken of access track Y/N
Catchment Area Comet Weather Fine
Rain in the Past week NIL Time of Day 9am Cloud Cover (%) 25

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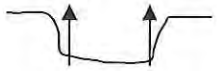
**OBSERVATIONS**

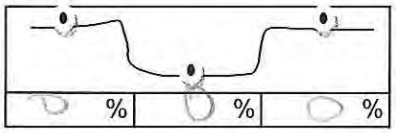
Mean Channel width (m) 1.5m
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % Width of riparian Zone (m): LB 0.5 RB 0.5

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**Riparian vegetation**: Grass % 95 Shrubs % 3
Trees < 10m % 2 Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

Notes: All grass and shrubs some trees under 10m

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 30 |
| | | Silt/clay (<1mm) | % 70 |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

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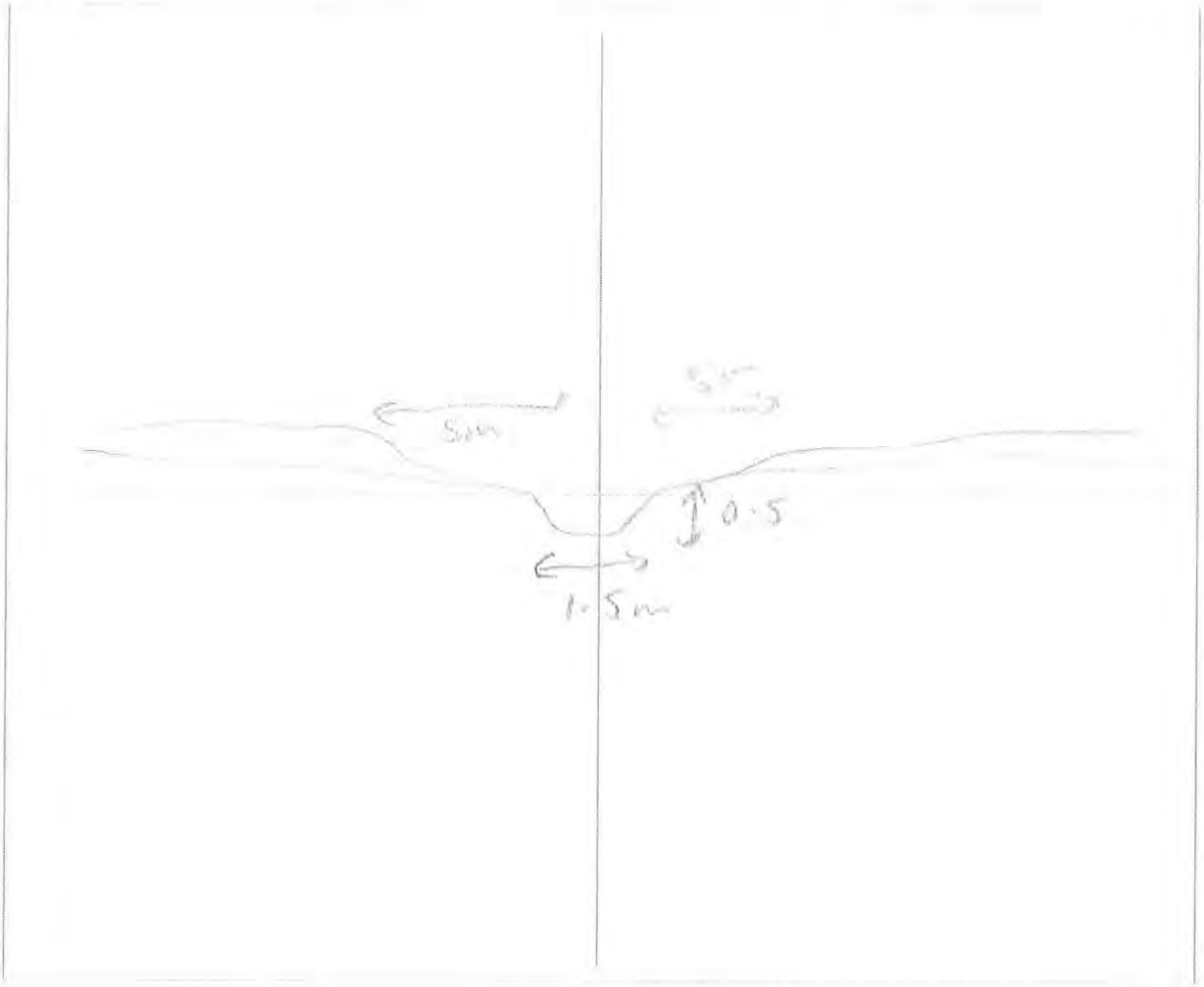
**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Dry watercourse, shallow with eroded banks.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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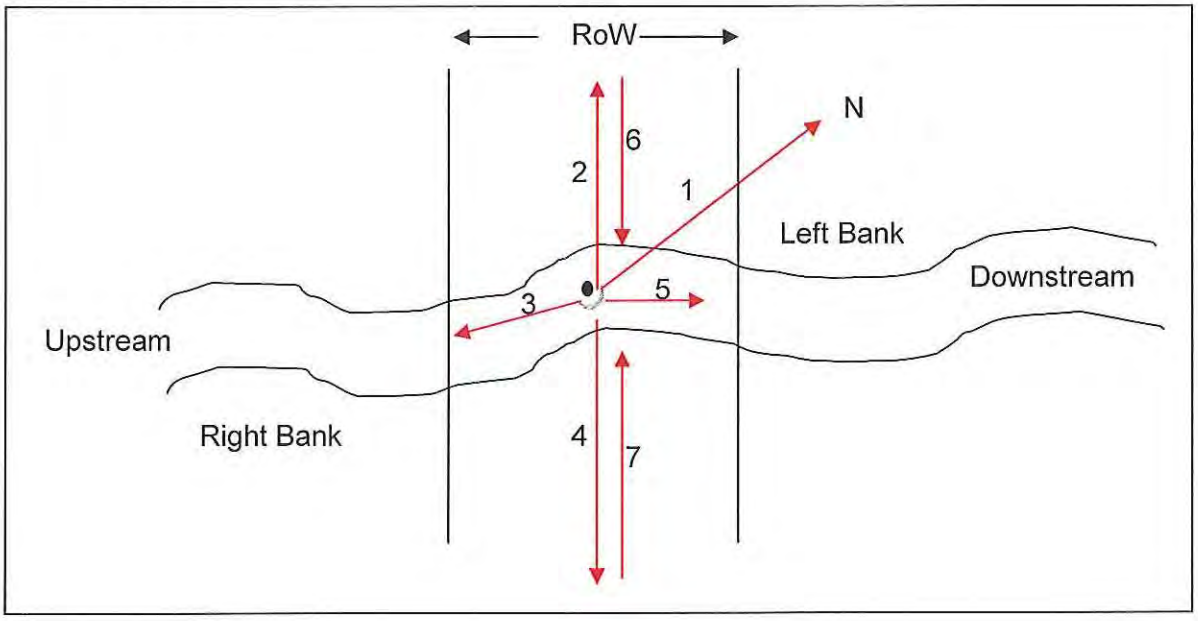
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 079 |
| Facing left bank (2) | 080 |
| Facing Upstream (3) | 081 |
| Facing Right Bank (4) | 083 |
| Facing Downstream (5) | 082 |
| From edge of Riparian on left (6) | 084 |
| From edge of Riparian on right (7) | 085 |

**General Comments:**

Dry watercourse with cracking clays 2 large shrubs (1D), Highly disturbed, extensive grass cover — limited vegetation other than grasses.

Un-named trib of ironbark creek.

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**Is water present?** Y/(N -) If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

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# Certificate of Analysis


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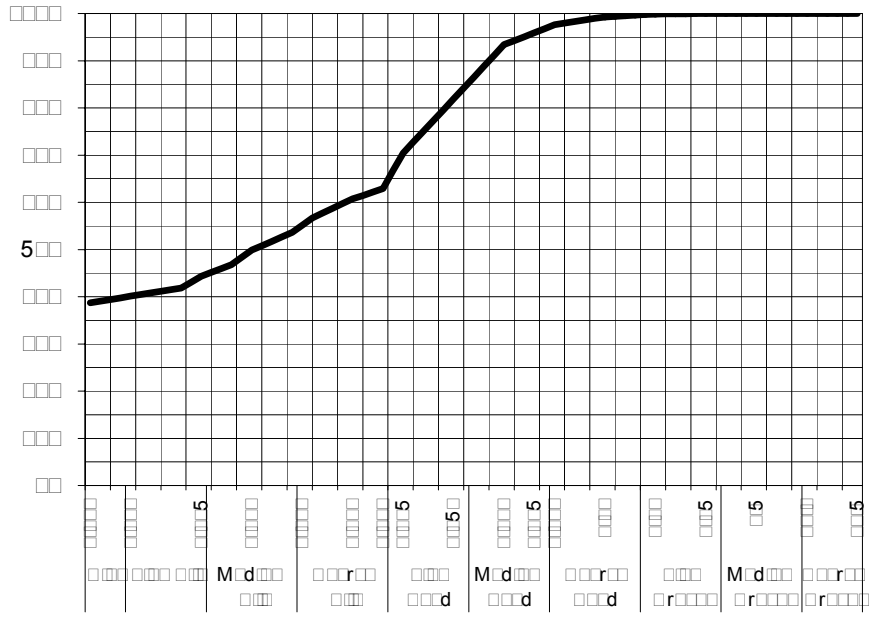


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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# Certificate of Analysis


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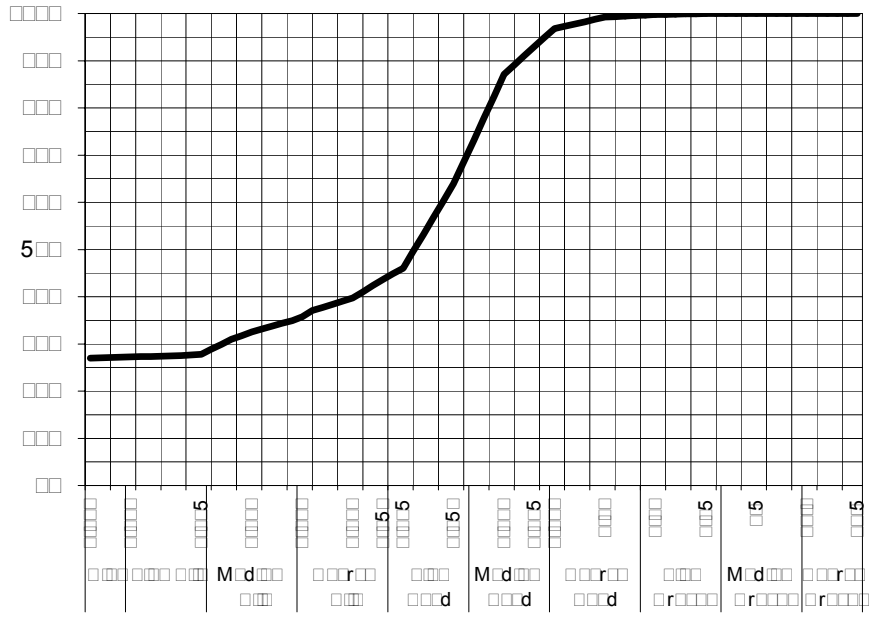
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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12-1 12 | KP Point 69.0 | Eastings 685079.2 | Northings 7212691
Watercourse Name unnamed Trib | Distance from Source 3.2 km | AMTD 10.1 km
Stream Order 1 | Photo taken of access track Y/N
Catchment Area Comet | Weather Fine
Rain in the Past week NIL | Time of Day 9.45 | Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 1

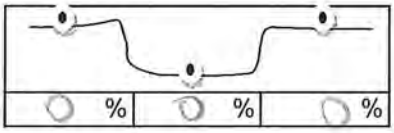
Height of Banks  Left 1 Right 1

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB N/A RB

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**Riparian vegetation**: Grass % 100 Shrubs %

Trees < 10m % Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

Notes: No riparian veg. Patchy grass cover
Stock route next to creek

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

Notes: scattered trees, cleared grazing lands

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

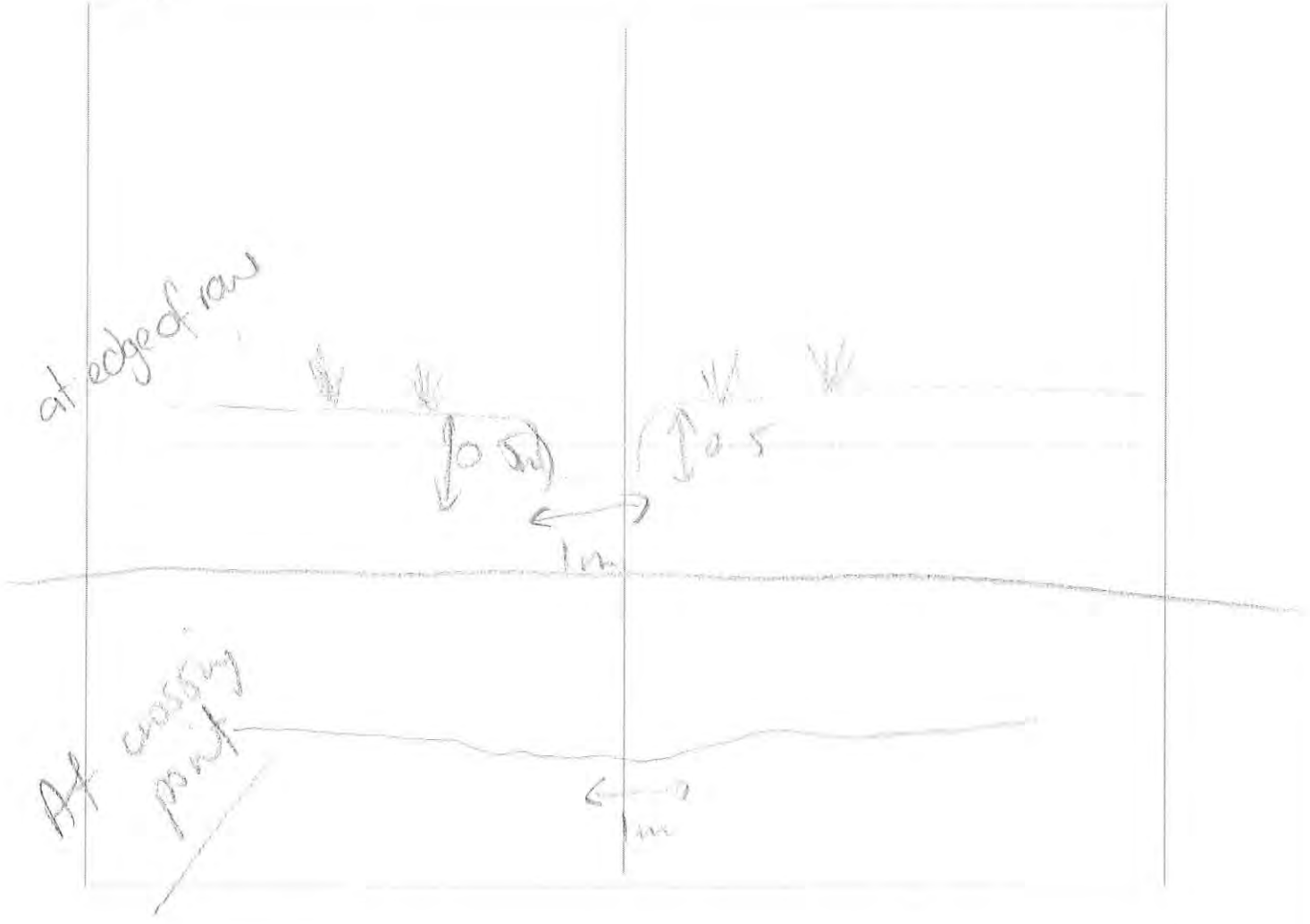
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Small watercourse, dry. Steep eroded banks 1m high. At point of crossing, stream is shallow, clayey soil

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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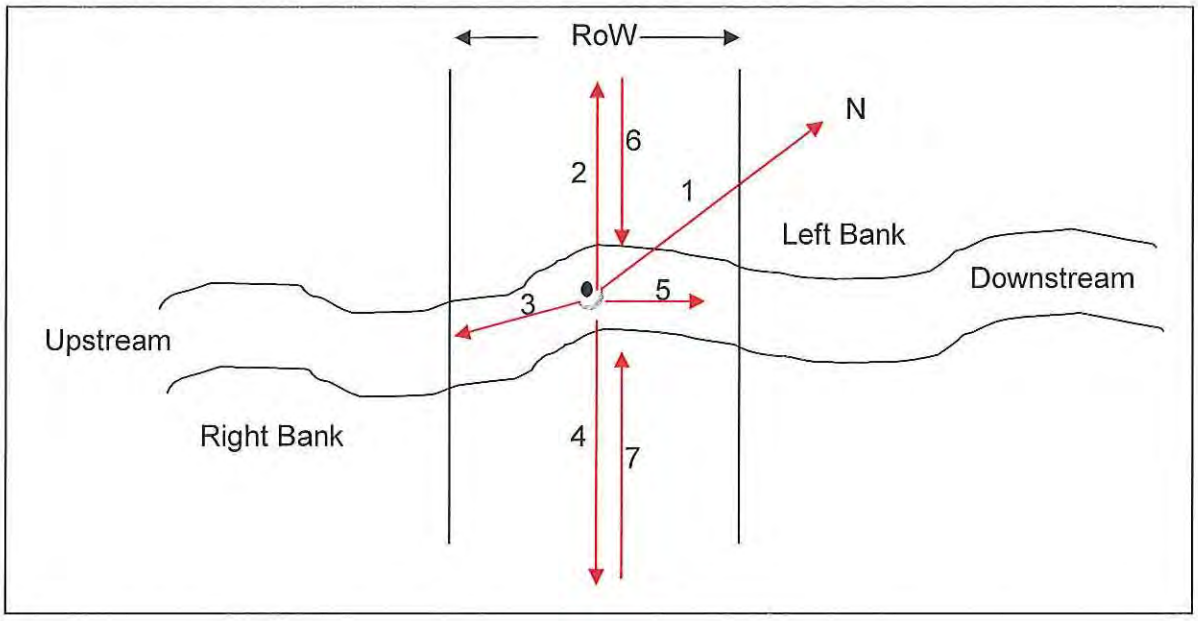
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 94 |
| Facing left bank (2) | 95 |
| Facing Upstream (3) | 96 |
| Facing Right Bank (4) | 97 |
| Facing Downstream (5) | 98 |
| From edge of Riparian on left (6) | 99 |
| From edge of Riparian on right (7) | 100 |

**General Comments:**

Steep banks 1m high, thick cracking clays scattered trees in grazing veg, no riparian cover, grasses.

At point of crossing, no noticeable bank, shallow depression

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**Is water present?** Y/ N If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

# Certificate of Analysis

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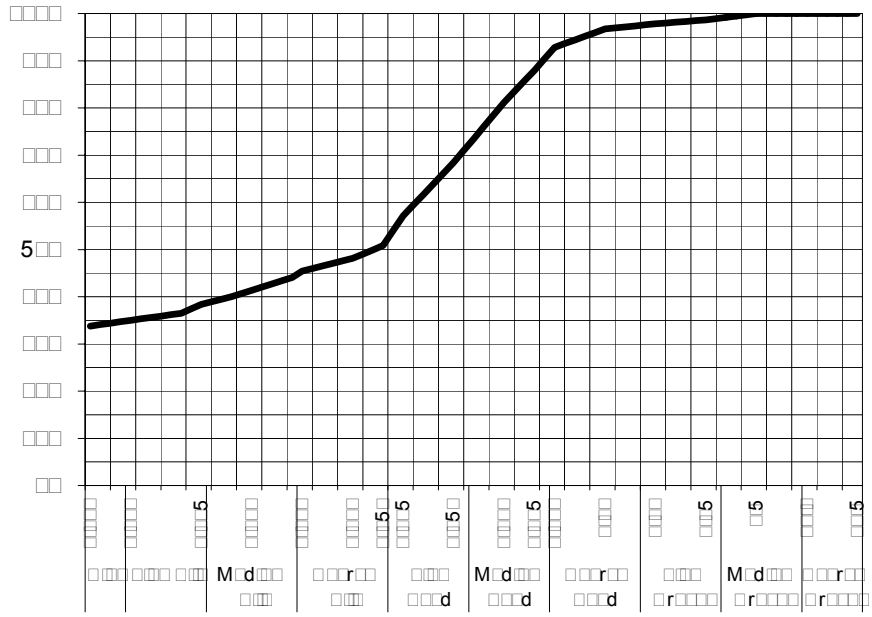


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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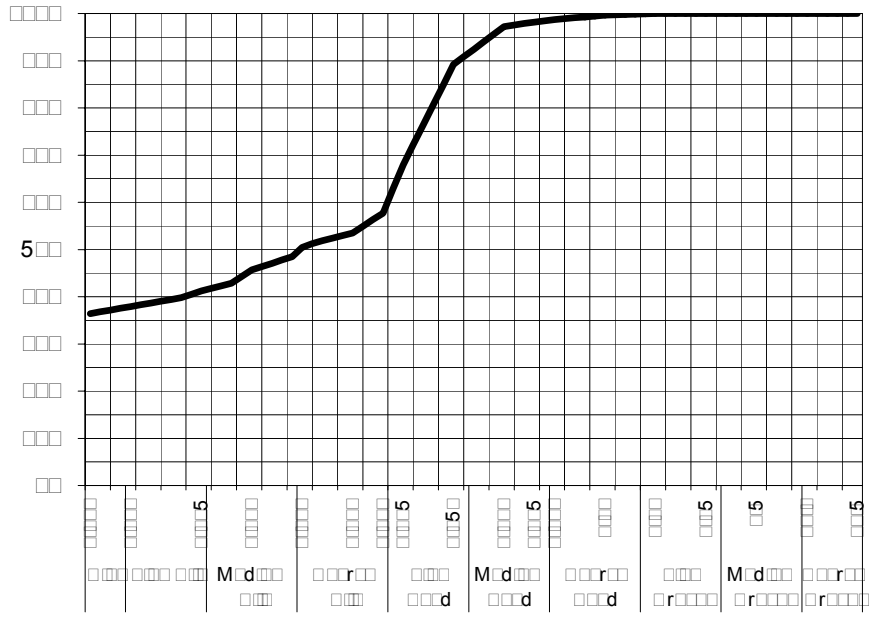


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

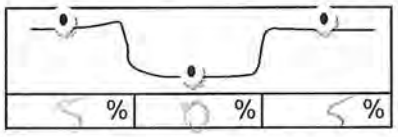
Date 5/1/17 KP Point 22N3 Eastings 777684.4 Northings 7290535
Watercourse Name Un-named Distance from Source 1.48 km AMTD 1.29 km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Dawson Weather Fine
Rain in the Past week Nil Time of Day 4:15pm Cloud Cover (%) 5

---

**OBSERVATIONS**

Mean Channel width (m) 25m
Height of Banks  Left 1 Right 0.75

Velocity (m/s): Flow metre N/A Floating object N/A
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive (Moderate) Limited None
Canopy cover % Width of riparian Zone (m): LB 5m RB 5m

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**Riparian vegetation**: Grass % 75 Shrubs % 0
Trees < 10m % 5 Trees > 10m % 20

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 10 |
| | | Silt/clay (<1mm) | % 90 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

No flow, shallow depression with wide active channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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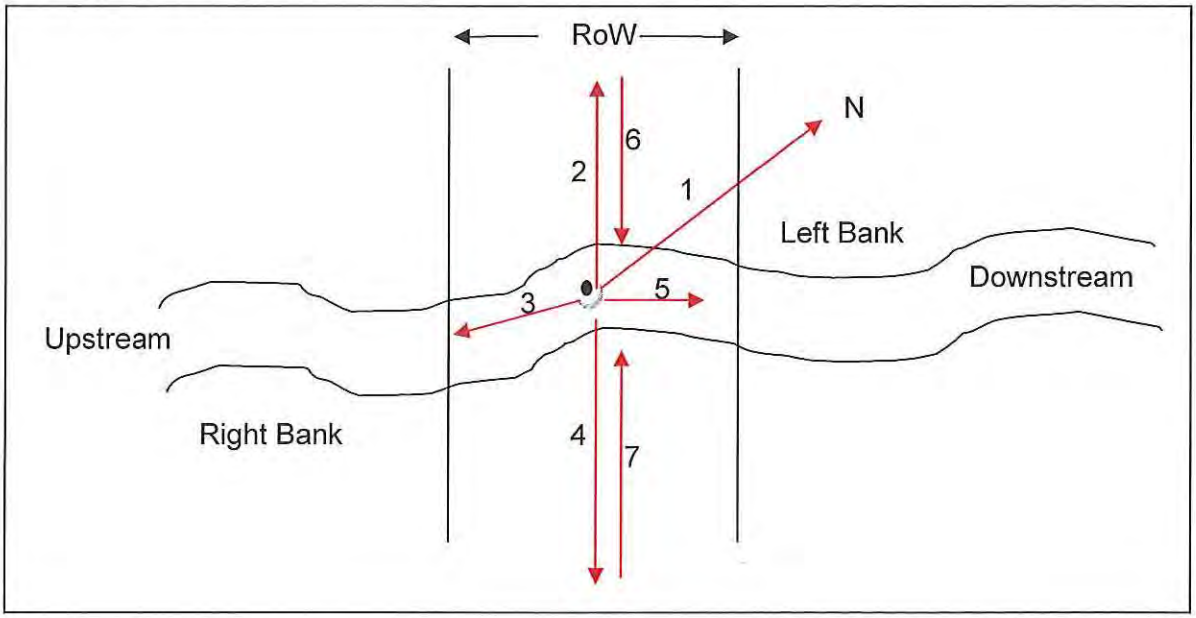
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 016 |
| Facing left bank (2) | 017 |
| Facing Upstream (3) | 018 |
| Facing Right Bank (4) | 019 |
| Facing Downstream (5) | 020 |
| From edge of Riparian on left (6) | 021 |
| From edge of Riparian on right (7) | 022 |

**General Comments:**

Trib of Mimosa Creek

Well cleared site with sparsely distributed tree's greater than 10 m.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

- *Cyperus betchei*

# Certificate of Analysis

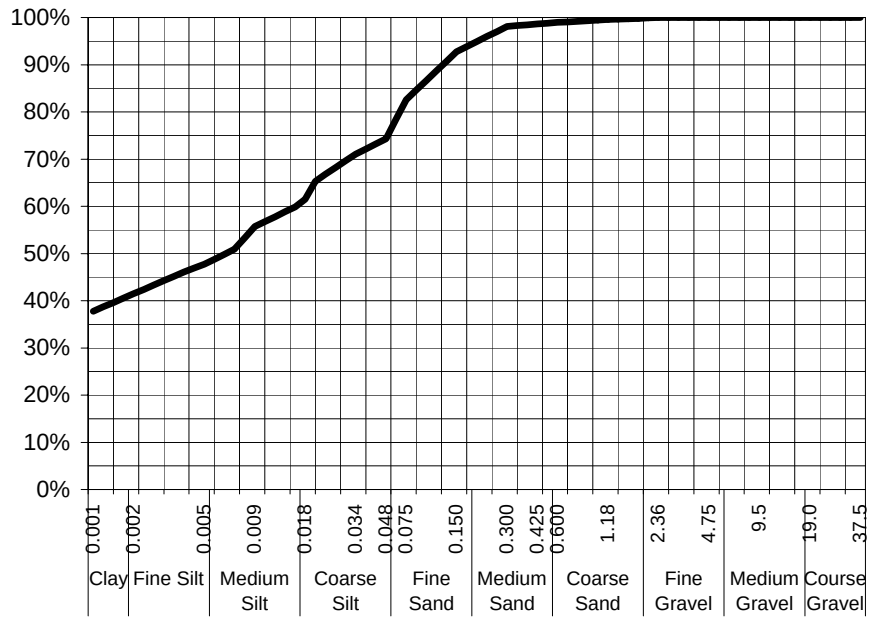
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-005 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP221.2 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 100% |
| 0.600 | 99% |
| 0.425 | 99% |
| 0.300 | 98% |
| 0.150 | 93% |
| 0.075 | 83% |
| Particle Size (microns) | |
| 48 | 74% |
| 34 | 71% |
| 18 | 61% |
| 9 | 56% |
| 5 | 48% |
| 3 | 46% |
| 1 | 38% |

| | |
|---|---|
| Median Particle Size (mm) | 0.007 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

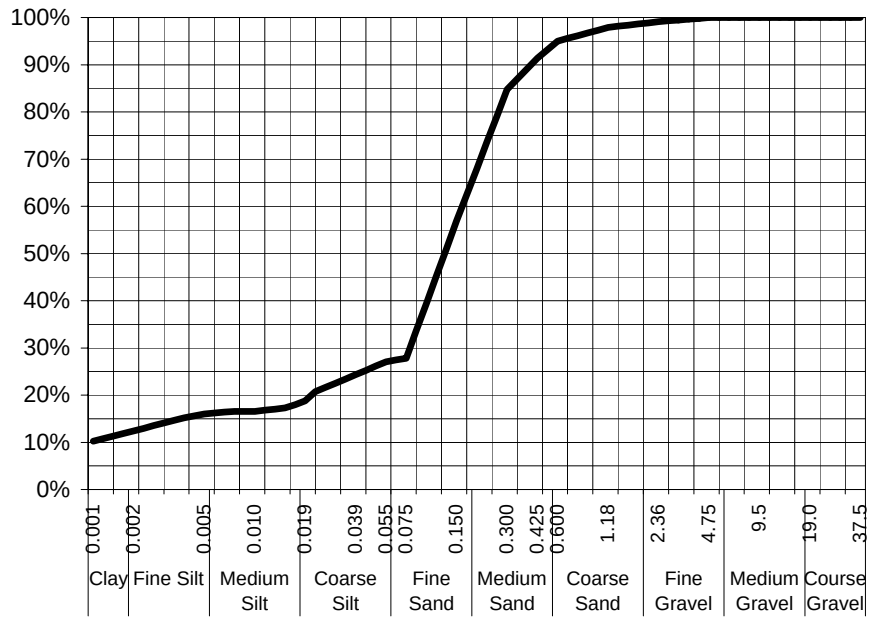
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-006 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP221.2 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 98% |
| 0.600 | 95% |
| 0.425 | 91% |
| 0.300 | 85% |
| 0.150 | 57% |
| 0.075 | 28% |
| Particle Size (microns) | |
| 55 | 27% |
| 39 | 24% |
| 19 | 19% |
| 10 | 17% |
| 5 | 16% |
| 4 | 15% |
| 1 | 10% |

| | |
|---|---|
| Median Particle Size (mm) | 0.075 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium fine sand and silty clay

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 18/3/12 KP Point 224 97 Eastings 781171 Northings 7290008
Watercourse Name Unnamed Distance from Source 300m AMTD 3km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Mimosa Weather Overcast
Rain in the Past week 30mL Time of Day 8am Cloud Cover (%) 100

---

**OBSERVATIONS**

Mean Channel width (m) 1m (high) and 3m

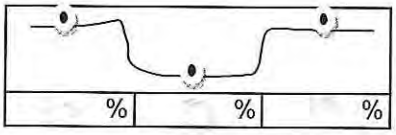
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB RB




---

**Riparian vegetation**: Grass % 90 Shrubs %

Trees < 10m % 5 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

grasses & some small trees

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GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 60 |
| | | Silt/clay (<1mm) | % 40 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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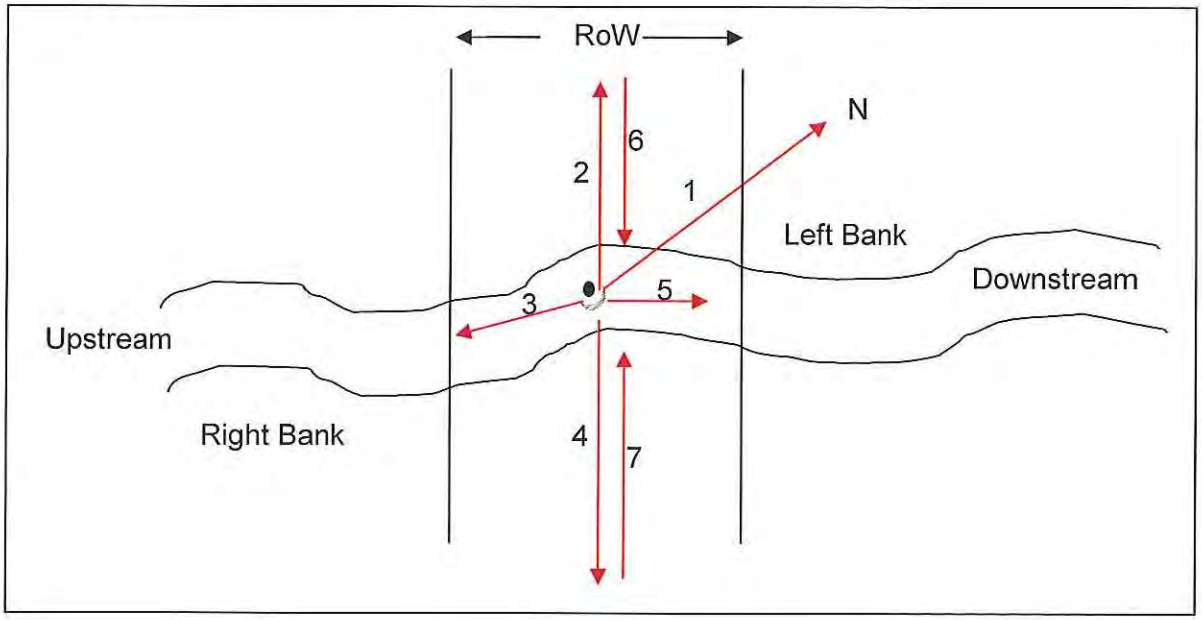
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 220-2 |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | 220-3 |
| From edge of Riparian on right (7) | 220-4 |

**General Comments:**

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

[illegible]**4**[illegible]

[illegible]

- [illegible]*Acacia fasciculifera*
- **Acacia fasciculifera*
- **Alectryon diversifolius*
- **Apophyllum anomalum*
- **Carissa ovata*
- **Eucalyptus sp.,* [illegible]d[illegible]d

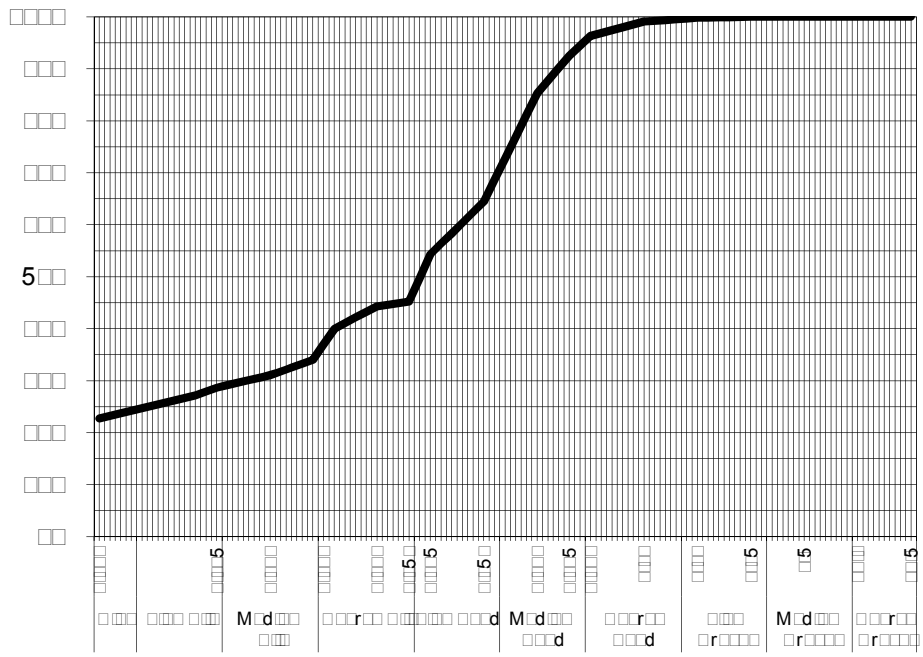
[illegible]d[illegible]d [illegible]d [illegible]r[illegible]r[illegible]M

# Certificate of Analysis


ALS Environmental

Newcastle, NSW



| Particle Size (mm) | Cumulative Passing (%) |
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| | |
|---|---|
| Median Particle Size (mm) | |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


5 NATA WORLD RECOGNISED ACCREDITATION


**Dianne Blane**

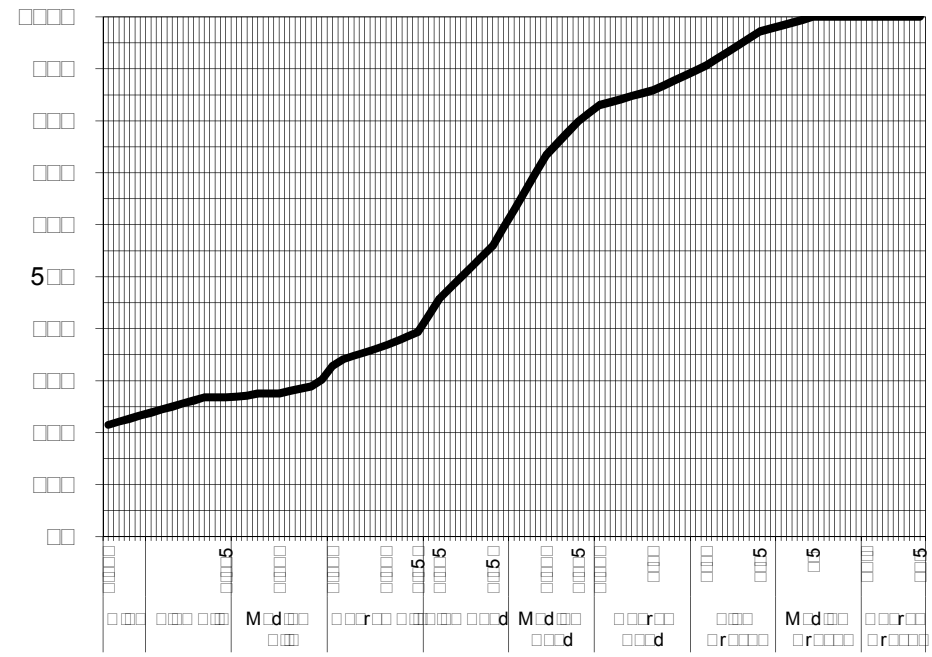
*Authorised Signatory*

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


NATA
WORLD RECOGNISED
ACCREDITATION


**Dianne Blane**

***Authorised Signatory***









Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/06/12 KP Point 238.01 Eastings 792109.14 Northings 7295098.74

Watercourse Name unnamed minor 103 Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson Weather Clear

Rain in the Past week - Time of Day 1.40pm Cloud Cover (%) 0

Second Survey location → see KP238.31

**OBSERVATIONS**

Mean Channel width (m) 12.5m

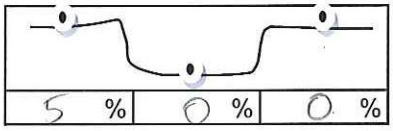
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)

Canopy cover % Width of riparian Zone (m): LB <1 RB <1




---

**Riparian vegetation**: Grass % 95 Shrubs % _____

Trees < 10m % 5 Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

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GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

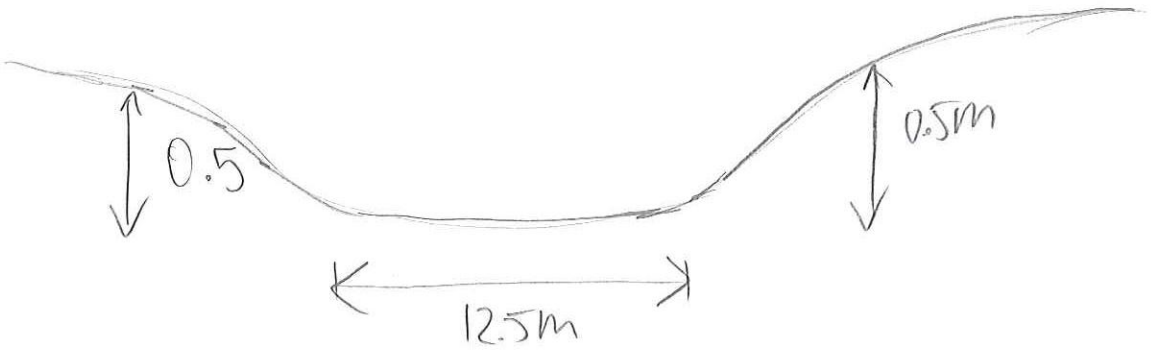
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Shallow, fairly flat watercourse, mainly dry, sparse, bare vegetation, few trees

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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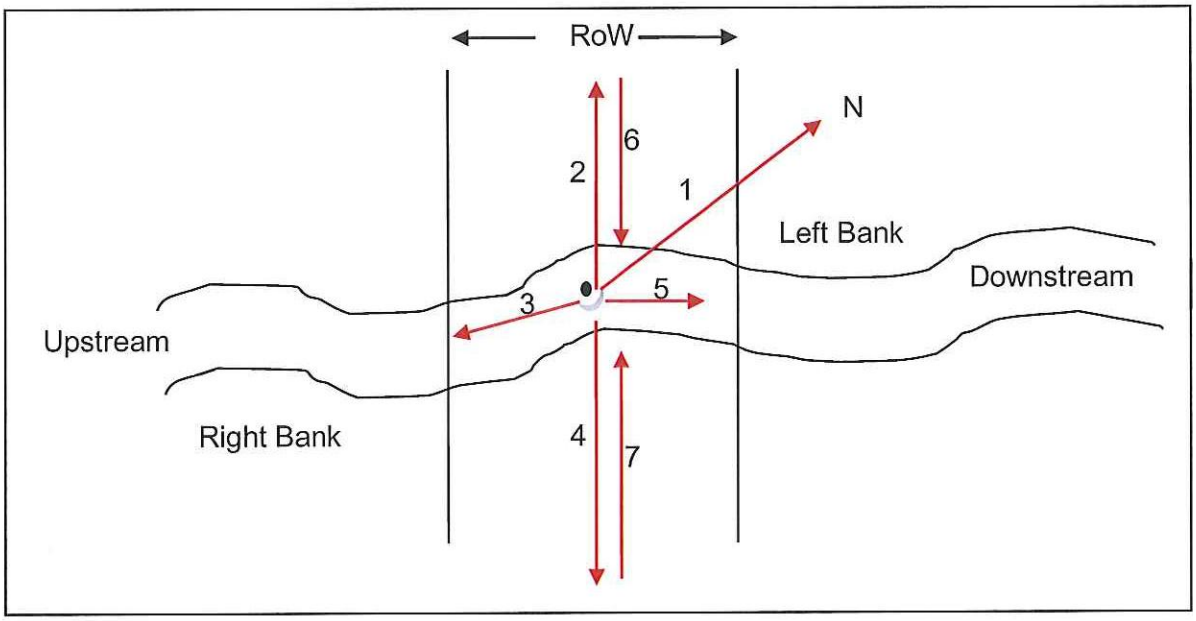
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/6/12 KP Point 238.31 Eastings 792409.39 Northings 7295094.01

Watercourse Name unnamed minor 104 Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson Weather Fine

Rain in the Past week — Time of Day 1:30 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 42.5m – 10m

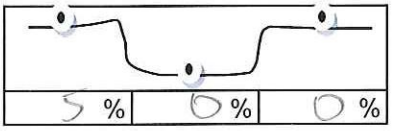
Height of Banks  Left / Right /

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % Width of riparian Zone (m): LB <1 RB <1




---

**Riparian vegetation**: Grass % 95 Shrubs % _____

Trees < 10m % 5 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

mainly grazing land
few scattered trees.

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

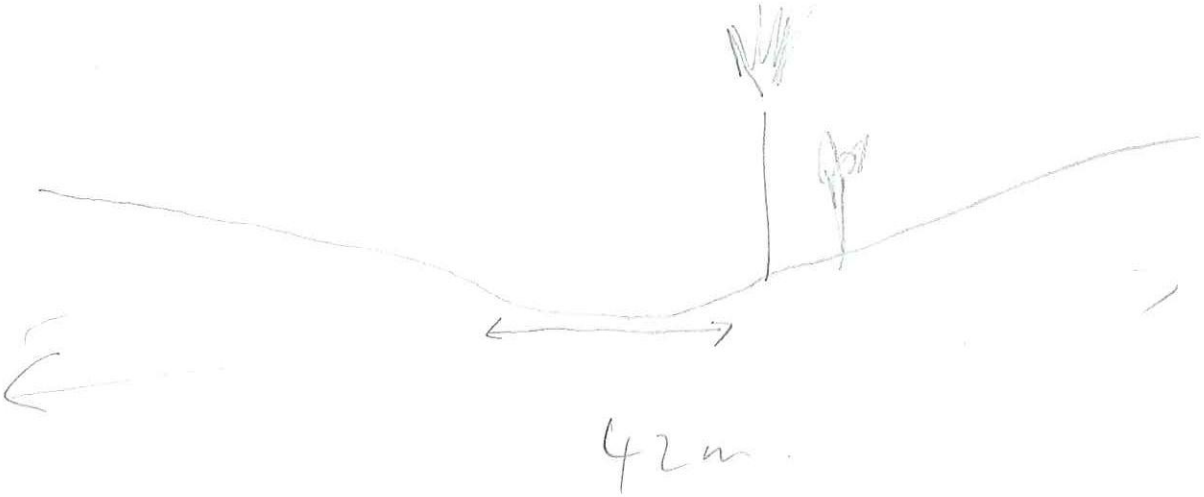
Instream + Bank

## GEOMORPHOLOGY

**General Comments / Reach Description:**

Shallow wide watercourse. Mainly dry.
Main channel only 10m wide, high flow channel 42.5m

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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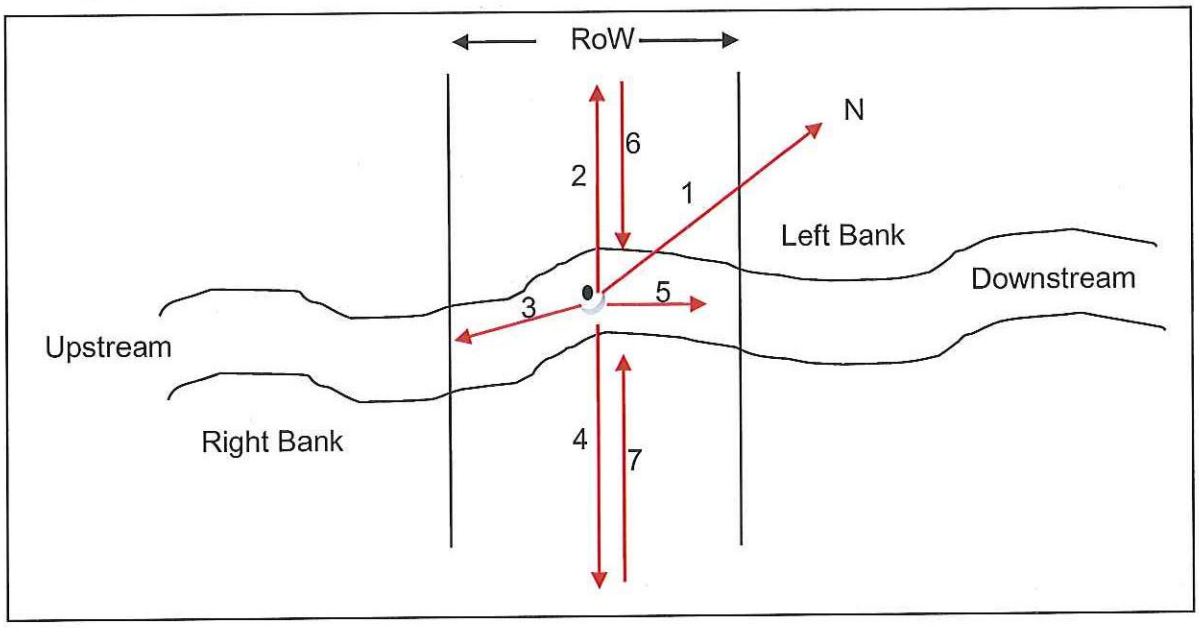
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 236-1 |
| Facing left bank (2) | 236-2 |
| Facing Upstream (3) | 236-3 |
| Facing Right Bank (4) | 236-4 |
| Facing Downstream (5) | 236-5 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Shallow. Dry watercourse, scattered Eucalypts & ironbark and mainly grasses. Limited erosion, mainly from cattle movement. Mainly surrounded roots of grasses.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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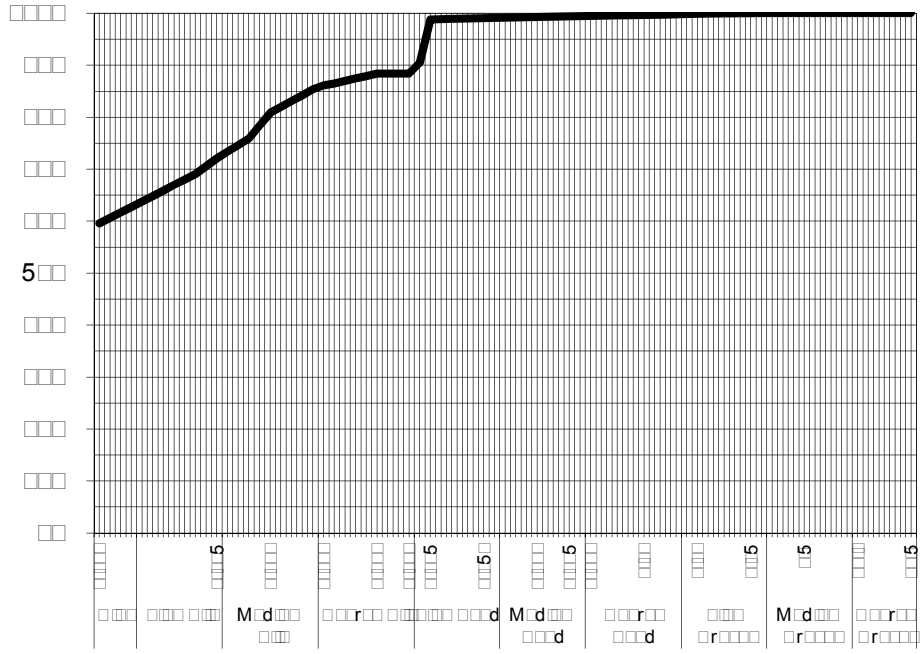


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*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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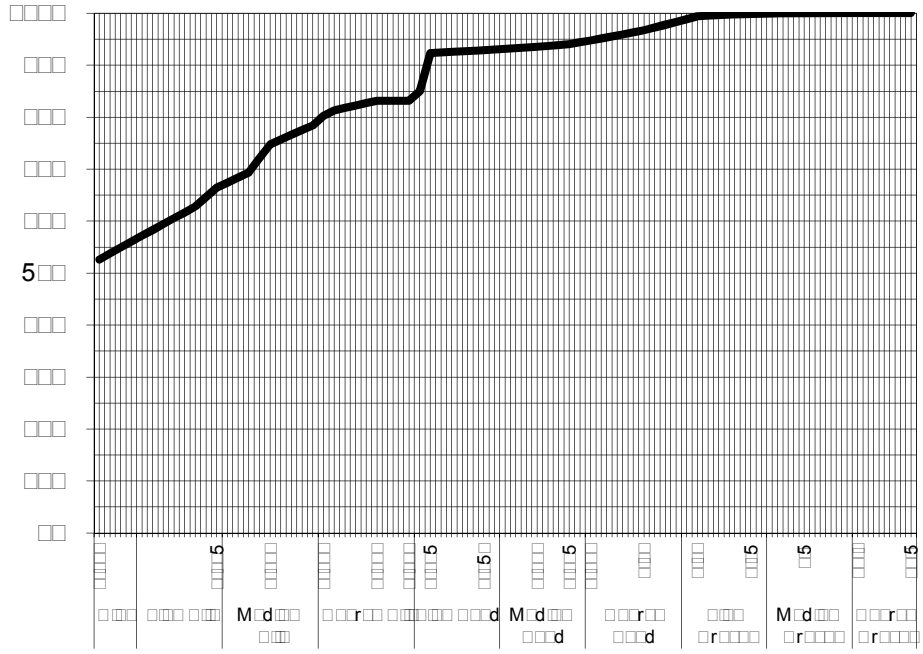
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***



**Facing north from proposed GTP crossing location (KP238.3)**



**Facing right bank from proposed GTP crossing location (KP238.3)**



**Facing left bank from proposed GTP crossing location (KP238.3)**



**Facing downstream from proposed GTP crossing location (KP238.3)**



**Facing upstream from proposed GTP crossing location (KP238.3)**

Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/6/12 KP Point 258.24 Eastings 201047.41 Northings 7302284.57

Watercourse Name Unnamed minor 110 Distance from Source ____ AMTD ____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson Weather Fine

Rain in the Past week — Time of Day 12:30pm Cloud Cover (%) 0

Second survey location → See KP 258.14

**OBSERVATIONS**

Mean Channel width (m) 10m

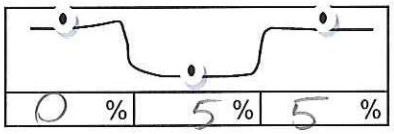
Height of Banks  Left 1 Right 1.5

Velocity (m/s): Flow metre N/A Floating object ____

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




**Riparian vegetation**: Grass % 95 Shrubs % ____

Trees < 10m % 5 Trees > 10m % ____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

patchy trees

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100. |

**Bank Material** Dispersive/Sodic Y/N

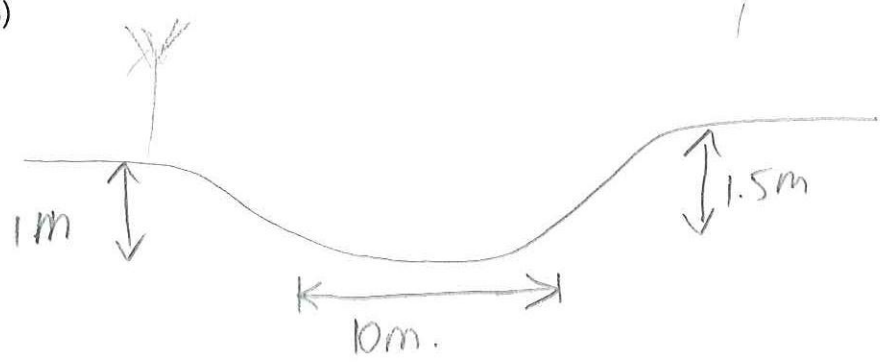
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Scattered veg., mostly dry

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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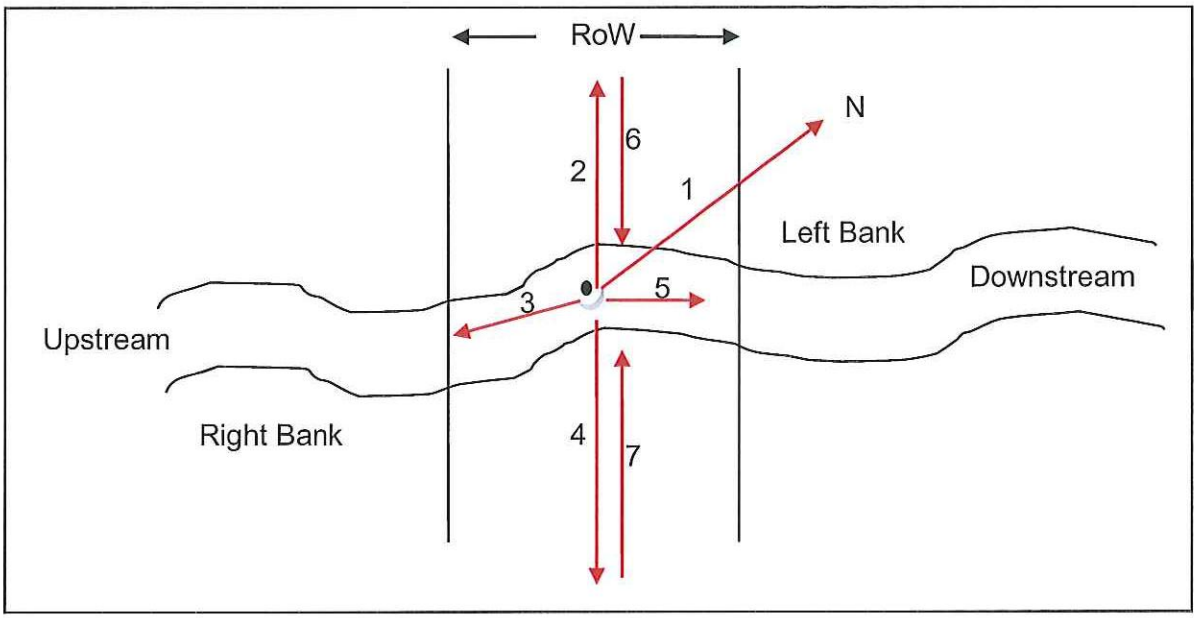
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/6/12 KP Point 258.74 Eastings 201531.84 Northings 7302405.04

Watercourse Name unnamed minor III Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson Weather Fine

Rain in the Past week — Time of Day 12pm Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 10m → 3m

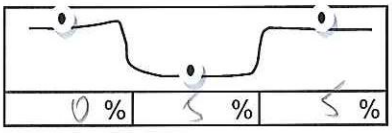
Height of Banks  Left 1.5 Right 1

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % 5 Width of riparian Zone (m): LB 1 RB 1

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**Riparian vegetation**: Grass % 95 Shrubs % _____

Trees < 10m % 5 Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

↓ patchy trees.

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

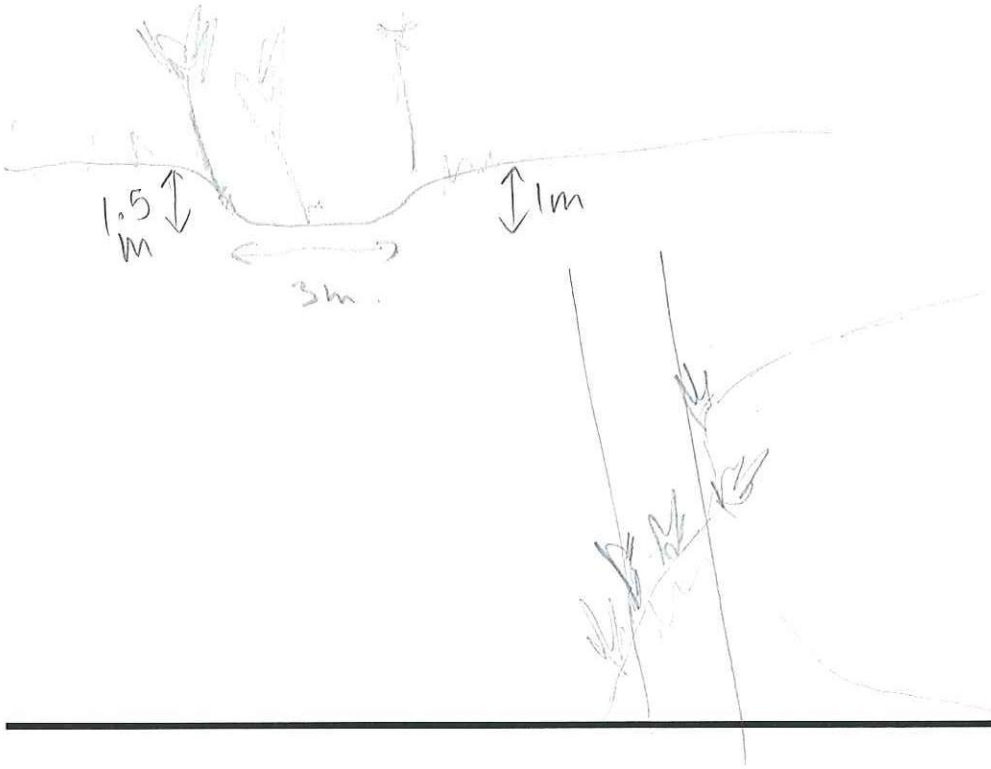
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Winding channel, small, dry, scattered riparian veg.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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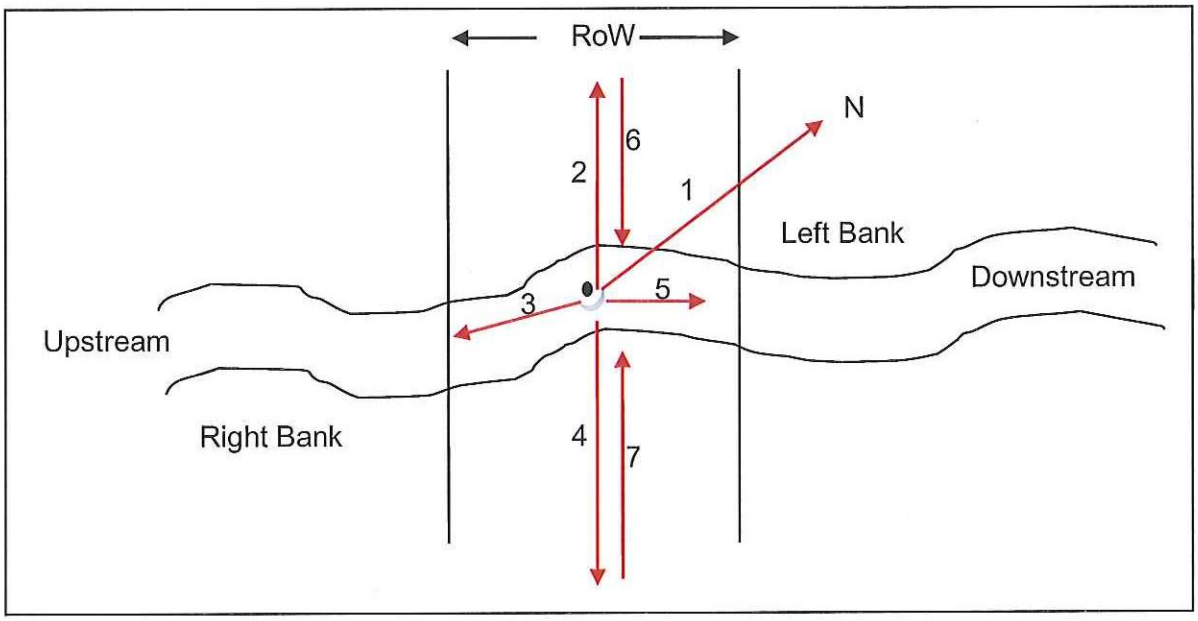
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 258-1 |
| Facing left bank (2) | 258-2 |
| Facing Upstream (3) | 258-3 |
| Facing Right Bank (4) | 258-4 |
| Facing Downstream (5) | 258-5 |
| From edge of Riparian on left (6) | 258-6 |
| From edge of Riparian on right (7) | 258-7 |

**General Comments:**

Small winding channel, moderate/extensive erosion limited riparian vegetation.

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP258.74**

Botanical specimens list:

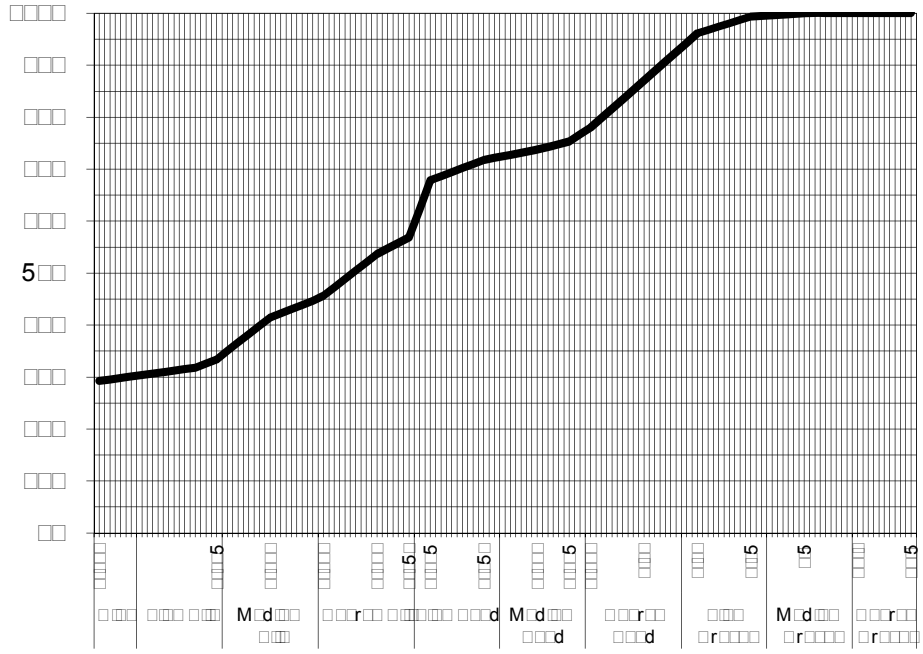
- **Leucaena leucocephala*
- **Lysiphyllum carronii*
- **Psydrax oleifolium*
- **Citrus glauca*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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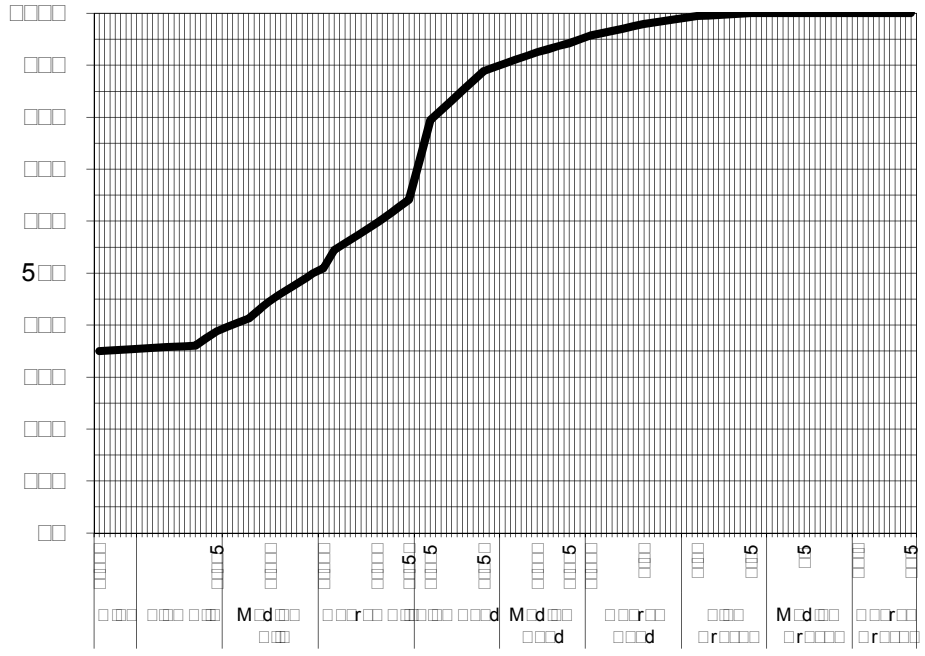
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**Facing north from proposed GTP crossing location (KP258.74)**



**Facing right bank from proposed GTP crossing location (KP258.74)**



**Facing left bank from proposed GTP crossing location (KP258.74)**



**Facing downstream from proposed GTP crossing location (KP258.74)**



**Facing upstream from proposed GTP crossing location (KP258.74)**



**Facing proposed crossing location from edge of left riparian (KP258.74)**



**Facing proposed crossing location from edge of right riparian (KP258.74)**

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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

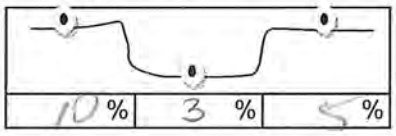
Date 06.01.12 KP Point 280.2 Eastings 630968.7 Northings 7305420
Watercourse Name Sellheim ck Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Dawson Weather Fine
Rain in the Past week N/L Time of Day 9am Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 4
Height of Banks  Left 1.5 m Right 3m

Velocity (m/s): Flow metre N/A Floating object 1m/minute
Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Stagnant at centre of flow
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB _____ RB _____
At centre of flow, limited riparian veg




---

**Riparian vegetation**: Grass % 70 Shrubs % 5
Trees < 10m % 10 Trees > 10m % 15

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % 50 |

**Bank Material** Dispersive/Sodic Y/N

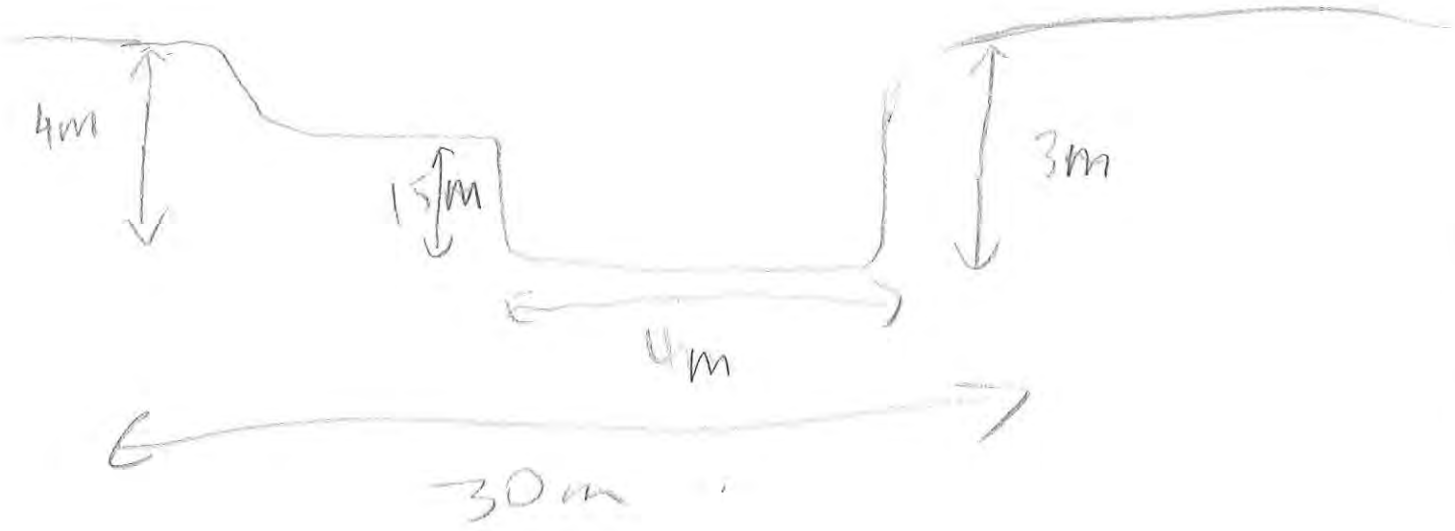
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

4m active channel, steep eroded banks

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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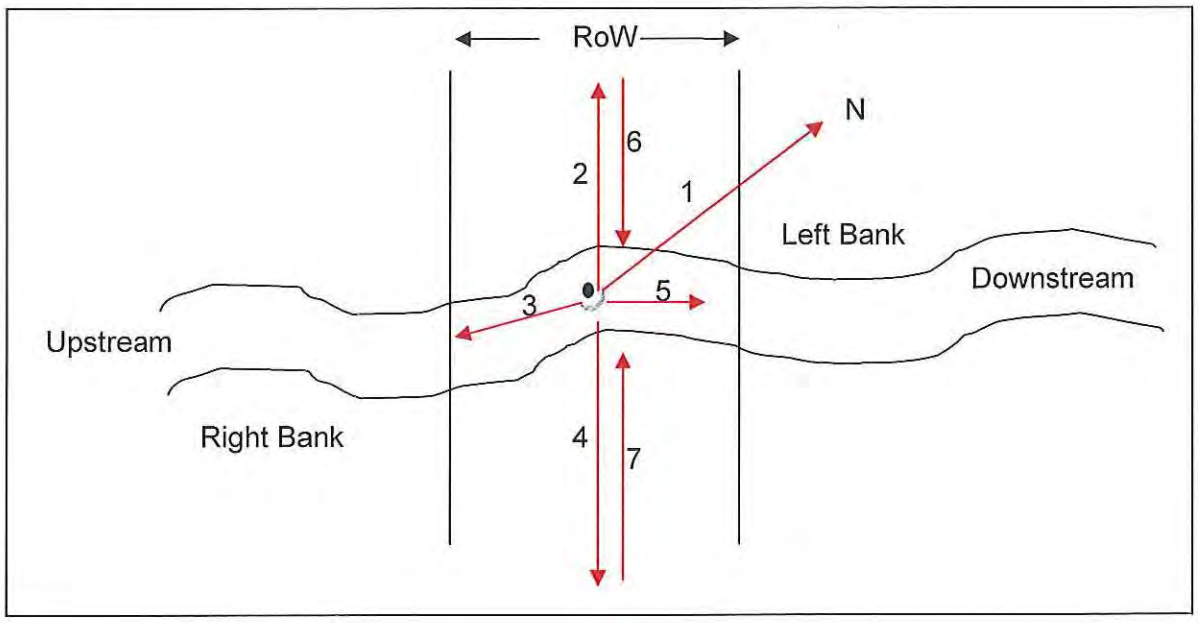
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 023 |
| Facing left bank (2) | 024 |
| Facing Upstream (3) | 025 |
| Facing Right Bank (4) | 026 |
| Facing Downstream (5) | 027 |
| From edge of Riparian on left (6) | 028 |
| From edge of Riparian on right (7) | 029 |

**General Comments:**

Relatively clear in centre of RoW
stagnant water, & low flow.
Steep banks.
Starts flow at RoW. Immediately
upstream of RoW, stream is dry
Stagnant at centre of RoW however has
flow to the north/downside of RoW.

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 27.1 | 27.3 | – | 27.2 |
| Conductivity (µS/cm) | 2649 | 2623 | – | 2636 |
| pH | 8.18 | 8.22 | – | 8.20 |
| Dissolved $O_2$ (mg/L) | 4.42 | 4.20 | – | 4.31 |
| Turbidity (NTU) | 18.2 | 18.0 | – | 18.1 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | (Little) | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | (Little) | Moderate | Lot |
| Submerged: | None | (Little) | Moderate | Lot |
| Floating: | (None) | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

# Certificate of Analysis

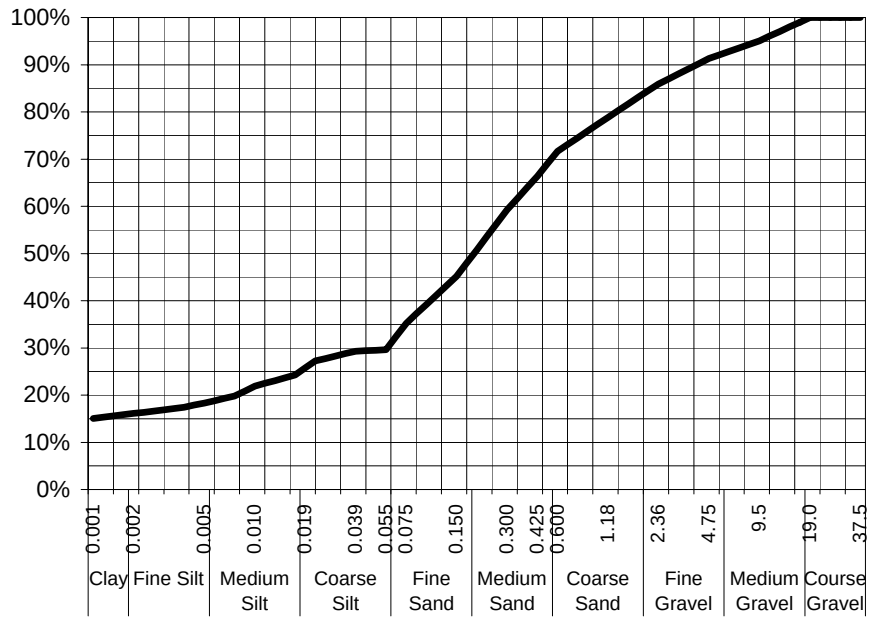
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-007 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP280.3 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 95% |
| 4.75 | 91% |
| 2.36 | 86% |
| 1.18 | 79% |
| 0.600 | 72% |
| 0.425 | 66% |
| 0.300 | 59% |
| 0.150 | 45% |
| 0.075 | 35% |
| Particle Size (microns) | |
| 55 | 30% |
| 39 | 29% |
| 19 | 26% |
| 10 | 22% |
| 5 | 18% |
| 4 | 17% |
| 1 | 15% |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

| | |
|---|---|
| Median Particle Size (mm) | 0.150 |

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Sand, silty clay and gravel

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

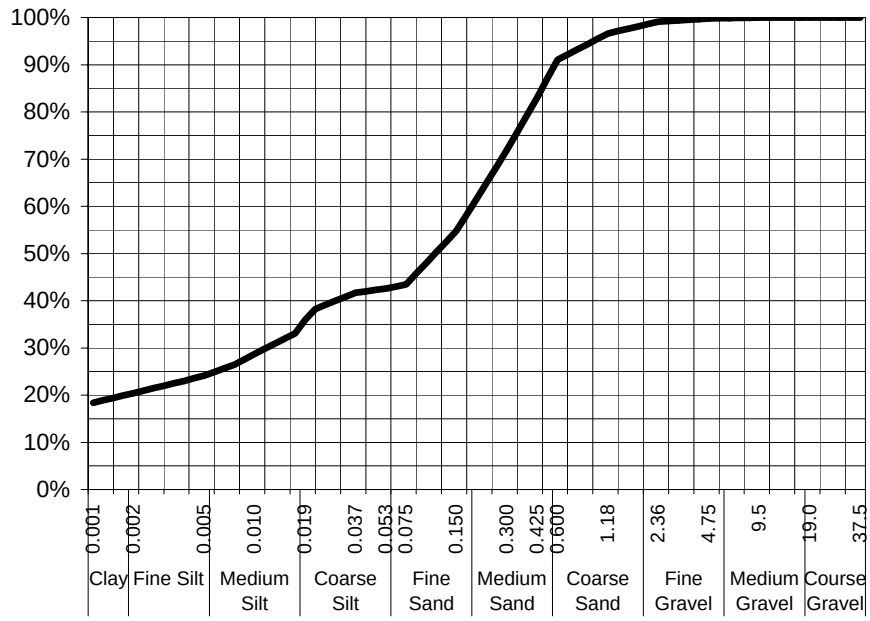
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-008 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP280.3 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 97% |
| 0.600 | 91% |
| 0.425 | 83% |
| 0.300 | 72% |
| 0.150 | 55% |
| 0.075 | 43% |
| Particle Size (microns) | |
| 53 | 43% |
| 37 | 42% |
| 19 | 36% |
| 10 | 29% |
| 5 | 24% |
| 4 | 23% |
| 1 | 18% |

| | |
|---|---|
| Median Particle Size (mm) | 0.075 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium fine sand and silty clay

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

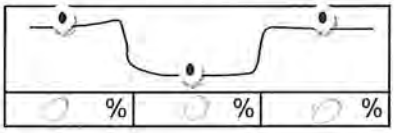
Date 8/7/12 KP Point 307.1 Eastings 241043 Northings 7313845
Watercourse Name Unnamed Distance from Source 0.61 km AMTD 0.12 km
Stream Order 2 Photo taken of access track Y/N
Catchment Area Dawson Weather Blue / cloudy
Rain in the Past week 7 litres Time of Day 9:20 Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 6
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object 0.03
Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB ____ RB ____




---

**Riparian vegetation**: Grass % 100 Shrubs % ____
Trees < 10m % ____ Trees > 10m % ____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|
| good grass cover | | | |

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % 50 |

**Bank Material** Dispersive/Sodic Y/N

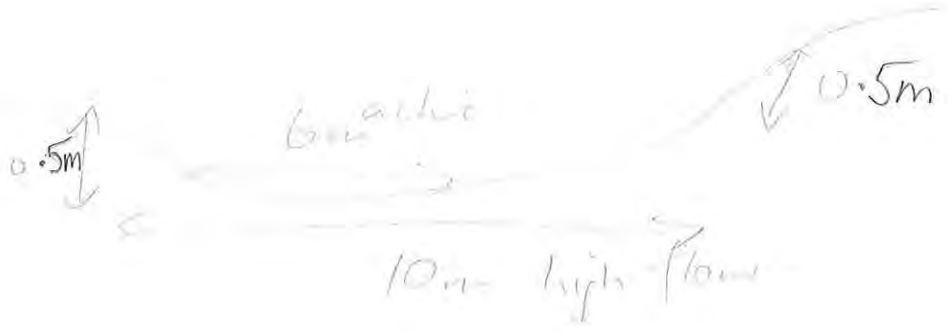
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

6m active channel with moderate flow

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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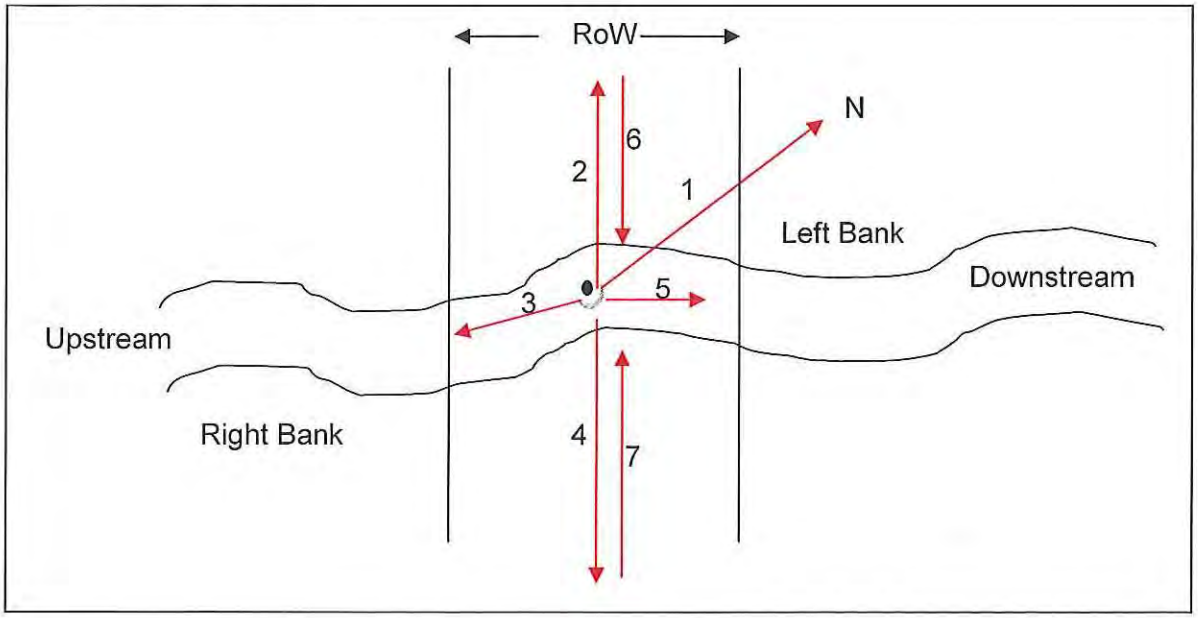
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) 1 | 147 |
| Facing left bank (2) 2 | 148 |
| Facing Upstream (3) 3 | 149 |
| Facing Right Bank (4) 6 | 154 |
| Facing Downstream (5) 4 | 150 |
| From edge of Riparian on left (6) 7 | 153 |
| From edge of Riparian on right (7) 5 | 151 |

**General Comments:**

highly turbid low flowing active channel → from recent rain. Heavily grassed. Trailing veg is limited to non existent. Scattered silver leafed iron bark present

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 25.1 | 26.2 | — | 25.65 |
| Conductivity (µS/cm) | 642.8 | 641.3 | — | 644.55 |
| pH | 6.44 | 6.60 | | 6.52 |
| Dissolved $O_2$ (mg/L) | 6.86 | 6.52 | | 6.69 |
| Turbidity (NTU) | 902 | 916 | | 909 |

---

**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

- *Fimbristylis ferruginea*
- *Cyperaceae sp.,

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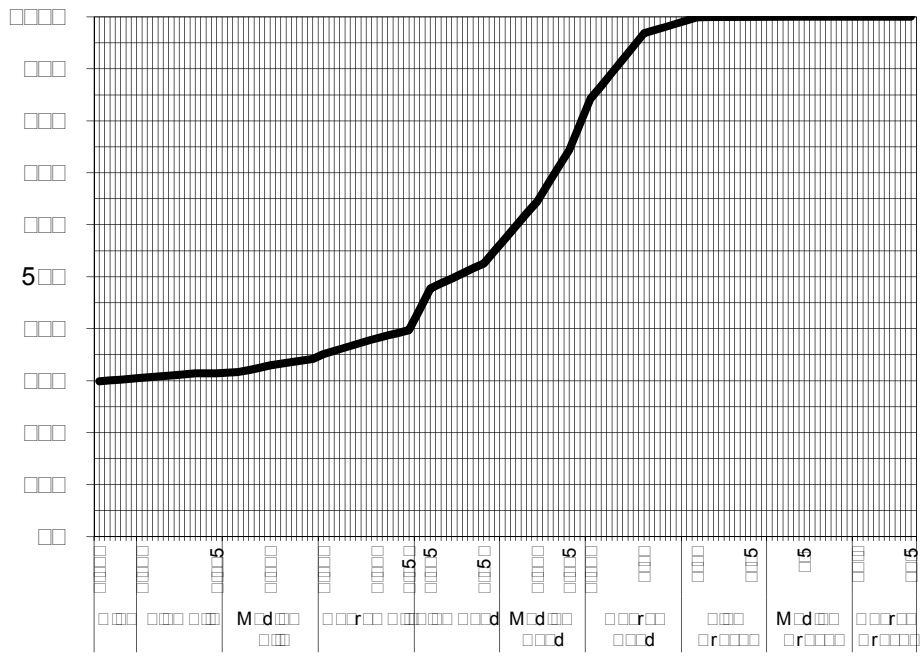

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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*




5




**Dianne Blane**

***Authorised Signatory***

# Certificate of Analysis


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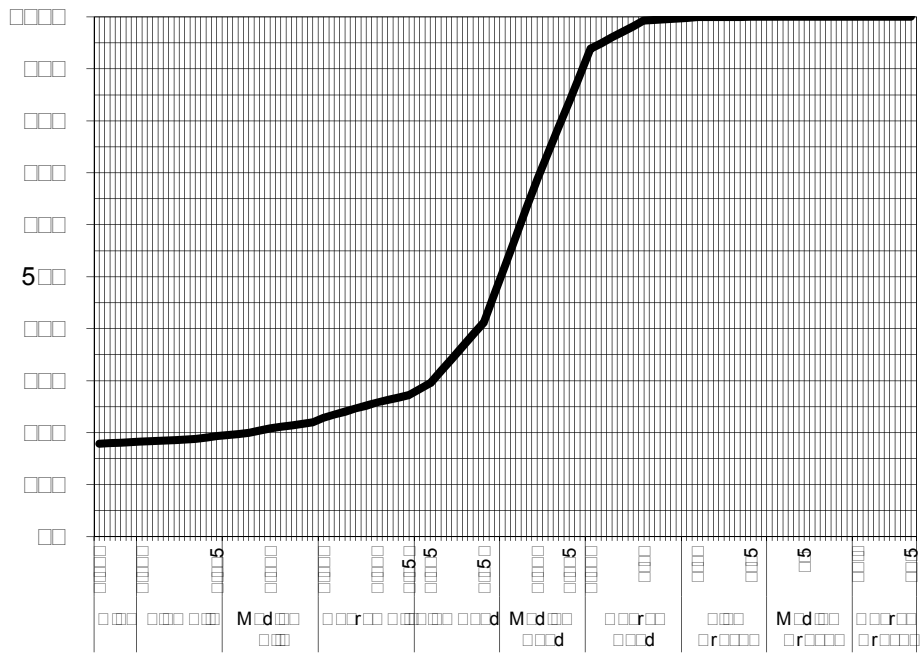
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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

320.5 crossed twice
320.6

Date 06.01.12 KP Point ____ Eastings 767450.4 Northings 7317056

Watercourse Name un-named Distance from Source 4.6km AMTD 1.16 km

Stream Order 2 Photo taken of access track Y/N

Catchment Area Dawson Weather Fine

Rain in the Past week NIL Time of Day 11.45 Cloud Cover (%) 0

---

**OBSERVATIONS**

320.3 (1m channel width)

Mean Channel width (m) 15

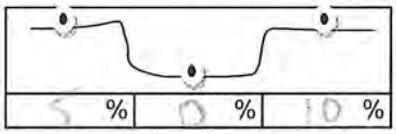
Height of Banks  Left 8 Right 1

Velocity (m/s): Flow metre N/A Floating object N/A

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB 1 RB 10




---

**Riparian vegetation**: Grass % 30 Shrubs % 40

Trees < 10m % 15 Trees > 10m % 15

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

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| **Substrate Description:** | | | | | |
|---|---|---|---|---|---|
| Bedrock | % | 40 | Pebble (16-64mm) | % | 10 |
| Boulder (>256mm) | % | 20 | Gravel (4-16mm) | % | 20 |
| Cobble (64-256mm) | % | 10 | Sand (1-4mm) | % | – |
| | | | Silt/clay (<1mm) | % | – |

**Bank Material** Dispersive/Sodic Y/(N)

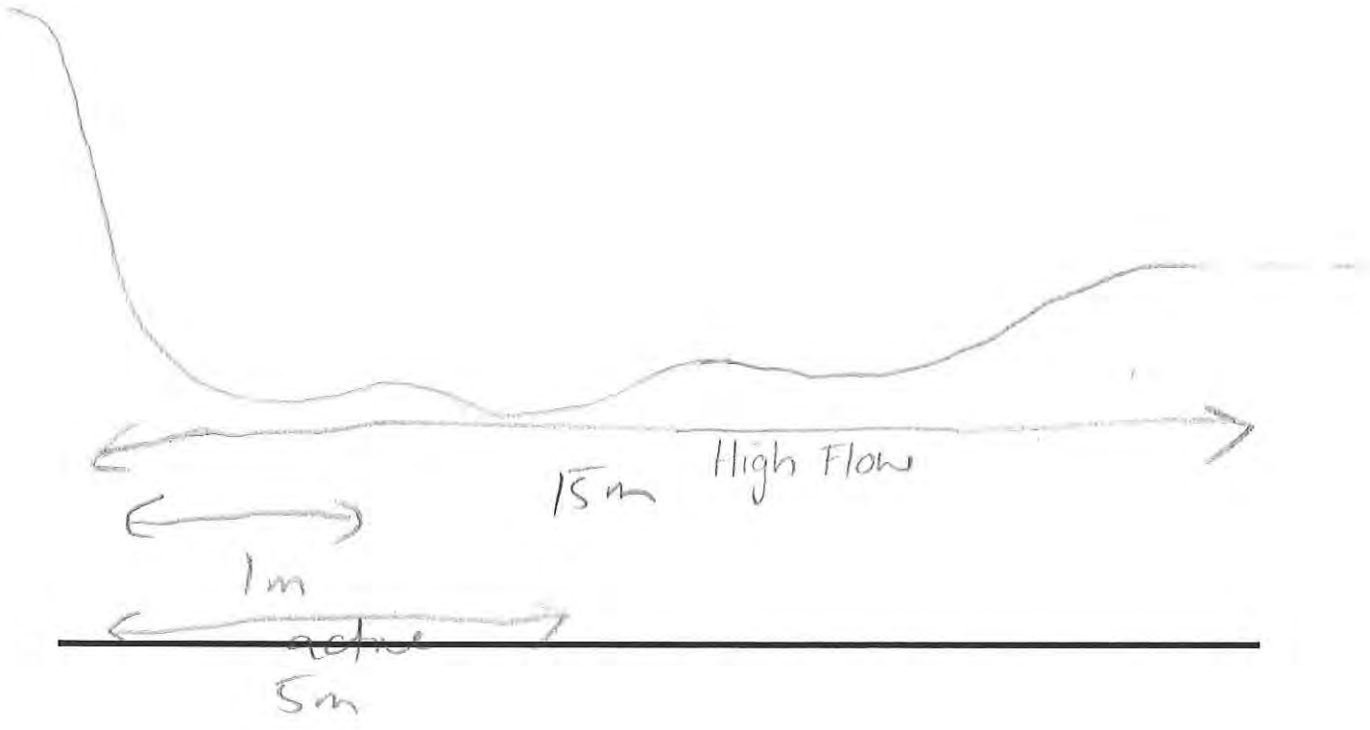
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

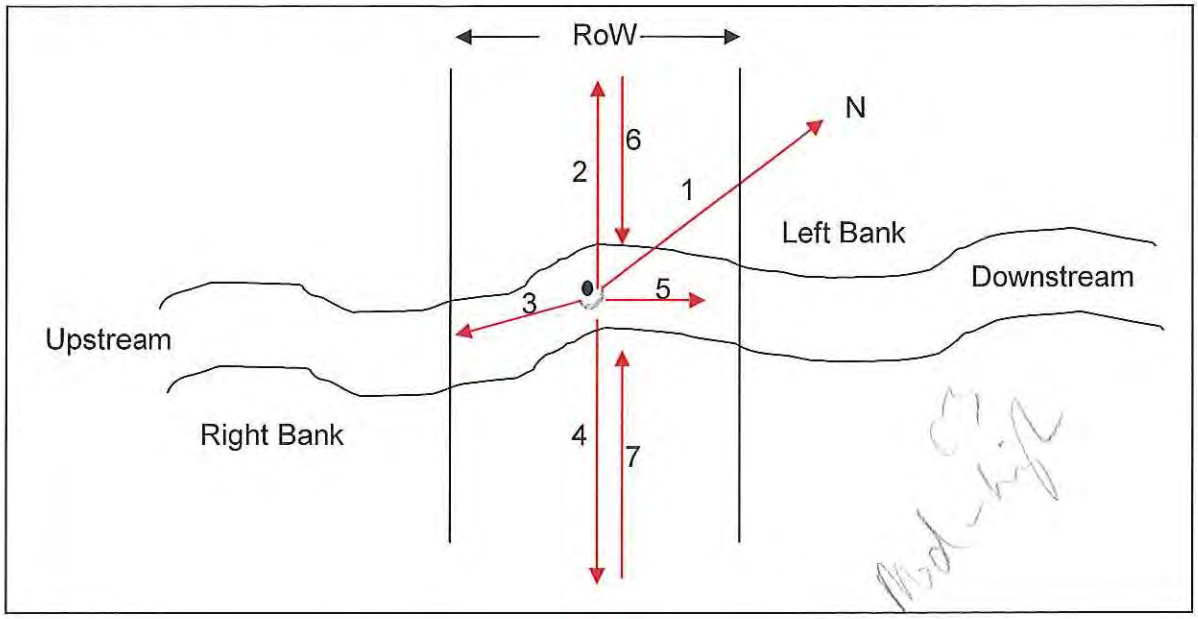
1m low flow channel with 5m active Very dry

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 036 |
| Facing left bank (2) | 037 |
| Facing Upstream (3) | 038 |
| Facing Right Bank (4) | 039 |
| Facing Downstream (5) | 040 |
| From edge of Riparian on left (6) | 041 |
| From edge of Riparian on right (7) | 042 |

053
052
051
Looking upstream of second crossing

**General Comments:**

Dry creek with very small stagnant pool. Wide at first crossing with several boulders.
At second crossing (320.3) location channel is only about 1m wide. Wide spread Lantana and Noogoora Burr.
4 x Cycas megacarpa within alignment
Bottle tree
Thin Leaved Iron Bark
Paper Bark

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 33.2 | 32.7 | – | 32.95 |
| Conductivity (µS/cm) | 1415 | 1319 | – | 1367 |
| pH | 8.66 | 8.69 | – | 8.675 |
| Dissolved $O_2$ (mg/L) | 10.63 | 9.65 | – | 10.14 |
| Turbidity (NTU) | 24.9 | 21.7 | – | 23.3 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**KP320.5 & 320.6**

Botanical specimens list:

- * *Melaleuca sp.,* possibly *M. trichostachya*
- **Cyperaceae sp.,* unidentified
- **Xanthium occidentale*
- **Eucalyptus sp.,* unidentified
- Bottle Tree
- Narrow Leaved Ironbark
- Paperbark
- *Lantana camara*
- Noogoora Burr

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

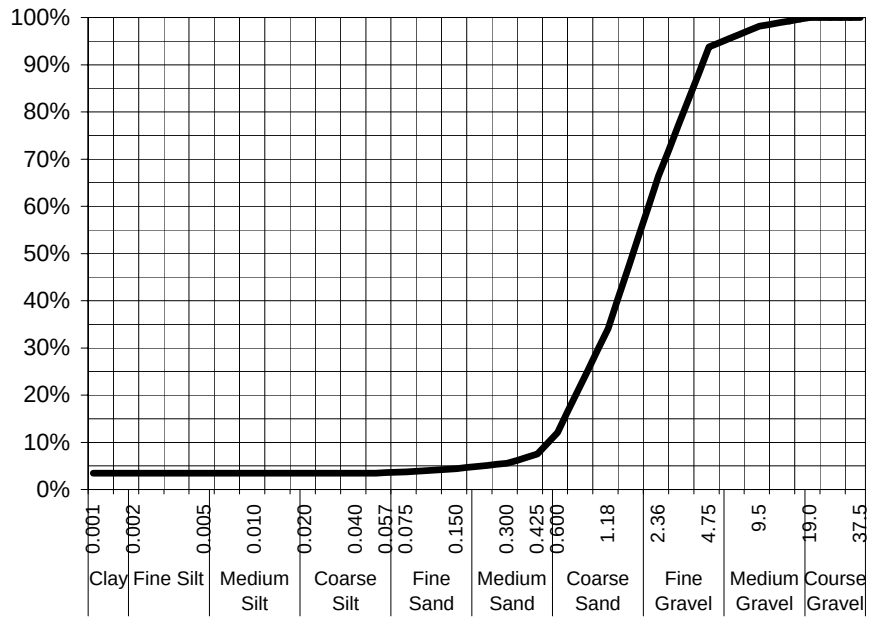
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-009 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP320.2 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 98% |
| 4.75 | 94% |
| 2.36 | 66% |
| 1.18 | 34% |
| 0.600 | 12% |
| 0.425 | 7% |
| 0.300 | 6% |
| 0.150 | 4% |
| 0.075 | 4% |
| Particle Size (microns) | |
| 57 | 4% |
| 40 | 3% |
| 20 | 3% |
| 10 | 3% |
| 5 | 3% |
| 4 | 3% |
| 1 | 3% |

| Median Particle Size (mm) | 1.180 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Loss on Pretreatment** NA

**Sample Description:** Coarse sand and gravel

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Soil Particle Density*** 2.65 g/cm$^3$

**Analysed:** 13-Jan-12

**Limit of Reporting:** 1%

**Dispersion Method** Shaker

**Hydrometer Type** ASTM E100

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

**ALS Environmental**

**Newcastle, NSW**

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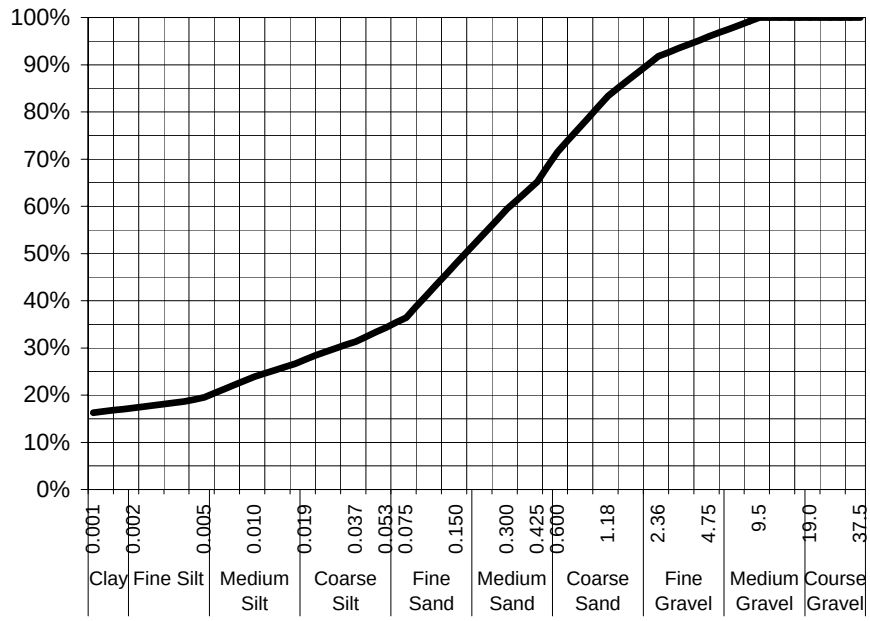
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-010 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP320.2 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 96% |
| 2.36 | 92% |
| 1.18 | 83% |
| 0.600 | 72% |
| 0.425 | 65% |
| 0.300 | 59% |
| 0.150 | 48% |
| 0.075 | 36% |
| Particle Size (microns) | |
| 53 | 34% |
| 37 | 31% |
| 19 | 28% |
| 10 | 24% |
| 5 | 20% |
| 4 | 19% |
| 1 | 16% |

| Median Particle Size (mm) | 0.150 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Sand and silty clay

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

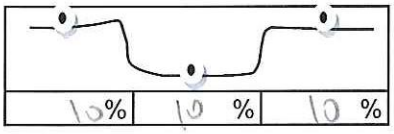
Date 13/06/12 KP Point 328.37 Eastings 264406.61 Northings 7321100.91
Watercourse Name Unnamed number 136 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne / Calliope Weather Fine
Rain in the Past week _____ Time of Day 9am Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 7.5m
Height of Banks  Left 2 Right 2

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None
Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 80 Shrubs % _____
Trees < 10m % _____ Trees > 10m % 20

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | (Moderate) | Slight | Nil |
|---|---|---|---|

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % 70 | Pebble (16-64mm) | % | |
| Boulder (>256mm) | % | Gravel (4-16mm) | % | |
| Cobble (64-256mm) | % | Sand (1-4mm) | % | |
| | | Silt/clay (<1mm) | % 30 | |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

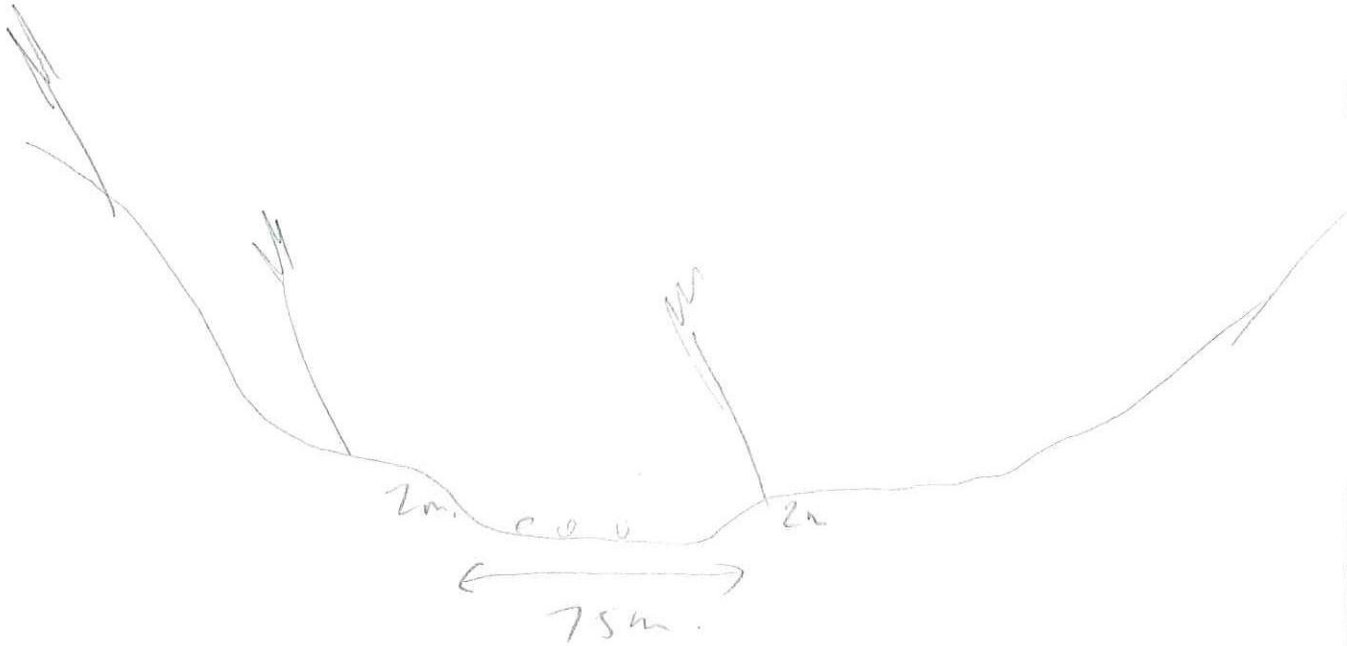
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Steep banks, active channel approx 7.5m wide

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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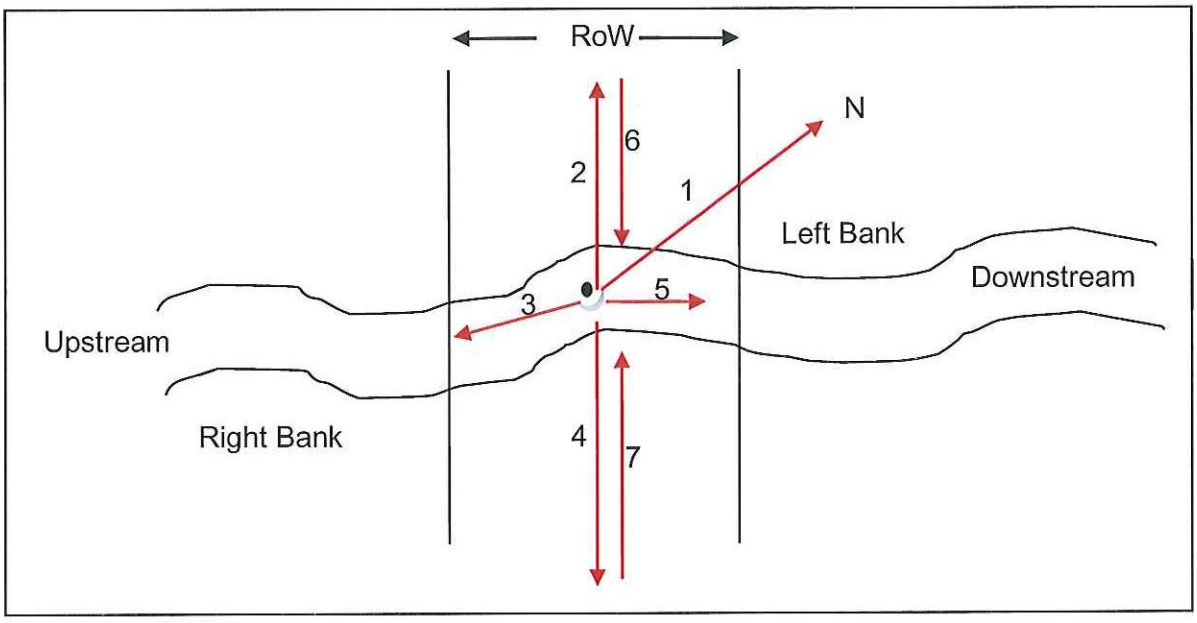
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 328-1 |
| Facing left bank (2) | 328-2 |
| Facing Upstream (3) | 328-5 |
| Facing Right Bank (4) | 328-4 |
| Facing Downstream (5) | 328-3 |
| From edge of Riparian on left (6) | 328-6 |
| From edge of Riparian on right (7) | |

**General Comments:**

winding channel, rocky substrate, steep banks. Small amounts of erosion. Scattered wombats and Eucalypts. Moderately vegetated with tall trees, Xanthorrea's, grasses

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis


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**ALS Environmental**

**Newcastle, NSW**

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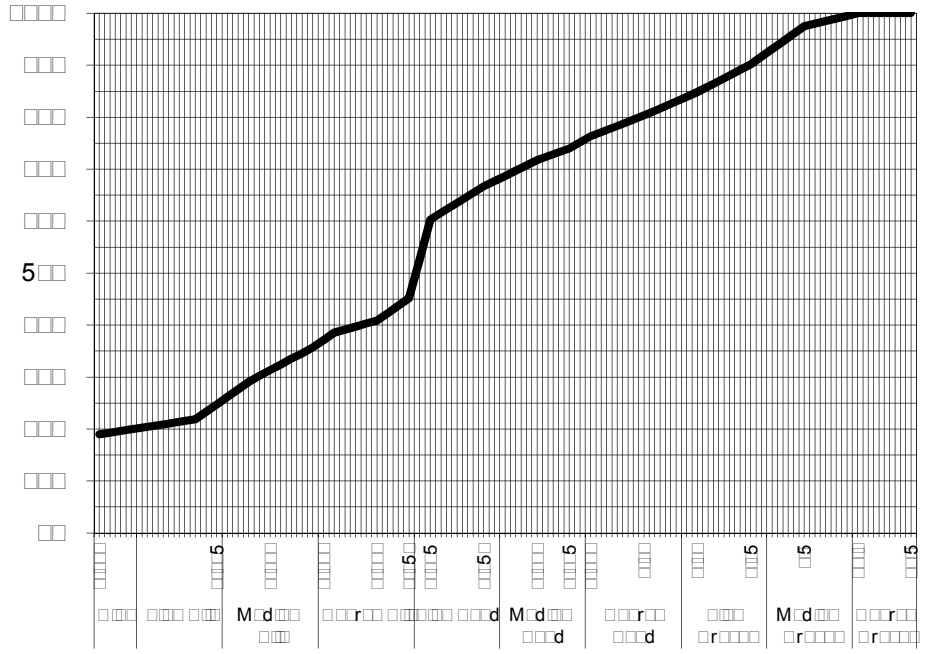


*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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NATA
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ACCREDITATION



**Hamish Murray**

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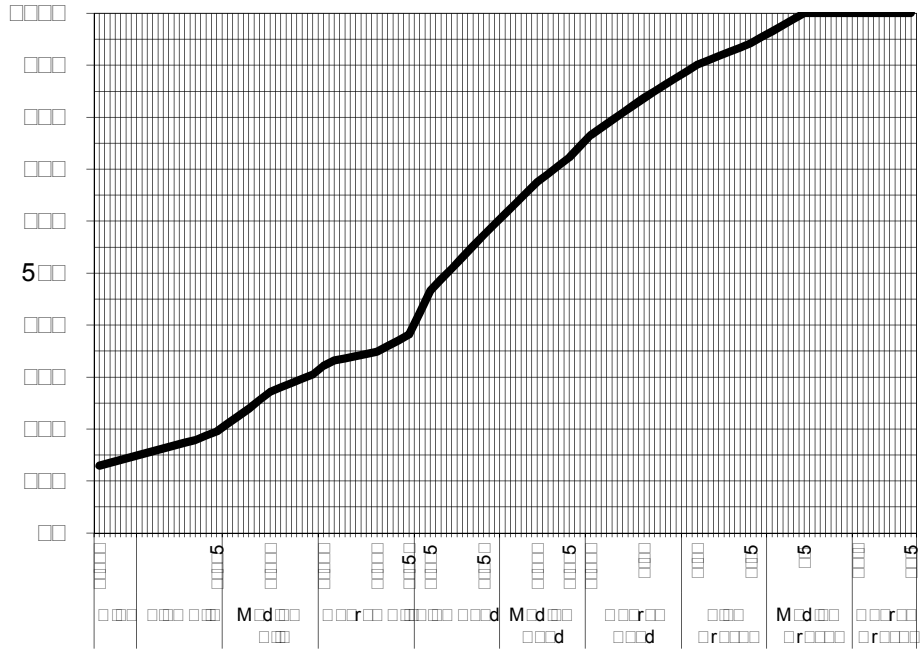
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***



**Facing north from proposed GTP crossing location (KP328.37)**



**Facing right bank from proposed GTP crossing location (KP328.37)**



**Facing left bank from proposed GTP crossing location (KP328.37)**



**Facing downstream from proposed GTP crossing location (KP328.37)**



**Facing upstream from proposed GTP crossing location (KP328.37)**



**Facing proposed crossing location from edge of left riparian (KP328.37)**

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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 8/2/12 KP Point 345.5 Eastings 275070 Northings 7332229
Watercourse Name Unnamed Distance from Source 2.097km AMTD 1-189km
Stream Order 2 Photo taken of access track Y/N
Catchment Area Calliope Weather Fine
Rain in the Past week Limited Time of Day 11:40 Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 3

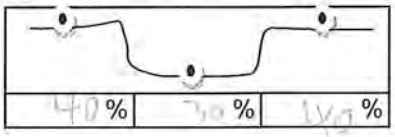
Height of Banks  Left 10 Right 10

Velocity (m/s): Flow metre N/A Floating object 0.02

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 10 RB _____

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**Riparian vegetation**: Grass % 70 Shrubs % _____

Trees < 10m % 25 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

pasture land

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

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**Substrate Description:**

| | | | | | |
|---|---|---|---|---|---|
| Bedrock | % | | Pebble (16-64mm) | % | 20 |
| Boulder (>256mm) | % | | Gravel (4-16mm) | % | |
| Cobble (64-256mm) | % | 10 | Sand (1-4mm) | % | 50 |
| | | | Silt/clay (<1mm) | % | 10 |

**Bank Material** Dispersive/Sodic Y/N

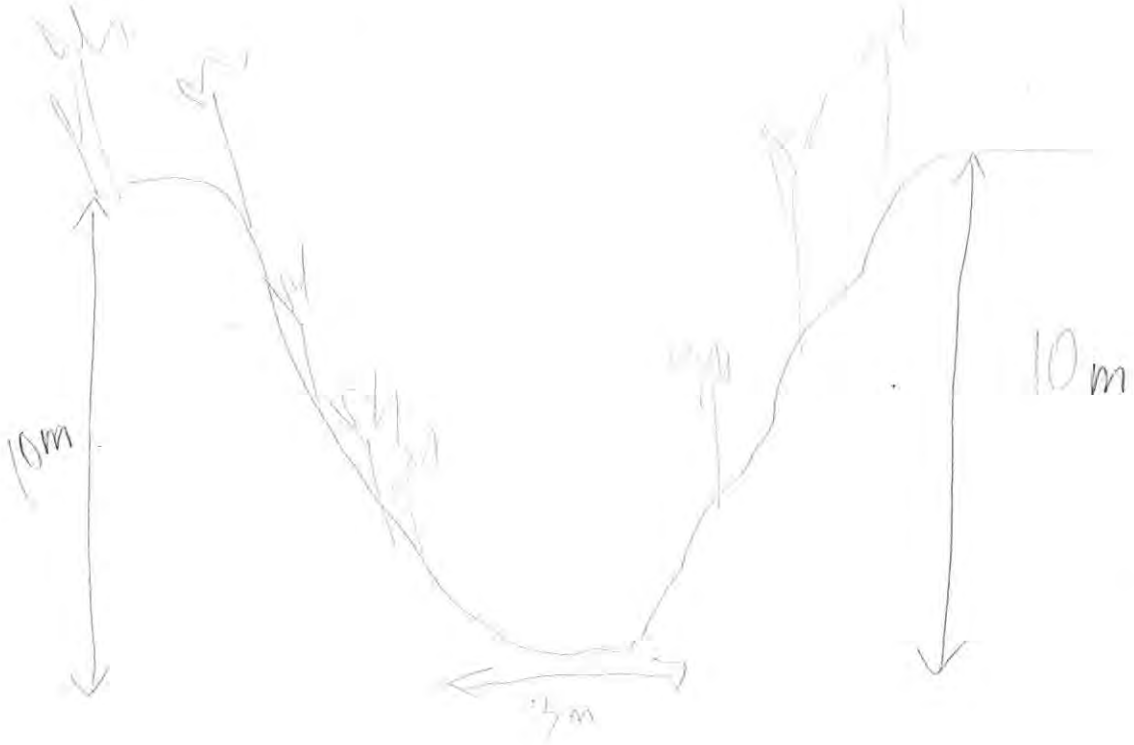
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Steep banks small active channel

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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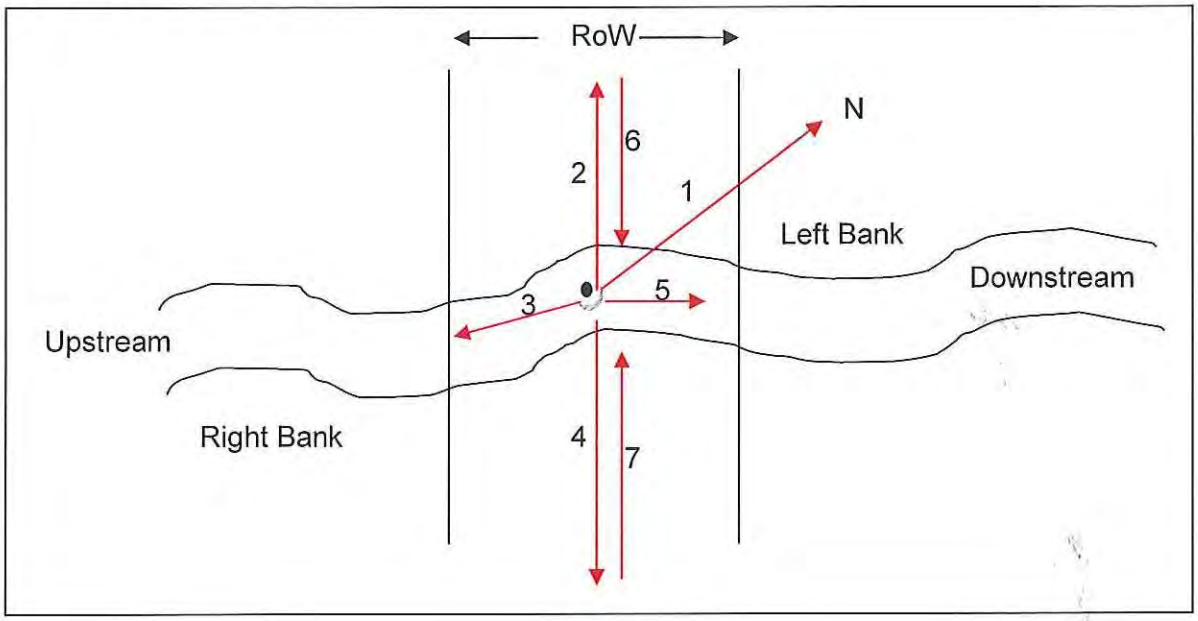
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 155 |
| Facing left bank (2) | 156 |
| Facing Upstream (3) | 157 |
| Facing Right Bank (4) | 158 |
| Facing Downstream (5) | 159 |
| From edge of Riparian on left (6) | 060 |
| From edge of Riparian on right (7) | 061 |

**General Comments:**

Steep banks. Have small flow from recent rainfall; good grass cover. Slight-moderate riparian veg. consisting of mainly paperbark & eucalypt. Some koonbah species present

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 29-8 | 29-6 | – | 29-7 |
| Conductivity (µS/cm) | 97·37 | 97·89 | – | 97·63 |
| pH | 7·35 | 7·39 | – | 7·37 |
| Dissolved $O_2$ (mg/L) | 6·03 | 6·26 | – | 6·15 |
| Turbidity (NTU) | 121 | 118 | – | 119·5 |
| TDS ppm | 92·36 mm | 92·76 | – | 92·56 |

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

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- □*Erythrina vespertilio*
- **Melaleuca sp.,* □□□□□□□□ *M. fluviatilis*
- **Eustrephus latifolius*
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# Certificate of Analysis


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**ALS Environmental**

**Newcastle, NSW**

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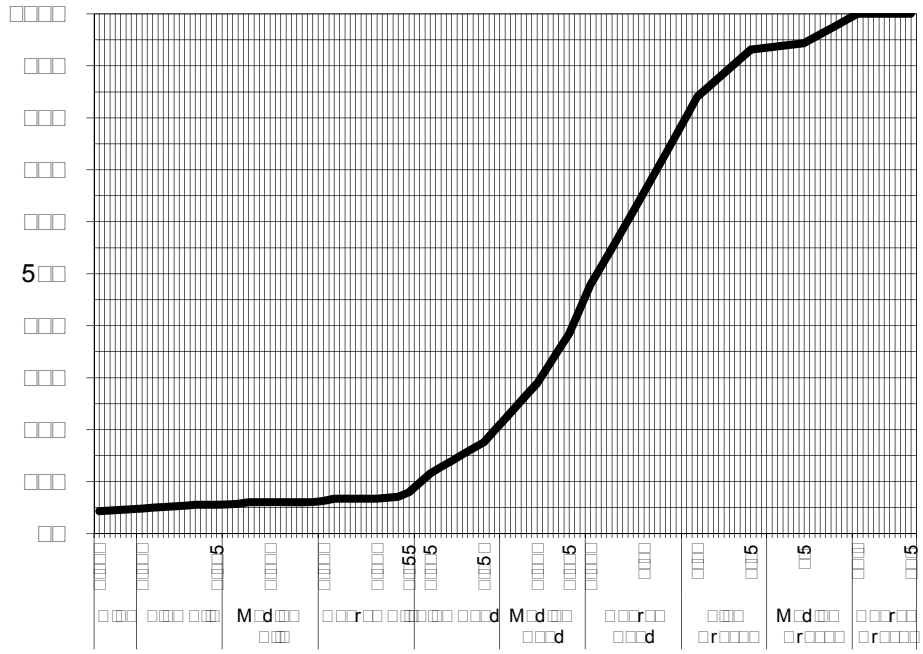


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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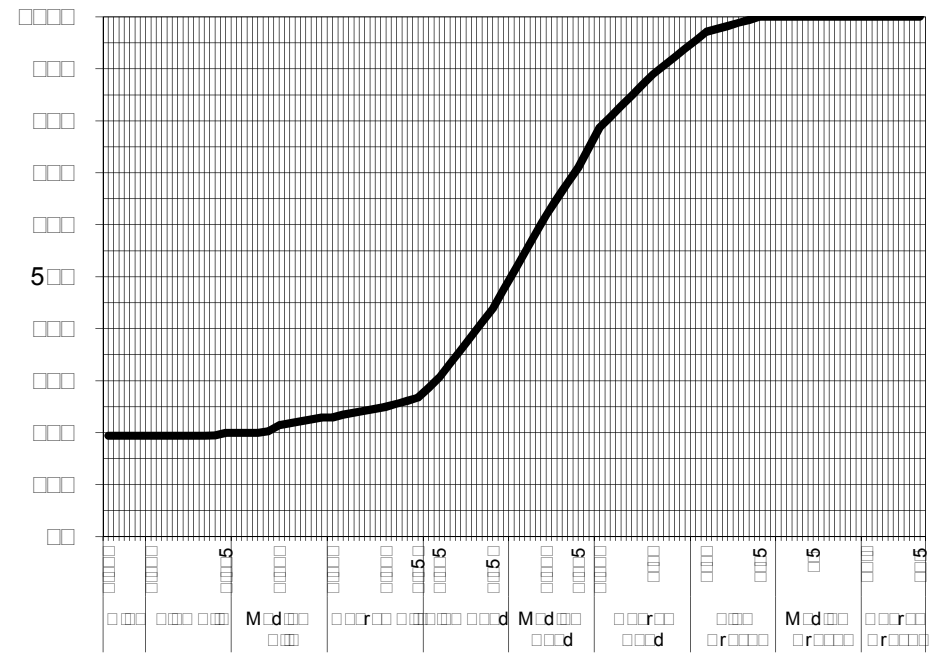
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


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**Dianne Blane**

***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

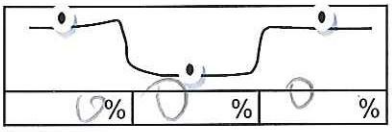
Date 13/06/12 KP Point 352.06 Eastings 280279.39 Northings 7335478.13
Watercourse Name unnamed minor 152 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne/Calliope Weather Clear/Fine
Rain in the Past week — Time of Day 10am Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 70m
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)
Canopy cover % Width of riparian Zone (m): LB — RB —

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**Riparian vegetation**: Grass % 100 Shrubs % _____
Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | (Nil) |
|---|---|---|---|

grasses.

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

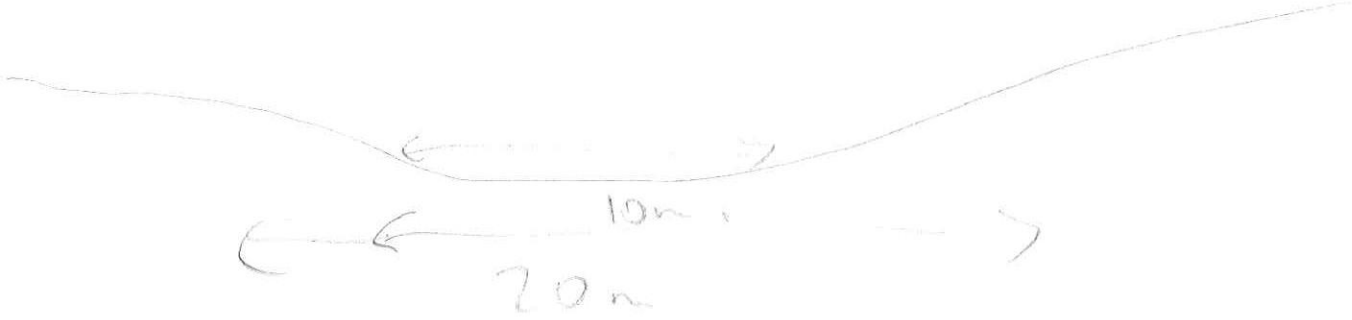
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

grassed drainage channel. SOI flows into tributary of Calliope River.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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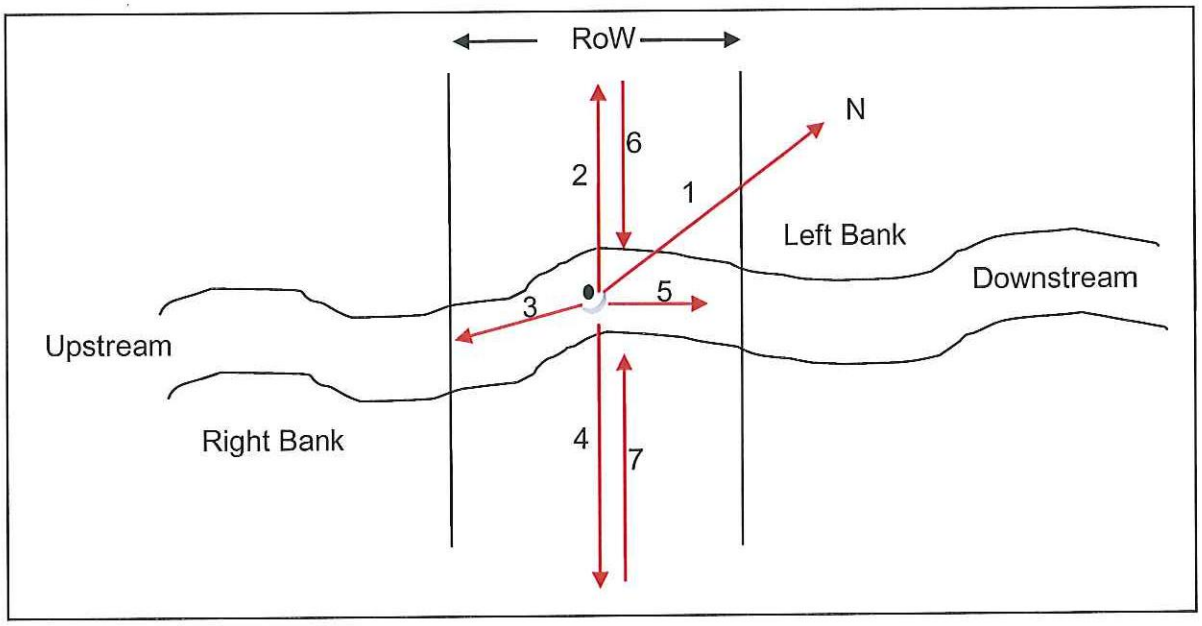
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | — |
| Facing left bank (2) | 352-2 |
| Facing Upstream (3) | 352-3 |
| Facing Right Bank (4) | 352-4 |
| Facing Downstream (5) | 352-5 |
| From edge of Riparian on left (6) | — |
| From edge of Riparian on right (7) | — |

**General Comments:**

flat grassed drainage channel. Riparian & trailing veg absent - consist solely of grasses. ~~[illegible]~~ shallow rolling banks, not well defined

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

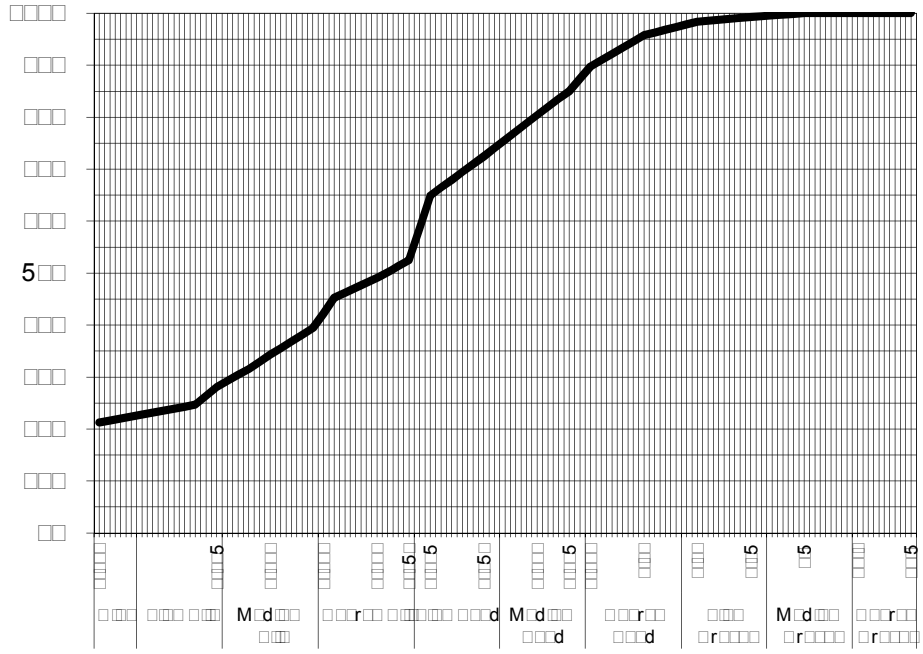
**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis

**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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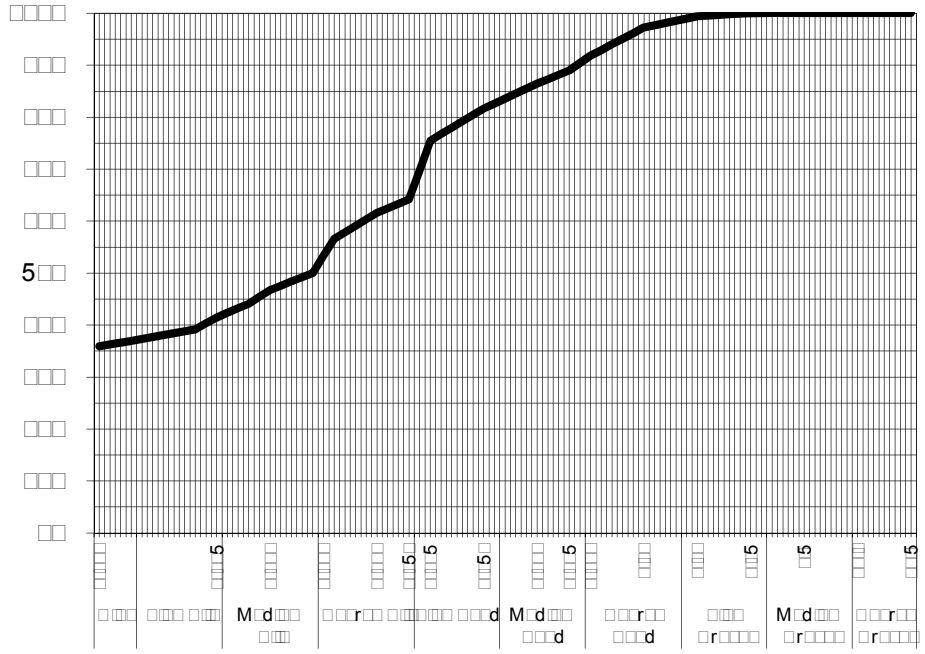


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*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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**Facing left bank from proposed GTP crossing location (KP352.06)**



**Facing downstream from proposed GTP crossing location (KP352.06)**



**Facing upstream from proposed GTP crossing location (KP352.06)**



**Facing right bank from proposed GTP crossing location (KP352.06)**

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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 8/2/12 KP Point 353A Eastings 281113 Northings 7336536
Watercourse Name Unnamed Distance from Source 1.398km AMTD 3.575km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Callione Weather Fine
Rain in the Past week 2 inches (70mm previous night) Time of Day 12:30 Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 1

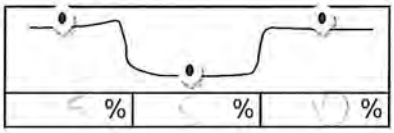
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object 0.2m/s

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 0.1 RB 1

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**Riparian vegetation**: Grass % 95 Shrubs % _____

Trees < 10m % _____ Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|
| | | | |

Broad leaved [illegible]

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % 30 |
| | | | Silt/clay (<1mm) | % 70 |

**Bank Material** Dispersive/Sodic Y/N

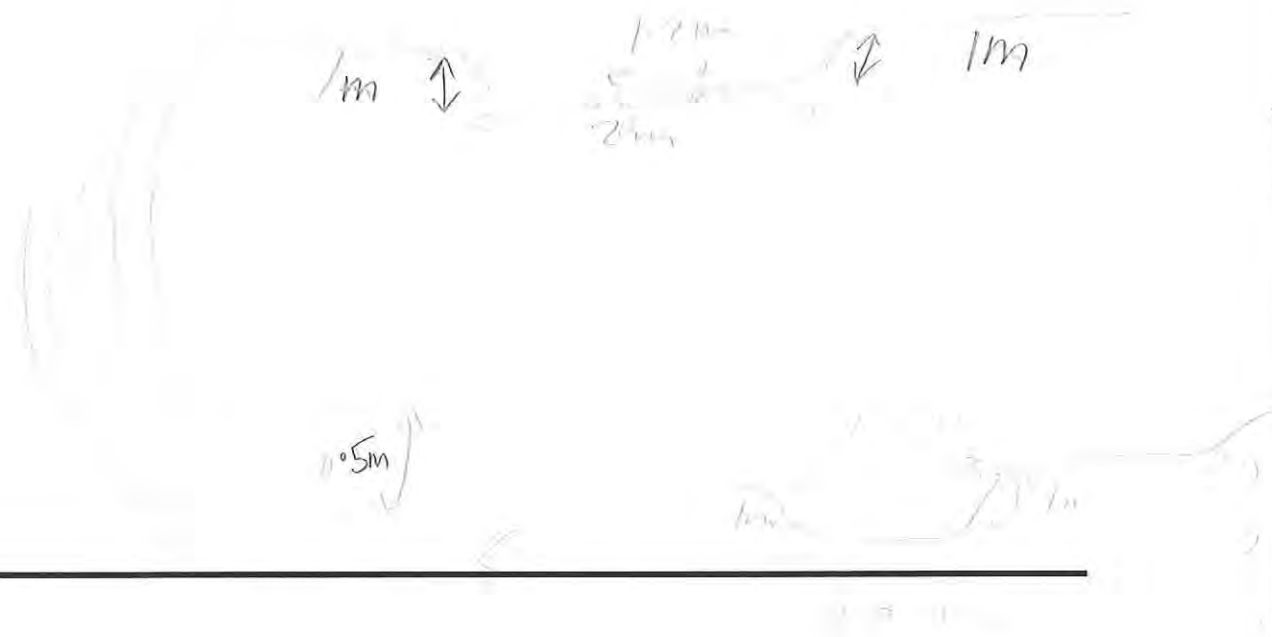
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

By watercourse branches off and reconnects. main riparian zone on left channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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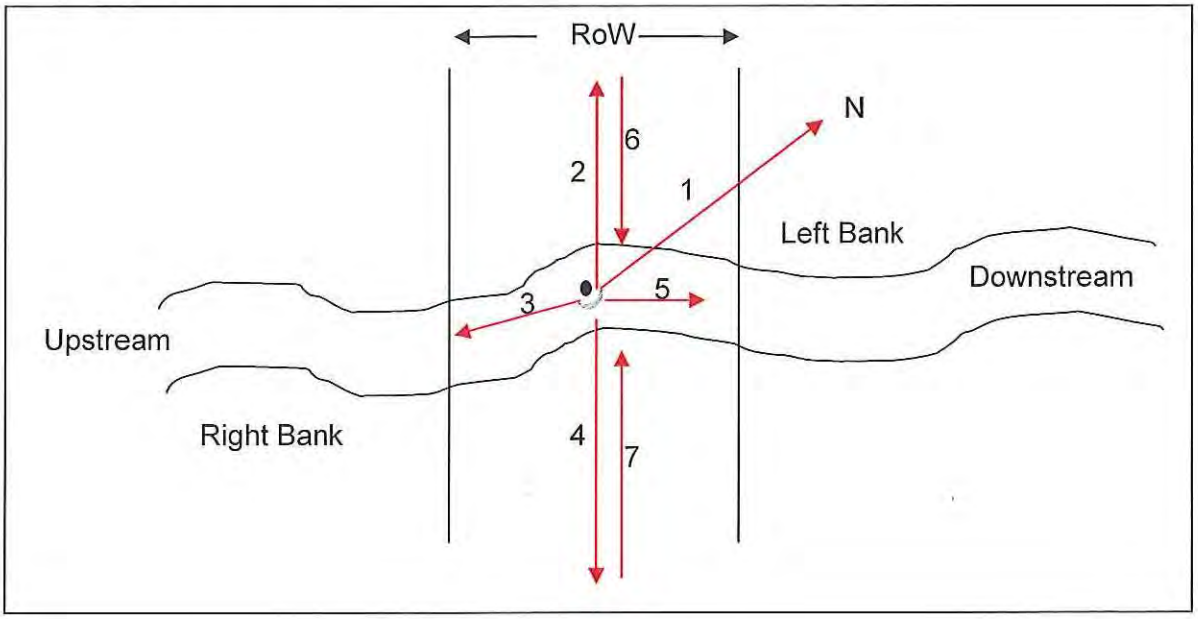
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 162 |
| Facing left bank (2) | 163 |
| Facing Upstream (3) | 164 |
| Facing Right Bank (4) | 165 |
| Facing Downstream (5) | 166 |
| From edge of Riparian on left (6) | 167 |
| From edge of Riparian on right (7) | 0168 |

**General Comments:**

Stream banks cut off caused from overflow, main channel is approx 0.5m deep with 0.5m banks. extensive grasses, fair amount of

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 31.7 | [illegible] | – | 31.2 |
| Conductivity (µS/cm) | 50.74 | 50.06 | – | 50.4 |
| pH | 6.8 | [illegible] | – | 6.74 |
| Dissolved $O_2$ (mg/L) | 4.82 | 5.28 | – | 5.05 |
| Turbidity (NTU) | 96.7 | 95.2 | – | 95.95 |
| TDS mg/L | [illegible] | 47.53 | – | 48.4 |

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**5 4**

- *Cyperus exaltatus*
- **Ludwigia sp.* d d
- **Eclipta prostrata*
- **Persicaria attenuata*
- **Ottelia ovalifolia*
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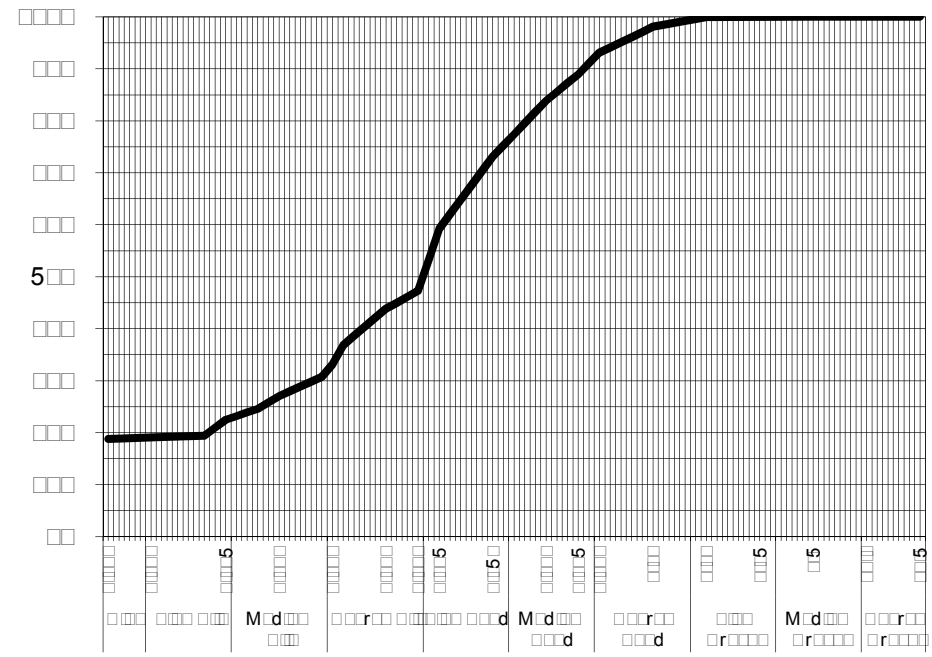
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*



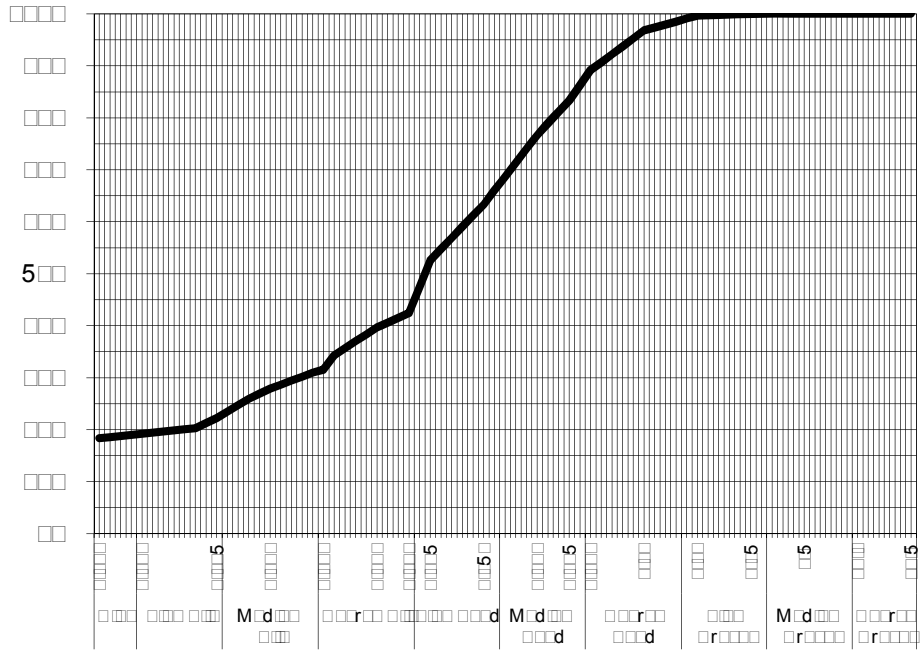
**Dianne Blane**

***Authorised Signatory***

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

**Dianne Blane**

***Authorised Signatory***















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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 13/06/12 KP Point 365.71 Eastings 290778.38 Northings 7342861.95

Watercourse Name unnamed minor 161 Distance from Source _____ AMTD _____

Stream Order 2 Photo taken of access track Y/N

Catchment Area Bayne / calliope Weather Fine

Rain in the Past week 0 Time of Day 11:15 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 17.5m - active 3m.

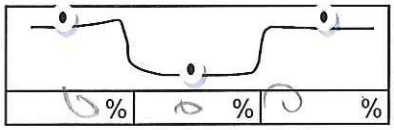
Height of Banks  Left 5 Right 5.

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB — RB —

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**Riparian vegetation**: Grass % 100 Shrubs % _____

Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

sedges, grasses.

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GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

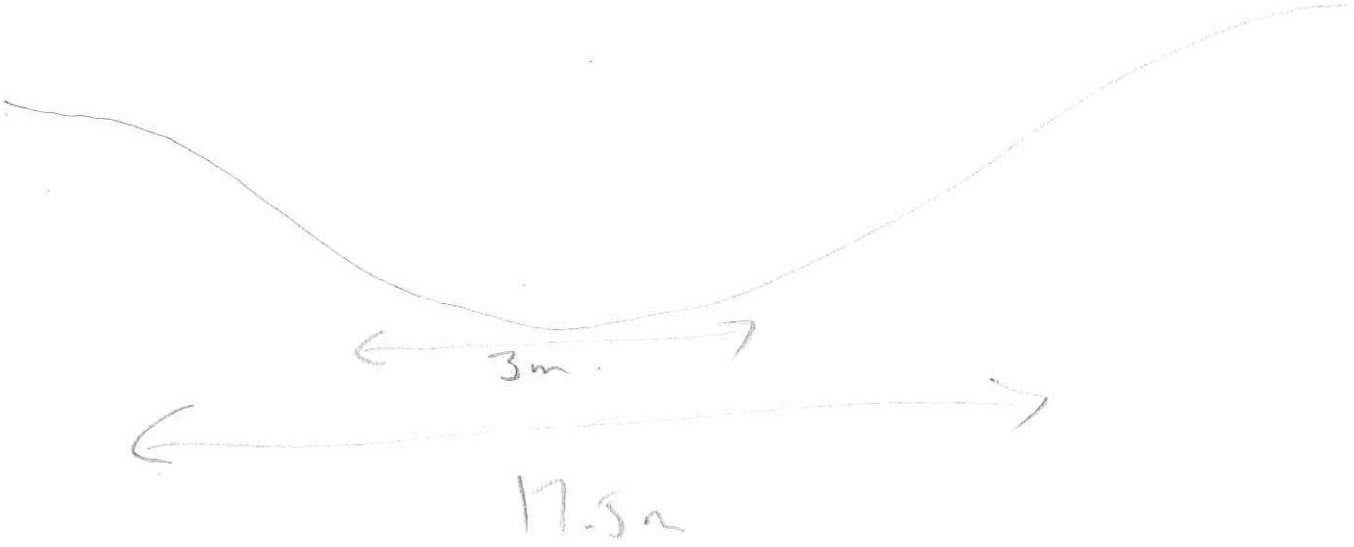
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

wide high flow channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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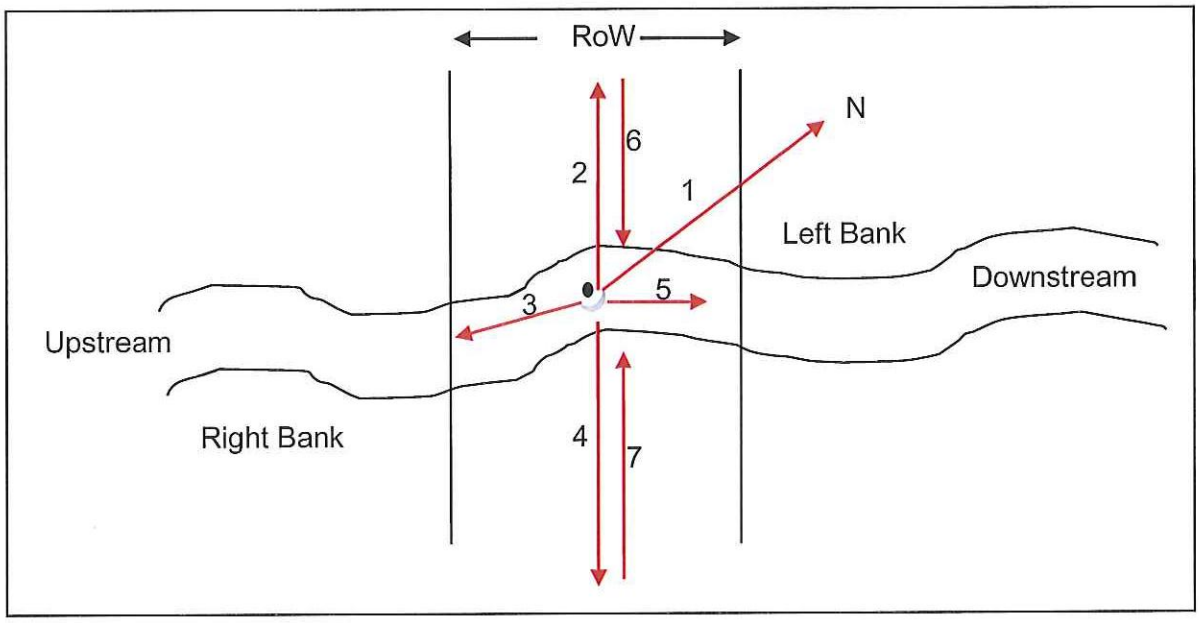
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | 365-3 3 |
| Facing Upstream (3) | 365-1 1 |
| Facing Right Bank (4) | 365-4 4 |
| Facing Downstream (5) | 365-2 2 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

grassed channel, SO2 overgrown upstream.

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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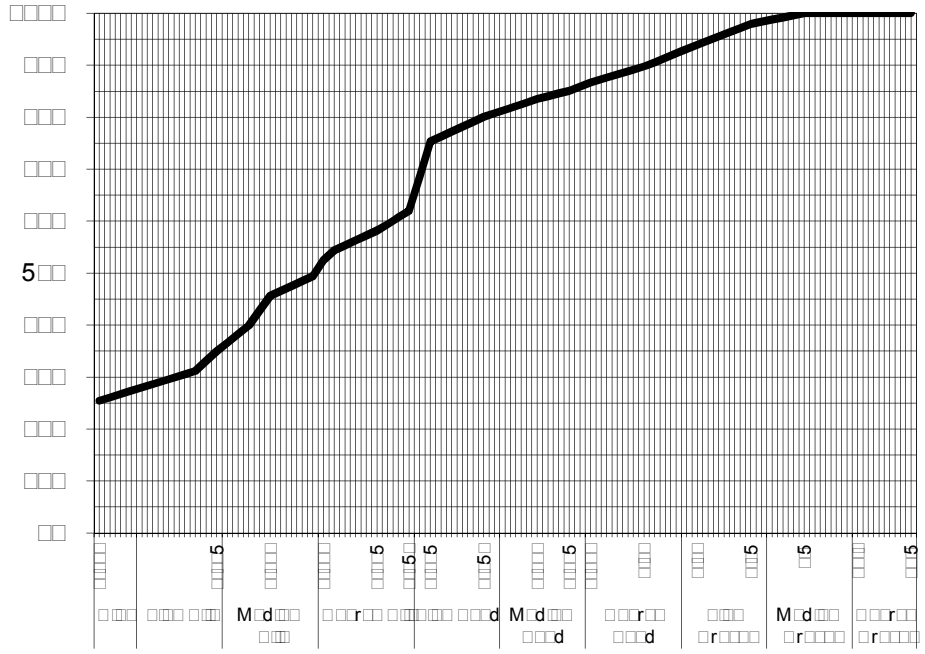
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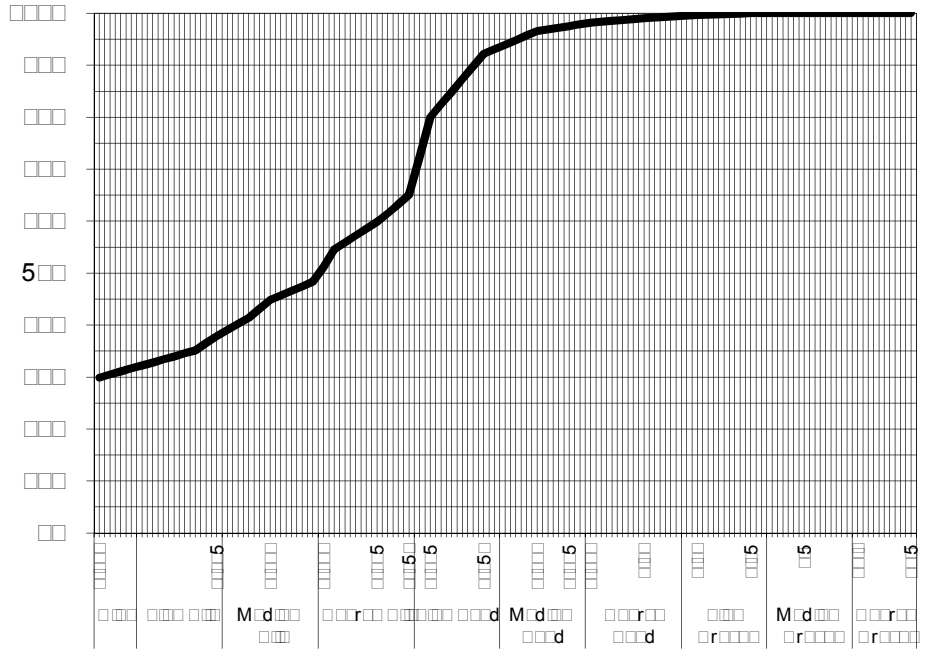
# Certificate of Analysis

**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***



**Facing left bank from proposed GTP crossing location (KP365.71)**



**Facing downstream from proposed GTP crossing location (KP365.71)**



**Facing upstream from proposed GTP crossing location (KP365.71)**



**Facing right bank from proposed GTP crossing location (KP365.71)**

Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

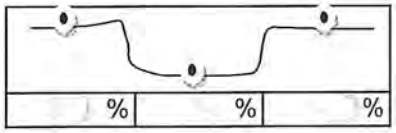
Date 8/2/12 KP Point 366.7 Eastings 291302 Northings 7343535
Watercourse Name Unnamed Distance from Source 1.044 km AMTD 0.95 km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Calliope Weather fine
Rain in the Past week 15 mls Time of Day 2:30 Cloud Cover (%) 15

---

**OBSERVATIONS**

Mean Channel width (m) 3m
Height of Banks  Left 2.5 Right

Velocity (m/s): Flow metre N/A Floating object 0.07
Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB 5 RB 5

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**Riparian vegetation**: Grass % 75 Shrubs %
Trees < 10m % 5 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Eucalypts & Melaleuca

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GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % 50 |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Large channel with 2 low flow channels and formed island in centre of channel

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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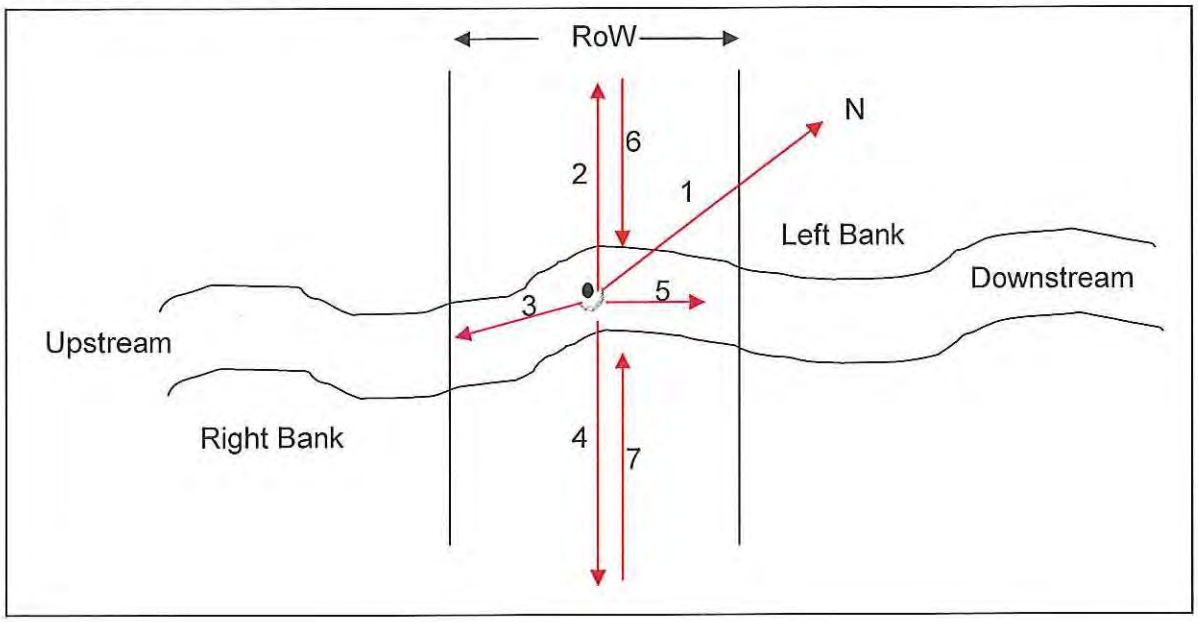
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 183 |
| Facing left bank (2) | 184 |
| Facing Upstream (3) | 185 |
| Facing Right Bank (4) | 186 |
| Facing Downstream (5) | 187 |
| From edge of Riparian on left (6) | 188 |
| From edge of Riparian on right (7) | 189 |

**General Comments:**

fast flowing low flow channel from previous rainfall. Riparian veg eucalypts & silver leafed ironbark. Scattered Lantana.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 34.0 | 33.4 | — | 33.7 |
| Conductivity (µS/cm) | 98.64 | 102.1 | — | 100.37 |
| pH | 6.12 | 5.98 | — | 6.05 |
| Dissolved $O_2$ (mg/L) | 6.33 | 6.31 | - | 6.32 |
| Turbidity (NTU) | 31.8 | 30.7 | - | 31.25 |
| TDS mg/L | 94.55 | 96.52 | | 95.54 |

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP366.2**

Botanical specimens list:

- * *Lophostemon sp.,* possibly *L. suaveolens*
- **Lophostemon suaveolens*
- Silver Leaved Ironbark
- Eucalyptus
- *Lantana camara*

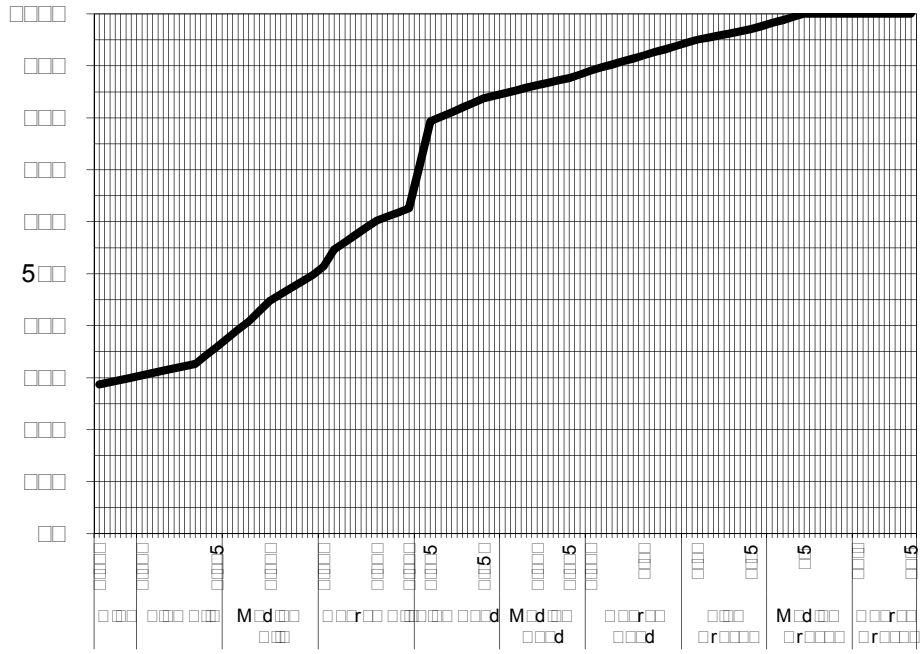
*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


ALS Environmental

Newcastle, NSW



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


NATA
WORLD RECOGNISED ACCREDITATION


**Dianne Blane**

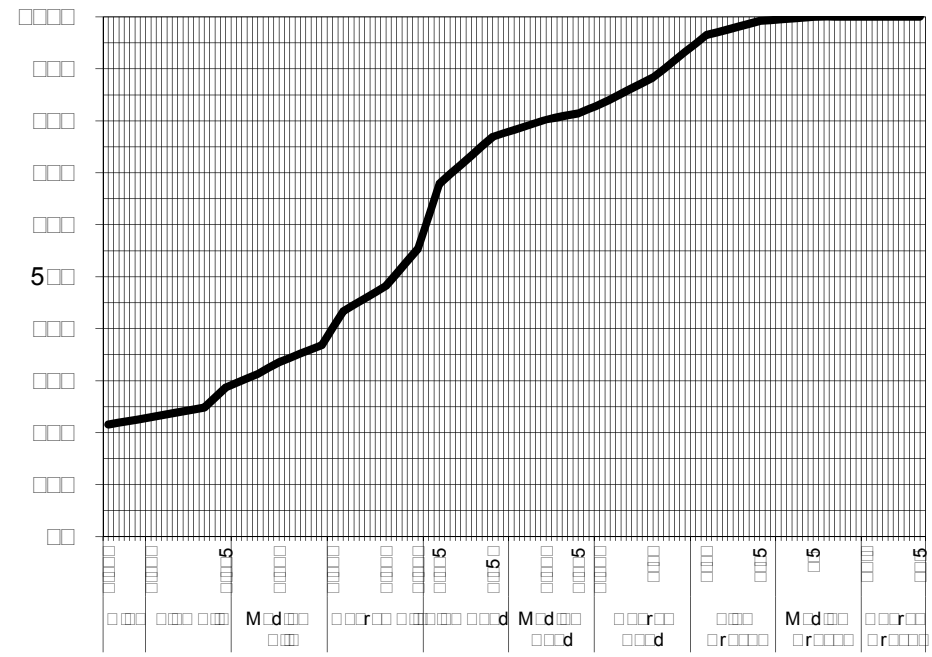
***Authorised Signatory***

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 9/2/12 KP Point 374.9 Eastings 294406 Northings 7349685
Watercourse Name Unnamed Distance from Source 0.23km AMTD 1.146km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Calliope Weather Fine
Rain in the Past week 1-5mm Time of Day 10:10 Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 10m

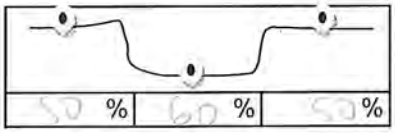
Height of Banks  Left 1 Right 1

Velocity (m/s): Flow metre N/A Floating object 0-01

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 50 Shrubs %

Trees < 10m % 40 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Eucalypts

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GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

low flowing water

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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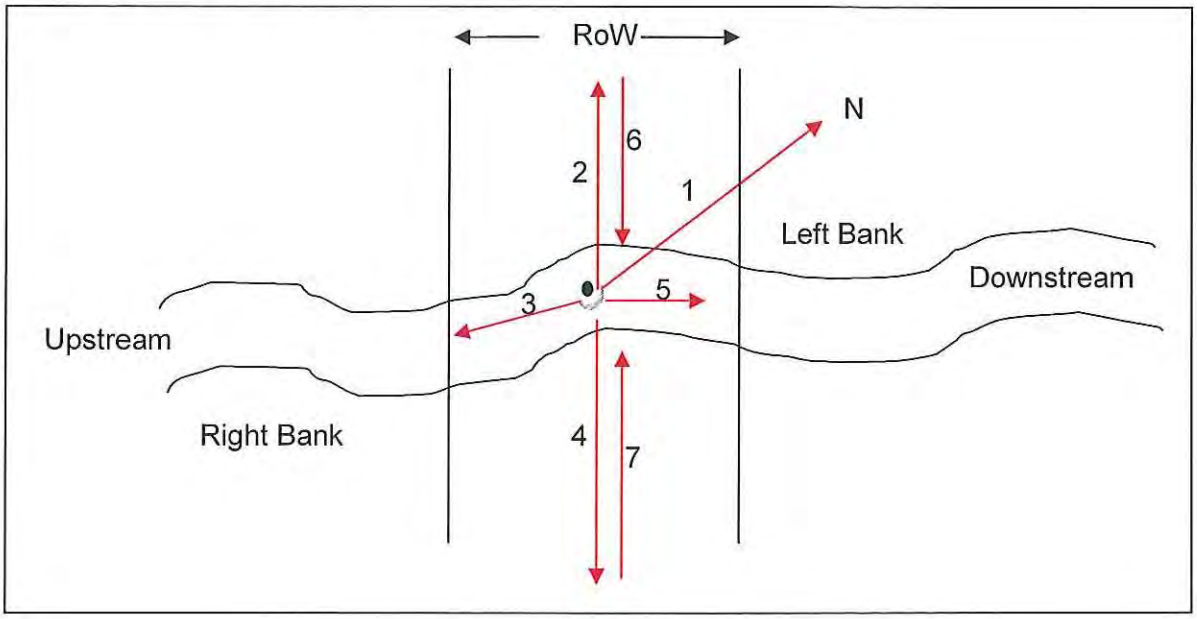
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 1 210 |
| Facing left bank (2) | 2 211 |
| Facing Upstream (3) | 1 213 |
| Facing Right Bank (4) | 215 |
| Facing Downstream (5) | 5 214 |
| From edge of Riparian on left (6) | 4 216 |
| From edge of Riparian on right (7) | 3 212 |

**General Comments:**

Deep channel approx 15m wide good canopy cover cleared pastoral land. heavy kinds of [illegible] present on banks some

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 27.4 | 27.2 | | 27.3 |
| Conductivity (µS/cm) | 1.01 mS/cm | 1.03 mS/cm | | 1.02mS/cm |
| pH | 7.95 | 7.95 | | 7.95 |
| Dissolved $O_2$ (mg/L) | 4.94 | 5.20 | | 5.07 |
| Turbidity (NTU) | 19.1 | 21.3 | | 20.2 |
| TDS mg/L | 964.2 | 967.0 | | 965.60 |

---

**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**4.4**

- *Cyperaceae sp.,*
- **Melaleuca sp., M. viminalis*
- **Melaleuca sp., M. trichostachya*
- **Crinum sp.,*

# Certificate of Analysis


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**ALS Environmental**

**Newcastle, NSW**

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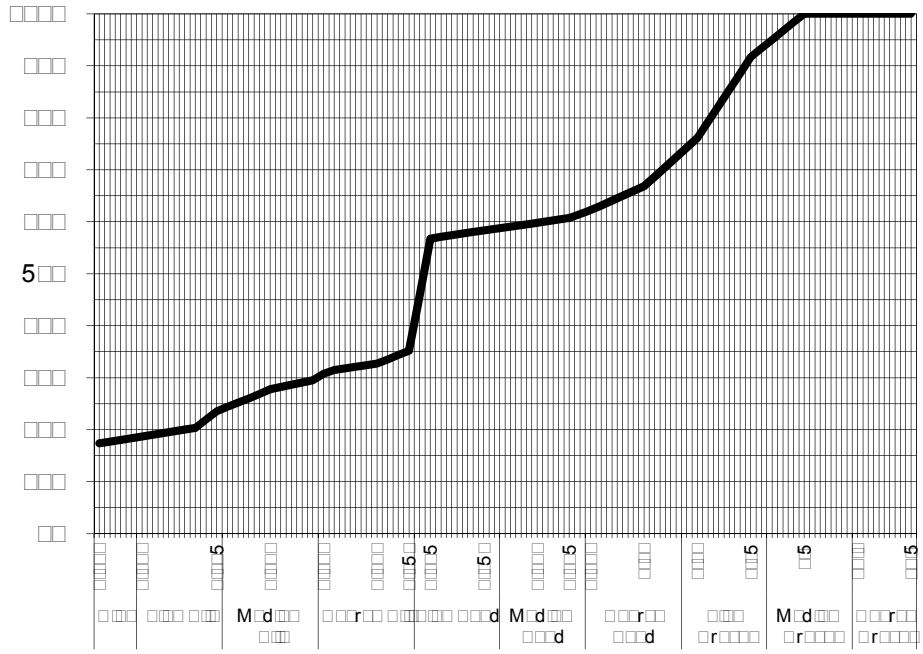


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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

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NATA
WORLD RECOGNISED ACCREDITATION

**Dianne Blane**
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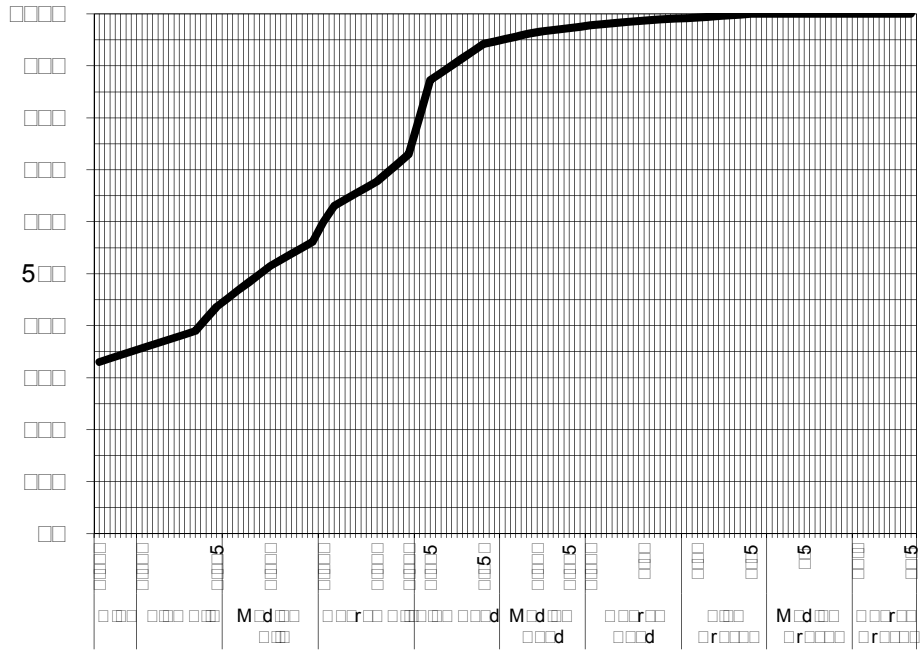
***Authorised Signatory***

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


**Dianne Blane**

***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

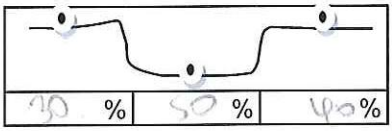
Date 13/06/12 KP Point 375.7 Eastings 295020.11 Northings 7350806.7
Watercourse Name Unnamed minor trib Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne / Calliope Weather _____
Rain in the Past week _____ Time of Day 12pm Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 12.5 – 5m active
Height of Banks  Left \ Right \

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)
Canopy cover % Width of riparian Zone (m): LB \ RB \

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**Riparian vegetation**: Grass % 60 Shrubs % _____
Trees < 10m % 20 Trees > 10m % 20

- Collect samples and produce species list after identification (refer to guide)

melaleucas.

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

mostly grasses - pasture land

Santos
GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % 50 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

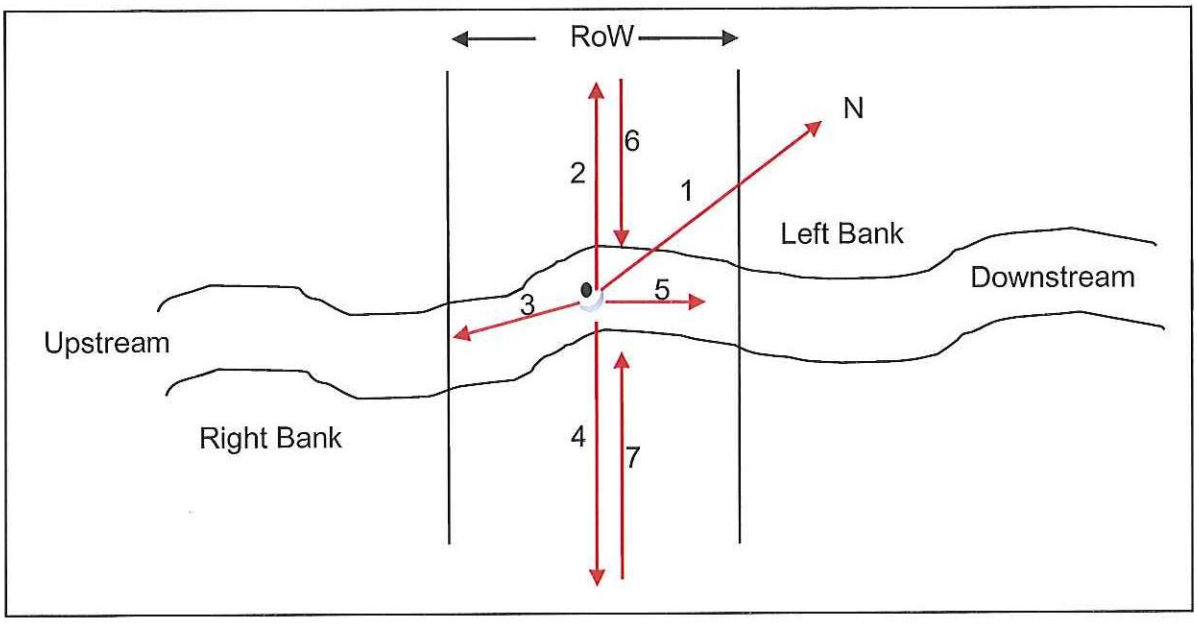
Winding channel ~~~~ 5m active channel with wider high flow.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



Santos
GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 375-1 |
| Facing left bank (2) | 375-2 |
| Facing Upstream (3) | 375-3 |
| Facing Right Bank (4) | 375-4 |
| Facing Downstream (5) | 375-5. |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Winding anabranch of gravel creek. Melaleucas ~~dom~~ fossed. Dry at time ~~but~~ would flow during wet season

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP375.7**

Botanical specimens list:

- **Melaleuca viminalis*
- **Melaleuca trichostachya*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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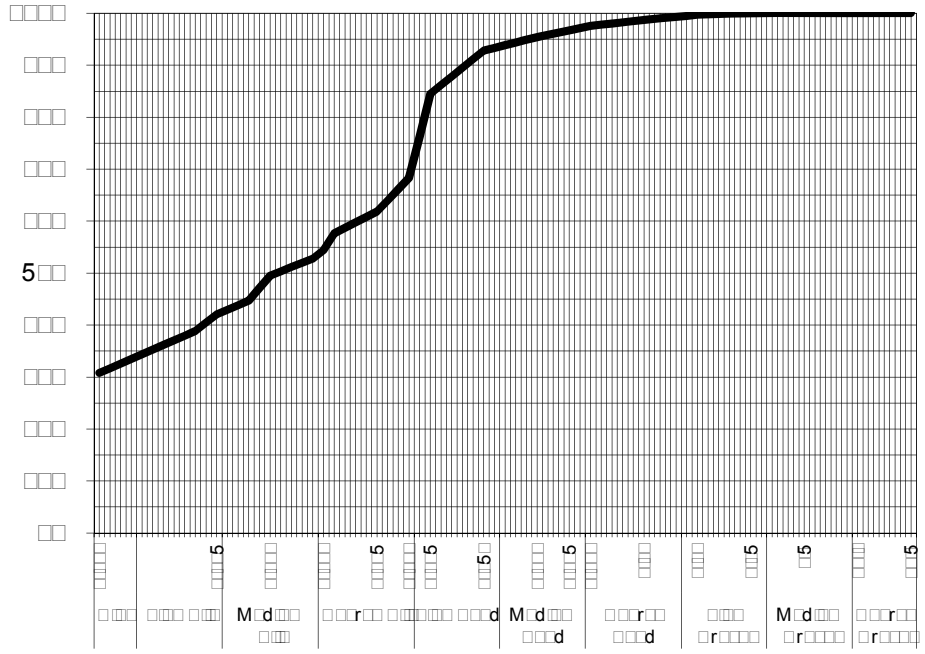
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# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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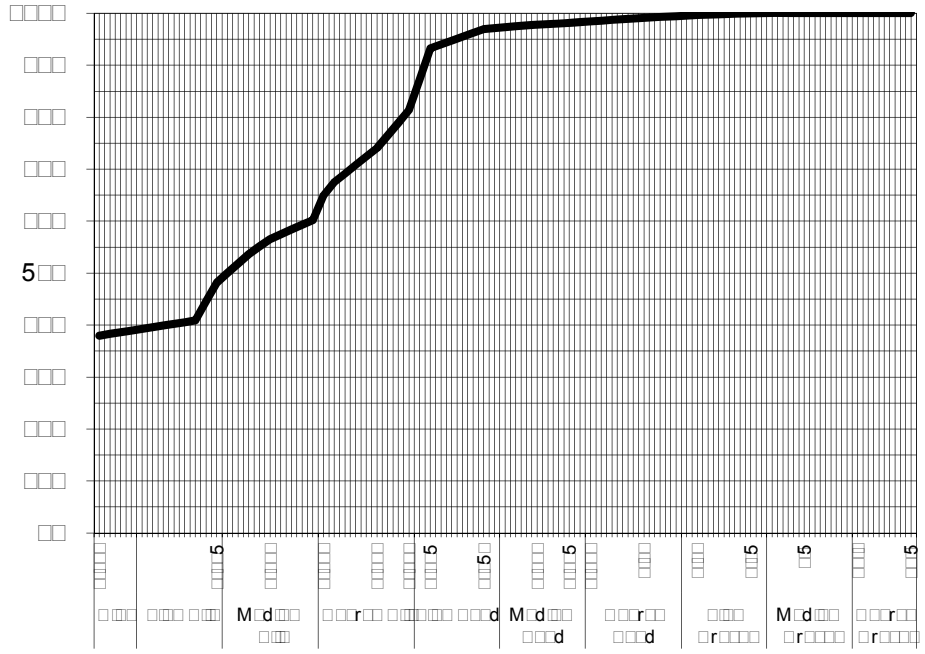


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*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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ACCREDITATION

**Hamish Murray**
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**Facing north from proposed GTP crossing location (KP375.7)**



**Facing right bank from proposed GTP crossing location (KP375.7)**



**Facing left bank from proposed GTP crossing location (KP375.7)**



**Facing downstream from proposed GTP crossing location (KP375.7)**



**Facing upstream from proposed GTP crossing location (KP375.7)**

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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

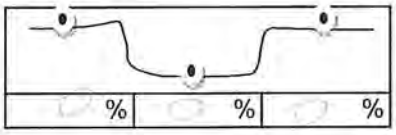
Date 9/2/12 KP Point 378 Eastings 295778 Northings 7352438
Watercourse Name Unnamed Distance from Source 2.4km AMTD 0.436km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Calliope Weather Fine
Rain in the Past week Nil Time of Day 3.30 Cloud Cover (%) 10

---

**OBSERVATIONS**

Mean Channel width (m) 0.5
Height of Banks  Left 10 cm Right 10 cm

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB _____ RB _____

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**Riparian vegetation**: Grass % 100 Shrubs % _____
Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

small depression - small drainage line

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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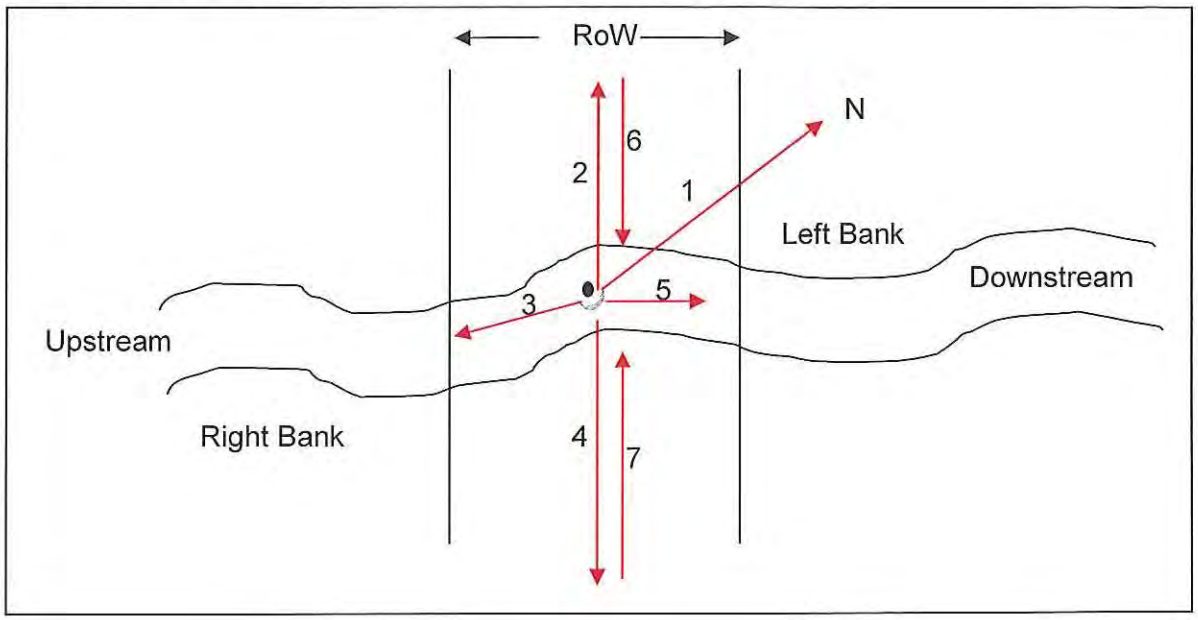
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 205 |
| Facing left bank (2) | |
| Facing Upstream (3) | 206 |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 207 |
| From edge of Riparian on left (6) | 208 |
| From edge of Riparian on right (7) | |

**General Comments:**

Small dry depression. Absent [illegible] veg only [illegible] in very large [illegible]

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

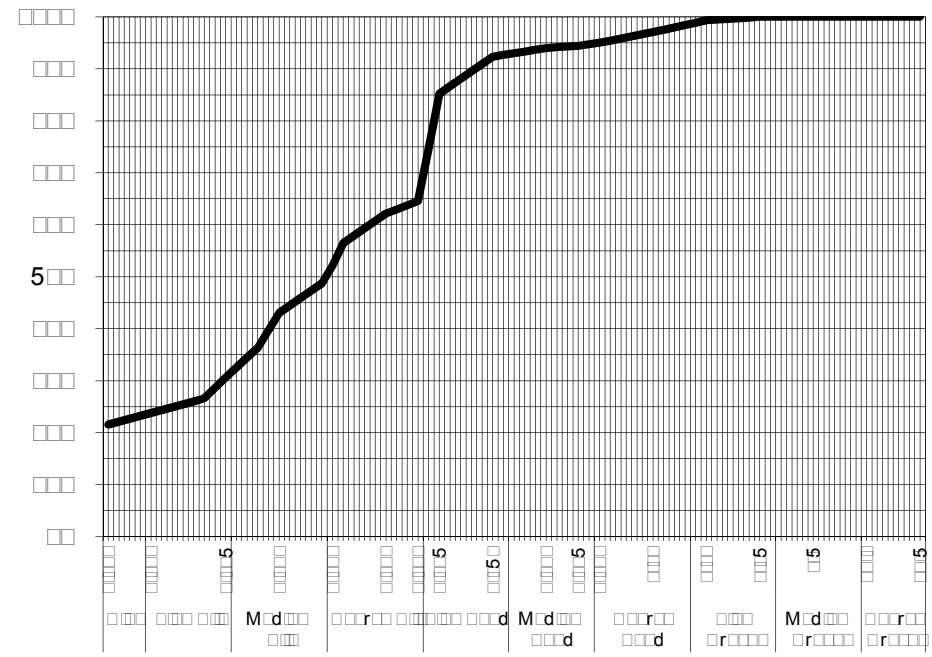
- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


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**Dianne Blane**

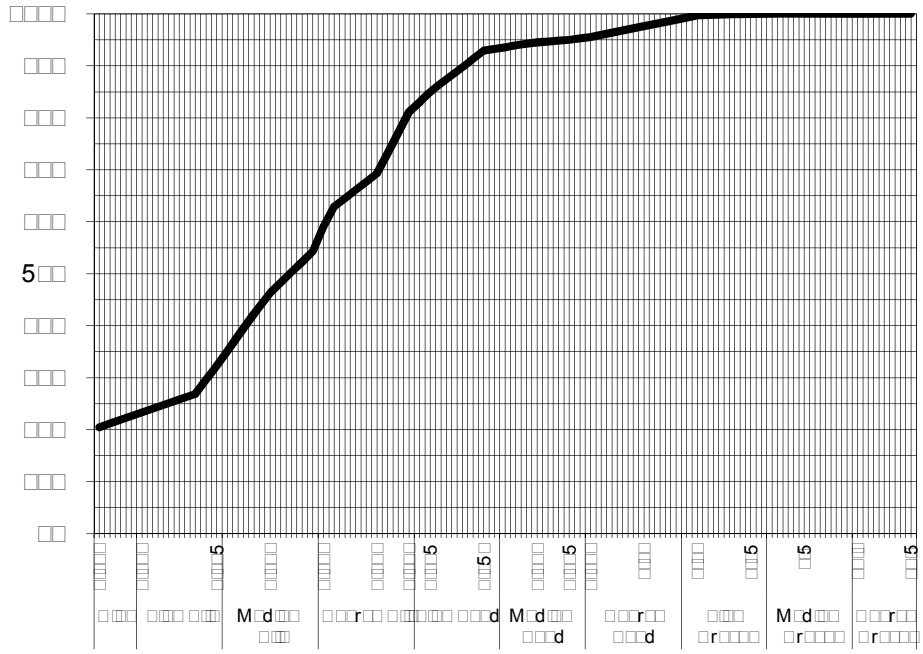
***Authorised Signatory***

# Certificate of Analysis


ALS Environmental

Newcastle, NSW



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


5 NATA WORLD RECOGNISED ACCREDITATION


**Dianne Blane**

***Authorised Signatory***









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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

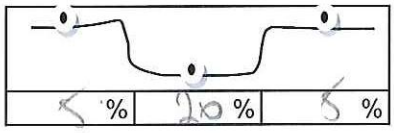
Date 13/06/12 KP Point 380.73 Eastings 297002.43 Northings 7355408.25
Watercourse Name unnamed minor 175 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne/Calliope Weather Fine
Rain in the Past week — Time of Day 12:40 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 7.5m - active 2m
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)
Canopy cover % Width of riparian Zone (m): LB 0.5 RB 0.5

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**Riparian vegetation**: Grass % 90 Shrubs % _____
Trees < 10m % 5 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

- mainly grasses
- scattered trees.

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

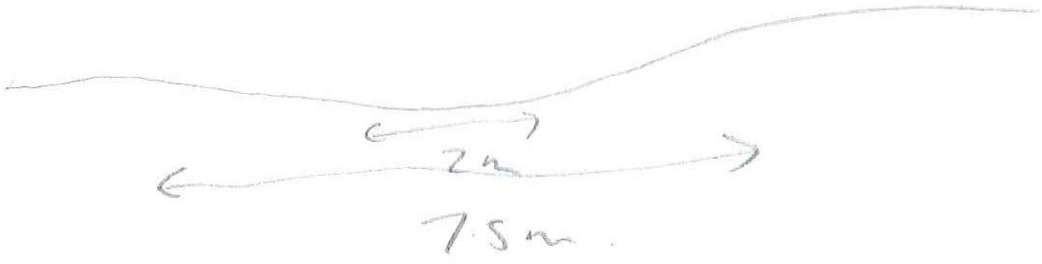
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

gentle sloping banks, small active channel with larger high flow channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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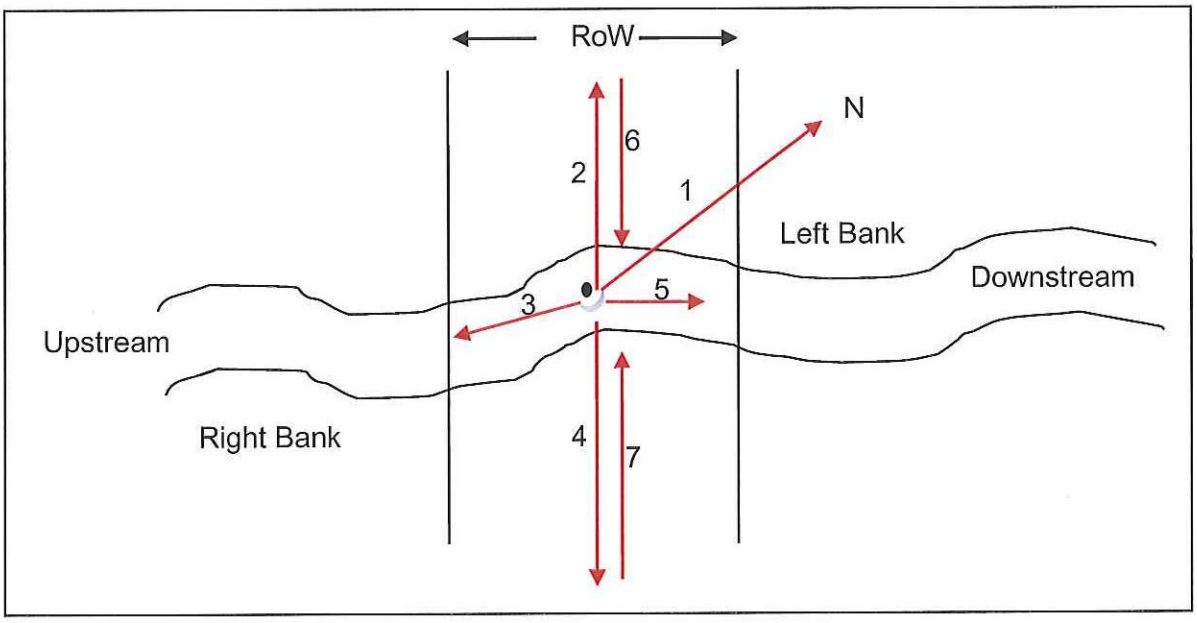
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 380 - up |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 380 - down + 380 - down 2 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Moist ground. scattered semi-aquatic species mostly grassed with scattered iron bark and eucalypts. Trailing veg limited

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP380.73**

Botanical specimens list:

- **Eleocharis cylindrostachys*
- **Juncus* sp., unidentified
- Eucalyptus
- Ironbark

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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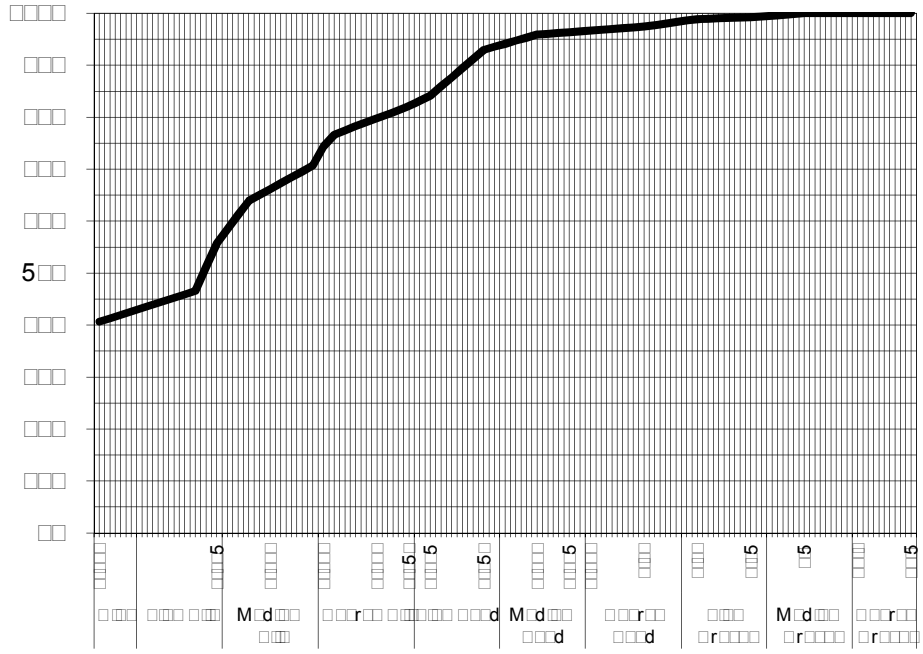
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# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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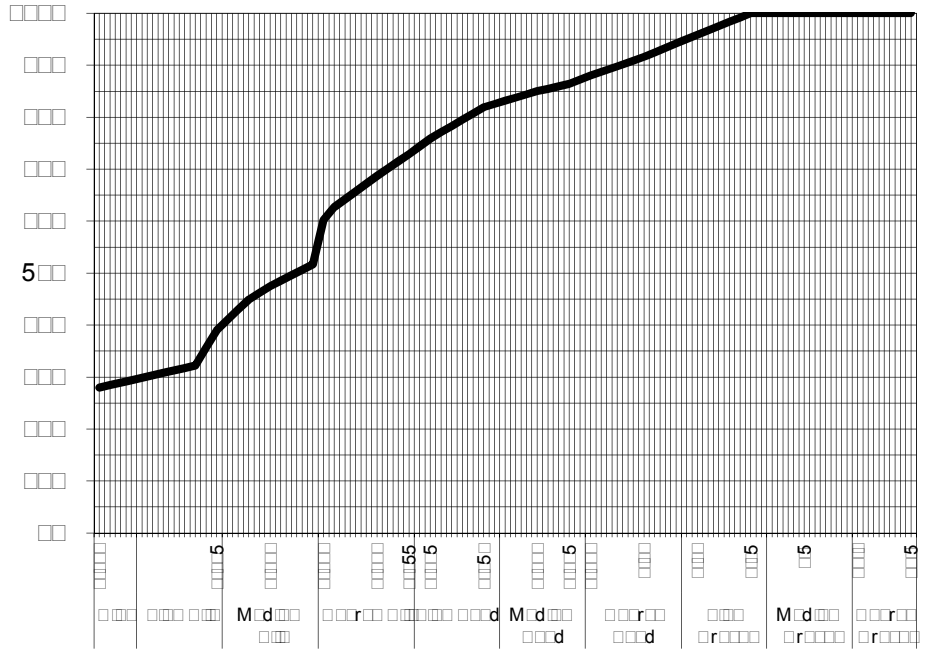
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**Facing upstream from proposed GTP crossing location (KP380.73)**



**Facing downstream from proposed GTP crossing location (KP380.73)**



**Facing downstream from proposed GTP crossing location (KP380.73)**

Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

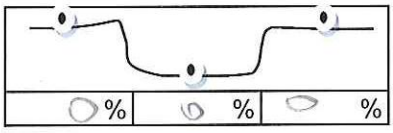
Date 13/06/12 2pm & 14/06/12 → 4pm KP Point 391.1 Eastings 296905.37 Northings 7364069.26
Watercourse Name Unnamed Stream 182 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne / Calliope Weather Fine
Rain in the Past week — Time of Day _____ Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 12.5m X 25m
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)
Canopy cover % Width of riparian Zone (m): LB — RB —

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**Riparian vegetation**: Grass % 100 Shrubs % _____
Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

Scattered grasses.

Herbarium samples 1

Santos
GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

wet pool, big large wetland area with inland

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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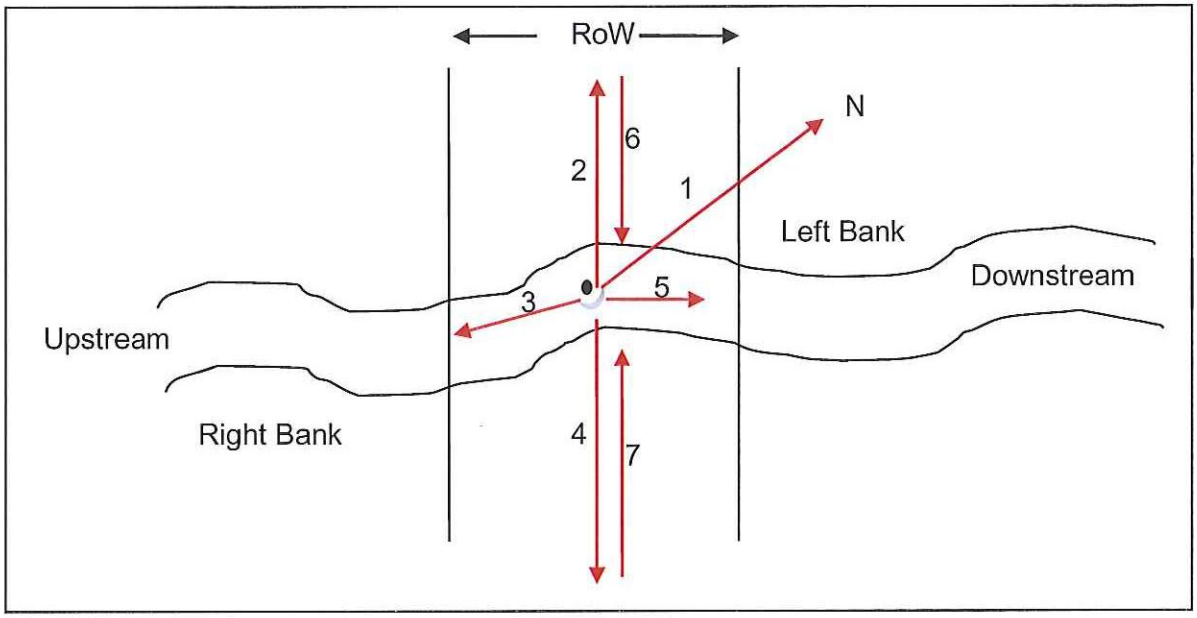
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | 391. left |
| Facing Upstream (3) | 391. up. |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 391. dow |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Wetland, pooled. Riparian veg absent some emergent macrophytes and submerged but density very low, training veg mainly grasses with scattered trees

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

SAMPLE TAKEN

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | 1100 | | | |
| pH | 8.33 | | | |
| Dissolved $O_2$ (mg/L) | 10.1 | | | |
| Turbidity (NTU) | 3.0 | | | |
| Total Dissolved Solids | 715mg/L | | | |

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

Nitella sp. needs

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

Edge & Bed

**KP391.1**

Botanical specimens list:

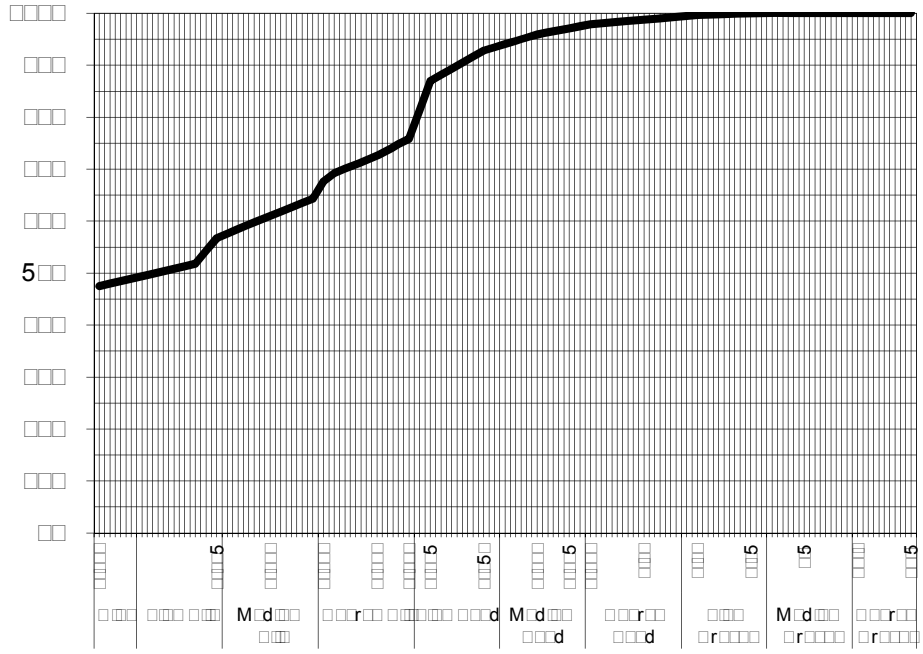
- **Typha* sp., unidentified

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Hamish Murray**

***Authorised Signatory***

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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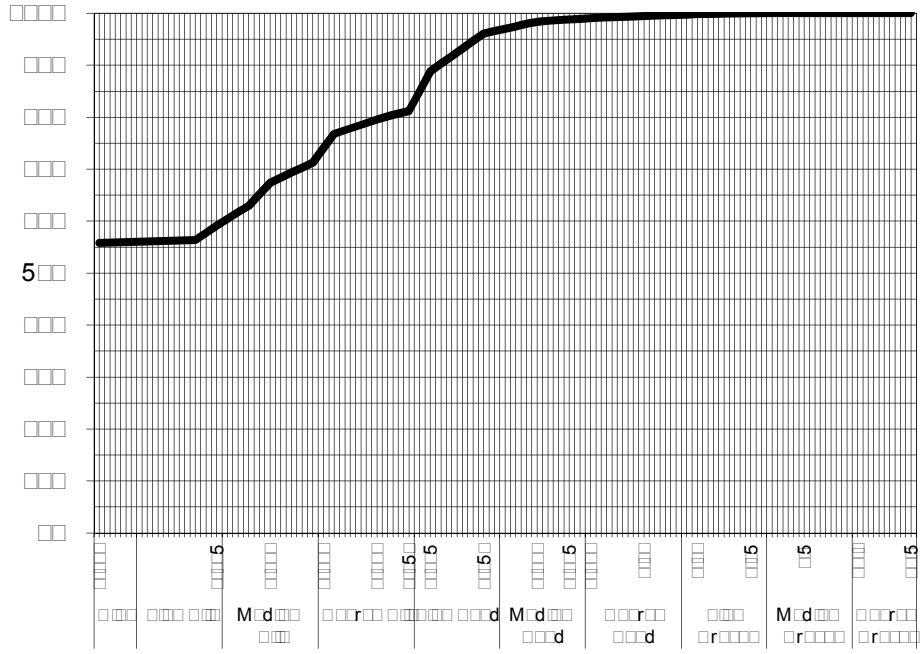
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**Facing left bank from proposed GTP crossing location (KP391.1)**



**Facing upstream from proposed GTP crossing location (KP391.1)**



**Facing downstream from proposed GTP crossing location (KP391.1)**

Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 9/2/12 KP Point 396.5 Eastings 350177 Northings 7368101
Watercourse Name Unnamed Distance from Source 1.29km AMTD 0.21km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Calliope Weather
Rain in the Past week Time of Day Cloud Cover (%)

---

**OBSERVATIONS**

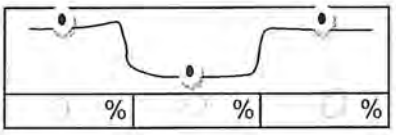
Mean Channel width (m)
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB RB

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**Riparian vegetation**: Grass % 95 Shrubs %
Trees < 10m % Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

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GLNG Project

| | | | | |
|---|---|---|---|---|
| **Substrate Description:** | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Stagnant pool at Row hollow
no flow

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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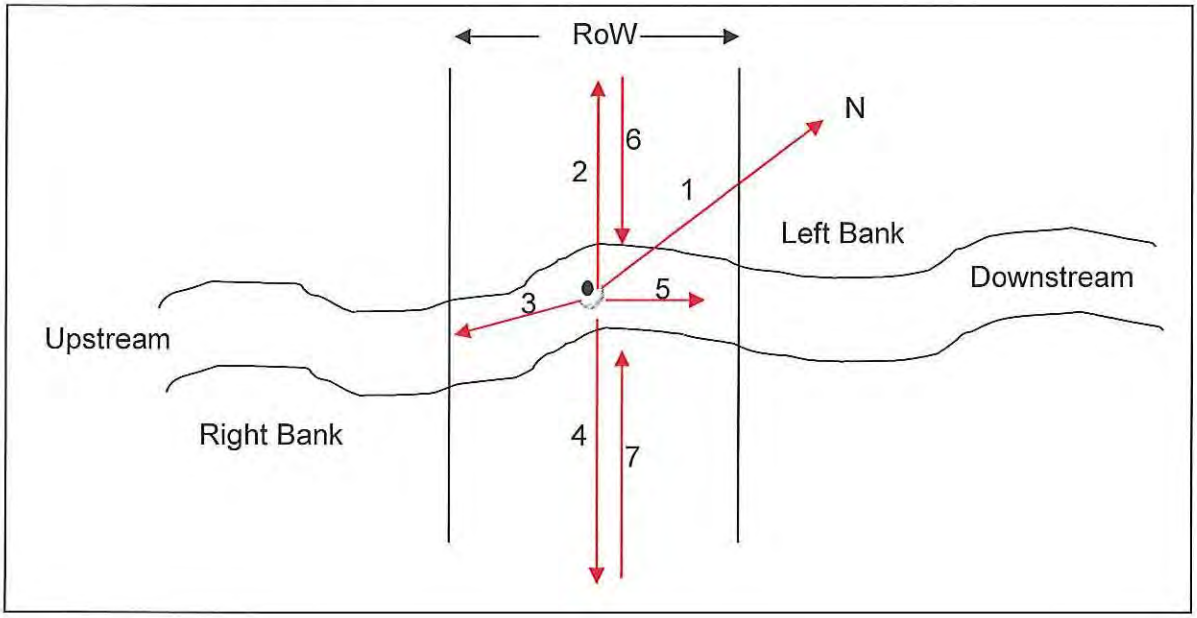
GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 217 |
| Facing left bank (2) | 218 |
| Facing Upstream (3) | 219 |
| Facing Right Bank (4) | 221 |
| Facing Downstream (5) | 220 ~~220~~ 219 |
| From edge of Riparian on left (6) | 222 |
| From edge of Riparian on right (7) | ~~224~~ |

**General Comments:**

Stagnant pool at ROW. Watercourse has several pool both upstream & downstream but not connected. Paperbal & exclusive grasses few emergent macrophytes.

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 30·6 | 30·1 | – | 30·35 |
| Conductivity (µS/cm) | 720·4 | 720·6 | – | 720·5 |
| pH | 7·54 | 7·31 | – | 7·43 |
| Dissolved $O_2$ (mg/L) | 3·85 | 3·95 | – | 3·4 |
| Turbidity (NTU) | 4·83 | 6·29 | – | 5·56 |
| 105 mg/L | 681·8 | 682·6 | – | 682·2 |

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**5**

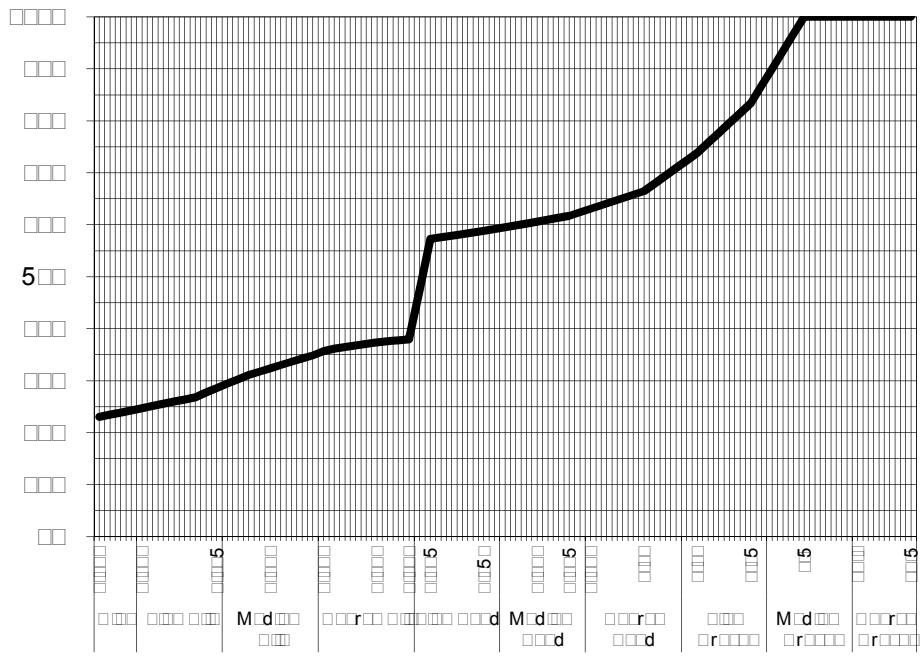
- *Gomphocarpus physocarpus*
- **Chara sp.*
- **Melaleuca viridiflora*
- **Cyperaceae sp.*

# Certificate of Analysis


ALS Environmental

Newcastle, NSW



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*



**Dianne Blane**

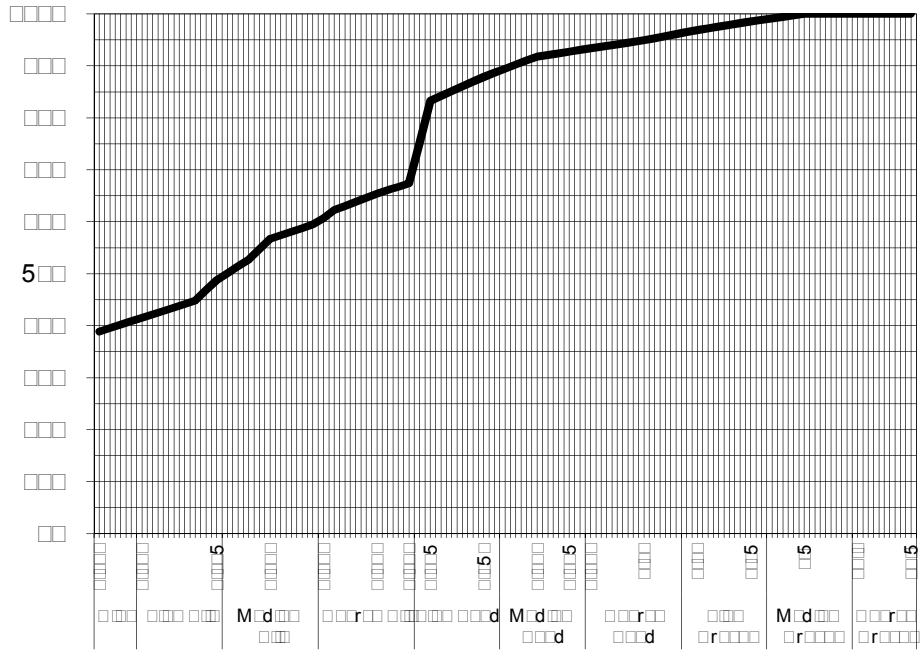
*Authorised Signatory*

# Certificate of Analysis


ALS Environmental

Newcastle, NSW



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 14/6/12 KP Point 399.21 Eastings 301970.02 Northings 7369677.03

Watercourse Name Unnamed Mina 190 Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Boyne / Calliope Weather _____

Rain in the Past week Nil Time of Day 1:30 Cloud Cover (%) _____

---

**OBSERVATIONS**

Mean Channel width (m) 20m – 11m Channel.

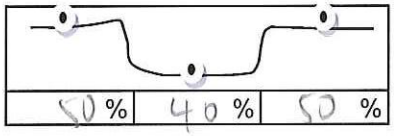
Height of Banks  Left 2 Right 3

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 5 RB 5

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**Riparian vegetation**: Grass % 40 Shrubs % _____

Trees < 10m % 30 Trees > 10m % 30

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Herbarium Samples – HHT HHT II

Santos
GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % 30 |
| Boulder (>256mm) | % 30 | Gravel (4-16mm) | % 10 |
| Cobble (64-256mm) | % 20 | Sand (1-4mm) | % 10 |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

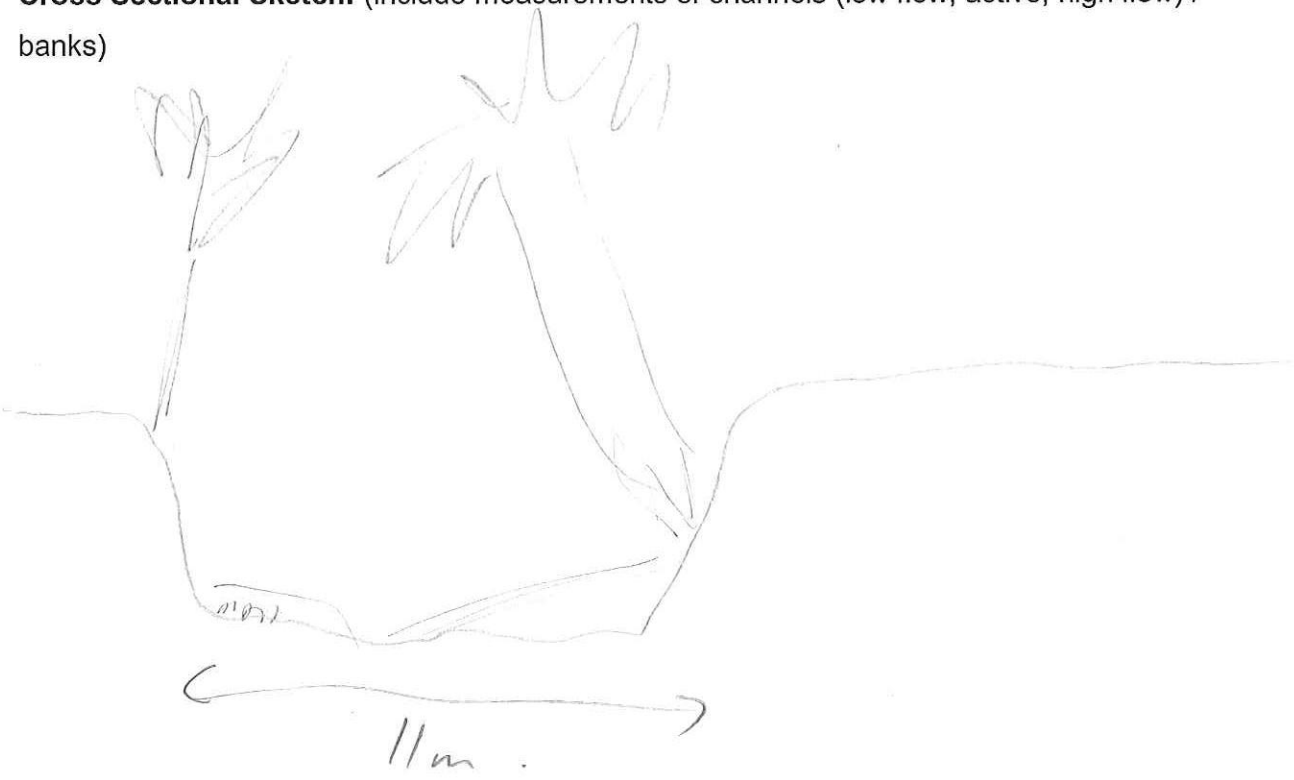
Instream + Bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

winding channel with steep ~~sodic~~ banks. Rocky substrate. Extensive erosion

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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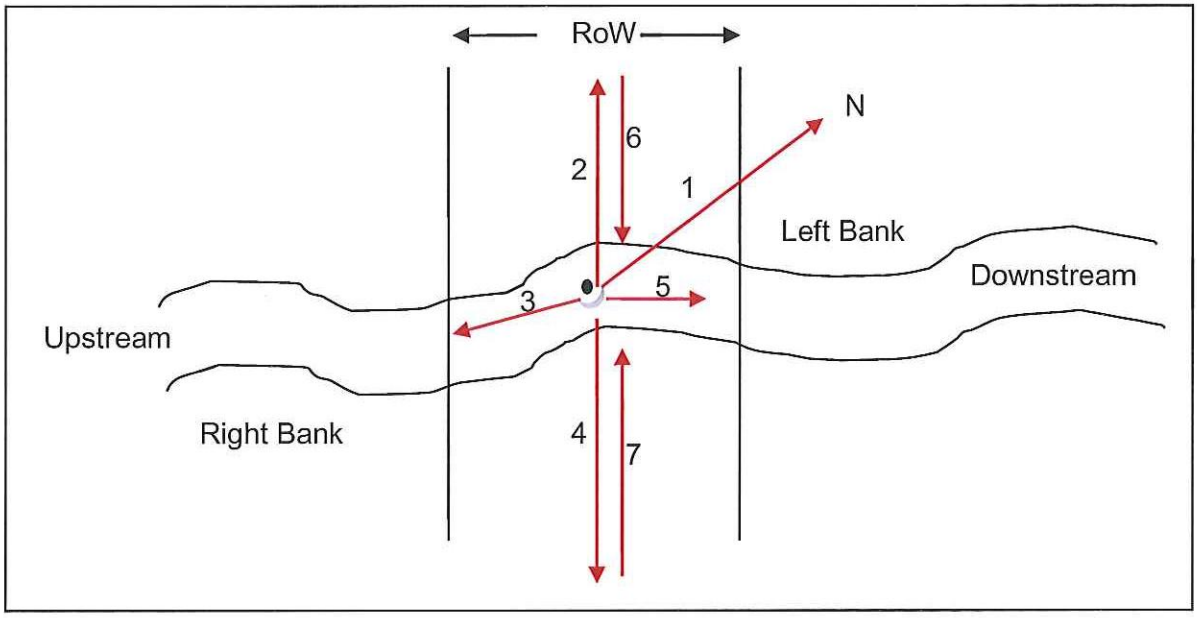
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | 39921-2 |
| Facing Upstream (3) | 39921-3 |
| Facing Right Bank (4) | 39921-4 |
| Facing Downstream (5) | 39921-5 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

winding channel with very low flow and several stagnant pools. Film of algae on top of pools. both riffle & pool habitat present. Extreme bank erosion, indicative of heavy flows during rain events. Several fallen logs and woody debris.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

SAMPLE TAKEN

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | 3270 | | | |
| pH | 7,70 | | | |
| Dissolved $O_2$ (mg/L) | 3.5 | | | |
| Turbidity (NTU) | 5,8 | | | |

Total Dissolved Solids (mg/L) 2120

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

slight coverage on top of water.

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP399.21**

Botanical specimens list:

- **Acacia fasciculifera*
- **Acacia disparrima*
- **Jasminum simplicifolium* subsp. *australiensis*
- **Mallotus claoxyloides*
- **Mallotus philippensis*
- **Coatesia paniculata*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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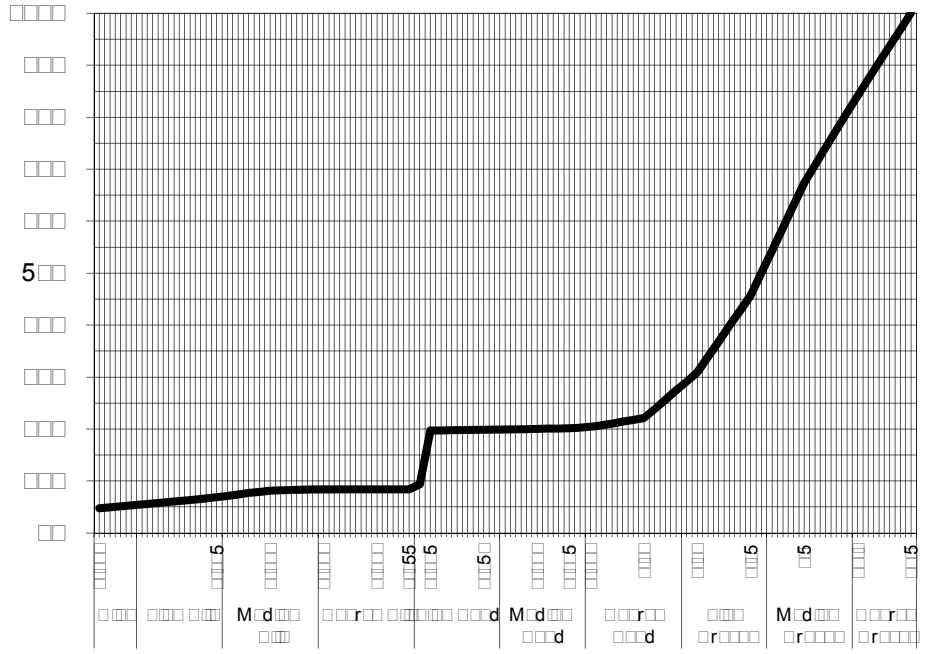
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# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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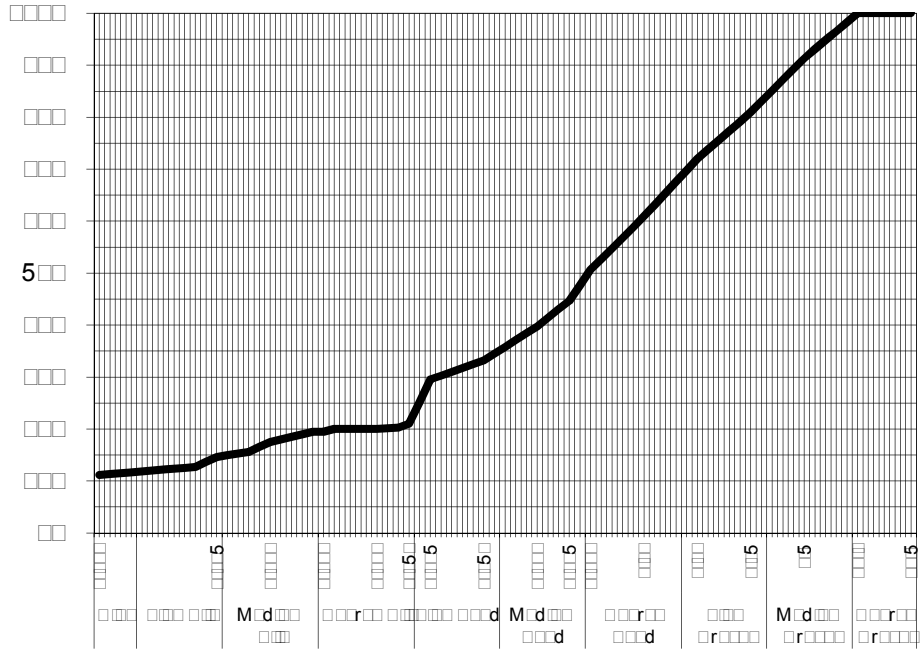
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**Facing left bank from proposed GTP crossing location (KP399.21)**



**Facing downstream from proposed GTP crossing location (KP399.21)**



**Facing upstream from proposed GTP crossing location (KP399.21)**



**Facing right bank from proposed GTP crossing location (KP399.21)**

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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

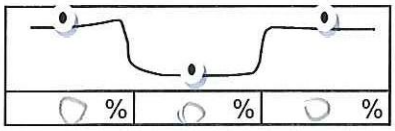
Date 14/6/12 KP Point 399.68 Eastings 367215.3 Northings 7370065.38
Watercourse Name Unnamed Minor 193 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne/Calliope Weather Fine
Rain in the Past week Nil Time of Day 12:15 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 13.4m - 4m.
Height of Banks  Left | Right |

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB — RB —

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**Riparian vegetation**: Grass % 100 Shrubs % _____
Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

hidden area has moderate trailing veg, but in existing location, veg is cleared.

Herbarium Samples 1111

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GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % 50 |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % 25 |
| | | | Silt/clay (<1mm) | % 25 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

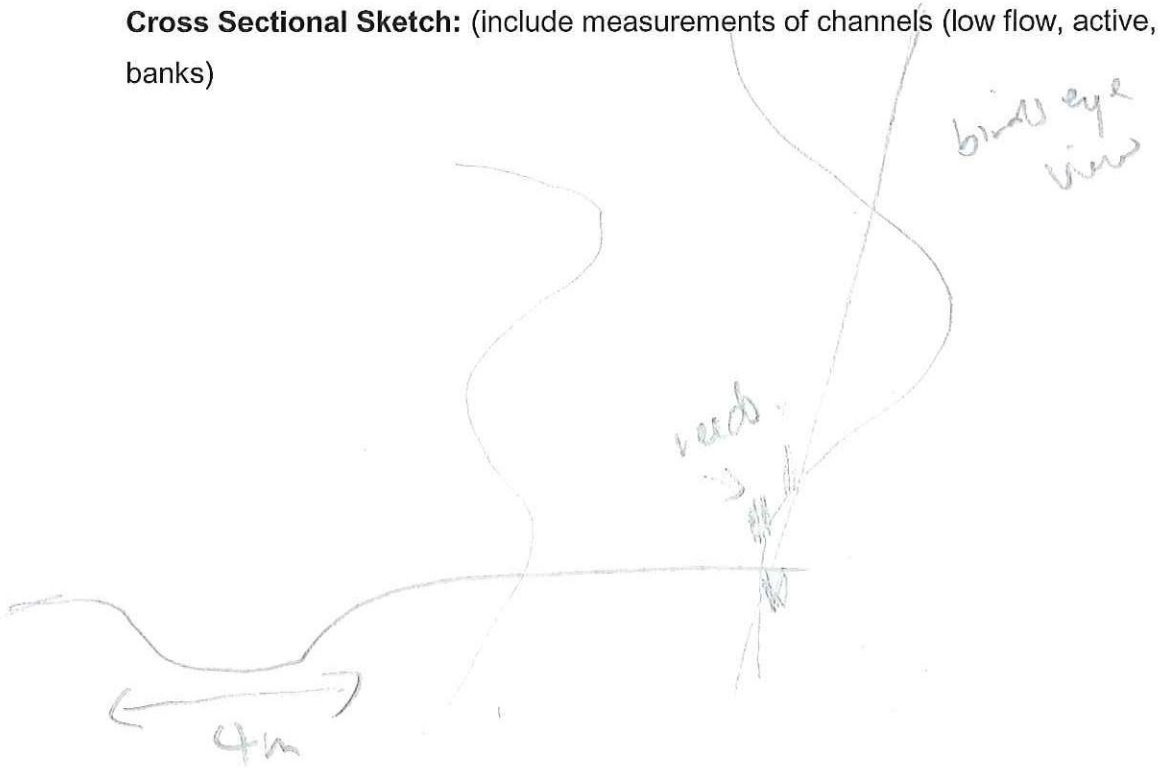
Instream only

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

winding channel, crossed by ROW 3 times

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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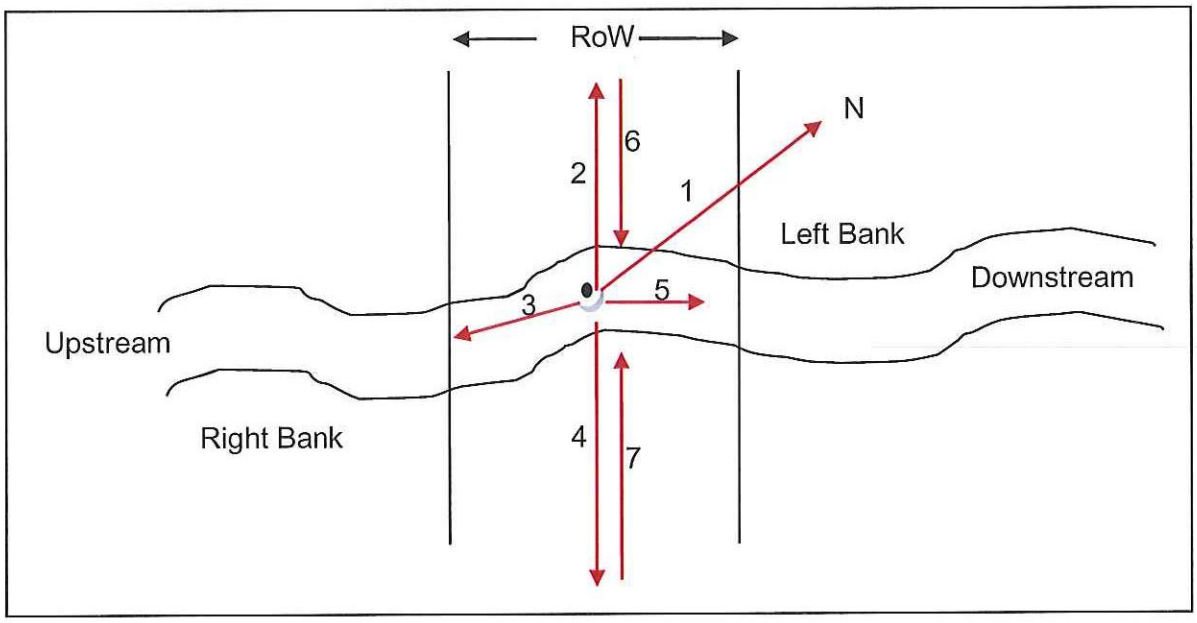
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 39968 up |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 39968 down 1 39968 down 2. |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

windy, channel mainly grassed, moist soil, several stagnant pool (small) downstream. Some semi-aquatic species present. Frogs spotted

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP399.68**

Botanical specimens list:

- *Probably *Gomphocarpus* sp.
- **Typha* sp. indet.
- **Cyperus javanicus*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

## Newcastle, NSW

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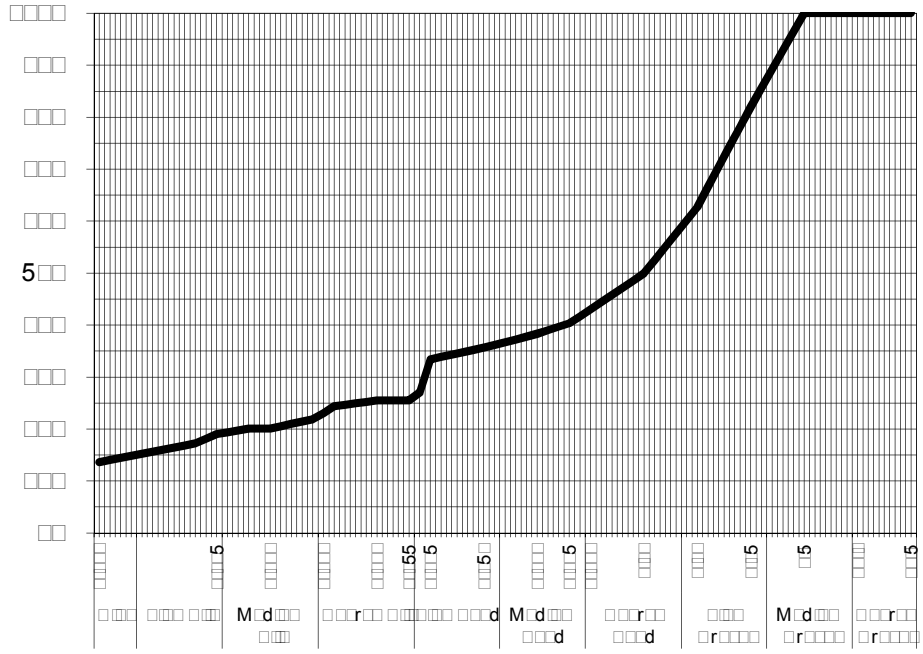


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*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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NATA
WORLD RECOGNISED
ACCREDITATION

**Hamish Murray**
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**Facing upstream from proposed GTP crossing location (KP399.68)**



**Facing downstream from proposed GTP crossing location (KP399.68)**



**Facing downstream from proposed GTP crossing location (KP399.68)**

Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

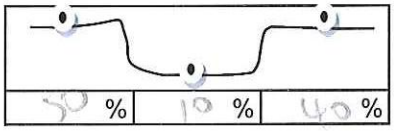
Date 14/08/12 KP Point 400.03 Eastings 308507.21 Northings 7370232.09
Watercourse Name Unnamed minor 195 Distance from Source _____ AMTD _____
Stream Order 1 Photo taken of access track Y/N
Catchment Area Boyne/Calliope Weather Fine
Rain in the Past week Nil Time of Day 11:40 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 25m → 5m.
Height of Banks  Left 2 Right 2

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive (Moderate) Limited None
Canopy cover % Width of riparian Zone (m): LB 3 RB 3

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**Riparian vegetation**: Grass % 60 Shrubs % _____
Trees < 10m % 30 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | (Moderate) | Slight | Nil |
|---|---|---|---|

Herbarium Samples - HT 1118

Santos
GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % 20 |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % 80 |
| | | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

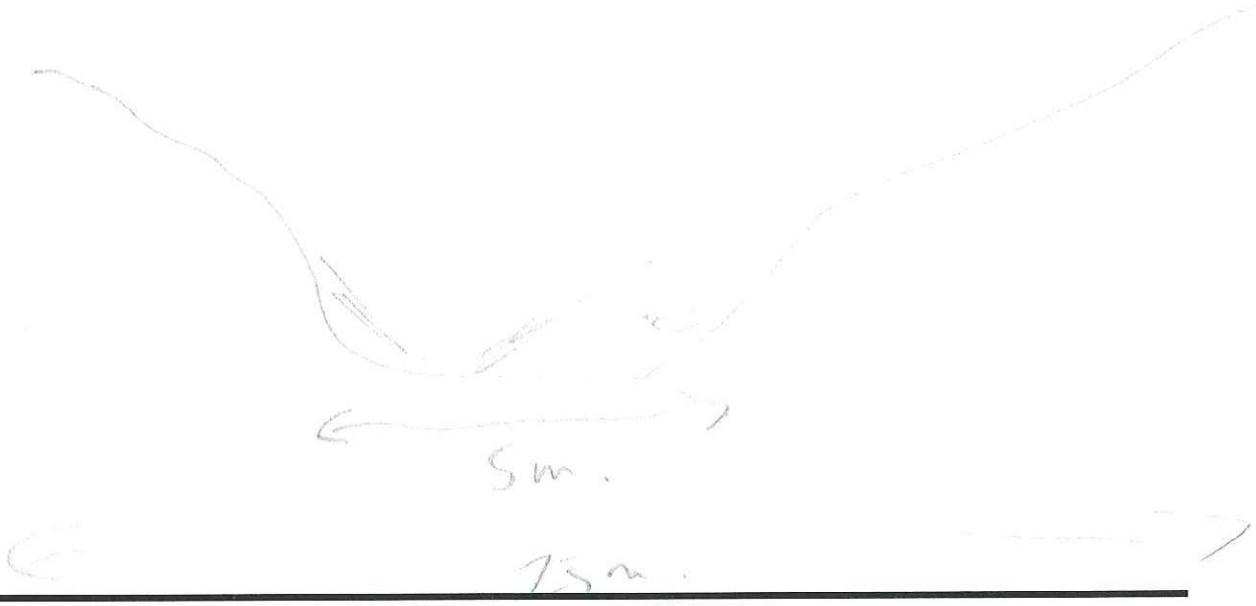
Upstream only

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

5m active channel with sandy substrate
Steepish gradient, no pools

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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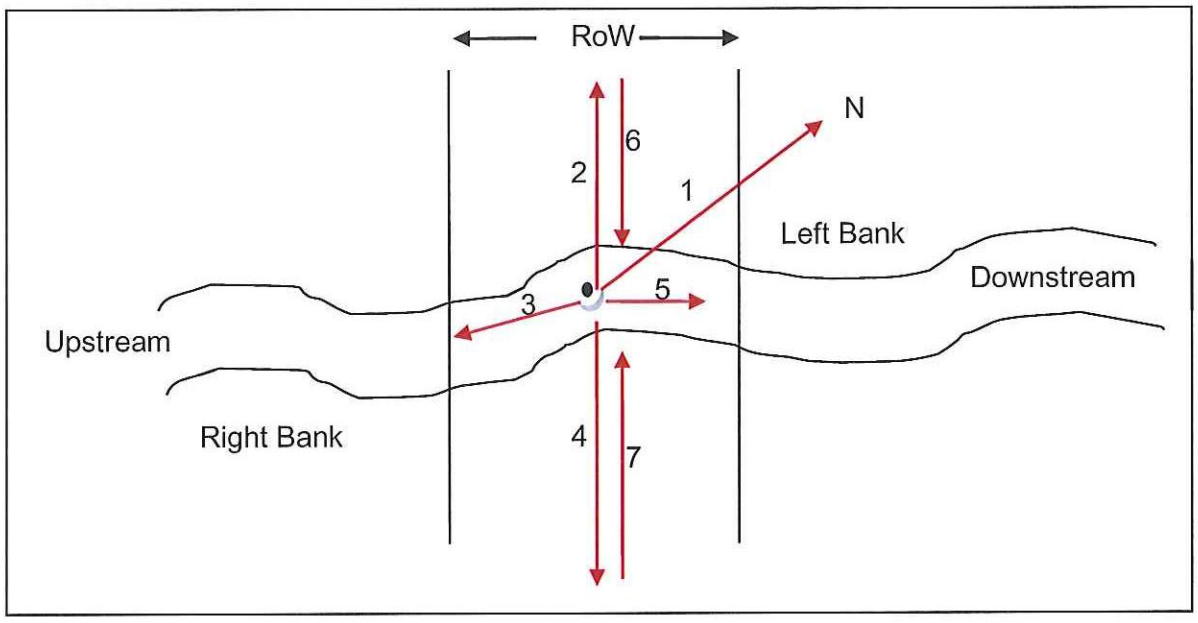
GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 40003-1 |
| Facing left bank (2) | 40003-2 |
| Facing Upstream (3) | 40003-3 |
| Facing Right Bank (4) | 40003-4 |
| Facing Downstream (5) | 40003-5 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Sloping gradient with no pool. Significant amount of taller debris in crossing location. Evidence of significant flows after rain events. Moderate trailing veg

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP400.03**

Botanical specimens list:

- * *Notelaea microphylla*
- **Passiflora suberosa*
- **Jasminum simplicifolium* subsp. *australiensis*
- **Acacia disparrima*
- **Eucalyptus* sp., unidentified
- **Hibiscus heterophyllus*

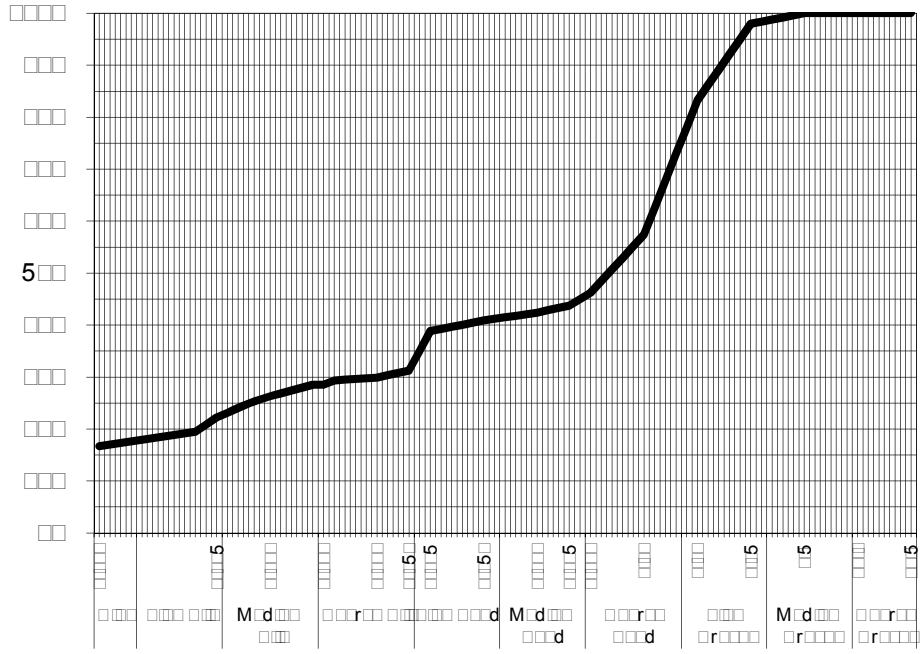
*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*



**Hamish Murray**

***Authorised Signatory***



**Facing north from proposed GTP crossing location (KP400.03)**



**Facing right bank from proposed GTP crossing location (KP400.03)**



**Facing left bank from proposed GTP crossing location (KP400.03)**



**Facing downstream from proposed GTP crossing location (KP400.03)**



**Facing upstream from proposed GTP crossing location (KP400.03)**

**Santos**
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 14/6/12 KP Point 400.13 Eastings 302584.91 Northings 7370297.99

Watercourse Name Unnamed Mow 196 Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Boyne / calliope Weather Fine

Rain in the Past week Nil Time of Day 11.30 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 22.5m - 7m active channel.

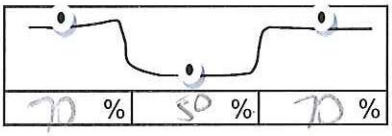
Height of Banks  Left 3 Right 2

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 10 RB 10

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**Riparian vegetation**: Grass % 20 Shrubs % 20

Trees < 10m % 30 Trees > 10m % 30

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| | | | |
|---|---|---|---|
| Extensive | Moderate | Slight | Nil |

Herbarium Samples - HH1

Santos
GLNG Project

| **Substrate Description:** | | | | | |
|---|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % | 20 |
| | Boulder (>256mm) | % 30 | Gravel (4-16mm) | % | 20 |
| | Cobble (64-256mm) | % 20 | Sand (1-4mm) | % | 10 |
| | | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

Upstream only

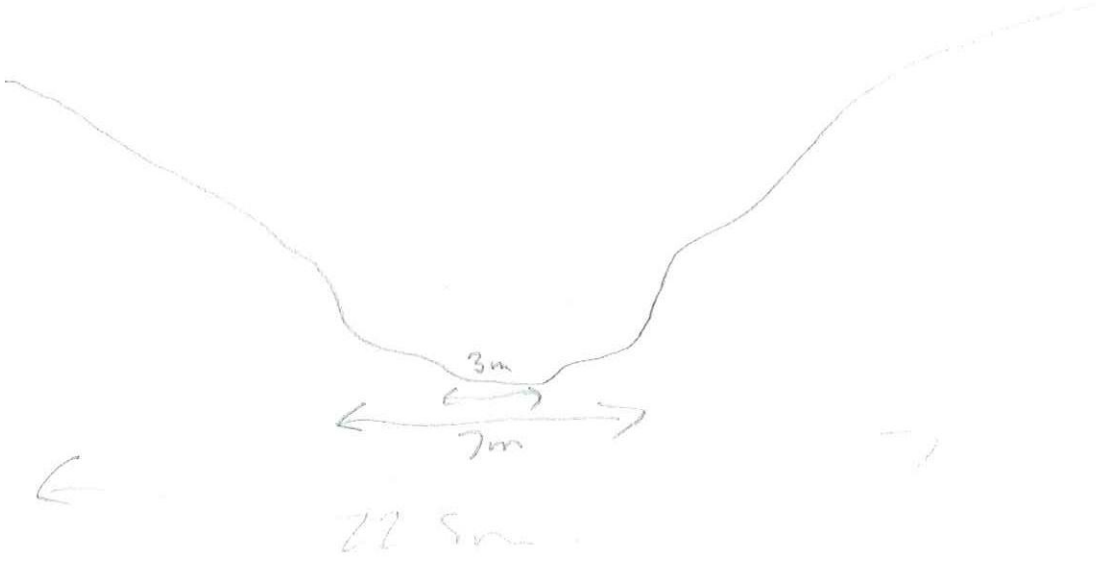
**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Rocky channel, wide high flow channel well defined banks of active channel

Relatively steep gradient with no pools in assessment reach

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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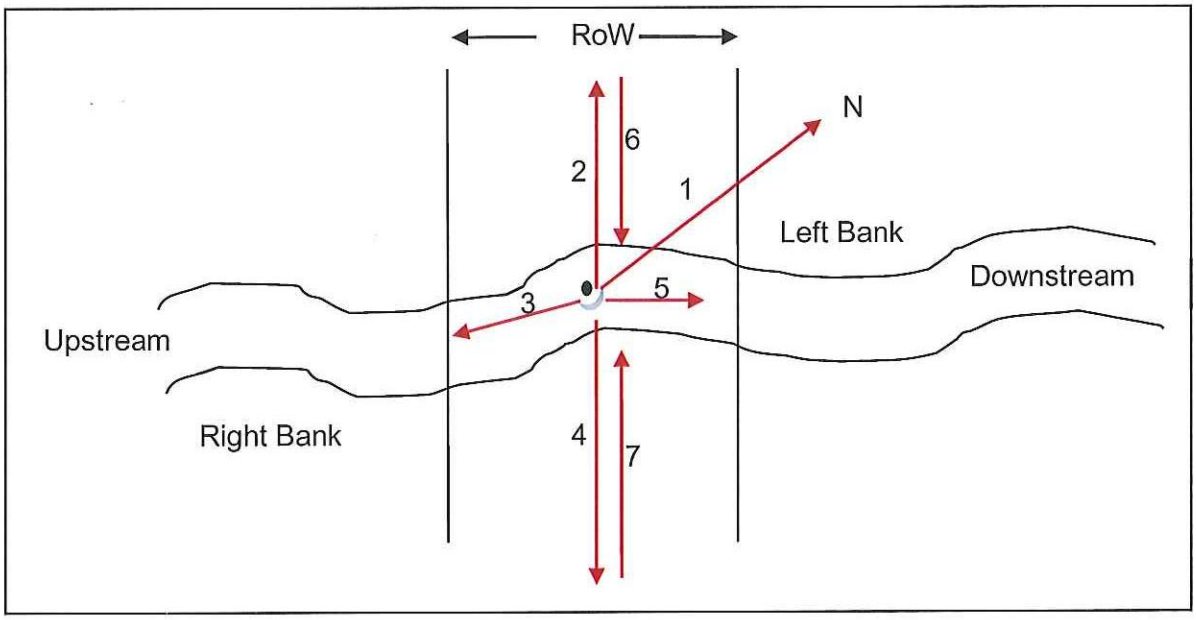
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 40013-1 |
| Facing left bank (2) | 40013-2 |
| Facing Upstream (3) | 40013-3 |
| Facing Right Bank (4) | 40013-4 |
| Facing Downstream (5) | 40013-5 |
| From edge of Riparian on left (6) | 400[illegible] |
| From edge of Riparian on right (7) | 40013-6. |

**General Comments:**

Rocky substate, heavily vegetated significant amount of fallen timber & debris for [illegible] religia habitat. Small amounts of erosion and airline of high flows during heavy rain events. Dry at time of survey. [illegible]

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (ºC) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP400.13**

Botanical specimens list:

- **Lophostemon confertus*
- **Turraea pubescens*
- **Glochidion ferdinandi*
- **Diospyros geminata*
- **Lantana camara*
- **Eucalyptus* sp., unidentified
- **Turraea pubescens*
- **Acacia maidenii*
- **Cupaniopsis wadsworthii*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

### Newcastle, NSW

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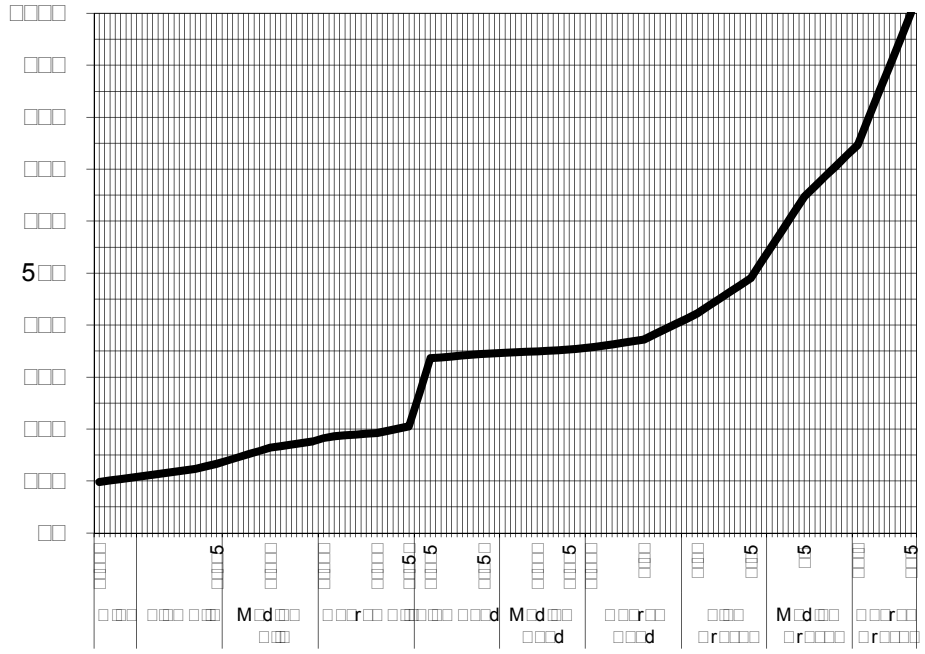


*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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**Facing north from proposed GTP crossing location (KP400.13)**



**Facing right bank from proposed GTP crossing location (KP400.13)**



**Facing left bank from proposed GTP crossing location (KP400.13)**



**Facing downstream from proposed GTP crossing location (KP400.13)**



**Facing upstream from proposed GTP crossing location (KP400.13)**



**Facing proposed crossing location from edge of right riparian (KP400.13)**

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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 14/6/12 KP Point 400.8 Eastings 302989.86 Northings 7370815.02

Watercourse Name Unnamed minor 198 Distance from Source _____ AMTD _____

Stream Order 1 Photo taken of access track Y/N

Catchment Area Boyne/Calliope Weather Fine

Rain in the Past week Nil Time of Day 9.40 Cloud Cover (%) 0

---

**OBSERVATIONS**

Mean Channel width (m) 12.5

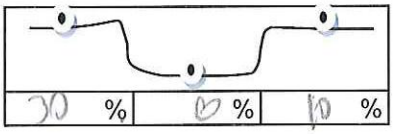
Height of Banks  Left 4.5 Right 4.5

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 5 RB 5

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**Riparian vegetation**: Grass % 40 Shrubs % _____

Trees < 10m % 30 Trees > 10m % 30

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Santos
GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % 15 |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 15 |
| | | Silt/clay (<1mm) | % 70 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

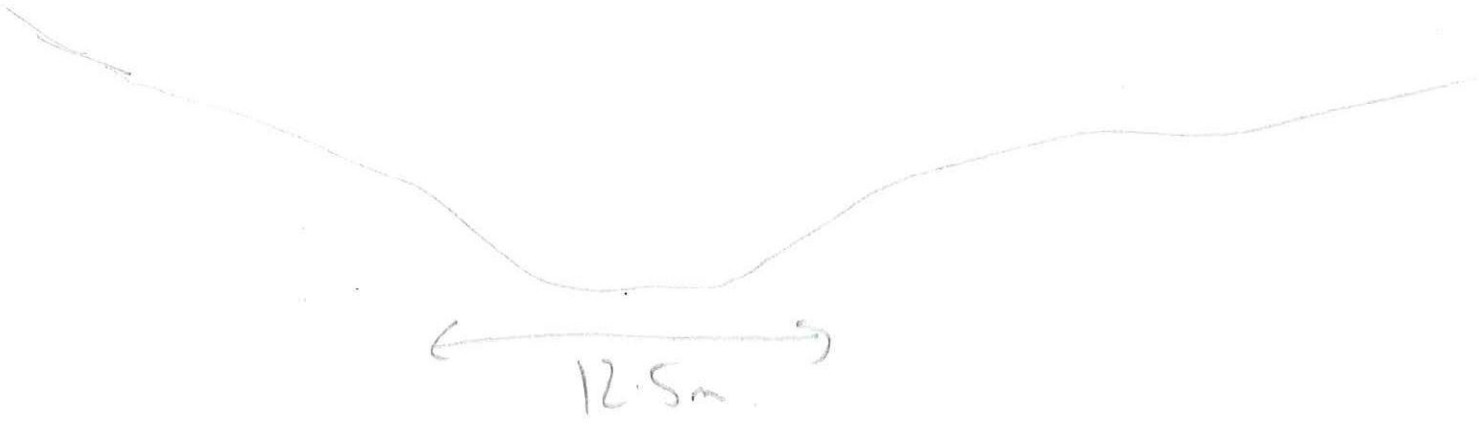
Instream + bank

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Steep watercourse, flows into large lake

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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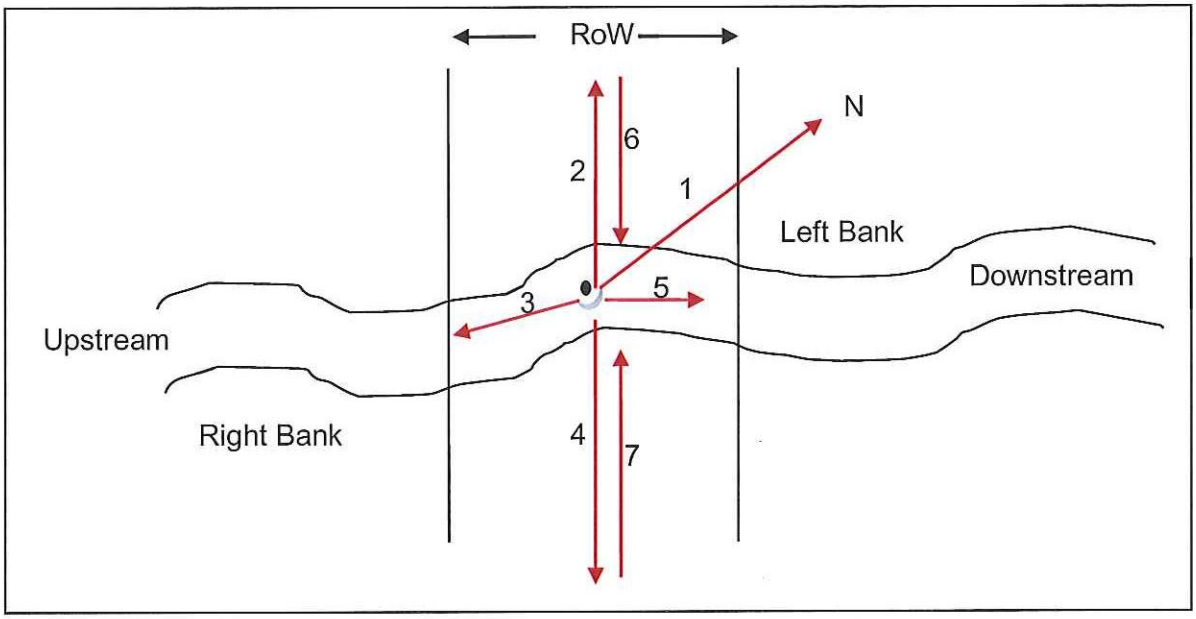
GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 4008-1 |
| Facing left bank (2) | 4008-2 |
| Facing Upstream (3) | 4008-3 |
| Facing Right Bank (4) | 4008-4 |
| Facing Downstream (5) | 4008-5, 400/down |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

winding channel ~~with~~ with steep gradient, flows into large lake with riparian/light aquatic value. Dry at crossing location, crossing should be in dry season, as lake bed could rise in wet season & inundate crossing location. grassed bottom of native, scattered trees.

Santos
GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| Substrate: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| Emergent: | None | Little | Moderate | Lot |
|---|---|---|---|---|
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP400.8**

Botanical specimens list:

- **Acacia fasciculifera*
- **Lantana camara*
- **Ehretia membranifolia*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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## ALS Environmental

### Newcastle, NSW

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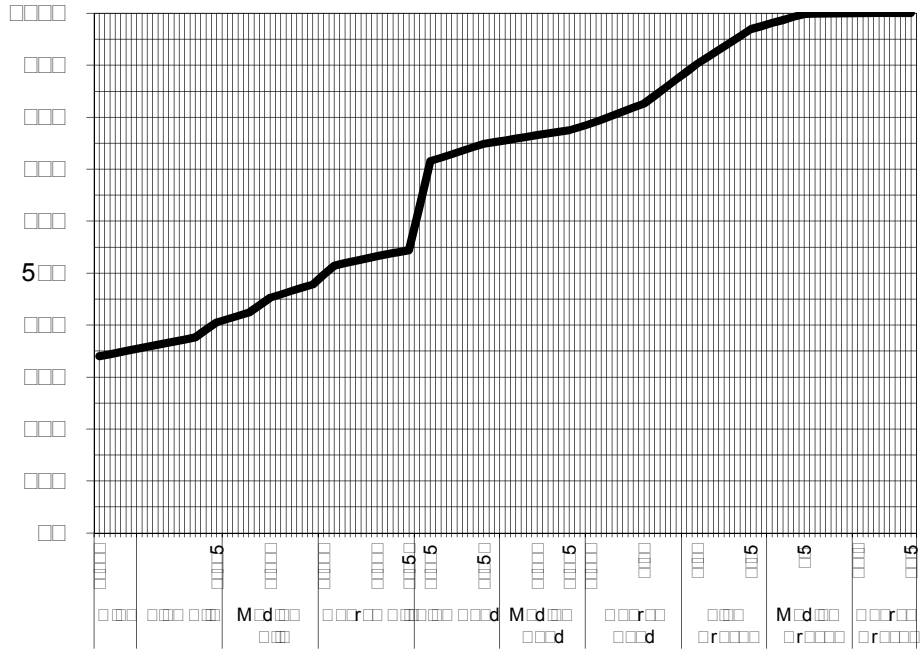


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*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

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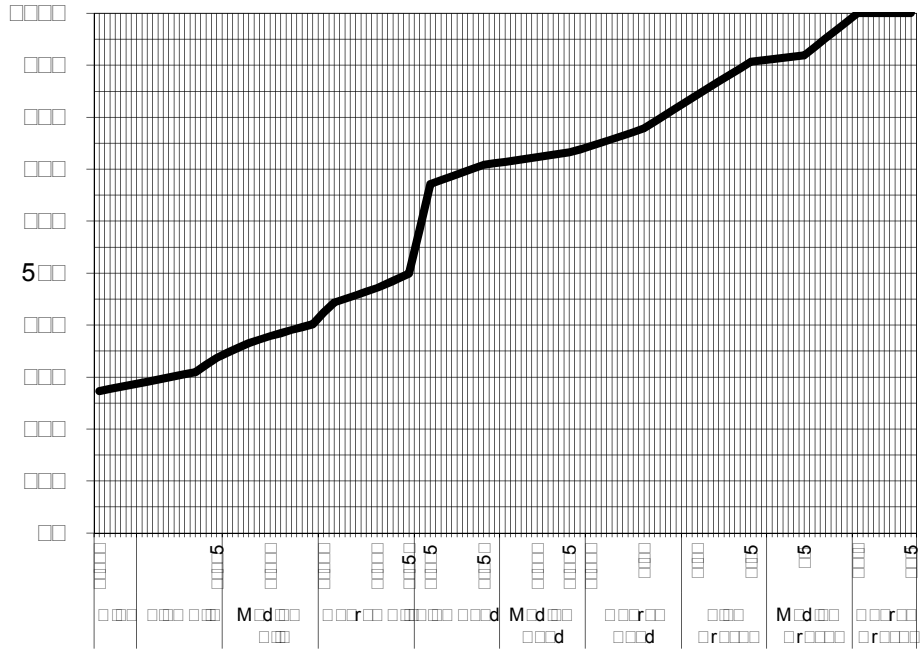
# Certificate of Analysis


ALS Environmental

Newcastle, NSW



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*Samples analysed as received.*

*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*



**Hamish Murray**

***Authorised Signatory***



**Facing north from proposed GTP crossing location (KP400.8)**



**Facing right bank from proposed GTP crossing location (KP400.8)**



**Facing left bank from proposed GTP crossing location (KP400.8)**



**Facing downstream from proposed GTP crossing location (KP400.8)**



**Facing upstream from proposed GTP crossing location (KP400.8)**

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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 9/2/12 KP Point 916 Eastings 316480 Northings 7372602
Watercourse Name Unnamed Distance from Source 1.19 AMTD 0.154 km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Curtis Island Weather Fine
Rain in the Past week 1inch Time of Day 9.15am Cloud Cover (%) 70

---

**OBSERVATIONS**

Mean Channel width (m) 1

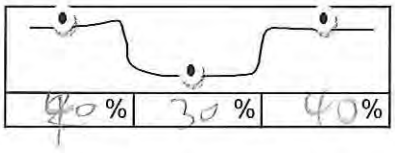
Height of Banks  Left 0.5 Right 3

Velocity (m/s): Flow metre N/A Floating object —

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited (None)

Canopy cover % Width of riparian Zone (m): LB 10 RB 10

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**Riparian vegetation**: Grass % 40 Shrubs % 10
Trees < 10m % 25 Trees > 10m % 25

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| | | | |
|---|---|---|---|
| (Extensive) | Moderate | Slight | Nil |

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

very shallow minor stream. Only holds water during heavy events.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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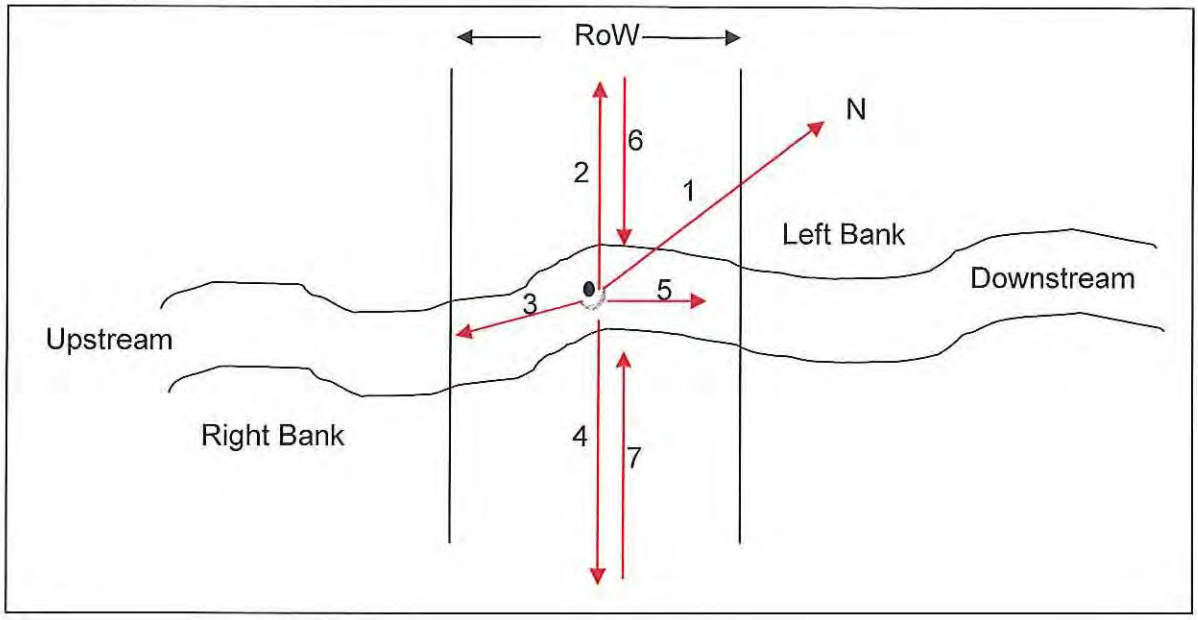
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 190 |
| Facing left bank (2) | 191 |
| Facing Upstream (3) | 192 |
| Facing Right Bank (4) | 193 |
| Facing Downstream (5) | 194 |
| From edge of Riparian on left (6) | 195 |
| From edge of Riparian on right (7) | 196 |

**General Comments:**

No flow overgrown heavily vegetated eucalypts scattered landuse and grasses dominant.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP416**

Botanical specimens list:

- **Urena lobata*
- **Asclepias curassavica*
- **Indigofera sp.,* possibly *I. hirta*
- **Gomphocarpus physocarpus*
- **Eucalyptus sp.,* unidentified
- **Lophostemon sp.,* possibly *L. suaveolens*
- **Praxelis clematidea*
- **Acacia sp.,* unidentified
- **Passiflora suberosa*
- **Breynia oblongifolia*
- **Planchonia careya*
- **Alphitonia excelsa*
- **Planchonia careya*
- *Lantana camara*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis


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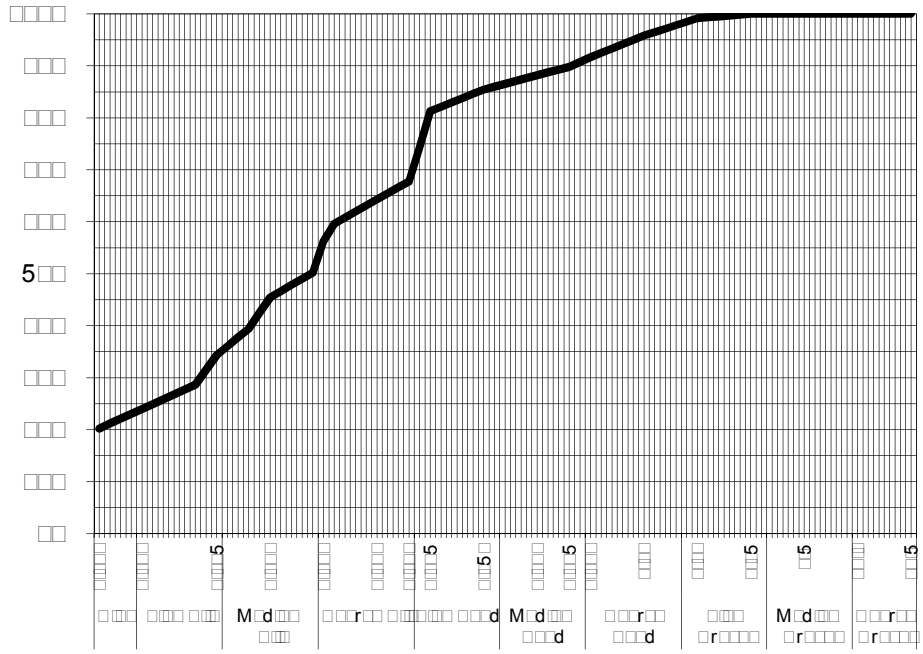

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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*



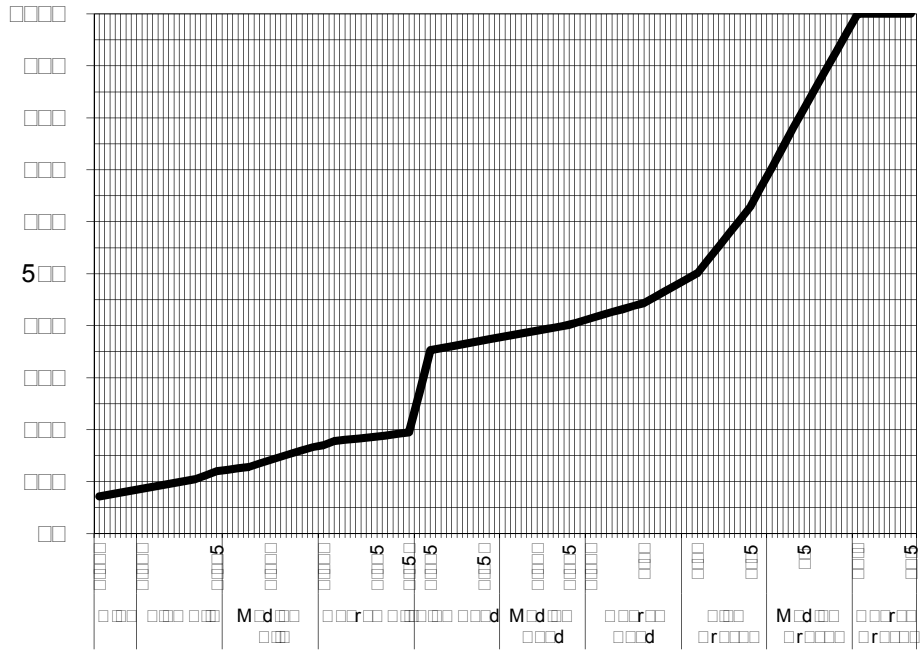
**Dianne Blane**

***Authorised Signatory***

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

**Dianne Blane**

***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

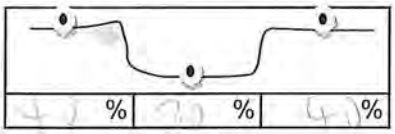
Date 9/2/12 KP Point 418.1 Eastings 317356 Northings 7571219
Watercourse Name Unnamed Distance from Source 10m AMTD 2.711km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Curtis Island Weather Fine
Rain in the Past week 1 inch Time of Day 10am Cloud Cover (%) 60

---

**OBSERVATIONS**

Mean Channel width (m) 1.5
Height of Banks  Left 0.8 Right 0.8

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None
Canopy cover % Width of riparian Zone (m): LB 10 RB 1

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**Riparian vegetation**: Grass % 50 Shrubs % 10
Trees < 10m % 10 Trees > 10m % 30

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| | | | |
|---|---|---|---|
| (Extensive) | Moderate | Slight | Nil |

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**Substrate Description:**

| | | | | | |
|---|---|---|---|---|---|
| Bedrock | % | | Pebble (16-64mm) | % | 20 |
| Boulder (>256mm) | % | 10 | Gravel (4-16mm) | % | 40 |
| Cobble (64-256mm) | % | 20 | Sand (1-4mm) | % | 10 |
| | | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

rocky bottom, small channel dry

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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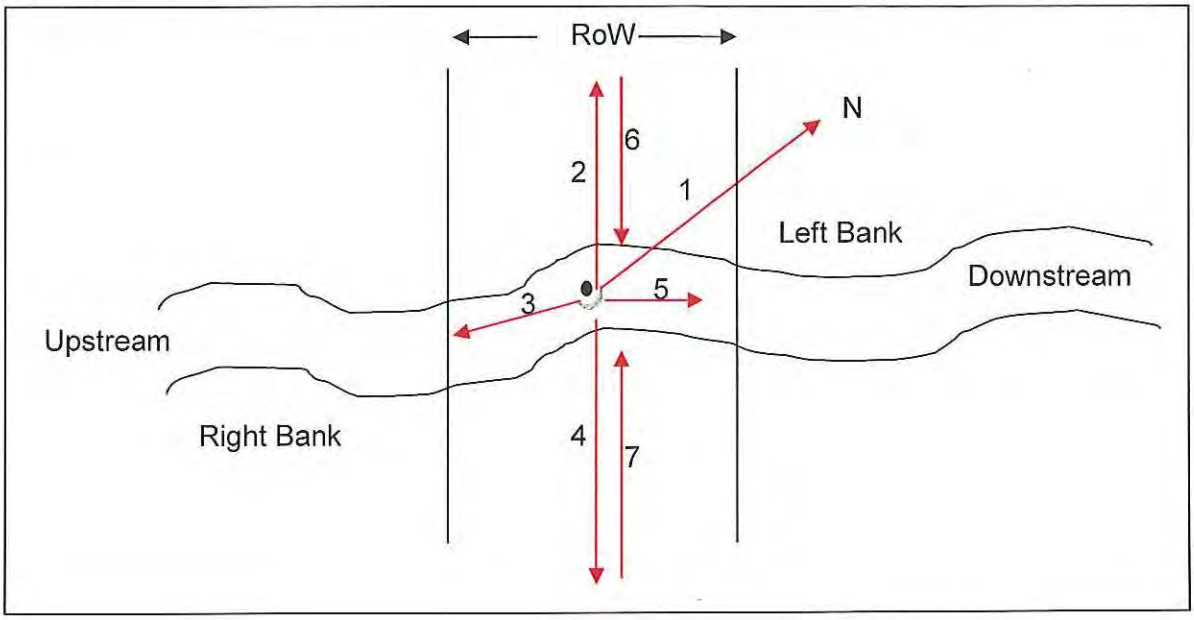
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 197 |
| Facing left bank (2) | 198 |
| Facing Upstream (3) | 199 |
| Facing Right Bank (4) | 200 |
| Facing Downstream (5) | 201 |
| From edge of Riparian on left (6) | 203 |
| From edge of Riparian on right (7) | 202 |

**General Comments:**

Small channel steep sides, rocky bottom. Dry
heavily vegetated with [illegible]
amounts of bank erosion. [illegible]
scattered xanthorrhea's

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

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**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

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- □*Eucalyptus sp.,* □□□d□□□□□□□d
- **Dodonaea lanceolata var. sessiliflora*
- **Acacia sp.,* □□□d□□□□□□□d
- **Passiflora suberosa*
- **Glochidion lobocarpum*
- **Timonius timon*
- **Conyza sumatrensis*
- **Lomandra sp.,* □□□d□□□□□□□d
- **Breynia oblongifolia*
- **Stephania japonica*
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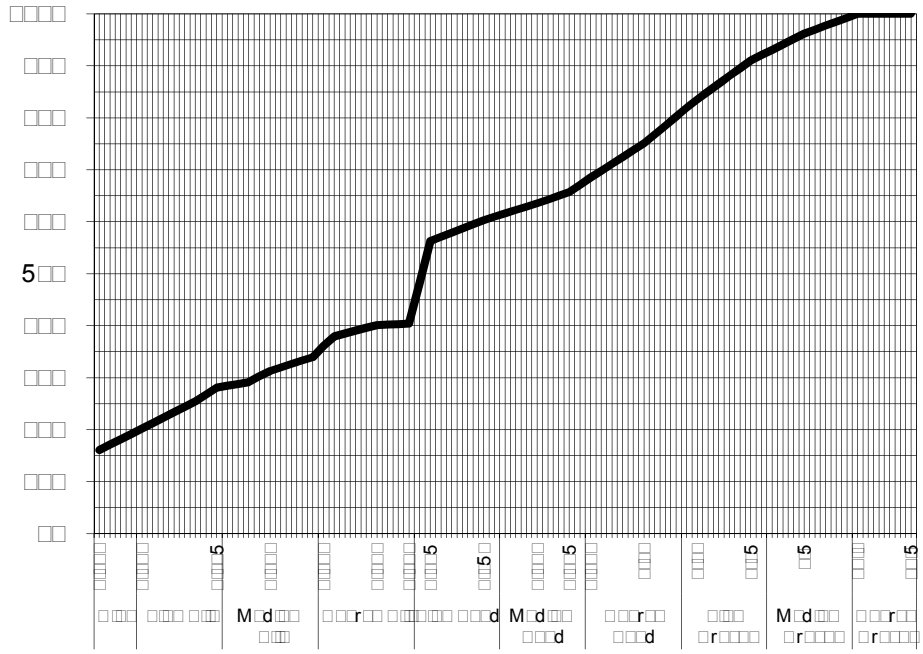
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**



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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*


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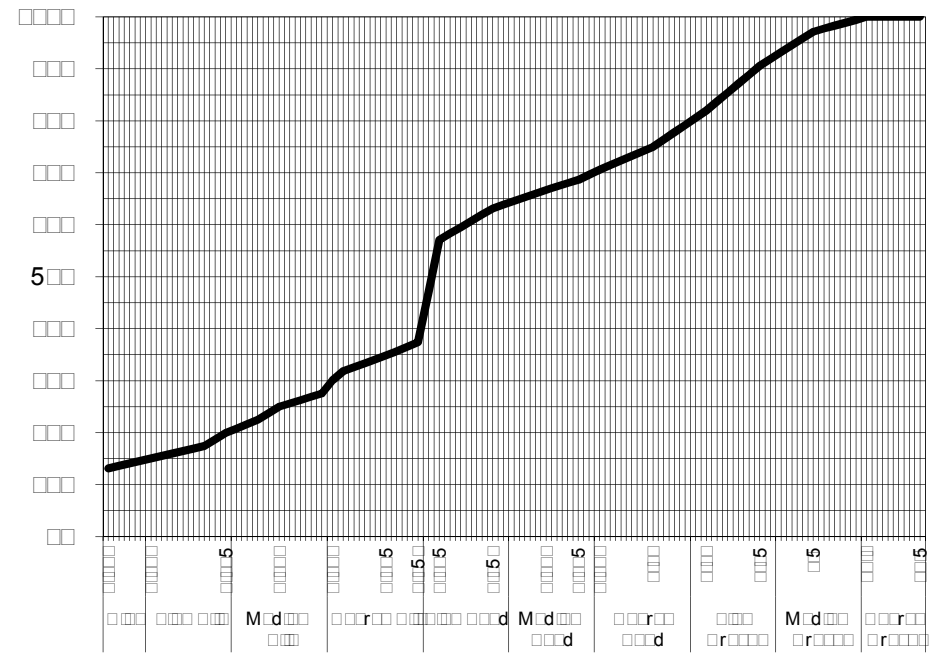
# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

**Dianne Blane**

***Authorised Signatory***















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Santos
GLNG Project

# APPENDIX B MINOR WATERCOURSES

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GLNG Project

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings | RoW Width(m) |
|---|---|---|---|---|---|---|---|
| Unnamed Minor watercourse 1 | 13.583 | 1 | | Non-remnant | 689073.571 | 7161699.367 | 40 |
| Unnamed Minor watercourse 2 | 15.503 | 1 | | Non-remnant | 688151.664 | 7163290.501 | 30 |
| Unnamed Minor watercourse 3 | 17.462 | 1 | | Non-remnant | 688353.794 | 7165050.531 | 40 |
| Unnamed Minor watercourse 4 | 18.969 | 2 | | Non-remnant | 688203.144 | 7166412.517 | 40 |
| Unnamed Minor watercourse 5 | 21.097 | 1 | | Non-remnant | 687757.223 | 7168362.222 | 30 |
| Unnamed Minor watercourse 6 | 22.003 | 2 | Least concern | 11.10.3/11.3.25 | 688185.118 | 7169093.687 | 30 |
| Unnamed Minor watercourse 7 | 23.064 | 1 | | Non-remnant | 689040.225 | 7169706.349 | 30 |
| Unnamed Minor watercourse 8 | 23.847 | 1 | | Non-remnant | 688935.408 | 7170462.902 | 40 |
| Unnamed Minor watercourse 9 | 24.885 | 2 | Least concern | 11.10.1 | 688814.459 | 7171404.723 | 30 |
| Unnamed Minor watercourse 10 | 30.591 | 1 | Of concern | 11.3.2 | 690702.763 | 7175865.562 | 30 |
| Gratz Gully | 31.341 | 2 | | Non-remnant | 690957.311 | 7176570.921 | 30 |
| Gratz Gully | 32.499 | 2 | Of concern | 11.3.17 | 690946.081 | 7177671.350 | 30 |
| Unnamed Minor watercourse 11 | 32.570 | 2 | Of concern | 11.3.17 | 690925.521 | 7177739.308 | 30 |
| Unnamed Minor watercourse 12 | 35.174 | 1 | Endangered | 11.9.5/11.9.5a | 690171.030 | 7180232.589 | 30 |

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|---|---|---|---|---|---|---|---|
| Unnamed Minor watercourse 13 | 39.256 | 1 | | Non-remnant | 690397.602 | 7184158.863 | 30 |
| Unnamed Minor watercourse 14 | 39.271 | 2 | | Non-remnant | 690394.381 | 7184174.821 | 40 |
| Unnamed Minor watercourse 15 | 40.396 | 1 | | Non-remnant | 690171.747 | 7185277.682 | 35 |
| Unnamed Minor watercourse 16 | 43.466 | 1 | | Non-remnant | 689730.897 | 7188245.524 | 35 |
| Unnamed Minor watercourse 17 | 43.497 | 1 | | Non-remnant | 689731.705 | 7188276.623 | 35 |
| Unnamed Minor watercourse 18 | 43.527 | 1 | | Non-remnant | 689732.487 | 7188306.743 | 40 |
| Unnamed Minor watercourse 19 | 48.911 | 1 | | Non-remnant | 690616.837 | 7193500.002 | 40 |
| Unnamed Minor watercourse 20 | 53.252 | 1 | | Non-remnant | 689185.839 | 7197578.946 | 35 |
| Unnamed Minor watercourse 21 | 65.647 | 2 | | Non-remnant | 686445.504 | 7209513.642 | 40 |
| Unnamed Minor watercourse 22 | 67.569 | 1 | | Non-remnant | 685706.309 | 7211287.970 | 40 |
| Unnamed Minor watercourse 23 | 67.804 | 1 | | Non-remnant | 685607.095 | 7211500.027 | 30 |
| Unnamed Minor watercourse 24 | 69.224 | 1 | | Non-remnant | 685033.621 | 7212799.162 | 30 |
| Unnamed Minor watercourse 25 | 69.542 | 1 | | Non-remnant | 684923.117 | 7213095.390 | 30 |
| Unnamed Minor watercourse 94 | 202.562 | 2 | | Non-remnant | 759847.953 | 7287752.881 | 40 |
| Unnamed Minor watercourse 95 | 204.795 | 1 | | Non-remnant | 761964.851 | 7288450.714 | 40 |
| Unnamed Minor watercourse 96 | 204.855 | 1 | | Non-remnant | 762022.594 | 7288464.711 | 40 |

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|---|---|---|---|---|---|---|---|
| Unnamed Minor watercourse 97 | 206.639 | 2 | | Non-remnant | 763685.541 | 7289110.035 | 40 |
| Unnamed Minor watercourse 98 | 207.955 | 2 | | Non-remnant | 764912.878 | 7289573.924 | 40 |
| Unnamed Minor watercourse 99 | 213.548 | 2 | | Non-remnant | 770412.644 | 7290535.435 | 40 |
| Unnamed Minor watercourse 100 | 221.390 | 1 | | Non-remnant | 777716.656 | 7290542.240 | 40 |
| Unnamed Minor watercourse 101 | 224.968 | 1 | | Non-remnant | 781177.035 | 7290008.247 | 40 |
| Unnamed Minor watercourse 102 | 225.003 | 1 | | Non-remnant | 781208.581 | 7289992.941 | 40 |
| Unnamed Minor watercourse 103 | 238.013 | 1 | | Non-remnant | 792109.139 | 7295098.736 | 40 |
| Unnamed Minor watercourse 104 | 238.312 | 1 | | Non-remnant | 792409.388 | 7295094.015 | 40 |
| Unnamed Minor watercourse 105 | 245.522 | 2 | | Non-remnant | 798861.762 | 7297236.812 | 40 |
| Unnamed Minor watercourse 108 | 254.594 | 1 | | Non-remnant | 197584.976 | 7301155.482 | 40 |
| Unnamed Minor watercourse 109 | 255.552 | 1 | | Non-remnant | 198490.869 | 7301463.129 | 40 |
| Unnamed Minor watercourse 110 | 258.240 | 1 | | Non-remnant | 201047.407 | 7302284.536 | 40 |
| Unnamed Minor watercourse 111 | 258.740 | 1 | | Non-remnant | 201531.842 | 7302405.036 | 40 |
| Unnamed Minor watercourse 112 | 260.971 | 1 | | Non-remnant | 203684.268 | 7302905.087 | 40 |
| Unnamed Minor watercourse 113 | 261.944 | 1 | | Non-remnant | 204636.994 | 7302714.323 | 40 |
| Unnamed Minor watercourse 114 | 265.540 | 1 | | Non-remnant | 208168.278 | 7302182.336 | 40 |

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|---|---|---|---|---|---|---|---|
| Unnamed Minor watercourse 115 | 266.257 | 1 | | Non-remnant | 208881.365 | 7302102.757 | 40 |
| Unnamed Minor watercourse 116 | 266.889 | 1 | | Non-remnant | 209508.847 | 7302032.701 | 40 |
| Unnamed Minor watercourse 117 | 271.791 | 1 | | Non-remnant | 213867.038 | 7304005.136 | 40 |
| Unnamed Minor watercourse 118 | 278.750 | 1 | | Non-remnant | 220312.575 | 7306350.022 | 30 |
| Unnamed Minor watercourse 119 | 280.055 | 2 | | Non-remnant | 221579.097 | 7306645.208 | 30 |
| Unnamed Minor watercourse 120 | 280.100 | 2 | | Non-remnant | 221614.928 | 7306628.620 | 30 |
| Unnamed Minor watercourse 121 | 280.586 | 1 | | Non-remnant | 222041.890 | 7306563.397 | 40 |
| Unnamed Minor watercourse 122 | 283.559 | 2 | | Non-remnant | 224756.987 | 7307339.814 | 40 |
| Unnamed Minor watercourse 123 | 285.221 | 1 | | Non-remnant | 226251.339 | 7308049.772 | 40 |
| Unnamed Minor watercourse 124 | 288.588 | 1 | | Non-remnant | 229385.857 | 7309134.185 | 40 |
| Unnamed Minor watercourse 125 | 300.838 | 1 | | Non-remnant | 240999.445 | 7312135.960 | 40 |
| Unnamed Minor watercourse 126 | 307.168 | 2 | | Non-remnant | 247047.326 | 7313854.935 | 40 |
| Unnamed Minor watercourse 127 | 307.713 | 2 | | Non-remnant | 247547.526 | 7314070.853 | 40 |
| Unnamed Minor watercourse 128 | 307.976 | 2 | | Non-remnant | 247789.954 | 7314175.492 | 30 |
| Unnamed Minor watercourse 129 | 315.533 | 1 | Least concern | 11.3.26 | 253761.523 | 7318668.064 | 30 |
| Unnamed Minor watercourse 130 | 317.935 | 2 | | Non-remnant | 255770.295 | 7319715.113 | 30 |

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| Unnamed Minor watercourse 131 | 318.406 | 1 | Least concern | 11.11.15/11.3.25/11.11.4/11.11.4a | 256225.326 | 7319704.412 | 30 |
| Unnamed Minor watercourse 132 | 318.709 | 1 | | Non-remnant | 256528.877 | 7319700.191 | 30 |
| Unnamed Minor watercourse 133 | 320.524 | 2 | Least concern | 11.11.15/11.11.4 | 257976.049 | 7319734.756 | 30 |
| Unnamed Minor watercourse 134 | 320.639 | 2 | Least concern | 11.11.15/11.11.4 | 258052.595 | 7319821.134 | 30 |
| Unnamed Minor watercourse 135 | 323.817 | 1 | Least concern | 11.11.15/11.11.4 | 261046.239 | 7319657.000 | 30 |
| Unnamed Minor watercourse 136 | 328.370 | 1 | Least concern | 11.11.15//11.11.4 | 264606.610 | 7321100.907 | 30 |
| Unnamed Minor watercourse 137 | 331.483 | 1 | | Non-remnant | 265855.261 | 7323415.752 | 40 |
| Unnamed Minor watercourse 138 | 332.757 | 1 | | Non-remnant | 266046.936 | 7324634.837 | 40 |
| Unnamed Minor watercourse 139 | 333.012 | 2 | | Non-remnant | 266142.325 | 7324846.872 | 40 |
| Unnamed Minor watercourse 140 | 333.951 | 2 | | Non-remnant | 266359.762 | 7325741.899 | 30 |
| Unnamed Minor watercourse 141 | 338.834 | 2 | | Non-remnant | 269290.150 | 7329233.100 | 40 |
| Unnamed Minor watercourse 142 | 343.446 | 2 | | Non-remnant | 273026.663 | 7331633.925 | 40 |
| Unnamed Minor watercourse 143 | 344.259 | 1 | | Non-remnant | 273808.859 | 7331855.017 | 30 |
| Unnamed Minor watercourse 144 | 345.586 | 2 | | Non-remnant | 275079.892 | 7332234.414 | 40 |
| Unnamed Minor watercourse 145 | 346.776 | 2 | | Non-remnant | 276148.879 | 7332757.776 | 40 |

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|---|---|---|---|---|---|---|---|
| Unnamed Minor watercourse 146 | 348.634 | 1 | | Non-remnant | 277867.111 | 7333455.022 | 40 |
| Unnamed Minor watercourse 147 | 348.649 | 2 | | Non-remnant | 277881.733 | 7333461.080 | 40 |
| Unnamed Minor watercourse 148 | 348.666 | 2 | | Non-remnant | 277897.778 | 7333467.727 | 40 |
| Unnamed Minor watercourse 149 | 349.182 | 2 | | Non-remnant | 278373.098 | 7333664.635 | 40 |
| Unnamed Minor watercourse 150 | 349.259 | 2 | | Non-remnant | 278414.154 | 7333722.278 | 40 |
| Unnamed Minor watercourse 151 | 350.160 | 1 | | Non-remnant | 278635.469 | 7334583.969 | 40 |
| Unnamed Minor watercourse 195 | 400.028 | 1 | | Non-remnant | 302507.211 | 7370232.086 | 40 |
| Unnamed Minor watercourse 196 | 400.134 | 1 | | Non-remnant | 302584.911 | 7370297.987 | 40 |
| Unnamed Minor watercourse 197 | 400.257 | 1 | | Non-remnant | 302650.495 | 7370400.322 | 40 |
| Unnamed Minor watercourse 198 | 400.797 | 1 | Endangered | 11.11.15/11.11.18/ 11.11.3 | 302989.857 | 7370815.019 | 30 |
| Unnamed Minor watercourse 199 | 401.077 | 1 | Endangered | 11.11.15/11.11.18/ 11.11.3 | 303197.774 | 7371002.748 | 30 |
| Unnamed Minor watercourse 200 | 402.480 | 1 | | Non-remnant | 304338.563 | 7371731.056 | 40 |
| Unnamed Minor watercourse 201 | 402.509 | 1 | | Non-remnant | 304365.426 | 7371744.318 | 40 |
| Unnamed Minor watercourse 205 | 416.137 | 1 | Endangered | 12.3.3/12.3.7 | 316529.995 | 7372579.587 | 30 |
| Unnamed Minor watercourse 206 | 418.172 | 1 | Of concern | 12.11.6/12.11.14 | 317560.764 | 7370883.328 | 30 |

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# APPENDIX D2 – Aquatic Values Assessment for Minor Watercourses KP70-200

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## Aquatic Values Assessment for Minor Watercourses KP 70 to KP200

Document Number: 3380-GLNG-4-1.3-0078

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A.Hampson | | 14/5/12 |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| FRC Aquatic Ecologists | L.Thorburn | | 14/5/12 |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | I.Bridge | | 14/5/12 |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 4/4/12 | A | For review | AH | AW | IB |
| 14/05/12 | 0 | Draft | AH | LT | IB |
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[illegible] *Citrus gauca* [illegible] *Geijera parviflora* [illegible] *Acacia harpophylla.*

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**Figure 4** **Photograph** **of** **the** **proposed** **Project** **area** **showing** **the** **vegetation** **and** **topography** **in** **the** **area**

## 5.5 Flora and Fauna

Flora and fauna in the project area are described in Section 5.5. The flora and fauna survey was undertaken in accordance with the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (DEWHA 2009) and the Queensland Nature Conservation Act 1992. The survey was undertaken by a team of experienced ecologists and botanists. The survey methodology is described in detail in Section 5.5.

The flora survey identified 350 species of vascular plants in the project area. Of these, 10 species are listed as threatened under the Queensland Nature Conservation Act 1992 or the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. These species are *Citrus glauca* and *Lysiphyllum*.

The fauna survey recorded 120 species of vertebrates in the project area. Of these, 5 species are listed as threatened under the Queensland Nature Conservation Act 1992 or the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.



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Figure 5-1 Typical Gully Erosion Observed in Project Area

## 5.2 Soil Management Practices

Soil management practices are required to minimise the potential for soil erosion and sedimentation to occur during construction activities. Soil management practices are also required to maintain the quality of soil resources for rehabilitation purposes.

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[illegible] *Juncus aridicola, Vachellia bidwillii, Petalostigma pubescens* [illegible] *Eucalyptus melanophloia.*

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[illegible] *Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual* [illegible]

[illegible] *AS2885.1 Pipelines—Gas and liquid petroleum.* [illegible]

[illegible] *GLNG Environmental Impact Statement* [illegible]

*Water Act 2000* [illegible]

*Water Regulation 2002* [illegible]

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## Gas Transmission Pipeline

## Field Data Sheet for Watercourse Assessments

Document Number: 3380-GLNG-4-1.3-0047

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A.Hampson | | 18/1/12 |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Coordinator | B.Angus | | 18/1/12 |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | I.Bridge | | 18/1/12 |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
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| 4/01/12 | A | For Review | AH | BA | IB |
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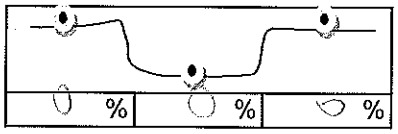
**FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT**

Date 15/3/12 KP Point 75.73 Eastings 681755.73 Northings 7218329
Watercourse Name Unnamed 75.73 Distance from Source 15m AMTD ~2km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Comet Weather Fine
Rain in the Past week 20mm Time of Day 8am Cloud Cover (%) 100
flows into late Nyga Nyga.

**OBSERVATIONS**

Mean Channel width (m) 50cm
Height of Banks  Left 50 Right 50

Velocity (m/s): Flow metre N/A Floating object
Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive (Moderate) Limited None
Canopy cover % Width of riparian Zone (m): LB <1 RB <1




**Riparian vegetation**: Grass % 95 Shrubs %
Trees < 10m % 5 Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

grasses & small shrubs/trees

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % 30 |

**Bank Material** Dispersive/Sodic Y/N

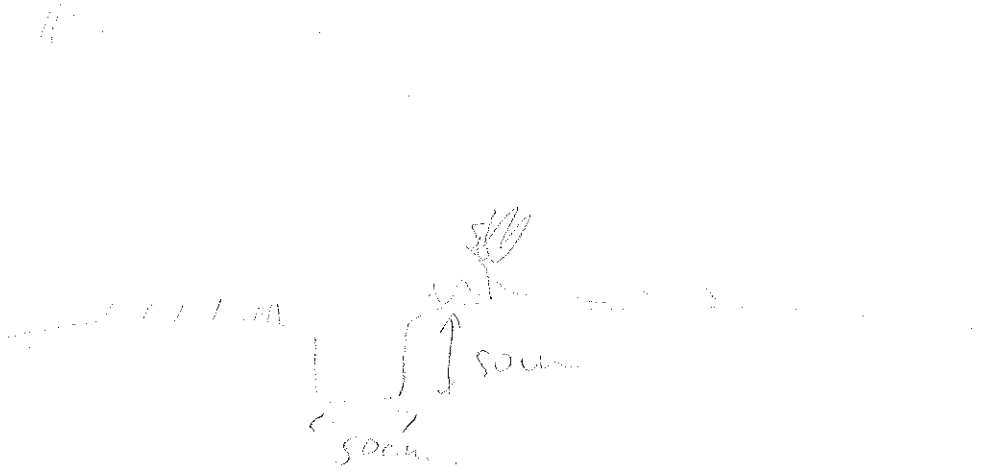
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

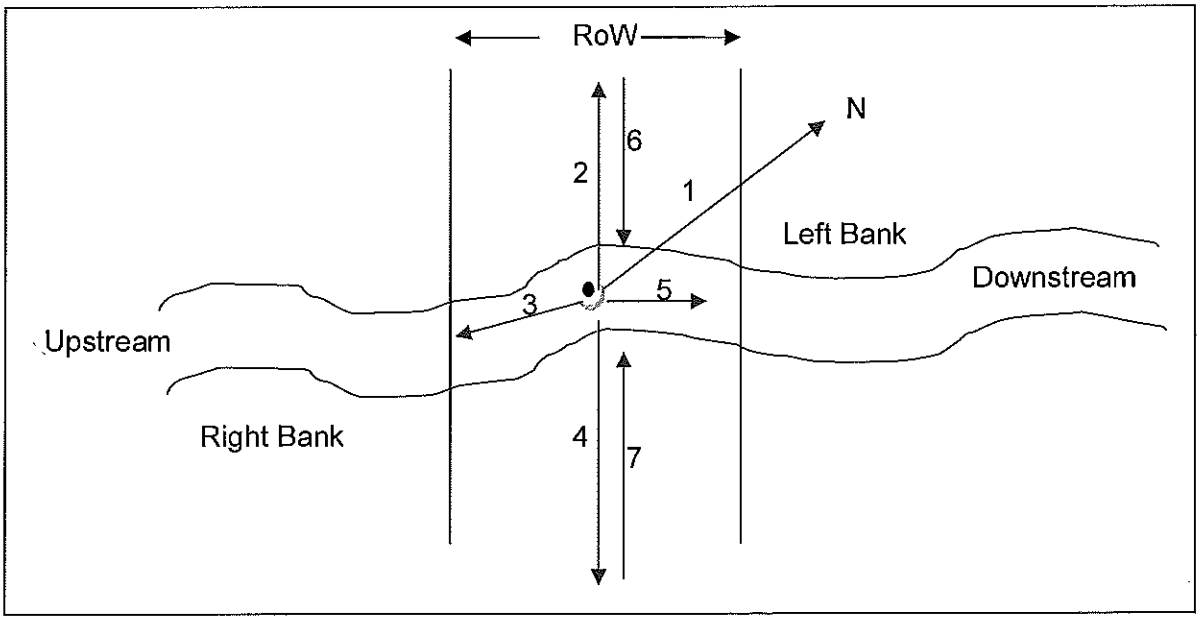
small drainage channel. with small eroded banks to the north.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 75_north |
| Facing left bank (2) | 75_2 |
| Facing Upstream (3) | 75_3 |
| Facing Right Bank (4) | 75_4 |
| Facing Downstream (5) | 75_5 |
| From edge of Riparian on left (6) | 75_6 |
| From edge of Riparian on right (7) | 75_7 |

**General Comments:**

small channel, mixed vegetation, comprising mainly of grasses and small trees. Heavy clay/sandy substrate.

Santos
GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP75.73**

Botanical specimens list:

- **Acacia sp.,* possibly *A. crassicarpa*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

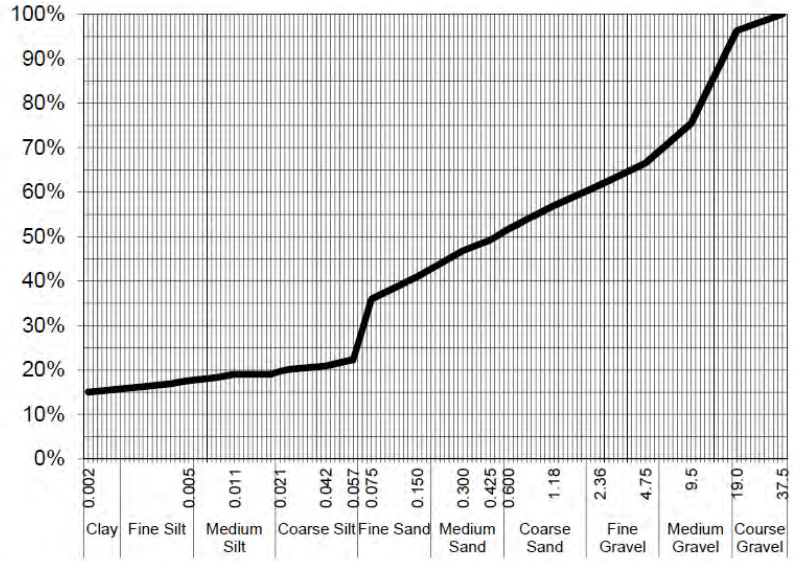
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-003 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP75.73 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| 37.5 | 100% |
| 19.0 | 96% |
| 9.5 | 75% |
| 4.75 | 67% |
| 2.36 | 62% |
| 1.18 | 57% |
| 0.600 | 52% |
| 0.425 | 49% |
| 0.300 | 47% |
| 0.150 | 41% |
| 0.075 | 36% |
| Particle Size (microns) | |
| 57 | 22% |
| 42 | 21% |
| 21 | 20% |
| 11 | 19% |
| 5 | 18% |
| 4 | 17% |
| 2 | 15% |

| Median Particle Size (mm) | 0.425 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Gravel, sand and silty clay

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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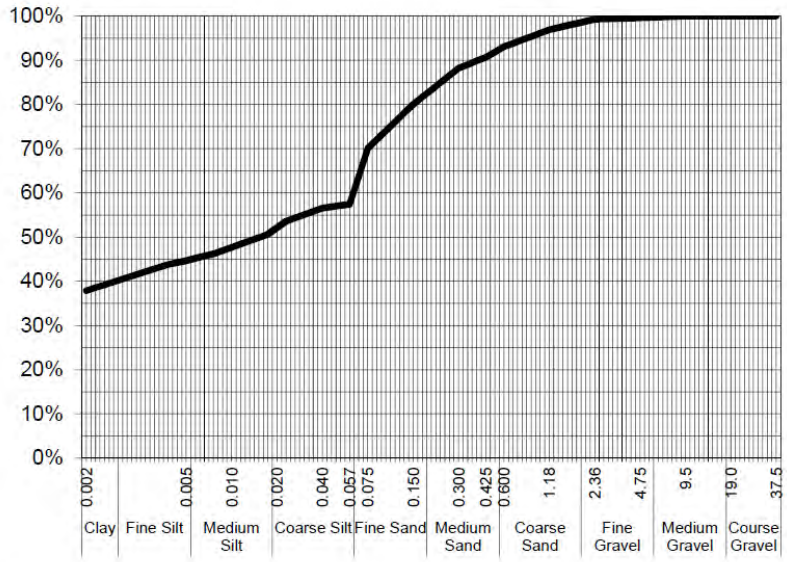
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-004 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP75.73 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 97% |
| 0.600 | 93% |
| 0.425 | 91% |
| 0.300 | 88% |
| 0.150 | 80% |
| 0.075 | 70% |
| Particle Size (microns) | |
| 57 | 57% |
| 40 | 57% |
| 20 | 52% |
| 10 | 48% |
| 5 | 45% |
| 4 | 44% |
| 2 | 38% |

| | |
|---|---|
| Median Particle Size (mm) | 0.017 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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# Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12.1.12 KP Point 35.69 Eastings 679261.7 Northings 7228918
Watercourse Name Un-named Distance from Source 3.5 km AMTD 4.9 km
Stream Order 2 Photo taken of access track Y/N
Catchment Area Comet Weather Fine
Rain in the Past week NIL Time of Day 11am Cloud Cover (%) 50

---

**OBSERVATIONS**

Mean Channel width (m) 0.5

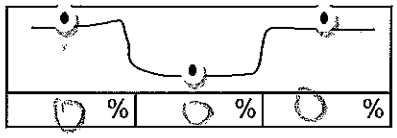
Height of Banks  Left 0.2 Right 0.2

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB RB




---

**Riparian vegetation**: Grass % 98 Shrubs % 3
Trees < 10m % 2 Trees > 10m %

- Collect samples and produce species list after identification (refer to guide)

Notes: Very few trees
Bigalow

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

Notes: Heavily cleared - good grass cover
A few shrubs + trees < 10m

# Santos
## GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

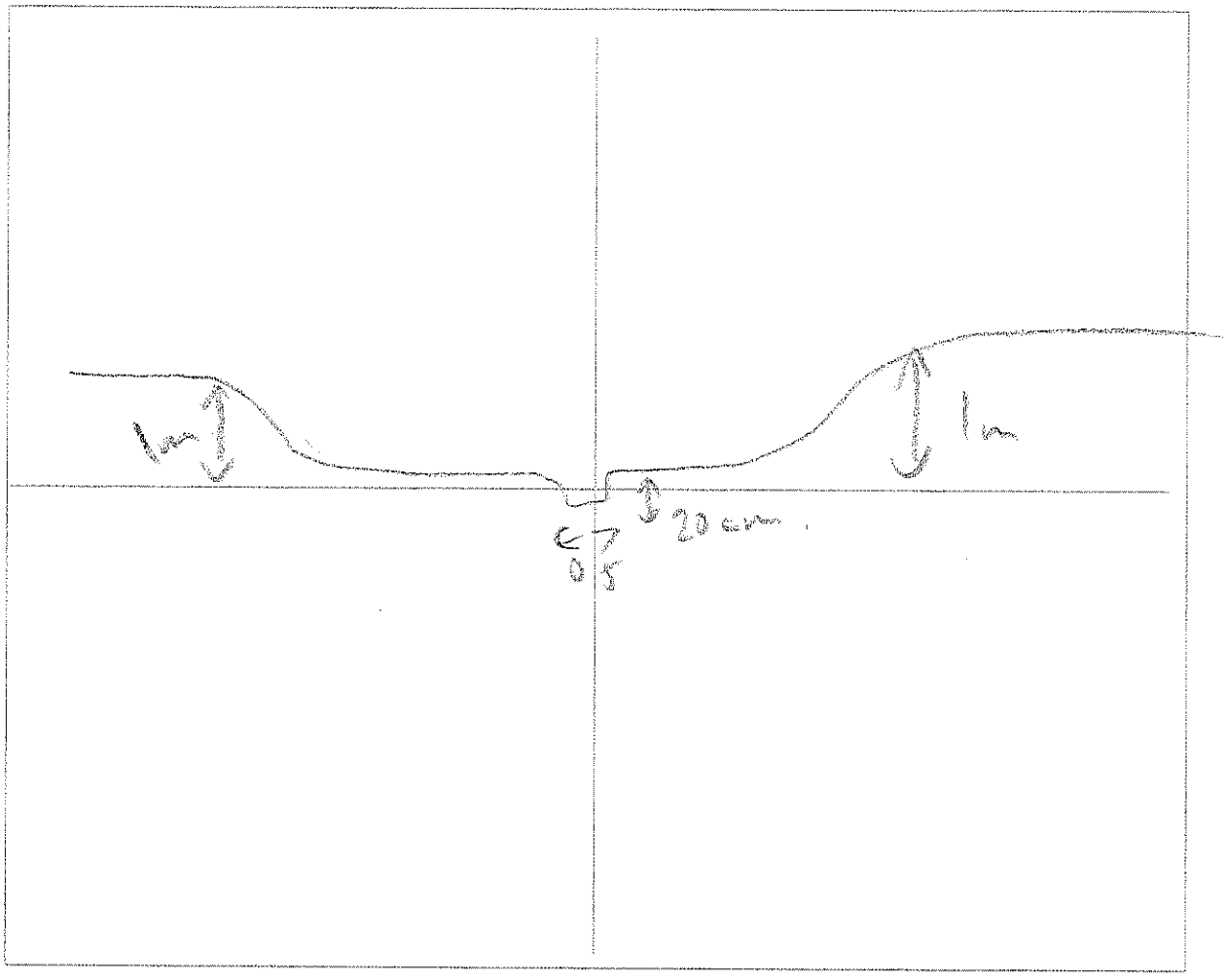
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

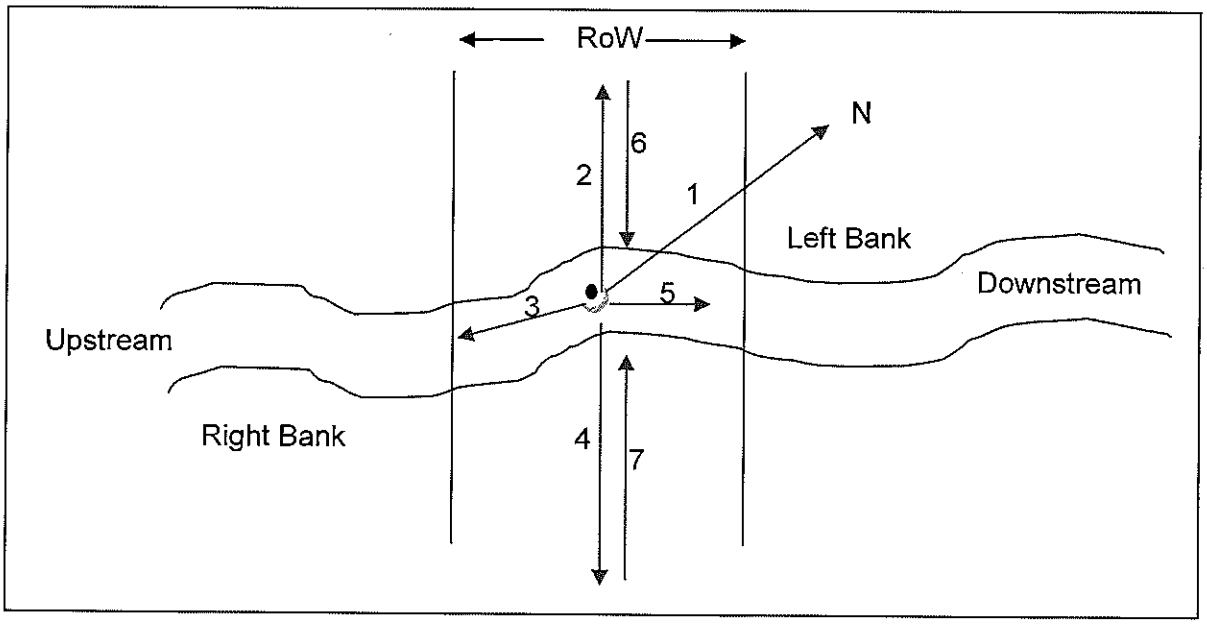
Shallow eroded depression

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 106 |
| Facing left bank (2) | 107 |
| Facing Upstream (3) | 108 |
| Facing Right Bank (4) | 109 |
| Facing Downstream (5) | 110 |
| From edge of Riparian on left (6) | 111 |
| From edge of Riparian on right (7) | 0112 |

**General Comments:**

Shallow eroded depression. Good grass cover.
Cracking clay soils. Few brigalow. Heavily disturbed.

Un-named trib of Brown River

(86.1 -> very shallow -> no veg)

Santos
GLNG Project

**Is water present?** Y/(N) If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**KP85.6**

Botanical specimens list:

- **Acacia* sp., unidentified
- **Alectryon* sp., possibly *A. diversifolius*
- **Citrus glauca*
- **Geijera parviflora*
- Brigalow

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

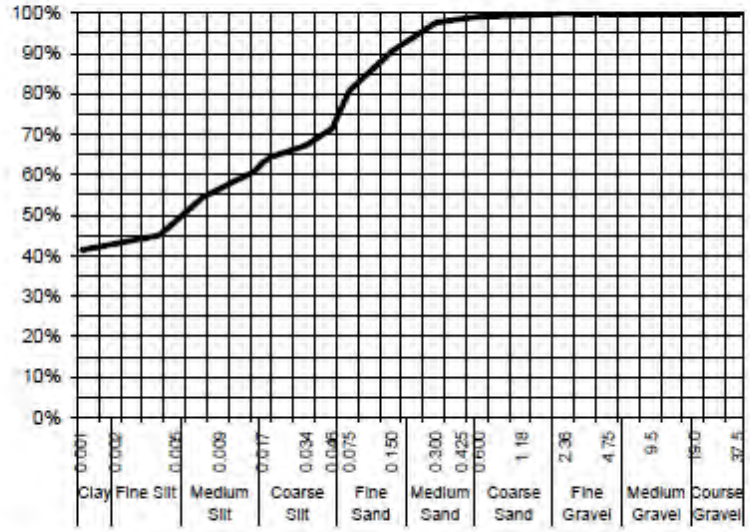
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
ph 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 20-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 13-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1201003-011 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP85.6 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 99% |
| 0.425 | 99% |
| 0.300 | 98% |
| 0.150 | 91% |
| 0.075 | 81% |
| Particle Size (microns) | |
| 46 | 71% |
| 34 | 67% |
| 17 | 63% |
| 9 | 57% |
| 5 | 49% |
| 3 | 45% |
| 1 | 41% |

| | |
|---|---|
| Median Particle Size (mm) | 0.005 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 18-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
*Authorised Signatory*

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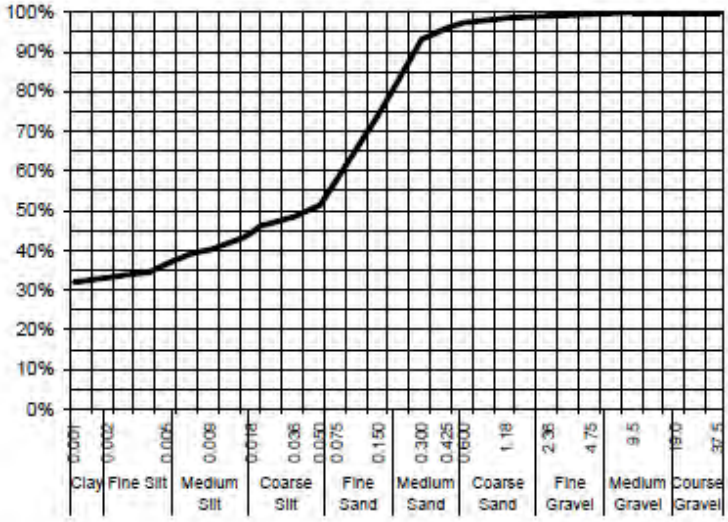
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 20-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 13-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1201003-012 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP85.6 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 99% |
| 2.36 | 99% |
| 1.18 | 98% |
| 0.600 | 97% |
| 0.425 | 96% |
| 0.300 | 93% |
| 0.150 | 75% |
| 0.075 | 58% |
| Particle Size (microns) | |
| 50 | 51% |
| 36 | 49% |
| 18 | 45% |
| 9 | 40% |
| 5 | 37% |
| 3 | 35% |
| 1 | 32% |

| | |
|---|---|
| Median Particle Size (mm) | 0.043 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 18-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
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r□□□r□□□ □□ □□5□□□

**Santos**
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 16/3/12 KP Point 86.02 Eastings 679288 Northings 7228301
Watercourse Name Membrance Ck Distance from Source 7km AMTD 3.7km
Stream Order 2/3 Photo taken of access track Y/N
Catchment Area Lake Nuga Nuga Weather aucent.
Rain in the Past week 40mL Time of Day 10am Cloud Cover (%) 95

---

**OBSERVATIONS**

Mean Channel width (m) 2m.

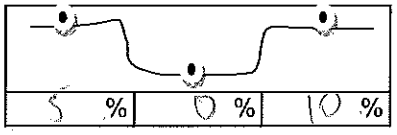
Height of Banks  Left 50cm Right 80cm.

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 5 RB 10




---

**Riparian vegetation**: Grass % 70 Shrubs % 10
Trees < 10m % 15 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

mostly grasses & scattered ironbarks

# Santos
GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/Sodic Y/N

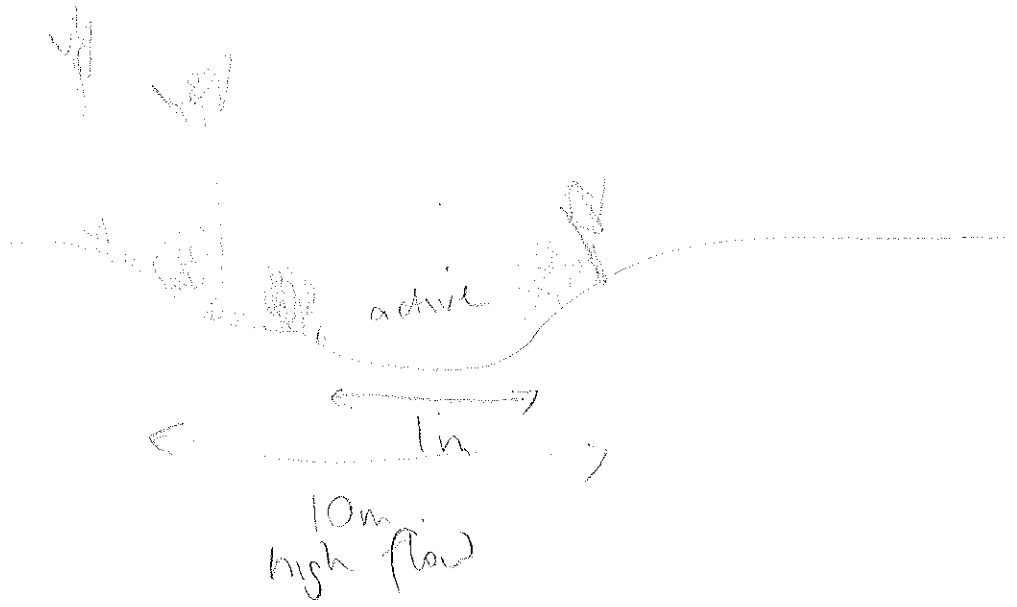
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

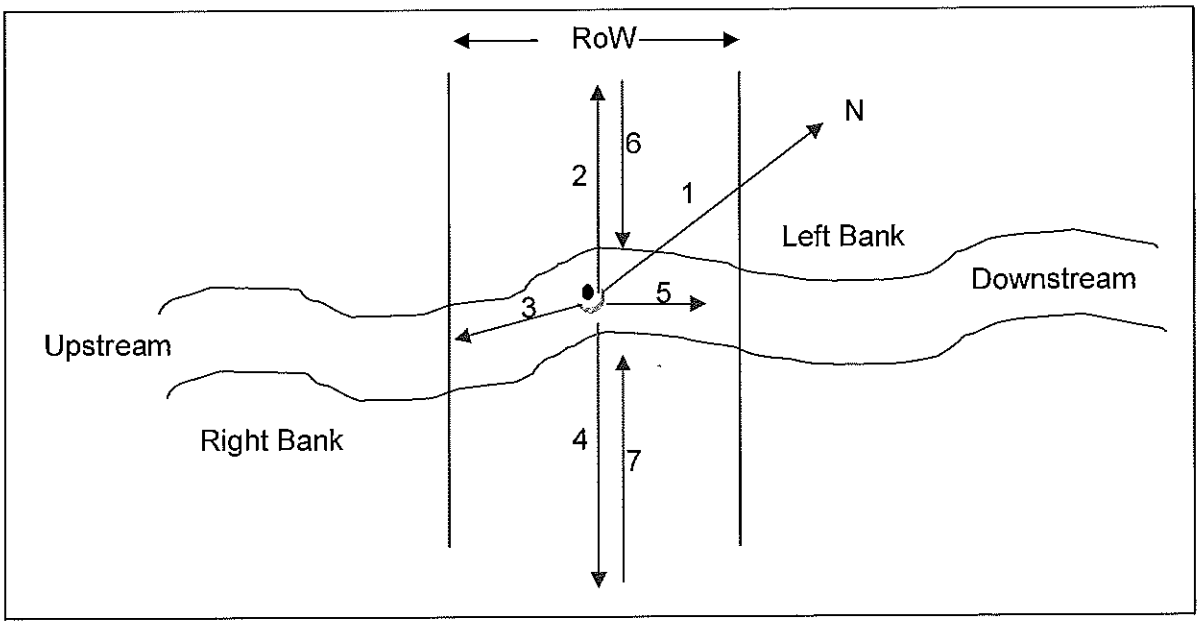
Small windy drained, dry, In active channel. Cracking clay substrate.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 86_1 |
| Facing left bank (2) | 86_2 |
| Facing Upstream (3) | 86_3 |
| Facing Right Bank (4) | 86_4 |
| Facing Downstream (5) | 86_5 |
| From edge of Riparian on left (6) | 86_6 |
| From edge of Riparian on right (7) | 86_7 |

**General Comments:**

small windy channel heavy veg cover consisting mainly grasses & scattered shrubs & trees. Flow would reduce heavy rainfall.

Santos

GLNG Project

**Is water present? Yes/No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP86.02**

Botanical specimens list:

- **Acacia sp.,* possibly *A. crassicarpa*
- **Alectryon diversifolius*
- **Citrus glauca*
- **Geijera parviflora*
- **Lysiphyllum carronii*
- Ironbark

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

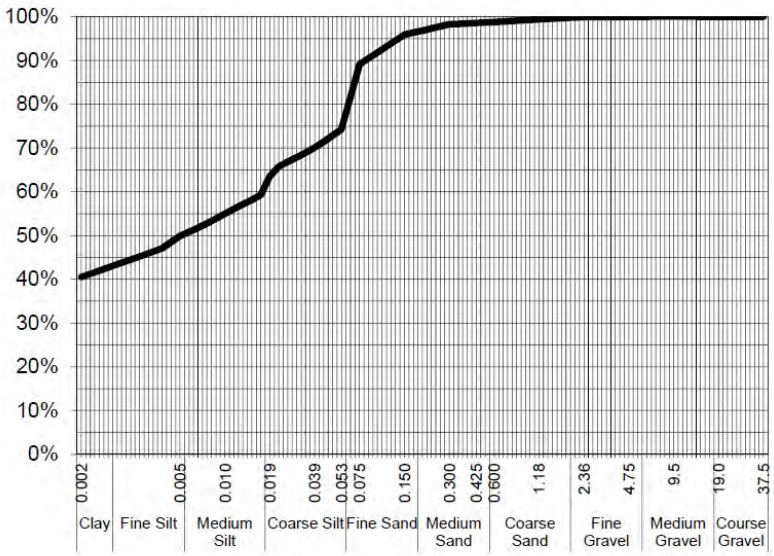
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-005 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP86.02 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 99% |
| 0.425 | 99% |
| 0.300 | 98% |
| 0.150 | 96% |
| 0.075 | 89% |
| Particle Size (microns) | |
| 53 | 74% |
| 39 | 70% |
| 19 | 63% |
| 10 | 55% |
| 5 | 50% |
| 4 | 47% |
| 2 | 41% |

| Median Particle Size (mm) | 0.006 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

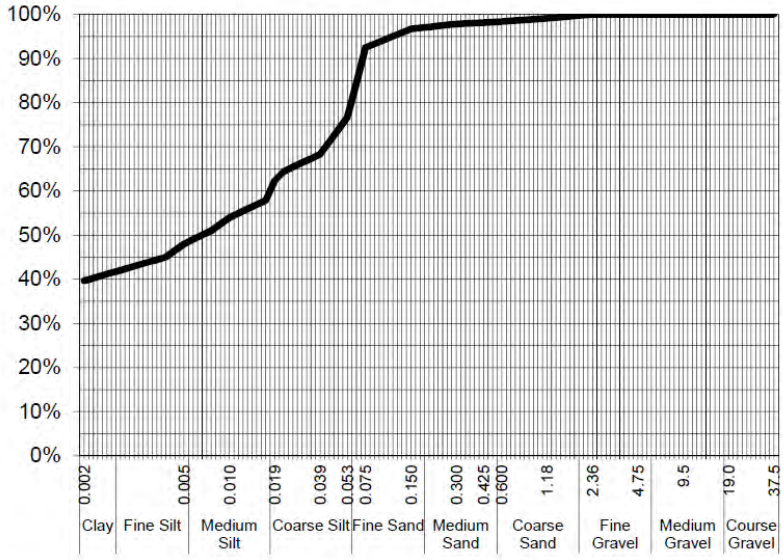
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-006 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP86.02 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 98% |
| 0.425 | 98% |
| 0.300 | 98% |
| 0.150 | 97% |
| 0.075 | 92% |
| Particle Size (microns) | |
| 53 | 77% |
| 39 | 68% |
| 19 | 62% |
| 10 | 54% |
| 5 | 48% |
| 4 | 45% |
| 2 | 40% |

| | |
|---|---|
| Median Particle Size (mm) | 0.007 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

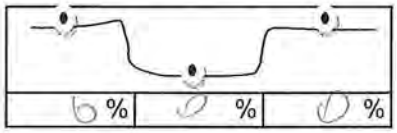
Date 15/3 KP Point 120.24 Eastings 688405.02 Northings 7258993
Watercourse Name unnamed. Distance from Source 1.86 km AMTD 3.5km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Land - Clematis Weather Overcast
Rain in the Past week Dry Time of Day 11:05 Cloud Cover (%) 95

---

**OBSERVATIONS**

Mean Channel width (m) 1-2m
Height of Banks  Left 80cm Right 80 cm

Velocity (m/s): Flow metre N/A Floating object _____
Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood
Bank Erosion (see guide): Extreme Extensive Moderate Limited None
Canopy cover % Width of riparian Zone (m): LB — RB —




---

**Riparian vegetation**: Grass % 90 Shrubs % _____
Trees < 10m % 10 Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

grasses and small trees.

# Santos
## GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % | |
| Boulder (>256mm) | % | Gravel (4-16mm) | % | |
| Cobble (64-256mm) | % | Sand (1-4mm) | % | 90 |
| | | Silt/clay (<1mm) | % | 10 |

**Bank Material** Dispersive/Sodic Y/N

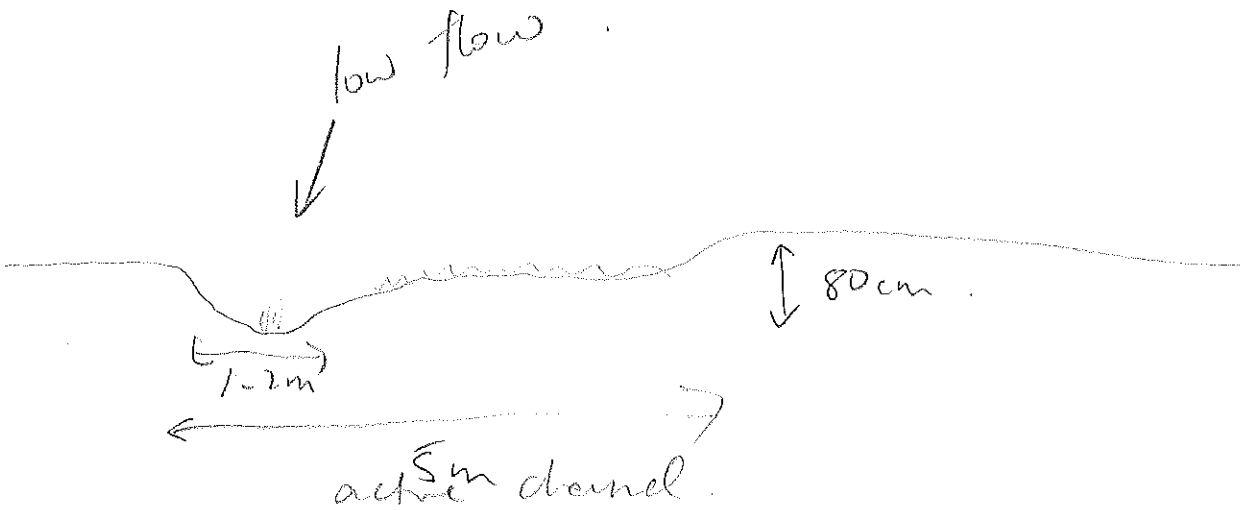
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

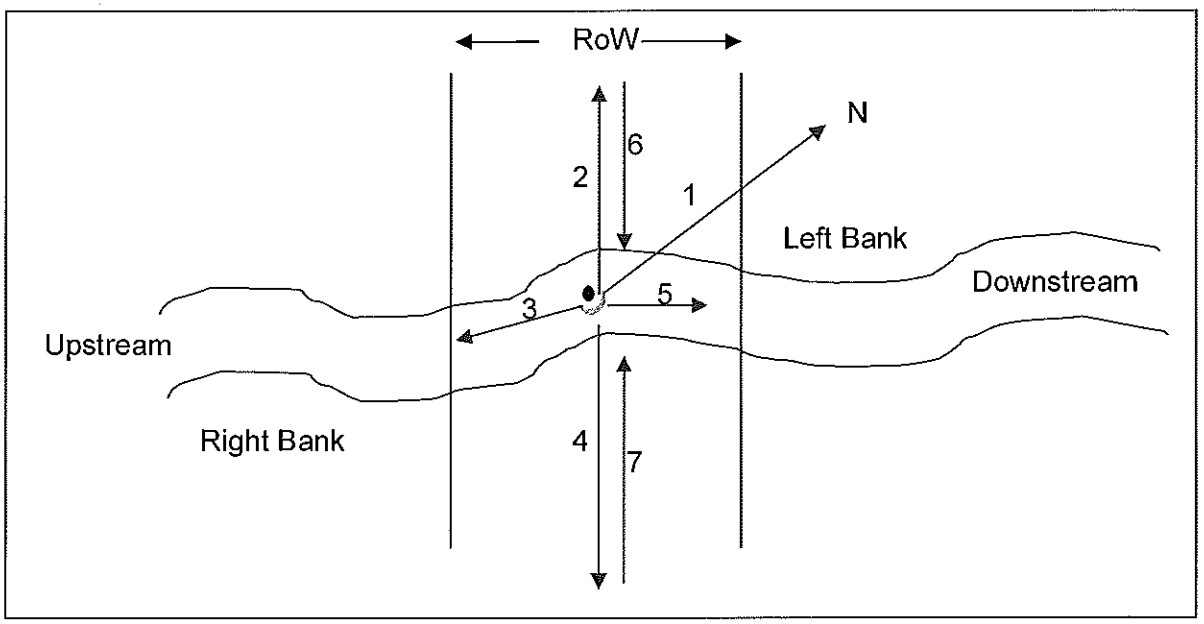
small channel, mostly grassed.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 120_upstream_low, 120_upstream_active |
| Facing Right Bank (4) | 120 |
| Facing Downstream (5) | 120_downstream_low, 120_downstream_active |
| From edge of Riparian on left (6) | 1 |
| From edge of Riparian on right (7) | 120_rip_right |

**General Comments:**

small channel, mostly grassed. Wide grassed active channel with small, moderately eroded low flow channel. Dry

Santos
GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP120.5**

Botanical specimens list:

- A*cacia sp.,* possibly *A. crassicarpa*

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

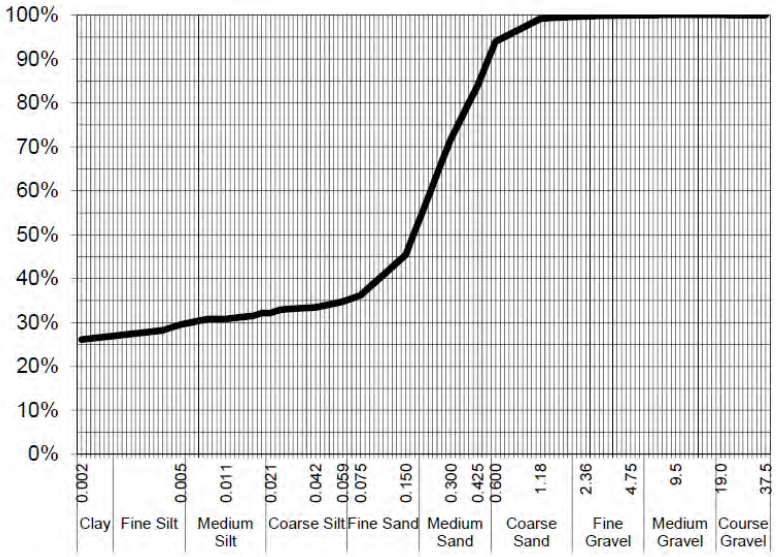
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-009 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP120.5 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 94% |
| 0.425 | 84% |
| 0.300 | 72% |
| 0.150 | 45% |
| 0.075 | 36% |
| Particle Size (microns) | |
| 59 | 35% |
| 42 | 33% |
| 21 | 32% |
| 11 | 31% |
| 5 | 30% |
| 4 | 28% |
| 2 | 26% |

| Median Particle Size (mm) | 0.150 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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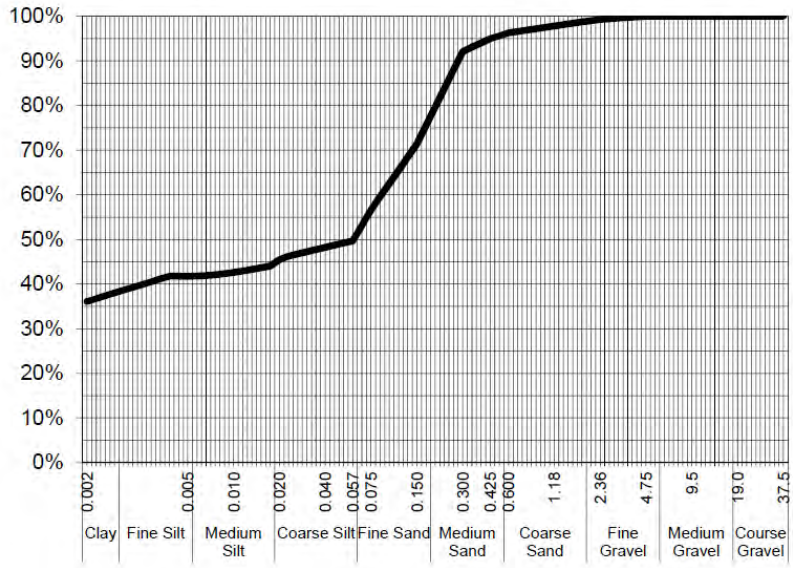
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-010 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP120.5 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 98% |
| 0.600 | 96% |
| 0.425 | 95% |
| 0.300 | 92% |
| 0.150 | 71% |
| 0.075 | 57% |
| Particle Size (microns) | |
| 57 | 50% |
| 40 | 48% |
| 20 | 45% |
| 10 | 43% |
| 5 | 42% |
| 4 | 42% |
| 2 | 36% |

| | |
|---|---|
| Median Particle Size (mm) | 0.057 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
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# Santos
## GLNG Project

**FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT**

Date 15/3/12 KP Point 125.35 Eastings 690592 Northings 7263616

Watercourse Name Unnamed Distance from Source 2km AMTD 700m.

Stream Order 2. Photo taken of access track Y/N

Catchment Area Comet - clematis Weather

Rain in the Past week 30ml Time of Day 1pm. Cloud Cover (%) 80

---

**OBSERVATIONS**

Mean Channel width (m) 3

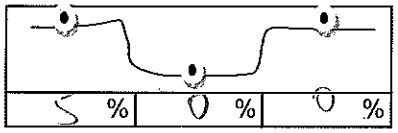
Height of Banks  Left 1.5 Right 1-5

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (≈watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB <1 RB <1




---

**Riparian vegetation**: Grass % 90 Shrubs %

Trees < 10m % 5 Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

mainly grasses & ironbark.

# Santos
## GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

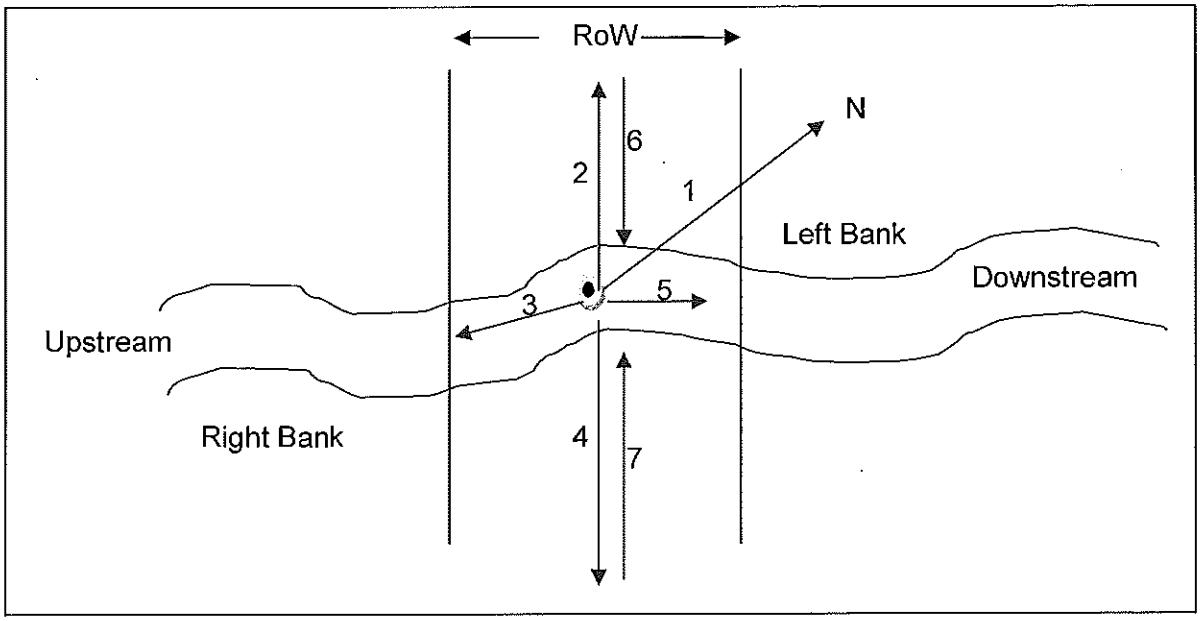
**General Comments / Reach Description:**
wide channel, eroded banks

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 125_1 |
| Facing left bank (2) | 125_2 |
| Facing Upstream (3) | 125_3 |
| Facing Right Bank (4) | 125_4 |
| Facing Downstream (5) | 125_5 |
| From edge of Riparian on left (6) | 125_6 |
| From edge of Riparian on right (7) | 125_7 |

**General Comments:**

wide channel, dry, few scattered trees on riparian veg, mainly wombat/Eucalypts relatively clear in crossing location, lower riparian is more pronounced upstream & downstream

Santos

GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP125.35**

Botanical specimens list:

- **Acacia* sp., possibly *A. crassicarpa*
- **Citrus glauca*
- **Lysiphyllumcarronii*
- Ironbark
- Eucalyptus

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

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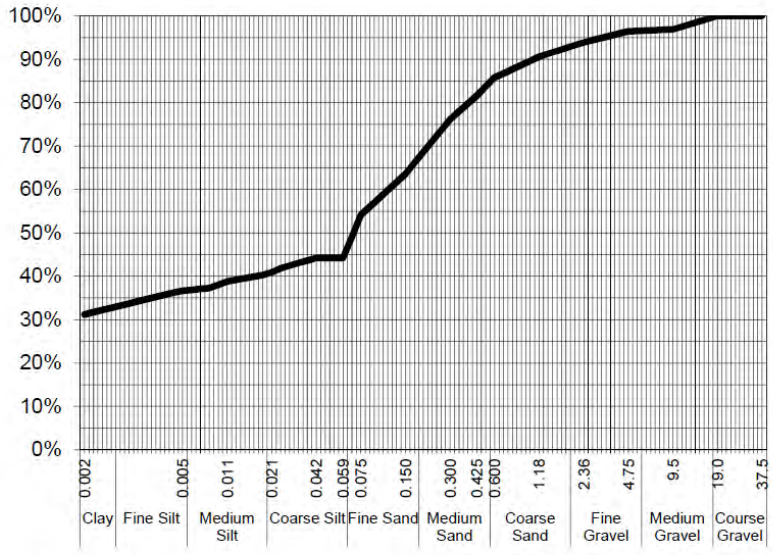
| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-011 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP125.35 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 97% |
| 4.75 | 96% |
| 2.36 | 94% |
| 1.18 | 91% |
| 0.600 | 86% |
| 0.425 | 82% |
| 0.300 | 76% |
| 0.150 | 64% |
| 0.075 | 54% |
| Particle Size (microns) | |
| 59 | 44% |
| 42 | 44% |
| 21 | 41% |
| 11 | 39% |
| 5 | 37% |
| 4 | 36% |
| 2 | 31% |

| | |
|---|---|
| Median Particle Size (mm) | 0.067 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***

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ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

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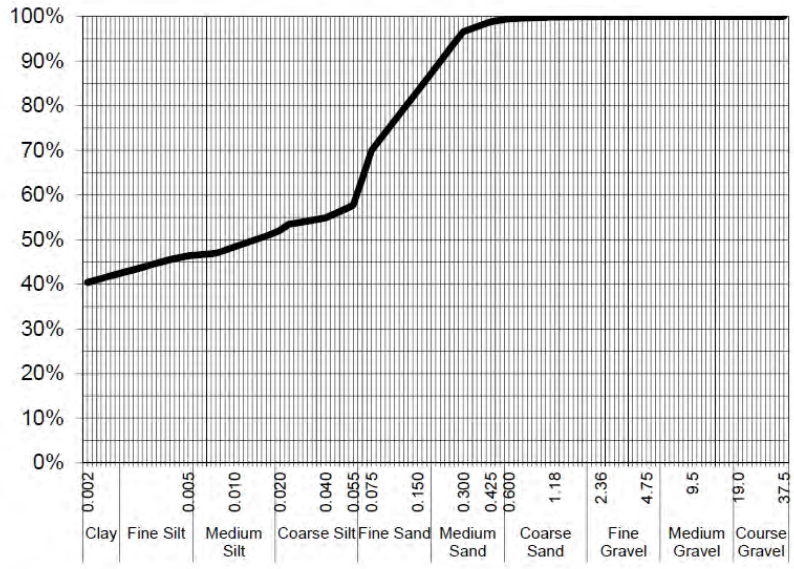
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-012 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP125.35 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 100% |
| 0.600 | 99% |
| 0.425 | 99% |
| 0.300 | 97% |
| 0.150 | 83% |
| 0.075 | 70% |
| Particle Size (microns) | |
| 55 | 58% |
| 40 | 55% |
| 20 | 52% |
| 10 | 48% |
| 5 | 46% |
| 4 | 46% |
| 2 | 40% |

| Median Particle Size (mm) | 0.015 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***















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r□□□r□□□ □□ □□□5□□5□

# Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 15/3/12 KP Point 27.52 Eastings _____ Northings _____

Watercourse Name _____ Distance from Source 420m. AMTD 3.6km

Stream Order 2. Photo taken of access track Y/N (Intercepted by dam)

Catchment Area Comet - clematis Weather Fine

Rain in the Past week 30ml. Time of Day 2pm. Cloud Cover (%) 70

---

**OBSERVATIONS**

Mean Channel width (m) 2m.

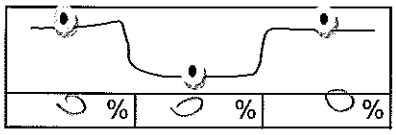
Height of Banks  Left 50cm Right 50cm.

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB — RB —




---

**Riparian vegetation**: Grass % 100 Shrubs % _____

Trees < 10m % _____ Trees > 10m % _____

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

grasses.

Santos
GLNG Project

| **Substrate Description:** | | | | |
|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % |
| | Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | | Silt/clay (<1mm) | % 100. Blackpool |

**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

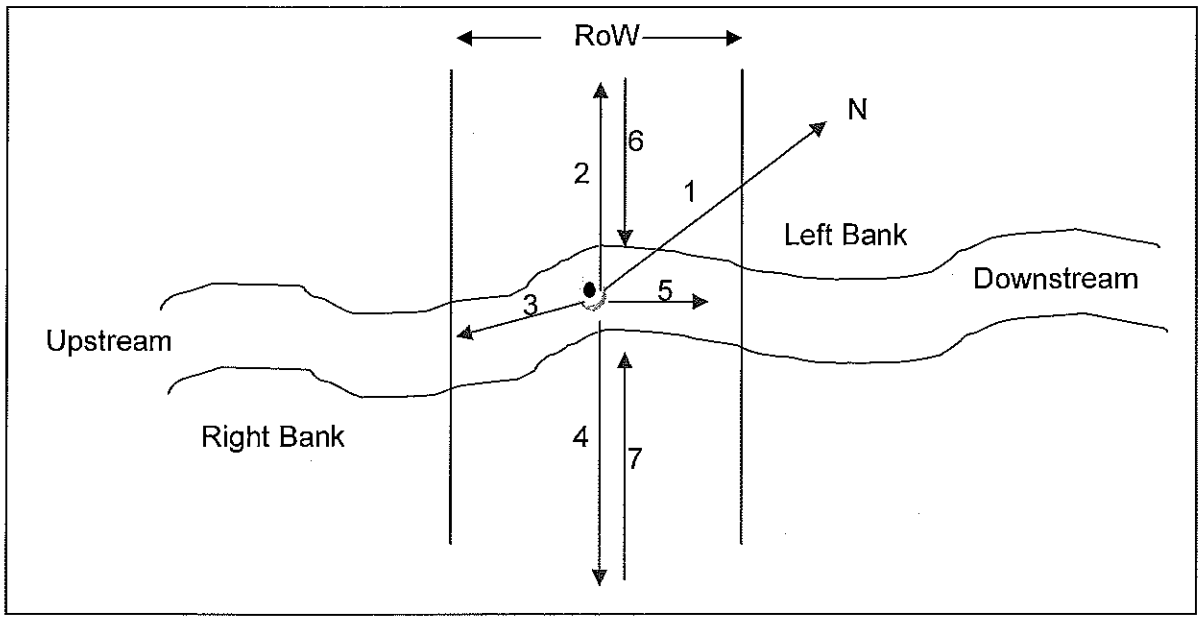
**General Comments / Reach Description:**
small windy channel. shallow banks.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 127-1 |
| Facing left bank (2) | 127-2 |
| Facing Upstream (3) | 127-3 |
| Facing Right Bank (4) | 127-4 |
| Facing Downstream (5) | 127-5 |
| From edge of Riparian on left (6) | 127-6 |
| From edge of Riparian on right (7) | 127-7 |

**General Comments:**

Small channel dry. Flows to dam
grassed on bottom. Extensive erosion
around grass roots. Blackspoil.

Santos

GLNG Project

**Is water present? Yes/No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

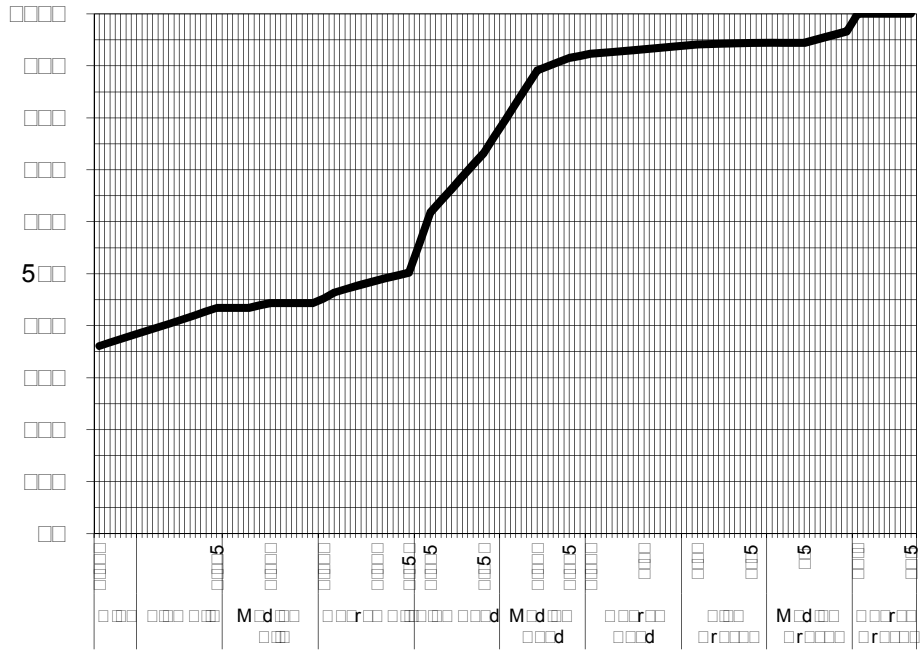
**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

# Certificate of Analysis


**ALS Environmental**

**Newcastle, NSW**

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*



**Dianne Blane**

***Authorised Signatory***

# Certificate of Analysis

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**ALS Environmental**

**Newcastle, NSW**

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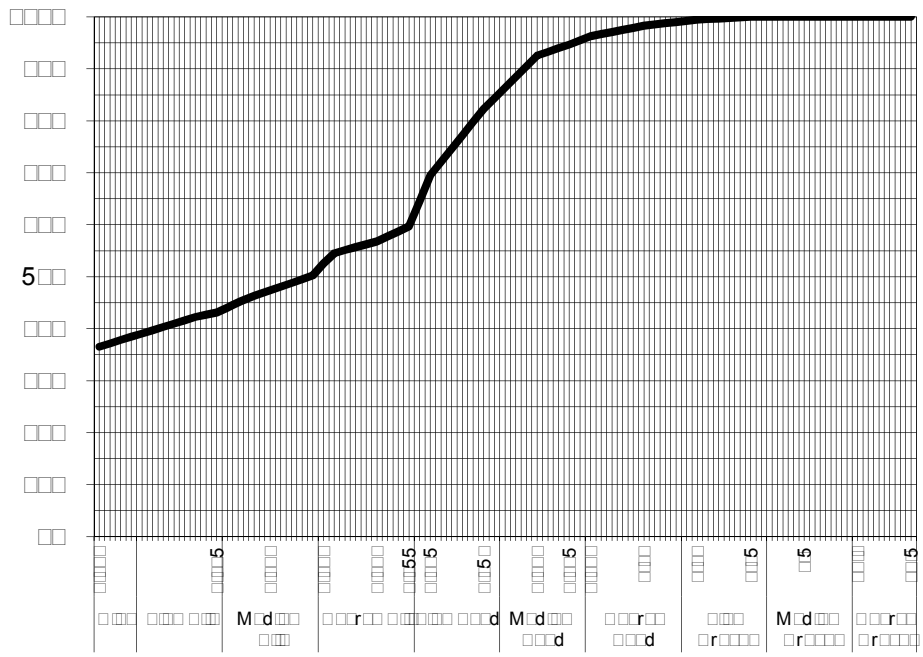

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*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006.*
*Typical sediment SPD values used for calculations*

[illegible]

**Dianne Blane**

[illegible]

***Authorised Signatory***

[illegible]















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# Santos
## GLNG Project

### FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/1/12 KP Point 136.68 Eastings 699749.5 Northings 7269693

Watercourse Name un-named Distance from Source 5.0 km AMTD 6.9 km

Stream Order 2 Photo taken of access track Y/N

Catchment Area Comet Weather Fine

Rain in the Past week NIL Time of Day 1.30 Cloud Cover (%) 20

---

**OBSERVATIONS**

Mean Channel width (m) 25

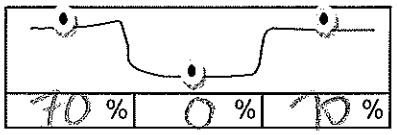
Height of Banks  Left 3 Right 2

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): (Extreme) Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 5 RB 5

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**Riparian vegetation**: Grass % 30 Shrubs % 10

Trees < 10m % 10 Trees > 10m % 50

- Collect samples and produce species list after identification (refer to guide)

Notes: Cut out from last flood. A lot of riparian veg has been washed away.

**Trailing Vegetation:**

| (Extensive) | Moderate | Slight | Nil |
|---|---|---|---|

Notes:

Broad leaved and silver leaved iron bark species present.

# Santos
## GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 100 |
| | | Silt/clay (<1mm) | % |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

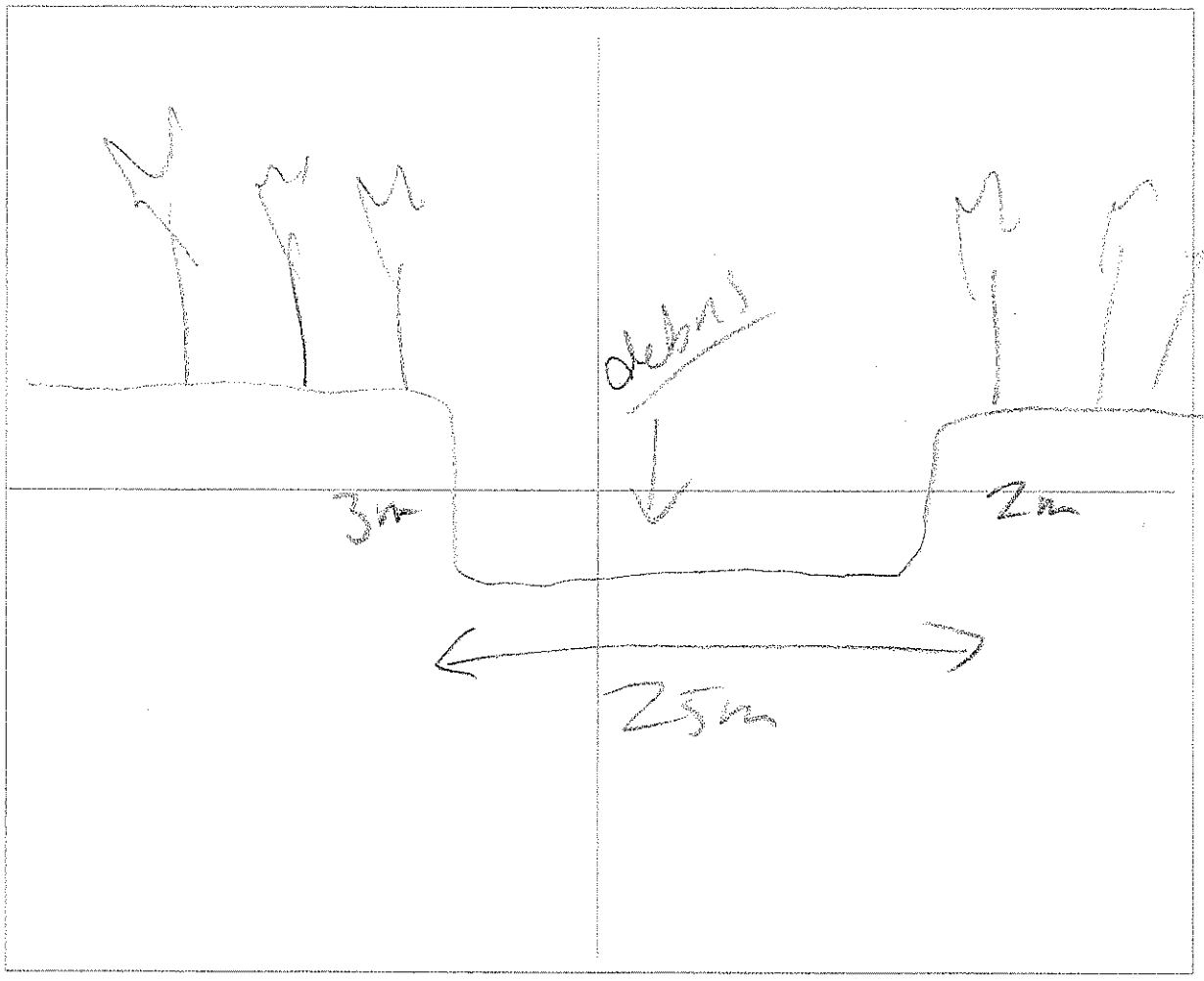
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

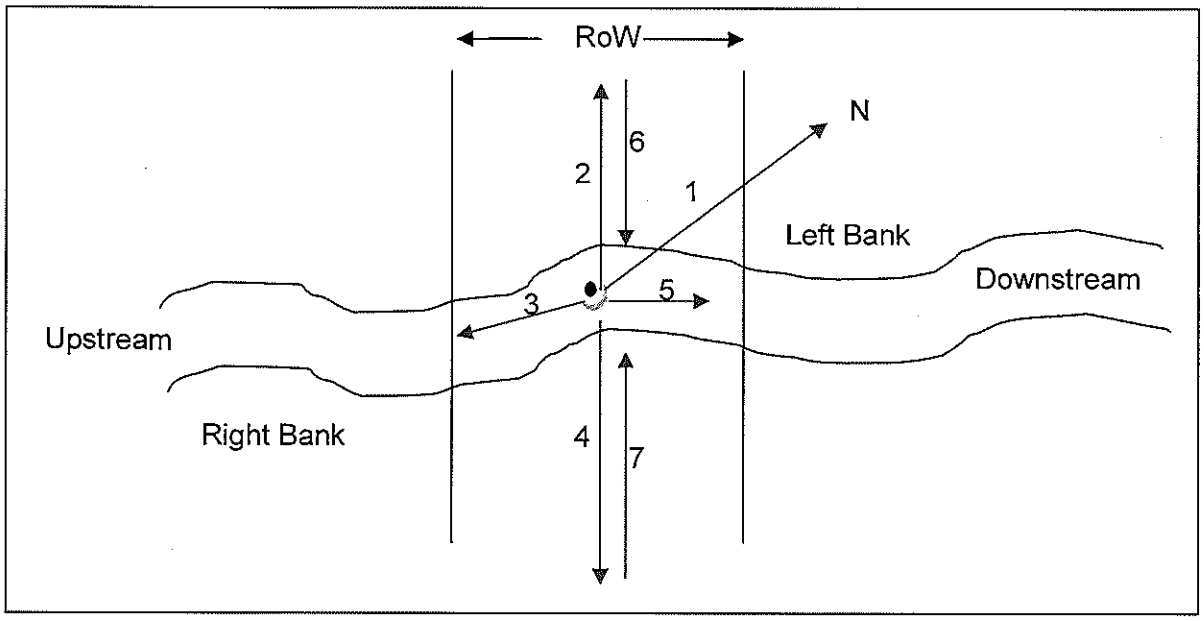
Highly eroded wide channel with steep banks.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 117 |
| Facing left bank (2) | 118 |
| Facing Upstream (3) | 119 |
| Facing Right Bank (4) | 120 |
| Facing Downstream (5) | 121 |
| From edge of Riparian on left (6) | 123 |
| From edge of Riparian on right (7) | 122 |

**General Comments:**

Highly eroded dry watercourse which has been cut out at last flood. Much debris in creek bed. Steep banks and sandy bottom. Extensive trailing veg with around 70% cover.

Santos
GLNG Project

**Is water present?** Y/ N If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**KP136.9**

Botanical specimens list:

- **Acacia* sp., unidentified
- **Eucalyptus* sp., unidentified
- **Ficus fraseri*
- **Indigofera* sp., unidentified
- Silver leaved Ironbark
- Broad leaved Ironbark

*As identified by Queensland Herbarium, DERM

# Certificate of Analysis

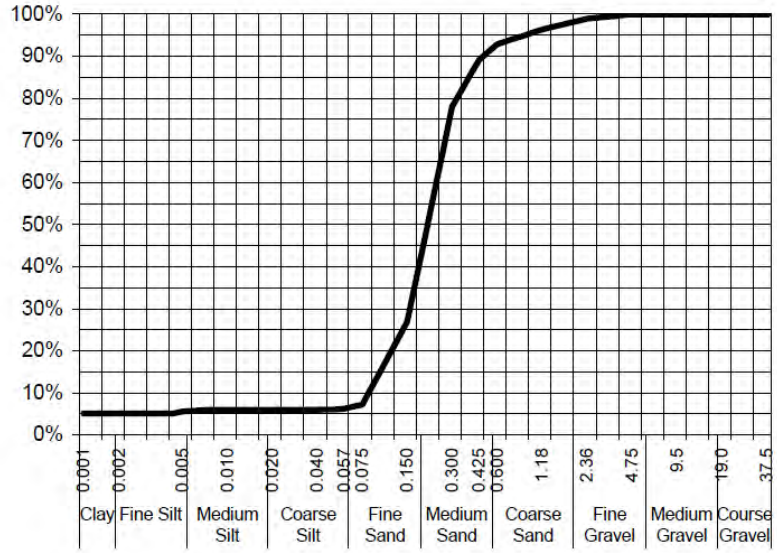
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 20-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 13-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1201003-013 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP136.6 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 96% |
| 0.600 | 93% |
| 0.425 | 89% |
| 0.300 | 78% |
| 0.150 | 27% |
| 0.075 | 7% |
| Particle Size (microns) | |
| 57 | 6% |
| 40 | 6% |
| 20 | 6% |
| 10 | 6% |
| 5 | 6% |
| 4 | 5% |
| 1 | 5% |

| | |
|---|---|
| Median Particle Size (mm) | 0.150 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 18-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

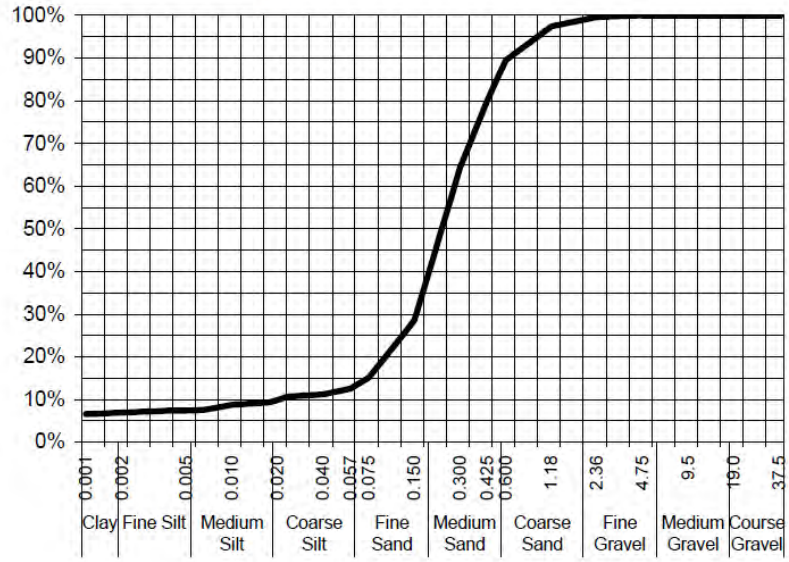
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 20-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 13-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1201003-014 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP136.6 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 97% |
| 0.600 | 89% |
| 0.425 | 80% |
| 0.300 | 64% |
| 0.150 | 29% |
| 0.075 | 15% |
| Particle Size (microns) | |
| 57 | 13% |
| 40 | 11% |
| 20 | 10% |
| 10 | 9% |
| 5 | 7% |
| 4 | 7% |
| 1 | 7% |

| Median Particle Size (mm) | 0.150 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 18-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***















Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 12/1/12 KP Point 144.60 Eastings 705609.6 Northings 7271794
Watercourse Name un-named Distance from Source 3.7 km AMTD 4.8 km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Dawson Weather Fine
Rain in the Past week Nil Time of Day 3pm Cloud Cover (%) 10

---

**OBSERVATIONS**

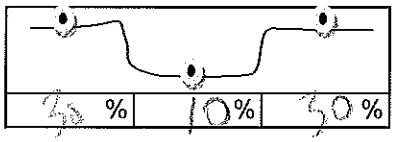
Mean Channel width (m) 8
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | (Extensive) | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB N/A RB 50m

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**Riparian vegetation**: Grass % 70 Shrubs % 10
Trees < 10m % 10 Trees > 10m % 20

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Trailing Vegetation:**

| Extensive | (Moderate) | Slight | Nil |
|---|---|---|---|

Notes: Heavy growth of grasses. Tall trees < 10m

# Santos
## GLNG Project

**Substrate Description:**

| | | | | | |
|---|---|---|---|---|---|
| Bedrock | % 60 | | Pebble (16-64mm) | % | |
| Boulder (>256mm) | % 10 | | Gravel (4-16mm) | % | |
| Cobble (64-256mm) | % 10 | | Sand (1-4mm) | % | 20 |
| | | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/ Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

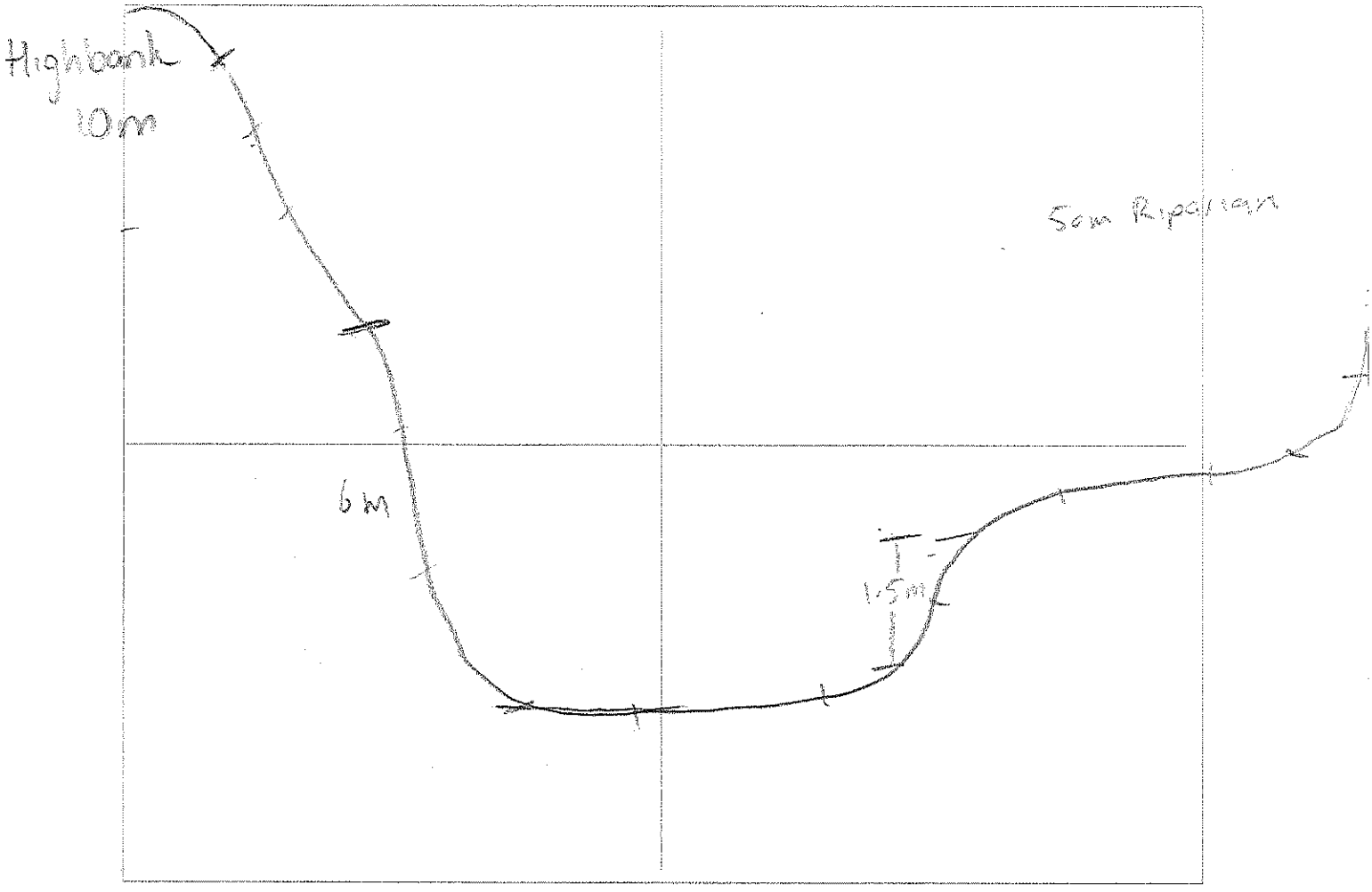
---

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

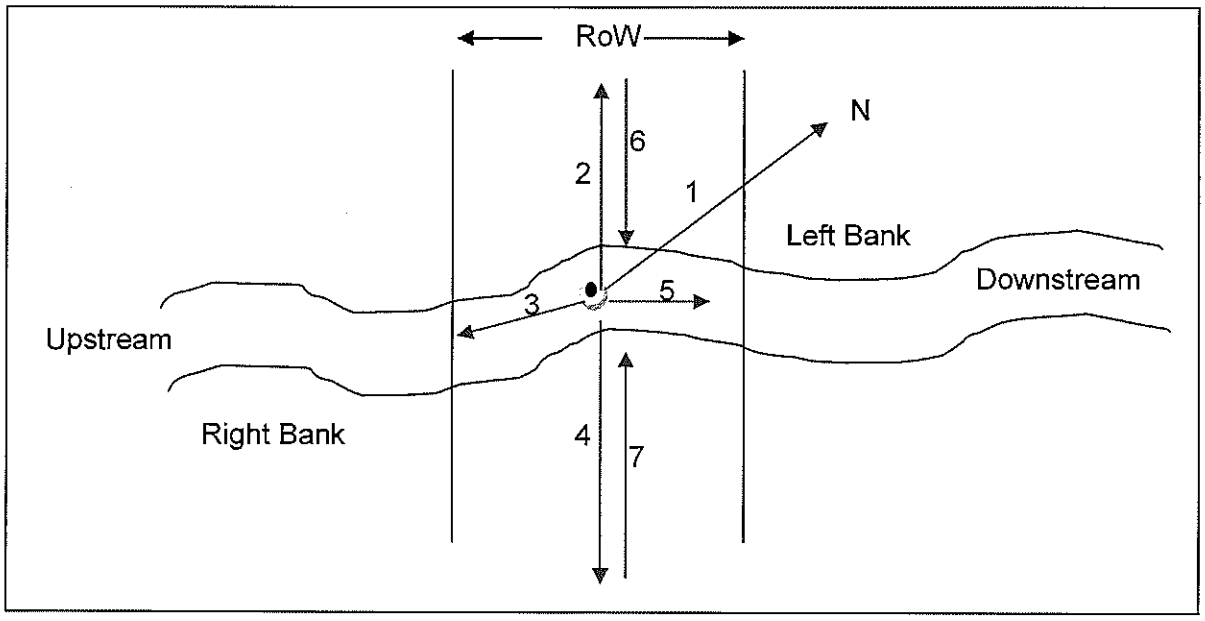
Steep incised banks.
highly eroded. Rocky sandy bottom

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 131 |
| Facing left bank (2) | 132 |
| Facing Upstream (3) | 133 |
| Facing Right Bank (4) | 134 |
| Facing Downstream (5) | 135 |
| From edge of Riparian on left (6) | 130 |
| From edge of Riparian on right (7) — looking right | 136 |

**General Comments:**

Left hand bank very steep. Limited riparian veg on left bank. Vegetation on right bank is extensive but mainly grasses.

Un-named trib of Conciliation Creek

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GLNG Project

**Is water present?** Y/(N) If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

Notes:

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

Notes:

# Certificate of Analysis


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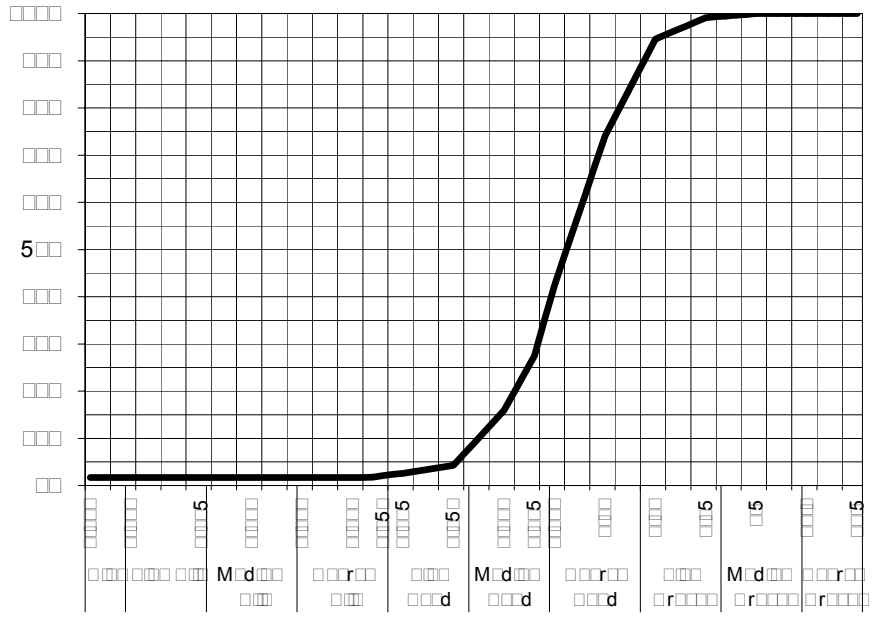
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# Certificate of Analysis


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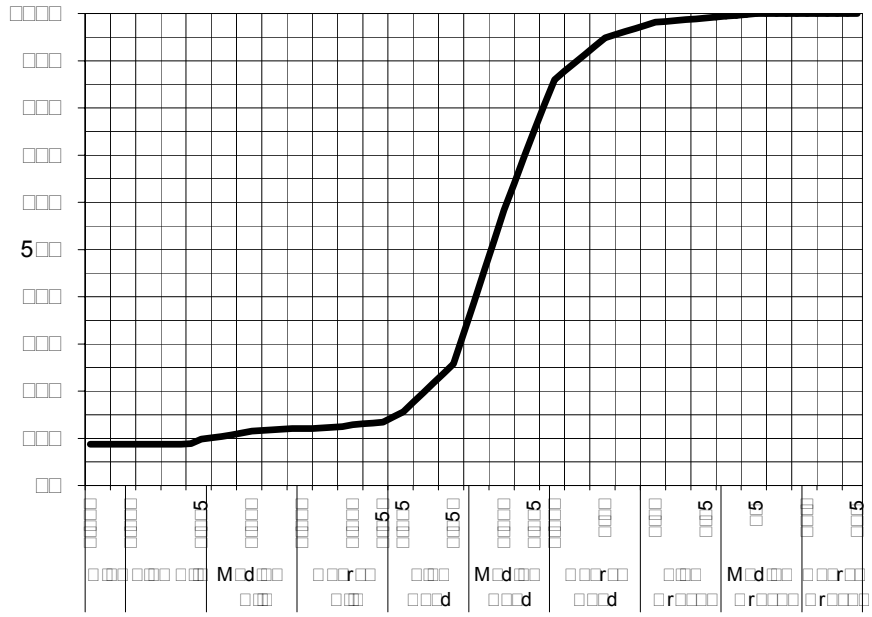
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# Santos
## GLNG Project

**FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT**

Date 16/3/12 KP Point 146·26 Eastings 707218 Northings 7271826

Watercourse Name Unnamed Distance from Source 248m AMTD 600m

Stream Order 1 Photo taken of access track Y/N

Catchment Area Confluation of Weather Overcast

Rain in the Past week 30mL Time of Day 2:20 Cloud Cover (%) 70

---

**OBSERVATIONS**

Mean Channel width (m) 3

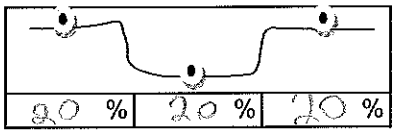
Height of Banks  Left 1 Right 3

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): (Extreme) Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 85 Shrubs %

Trees < 10m % 5 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Expedition range - riverbanks, extensive grass cover.

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | %90 | Gravel (4-16mm) | % |
| Cobble (64-256mm) | %10 | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % |

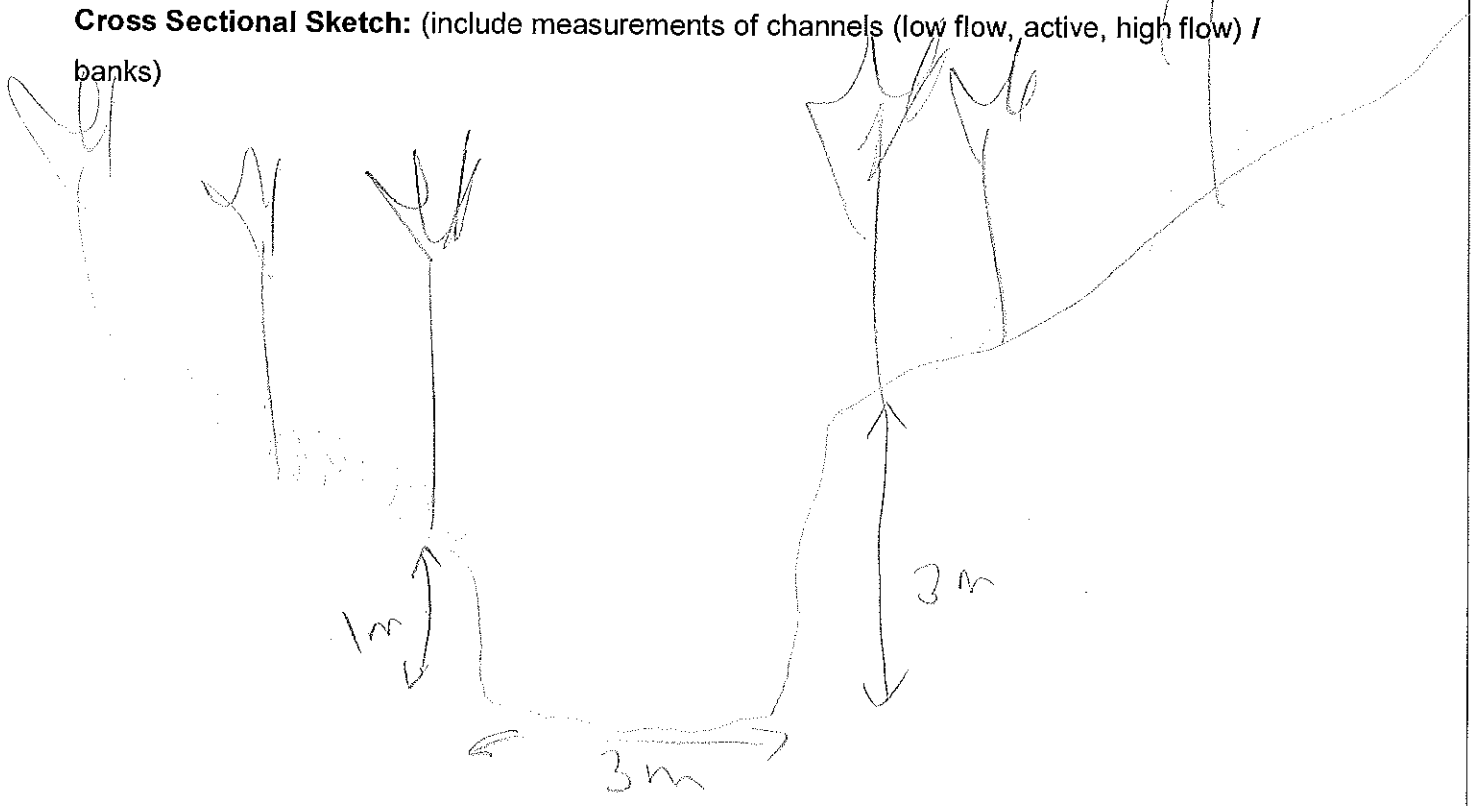
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

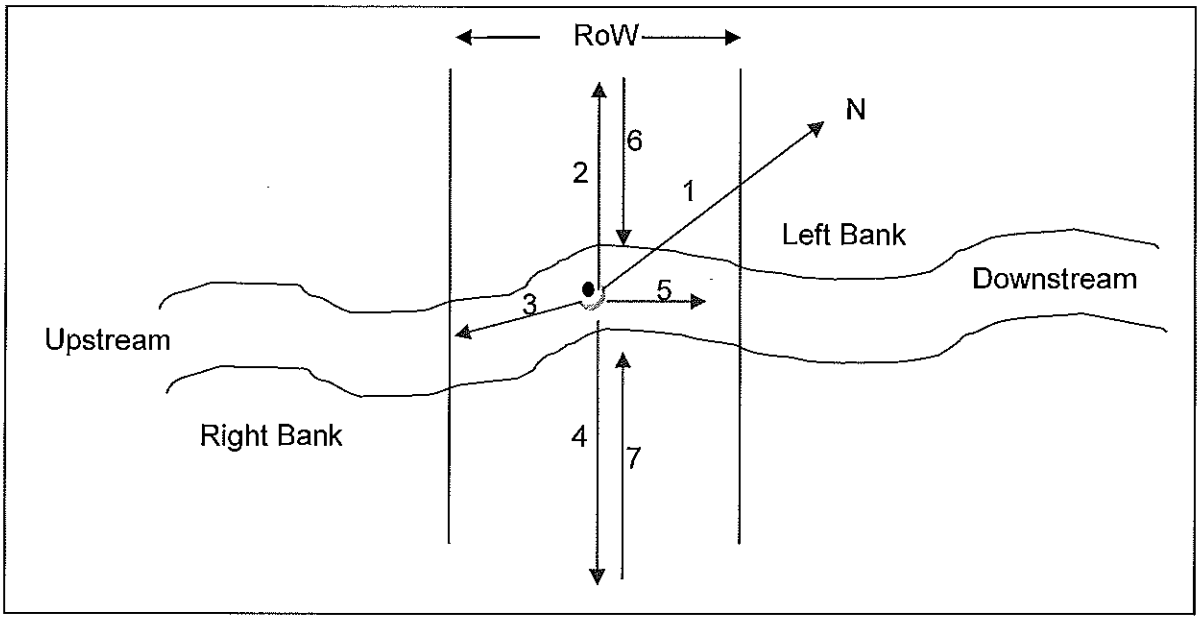
**General Comments / Reach Description:**
highly eroded steep banks, well defined active channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 146_1 |
| Facing left bank (2) | 146_2 |
| Facing Upstream (3) | 146_3 |
| Facing Right Bank (4) | 146_4 |
| Facing Downstream (5) | 146_5 |
| From edge of Riparian on left (6) | — |
| From edge of Riparian on right (7) | — |

**General Comments:**

well defined active channel. Heavy fouling veg consisting mainly of grasses & broad leaved rainbush. Substrate rocky with layer amount of debris. exposed roots along banks. Extensive erosion.

Santos

GLNG Project

**Is water present? Yes/No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP146.26**

Botanical specimens list:

- **Acacia sp.*, possibly *A. crassicarpa*
- **Eucalyptus melanophloia* subsp. *Melanophloia*
- **Indigofera hirsuta*
- **Juncus aridicola*
- **Lophostemon suaveolens*
- **Petalostigma pubescens*
- **Vachellia bidwillii*
- Broad Leaved Ironbark
- Silver Leaved Ironbark

*As identified by Queensland Herbarium, DERM.

# *Certificate of Analysis*

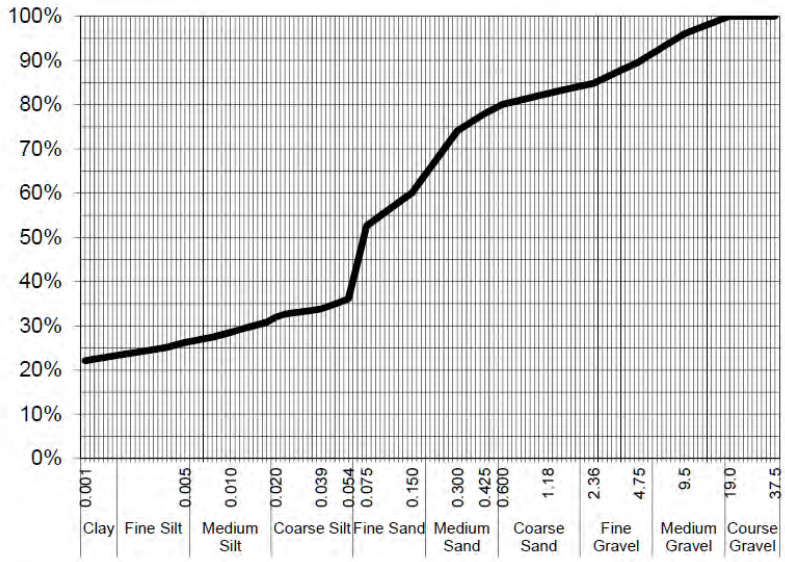
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-015 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP146.26 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 96% |
| 4.75 | 90% |
| 2.36 | 85% |
| 1.18 | 83% |
| 0.600 | 80% |
| 0.425 | 78% |
| 0.300 | 74% |
| 0.150 | 60% |
| 0.075 | 53% |
| Particle Size (microns) | |
| 54 | 36% |
| 39 | 34% |
| 20 | 32% |
| 10 | 29% |
| 5 | 26% |
| 4 | 25% |
| 1 | 22% |

| Median Particle Size (mm) | 0.064 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

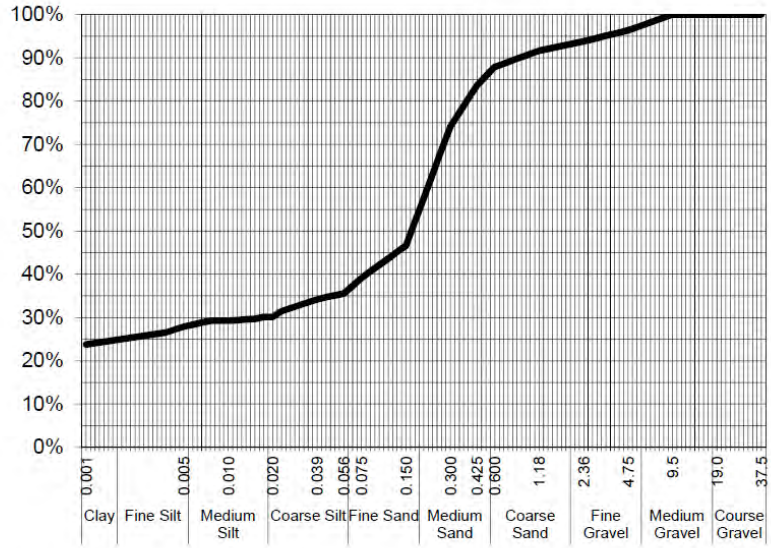
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-016 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP146.26 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 96% |
| 2.36 | 94% |
| 1.18 | 92% |
| 0.600 | 88% |
| 0.425 | 84% |
| 0.300 | 74% |
| 0.150 | 47% |
| 0.075 | 39% |
| Particle Size (microns) | |
| 56 | 36% |
| 39 | 34% |
| 20 | 30% |
| 10 | 29% |
| 5 | 28% |
| 4 | 27% |
| 1 | 24% |

| Median Particle Size (mm) | 0.150 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***











**Santos**
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 17/3/12 KP Point 148.85 Eastings 709578 Northings 7271678
Watercourse Name Unnamed Distance from Source 6km AMTD 1481km
Stream Order 2/3 Photo taken of access track Y/N
Catchment Area ~~Comet~~ Dawson ~ Conciliation Weather Overcast
Rain in the Past week 30 mt Time of Day 10am Cloud Cover (%) 100

---

**OBSERVATIONS**

Mean Channel width (m) 3m.

Height of Banks  Left 1 Right 2

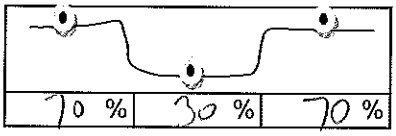
stagnant pool at crossing.

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 3 RB 3




---

**Riparian vegetation**: Grass % 40 Shrubs % _____

Trees < 10m % 20 Trees > 10m % 40

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

tall trees, approx 90% veg cover.

Santos
GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | %20 | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 80 |
| | | Silt/clay (<1mm) | % |

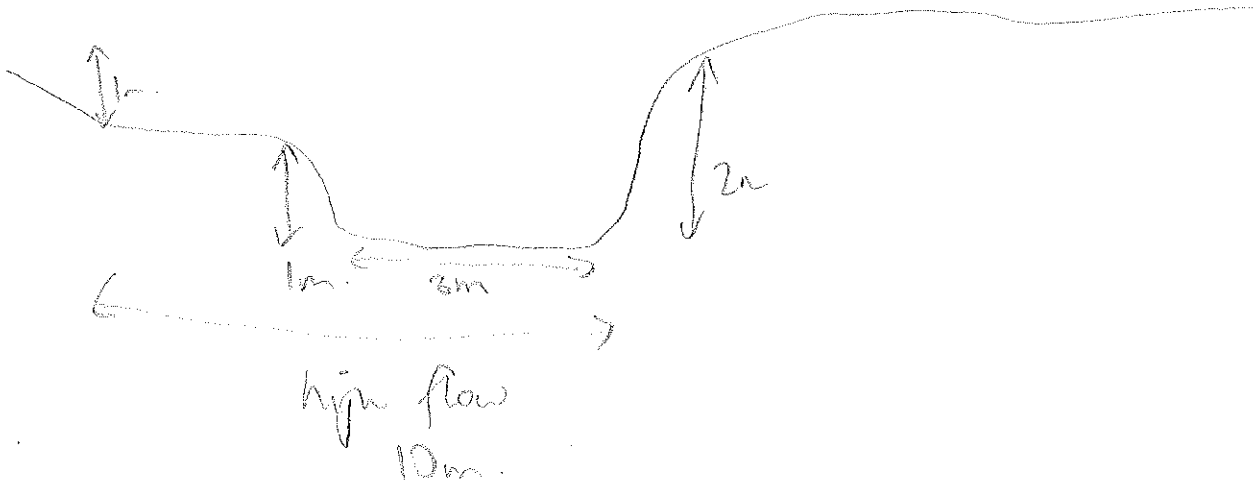
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

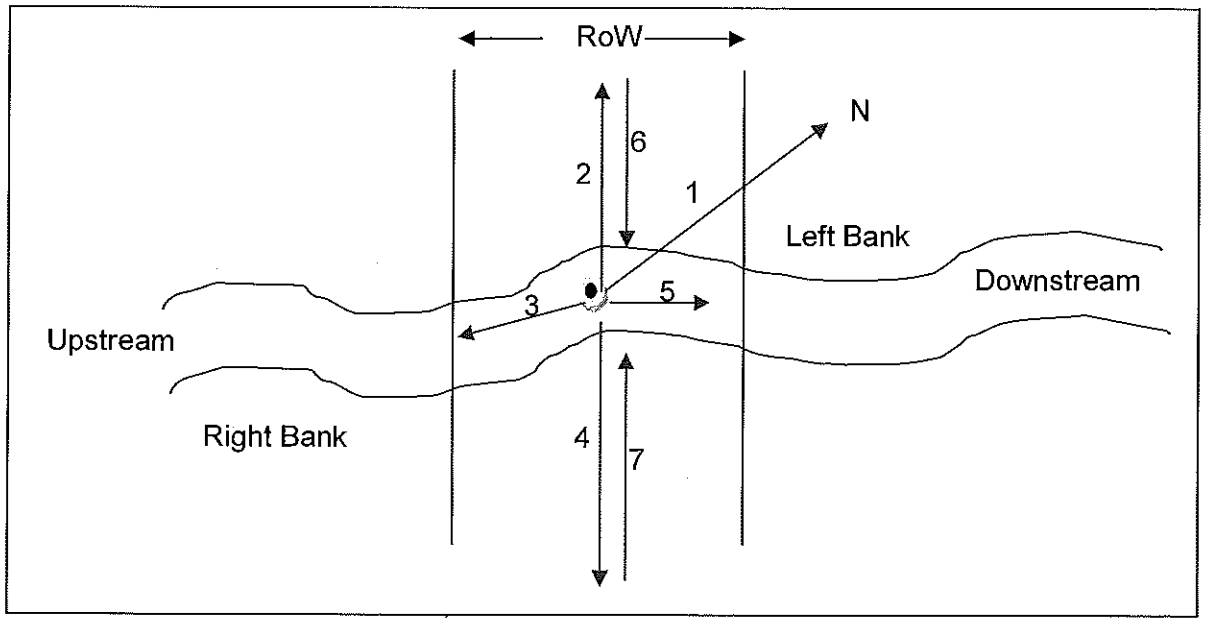
**General Comments / Reach Description:**
Narrow channel, steep banks, scattered large boulders. 3m active channel

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 148-1 |
| Facing left bank (2) | 148-7 |
| Facing Upstream (3) | 148-2 |
| Facing Right Bank (4) | 148-3 |
| Facing Downstream (5) | 148-4 |
| From edge of Riparian on left (6) | 148-5 |
| From edge of Riparian on right (7) | 148-6 |

**General Comments:**

highly turbid

3 m active channel, stagnant pool at crossing location, approx 20cm deep and extending entire length of ROW. Upstream & downstream completely dry. Large density and good veg cover. scattered boulders.

Santos

GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (ºC) | — | — | — | |
| Conductivity (µS/cm) | 108·2 | 107·9 | | 108·05 |
| pH | [illegible] | 6·53 | | 6·53 |
| Dissolved $O_2$ (mg/L) | [illegible] 3·56 | 3·70 [illegible] | | 3·63 |
| Turbidity (NTU) | 105 | 107 | | 106 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

Sedges

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP148.85**

Botanical specimens list:

- **Acacia sp.,* possibly *A. crassicarpa*
- **Acacia flavescens*
- **Alphitonia excelsa*
- **Cyperus flaccidus*
- **Cyperus polystachyos* var. *polystachyos*
- **Eucalyptus* sp., unidentified
- **Juncus prismatocarpus*
- **Juncus usitatus*
- **Lophostemon suaveolens*
- **Petalostigma pubescens*

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

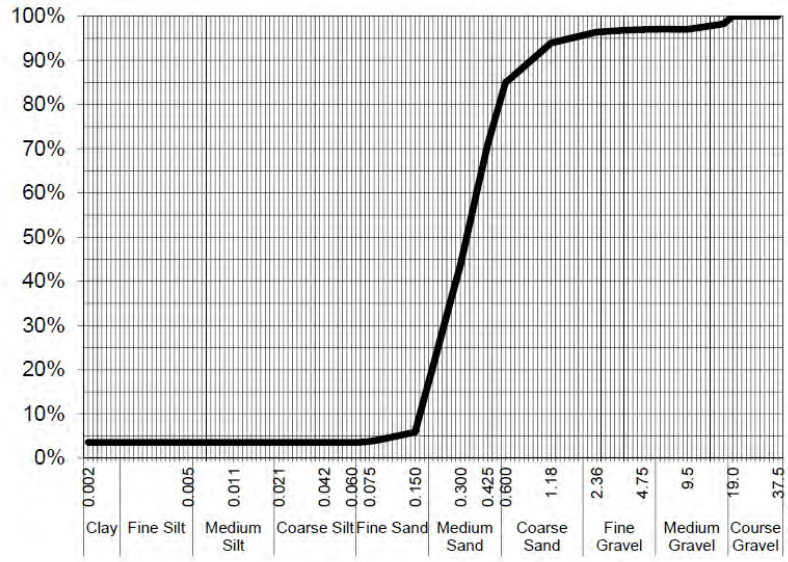
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-017 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP148.85 - Bottom |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 97% |
| 4.75 | 97% |
| 2.36 | 96% |
| 1.18 | 94% |
| 0.600 | 85% |
| 0.425 | 71% |
| 0.300 | 44% |
| 0.150 | 6% |
| 0.075 | 4% |
| Particle Size (microns) | |
| 60 | 4% |
| 42 | 4% |
| 21 | 4% |
| 11 | 4% |
| 5 | 4% |
| 4 | 4% |
| 2 | 4% |

| Median Particle Size (mm) | 0.300 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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Laboratory Supervisor, Newcastle
***Authorised Signatory***

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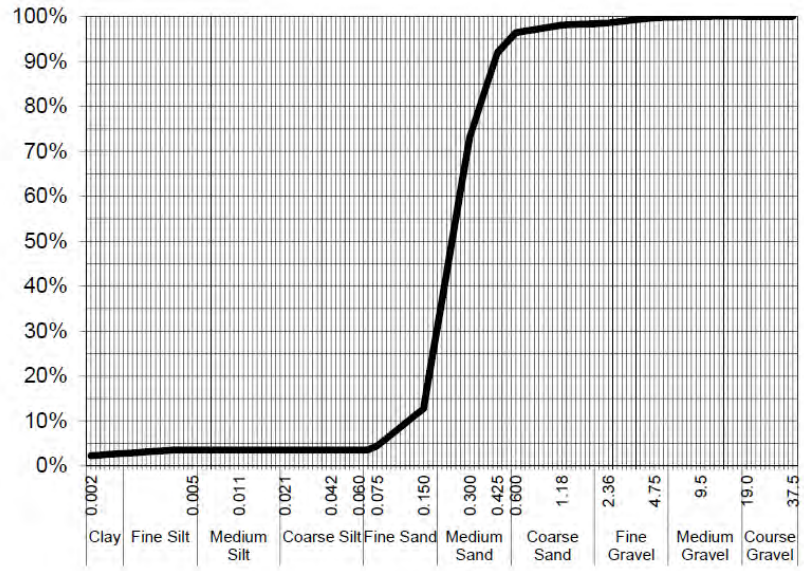
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-018 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP148.85 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 99% |
| 1.18 | 98% |
| 0.600 | 96% |
| 0.425 | 92% |
| 0.300 | 73% |
| 0.150 | 13% |
| 0.075 | 4% |
| Particle Size (microns) | |
| 60 | 4% |
| 42 | 4% |
| 21 | 4% |
| 11 | 4% |
| 5 | 4% |
| 4 | 4% |
| 2 | 2% |

| | |
|---|---|
| Median Particle Size (mm) | 0.150 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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# Santos
## GLNG Project

**FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT**

Date 5/1/12 KP Point 150-41 Eastings 711067.9 Northings 7271844

Watercourse Name un-named Distance from Source 2.97 AMTD 1.45 km

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson Weather Fine

Rain in the Past week Nil Time of Day 11:00am Cloud Cover (%) 0

---

**OBSERVATIONS** Facing downstream

Mean Channel width (m) 5

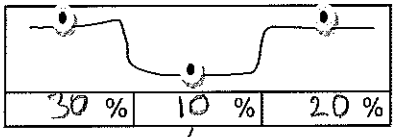
Height of Banks  Left 1.5 Right 2.5m

Velocity (m/s): Flow metre N/A Floating object N/A

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood waterhole.

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % Width of riparian Zone (m): LB <1m RB <1m




1 overhanging tree

---

**Riparian vegetation**: Grass % 80 Shrubs % 0

Trees < 10m % 10 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

Silver leaved Ironbark
Eucalyptus (white gum)

# Santos
## GLNG Project

**Substrate Description:**

| | | | | | |
|---|---|---|---|---|---|
| Bedrock | | % | Pebble (16-64mm) | | % |
| Boulder (>256mm) | | % | Gravel (4-16mm) | | % |
| Cobble (64-256mm) | | % | Sand (1-4mm) | | % |
| | | | Silt/clay (<1mm) | 100 | % |

**Bank Material** Dispersive/Sodic Y/(N) Slightly

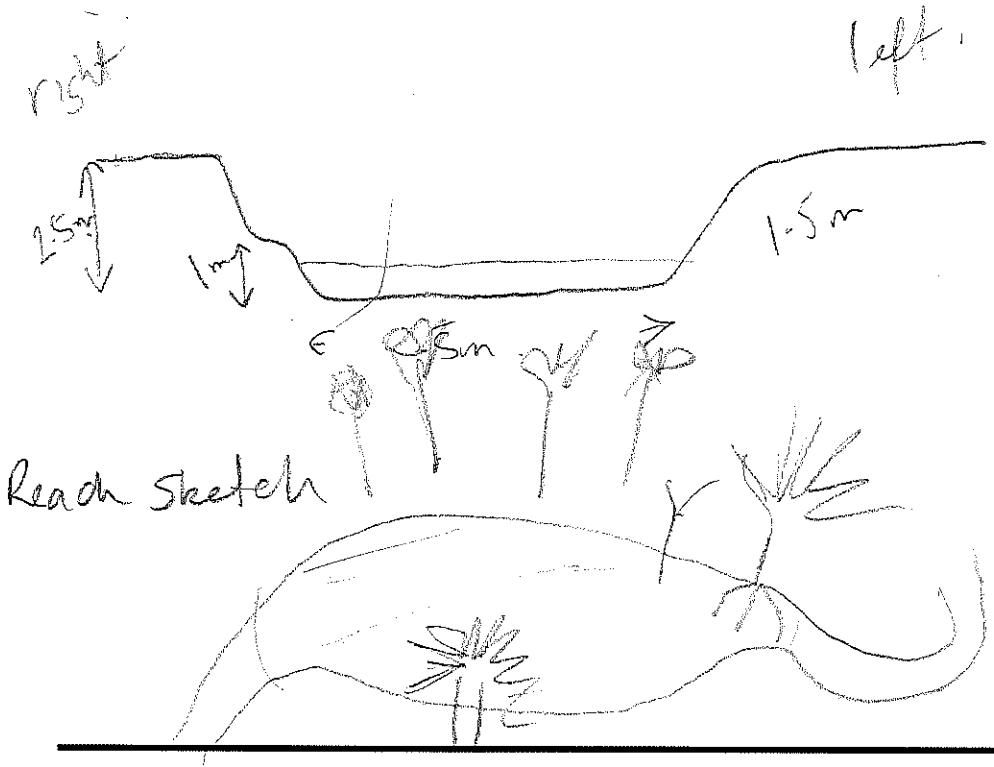
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

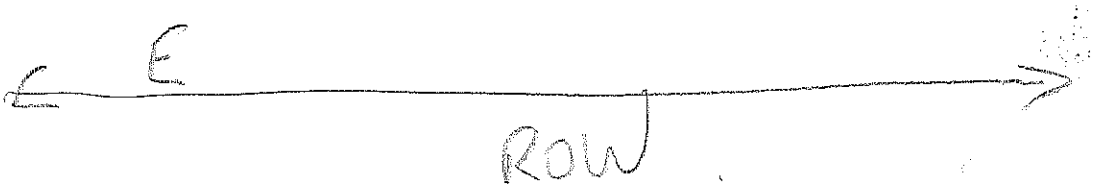
**GEOMORPHOLOGY**

**General Comments / Reach Description:**

Shallow pool 5m width at centre of ROW
Initial erosion

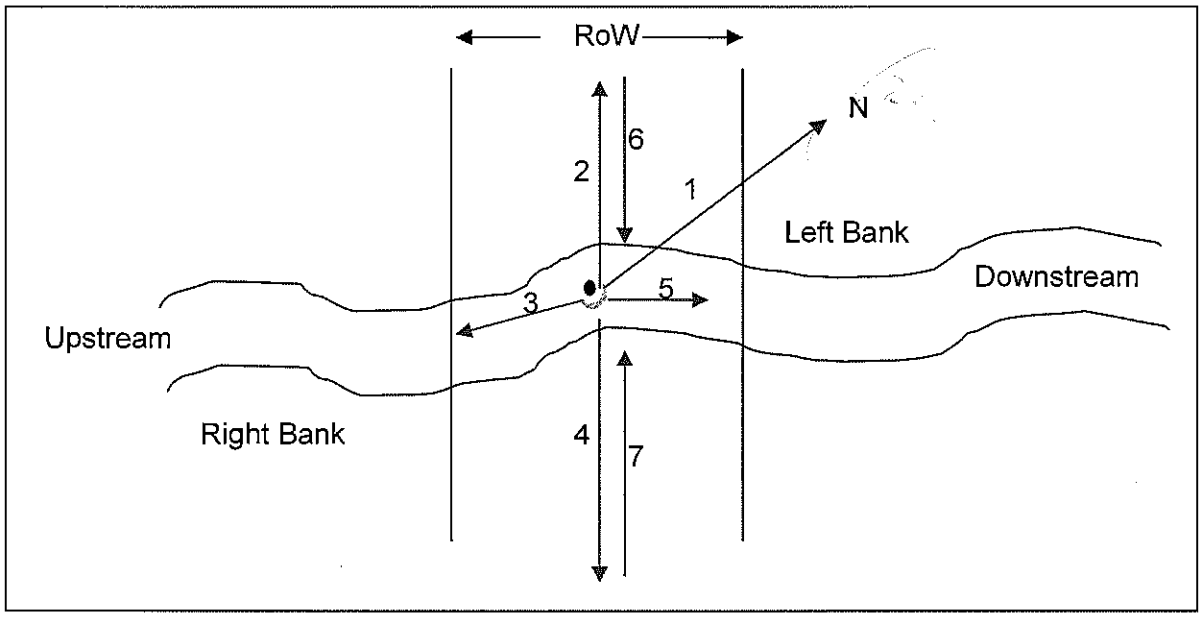
**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 0001 |
| Facing left bank (2) | 002 |
| Facing Upstream (3) | 003 |
| Facing Right Bank (4) | 004 |
| Facing Downstream (5) | 005 |
| From edge of Riparian on left (6) | 006 |
| From edge of Riparian on right (7) | 007 |

**General Comments:**

Shallow pool in dry/ephemeral watercourse
No suitable habitat for threatened species
limited vegetation next to no riparian and limited fauling veg

# Santos
## GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 30.1 | 29.9 | 31 | 30.33 |
| Conductivity (µS/cm) EC | 250 | 236 | 224 | 236.67 |
| pH | 7.28 | 7.38 | 7.38 | 7.35 |
| Dissolved $O_2$ (mg/L) | 4.07 | 4.75 | 4.17 | 4.33 |
| Turbidity (NTU) | 60.1 | 59.2 | 60.6 | 59.67 |
| TDS (mg/L) | 159 | 151 | 146 | 152 |

**Algae:**

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**KP150.8**

Botanical specimens list:

- **Centipeda* sp., unidentified
- **Cyperus difformis*
- **Geijera parviflora*
- **Ludwigia peploides* subsp. *Montevidensis*
- **Melaleuca* sp., possibly *M. bracteata*
- **Poaceae* sp., unidentified
- Silver Leaved Ironbark
- White Gum Eucalyptus

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

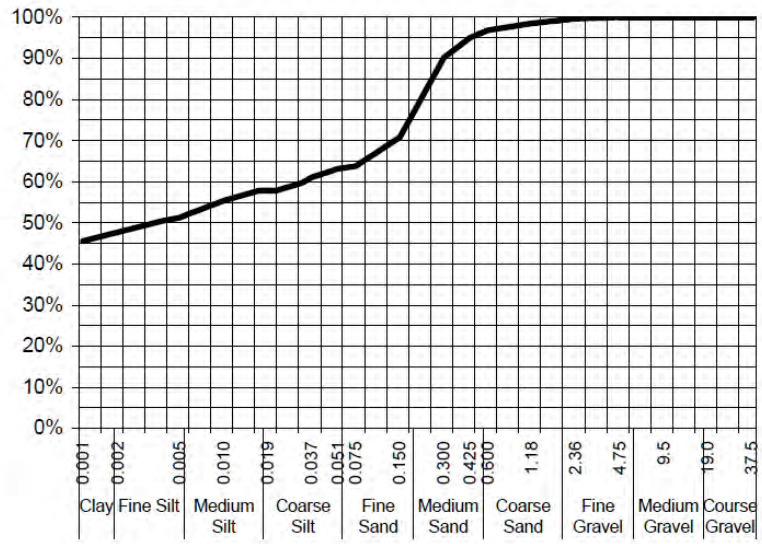
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-001 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP150.8 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 98% |
| 0.600 | 97% |
| 0.425 | 95% |
| 0.300 | 90% |
| 0.150 | 71% |
| 0.075 | 64% |
| Particle Size (microns) | |
| 51 | 63% |
| 37 | 61% |
| 19 | 58% |
| 10 | 55% |
| 5 | 51% |
| 3 | 50% |
| 1 | 46% |

| Median Particle Size (mm) | 0.004 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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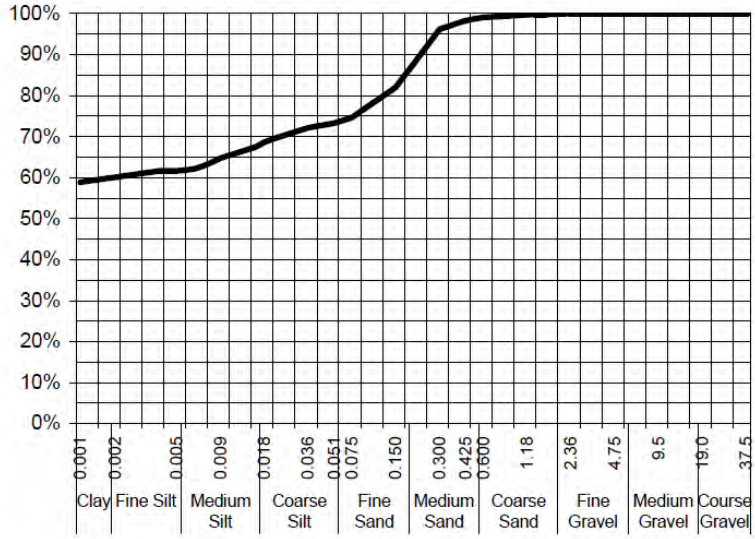
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-002 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP150.8 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 100% |
| 0.600 | 99% |
| 0.425 | 98% |
| 0.300 | 96% |
| 0.150 | 82% |
| 0.075 | 75% |
| Particle Size (microns) | |
| 51 | 73% |
| 36 | 72% |
| 18 | 69% |
| 9 | 65% |
| 5 | 62% |
| 3 | 62% |
| 1 | 59% |

| Median Particle Size (mm) | #N/A |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Loss on Pretreatment** NA

**Sample Description:** Silty clay and medium fine sand

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Soil Particle Density*** 2.65 g/cm$^3$

**Analysed:** 13-Jan-12

**Limit of Reporting:** 1%

**Dispersion Method** Shaker

**Hydrometer Type** ASTM E100

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Laboratory Supervisor, Newcastle
***Authorised Signatory***















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# Santos
## GLNG Project

**FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT**

Date 17/3/12 KP Point 58.1 Eastings 718803 Northings 7274265

Watercourse Name Unnamed Distance from Source 1-5km AMTD 37m

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson - prospect Weather overcast

Rain in the Past week 30 ml Time of Day 12pm Cloud Cover (%) 80%

---

**OBSERVATIONS**

Mean Channel width (m) 15m

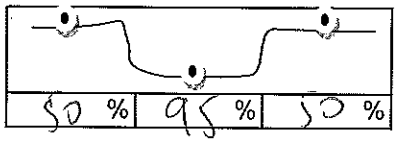
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object 1m/3sec

Flow level: No flow (Low (<watermark)) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 3 RB 3




---

**Riparian vegetation**: Grass % 60 Shrubs %

Trees < 10m % Trees > 10m % 40

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

good grass cover & scattered small trees.

# Santos
## GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % 100 |

**Bank Material** Dispersive/Sodic Y/N

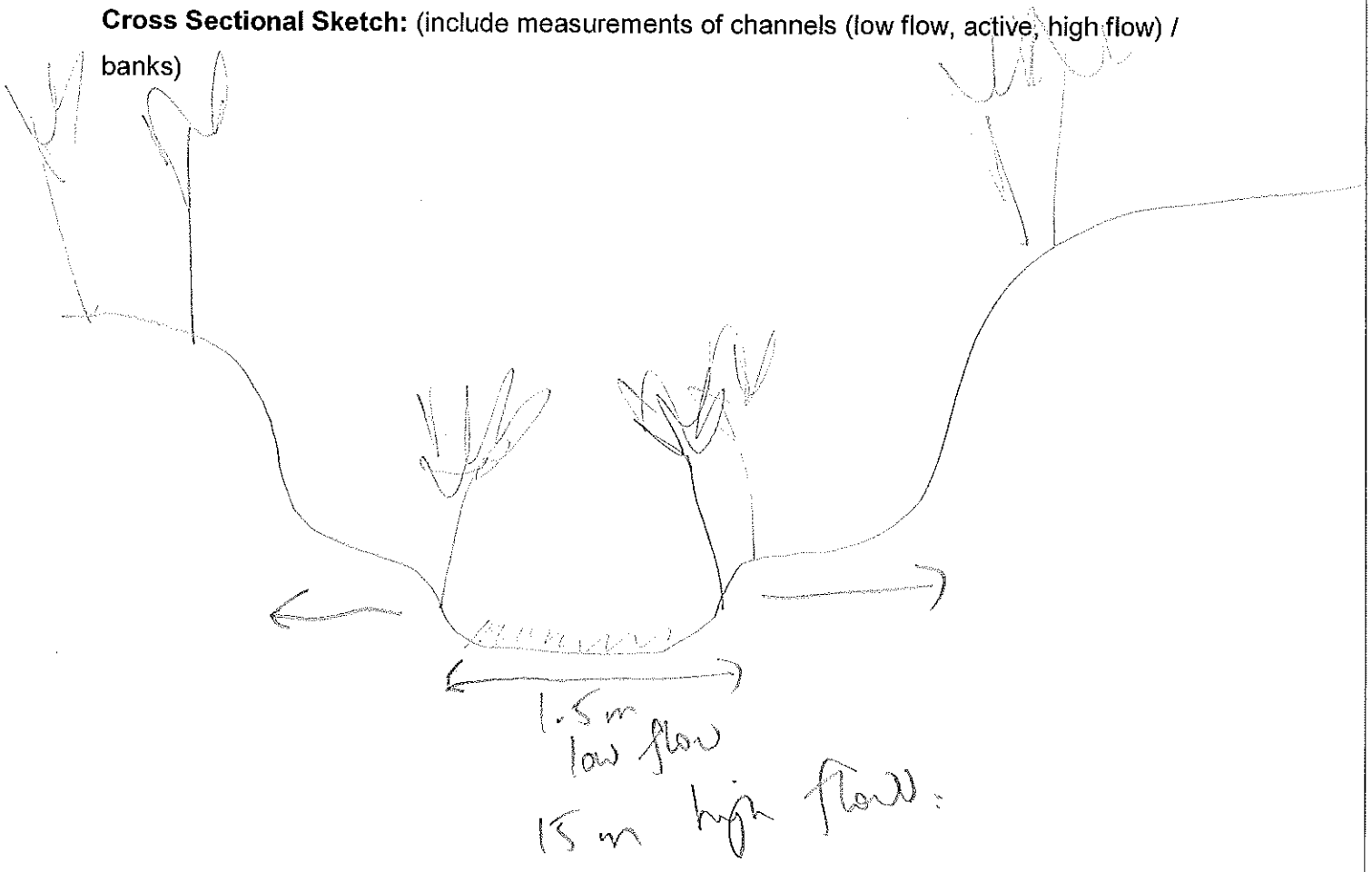
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

### GEOMORPHOLOGY

**General Comments / Reach Description:**

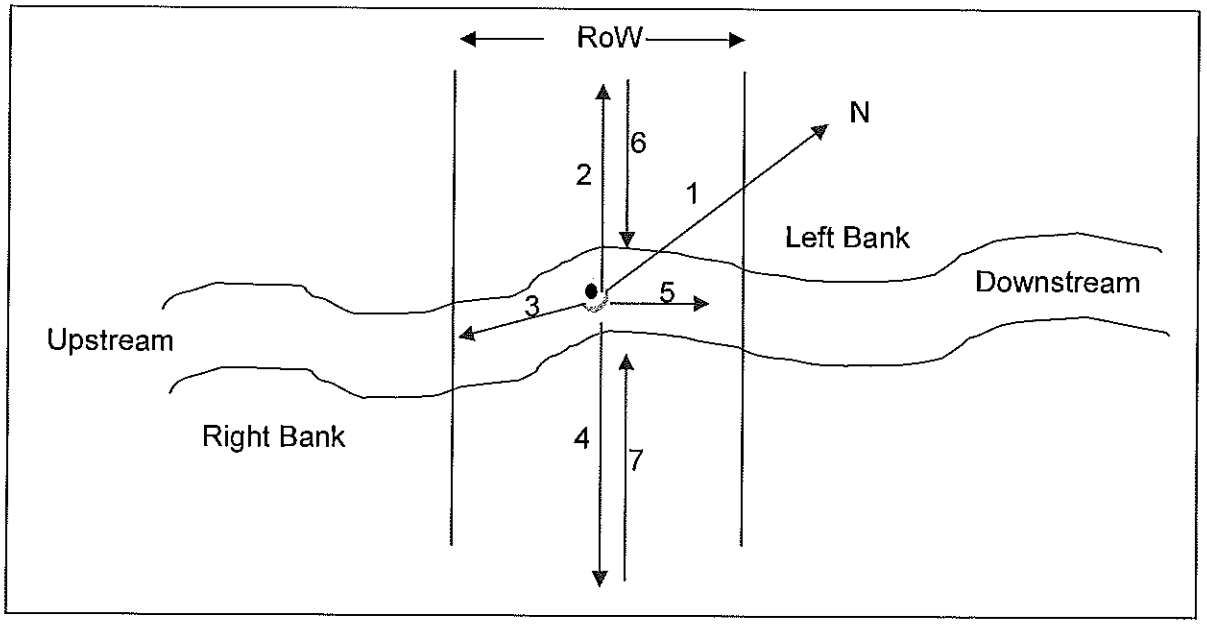
small low flow channel, fast flowing about 1.5m wide. 15m high flow channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



**Santos**
GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 158-1 |
| Facing left bank (2) | 158-2 |
| Facing Upstream (3) | 158-3 |
| Facing Right Bank (4) | 158-4 |
| Facing Downstream (5) | 158-5 |
| From edge of Riparian on left (6) | 158-6 |
| From edge of Riparian on right (7) | |

**General Comments:**

Well vegetated moderately fast flowing stream. extensive algal mats & emergent macrophytes. Riparian veg consists mainly of Maleleucas. and grasses. Steep high banks forming a wide active/low flow channel.

# Santos
## GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 26.6 | 27.3 | | 26.95 |
| Conductivity (µS/cm) | 1.330m/s | 1.280m/s | | 1.305 m/s |
| pH | 7.97 | 8.16 | | 8.08 |
| Dissolved $O_2$ (mg/L) | 3.80 | 3.96 | | 3.88 |
| Turbidity (NTU) | 18.6 | 19.0 | | 18.8 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification. Not large enough to obtain sample.

**KP158.15**

Botanical specimens list:

- **Acacia fasciculifera*
- **Melaleuca decora*
- **Nitella* sp., unidentified
- **Pittosporum spinescens*
- **Juncus continuus*
- Eucalyptus

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

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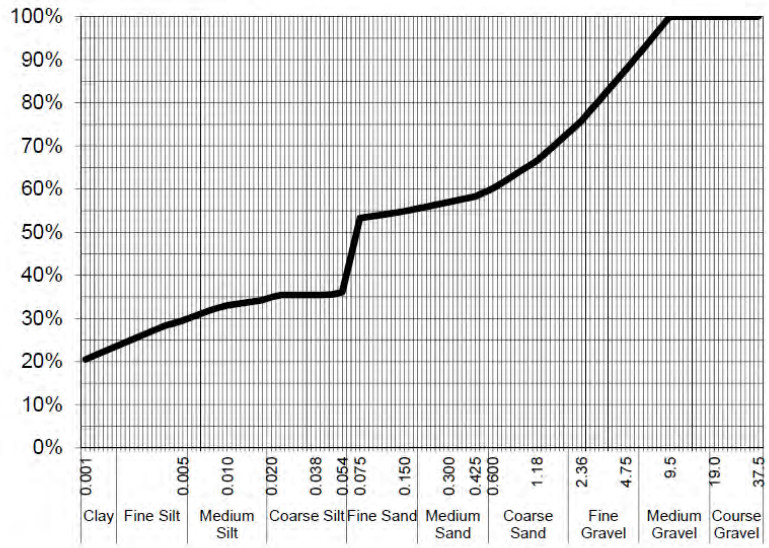
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-019 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP158.15 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 88% |
| 2.36 | 76% |
| 1.18 | 67% |
| 0.600 | 60% |
| 0.425 | 58% |
| 0.300 | 57% |
| 0.150 | 55% |
| 0.075 | 53% |
| Particle Size (microns) | |
| 54 | 36% |
| 38 | 35% |
| 20 | 35% |
| 10 | 33% |
| 5 | 30% |
| 4 | 28% |
| 1 | 21% |

| | |
|---|---|
| Median Particle Size (mm) | 0.064 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay, gravel and sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***

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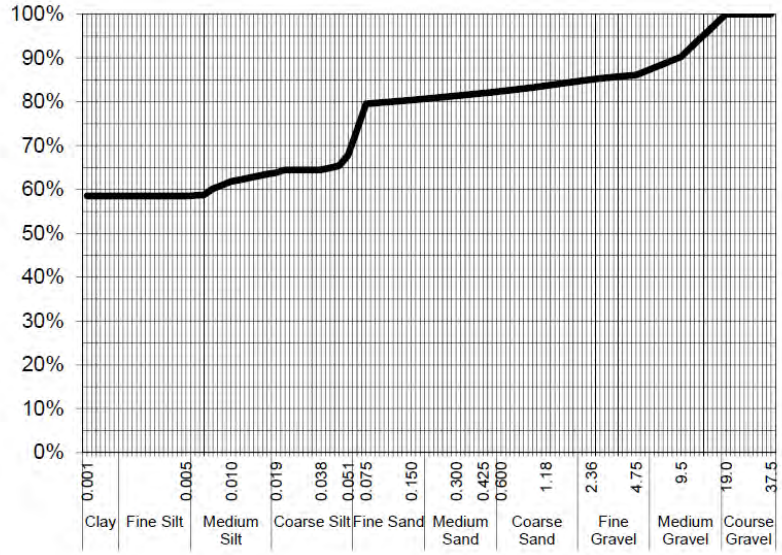
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-020 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP158.15 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 90% |
| 4.75 | 86% |
| 2.36 | 85% |
| 1.18 | 84% |
| 0.600 | 82% |
| 0.425 | 82% |
| 0.300 | 81% |
| 0.150 | 80% |
| 0.075 | 80% |
| Particle Size (microns) | |
| 51 | 68% |
| 38 | 64% |
| 19 | 64% |
| 10 | 62% |
| 5 | 59% |
| 3 | 59% |
| 1 | 59% |

| Median Particle Size (mm) | #N/A |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and gravel

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 5/1/12 KP Point 161.58 Eastings 721351 Northings 7275064
Watercourse Name Un-named Distance from Source 2.3km AMTD 0.38 km
Stream Order 2 Photo taken of access track Y/N 0008
Catchment Area Dawson Weather Fine
Rain in the Past week NIL Time of Day 1:65 Cloud Cover (%) 2
AIR TEMP 34°

**OBSERVATIONS**

Mean Channel width (m) 5

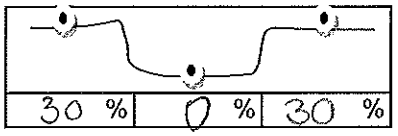
Height of Banks  Left Right

Velocity (m/s): Flow metre N/A Floating object 0-04m/s

Flow level: No flow (Low (<watermark)) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme (Extensive) Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 0 RB 10m




**Riparian vegetation**: Grass % 70 Shrubs % 5
Trees < 10m % 15 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

# Santos
## GLNG Project

**Substrate Description:**

| | | | | | |
|---|---|---|---|---|---|
| Bedrock | % | | Pebble (16-64mm) | % | 5 |
| Boulder (>256mm) | % | 60 | Gravel (4-16mm) | % | 5 |
| Cobble (64-256mm) | % | 20 | Sand (1-4mm) | % | 5 |
| | | | Silt/clay (<1mm) | % | 5 |

**Bank Material** Dispersive/Sodic Y/(N)

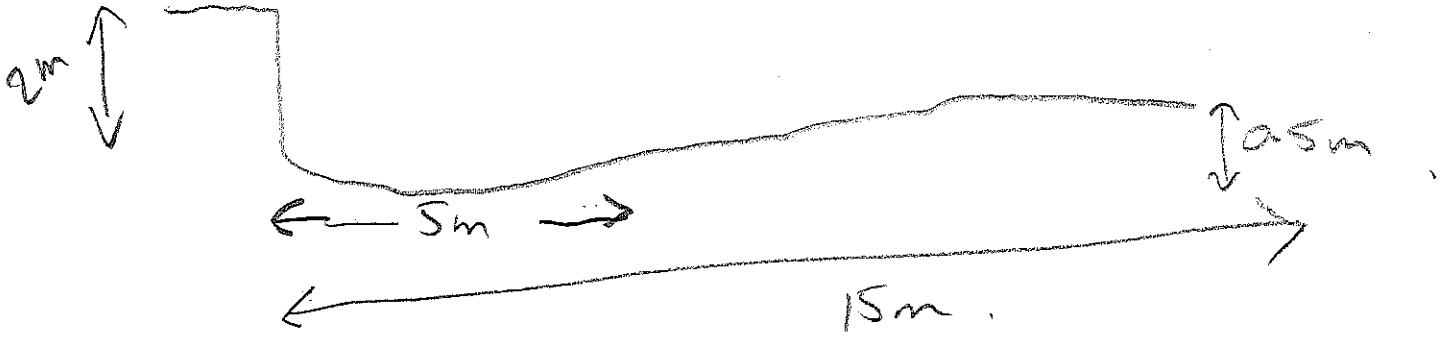
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

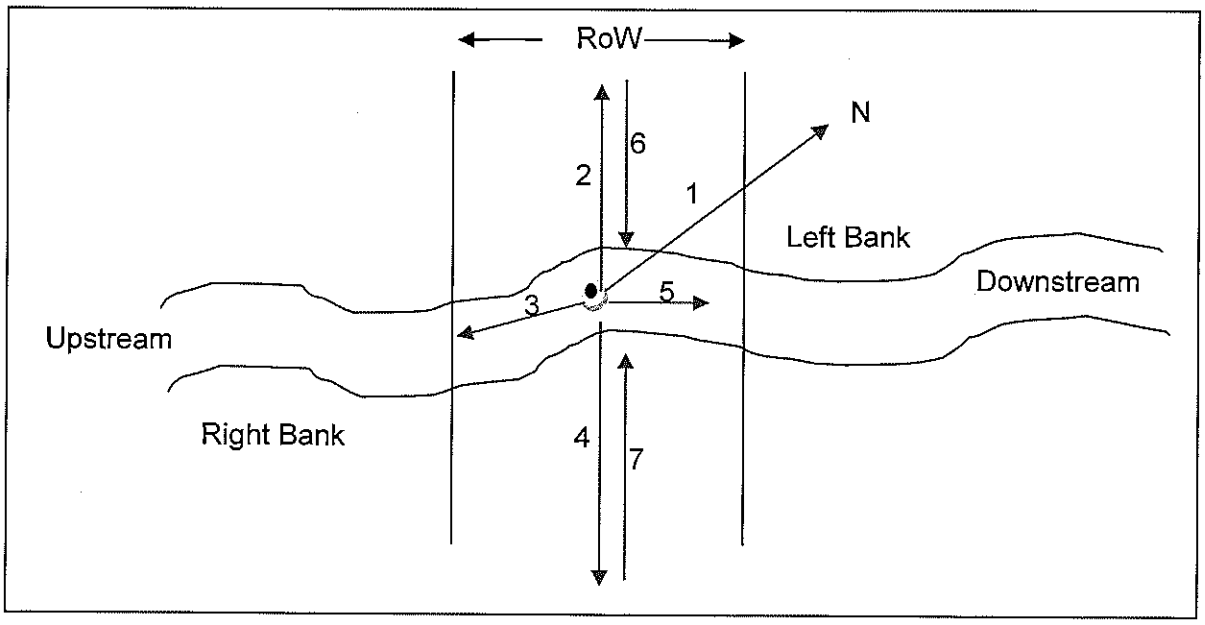
Highly eroded left banks approx 2m tall
Two meter low flow channel, 15m active channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 009 |
| Facing left bank (2) | 010 |
| Facing Upstream (3) | 011 |
| Facing Right Bank (4) | 012 |
| Facing Downstream (5) | 015 |
| From edge of Riparian on left (6) | 013 |
| From edge of Riparian on right (7) | 014 |

**General Comments:**

highly eroded left bank 2m high. No riparian veg on left side, 10m on right. Filamentous algae.

# Santos
## GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 31.9 | 31.8 | — | 31.85 |
| Conductivity (µS/cm) | 1426 | 1426 | — | 1426 |
| pH | 8.31 | 8.37 | — | 8.34 |
| Dissolved $O_2$ (mg/L) | 12.77 | 13.70 | — | 13.24 |
| Turbidity (NTU) | 5.3 | 5.3 | — | 5.3 |
| TDS mg/L | 928 | 926 | | 927 |

**Algae:**

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**KP161.58**

Botanical specimens list:

- **Diospyros humilis*
- **Casuarina* sp., possibly *C. cunninghamii*
- **Ficus opposita*
- **Melaleuca* sp., possibly *M. bracteata*
- **Nitella* sp., unidentified

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

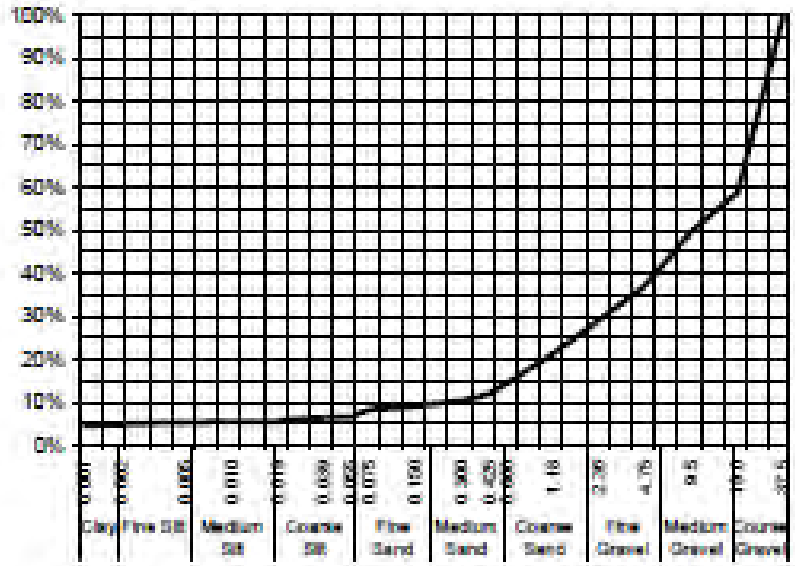
ALS Laboratory Group Pty Ltd
6 Rosegum Road
Warabrook, NSW 2304
ph 02 4968 9433
fax 02 4968 9349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-003 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP150.1 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| 37.5 | 100% |
| 19.0 | 59% |
| 9.5 | 50% |
| 4.75 | 37% |
| 2.36 | 29% |
| 1.18 | 21% |
| 0.600 | 14% |
| 0.425 | 12% |
| 0.300 | 10% |
| 0.150 | 9% |
| 0.075 | 8% |
| Particle Size (nominal) | |
| 55 | 7% |
| 39 | 6% |
| 19 | 5% |
| 10 | 5% |
| 5 | 5% |
| 4 | 5% |
| 1 | 5% |

| | |
|---|---|
| Median Particle Size (mm) | 9.500 |

Samples analysed as received.
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations.*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Gravel and coarse sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm³

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Dianne Blane
Laboratory Supervisor, Newcastle
*Authorised Signatory*

# Certificate of Analysis

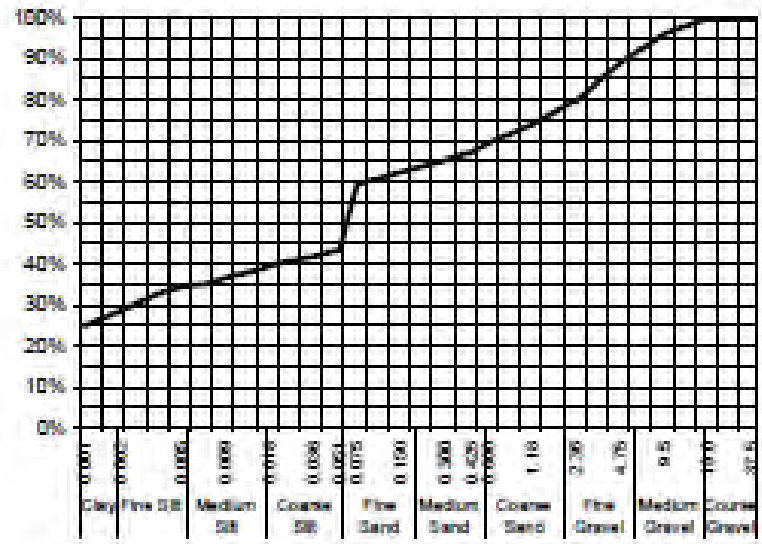
ALS Laboratory Group Pty Ltd
6 Rosegum Road
Warabrook, NSW 2304
ph 02 4968 9433
fax 02 4968 9349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 18-Jan-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 10-Jan-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1200501-004 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP160.1 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 96% |
| 4.75 | 89% |
| 2.36 | 80% |
| 1.18 | 74% |
| 0.600 | 69% |
| 0.425 | 67% |
| 0.300 | 65% |
| 0.150 | 62% |
| 0.075 | 59% |
| Particle Size (microns) | |
| 51 | 43% |
| 36 | 42% |
| 18 | 39% |
| 9 | 36% |
| 5 | 34% |
| 3 | 33% |
| 1 | 28% |

| | |
|---|---|
| Median Particle Size (mm) | 0.061 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations.*

**Sample Comments:**

**Analysed:** 13-Jan-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay, gravel and sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.66 g/cm³

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Laboratory Supervisor, Newcastle
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# Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 17/3/12 KP Point 168.07 Eastings 727425 Northings 7276778

Watercourse Name Unnamed Distance from Source 2.5km AMTD 3km

Stream Order 2 Photo taken of access track Y/N

Catchment Area Dawson - Prospect ch Weather Fine

Rain in the Past week 30mL Time of Day 3pm Cloud Cover (%) 90

---

**OBSERVATIONS**

Mean Channel width (m) 5m active (20m High banks)

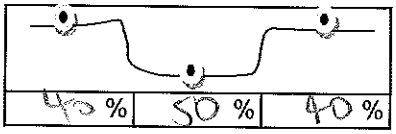
Height of Banks  Left 2.5 Right 2.5

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: **No flow** Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): **Extreme** Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 5 RB 5




---

**Riparian vegetation**: Grass % 50 Shrubs % _____

Trees < 10m % 25 Trees > 10m % 25

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | **Slight** | Nil |
|---|---|---|---|

grasses & scattered trees.

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GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % 10 |
| Boulder (>256mm) | % 30 | Gravel (4-16mm) | % 30 |
| Cobble (64-256mm) | % 30 | Sand (1-4mm) | % |
| | | Silt/clay (<1mm) | % |

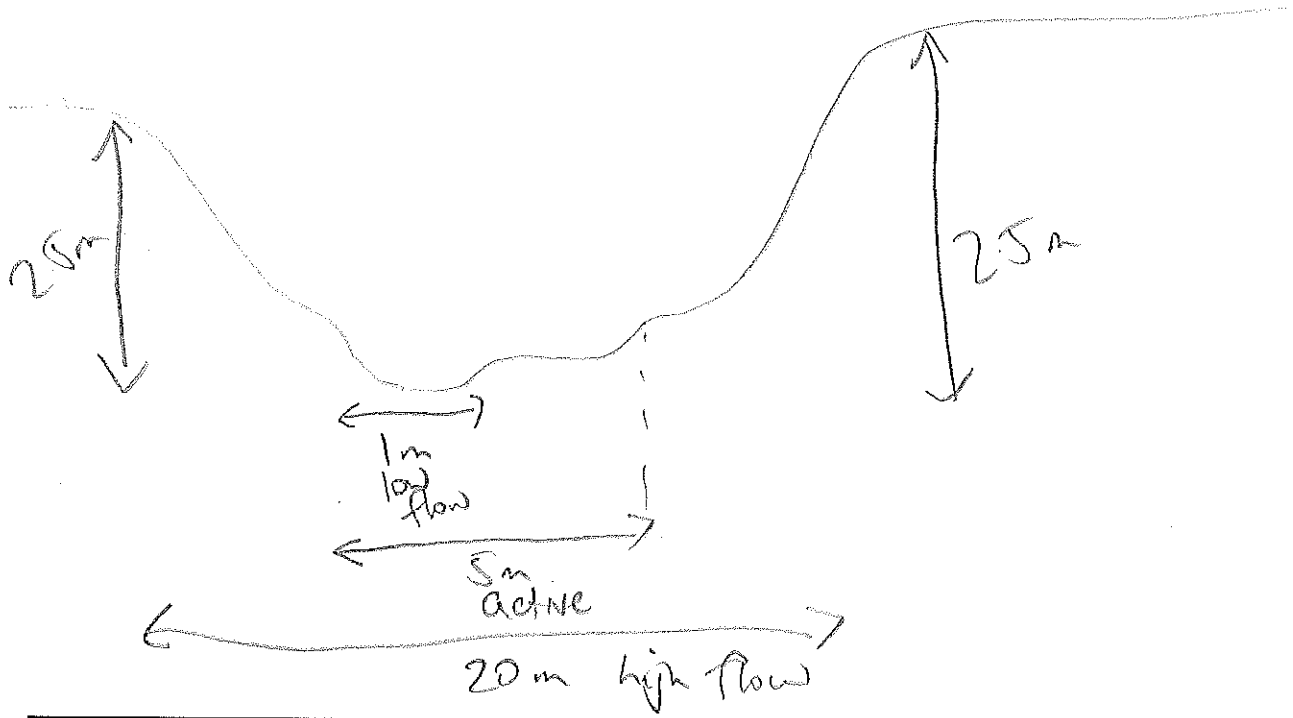
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

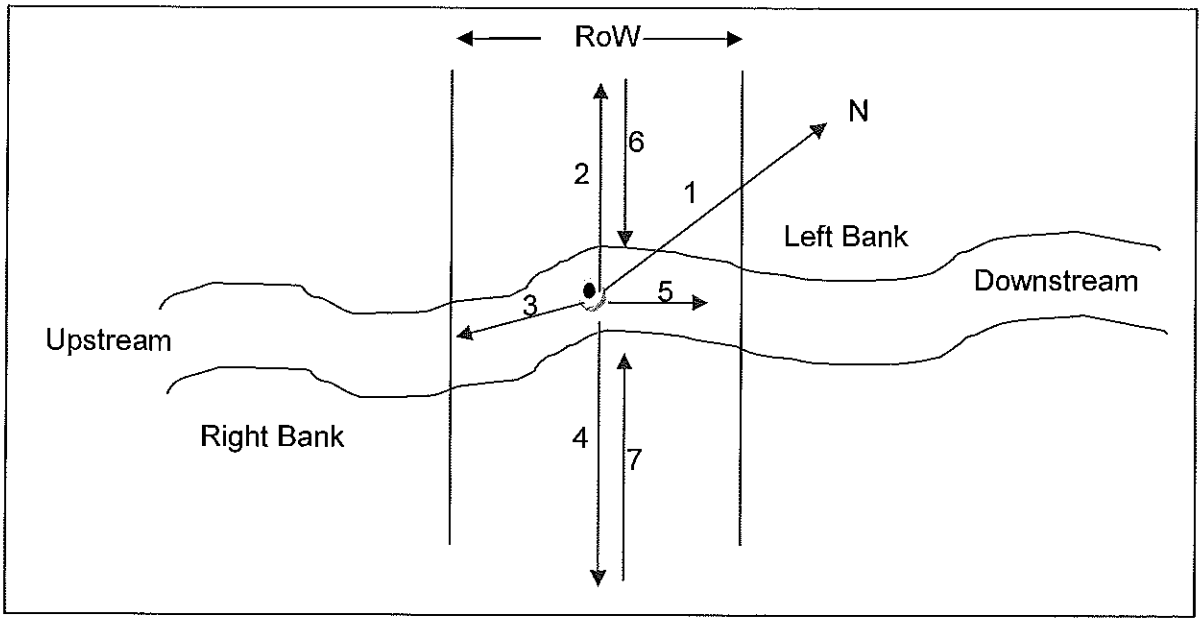
**General Comments / Reach Description:**
1m low flow 5m active with rocky bottom 20m grass high flow banks.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 168-1 |
| Facing left bank (2) | 168-2 |
| Facing Upstream (3) | 168-3 |
| Facing Right Bank (4) | 168-4 |
| Facing Downstream (5) | 168-5 |
| From edge of Riparian on left (6) | 168-6 |
| From edge of Riparian on right (7) | 168-7 |

**General Comments:**

Rocky channel with pronounced yet sparse riparian veg. Extensive erosion due to cattle movement, many exposed roots. Grass patchy in places and exposed banks.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP168.07**

Botanical specimens list:

- **Acacia sp.,* possibly *A. crassicarpa*
- **Melaleuca decora*
- *Terminalia oblongata* subsp. *Oblongata*
- Ironbark
- Eucalyptus

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

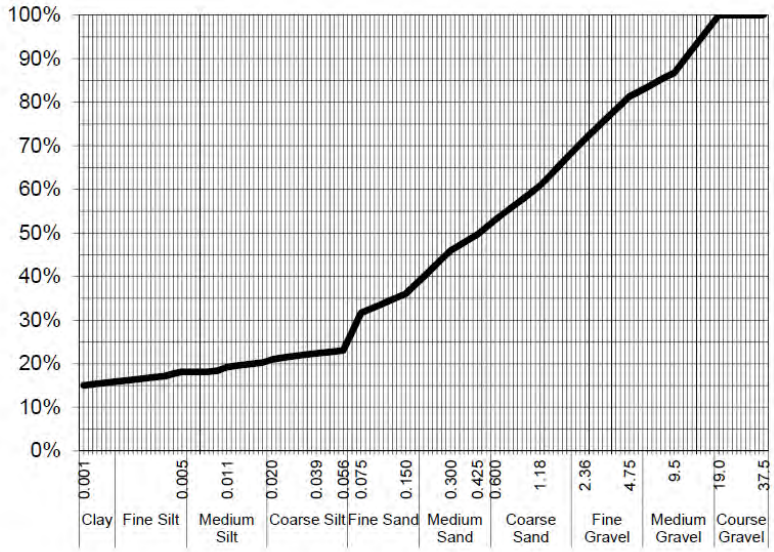
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-021 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP168.07 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 87% |
| 4.75 | 81% |
| 2.36 | 71% |
| 1.18 | 61% |
| 0.600 | 53% |
| 0.425 | 50% |
| 0.300 | 46% |
| 0.150 | 36% |
| 0.075 | 32% |
| Particle Size (microns) | |
| 56 | 23% |
| 39 | 22% |
| 20 | 21% |
| 11 | 19% |
| 5 | 18% |
| 4 | 17% |
| 1 | 15% |

| Median Particle Size (mm) | 0.425 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay, gravel and sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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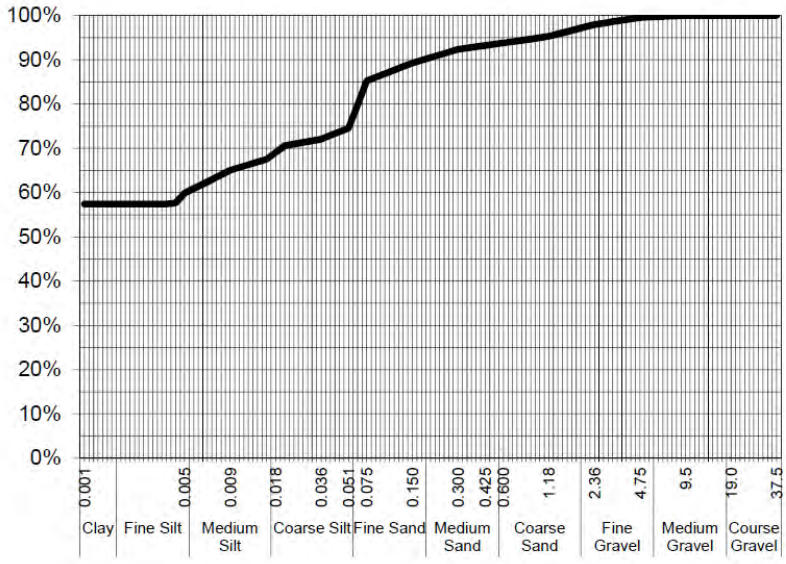
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-022 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP168.07 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 98% |
| 1.18 | 95% |
| 0.600 | 94% |
| 0.425 | 93% |
| 0.300 | 92% |
| 0.150 | 89% |
| 0.075 | 85% |
| Particle Size (microns) | |
| 51 | 75% |
| 36 | 72% |
| 18 | 69% |
| 9 | 65% |
| 5 | 60% |
| 3 | 57% |
| 1 | 57% |

| Median Particle Size (mm) | #N/A |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***















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Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 17/3/12. KP Point 171.66 Eastings 730917 Northings 7277531

Watercourse Name unnamed Distance from Source 1.2km AMTD 1km

Stream Order 1 Photo taken of access track Y/N

Catchment Area Dawson - Prospect Weather Fine

Rain in the Past week 30mL Time of Day 2pm Cloud Cover (%) 90

---

**OBSERVATIONS**

Mean Channel width (m) 1.5

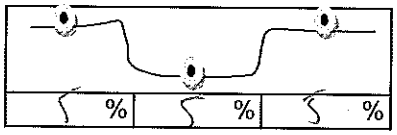
Height of Banks  Left 0.5 Right 0.5

Velocity (m/s): Flow metre N/A Floating object

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive (Moderate) Limited None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 95 Shrubs %

Trees < 10m % Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

grasses & scattered tall trees.

# Santos
GLNG Project

**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 30 |
| | | Silt/clay (<1mm) | % 70 |

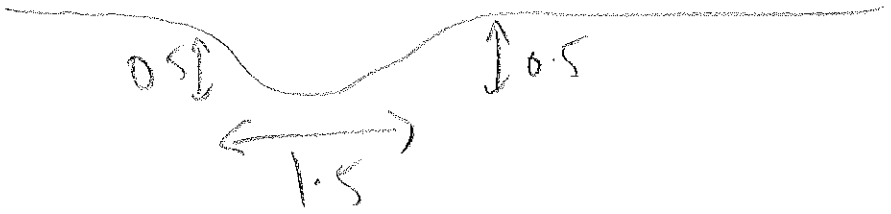
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

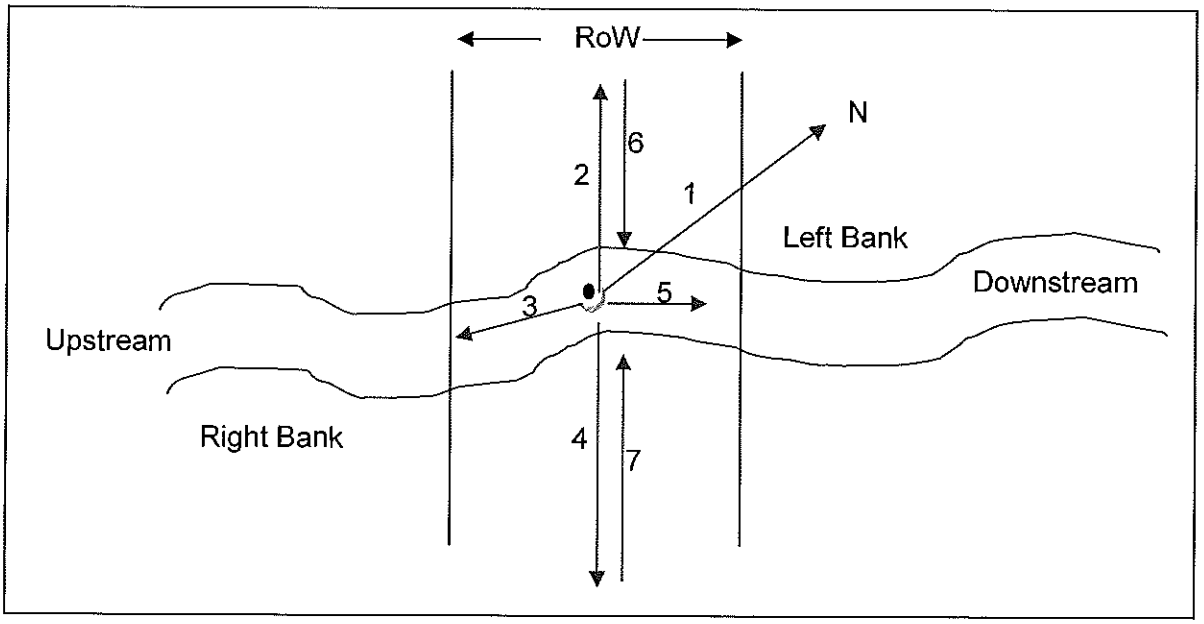
**General Comments / Reach Description:** small drainage line, shallow depression

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 171-1 |
| Facing left bank (2) | 171-2 |
| Facing Upstream (3) | 171-3 |
| Facing Right Bank (4) | 171-4 |
| Facing Downstream (5) | 171-5 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | 171-6. |

**General Comments:**

shallow drainage line, few scattered trees in shallow area. upstream cleared for Gemena pipeline, ~~between~~ good grass cover, moderate erosion from cattle trampling.

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GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**KP171.66**

Botanical specimens list:

- **Acaciasp.,* possibly *A. crassicarpa*
- **Alectryon diversifolius*
- **Geijera parviflora*
- **Lysiphyllum carronii*

*As identified by Queensland Herbarium, DERM.

# Certificate of Analysis

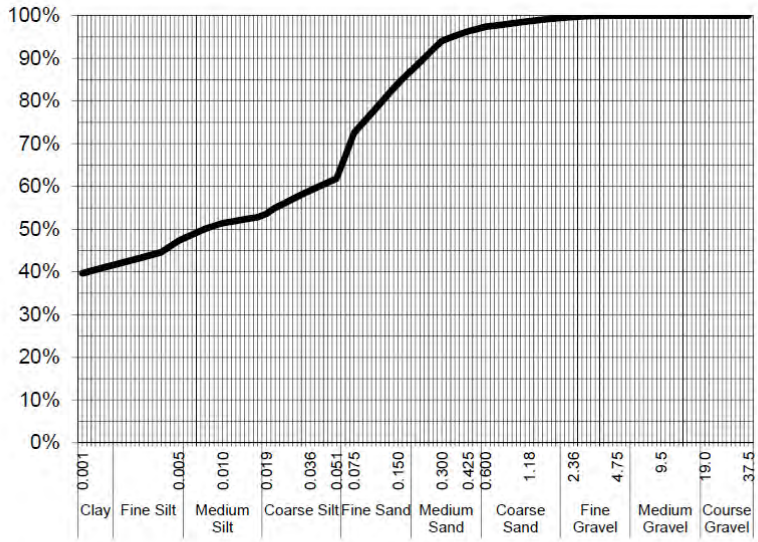
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-023 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP171.66 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 97% |
| 0.425 | 96% |
| 0.300 | 94% |
| 0.150 | 84% |
| 0.075 | 73% |
| Particle Size (microns) | |
| 51 | 62% |
| 36 | 59% |
| 19 | 54% |
| 10 | 51% |
| 5 | 47% |
| 3 | 45% |
| 1 | 40% |

| | |
|---|---|
| Median Particle Size (mm) | 0.007 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***

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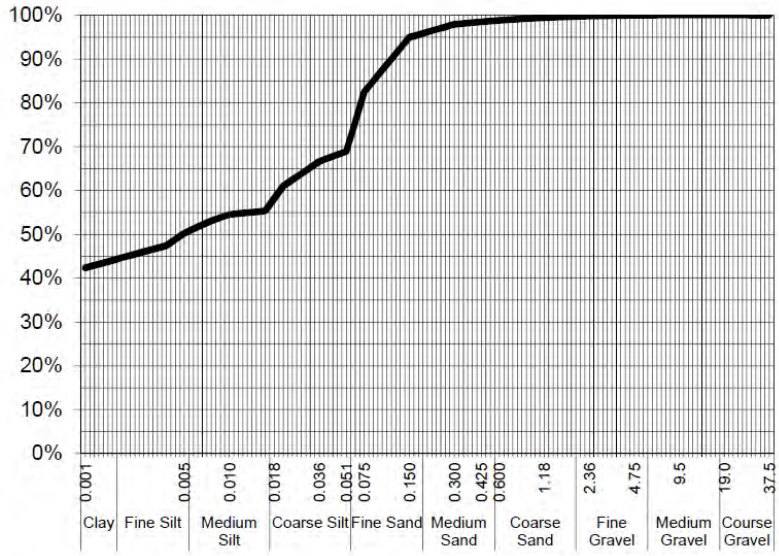
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-024 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP171.66 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 99% |
| 0.425 | 99% |
| 0.300 | 98% |
| 0.150 | 95% |
| 0.075 | 83% |
| Particle Size (microns) | |
| 51 | 69% |
| 36 | 67% |
| 18 | 58% |
| 10 | 55% |
| 5 | 50% |
| 3 | 47% |
| 1 | 42% |

| Median Particle Size (mm) | 0.005 |
|---|---|

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***













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GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 17/3/12 KP Point 173.81 Eastings 733067 Northings 7275404
Watercourse Name Unnamed Distance from Source 600m AMTD 31km
Stream Order 1 Photo taken of access track Y/N
Catchment Area Vanna prospect Weather Fine
Rain in the Past week Wet Time of Day 3:50pm Cloud Cover (%) 30

---

**OBSERVATIONS**

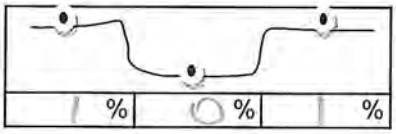
Mean Channel width (m) 2
Height of Banks  Left 0.3 Right 0.3

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: (No flow) Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate (Limited) None

Canopy cover % Width of riparian Zone (m): LB 0.5 RB 0.5

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**Riparian vegetation**: Grass % 95 Shrubs % _____
Trees < 10m % _____ Trees > 10m % 5

- Collect samples and produce species list after identification (refer to guide)

**Trailing Vegetation:**

| Extensive | Moderate | (Slight) | Nil |
|---|---|---|---|

grasses & scattered trees.

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 50 |
| | | Silt/clay (<1mm) | % 50 |

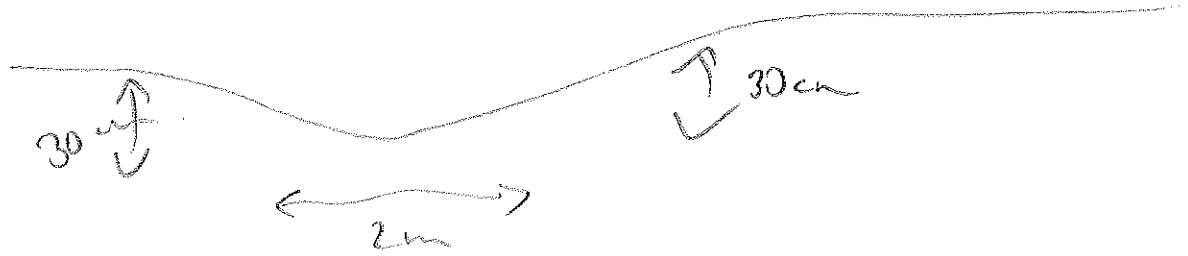
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**
Small drainage line. Not well defined channel.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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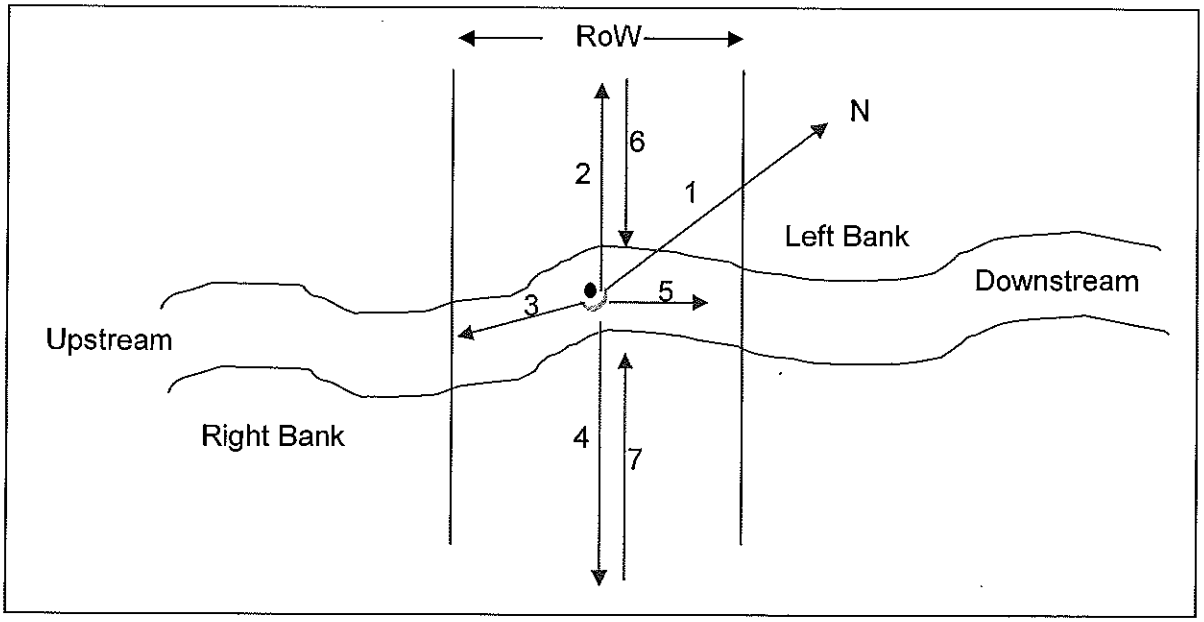
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 173-1 |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 173-2 |
| From edge of Riparian on left (6) | 173-3 |
| From edge of Riparian on right (7) | |

**General Comments:**

Small drainage line, forms eroded defined channel downstream, however not well defined channel in the crossing location. Riparian veg present, absence of sight line scattered trees.

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | | | | |
| Conductivity (µS/cm) | | | | |
| pH | | | | |
| Dissolved $O_2$ (mg/L) | | | | |
| Turbidity (NTU) | | | | |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

- * *Acacia sp., possibly A. crassicarpa*
- **Atalaya hemiglauca*

# Certificate of Analysis

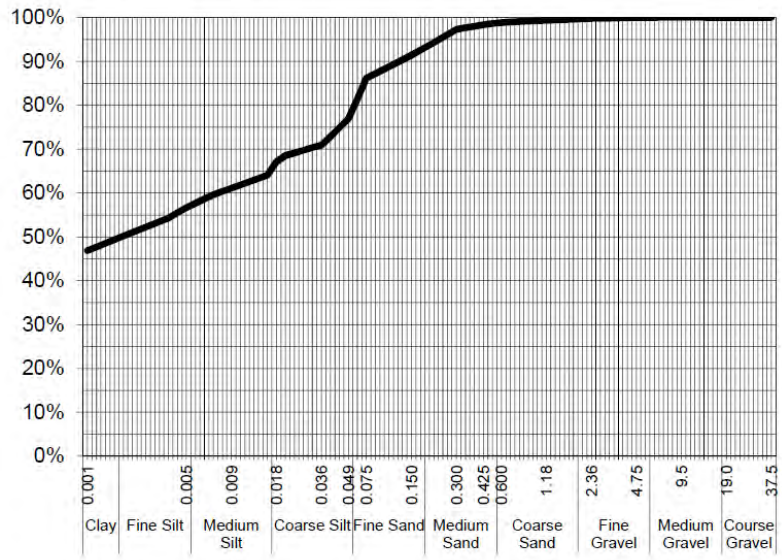
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-025 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP173.98 - Bottom |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 99% |
| 0.600 | 99% |
| 0.425 | 98% |
| 0.300 | 97% |
| 0.150 | 91% |
| 0.075 | 86% |
| Particle Size (microns) | |
| 49 | 77% |
| 36 | 71% |
| 18 | 67% |
| 9 | 61% |
| 5 | 57% |
| 3 | 54% |
| 1 | 47% |

| | |
|---|---|
| Median Particle Size (mm) | 0.002 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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Laboratory Supervisor, Newcastle
***Authorised Signatory***

# Certificate of Analysis

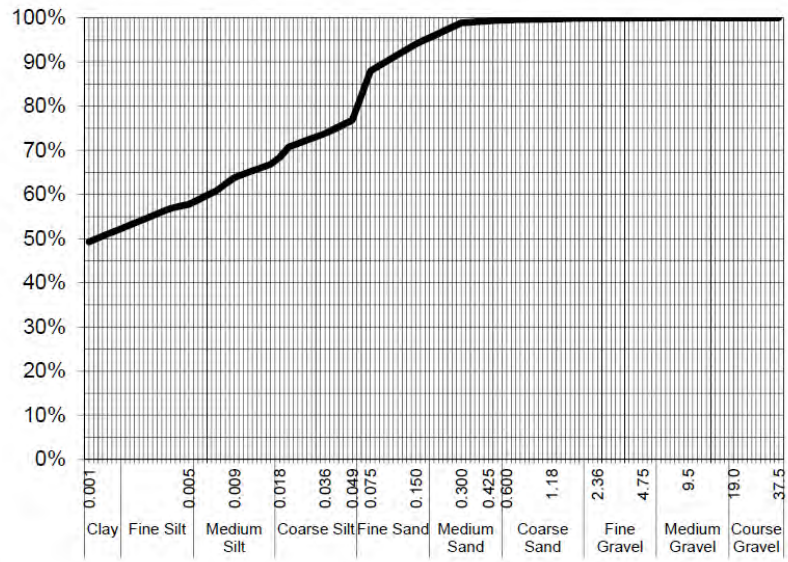
ALS Laboratory Group Pty Ltd
5 Rosegum Road
Warabrook, NSW 2304
pH 02 4968 9433
fax 02 4968 0349
samples.newcastle@alsenviro.com

**ALS Environmental**

**Newcastle, NSW**

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 5-Apr-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 29-Mar-2012 |
| **ADDRESS:** | GPO Box 1010<br>Level 22, 32 Turbot Street,<br>Brisbane, Qld 4001 | **REPORT NO:** | EB1208820-026 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP173.98 - Bank |

## Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 100% |
| 4.75 | 100% |
| 2.36 | 100% |
| 1.18 | 100% |
| 0.600 | 100% |
| 0.425 | 99% |
| 0.300 | 99% |
| 0.150 | 94% |
| 0.075 | 88% |
| Particle Size (microns) | |
| 49 | 77% |
| 36 | 74% |
| 18 | 68% |
| 9 | 64% |
| 5 | 58% |
| 3 | 57% |
| 1 | 49% |

| | |
|---|---|
| Median Particle Size (mm) | 0.002 |

*Samples analysed as received.*
** Insufficient sample provided for Soil Particle Density analysis according to AS 1289.3.5.1—2006. Typical sediment SPD values used for calculations*

**Sample Comments:**

**Analysed:** 2-Apr-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Silty clay and medium fine sand

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.2/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density*** 2.65 g/cm$^3$

**NATA Accreditation: 825 Site: Newcastle**
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Laboratory Supervisor, Newcastle
***Authorised Signatory***







**REFERENCE GUIDES**

**Categories of Bank erosion:**

| | |
|---|---|
| None: | *Typical Features* – good vegetation cover, no significant damage to bank structure, no exposed roots |
| Limited Erosion: | *Typical Features* – good vegetation cover, minor isolated erosion, no continuous damage to bank, some exposed roots |
| Moderate Erosion: | *Typical Features* – discontinuous vegetation, obvious damage to bank structure, moderate exposure of roots |
| Extensive Erosion: | *Typical Features* – little effective vegetation, recent bank movement, large amounts of exposed roots |
| Extreme Erosion: | *Typical Features* – evidence of rapid unchecked erosion, little effective vegetation, abundant exposure of roots |

Environment Australia, *National River Health Program: South Australian Sampling and Processing Manual* Accessed: December 2011, Available http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/manual-sa/pubs/manual-sa.pdf

**Plant specimen collection method:**

Queensland Herbarium, 2010, *Collecting and preserving plant speciments, a manual.* Accessed: December 2011, available: http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/publications/pdf/collecting_manual_v5.pdf

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[illegible] M[illegible]

| Watercourse Name | KP | SO | Regional Ecosystem Status (VM Act) | Regional Ecosystem Code | Eastings | Northings |
|---|---|---|---|---|---|---|
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**APPENDIX D3 – Field Data Sheets, Photographs, Laboratory Results and Herbarium Results Minor Watercourses KP406-409**

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# GLNG

## Gas Transmission Pipeline

## Field Data Sheet for Watercourse Assessments

Document Number: 3380-GLNG-4-1.3-0047

**PREPARED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Scientist | A.Hampson | | |

**ENDORSED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Coordinator | B.Angus | | |

**APPROVED BY:**

| Title | Name | Signature | Date |
|---|---|---|---|
| Environmental Manager | I.Bridge | | |

| DATE | REV | REASON FOR ISSUE | AUTHOR | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 4/01/12 | A | For Review | | | |
| | | | | | |
| | | | | | |
| | | | | | |

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### FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 30/3/12 KP Point 40678 Eastings 308374 Northings 7371857.67

Watercourse Name Unnamed Distance from Source 300m AMTD 850m

Stream Order 1 Photo taken of access track Y/N

Catchment Area Calliope-Mosquito Weather Fine

Rain in the Past week _____ Time of Day 9am Cloud Cover (%) _____

---

**OBSERVATIONS**

Mean Channel width (m) 20m

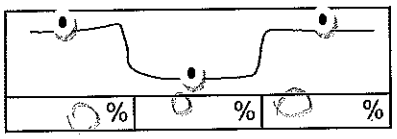
Height of Banks  Left 1.5 Right 1.5

Velocity (m/s): Flow metre N/A Floating object 0.02 m/s

Flow level: No flow (Low (<watermark)) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive (Moderate) Limited None

Canopy cover % Width of riparian Zone (m): LB _____ RB _____




---

**Riparian vegetation**: Grass % 80% Shrubs % 5%

Trees < 10m % _____ Trees > 10m % 15%

- Collect samples and produce species list after identification (refer to guide)

Mangroves present

**Trailing Vegetation:**

| Extensive | (Moderate) | Slight | Nil |
|---|---|---|---|

Iron bark

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**Substrate Description:**

| | | | |
|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % |
| Boulder (>256mm) | % | Gravel (4-16mm) | % |
| Cobble (64-256mm) | % | Sand (1-4mm) | % 100 |
| | | Silt/clay (<1mm) | % |

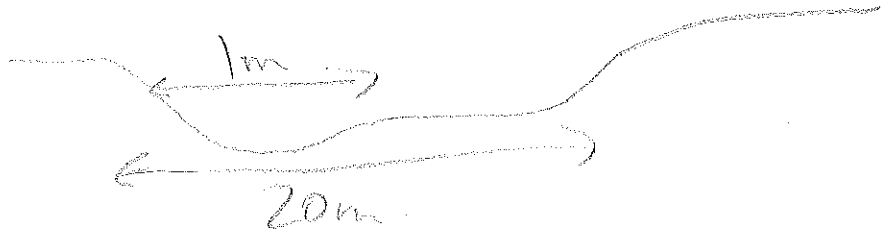
**Bank Material** Dispersive/Sodic Y/N

- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

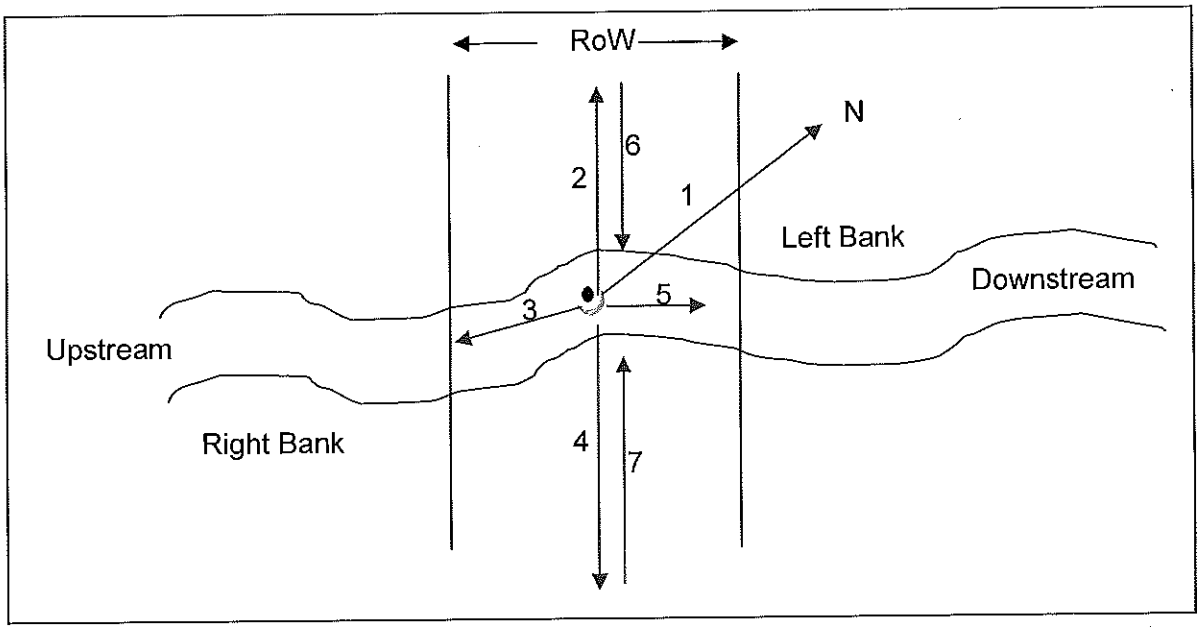
**General Comments / Reach Description:**
small winding channel. low flow. Approx 1m wide active channel, high flow channel approx 20m wide.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | 1 |
| Facing Right Bank (4) | |
| Facing Downstream (5) | 2 |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

3 - 20m distance
4 - Right bank / mangrove
5 - Lumnitzera sp.

**General Comments:**

Trailing veg consists of Ironbark & Eucalypts. Relatively clear at crossing location, scattered mangroves (lumnitzera) very small ~ 1m tall. Downstream veg changes to casuarinas

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## GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 26·01 | 26·89 | 27·65 | |
| Conductivity (µS/cm) | 43352 | 1741 | 1828 | |
| pH | 6·32 | 7·41 | 7·42 | |
| Dissolved $O_2$ (mg/L) | 4·66 | 8·13 | 8·44 | |
| Turbidity (NTU) | 14·9 | 18·0 | 26·0 | |

pool. 10.05 20mDS

* highly saline in small pool.

**Algae:**

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

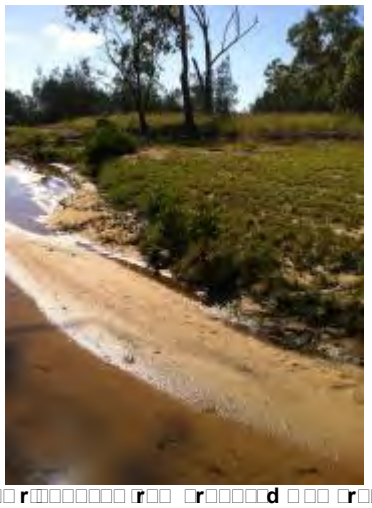
- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification. Not enough water

**4**

- *Avicennia marina . australasica*
- **Lumnitzera racemosa*
- M r
- r r
- 

d d d r r M









***Lumnitzera racemosa***



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## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 30/3/12 KP Point 407.87 Eastings 309234 Northings 7371274
Watercourse Name Hungry Creek Distance from Source 2.7km AMTD 1-3km
Stream Order 3 Photo taken of access track Y/N
Catchment Area Mosquito Weather Fine.
Rain in the Past week _____ Time of Day 2pm Cloud Cover (%) 20.
HTide 2.13.

---

**OBSERVATIONS**

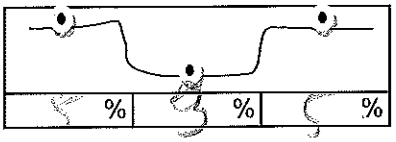
Mean Channel width (m) 10m.
Height of Banks  Left 4 Right 2

Velocity (m/s): Flow metre N/A Floating object _____

Flow level: No flow | Low (<watermark) | Moderate (= watermark) | High (>watermark) | Flood

Bank Erosion (see guide): Extreme | Extensive | Moderate | Limited | None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




---

**Riparian vegetation**: Grass % 50 Shrubs % _____
Trees < 10m % 40 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)
  - crops, scattered mangroves.

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Eucalypts, Narrow leaved ironbark.

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| **Substrate Description:** | | | | |
|---|---|---|---|---|
| Bedrock | % | Pebble (16-64mm) | % | |
| Boulder (>256mm) | % | Gravel (4-16mm) | % | /100 |
| Cobble (64-256mm) | % | Sand (1-4mm) | % | |
| | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

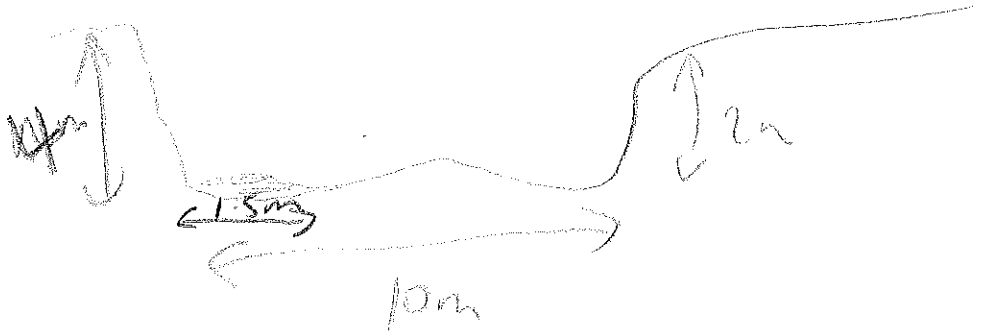
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

## GEOMORPHOLOGY

**General Comments / Reach Description:**

Straight winding channel, steep banks. Moderate level of erosion.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



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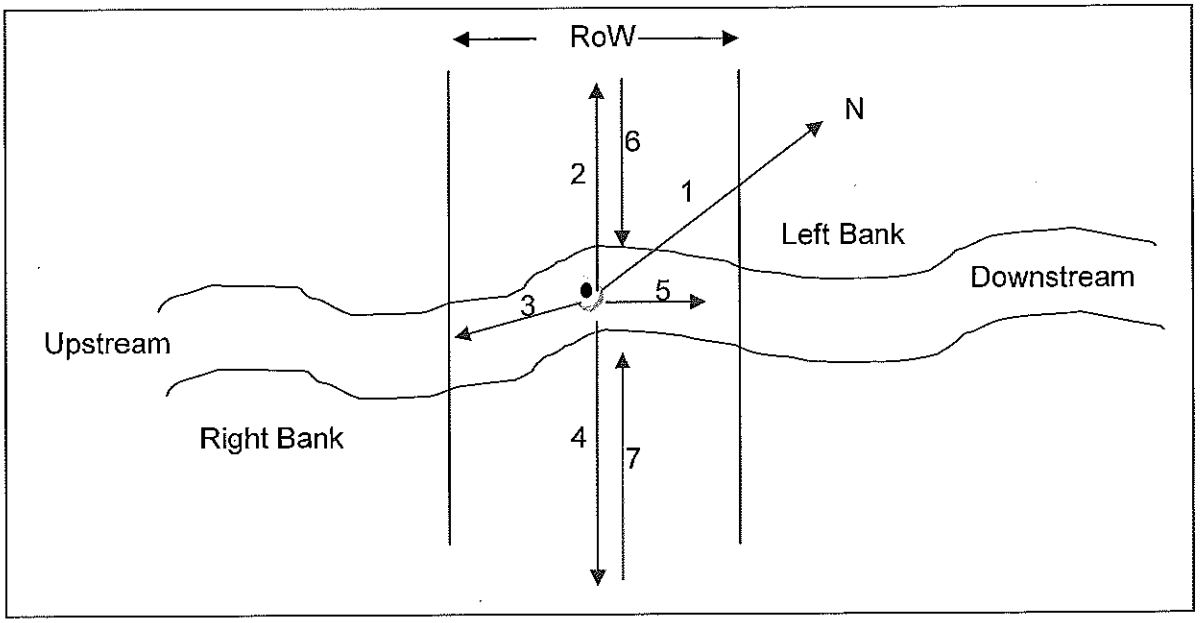
**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | |
| Facing left bank (2) | |
| Facing Upstream (3) | |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

**General Comments:**

Winding channel, limited riparian veg. scattered Ceriops ~ 20 individuals in crossing location scattered both upstream & d/stream of crossing. Other mangrove species also present. Watercourse moderately flowing, well below watermark, moderately saline. Evidence of saltwater intrusion.

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**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 31·31 | 31·26 | | 31·23 |
| Conductivity (µS/cm) | 6267 | 6363 | | 6315 |
| pH | 7·86 | 7·87 | | 7·865 |
| Dissolved $O_2$ (mg/L) | 9·05 | 8·95 | | 9·0 |
| Turbidity (NTU) | 7·8 | 8·1 | | 7·95 |

---

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**4**

- *Aegialitis annulata*
- **Ceriops tagal*
- **Lumnitzera racemosa*
- **Myrsine crassifolia*
- rr d r r

d d d r r M

# Certificate of Analysis

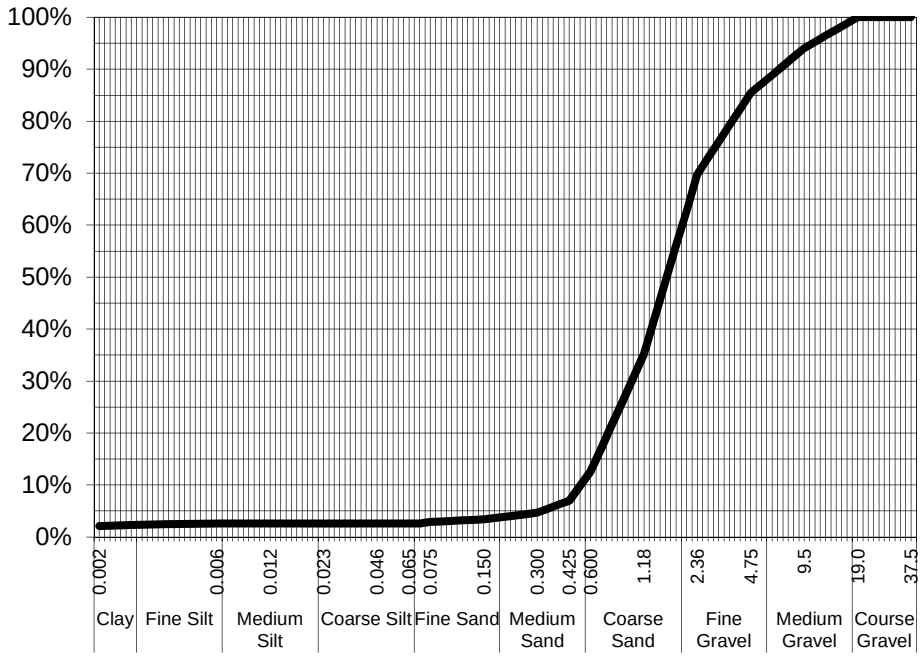
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-001 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP407.87 - Bottom |

### Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 94% |
| 4.75 | 85% |
| 2.36 | 70% |
| 1.18 | 35% |
| 0.600 | 13% |
| 0.425 | 7% |
| 0.300 | 5% |
| 0.150 | 3% |
| 0.075 | 3% |
| Particle Size (microns) | |
| 65 | 3% |
| 46 | 3% |
| 23 | 3% |
| 12 | 3% |
| 6 | 3% |
| 4 | 3% |
| 2 | 2% |

| | |
|---|---|
| Median Particle Size (mm) | 1.180 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

**Sample Comments:**

**Analysed:** 15-May-12

**Loss on Pretreatment** NA

**Limit of Reporting:** 1%

**Sample Description:** Medium coarse sand and gravel

**Dispersion Method** Shaker

**Test Method:** AS1289.3.6.1/AS1289.3.6.3

**Hydrometer Type** ASTM E100

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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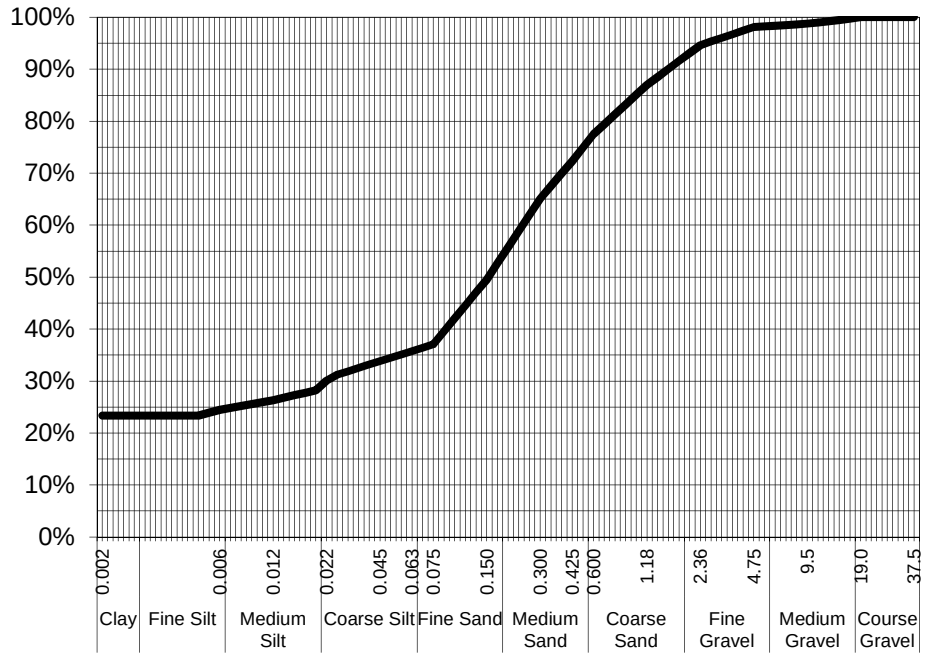
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-002 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP407.87 - Bank |

### Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 99% |
| 4.75 | 98% |
| 2.36 | 95% |
| 1.18 | 87% |
| 0.600 | 77% |
| 0.425 | 72% |
| 0.300 | 65% |
| 0.150 | 50% |
| 0.075 | 37% |
| Particle Size (microns) | |
| 63 | 36% |
| 45 | 34% |
| 22 | 30% |
| 12 | 26% |
| 6 | 24% |
| 4 | 23% |
| 2 | 23% |

| | |
|---|---|
| Median Particle Size (mm) | 0.150 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

| | | | |
|---|---|---|---|
| **Sample Comments:** | | **Analysed:** | 15-May-12 |
| **Loss on Pretreatment** | NA | **Limit of Reporting:** | 1% |
| **Sample Description:** | Sand and silty clay | **Dispersion Method** | Shaker |
| **Test Method:** | AS1289.3.6.1/AS1289.3.6.3 | **Hydrometer Type** | ASTM E100 |

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***











# Santos
GLNG Project

## FIELD DATA SHEET FOR STREAM ORDER 1 AND 2 ASSESSMENT

Date 30/3/12 KP Point 408.50 Eastings 309691 Northings 7370185

Watercourse Name Taginnie Distance from Source 2.5km AMTD 1.3km

Stream Order 2 Photo taken of access track Y/N

Catchment Area Mosquito Weather Fine

Rain in the Past week — Time of Day 1pm Cloud Cover (%) 20

High tide 2.13pm.

**OBSERVATIONS**

Mean Channel width (m) 10m

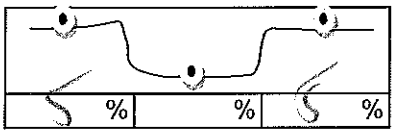
Height of Banks  Left 2 Right 3

Velocity (m/s): Flow metre N/A Floating object 0.3m/s

Flow level: No flow Low (<watermark) Moderate (= watermark) High (>watermark) Flood

Bank Erosion (see guide): Extreme Extensive Moderate Limited None

Canopy cover % Width of riparian Zone (m): LB 1 RB 1




**Riparian vegetation**: Grass % 70 Shrubs % _____

Trees < 10m % 20 Trees > 10m % 10

- Collect samples and produce species list after identification (refer to guide)

-majors present

**Trailing Vegetation:**

| Extensive | Moderate | Slight | Nil |
|---|---|---|---|

Eucalypts, Moreton Bay Ash.

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| **Substrate Description:** | | | | | |
|---|---|---|---|---|---|
| | Bedrock | % | Pebble (16-64mm) | % | 20 |
| | Boulder (>256mm) | % | Gravel (4-16mm) | % | 10 |
| | Cobble (64-256mm) | % 70 | Sand (1-4mm) | % | |
| | | | Silt/clay (<1mm) | % | |

**Bank Material** Dispersive/Sodic Y/N

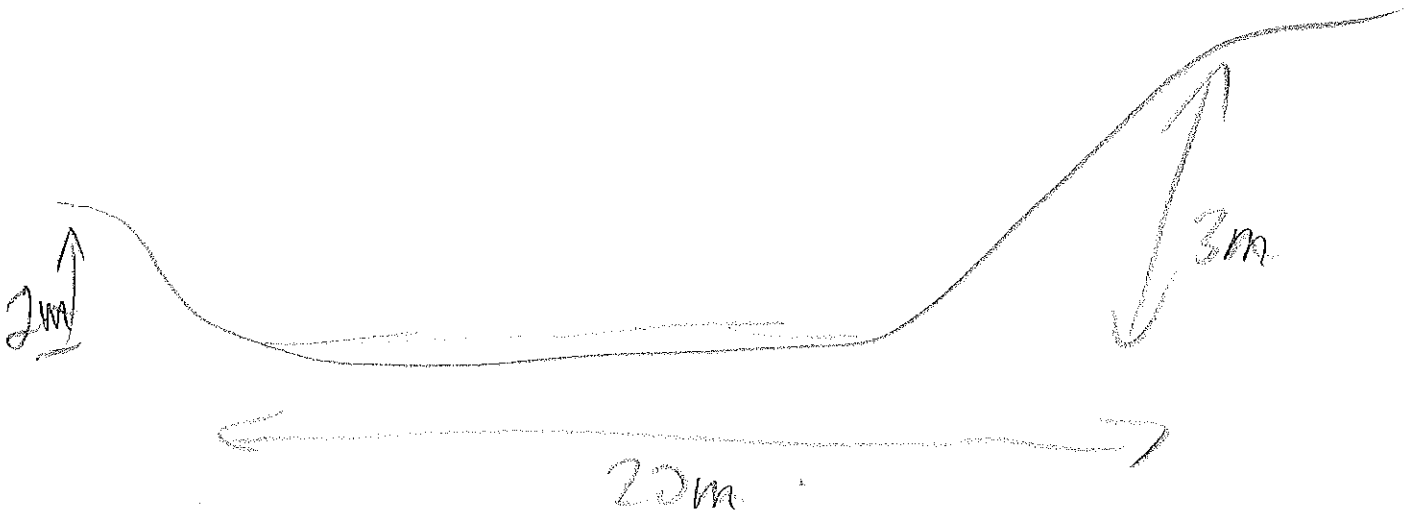
- Collect two samples for laboratory analysis of particle size distribution (refer to guide)

**GEOMORPHOLOGY**

**General Comments / Reach Description:**

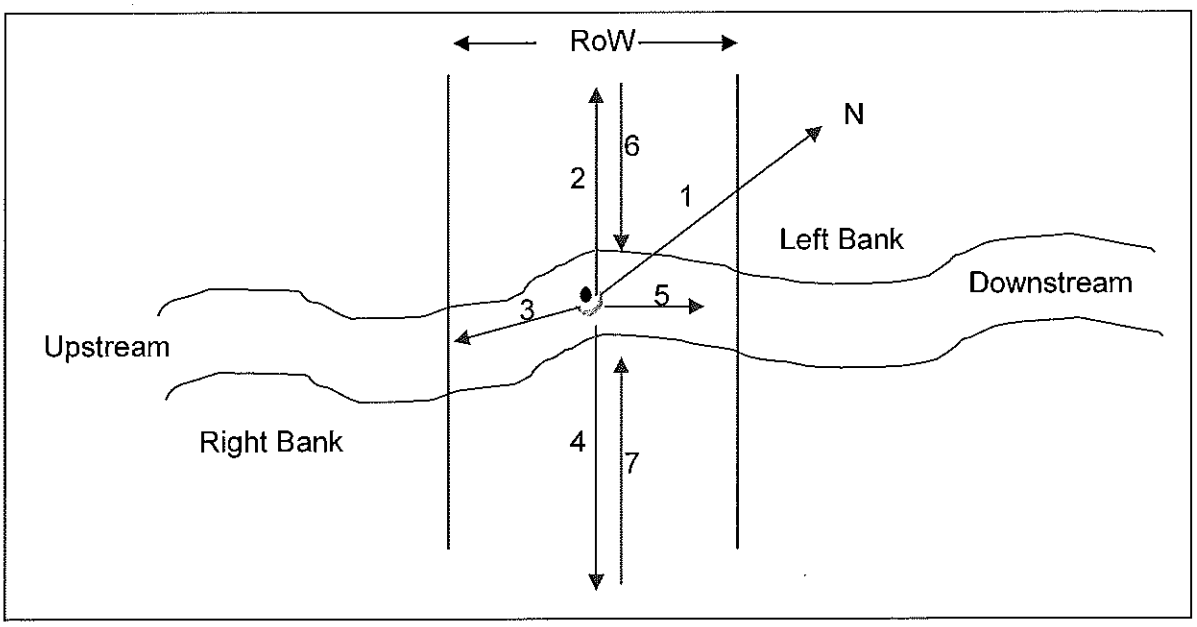
Large pool in crossing location. Fast flowing riffle section downstream. Channel divides into 2 channels d/stream.

**Cross Sectional Sketch:** (include measurements of channels (low flow, active, high flow) / banks)



# Santos
## GLNG Project

**Photographs to be taken:**




Minimum of 7 photographs to be taken:

| Photo | File name |
|---|---|
| Facing north (1) | 8 - small anabranch. |
| Facing left bank (2) | 9 - left bank. |
| Facing Upstream (3) | 10 - d/stream. |
| Facing Right Bank (4) | |
| Facing Downstream (5) | |
| From edge of Riparian on left (6) | |
| From edge of Riparian on right (7) | |

1 - facing u/stream from 30m d/s of crossing looking X
2 - " from 10m d/s X
3. facing d/stream from 30m X
4. d/stream / 30m d/s X
5. Upstream / " " X
6. Upstream at crossing loc.
7. d/stream crossing.

**General Comments:**

Large Pool in crossing location, fast flowing riffle section downstream (10m) from crossing. divided into 2 channels. Small anabranch at crossing location approximately 10m long. Large grassed island in main channel downstream. ~~Veg~~ Riparian veg in patches & consists mainly of Eucalypts, Melaleuca, Moreton Bay Ash, Ironbark, Mangroves present. No macrophytes present but ~~#~~ algae present on substrate.

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## GLNG Project

**Is water present? Yes No**

If yes, the following page needs to be completed.

**WATER QUALITY**

- To be taken using a calibrated water quality meter

pool section (crossing) Riffle (10m downstream)

| Parameter | Reading 1 | Reading 2 | Reading 3 | Mean |
|---|---|---|---|---|
| Water temperature (°C) | 31.05 | 31.4 | 30.93 | 31.03 |
| Conductivity (µS/cm) | 415 | 393 | 493 | 550 |
| pH | 7.55 | 7.56 | 7.71 | 7.77 |
| Dissolved $O_2$ (mg/L) | 8.67 | 8.52 | 8.08 | 8.14 |
| Turbidity (NTU) | 41.1 | 5.8 | 24.0 | 4.9 |

*Little difference btw pool & riffle in term of WQ. → possible road error.

**Algae**:

| | | | | |
|---|---|---|---|---|
| Substrate: | None | Little | Moderate | Lot |
| In Water Column: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macrophytes:**

| | | | | |
|---|---|---|---|---|
| Emergent: | None | Little | Moderate | Lot |
| Submerged: | None | Little | Moderate | Lot |
| Floating: | None | Little | Moderate | Lot |

- Collect samples and produce species list after identification (refer to guide)

**Macroinvertebrates:**

- Collect samples according to AUSRIVAS protocol and send to laboratory fro identification.

**4 5**

- *Lumnitzera racemosa*
- 
- M r
- r r
- M

d d d r r M

# Certificate of Analysis

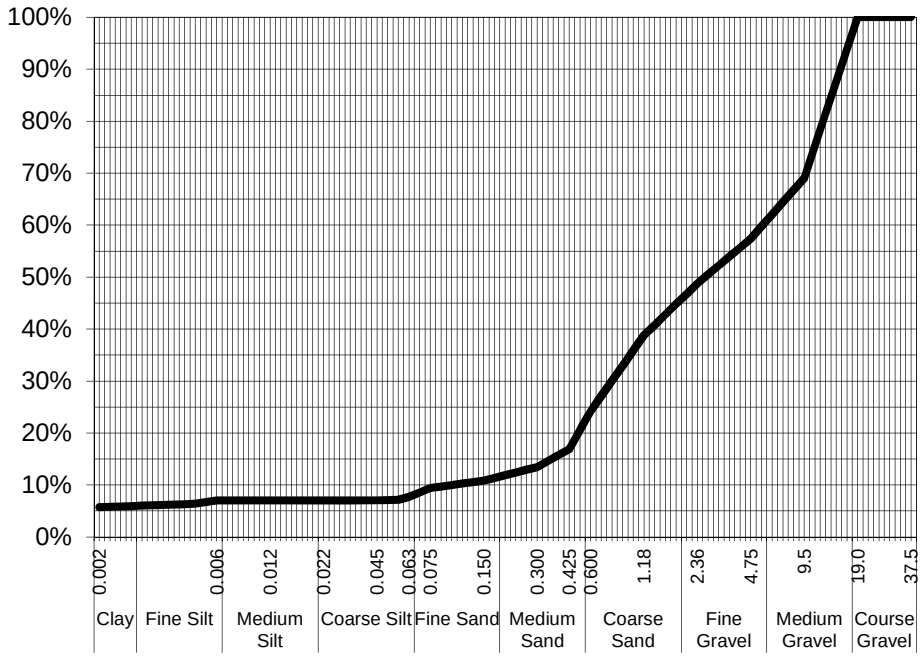
**ALS Laboratory Group Pty Ltd**
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-003 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP408.505 - Bottom |

### Particle Size Distribution




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 69% |
| 4.75 | 57% |
| 2.36 | 49% |
| 1.18 | 39% |
| 0.600 | 24% |
| 0.425 | 17% |
| 0.300 | 13% |
| 0.150 | 11% |
| 0.075 | 9% |
| Particle Size (microns) | |
| 63 | 8% |
| 45 | 7% |
| 22 | 7% |
| 12 | 7% |
| 6 | 7% |
| 4 | 6% |
| 2 | 6% |

| | |
|---|---|
| Median Particle Size (mm) | 2.360 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

| | | | |
|---|---|---|---|
| **Sample Comments:** | | **Analysed:** | 15-May-12 |
| **Loss on Pretreatment** | NA | **Limit of Reporting:** | 1% |
| **Sample Description:** | Gravel, shell and medium coarse sand | **Dispersion Method** | Shaker |
| **Test Method:** | AS1289.3.6.1/AS1289.3.6.3 | **Hydrometer Type** | ASTM E100 |

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

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**Dianne Blane**
Laboratory Supervisor, Newcastle
***Authorised Signatory***

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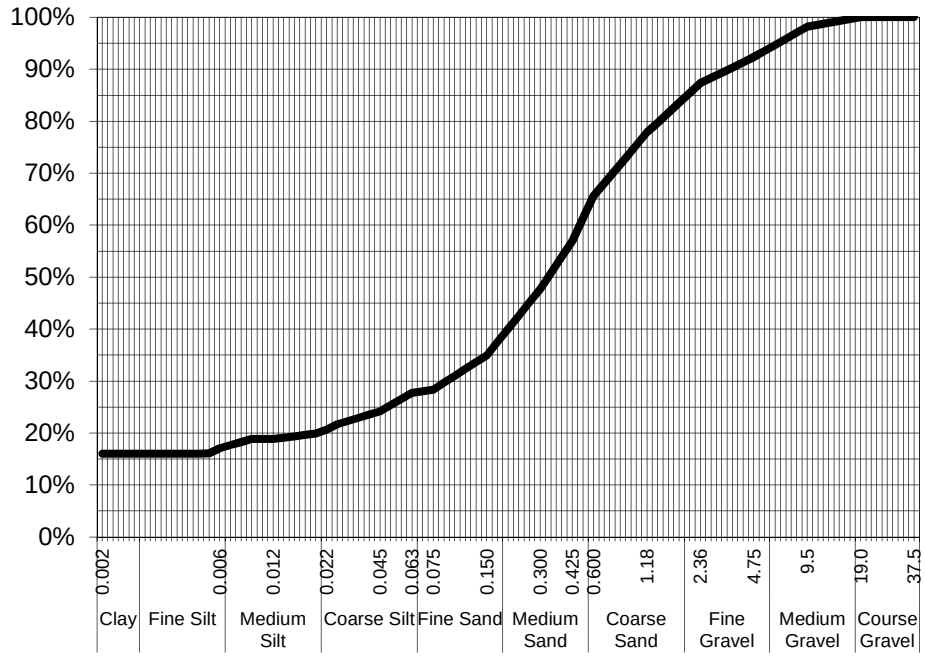
**5 Rosegum Road**
**Warabrook, NSW 2304**
**pH 02 4968 9433**
**fax 02 4968 0349**
**samples.newcastle@alsenviro.com**

## ALS Environmental

## Newcastle, NSW

| | | | |
|---|---|---|---|
| **CLIENT:** | Angela Hampson | **DATE REPORTED:** | 21-May-2012 |
| **COMPANY:** | Santos Ltd | **DATE RECEIVED:** | 4-May-2012 |
| **ADDRESS:** | GPO Box 1010<br>Brisbane, Qld, Australia 4001 | **REPORT NO:** | EB1212113-004 / PSD |
| **PROJECT:** | GLNG | **SAMPLE ID:** | KP408.505 - Bank |

**Particle Size Distribution**




| Particle Size (mm) | Percent Passing |
|---|---|
| | |
| | |
| | |
| 19.0 | 100% |
| 9.5 | 98% |
| 4.75 | 92% |
| 2.36 | 87% |
| 1.18 | 78% |
| 0.600 | 66% |
| 0.425 | 57% |
| 0.300 | 48% |
| 0.150 | 35% |
| 0.075 | 28% |
| Particle Size (microns) | |
| 63 | 28% |
| 45 | 24% |
| 22 | 21% |
| 12 | 19% |
| 6 | 17% |
| 4 | 16% |
| 2 | 16% |

| | |
|---|---|
| Median Particle Size (mm) | 0.300 |

*Samples analysed as received.*
*Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1—2006 was not requested by the client . Typical sediment SPD values used for calculations and consequently, NATA endorsement does not apply to hydrometer results*

| | | | |
|---|---|---|---|
| **Sample Comments:** | | **Analysed:** | 15-May-12 |
| **Loss on Pretreatment** | NA | **Limit of Reporting:** | 1% |
| **Sample Description:** | Sand, silty clay and shell | **Dispersion Method** | Shaker |
| **Test Method:** | AS1289.3.6.1/AS1289.3.6.3 | **Hydrometer Type** | ASTM E100 |

**Soil Particle Density (<2.36mm)** 2.65 g/cm$^3$

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Laboratory Supervisor, Newcastle
***Authorised Signatory***



**Facing upstream from proposed GTP crossing location (KP408.5)**



**Small anabranch located at proposed GTP crossing location (KP408.5)**



**Facing downstream from proposed GTP crossing location (KP408.5)**



**Facing proposed crossing location from edge of left riparian (KP408.5)**

**REFERENCE GUIDES**

**Categories of Bank erosion:**

| | |
|---|---|
| None: | *Typical Features* – good vegetation cover, no significant damage to bank structure, no exposed roots |
| Limited Erosion: | *Typical Features* – good vegetation cover, minor isolated erosion, no continuous damage to bank, some exposed roots |
| Moderate Erosion: | *Typical Features* – discontinuous vegetation, obvious damage to bank structure, moderate exposure of roots |
| Extensive Erosion: | *Typical Features* – little effective vegetation, recent bank movement, large amounts of exposed roots |
| Extreme Erosion: | *Typical Features* – evidence of rapid unchecked erosion, little effective vegetation, abundant exposure of roots |

Environment Australia, *National River Health Program: South Australian Sampling and Processing Manual* Accessed: December 2011, Available http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/manual-sa/pubs/manual-sa.pdf

**Plant specimen collection method:**

Queensland Herbarium, 2010, *Collecting and preserving plant specimens, a manual.* Accessed: December 2011, available: http://www.derm.qld.gov.au/wildlife-ecosystems/plants/queensland_herbarium/publications/pdf/collecting_manual_v5.pdf

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**APPENDIX E – Significant Species Management Profiles**

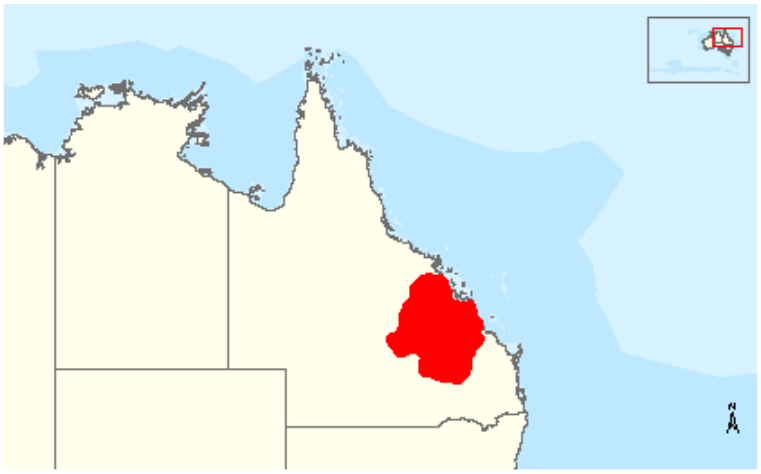
## [illegible]

[illegible] [illegible]

[illegible] [illegible]

[illegible] [illegible]

[illegible] *Rheodytes leukops* [illegible] [illegible] [illegible]



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Santos
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## 4.4 Groundwater

Groundwater monitoring is undertaken in accordance with the Groundwater Monitoring Plan (GMP) and Groundwater Management Plan (GMP) to assess the potential impacts of CSG production on groundwater resources. The GMP and GMP are reviewed annually and updated as required to reflect changes in the monitoring program, new data, and improvements in monitoring techniques. The GMP and GMP are also reviewed and updated in response to any changes in the regulatory framework or in response to any incidents or exceedances that occur during the reporting period. The GMP and GMP are reviewed and updated in consultation with the relevant regulatory authorities, including the Department of Environment and Science (DES) and the Department of Natural Resources, Mines and Energy (DNRME). The GMP and GMP are also reviewed and updated in consultation with the Community Consultative Committee (CCC) and other stakeholders as appropriate.

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# GLNG Gas Transmission Pipeline Corridor

- Kilometre Post Distance Marker (km)
- GLNG GTP ROW and Ancillary Work Areas

**Habitat Rating**

- General Habitat

Source:
Gas Transmission Pipeline (GTP): Santos, Apr 2012.
Aerial: BING, Feb 2011.

## Figure 22.2a: Fitzroy River Turtle (*Rheodytes leukops*) Habitat Ratings Based on Predictive Modelling KP0 to KP30

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A1 scale: 1:55,000

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GLNG No: XXXX-XX-XXXX

Coordinate system: GCS_GDA_1994

Date: 11/01/2013 Version: b




Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_237.mxd 23/10/2012 11:25

A1 scale:1:280,000

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GLNG No: XXXX-XX-XXXX

Coordinate system: GCS_GDA_1994

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# GLNG Gas Transmission Pipeline Corridor

Kilometre Post Distance Marker (km)

GLNG GTP ROW and Ancillary Work Areas

**Habitat Rating**

General Habitat

Source:
Gas Transmission Pipeline (GTP): Santos, Apr 2012.
Aerial: BING, Feb 2011.

## Figure 22.2b: Fitzroy River Turtle (*Rheodytes leukops*) Habitat Ratings Based on Predictive Modelling KP130 to KP312

Date: 23/10/2012 Version: a

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# GLNG Gas Transmission Pipeline Corridor

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**Habitat Rating**

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KP360

KP360.25

KP350

KP340

KP330

KP320

KP310

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## 4.5 Consultation

The Consultation Coordinator will be responsible for coordinating consultation activities undertaken and recorded in accordance with this Plan. Consultation activities undertaken will be recorded in the Consultation Database.

## 5 Consultation Objectives and Key Messages

- Provide accurate and timely information to stakeholders
- Seek and consider stakeholder feedback in relation to project activities
- Identify and address potential issues and concerns raised by stakeholders
- Foster positive relationships with stakeholders
- Maintain a high level of transparency and accountability

## Table 5 Consultation Objectives and Key Messages

Project activities will be communicated to stakeholders in accordance with the objectives and key messages outlined in Table 5. The objectives and key messages will be reviewed and updated as required throughout the life of the Project.

Table 5 Consultation Objectives and Key Messages

| Objectives | Key Messages |
|---|---|
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |
| Build and maintain | |

## 6 Methods of Consultation

### 6.1 Consultation Activities

Consultation activities undertaken during the Project will be recorded in the Consultation Database.

**Methods of consultation may include:**

- Consultation activities undertaken during the Project will be recorded in the Consultation Database. Consultation activities undertaken will be recorded in the Consultation Database. Consultation activities undertaken will be recorded in the Consultation Database.
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## 5.6 Aquatic fauna

### 5.6.1 White-throated snapping turtle Management Profile

Species Name: *Elseya albagula* (White-throated snapping turtle)

Status: EPBC Act = N/A
NC Act = Back on Track Species

Known and potential impacts of the Project on this species

- Loss of potential nesting habitat (Dawson River, Baffle and Hutton Creeks, Larcom Creek, Harper Creek and Mimosa Creek) between 1 and 2 ha (i.e. 30 wide x 100 to 150 m long at each crossing location).
- Temporary and permanent disturbance to in stream habitats.
- Temporary changes to environmental flows through the construction of temporary impoundments and crossings.
- Changes to water quality as a result of bank destabilisation, pollutant run-off, disturbance of substrate and removal of vegetation.
  Interred of nests during crossing activities.

Description: The White-throated snapping turtle is the largest *Elseya* species (carapace length of up to 420mm) and was only recently separated from the more common and widely distributed Northern snapping turtle *(Eiseya dentata).* It can be distinguished from similar species by the irregular white or cream markings present on the throat and lower sides of the face (DERM 20101, Thomson *et al*2006).

Breeding & Nesting Period: January to August is the peak breeding season for males, while females leave the water once per year between March and September. Most turtles lay one clutch per year (average 13 eggs), digging a shallow nest on the front face and top of steep sloping banks with sand or soil substrates (DERM 20101, Thomson *et al*2006). Hatchlings emerge during summer (December or January) after an incubation period of around 24 weeks (DERM 20101, Thomson *et al* 2006).



Source: Thomson *et al* 2006) (Source: A. Wain)

Habitat: The White-throated snapping turtle is herbivorous, but occasional preys on macro invertebrates. The species is widely distributed within the riverine systems it occupies, inhabiting permanent waters of the uppermost spring-fed pools to the freshwater-brackish water interface. The species prefers flowing waters with high degree if in stream complexity, including log tangles, undercut banks, and irregular rocky substrata. However, the species has been recorded from shallow turbid reaches of the Burnett and Fitzroy River which do not match their preferred habitat criteria (DERM 20101, Thomson *eta/* 2006). It is not usually observed in standing waters impounded by dams or weirs, unless associated with free-flowing streams. It does not inhabit brackish waters (DERM 20101, Thomson *et al*2006).

Distribution: This species is known to occur within the Burnett, Mary, Fitzroy, Raglan and Calliope River catchments (DERM 20101). Relevant to the project area, it has been recorded from the upstream reaches of the Dawson River, including spring-fed, permanent pools in Dawson River on

Korcha Station at 448 m altitude (Figure 4.2i), Hutton Creek on Warndoo Station at 365 m altitude (Dawson drainage) and the headwaters of Carnarvon Creek (Mcintyre drainage). This species has not been recorded upstream of these spring fed sections where there were no permanent pools during the dry season (Hamman *et* a/2007).

Locations within the GTP Corridor: During aquatic values surveys, potential habitat for this species was identified from a number of locations within the GTP ROW, including:

- Pool habitat on the Dawson River (Upstream and downstream crossing locations).
- Permanent pool habitat on Hutton Creek within the GTP ROW.
- Baffle Creek- GTP ROW intersects a large permanent pool with baseline flow.
- Mimosa Creek
- Harper Creek
- Calliope River
- Larcom Creek

Other watercourses intersected by the GTP ROW are not considered suitable habitat as there are no permanent pools within or in close proximity to the GTP ROW.

Specific Management Requirements:

*Pre-construction phase*

Pre-clearing ecological surveying will be undertaken by a suitably qualified Ecologist(s). The surveys will include carrying out a habitat assessment for this species and confirming its presence/absence within and adjacent the GTP ROW.

If suitable habitat is located during the pre-clearing surveys and construction activities occur within the breeding/nesting periods, an appropriately experienced professional/Ecologist will actively search the area(s) approx. 2 weeks prior to clearing activities beginning. If active nests are located the surrounding area (1OOm) will be declared a temporary no-go zone and potential actions will be developed in consultation with the design and construction teams and where necessary DERM..

The crossing(s) will be designed to ensure that construction time will be minimised and any associated rehabilitation works can be completed straight away.

Where applicable, a LRMP will be developed and will include specific monitoring requirements and rehabilitation completion criteria associated with the re-establishment of riparian zones in the above-listed locations.

- Prior to the commencement of construction clearing, a suitably qualified and experienced EO will mark out and barricade the buffer zones ('no go' zones) associated with the turtles habitat.
- Prior to site entry, all site personnel shall be appropriately trained and made aware of the sensitive environs in which they will be working (refer Section 7).
- DEHP will be notified of sightings and/or nesting areas observed during the pre-construction phase. This will be done as part of the project reporting (refer Section 8).

*Construction phase*

Where clearing within the known or likely habitat for the White-throated snapping turtle cannot be avoided, the following measures shall be implemented during the construction phase of the project.

All vegetation clearing within the riparian zones must comply with clearing approval conditions (e.g. NC Act approval).

Where applicable the works are undertaken in accordance with QPIF Code for self-assessable development Minor waterway barrier works on low order inland waterways.

The total clearing footprint within the riparian zones identified above will be no wider than 30m.

Unless otherwise agreed by DEHP, HOD will be undertaken within designated waterway crossings within the Fitzroy and Calliope River catchments. The minimum buffer width must be >15m from the waterway (maximum recorded nest distance from a waterway).

Any waterway and wetland crossing(s) will be designed to ensure that construction time will be minimised and rehabilitation can be completed straight away.

For minor waterway crossings where HOD is not the agreed construction method, the watercourse bed and bank material and trench spoil will be stockpiled separately outside the buffer zone (15m) to reduce any potential impacts to the turtle nest areas (where applicable). These measures will also reduce the likelihood of sedimentation build-up in the waterway from surface runoff.

- Where constructability allows, pipeline construction activities across known habitat for the White-throated snapping turtle should not take place during the known nesting and breeding season of this species. This includes scheduling works to occur within these areas during the dry season.
- A licensed and experienced spotter catcher(s) will be onsite during all clearing activities. If clearing occurs within or adjacent to permanent water pools the spotter catcher will undertake regular visual inspections of the area to ensure no White-throated snapping turtles are harmed. Refer to Section 9.4.2 if injury or harm occurs.
- All vehicles and pedestrians are to remain within the ROW throughout these areas or on designated access tracks.
- The clearing footprint within the above-listed locations and all 'no go' zones will be adequately marked out for the clearing crew.
- Clearing activities within these areas will be supervised by the relevant EO.
  Clearing will be conducted in a sequential manner and in a way that directs escaping wildlife away from the clearing activities and into adjacent natural areas.
- No permanent changes to environmental flows and/or overland flow, especially in catchments where the species is known to occur.
- Direct temporary lighting away from light-sensitive areas such as roost areas. Light shades and low lighting must be applied to construction and operational areas located adjacent to remnant native vegetation and other environmentally sensitive areas.
- The LRMP shall be implemented.
- Weather permitting, rehabilitation and reconsolidation of impacted watercourses shall commence immediately after the pipeline has been lowered in and backfilled (refer LRMP). With the exception of operational constraints, revegetation shall be consistent with the plant density, floristic composition and distribution of the adjacent riparian and creek bed communities. Replace in stream structures removed during construction to maintain habitat complexity and mitigate environmental flows and erosion.
- Wherever practicable, the use of large rocks and logs to moderate flows and/or stabilise banks should be employed as opposed to concrete.
- An Erosion and Sediment Control Plan will be developed and strictly adhered to in order to minimise potential water quality impacts. Controls should be regularly checked and maintained to ensure that they are working adequately and are not working at capacity.
- DEHP will be notified of sightings and/or nesting areas observed during the construction phase.
  This will be done as part of the project reporting (refer Section 8).

*Operational phase*

- To avoid impacting on regenerating riparian zone and associated turtle nesting habitat, vehicle and pedestrian access within the above-listed locations is restricted to the defined access tracks to and from the ROW and the defined access track within the ROW.
- The operational phase component of the LRMP will be implemented to encourage the re-establishment of turtle nesting habitat impacted as a result of construction works.
  In accordance with EA conditions, where there is a permanent loss of native vegetation (cannot re-establish within 3 yrs) or the area required for operation (e.g. 10m wide maintenance corridor along the GTP ROW for at least 30 years), the Proponent shall provide DEHP with a written detailed report of permanent vegetation loss, including the area, individuals species affects and mapping of affected areas within 12 months of completion of the pipeline construction (this report will be in addition to the required Return of Operations). Permanent loss of vegetation will be offset within the GLNG Offset Strategy where appropriate.
- The operational phase component of the PWMP shall be implemented to minimise the risk of weed and pest animal establishment. This may include working with the landholder to exclude cattle from riparian zones or fence *off* known nesting areas to minimise predation.
- DEHP will be notified of sightings and/or nesting areas observed during the operational phase.
  This will be done as part of the project reporting (refer Section 8).

Monitoring Process: If an active breeding site (nest) for the White-throated snapping turtle is located within or directly adjacent the GTP ROW, the site(s) will be checked weekly by the relevant EO for the duration of preliminary and construction works or until the site becomes inactive. This will be undertaken in a way that does not cause the damage to the nest.

The open pipeline trench adjacent these areas will be checked at least twice a day to ensure this species is not trapped. The trench will also be checked prior to infilling for the same purpose.

If active breeding sites are present within or directly adjacent the GTP ROW, monitoring the status of weed and pest animal proliferation within these areas will be monitored during the construction and operational phases as part of the PWMP. This will be done to minimise the chance for increased predation on both the turtles and their eggs.

During the operational phase targeted surveys in will be undertaken after the first year of rehabilitation works. The aim of the survey will be to determine if this species has recolonised the GTP ROW. These surveys would need to target areas in which the species was identified.

Species Specific Performance Criteria:

- No disturbance to or destruction of active turtle nests unless otherwise agreed with DERM.
- No injury or fatalities to the local White-throated snapping turtle population(s).
- Where HOD techniques are not applied, clearing does not occur outside the 30m ROW.
- Rehabilitation of riparian associated nesting areas has been completed.
- Weed and pest animal proliferation has not occurred as a result of construction and operation activities (predation on turtle nesting areas has not increased).

### 5.6.2 *Platypus Management Profile*

Species Name: *Omithorhynchus anatinus* (Platypus)

Status: EPBC Act = N/A
NC Act = Special Least Concern

Known and potential impacts of the Project on this species:
- Disturbance to known habitat through the removal of vegetation, changes to water quality, changes to bank structure and composition, instream assemblages.
- Destruction of burrows (breeding and rests).
- Changes to foraging behaviour which may impact on territorial behaviour as a result of impoundments, visual impacts, noise and vibration.
- Changes to breeding patterns by restricting breeding movement as a result of impoundments, visual impacts, noise and vibration.
- Temporary and permanent disturbance to instream habitats.
- Temporary changes to environmental flows through the construction of temporary impoundments and crossings.
- Changes to water quality as a result of bank destabilisation, pollutant run-off, disturbance of substrate and removal of vegetation.

Description: The Platypus is egg-laying, semi-aquatic mammal endemic to Australia. The species is characterised by a soft, toothless rubbery bill, webbed feet, fur and a single external opening to the urinary, digestive and reproductive tracts. On average, Platypus weigh between 1.0 to 2.4 km and range between 40 to 60 em in length (DERM 201Om and APC).

They are typically crepuscular species (active at dawn and dusk), however activity patterns are dependent on a number of factors (eg locality, degree of human activity, day length, air and water temperatures, water body productivity (Strahan 1995)). As such the Platypus could also be considered nocturnal or diurnal depending on these factors.

Breeding & Nesting Period: Mating occurs between June and October, however in Qld mating generally occurs in August (DERM 201Om and APC). Following mating, females seal themselves into the nesting chamber of the maternity burrow and lay 1 or 2 two eggs. Eggs hatch between 10 and 11 days and the young stay with their mother for up to 4 months (DERM 2010m and APC date unknown).

Maternity burrows are constructed in banks rising 1m or more above the water and can reach up to 30m in length (ie which can mean that although the entrance to a burrow may be obvious, the actual nursing chamber (at the end of the burrow) may be much further downstream and could in fact be within the area of disturbance) (DERM 2010m and APC date unknown).



(Source: Kraft 2004, Scheunis 2005 & Watts 2004)

Habitat: Platypus inhabit freshwater ecosystems, including a wide variety of permanent streams, rivers and lakes. The species also inhabits temporary and/or manmade water bodies, particularly when these are linked directly to streams or rivers (DERM 201Om and APC date unknown).

Adult platypus will utilise a number of different camping burrows (up to about a dozen) within a period of a few weeks. Camp burrows may be shared, are generally 3-5 m long and are constructed just

below the water's surface or where above the water surface they are often hidden by overhanging vegetation or an undercut bank (DERM 2010m and APC date unknown).

Distribution: The platypus is known from habitats within Tasmania, Vic, NSW and Qld to about as far north as Cooktown (DERM 2010m and APC date unknown). The species also occurs in South Australia, where it is considered rare and extinct in the wild.

Locations within the GTP Corridor: During aquatic values surveys, potential habitat for this species was identified from a number of locations within the GTP ROW, including:

- Dawson River (Upstream and downstream crossing locations).
- Hutton Creek within the GTP ROW.
- Baffle Creek- GTP ROW intersects a large permanent pool with baseline flow.
- Mimosa Creek
- Harper Creek
- Calliope River
- Larcom Creek

Specific Management Requirements:

*Pre-construction phase*

Ecological surveys will be undertaken by a suitably qualified Ecologist(s). The surveys will include carrying out a habitat assessment for this species and confirming its presence/absence of camp and/or nest burrows within and adjacent the GTP ROW.

If suitable habitat is located during the pre-clearing surveys and construction activities occur within the breeding/nesting periods, an appropriately experienced professional/Ecologist will actively search the area(s) approx. 2 weeks prior to clearing activities beginning. If burrows are located the surrounding area (100m) will be declared a temporary no-go zone and potential actions will be developed in consutlation with the design and construction teams and where necessary DERM.

If burrows are identified within or within 50 m of the GTP ROW, map the extent of the burrow(s). Where applicable, the crossing(s) will be designed to ensure that construction time will be minimised and rehabilitation can be completed as soon as practicable.

Where applicable, a LRMP will be developed and will include specific monitoring requirements and rehabilitation completion criteria associated with the re-establishment of riparian zones in the above-listed locations.

- Prior to the commencement of construction clearing, a suitably qualified and experienced EO will mark out and barricade the buffer zones ('no go' zones) associated with the Platypus habitat.
- Prior to site entry, all site personnel shall be appropriately trained and made aware of the sensitive environs in which they will be working (refer Section 7).
- DERM will be notified of sightings and/or nesting areas observed during the pre-construction phase. This will be done as part of the project reporting (refer Section 8).

*Construction phase*

Where clearing within the known or likely habitat for the platypus cannot be avoided, the following measures shall be implemented during the construction phase of the project.

All vegetation clearing within the riparian zones must comply with clearing approval conditions (eg. NC Act approval).

Where applicable the works will be undertaken in accordance with QPIF Code for self-assessable development Minor waterway barrier works on low order inland waterways.

The clearing footprint within the above-listed locations and all 'no go' zones will be adequately marked out for the clearing crew.

Clearing activities within these areas will be supervised by the relevant EO.

A licensed and experienced spotter catcher(s) will be onsite during all clearing activities. If clearing occurs within or adjacent to permanent water pools the spotter catcher will undertake regular visual inspections of the area to ensure any platypus are not harmed. Refer to Section 9.4.2 if injury or harm occurs.

Clearing will be conducted in a sequential manner and in a way that directs escaping wildlife away from the clearing activities and into adjacent natural areas.

If construction works are to occur within the known breeding period, observations for the presence of the Platypus within the disturbance footprint shall be carried out prior to works commencing (within 14 days) in order to ensure that another nesting burrow has not been constructed closer to, or within, the area since the initial survey.

If burrows are identified within or within 50 m of the GTP ROW, map the extent of the burrow(s).

- Unless otherwise agreed by DERM, HOD should be undertaken Hutton and Baffle Creeks. The minimum buffer width must be >50m from the waterway if platypus burrows are identified (maternity burrows can extend 30m).
- For minor waterway crossings where HOD is not the agreed construction method, the watercourse bed and bank material and trench spoil will be stockpiled separately outside the buffer zone (15m) to reduce any potential impacts to the platypus burrows (where applicable). These measures will also reduce the likelihood of sedimentation build-up in the waterway from surface runoff.
- All vehicles and pedestrians are to remain within the ROW throughout these areas or on designated access tracks.
- The total clearing footprint within the riparian zones identified above will be no wider than 30m.
- Where constructability allows, maximise the distance between the works and burrow sites by relocating the site further downstream or minimising the size of the crossing.
- Where constructability allows, avoid construction within known Platypus habitat during the breeding months (August to November).
- Ensure that appropriate chemical and hydrocarbon spill kits and procedures are implemented.
- Direct temporary lighting away from light-sensitive areas such as roost areas. Light shades and low lighting must be applied to construction and operational areas located adjacent to remnant native vegetation and other environmentally sensitive areas.
- All site offices, construction camps, stockpiling/laydown areas and plant and equipment storage areas (incl. heavy machinery) will be located on existing cleared lands at least 100m from the above-listed locations.
- Ensure no permanent changes to environmental flows and/or overland flow, especially in catchments where the species is known to occur.
- An Erosion and Sediment Control Plan will be developed and strictly adhered to in order to minimise potential water quality impacts. Controls should be regularly checked and maintained to ensure that they are working adequately and are not working at capacity.
- The LRMP shall be implemented.
- Weather permitting, rehabilitation and reconsolidation of impacted watercourses shall commence immediately after the pipeline has been lowered in and backfilled (refer LRMP). With the exception of operational considerations, revegetation shall be consistent with the plant density, floristic composition and distribution of the adjacent riparian and creek bed communities. Refer to Appendix B for specific rehabilitation criteria in these areas.
- Replace instream structures removed during construction to maintain habitat complexity and mitigate environmental flows and erosion.
- Wherever practicable, the use of large rocks and logs to moderate flows and/or stabilise banks should be employed as opposed to concrete.
  In the event of a non-compliance, the Proponent will issue a "stop work" order, upon which all work will cease until the non-compliance has been rectified and measures implemented to prevent the breach re-occurring.
- DERM will be notified of sightings and/or nesting areas observed during the construction phase.
  This will be done as part of the project reporting (refer Section 8).

*Operational phase*

- To avoid impacting on regenerating riparian zone and associated Platypus burrowing habitat, vehicle and pedestrian access within the above-listed locations is restricted to the defined access tracks to and from the ROW and the defined access track within the ROW.
- The operational phase component of the LRMP will be implemented to encourage the re-establishment of Platypus habitat impacted as a result of construction works.
  In accordance with EA conditions, where there is a permanent loss of native vegetation (cannot re-establish within 3 yrs) or the area required for operation (eg 10m wide maintenance corridor along the GTP ROW for at least 30 years), the Proponent shall provide DERM with a written detailed report of permanent vegetation loss, including the area, individuals species affects and mapping of affected areas within 12 months of completion of the pipeline construction (this report will be in addition to the required Return of Operations). Permenant loss of vegetation will be offset within the GLNG Offset Strategy where approapriate.
- The operational phase component of the PWMP shall be implemented to minimise the risk of weed and pest animal establishment.

- Work with the local landholder to exclude cattle, manage weeds and erosion within known habitat locations.
- DEHP will be notified of sightings and/or burrows observed during the operational phase. This will be done as part of the project reporting (refer Section 8).

*Decommissioning Phase*

- A Decommissioning strategy or plan will be developed by GLNG and provided for approval. The plan will aim to address the requirements of AS2885 and also to ensure environmental harm is mitigated, including:
  - It no longer contains hazardous contaminants. It is left in stable condition.
  - All the above ground infrastructure is removed.
  - All areas disturbed by above ground infrastructure are rehabilitated in accordance with the relevant conditions.
- For a minimum of five (5) years after the completion of rehabilitation, rehabilitated areas will be monitored on a yearly basis.
- The monitoring programme will include, but not necessarily be limited to:
  - Methods to measure subsidence and erosion rates at rehabilitated buried transmission pipeline corridors and buried flow lines.
  - Biocondition assessment in accordance with the BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland: Assessment Manual: Version 2.1 (Eyre et al. 2011).
  - Monitoring of indicators identified in the LRMP at analogue sites to measure progressive and final rehabilitation success relevant to the final land use(s).
  - Frequency and seasonality of monitoring analogue sites and rehabilitated areas to assess rehabilitation success.
  - Identification of the experimental design for analysing analogue and rehabilitated site data including statistical methods of analyses.

Monitoring Process: If an active burrow(s) is located within or directly adjacent the GTP ROW, the site(s) will be checked weekly by the relevant EO for the duration of preliminary and construction works or until the site becomes inactive. This will be undertaken in a way that does not cause the damage to the nest or cause the Platypus to abandon the nest.

The open pipeline trench adjacent these areas will be checked daily by the spotter catcher to ensure this species is not trapped. The trench will also be checked prior to infilling for the same purpose.

If active breeding sites are present within or directly adjacent the GTP ROW, monitoring the status of weed and pest animal proliferation within these areas will be monitored during the construction and operational phases as part of the PWMP. This will be done to minimise the chance for increased predation on both the Platypus and their young.

During the operational phase targeted surveys in will be undertaken after the first year of rehbailtation works. The aim of the survey will be to determine if this species has recolonised the GTP ROW. These surveys would need to target areas in which the species was identified.

Species Specific Performance Criteria:

- No disturbance to or destruction of active burrows unless otherwise agreed with DERM.
- No injury or fatalities to the local platypus population(s).
- Where HOD techniques are not applied, clearing does not occur outside the 30m ROW.
- Rehabilitation of riparian associated burrowing areas has been completed. Also instream structures are replaced and the geomorphology of the creek is maintained (esp. retention of riffle habitats)
- Weed and pest animal proliferation has not occurred as a result of construction and operation activities (predation on burrows areas has not increased).

# 16 Water mouse

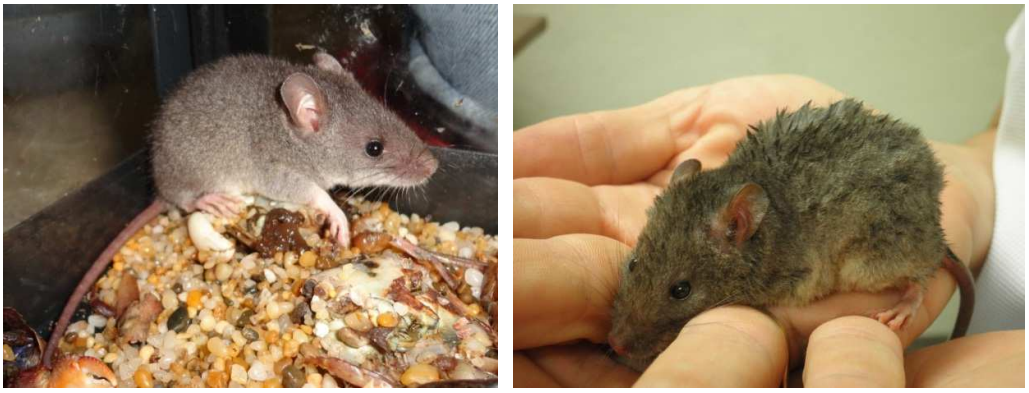
## 16.1 EPBC Act legal status

Vulnerable – listed 16 July 2000

## 16.2 Biology and ecology

### 16.2.1 Characteristics

The Water mouse (*Xeromys myoides*) is a small native rodent with a maximum head-body length of 126 mm and maximum weight of 64 g. Its fur is short and silky, and dark grey above with a white belly. Both the hands and feet are covered in fine white hair and the hindfeet are between 23 to 26 mm long. The tail is 85 to 100 mm in length, very finely ringed and covered in thin hairs (Gynther & Janetzki 2008). While the species is specialised to aquatic habitats, the feet are not webbed. The ears are short and rounded and the eyes are small. It has a distinctive hunched posture and often a 'mousy' odour.



**Sub-adult male Water mouse (left) and adult female Water mouse, both collected in the Gladstone region (Walters 2011)**

### 16.2.2 Known distribution

The Water mouse occurs in three discrete populations in Australia; the coastline of the Northern Territory, central south Queensland, and south-east Queensland. The central south Queensland population is relevant to the GLNG GTP Project in Gladstone, as this population extends from Cannonvale (Whitsunday Coast) in the north to Agnes Water in the south.

A number of recent surveys (GHD 2011, GHD 2012, Queensland Museum 2012, Aurecon 2012a, Worley Parsons 2011) have confirmed the presence of the Water mouse in the Gladstone region, and in close proximity to KP408.81 to KP409.04 of the GTP.

Within Queensland, the population size of the Water mouse is thought to be between 1,001 and 10,000 individuals, occupying an area of between 101 to 1,000 $km^2$ (Dickman *et al* 2000).

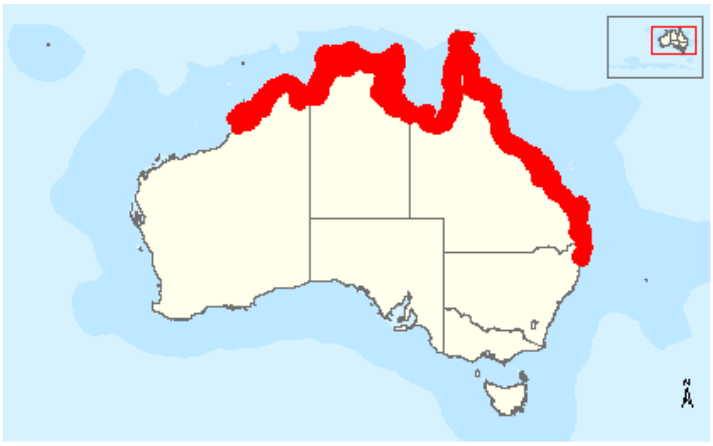


**Figure 16.1 Distribution range of the Water mouse (Source: DSEWPaC 2012z)**

### 16.2.3 Known species populations and their relationship with the GTP footprint

This species was identified during the pre-clearance survey in close proximity to KP408.81to KP409.04 of the GTP and ancillary areas, and potential habitat has also been identified in close proximity to the site.

### 16.2.4 Biology and reproduction

The diet of the Water mouse has been well surveyed. Van Dyck (1996) investigated the diet of the Water mouse on North Stradbroke Island in south-east Queensland. The composition of the diet included a variety of crustaceans (*Parasesarma erythrodactyla*, *Helice leachi* and *Australoplax tridentata*), Marine polyclads, Marine pulmonates (*Salinator solida*, *Ophicardelus quoyi* and *Ochidina australis*) and Marine bivalves (*Glauconome sp*.). Investigations of middens within and outside tree hollows also revealed the remains of the Mud lobster (*Laomedia healyi)* and Mottled shore crab (*Peragrapsis laevis)* (Van Dyck 1996). This suite of species is common on intertidal saltmarsh habitats in south-east Queensland (Breitfuss *et al* 2004).

The dietary preferences in central south Queensland appear to be similar and include grapsid crabs (Ball 2004). Plant foods to date have not been reported in the diet of the Water mouse, however gut morphology suggests that the diet of the Water mouse should not be totally carnivorous (Van Dyck 1996).

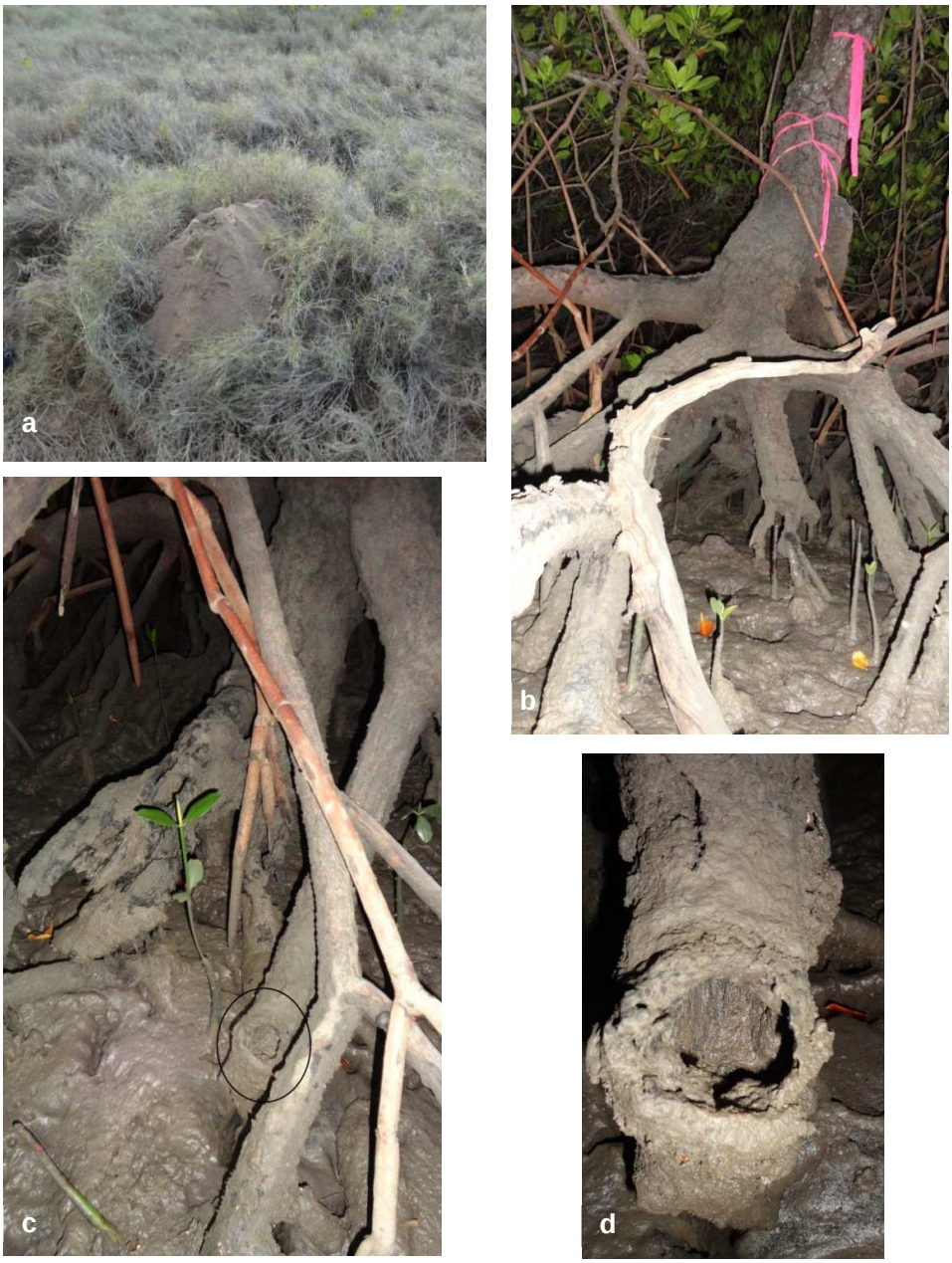
The Water mouse creates nests which are important for breeding and refuge from high tide and predators. Five types of nests have been identified (Van Dyck & Gynther 2003):

- Free-standing mound nests or mounds at the base of mangrove trees
- Mound nests on small elevated ‘islands’ within the tidal zone
- Mound nests or holes in supralittoral banks
- Nests inside hollow tree trunks
- Nests in spoil heaps created as a result of human activity

Recent surveys by Aurecon in the Gladstone region have detected:

- A free-standing mound nest above the high-tide mark, in a supralittoral bank vegetated with Saltwater couch (*Sporobolus virginicus*)

- A sub-adult male Water mouse that was radio-tracked to its daytime shelter inside a hollow stag of White-flowered black mangrove (*Lumnitzera racemosa*), below the high-tide mark, and approximately 100 m in to a dense forest of *Rhizophora stylosa*
- A second sub-adult male Water mouse that was radio-tracked to its daytime shelter beneath a rock pile adjacent to a dense mangrove forest of Yellow mangrove (*Ceriops tagal*)
- An apparent nest within a hollow mangrove tree containing four individuals, including one sub-adult male which was captured and subsequently released




**Water mouse nest structures recently observed in the Gladstone region: a) a free-standing mound nest in the supralittoral bank, b) a hollow stag c) location of the entrance hole within the mangrove roots of the hollow stag d) close image of the entrance hole**

## 16.3 Habitat

The Water mouse requires mangrove communities and associated saltmarsh, sedgelands, clay pans, heathlands and freshwater wetlands with intact hydrology that provide adequate nest sites and prey resources.

In central south Queensland, the Water mouse has been captured in the high inter-tidal zone in tall, closed fringing mangrove forest containing *Ceriops tagal* and/or *Bruguiera* sp and in saline grassland adjacent to this type of forest (Ball 2004, DSEWPaC 2012z). The Water mouse was also recorded in closed forest of *Avicennia marina* and a supralittoral bank is generally absent in the south central Queensland subregion (Ball 2004). Typical Water mouse habitat in this subregion has been described as the distinct ecotones between mangroves and dry sclerophyll woodlands and/or saltpan. However, very little research of the species has been completed, and recent surveys in the Gladstone region have added to the body of knowledge of Water mouse habitat use. This animal has recently been detected in the following habitats:

- Closed *Rhizophora stylosa* forest bordered by closed *Ceriops tagal* (Aurecon 2012a)
- Open *Avicennia marina* forest with supralittoral bank bordered by saline grassland (Aurecon 2012a)
- Closed *Ceriops tagal* forest (FEC 2012b)
- Closed *Avicennia marina*/*Ceriops tagal* forest bordered by closed *Rhizophora stylosa* (GHD 2011)

Very little is known about the dispersal and movement activities of the Water mouse. Only one published study has involved radio-tracking of individuals (Van Dyck 1996), which provided the following information:

- Animals may travel up to 3 km in a night
- The average home range is 0.7 ha
- Males generally have a larger home range than females (male average 0.77 ha, female 0.53 ha)
- Microhabitat complexity and width of mangrove strip influence the size of home range (ie animals will range further when the microhabitat is less complex and the mangrove strip is narrower)

The Water mouse is known to nest communally, and exhibit territorial behaviour (Gynther & Janetzki 2008). Van Dyck (1996) found that a nest usually contained only one sexually active male. It is reasonable to assume that animals and in particular sub-adult males will disperse from the original nest to establish new territories. Thus, areas that are not considered core habitat in terms of food or nesting resources, however may still provide important dispersal pathways.

## 16.4 Habitat assessment

Information obtained from Biodiversity Planning Assessment (BPA) (ie Brigalow Belt South Fauna Expert Panel Report (EPA 2006)), together with expert advice, site based species records and pre-clearance survey data has been used to define a set of assumptions that have been used to identify areas of habitat that are consistent with the definitions of 'core habitat', 'essential habitat' and 'general habitat' presented in Part 1 of this SSMP. The habitat assessment assumptions for the Water mouse are presented below.

### 16.4.1 General assumptions

The following general habitat assumptions have been made based on current scientific knowledge of this species:

- Species is associated the upper inter-tidal zone in tall, closed fringing mangrove forest containing only *Ceriops tagal* and/or *Bruguiera* sp (Ball 2004, DSEWPaC 2012z)
- Species is associated with saline grassland on the landward side of closed forest of *Ceriops tagal* and *Bruguiera* sp and within closed forest of *Avicennia marina* (DSEWPaC 2012z)
- Species is associated with open mangrove communities that support invertebrate prey (DSEWPaC 2012z)
- Areas with corresponding habitat features to that of RE 11.1.2a and RE 12.1.2 which are described as bare mud flats on Quaternary estuarine deposits, with very isolated individual stunted mangroves and very sparse saltpan vegetation including grassland and herbland on marine clay plains, are not considered to be habitat as they are lacking the required structural attributes of cover for foraging and structure/resources for nesting that have been referenced in literature and points above in addition to the increased risk and exposure of predation in the open areas
- An allowance has been made to accommodate Water mouse movements across and within these areas to reach adjacent suitable habitats, assuming the species will move no more than 50 m from cover (based on current scientific knowledge and pre-clearance survey and trapping programs and habitat assessments)

### 16.4.2 Core habitat

'Core habitat' consists of 'essential habitat' in which the species is known and the habitat is recognised under relevant recovery plans or other relevant plans/policies/regulations. Also included within this category are populations that are limited geographically within the region.

For the Water mouse, all REs or Pre-REs that contain a specimen backed record, which overlap with areas identified in the BPA mapping that have been identified as containing a 'State' or 'Regional' 'Corridor' (J-Rating) and/or 'Core habitat' (H-Rating) and/or 'Habitat for EVR Taxa' (A-Rating) have been mapped as 'Core habitat'.

No 'core habitat' for this species exists within KP0 to KP30, KP30 to KP40, KP40 to KP130, KP130 to KP312, KP312 to KP408.81, KP408.81 to KP409.04 and KP413.57 to KP419.69 of the GTP.

### 16.4.3 Essential habitat

'Essential habitat' is an area containing resources that are considered essential for the maintenance of populations of the species (eg potential habitat for breeding, roosting,

[illegible]

[illegible]

[illegible]

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Santos
GLNG Project

# GLNG Gas Transmission Pipeline Corridor

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**Habitat Rating**

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□□□□□

KP360

KP350

KP340

KP330

KP320

KP310

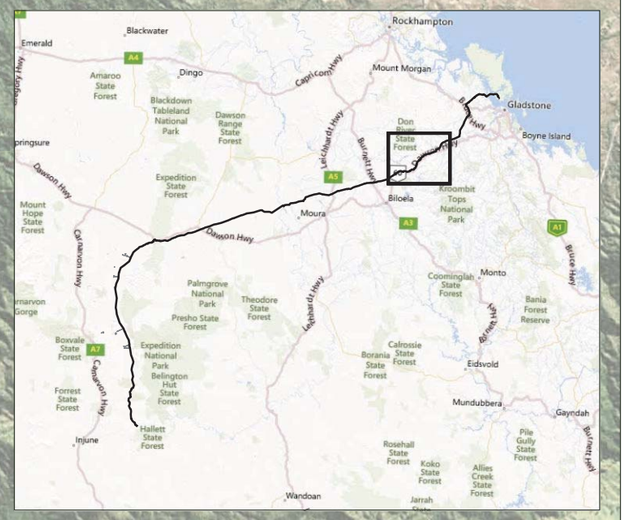


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**Figure 16.2a: Water Mouse (*Xeromys myoides*) Habitat Ratings Based on Predictive Modelling KP312 to KP408.81**

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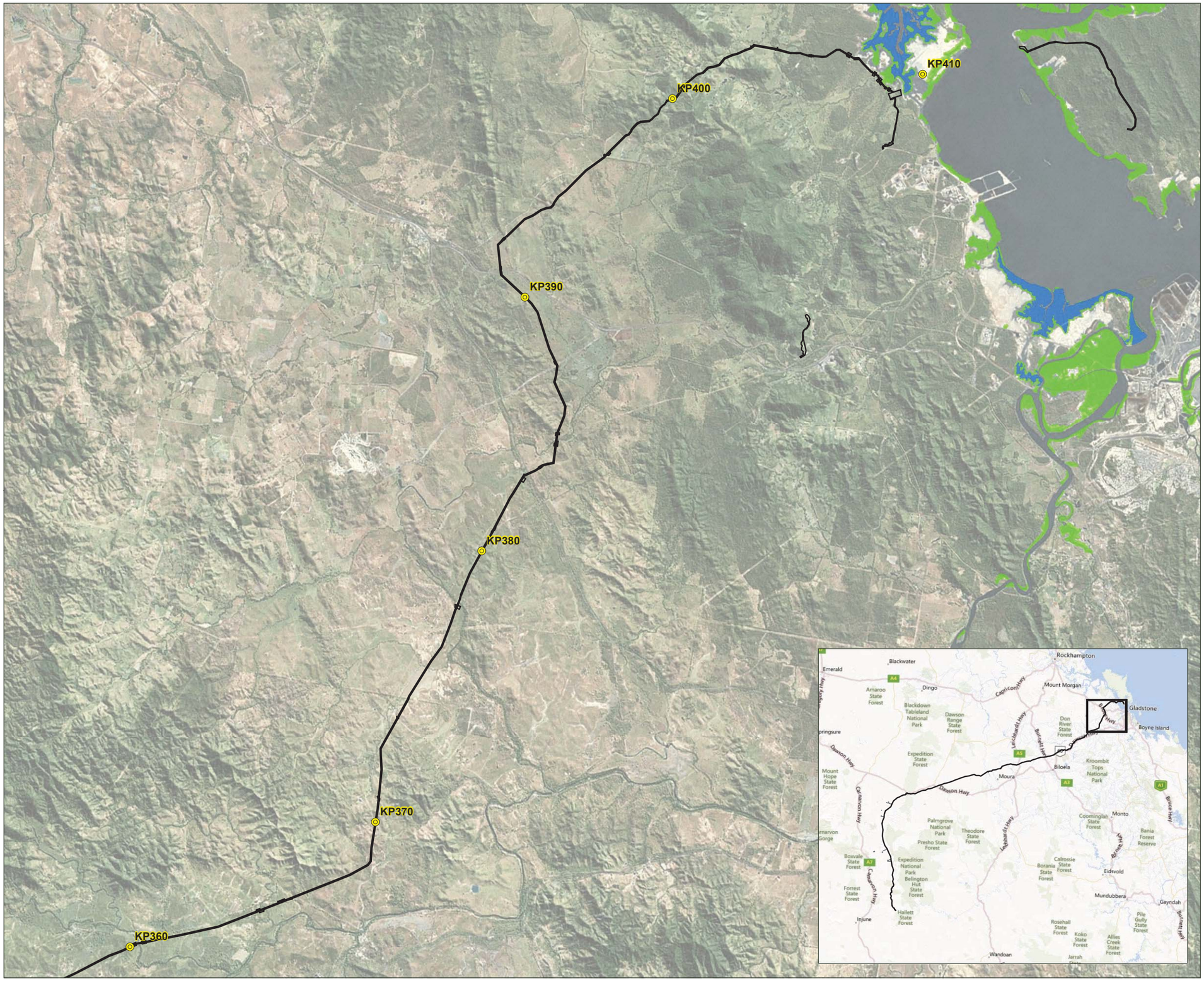


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GLNG Project

# GLNG Gas Transmission Pipeline Corridor

Habitat Rating

**Figure 16.2b: Water Mouse (*Xeromys myoides*) Habitat Ratings Based on Predictive Modelling KP312 to KP408.81**

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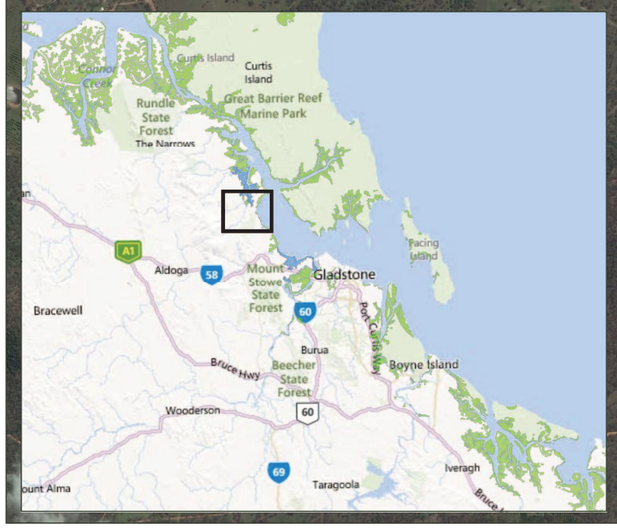
# Marine Crossing GTP Early Works

KP405
KP406
KP407
KP408
KP409




- Kilometre Post Distance Marker (km)
- GLNG GTP ROW and Ancillary Work Areas
- Proposed Access Road
- Construction Tunnel Launch Pad

**Habitat Ratings**

- General Habitat
- Essential Habitat

Source:
Aerial: BING, Feb 2011.

## Figure 16.2c: Water Mouse (*Xeromys myoides*) Habitat Ratings Based on Predictive Modelling KP408.81 to KP409.04

A1 scale: 1:10,000
0 0.25 0.5 0.75km

GLNG No: XXXX-XX-XXXX
Coordinate system: GDA 1994 MGA Zone 56

Date: 24/09/2012 Version: a

Map by: ZontaRA P:\Aurecon\215648 Santos\Mapping\221714\221714_Terns_1.mxd 02/08/2012 10:56

Santos
GLNG Project

# GLNG Gas Transmission Pipeline Corridor

- Kilometre Post Distance Marker (km)
- GLNG Narrows Pipeline Alignment
- GLNG GTP ROW and Ancillary Work Areas

**Habitat Rating**

- General

KP413
KP414
KP415
KP416
KP417
KP418
KP419




Source:
Gas Transmission Pipeline (GTP): Santos, Apr 2012.
Aerial: BING, Feb 2011.

**Figure 16.2d: Water Mouse (*Xeromys myoides*) Habitat Ratings Based on Predictive Modelling KP413.57 to KP419.69**

Map by: RB P:\GIS\Projects\214208_Santos_EMP\SEMP_356.mxd 02/04/2013 16:30

A1 scale: 1:10,000

0 250 500 750 Meters

GLNG No: XXXX-XX-XXXX

Coordinate system: GCS_GDA_1994

Date: 02/04/2013 Version: a

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| [illegible] | [illegible] |
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| [illegible] | [illegible] |
| [illegible] | [illegible] |

## [illegible] Management, monitoring and reporting

### [illegible] Groundwater monitoring and reporting

**Management and monitoring**

- [illegible] and groundwater monitoring bores in the vicinity of the Fairview and Roma gas fields and Condabri Central gas plant will be monitored in accordance with the Groundwater Monitoring and Management Plan.
- If there is a loss of supply to a water bore used for stock and domestic purposes or for irrigation purposes, and the loss is identified as being caused by the coal seam gas water extraction, the water bore will be replaced with a bore that has access to a similar quantity and quality of groundwater.
- If there is a loss of supply to a water bore used for stock and domestic purposes or for irrigation purposes, and the loss is identified as being caused by the coal seam gas water extraction, the water bore will be replaced with a bore that has access to a similar quantity and quality of groundwater.

**Management and the Water Act 2000**

- Groundwater monitoring and management will be undertaken in accordance with the Groundwater Monitoring and Management Plan.
- Groundwater bores will be monitored in accordance with the Groundwater Monitoring and Management Plan.
- The groundwater monitoring network will be reviewed and updated as required.
- Groundwater bores will be monitored in accordance with the Groundwater Monitoring and Management Plan.

### [illegible] Surface water monitoring and reporting

**Management and monitoring**

- Surface water monitoring will be undertaken in accordance with the Surface Water Monitoring and Management Plan.
- Surface water monitoring will be undertaken in accordance with the Surface Water Monitoring and Management Plan.

**Management and the Water Act 2000**

- Surface water monitoring will be undertaken in accordance with the Surface Water Monitoring and Management Plan.
- Surface water monitoring will be undertaken in accordance with the Surface Water Monitoring and Management Plan.

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**[illegible]**

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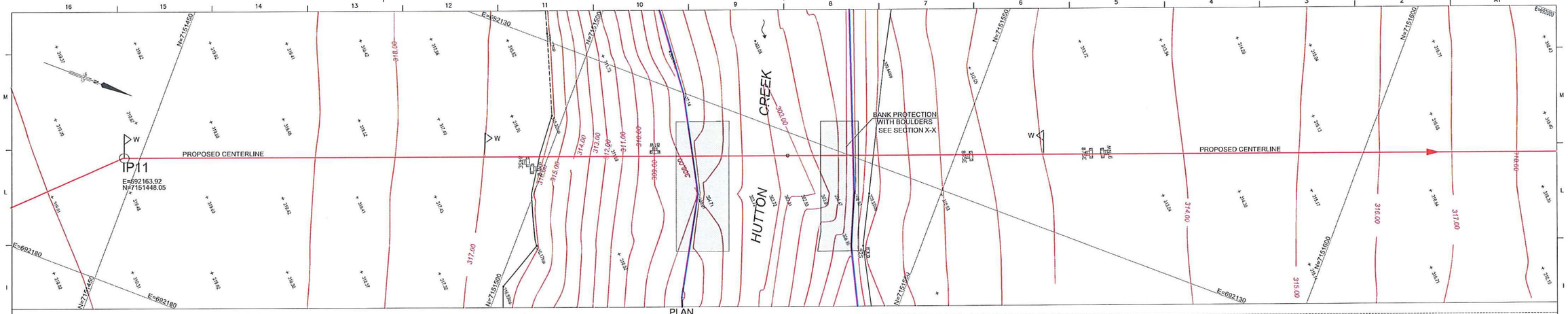
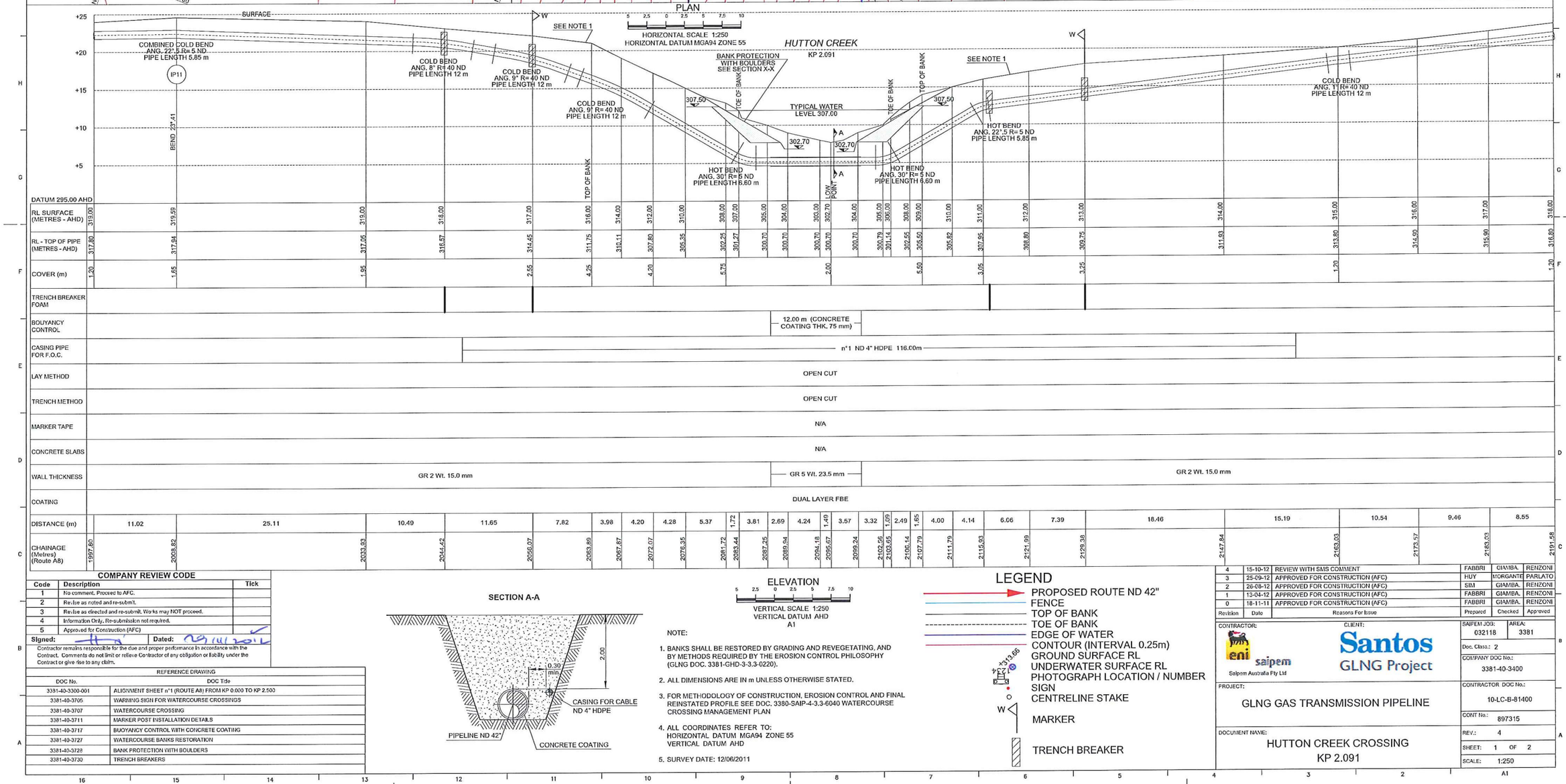
Santos
GLNG Project

**APPENDIX F – Design and Construction Drawings**




PLAN

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 55

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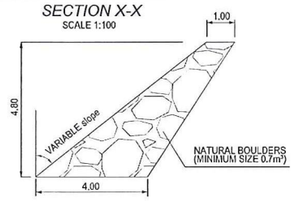
## BANK PROTECTION WITH NATURAL BOULDERS

SECTION X-X

SCALE 1:100




| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| | |
| | |
| | |
| | |

PROPOSED CENTRELINE

HUTTON CREEK

BANK PROTECTION WITH NATURAL BOULDERS
SEE SECTION X-X

E=692163.92
N=7151448.05

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |
| Signed: | | Dated: 19/12/2012 |

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 55
Vertical Datum AHD

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1:500


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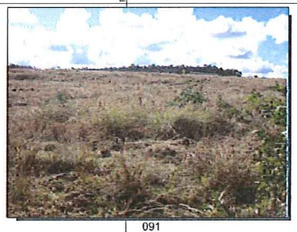
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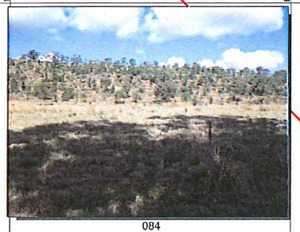
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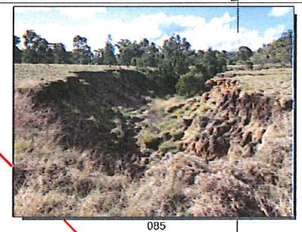
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| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
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| 4 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 3 | 25-09-12 | APPROVED FOR CONSTRUCTION (AFC) | HUY | MORGANTE | PARLATO |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 13-04-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 | AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3400

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81400

CONT No.: 897315

DOCUMENT NAME: HUTTON CREEK CROSSING KP 2.091

REV.: 4

SHEET: 2 OF 2

SCALE: 1:500




| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| 3381-40-3300-009 | ALIGNMENT SHEET n°9 (ROUTE AB) FROM KP 20,000 TO KP 22,500 |
| 3381-40-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

ELEVATION
5 2.5 0 2.5 5 7.5 10
VERTICAL SCALE 1:250
VERTICAL DATUM AHD
A1

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-6040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO:
HORIZONTAL DATUM MGA94 ZONE 55
VERTICAL DATUM AHD

LEGEND
- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 4 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 3 | 17-09-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 2 | 28-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 27-07-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd
CLIENT: Santos GLNG Project

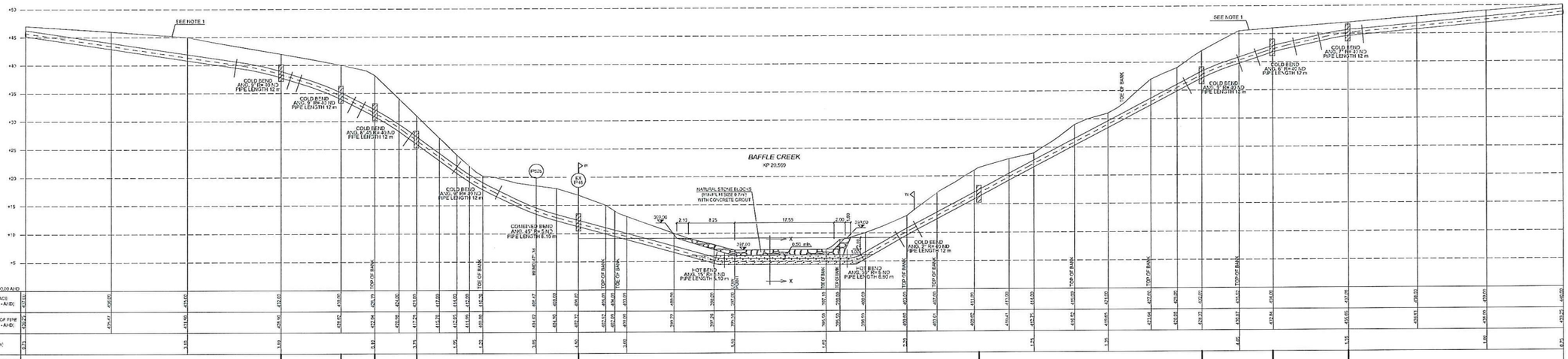
PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: BAFFLE CREEK CROSSING KP 20.569

| | |
|---|---|
| SAIPEM JOB: | 032118 |
| AREA: | 3381 |
| Doc. Class.: | 2 |
| COMPANY DOC No.: | 3381-40-3403 |
| CONTRACTOR DOC No.: | 10-LC-B-81403 |
| CONT No.: | 897315 |
| REV.: | 4 |
| SHEET: | 1 OF 3 |
| SCALE: | 1:250 |

## PLAN

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 55

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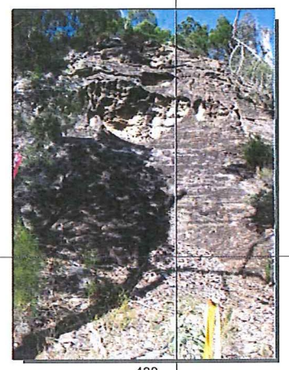

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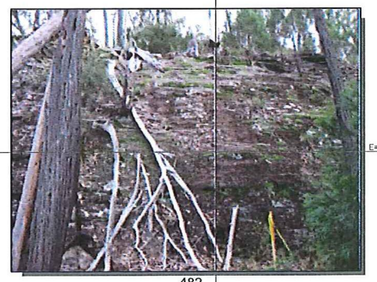

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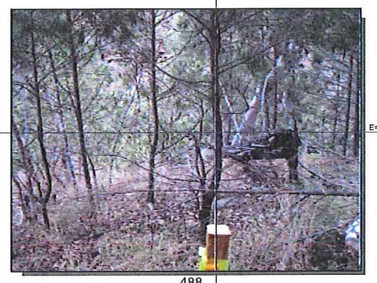

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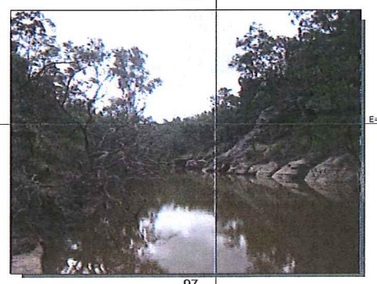

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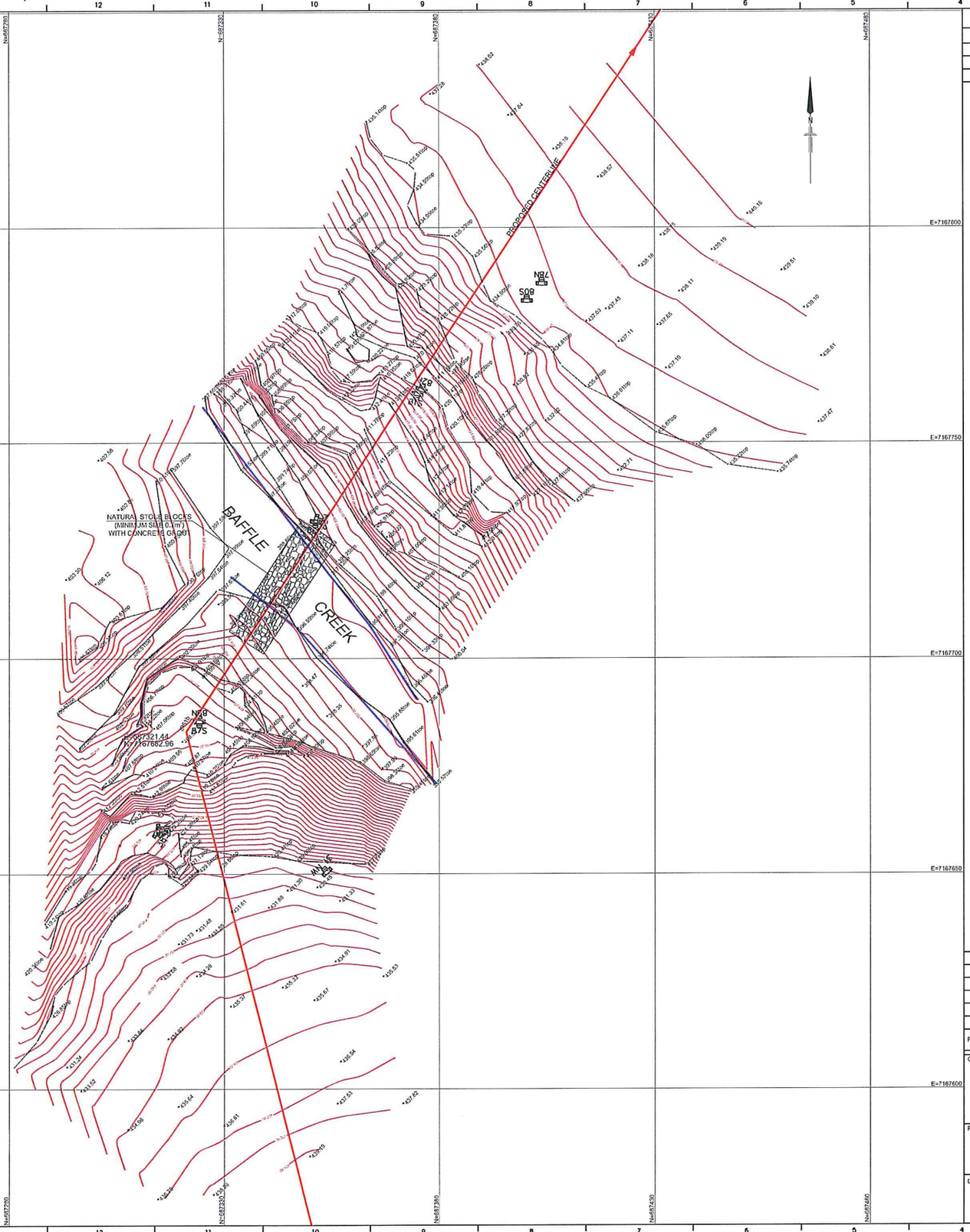


REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
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| | |

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Work may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 55
Vertical Datum AHD

10 5 0 5 10 15 20
1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
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| 4 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 3 | 17-09-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 2 | 28-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 27-07-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

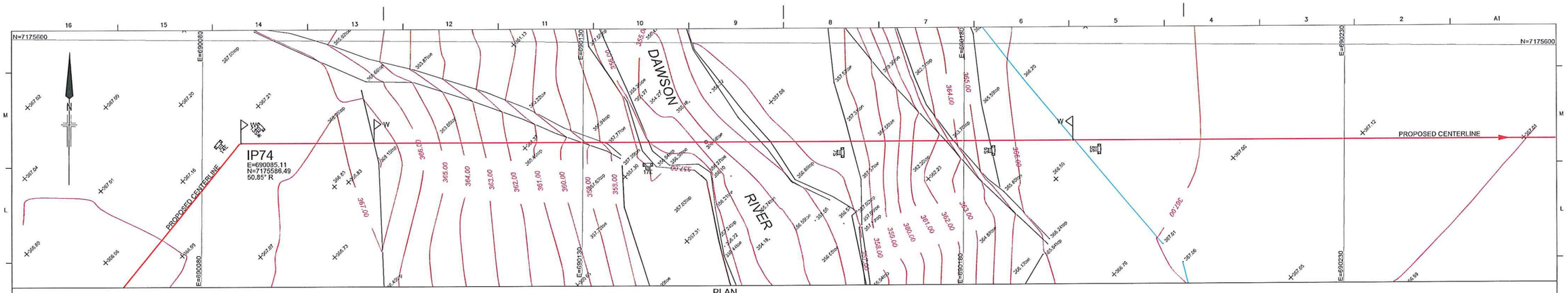
CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

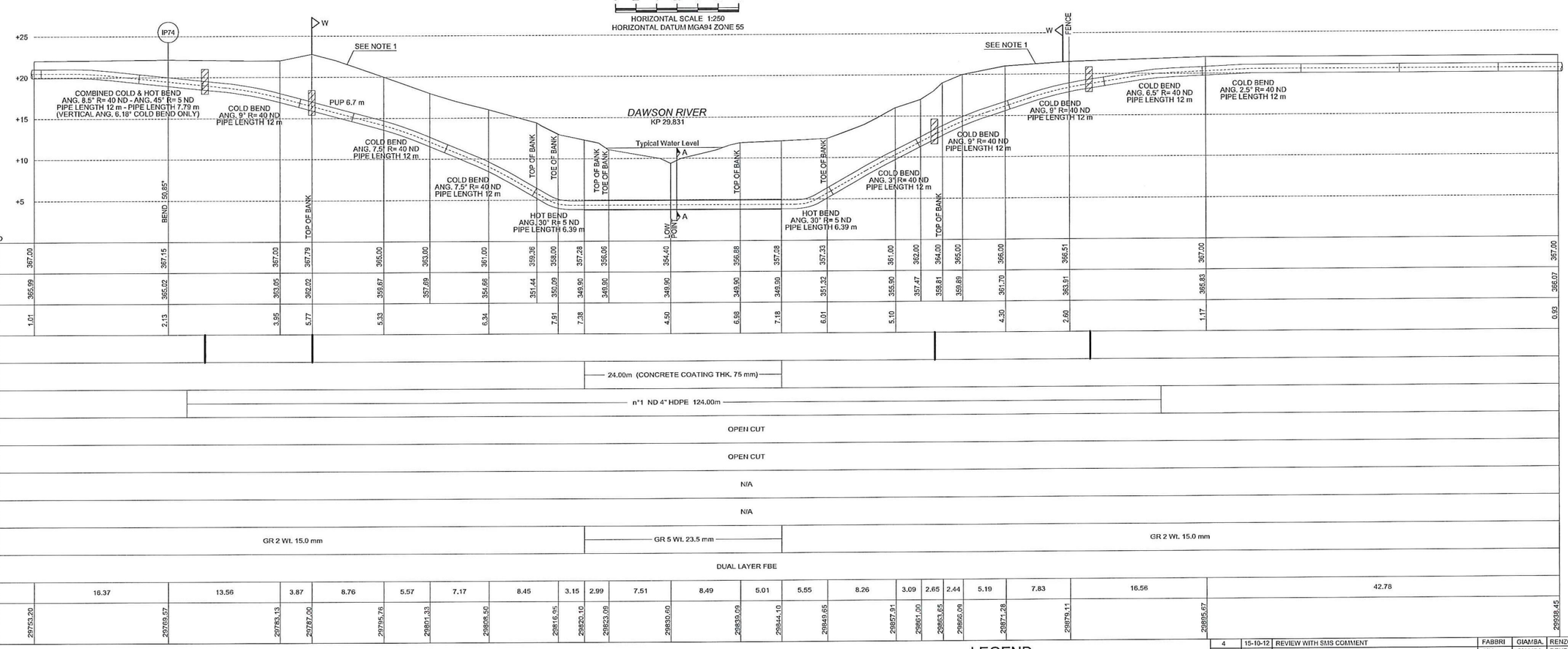
CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: BAFFLE CREEK CROSSING KP 20.569

SAIPEM JOB: 032118 AREA: 3381
Doc. Class.: 2
COMPANY DOC No.: 3381-40-3403
CONTRACTOR DOC No.: 10-LC-B-81403
CONT No. 897315
REV.: 4
SHEET: 3 OF 3
SCALE: 1:500

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VERTICAL SCALE 1:250
VERTICAL DATUM AHD
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DATUM 345.00 AHD

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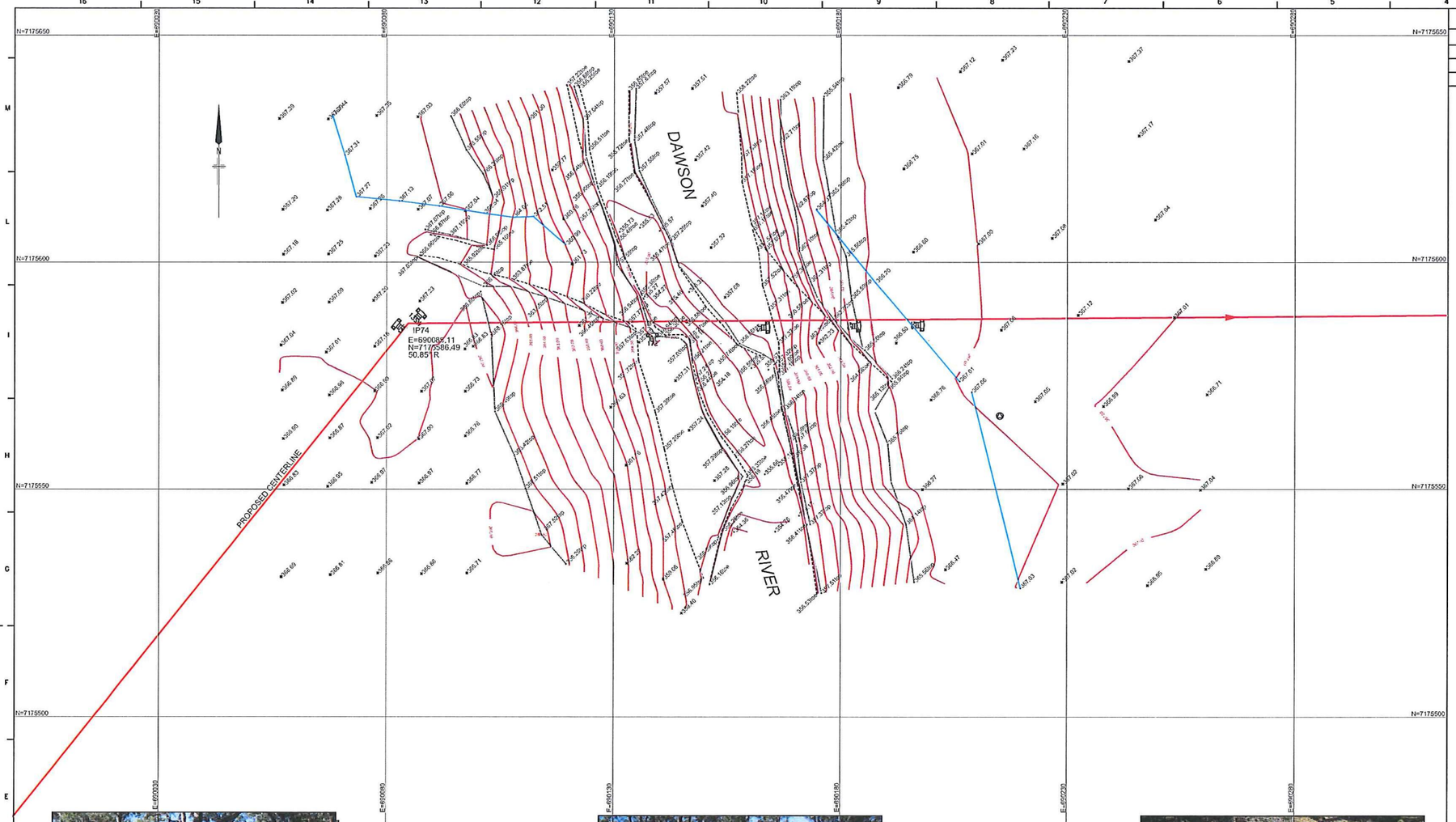


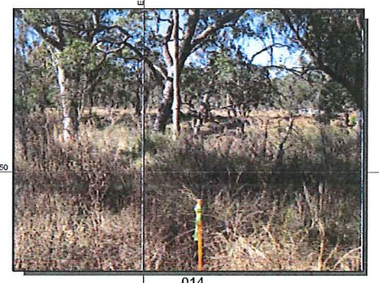

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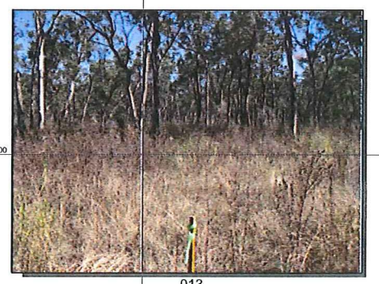

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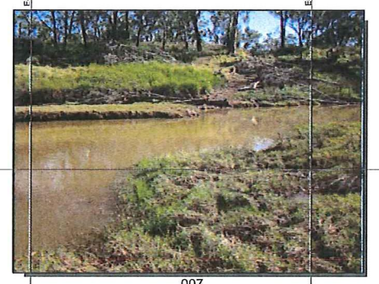
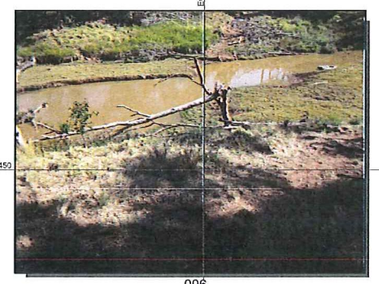


007



017



006



005

REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| | |
| | |
| | |
| | |

## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | — |

Signed: [signature] Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 55
Vertical Datum AHD

10 5 0 5 10 15 20

1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 4 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 3 | 22-09-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 13-04-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3406

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81406

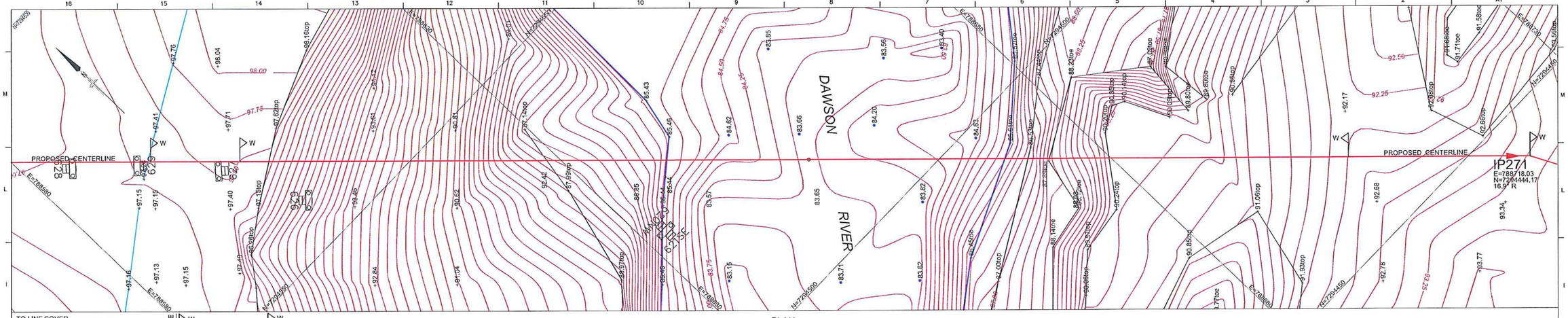
CONT No.: 897315

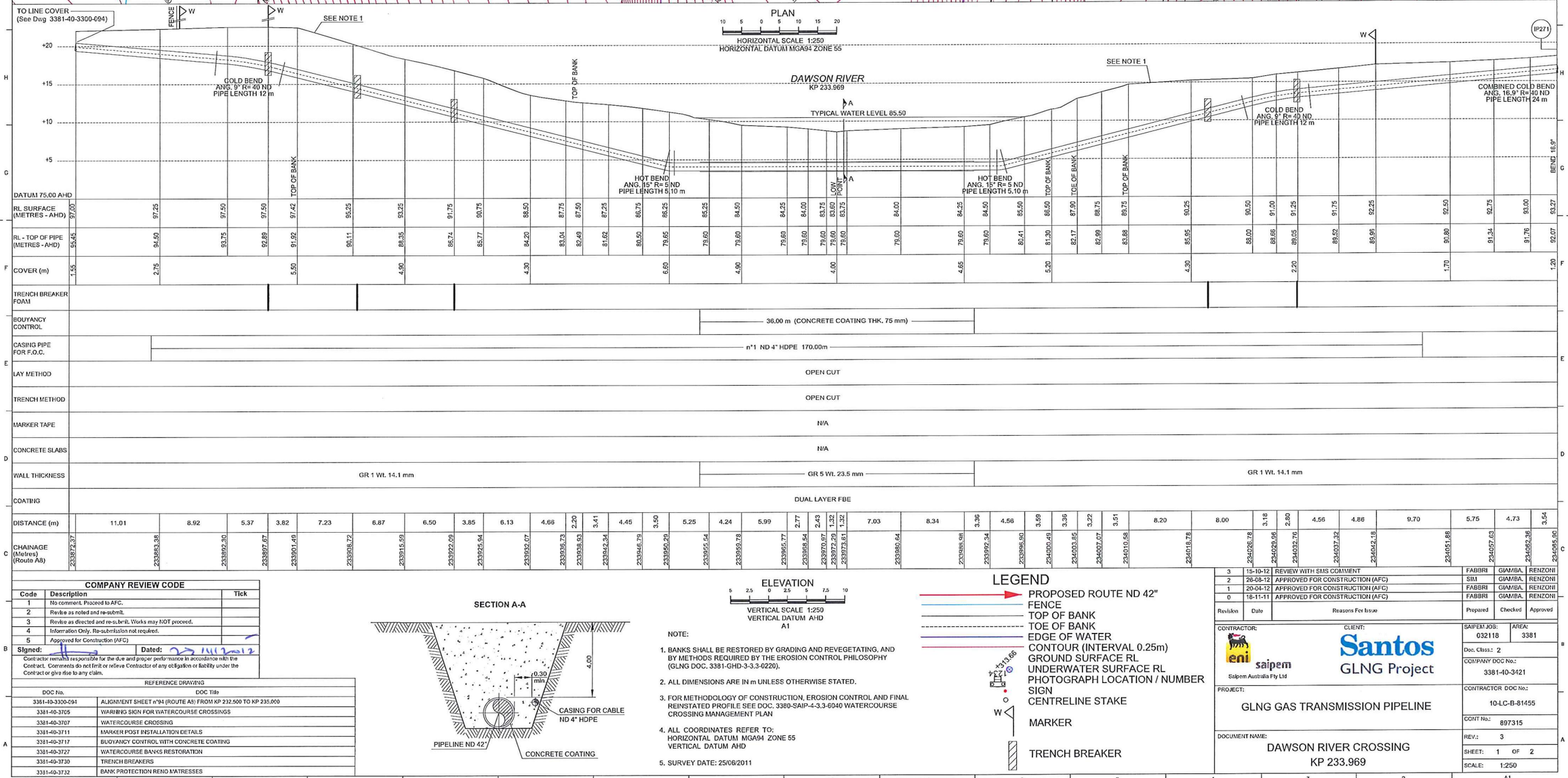
DOCUMENT NAME: DAWSON RIVER CROSSING KP 29.831

REV.: 4

SHEET: 2 OF 2

SCALE: 1:500




| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |
| Signed: | Dated: 23/11/2012 | |

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| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| 3381-40-3300-094 | ALIGNMENT SHEET n°94 (ROUTE A8) FROM KP 232.500 TO KP 235.000 |
| 3381-40-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

SECTION A-A




ELEVATION
VERTICAL SCALE 1:250
VERTICAL DATUM AHD
A1

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-6040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO:
   HORIZONTAL DATUM MGA94 ZONE 55
   VERTICAL DATUM AHD
5. SURVEY DATE: 25/06/2011

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 20-04-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |

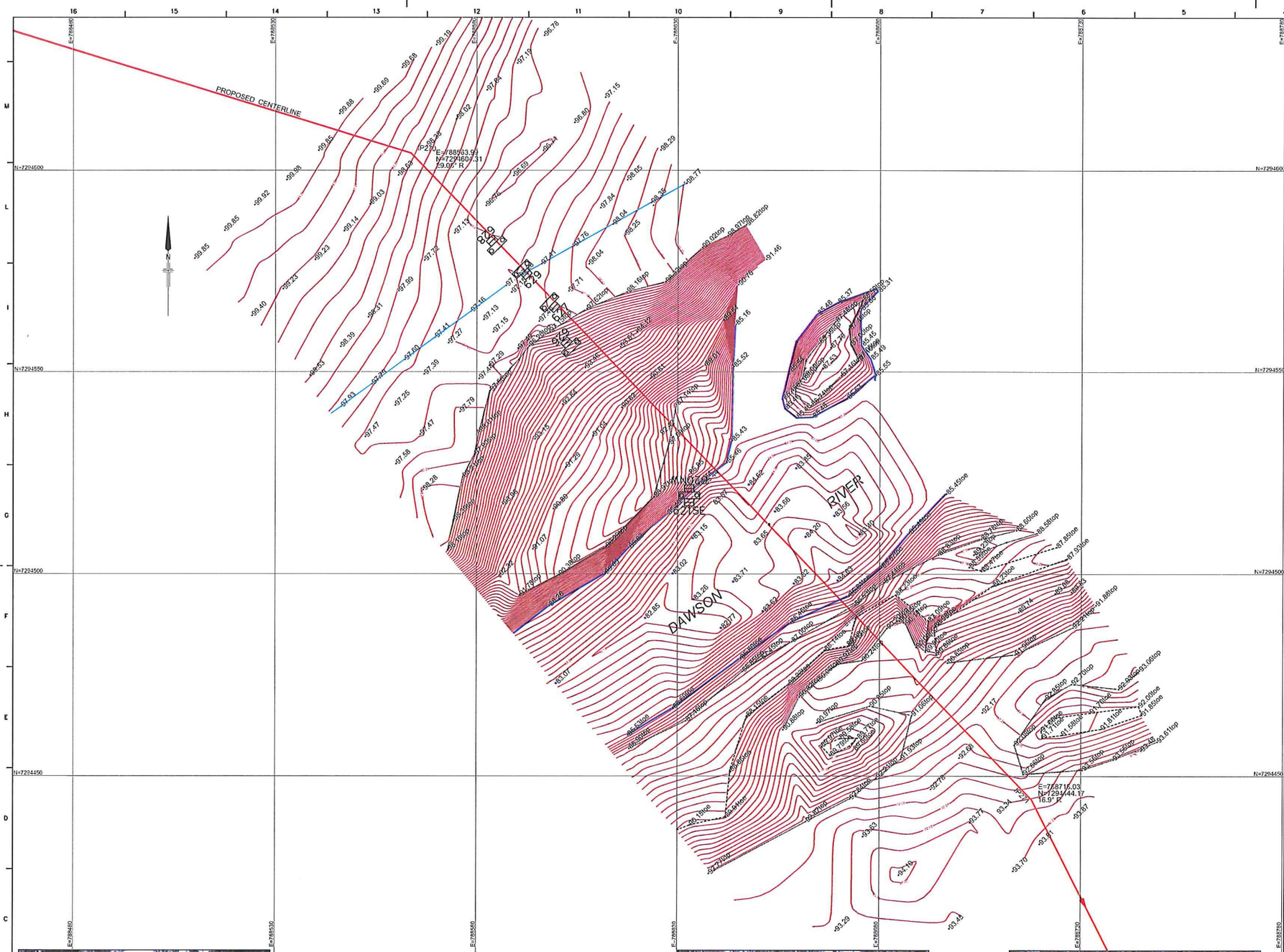
CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

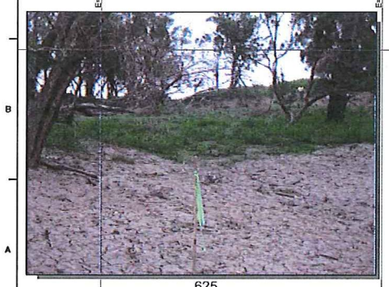
CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: DAWSON RIVER CROSSING KP 233.969

| | |
|---|---|
| SAIPEM JOB: | 032118 |
| AREA: | 3381 |
| Doc. Class.: | 2 |
| COMPANY DOC No.: | 3381-40-3421 |
| CONTRACTOR DOC No.: | 10-LC-B-81455 |
| CONT No.: | 897315 |
| REV.: | 3 |
| SHEET: | 1 OF 2 |
| SCALE: | 1:250 |



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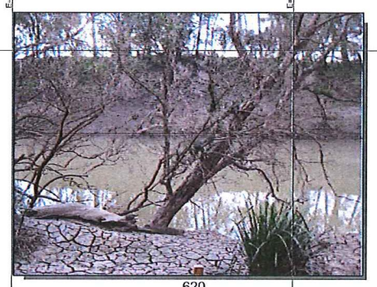

620



621

REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| | |
| | |
| | |

## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
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| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: [signature] Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 55
Vertical Datum AHD

10 5 0 5 10 15 20

1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | SIM | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 20-04-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3421

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81455

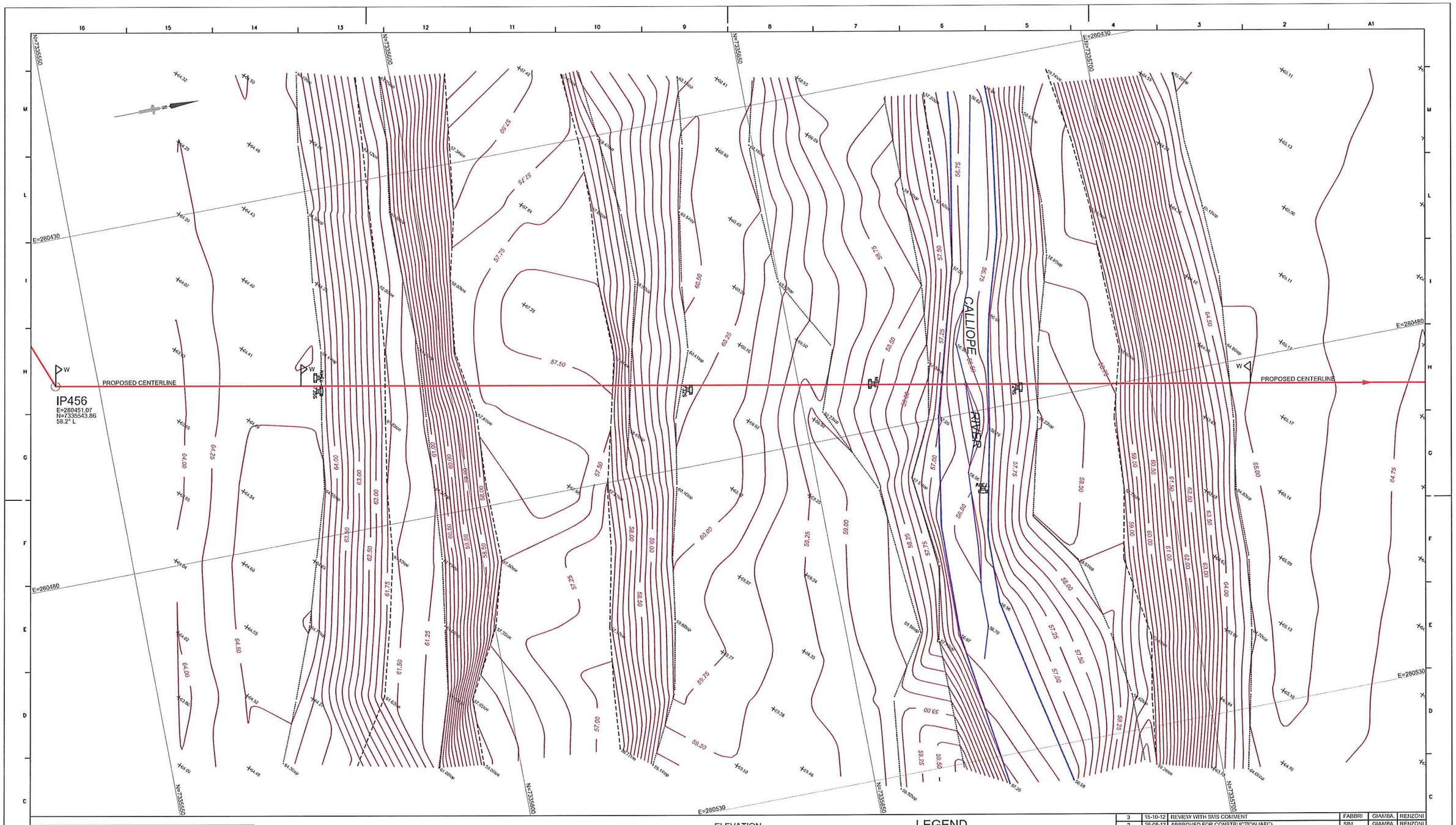
CONT No.: 897315

DOCUMENT NAME: DAWSON RIVER CROSSING KP 233.969

REV.: 3

SHEET: 2 OF 2

SCALE: 1:500




| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: Dated: 23/11/2012

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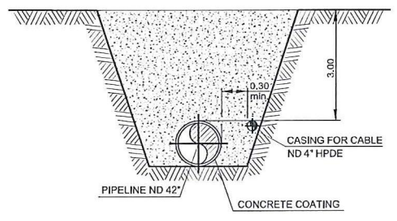
| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| 3381-40-3300-142 | ALIGNMENT SHEET n°142 (ROUTE A8) FROM KP 352.500 TO KP 355.000 |
| 3381-10-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

SECTION A-A




ELEVATION

5 2.5 0 2.5 5 7.5 10

VERTICAL SCALE 1:250
VERTICAL DATUM AHD
A1

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-5040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO:
   HORIZONTAL DATUM MGA94 ZONE 56
   VERTICAL DATUM AHD

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 28-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 28-06-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 05-12-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

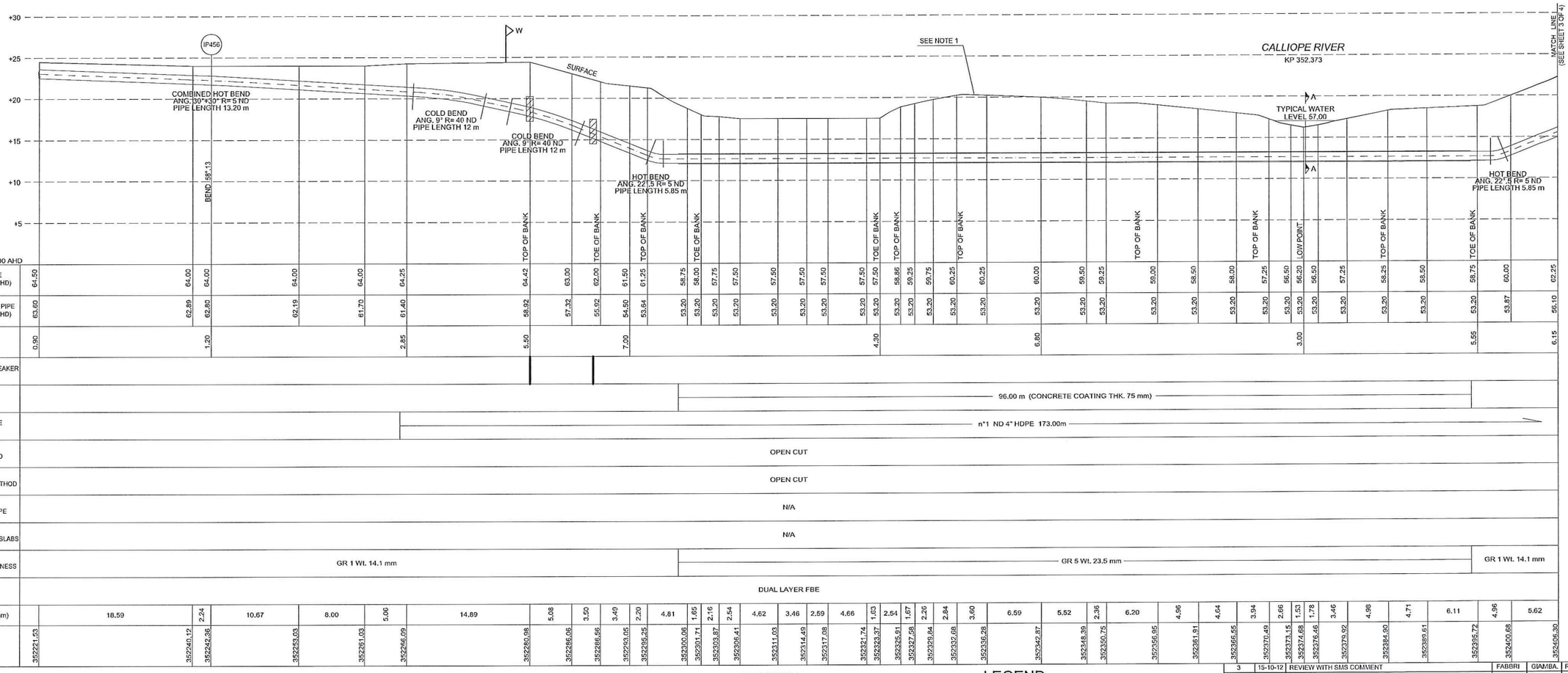
DOCUMENT NAME: CALLIOPE RIVER CROSSING KP 352.373

| | |
|---|---|
| SAIPEM JOB: | 032118 |
| AREA: | 3381 |
| Doc. Class.: | 2 |
| COMPANY DOC No.: | 3381-40-3442 |
| CONTRACTOR DOC No.: | 10-LC-B-81513 |
| CONT No.: | 897315 |
| REV.: | 3 |
| SHEET: | 1 OF 4 |
| SCALE: | 1:250 |

## PLAN

5 2.5 0 2.5 5 7.5 10

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 56



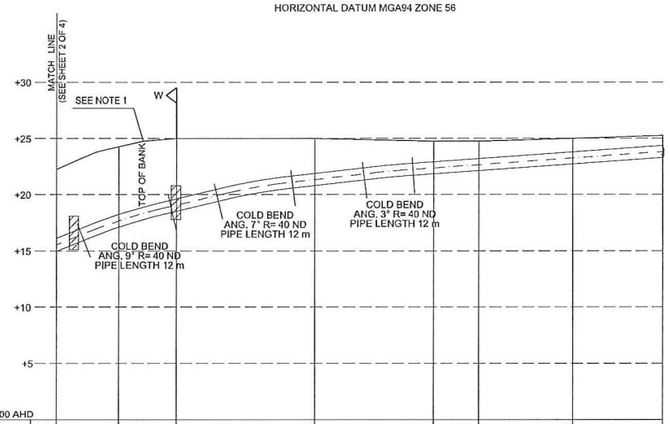

DATUM 40.00 AHD

| | | |

## PLAN

5 2.5 0 2.5 5 7.5 10

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 56




| DATUM 40.00 AHD | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RL SURFACE (METRES - AHD) | 62.25 | 64.25 | 65.00 | 65.00 | 64.75 | 64.75 | 65.00 | 65.25 |
| RL - TOP OF PIPE (METRES - AHD) | 56.10 | 58.24 | 59.60 | 61.85 | 62.90 | 63.20 | 63.79 | 64.35 |
| COVER (m) | 6.15 | | 5.40 | 3.15 | 1.85 | | | 0.90 |
| TRENCH BREAKER FOAM | | | | | | | | |
| BOUYANCY CONTROL | | | | | | | | |
| CASING PIPE FOR F.O.C. | n°1 ND 4" HDPE 173.00m | | | | | | | |
| LAY METHOD | OPEN CUT | | | | | | | |
| TRENCH METHOD | OPEN CUT | | | | | | | |
| MARKER TAPE | N/A | | | | | | | |
| CONCRETE SLABS | N/A | | | | | | | |
| WALL THICKNESS | GR 1 Wt. 14.1 mm | | | | | | | |
| COATING | DUAL LAYER FBE | | | | | | | |
| DISTANCE (m) | | 5.62 | 5.13 | 12.31 | 10.53 | 4.02 | 8.36 | 6.05 |
| CHAINAGE (Metres) (Route A8) | 352406.30 | 352411.92 | 352417.05 | 352429.36 | 352439.89 | 352443.91 | 352452.27 | 352460.32 |

### COMPANY REVIEW CODE

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | ✓ |

Signed: [signature] Dated: 23/11/2012

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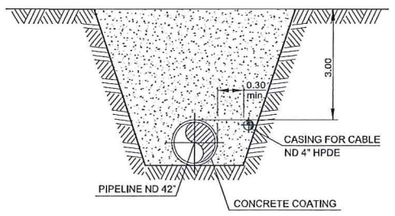
### REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| 3381-40-3300-142 | ALIGNMENT SHEET n°142 (ROUTE A8) FROM KP 352.500 TO KP 355.000 |
| 3381-40-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

### SECTION A-A




### ELEVATION

5 2.5 0 2.5 5 7.5 10

VERTICAL SCALE 1:250
VERTICAL DATUM AHD
A1

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-6040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO: HORIZONTAL DATUM MGA94 ZONE 56 VERTICAL DATUM AHD

### LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 28-06-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 05-12-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3442

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81513

CONT No.: 897315

DOCUMENT NAME: CALLIOPE RIVER CROSSING KP 352.373

REV.: 3

SHEET: 3 OF 4

SCALE: 1:250

PROPOSED CENTERLINE

CALLIOPE RIVER

KP 352.373
E=280451.07
N=7335543.86
58.2° L

734

735

732

731

730

729

| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| | |
| | |
| | |
| | |

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |
| Signed: | | Dated: 23/11/2012 |

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 56
Vertical Datum AHD

10 5 0 5 10 15 20

1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 28-06-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 05-12-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

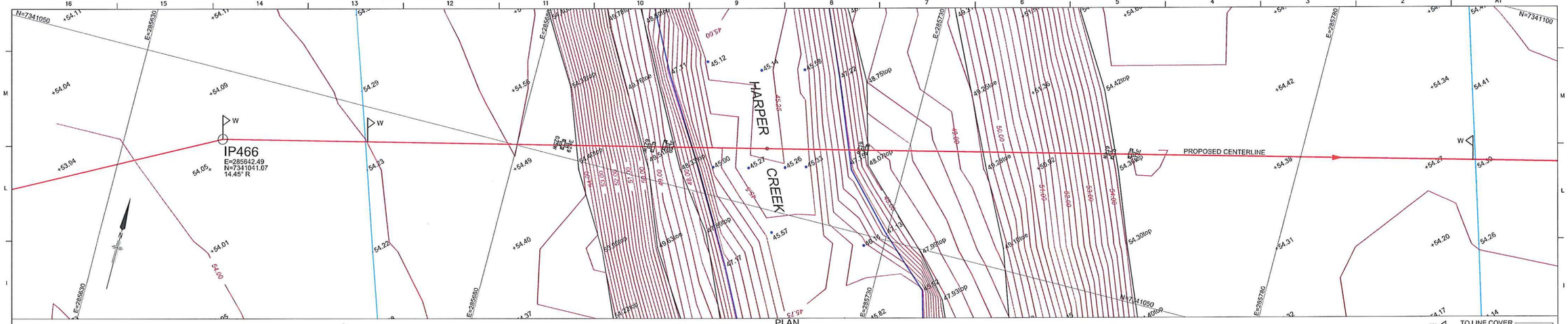
CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

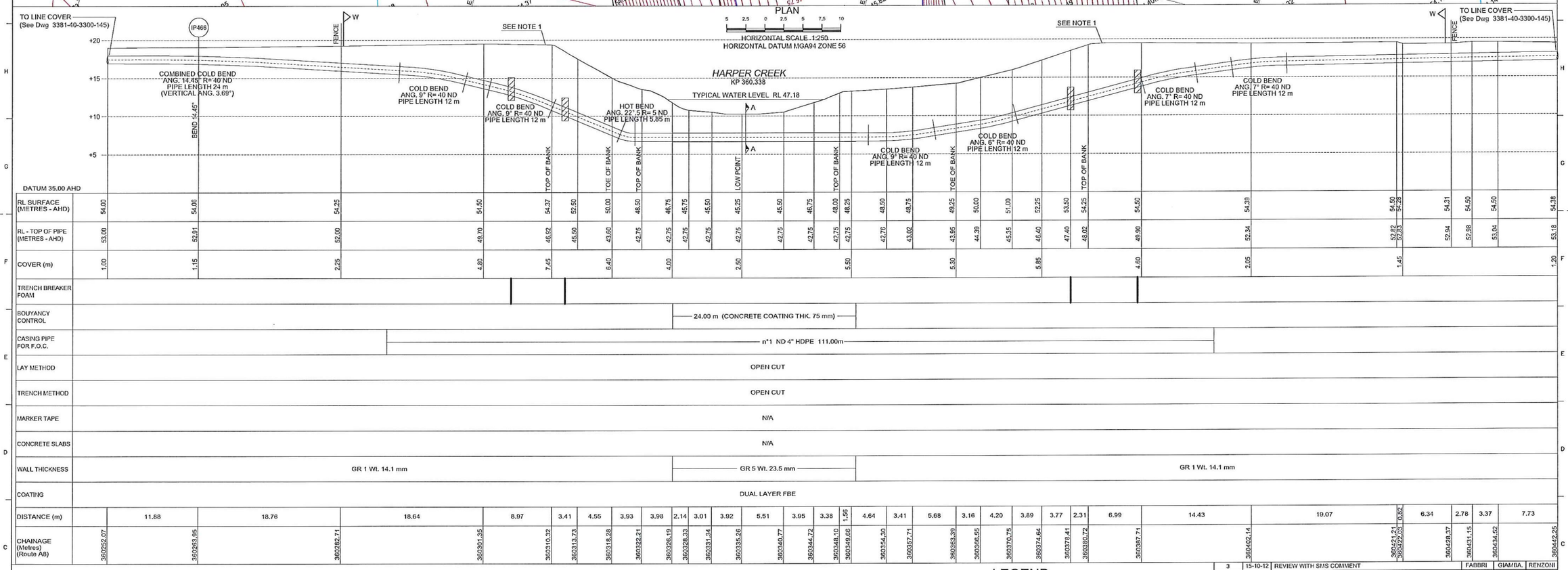
DOCUMENT NAME: CALLIOPE RIVER CROSSING KP 352.373

| | |
|---|---|
| SAIPEM JOB: | 032118 |
| AREA: | 3381 |
| Doc. Class.: | 2 |
| COMPANY DOC No.: | 3381-40-3442 |
| CONTRACTOR DOC No.: | 10-LC-B-81513 |
| CONT No.: | 897315 |
| REV.: | 3 |
| SHEET: | 4 OF 4 |
| SCALE: | 1:500 |




PLAN

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 56




| | | |

HARPER CREEK

PROPOSED CENTERLINE

E=285642.49
N=7341041.07
14.5° R
IP466

N=7341100
N=7341050
N=7341000
N=7340950
N=7340900

E=285580
E=285630
E=285680
E=285730
E=285780
E=285830

| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| | |
| | |
| | |
| | |

## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

### COMPANY REVIEW CODE

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: Dated: 29/11/12

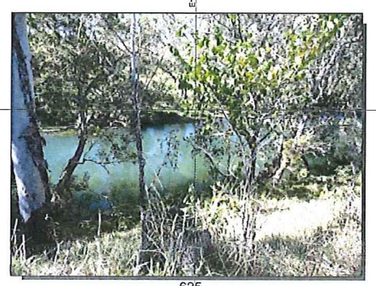
Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 56
Vertical Datum AHD

10 5 0 5 10 15 20
1:500

613


624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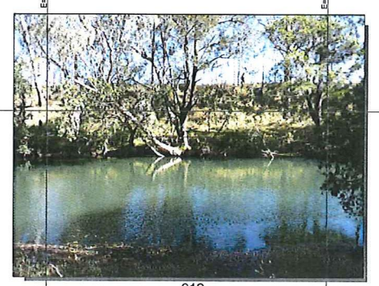
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614

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 28-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 28-06-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 05-12-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 | AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3443

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81514

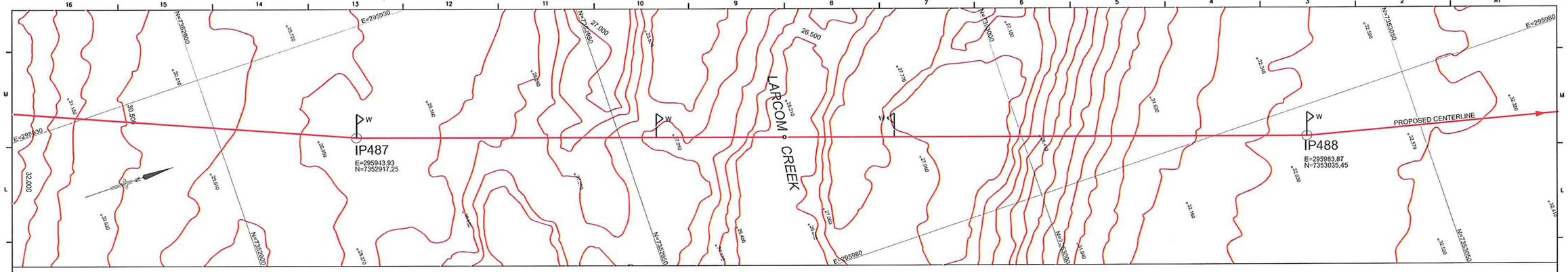
CONT No.: 897315

DOCUMENT NAME: HARPER CREEK CROSSING KP 360.338

REV.: 3

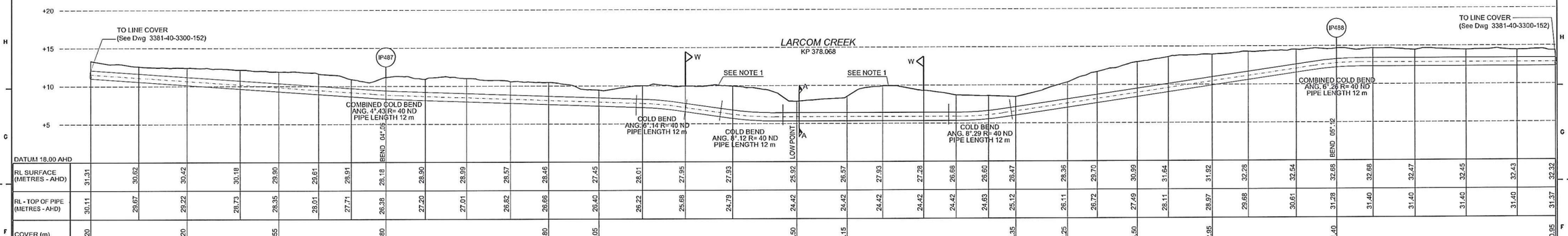
SHEET: 2 OF 2

SCALE: 1:500



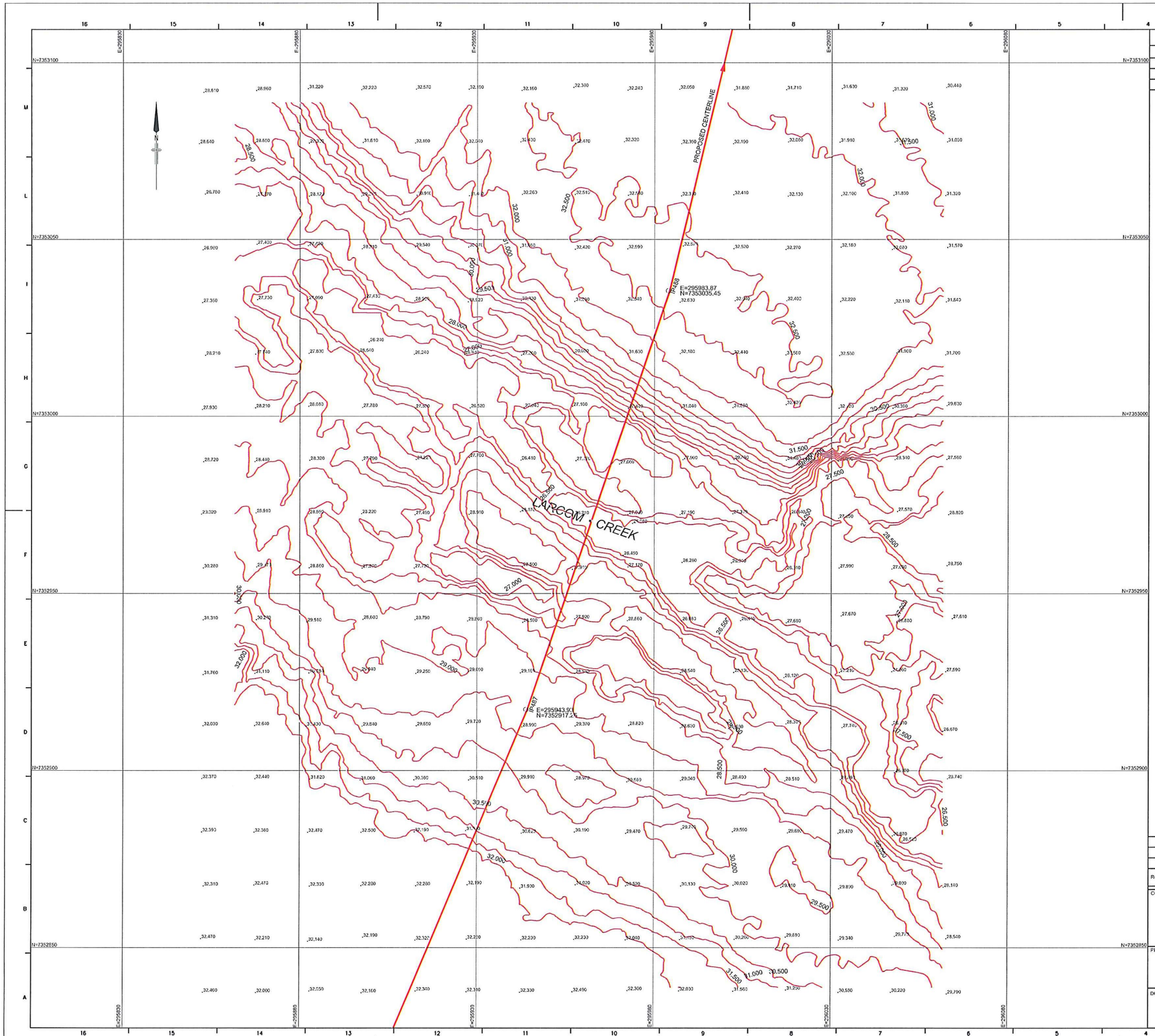

PLAN

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 56




DATUM 18.00 AHD

| | | |




REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| | |
| | |
| | |

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | ✓ |

Signed: Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 56
Vertical Datum AHD

10 5 0 5 10 15 20
1:500

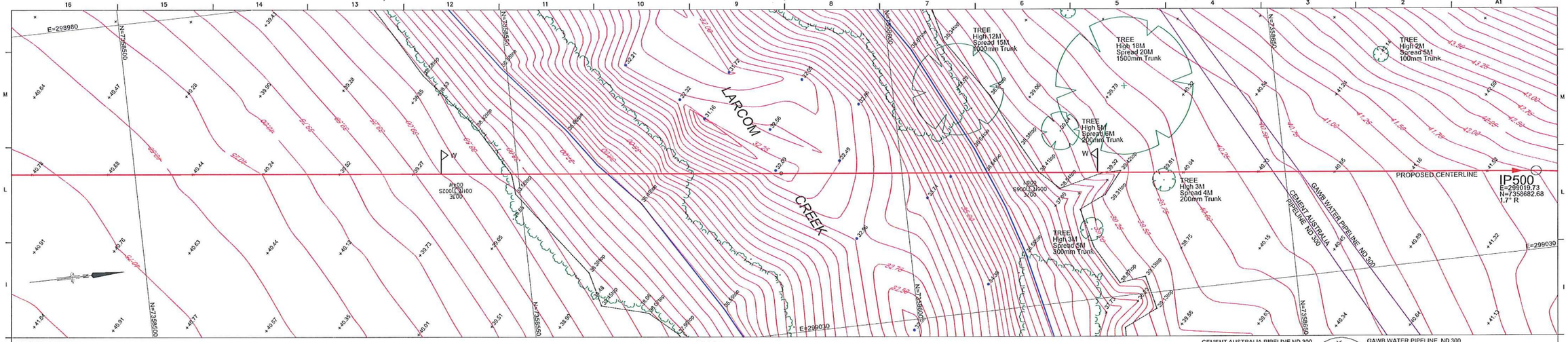
| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 1 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-05-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 09-01-12 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

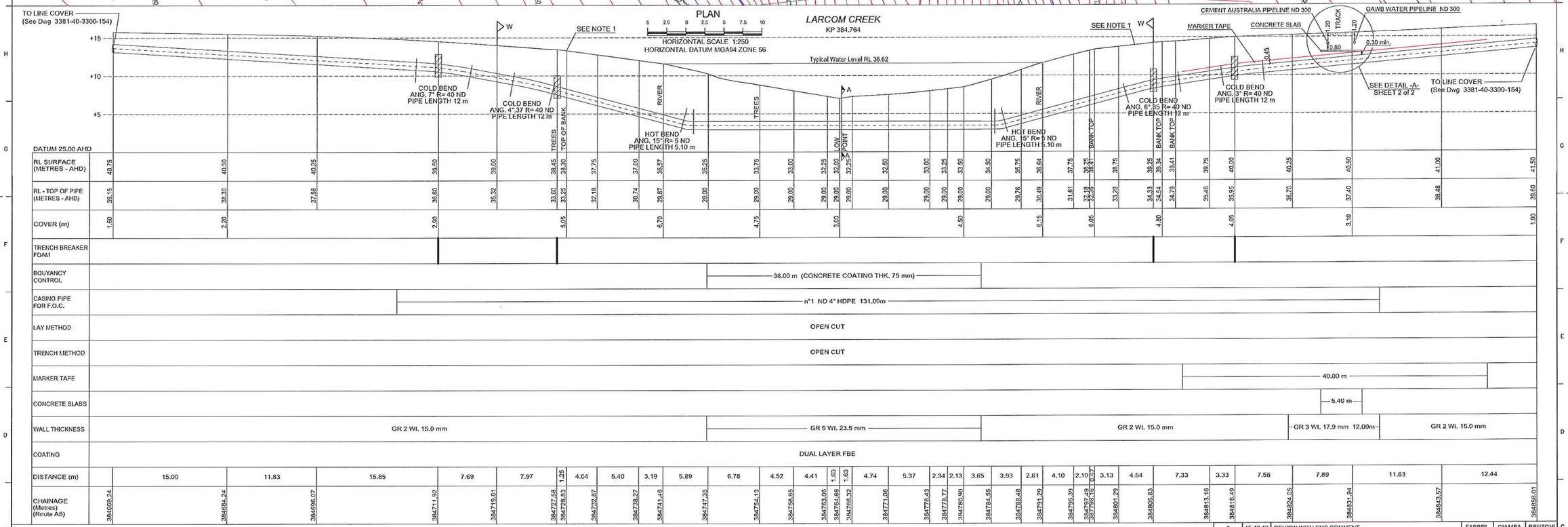
CONTRACTOR: eni saipem — Saipem Australia Pty Ltd
CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 | AREA: 3381
Doc. Class.: 2
COMPANY DOC No.: 3381-40-3492
CONTRACTOR DOC No.: 10-LC-B-81545
CONT No.: 897315
REV.: 1
SHEET: 2 OF 2
SCALE: 1:500

PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: LARCOM CREEK CROSSING KP 378.068



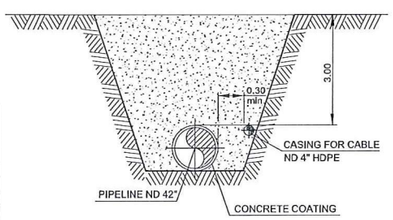

| COMPANY REVIEW CODE | | |
|---|---|---|
| Code | Description | Tick |
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | ✓ |

Signed: Dated: 23/11/12

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| 3381-40-3300-154 | ALIGNMENT SHEET n°154 (ROUTE A8) FROM KP 382.500 TO KP 385.000 |
| 3381-40-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3715 | CONCRETE SLAB |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

SECTION A-A




ELEVATION
5 2.5 0 2.5 5 7.5 10
VERTICAL SCALE 1:250
VERTICAL DATUM AHD

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-6040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO:
   HORIZONTAL DATUM MGA94 ZONE 56
   VERTICAL DATUM AHD
5. ACTUAL DEPTH OF COVER FOR CEMENT AUSTRALIA PIPE TO BE CONFIRMED ON SITE BY VACUUM METHODS.
6. SURVEY DATE: 05/02/2012

LEGEND
- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- EDGE OF TREES
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 16-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 14-03-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 03-02-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: LARCOM CREEK CROSSING KP 384.764

| | |
|---|---|
| SAIPEM JOB: 032118 | AREA: 3381 |
| Doc. Class.: 2 | |
| COMPANY DOC No.: 3381-40-3447 | |
| CONTRACTOR DOC No.: 10-LC-B-81518 | |
| CONT No.: 897315 | |
| REV.: 3 | |
| SHEET: 1 OF 2 | |
| SCALE: 1:250 | |



005N



006S



007E



008W



001N



002S



003E



004W

LARCOM CREEK

IP499

IP500

SEE DETAIL -A-

PROPOSED CENTERLINE

GAWB WATER PIPELINE ND 300

CEMENT AUSTRALIA PIPELINE ND 300

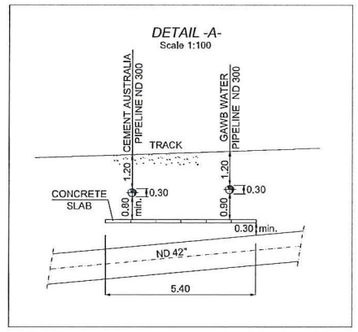
E=293930 E=296930 E=293980 E=296980 E=299030 E=299080 E=299130

N=7358450 N=7358500 N=7358550 N=7358600 N=7358650 N=7358700

REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| | |
| | |
| | |
| | |

*DETAIL -A-*
Scale 1:100




NOTE:

1. ACTUAL DEPTH OF COVER FOR CEMENT AUSTRALIA PIPE TO BE CONFIRMED ON SITE BY VACUUM METHODS.

LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- EDGE OF TREES
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | ✓ |

Signed: Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 56
Vertical Datum AHD

10 5 0 5 10 15 20
1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 2 | 16-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 14-03-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 03-02-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3380

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3447

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81518

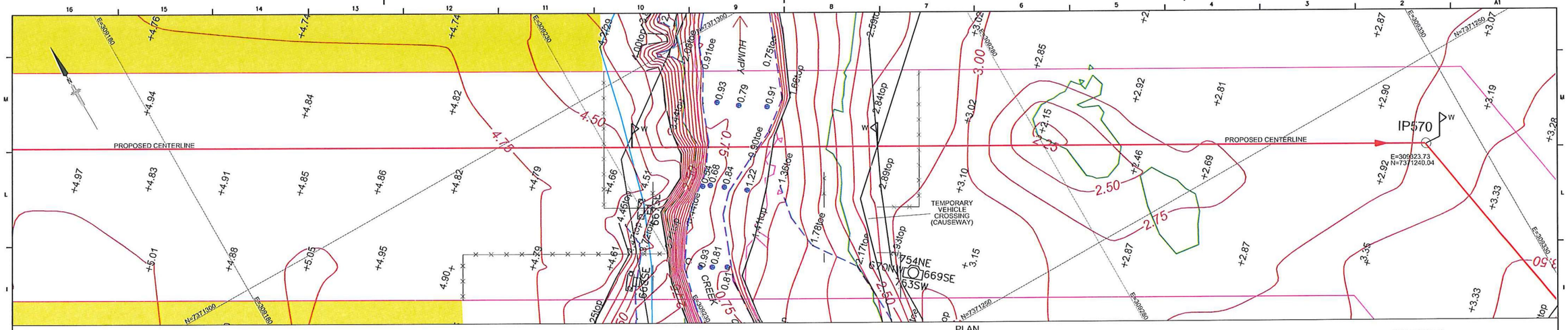
CONT No.: 897315

DOCUMENT NAME: LARCOM CREEK CROSSING KP 384.764

REV.: 3

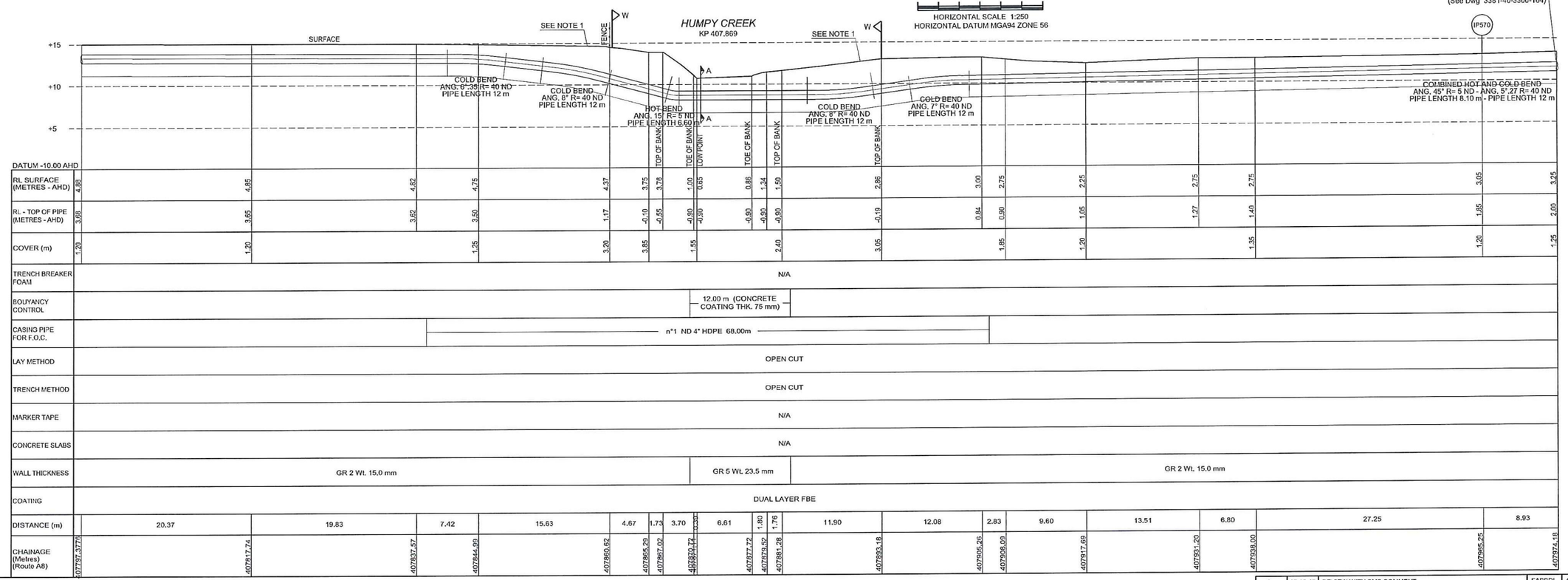
SHEET: 2 OF 2

SCALE: 1:500

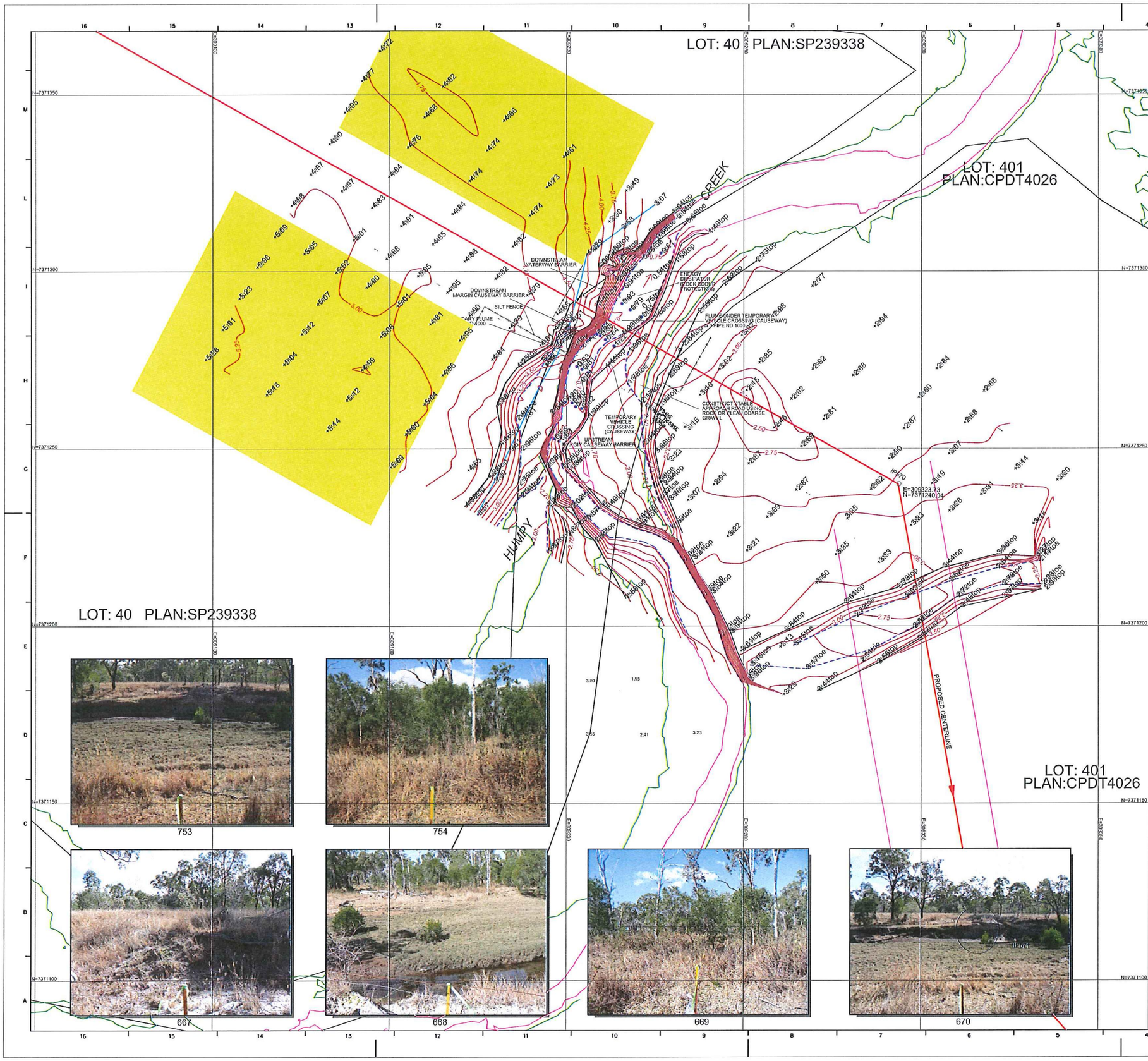



PLAN

HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 56




| | | |




REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
| | |
| | |
| | |

## NOTE

LAT tidal level is below natural ground level and do not impact the extent of works

HAT =+2.56 m (Highest Astronomical Tide)

MHWS=+1.69 m (Mean High Water Springs)

LAT=-2.27 m (Lowest Astronomical Tide))

The proposed works are entirely within the Coastal Management District boundary which includes all of:

Lot 3 RP613702
Lot 41 SP239338
Lot 40 SP239338
Lot 401 CPDT4026

## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- TEMPORARY ACCESS PATH TO ROW 30 m (10+20)
- EXTRA WORK SPACE
- HAT (Highest astronomical Tide)
- MHWS (Mean High Water Springs)
- Catastal Boundary

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

Signed: [signature] Dated: 29/11/2012

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 56
Vertical Datum AHD

10 5 0 5 10 15 20
1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 2 | 15-10-12 | REVIEW WITH SMS COMMENT | FABBRI | GIAMBA. | RENZONI |
| 1 | 11-09-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 0 | 22-12-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 26-10-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3451

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81522

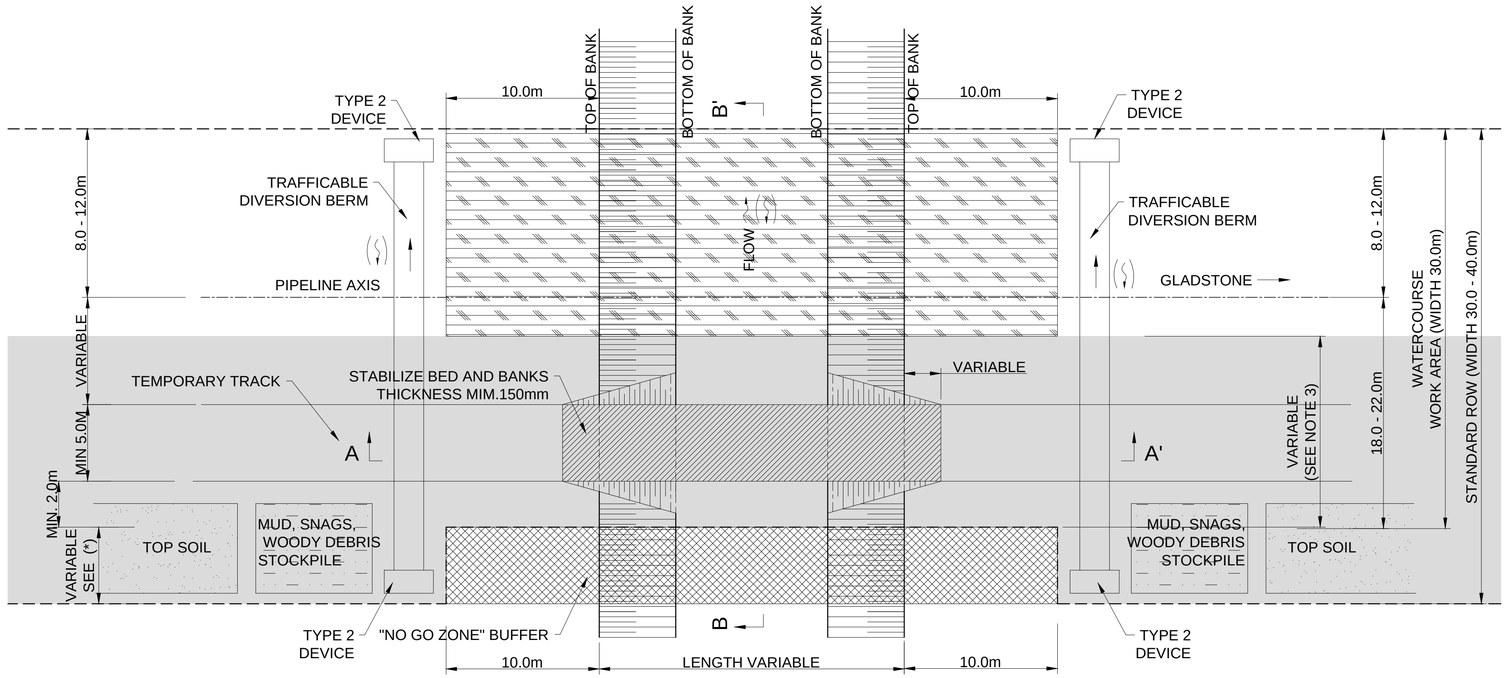
CONT No.: 897315

DOCUMENT NAME: HUMPY CREEK CROSSING KP 407.869

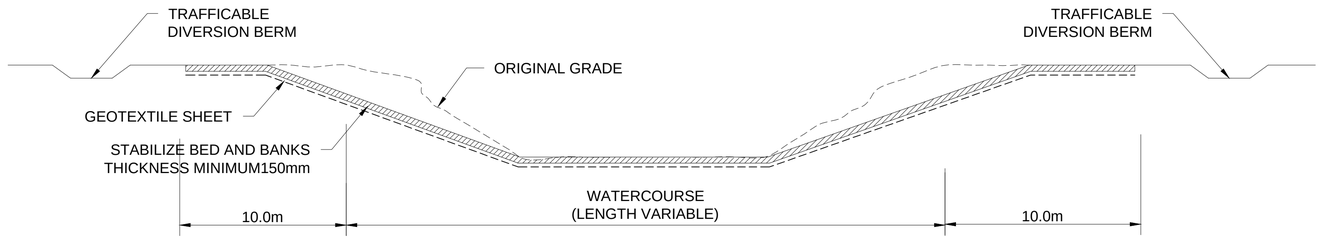
REV.: 2

SHEET: 2 OF 2

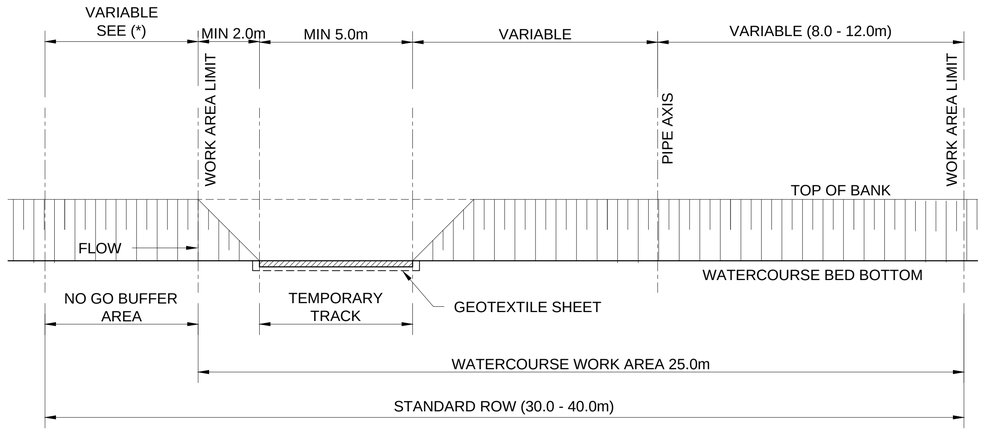
SCALE: 1:500




PLAN VIEW




SECTION A-A'




SECTION B-B'

## LEGEND

- STABILIZE BED AND BANKS ( THICKNESS MINIMUM150mm), USING GEOTEXTILE, ROCK OR CLEAN COURSE GRAVEL (MINIMUM SIZE 50mm)
- TEMPORARY WORK AREAS AT THE TIME OF ACCESS WAY CONSTRUCTION
- "NO GO ZONE" BUFFER
- NOT TO BE OPEN UNTIL THE TRENCHING WORKS
- WORK AREAS LIMIT DURING PIPELINE CROSSING CONSTRUCTION
- (*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
  LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE.
2. THE WORKS DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR WATERCOURSE THAT ARE DRY OR FOR SHALLOW, LOW FLOW WATERCOURSE AT THE TIME OF CONSTRUCTION. IF THE WATERCOURSE IS FLOWING IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE.
3. THIS IS A TYPICAL ( CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE ACCESS WAY, SEDIMENT CONTROL AND ETC. MAY VARY DUE TO CONDITIONS. THE KEY FEATURE IS TO HAVE A MINIMAL DISTURBANCE OF THE WATERCOURSE BED OR FLOWS. THE MAXIMUM WIDE OF WORK AREA FOR ACCESS WAY IS 10m.
4. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE FISHERIES CODE FOR SELF-DEVELOPMENT-MINOWATERWAY BARRIER WORKS- PART 4: BED LEVEL CROSSINGS, WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
5. TWO SIGNS OF DIMENSIONS 500mm BY 500mm ARE REQUIRED, ONE FOR EACH SIDE OF THE WATER COURSE AND FACING AWAY FROM WATERCOURSE. THE SIGNS SHALL READ AS PER THE APPLICABLE CODE OF PERMIT.
6. CLEARING OF BANKS AND DISTURBANCE OF THE WATERCOURSE SHALL BE LIMITED TO THAT NECESSARY TO CONSTRUCT THE BED LEVEL CROSSING, AND SHALL NOT EXCEED 10.0m WIDTH.
7. VEGETATION SHALL NOT BE FELLED SO AS TO FALL IN THE WATERCOURSE.
8. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDANCE WITH THE WATERCOURSE CROSSING MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
9. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE THE "NO GO BUFFER" AREA OF THE TOP OF BANK FOR LATER RE-INSTATEMENT AS PART OF THE REHABILITATION WORKS.
10. THE EXISTING MATERIAL FROM THE BED AND BANKS MUST BE SALVAGED PRIOR TO CONSTRUCTION AND STOCKPILED SEPARATELY FOR USE REHABILITATION WORKS AT THE COMPLETION OF CONSTRUCTION.
11. ALL SALVAGE MATERIALS WILL BE STOCKPILED SEPARATELY WHERE POSSIBLE.
12. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 10 m FROM THE TOP OF BANK. ALL STOCKPILES WILL BE PROTECTED ON THE DOWN SLOPE BY A SILT FENCE AND/OR A STOCKPILES BERM UNTIL SUCH TIME AS THE STOCKPILE IS STABILIZED.
13. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-1.3-1993).
14. IF SUSPECTED ASS ARE ENCOUNTERED DURING THE WORKS, THEY SHALL BE MANAGED IN ACCORDING WITH THE ACID SULPHATE SOILS MANAGEMENT PLAN (3380-SAIP-4-1.3-1832).

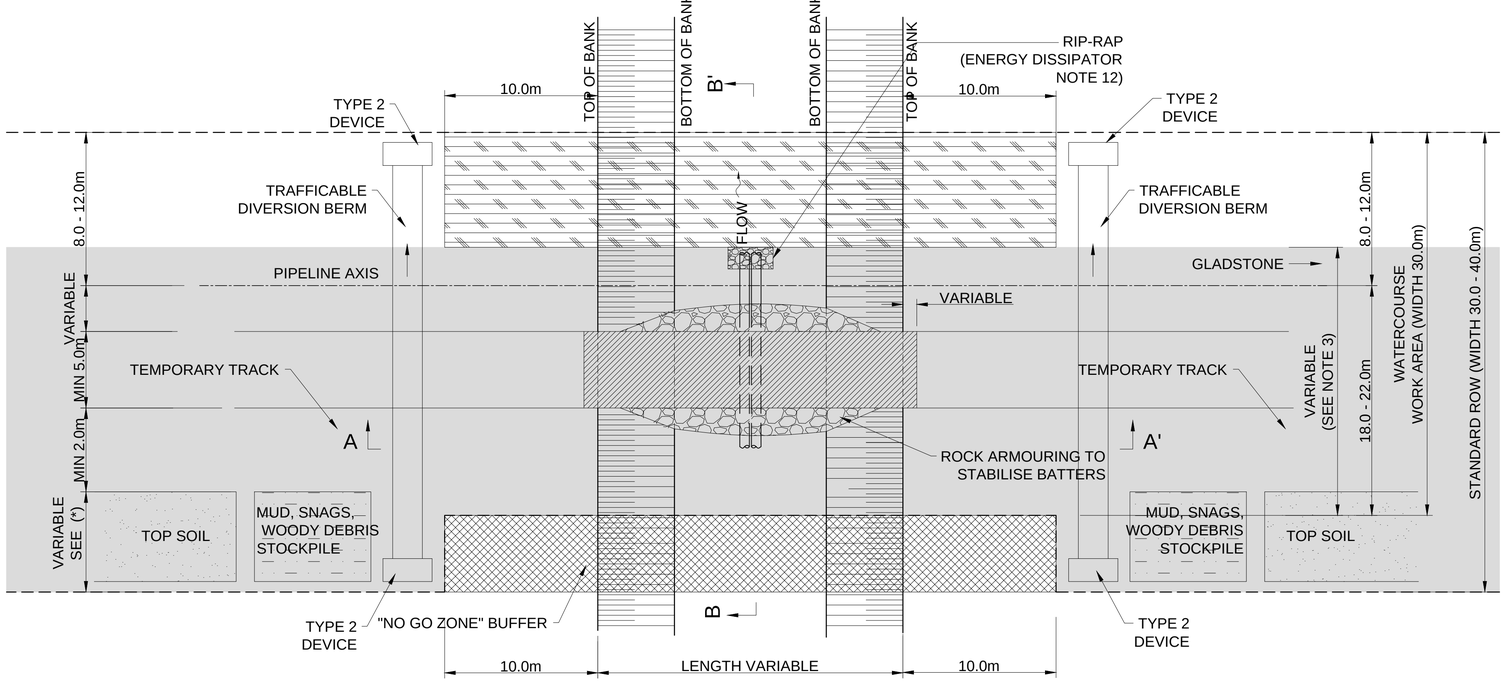
Saipem Australia Pty Ltd

APPENDIX: A1 (SHEET 1 OF 1)

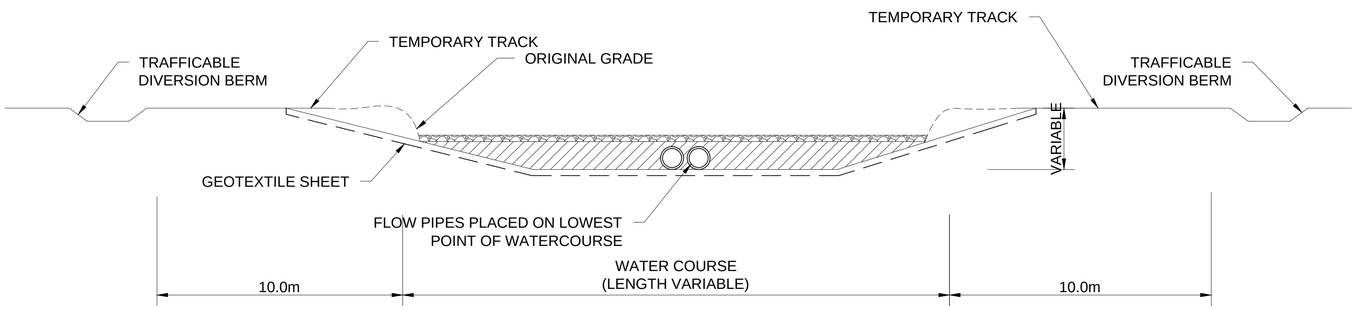
DATE: 06/10/12

DOCUMENT NAME:

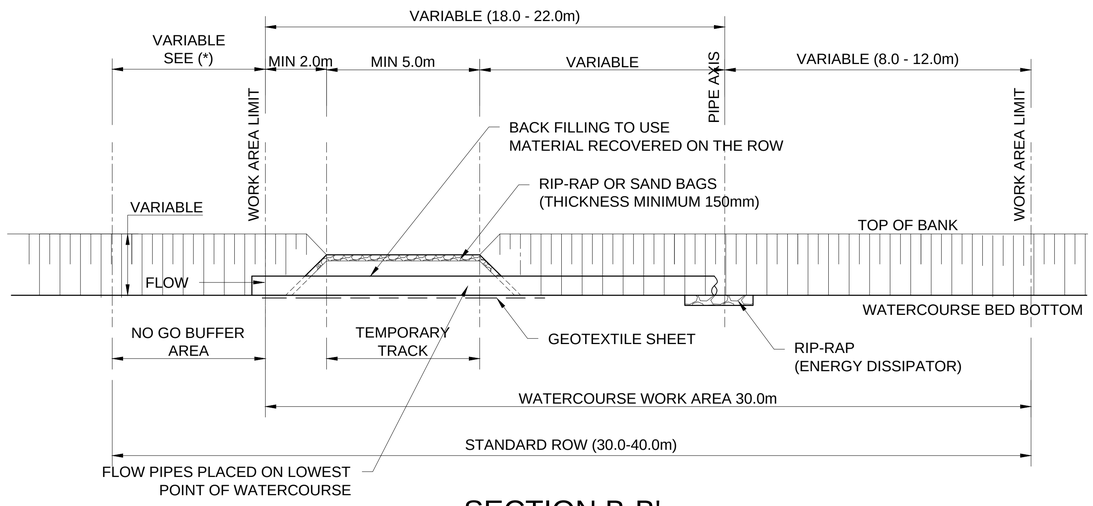
# TYPICAL STANDARD FOR WATERCOURSE ACCESS WAY. STABILISED BED LEVEL CROSSING




## PLAN VIEW




## SECTION A-A'




## SECTION B-B'

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE. WATERCOURSE FLOW DIRECTION SHOWN ON THE DRAWING COULD BE REVERSED.
2. THE WORK DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR WATERCOURSES AS IDENTIFIED IN THE WATERCOURSE CROSSING REGISTER . IF THE WATERCOURSE IS FLOWING IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE AT THE TIME OF PIPELINE CROSSING CONSTRUCTION.
3. THE KEY FEATURE IS TO HAVE A MINIMAL DISTURBANCE OF THE WATERCOURSE BED OR FLOWS. THE MAXIMUM WIDE OF WORK AREA DURING ACCESS WAY CONSTRUCTION IS 10m WHERE PRACTICABLE.
4. IF THE CREEK IS FLOWING, SILT CURTAIN ( OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW. THESE WILL BE REMOVED IMMEDIATELY FOLLOWING CONSTRUCTION OF ACCESS CROSSING.
5. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
6. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE PROJECT SPECIFIC CODE FOR DEVELOPMENT - TEMPORARY AND MINOR WATERWAY BARRIER WORKS ( 3380-SAIP-4-8.2-7001), THE WORKS SHALL BE CONDUCTED IN ACCORDANCE WITH THE REQUIREMENTS OF THAT CODE AND ANY CONDITIONS OF APPROVAL ISSUED BY DAFF.
7. CAUSEWAY TO BE INSTALLED DURING THE ROW CLEARING.
8. CLEARING OF THE BANKS AND DISTURBANCE OF THE WATERCOURSE SHALL BE LIMITED TO THAT NECESSARY TO CONSTRUCT THE CAUSEWAY, AND SHALL NOT EXCEED A TOTAL FOOTPRINT OF 10m WIDE WHERE PRACTICABLE.
9. THE FLUME PIPE(S) SHALL BE SUFFICIENT TO PASS FLOWS THAT CAN REASONABLY BE EXPECTED TO OCCUR DURING THE LIFE OF THE CROSSING. WHERE FLOW GAUGING DATA IS NOT AVAILABLE, THE SIZING OF THE CULVERTS IS TO BE BASED ON ENGINEERING JUDGEMENT, TO HAVE A MINIMUM DIAMETER OF 60cm. FLOW PIPE(S) POSITIONED BELOW THE ROCK BANK WILL BE PLACED AT THE START OF CAUSEWAY CONSTRUCTION PHASE. ADDITIONAL FLOW PIPE(S) AND ENERGY DISSIPATOR WILL BE INSTALLED AT THE START OF STANDARD ROW CLEARING PHASE( SEE SECTION B-B').
10. RIP-RAP/ ARMOUR TO BE PLACED ON BOTH BATTER SLOPES OF THE CAUSEWAY. SAND BAGS MAY BE SUBSTITUTED.
11. BACKFILL AROUND THE PIPES AT THE ROAD TO USE MATERIAL RECOVERED. MINIMUM COVERAGE MUST BE SUFFICIENT TO MAINTAIN STRUCTURAL INTEGRITY OF THE CAUSEWAY.
12. CAUSEWAY WILL BE FINISHED WITH SIZE OF CRUSHED ROCK ( THICKNESS 150mm MINIMUM). RIP-RAP/ ARMOUR TO BE PLACED ON BOTH BATTER SLOPES OF THE CAUSEWAY. SAND BAGS MAY BE SUBSTITUTED ( 100mm SIZE).
13. RIP-RAP ( ENERGY DISSIPATOR) TO BE PLACED LEVEL WITH THE BED AT THE DOWNSTREAM CULVERT OUTLET EXTENDING A MIN.OF 2.5PIPE DIAMETERS.
14. TO REDUCE THE RISK OF SEDIMENTS ENTERING THE WATERWAY, THE APPROACHES SHOULD BE RAISED AND GRAVELED A SUFFICIENT DISTANCE BACK FROM THE WATER. IF CUTS ARE NEEDED TO OBTAIN A SATISFACTORY GRADE, THEY ARE TO BE DUG WITH SIDE DITCHED AND STABLE SLOPES. TRAFFICABLE DIVERSION BERM ON CATCH DRAINS SHALL BE INSTALLED AT THE TOP OF APPROACHES. THESE SHALL TERMINATE IN TYPE 2 SED DEVICES.
15. PERIODICALLY INSPECT THE CAUSEWAY AND REMOVE ANY BUILD-UP OF SEDIMENT OR DEBRIS FROM THE PIPES OR CAUSEWAY.
16. NO SODIC SOILS TO BE USED FOR ANY CAUSEWAY WORKS.
17. DISTANCE BETWEEN EDGE OF THE BASE OF THE CAUSEWAY TO THE PIPELINE CENTER LINE IS APPROX 14.0m . ACTUAL SEPARATION DISTANCE TO BE DETERMINED ON SITE AND CONSIDER HEIGHT AND WIDTH OF BANKS.
18. VEGETATION SHALL NOT BE FELLED SO AS TO FALL IN THE WATERCOURSE.
19. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDING WITH THE WATERCOURSE CROSSING MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
20. IF THE CREEK IS FLOWING, SILT CURTAIN ( OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW. THESE WILL BE REMOVED IMMEDIATELY FOLLOWING CONSTRUCTION OF ACCESS CROSSING.
21. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE OF THE WORKS FOOTPRINT OR STOCKPILED SEPARATELY WHERE POSSIBLE LANDWARD OF THE TOP OF BANK FOR LATER RE-INSTATEMENT AS PART OF THE REHABILITATION WORK, OUTSIDE THE BUFFER AREA.
22. THE EXISTING BED AND BANK MATERIAL MUST BE SALVAGED PRIOR TO CONSTRUCTION AND PLACED BACK INTO THE WATERCOURSE AT THE COMPLETION OF CONSTRUCTION. STOCKPILES OF SPOIL OR MATERIAL EXCAVATED FROM THE BED OR BANKS OF THE WATERCOURSE SHALL BE STOCKPILED SEPARATELY WHERE POSSIBLE AND AT LEAST 10m LANDWARD OF THE TOP OF BANK AND PROTECTED ON THE DOWNSLOPE SIDE BY A SILT FENCE AND/OR AN ADEQUATE STOCKPILE BERM. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 10 m FROM THE TOP OF BANK.
23. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-1.3-1993).

## LEGEND

| | |
|---|---|
| | CONSTRUCTION STABLE APPROACH ROAD USING MATERIAL INDICATED IN THE NOTES 9, 10, 11, 12 |
| | TEMPORARY WORK AREAS AT THE TIME OF ACCESS WAY CONSTRUCTION |
| | "NO GO ZONE" BUFFER |
| | NOT TO BE OPEN UNTIL THE TRENCHING WORKS |
| — — — — | WORK AREAS LIMIT DURING PIPELINE CROSSING CONSTRUCTION |
| (*) | LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH<br>LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH |

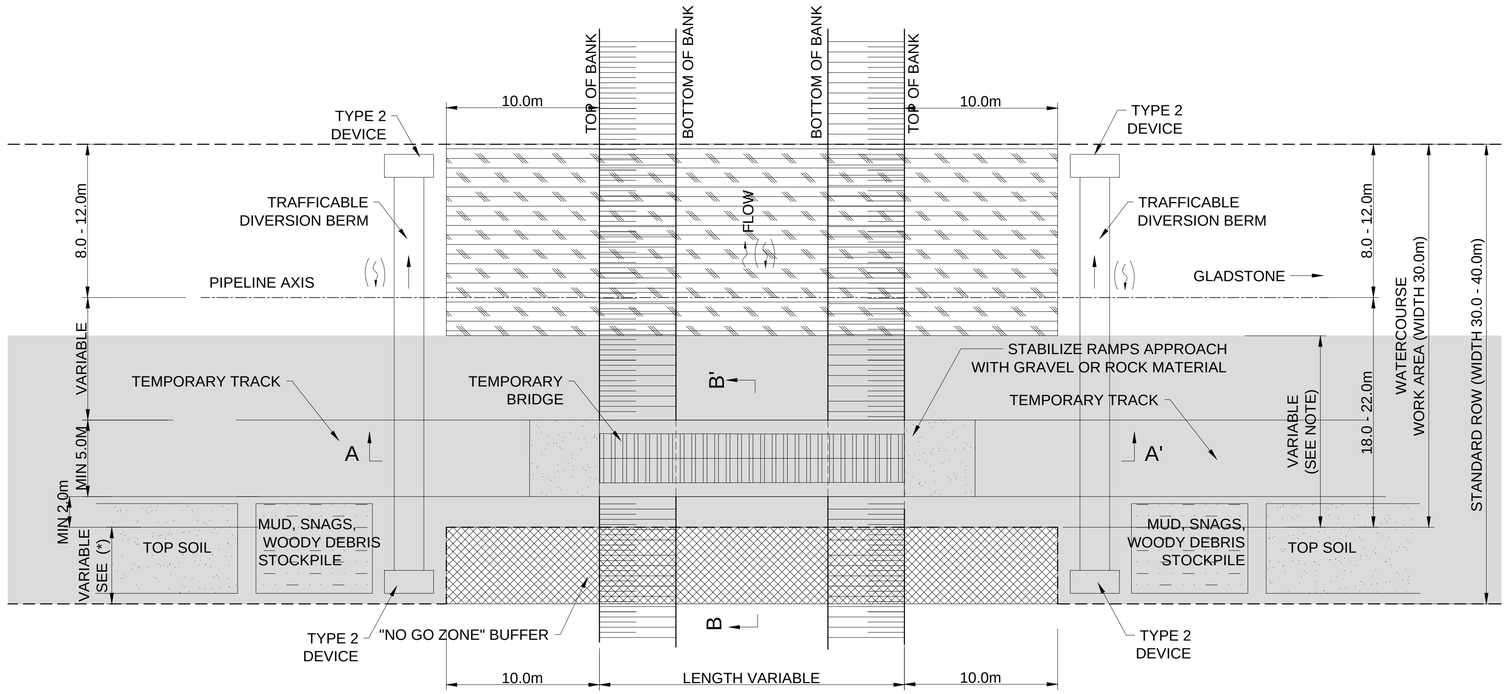
Saipem Australia Pty Ltd

APPENDIX: A2 (SHEET 1 OF 1)

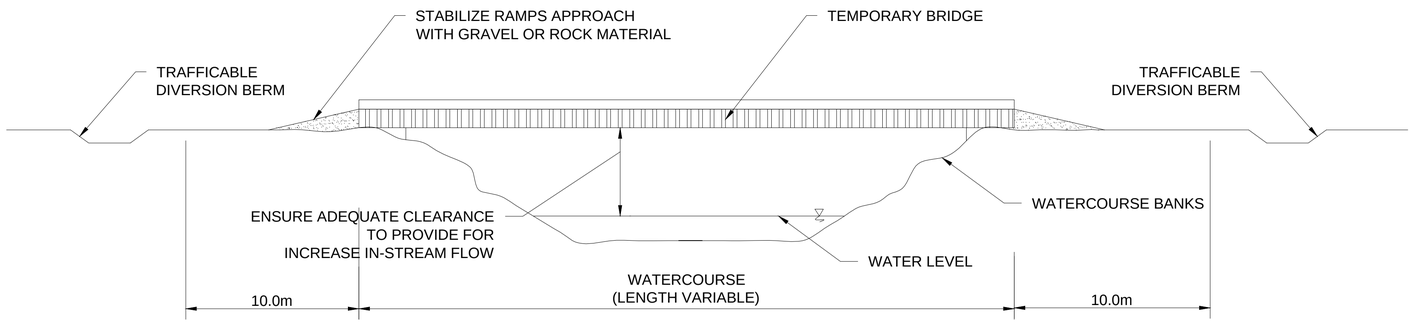
DATE: 06/10/12

DOCUMENT NAME:

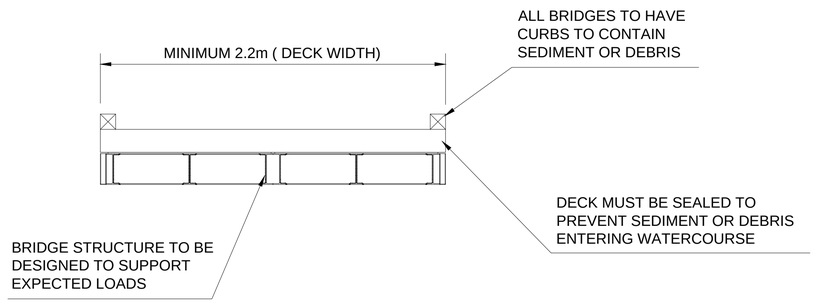
**TYPICAL STANDARD FOR WATERCOURES ACCESS WAY. CAUSEWAY CROSSING.**




## PLAN VIEW




## SECTION A-A'




## SECTION B-B'

## LEGEND

- TEMPORARY WORK AREAS AT THE TIME OF ACCESS WAY CONSTRUCTION
- "NO GO ZONE" BUFFER
- NOT TO BE OPEN UNTIL THE TRENCHING WORKS
- WORK AREAS LIMIT DURING PIPELINE CROSSING CONSTRUCTION
- (*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
  LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE.
2. THE WORKS DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR WATERCOURSES AS IDENTIFIED IN THE WATERCOURSE CROSSING REGISTER. IF THE WATERCOURSE IS FLOWING IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE AT THE TIME OF PIPELINE CROSSING CONSTRUCTION.
3. THE KEY FEATURE IS TO HAVE A MINIMAL DISTURBANCE OF THE WATERCOURSE BED OR FLOWS. THE MAXIMUM WIDE OF WORK AREA DURING ACCESS WAY CONSTRUCTION IS 10m.
4. THIS IS A TYPICAL (CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE ACCESS WAY, SEDIMENT CONTROLS AND ETC. MAY VARY DUE TO SITE CONDITIONS.
5. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
6. THE LEVEL OF THE UNDERSIDE OF THE BRIDGE SHALL BE SUFFICIENT TO PASS FLOWS THAT CAN REASONABLY BE EXPECTED TO OCCUR DURING THE LIFE OF THE CROSSING BASED ON ENGINEERING JUDGEMENT.
7. THE BRIDGE STRUCTURES TO BE DESIGNED, FABRICATED AND INSTALLED IN ACCORDANCE WITH THE AUSTRALIAN STANDARDS, RELEVANT STANDARDS AND SPECIFICATIONS. THE BRIDGE IS TO BE INSTALLED IN A MANNER SO AS TO MINIMISE THE RISK OF SEDIMENT ENTERING THE WATERWAY DURING USE. CURBS MUST BE INSTALLED ALONG THE EDGE OF THE DECK TO CONTAIN SEDIMENTS AND OTHER DEBRIS.
8. THE APPROACHES SHOULD BE RAISED AND GRAVELED A SUFFICIENT DISTANCE BACK FROM THE WATER.
9. PERIODICALLY CHECK THE BRIDGE INSTALLATION AND REMOVE ANY BUILD-UP OF SEDIMENT OR DEBRIS ON THE BRIDGE, AND FOR DISPOSAL REFEREED TO WASTE MANAGEMENT PLAN (3380-SAIP-4-1.3-1806).
10. DISTANCE BETWEEN EDGE OF THE BRIDGE TO THE PIPELINE CENTER LINE IS VARIABLE. THE SEPARATION DISTANCE TO BE DETERMINED ON SITE AND CONSIDER HEIGHT AND WIDTH OF BANKS.
11. VEGETATION SHALL NOT BE FELLED SO AS TO FALL IN THE WATERCOURSE.
12. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
13. STOCKPILES OF BED OR BANK MATERIAL WILL BE LOCATED NO LESS THAN 10m FROM TOP OF BANK. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 10m FROM TOP OF BANK. ALL SALVAGED MATERIALS WILL BE STOCKPILED SEPARATELY WHERE POSSIBLE.
14. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-1.3-1993).
15. IF SUSPECTED ASS ARE ENCOUNTERED DURING THE WORKS, THEY SHALL BE MANAGED IN ACCORDANCE WITH THE ACID SULPHATE SOILS MANAGEMENT PLAN (3380-SAIP-4-1.3-1832).

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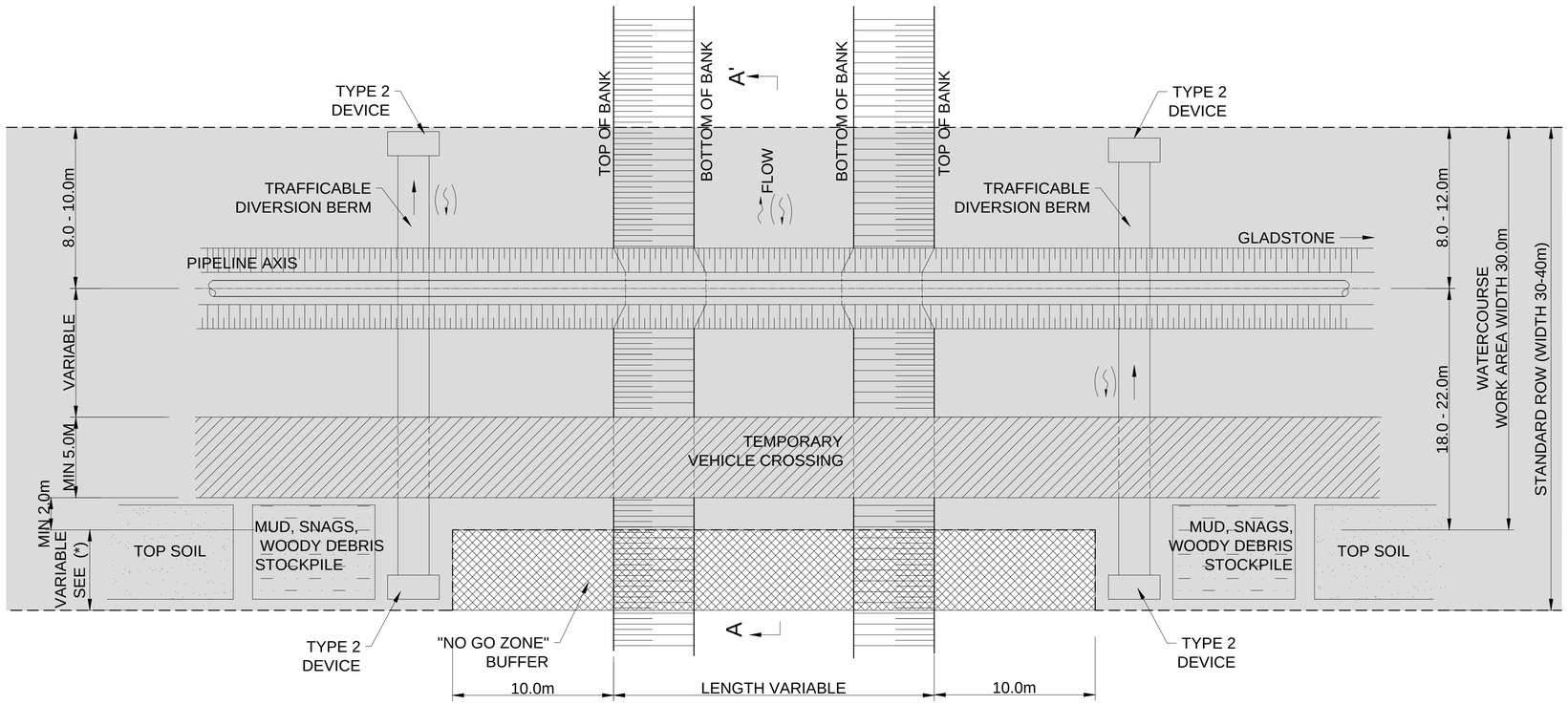
APPENDIX: A3 (SHEET 1 OF 1)

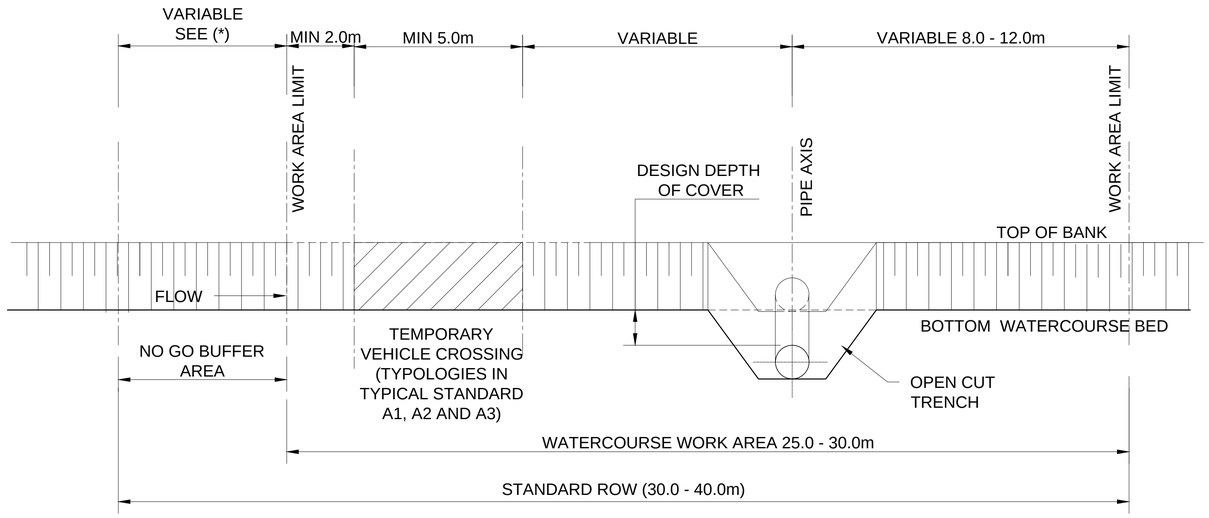
DATE: 06/10/12

DOCUMENT NAME:

# TYPICAL STANDARD FOR WATERCOURSE ACCESS WAY. BRIDGE ( STEEL RAMP) CROSSING.




# PLAN VIEW




# SECTION A-A'

## LEGEND

- TEMPORARY ACCESS WAY. CONSTRUCTIVE TYPOLOGIES DESCRIBED IN THE TYPICAL STANDARD A1, A2 ,A3 AND A4 SHALL BE APPLIED.
- TEMPORARY WORK AREAS AT THE TIME OF PIPELINE CROSSING CONSTRUCTION
- "NO GO ZONE" BUFFER
- (*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
  LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE.
2. THE WORKS DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR WATERCOURSE THAT ARE DRY AT THE TIME OF CONSTRUCTION. IF THE WATERCOURSE FLOWING IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE.
3. THIS IS A TYPICAL (CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE ACCESS WAY, SEDIMENT CONTROL MAY VARY DUE TO SITE CONDITIONS.
4. TEMPORARY ACCESS WAY COULD VARY ACCORDING TO CONDITIONS AS BED LEVEL CROSSING; NORMAL LEVEL CROSSING; CAUSEWAY OR ELEVATED BRIDGE/ STEEL RAMP ( SEE TYPICAL DRAWINGS A1, A2 AND A3).
5. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SA1P-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
6. THE AMOUNT OF TIME THE TRENCH IS OPEN WILL BE MINIMISED. BACKFILL WILL COMMENCE AS SOON AS POSSIBLE AFTER PIPELAY.
7. THE TRENCH WIDTH AND DEPTH WILL BE MINIMISED TO REDUCE SPOIL GENERATION WHERE POSSIBLE. TRENCH SHORING OR OTHER ALTERNATIVE MEASURES SHOULD BE USED IF REQUIRED.
8. THE RISK OF FAUNA ENTRAPMENT IN THE TRENCH SHALL BE MINIMISED IN ACCORDANCE WITH THE SPECIES MANAGEMENT PLAN (DOC. NO: 3380-SAIP-4-1.3-1963) AND THE FAUNA HANDLING PROCEDURE (DOC. NO: 3380-SA1P-4-1.3-1965).
9. TRENCHING ON APPROACHES TO WET WATERCOURSES WILL CEASE, LEAVING HARD TRENCH PLUGS IN PLACE FOR THE MAXIMUM PERIOD POSSIBLE PENDING PIPE LAYING.
10. TRENCH PLUGS SHALL BE EXCAVATED AND REPLACED WITH TRENCH BLOCKS OR SACK BREAKERS ABOVE THE SLOPE AND, AS REQUIRED, DOWN THE SLOPE TO PREVENT TURBID WATER FROM DIRECTLY ENTERING WATERWAYS.
11. IN THE EVENT THAT A VISIBLE SEDIMENT PLUME IS OBSERVED OUTSIDE OF THE WORKS AREA THE WORKS SHALL CEASE, AND THE EROSION AND SEDIMENT CONTROLS WILL BE INSPECTED AND REPAIRED AND/OR UPGRADED AS REQUIRED.
12. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
13. IF THE CREEK IS FLOWING, SILT CURTAINS (OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW.
14. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE OF THE WORKS FOOTPRINT OR STOCKPILED LANDWARD OF THE TOP OF BANK FOR LATER RE-INSTATEMENT AS PART OF THE REHABILITATION WORKS, OUTSIDE OF THE BUFFER AREA. ALL OTHERS STOCKPILES WILL BE LOCATED NO LESS THAN 10m FROM THE TOP OF BANK OR 50m FOR HIGH AQUATIC VALVE WATERCOURSES.
15. THE EXISTING BED AND BANK MATERIAL MUST BE SALVAGED PRIOR TO THE CONSTRUCTION AND PLACED BACK INTO THE WATERCOURSE AT THE COMPLETION OF CONSTRUCTION. STOCKPILES OF SPOIL OR MATERIAL EXCAVATED FROM THE BED OR BANKS OF THE WATERCOURSE SHALL BE STOCKPILED SEPARATELY WHERE POSSIBLE, AND AT LEAST 10m LANDWARD OF THE TOP OF BANK AND PROTECTED ON THE DOWNSLOPE SIDE BY A SILT FENCE AND/OR AN ADEQUATE STOCKPILE BERM, UNTIL STABILIZED.
16. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-1.3-1993).
17. IF SUSPECTED ASS ARE ENCOUNTERED DURING THE WORKS, THEY SHALL BE MANAGED IN ACCORDANCE WITH THE ACID SULPHATE SOILS MANAGEMENT PLAN (3380-SAIP-4-1.3-1832).
18. REESTABLISH SEDIMENT AND EROSION CONTROL ASAP AFTER PIPE IS BACKFILLED OR IF RAIN IS IMMINENT.

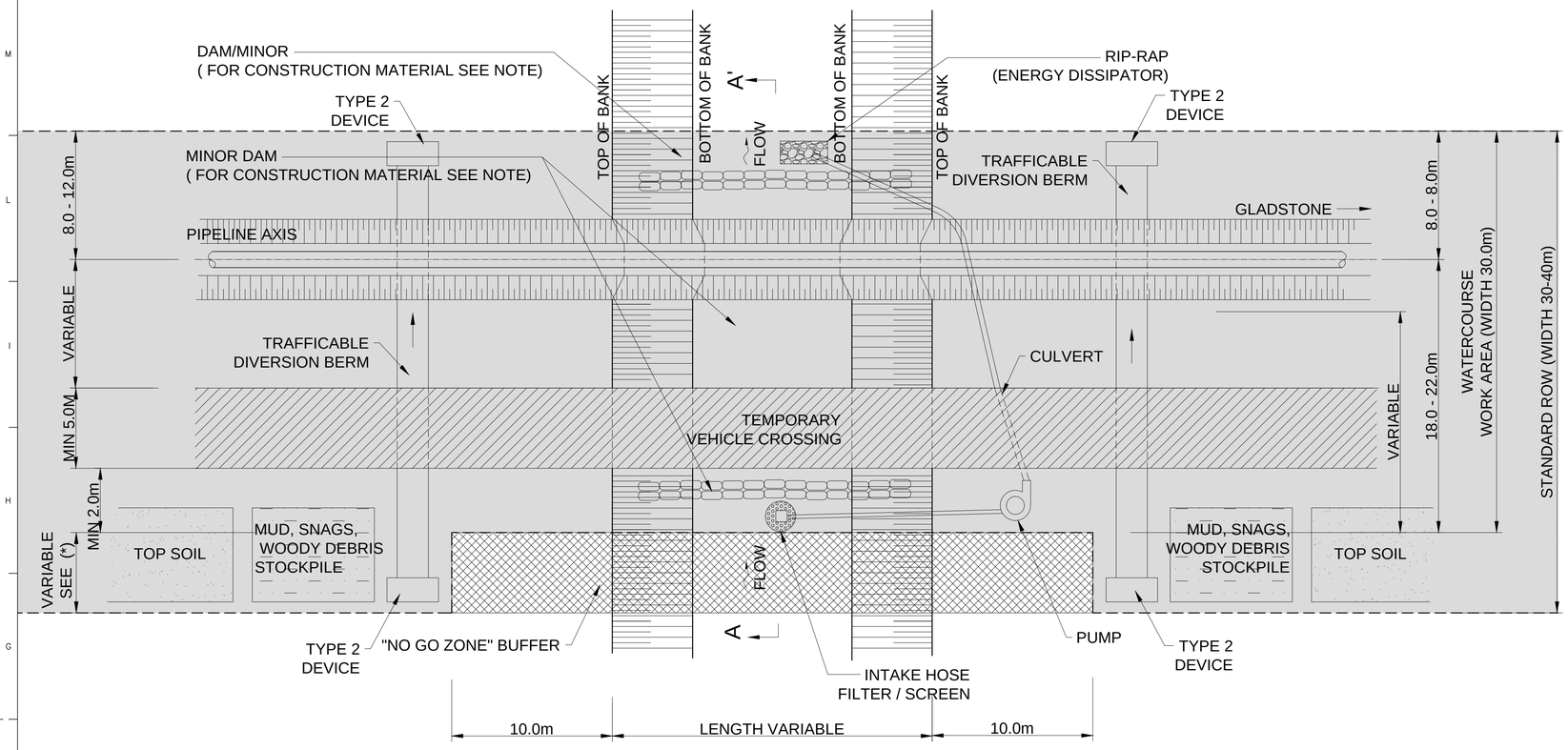
Saipem Australia Pty Ltd

APPENDIX: B1 (SHEET 1 OF 1)

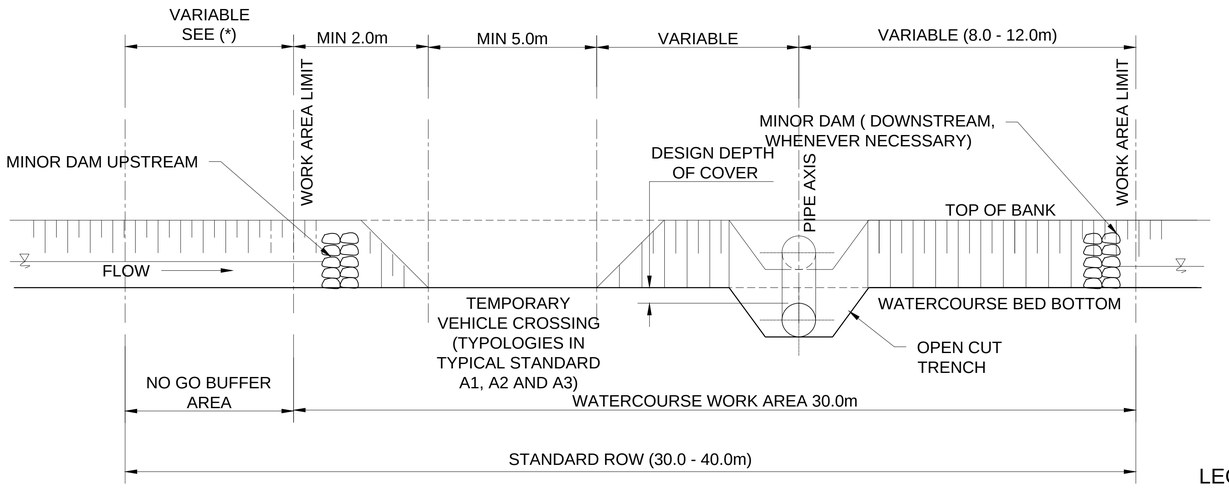
DATE: 06/10/12

DOCUMENT NAME:

**TYPICAL STANDARD FOR WATERCOURSE PIPELINE CONSTRUCTION. STANDARD MAINLINE METHOD.**




# PLAN VIEW




# SECTION A - A'

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE. FLOWING DIRECTION MAY BE OPPOSITE TO WHAT THE DRAWING SHOW.
2. THE WORKS DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR SHALLOW, LOW FLOW WATERCOURSES AT THE TIME OF CONSTRUCTION. IF THE WATERCOURSE FLOWING IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE.
3. THE AREA BETWEEN THE MINOR DAMS IS DE-WATERED. FLOWS COULD BE CONVEYED THROUGH / AROUND THE SITE VIA EITHER FLOW PIPES; A PIPED DIVERSION CONTROLLED VIA A PUMP OR A FLUME.
4. THE TEMPORARY WATERCOURSE ACCESS WAY COULD BE CONSTRUCTED VIA EITHER A NORMAL LEVEL CROSSING ( SEE TYPICAL DRAWING A2) OR A PREFABRICATED ELEVATE BRIDGE / STEEL RAMP ( SEE TYPICAL A4).
5. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSING MANAGEMENT PLAN ( 3380 - SAIP-4-3.3-6040), WATERCOURSE CROSSING ( OPEN CUT) PROCEDURE ( 3380-SAIP-4-3.3-6026) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
6. MINOR DAMS SHALL BE CONSTRUCTED OF APPROPRIATE MATERIALS SO AS TO MINIMIZE SEDIMENTATION (E.G. STEEL PLATES, SAND BAGS, GRAVEL BAGS, SHEET PILING OR INFLATABLE DAMS). THE USE OF UNPROTECTED EARTHEN DAMS SHALL BE AVOIDED. THE LOWER DAM COULD NOT BE BUILT IF IT IS LOCATED DOWNSTREAM AND THE HYDRAULIC CONDITIONS OF THE WATERCOURSE ALLOWS.
7. DE-WATERING SHOULD CEASE WHEN WATER LEVELS WITHIN THE WATERCOURSE REACH THE CRITICAL LEVEL NECESSARY TO SUSTAIN AQUATIC FAUNA SUCH AS FISH. ANY AQUATIC FAUNA (I.E. FISH, TURTLES OR FROGS) TRAPPED IN ANY IMPOUNDMENTS AREAS WILL BE SALVAGED IN ACCORDANCE WITH THE FAUNA HANDLING PROCEDURE (DOC. NO: 3380-SA1P-4-1.3-1965) AND THE DPIF (2004) FISH SALVAGE GUIDELINES, AFTER WHICH TIME, DE-WATERING MAY RE-COMMENCE.
8. ALL DE-WATERING, INCLUDING ANY WELL POINT DE-WATERING NECESSARY TO STABILIZE SATURATED SOILS, MUST BE CONDUCTED IN ACCORDANCE WITH THE PROCEDURE OUTLINED IN THE WATER QUALITY MANAGEMENT PLAN (DOC. NO: 3380-SAIP-4-1.34947).
9. ANY PUMPS USED FOR DE-WATERING OR BYPASSING SHALL BE BUNDED TO PREVENT FUEL SPILL CONTAMINATION.
10. THE INTAKE TO THE PUMPED BYPASS WILL BE SCREENED WITH AN INTAKE SCREEN NO LARGER THAN 2.54mm TO PREVENT THE INGRESS OF BIOTA.
11. THE AMOUNT OF TIME THE TRENCH IS OPEN WILL BE MINIMIZED. BACKFILL WILL COMMENCE AS SOON AS POSSIBLE AFTER PIPELAY.
12. THE TRENCH WIDTH AND DEPTH WILL BE MINIMIZED TO REDUCE SPOIL GENERATION WHERE POSSIBLE. TRENCH SHORING OR OTHER ALTERNATIVE MEASURES SHOULD BE USED IF REQUIRED.
13. DIVERTED FLOWS WILL BE PUMPED INTO A GEOFABRIC-LINED CONTAMINANT AREA AND SUBJECT TO A CONTROLLED RELEASE BACK INTO THE WATERCOURSE SO AS TO MINIMIZE THE RISK OF SCOUR AND EROSION.
14. THE RISK OF FAUNA ENTRAPMENT IN THE TRENCH SHALL BE MINIMIZED IN ACCORDANCE WITH THE SPECIES MANAGEMENT PLAN (DOC. NO: .3380-SAIP-4-1.3-1963) AND THE FAUNA HANDLING PROCEDURE (DOC. NO: 3380-SAIP-4-1.3-1965).
15. TRENCHING ON APPROACHES TO WET WATERCOURSES WILL CEASE, LEAVING HARD TRENCH PLUGS IN PLACE FOR THE MAXIMUM PERIOD POSSIBLE PENDING PIPE LAYING.
16. TRENCH PLUGS SHALL BE EXCAVATED AND REPLACED WITH TRENCH BLOCKS OR SACK BREAKERS ABOVE THE SLOPE AND, AS REQUIRED, DOWN THE SLOPE TO PREVENT TURBID WATER FROM DIRECTLY ENTERING WATERWAYS.
17. IN THE EVENT THAT A VISIBLE SEDIMENT PLUME IS OBSERVED OUTSIDE OF THE WORKS AREA THE WORKS SHALL CEASE, AND THE EROSION AND SEDIMENT CONTROLS WILL BE INSPECTED AND REPAIRED AND/OR UPGRADED AS REQUIRED.
18. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
19. THE CREEK IS FLOWING, SILT CURTAINS (OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW.
20. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE OF THE WORKS FOOTPRINT OR STOCKPILED LANDWARD OF THE TOP OF BANK FOR LATER RE-INSTATEMENT AS PART OF THE REHABILITATION WORKS.
21. THE EXISTING BED AND BANK MATERIAL MUST BE SALVAGED PRIOR TO THE CONSTRUCTION AND PLACED BACK INTO THE WATERCOURSE AT THE COMPLETION OF CONSTRUCTION. STOCKPILES OF SPOIL OR MATERIAL EXCAVATED FROM THE BED OR BANKS OF THE WATERCOURSE SHALL BE STOCKPILED AT LEAST 10m or 50m ( FOR HIGH AQUATIC VALVE WATERCOURSE) LANDWARD OF THE TOP OF BANK AND PROTECTED ON THE DOWNSLOPE SIDE BY A SILT FENCE AND/OR AN ADEQUATE STOCKPILE BERM, UNTIL STABILIZED. ALL SALVAGED MATERIAL WILL BE STOCKPILED SEPARATELY WHERE POSSIBLE.
22. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 10m OR 50m FROM TOP OF BANK.
23. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-L3-1993).
24. IF SUSPECTED ASS ARE ENCOUNTERED DURING THE WORKS, THEY SHALL BE MANAGED IN ACCORDANCE WITH THE ACID SULPHATE SOILS MANAGEMENT PLAN (3380-SAIP-4-1.3-1832).
25. THIS IS A TYPICAL ( CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE ACCESS WAY, SEDIMENT CONTROL AND ETC. MAY VARY DUE TO SITE CONDITIONS.

## LEGEND

TEMPORARY ACCESS WAY. CONSTRUCTIVE TYPOLOGIES DESCRIBED IN THE TYPICAL STANDARD A1, A2, A3 AND A4 SHALL BE APPLIED.

TEMPORARY WORK AREAS AT THE TIME OF PIPELINE CROSSING CONSTRUCTION

"NO GO ZONE" BUFFER

(*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

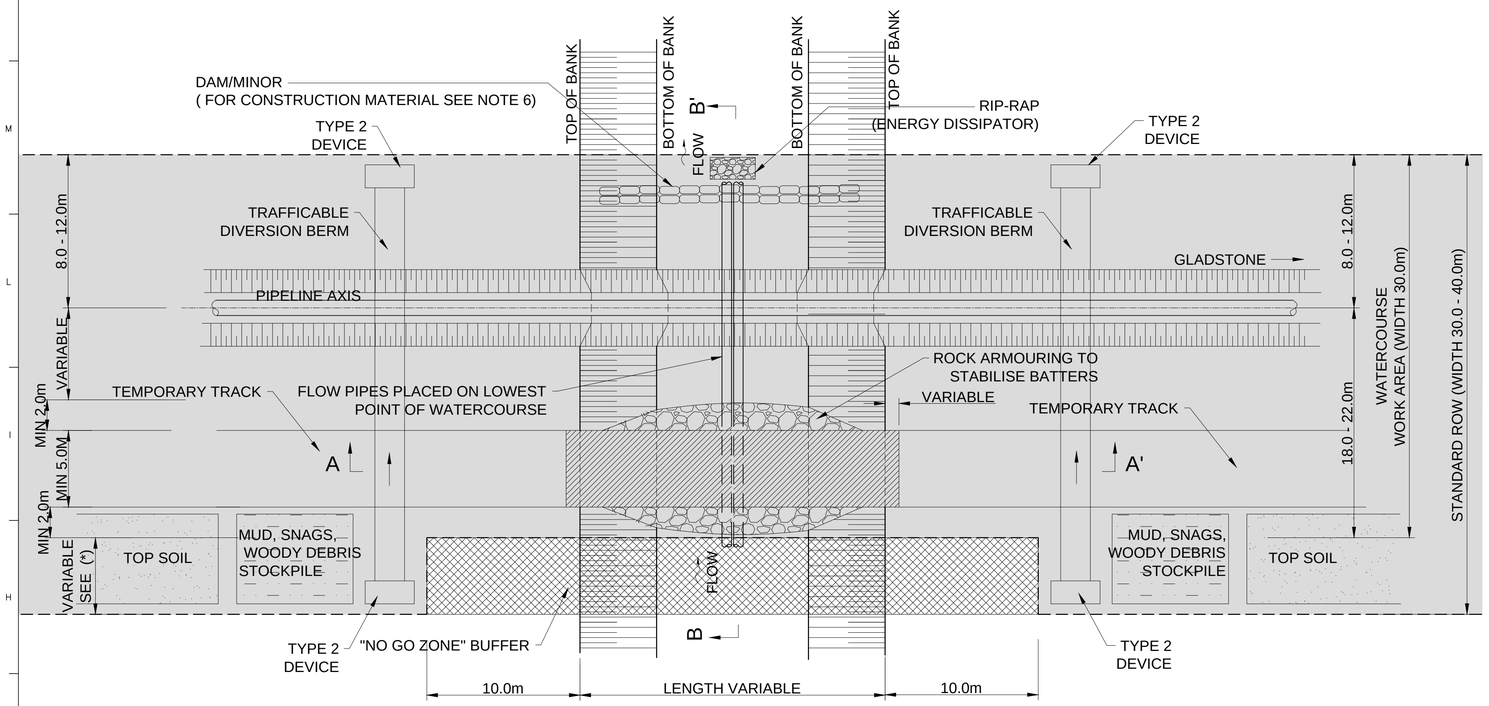
Saipem Australia Pty Ltd

APPENDIX: B2 (SHEET 1 OF 1)

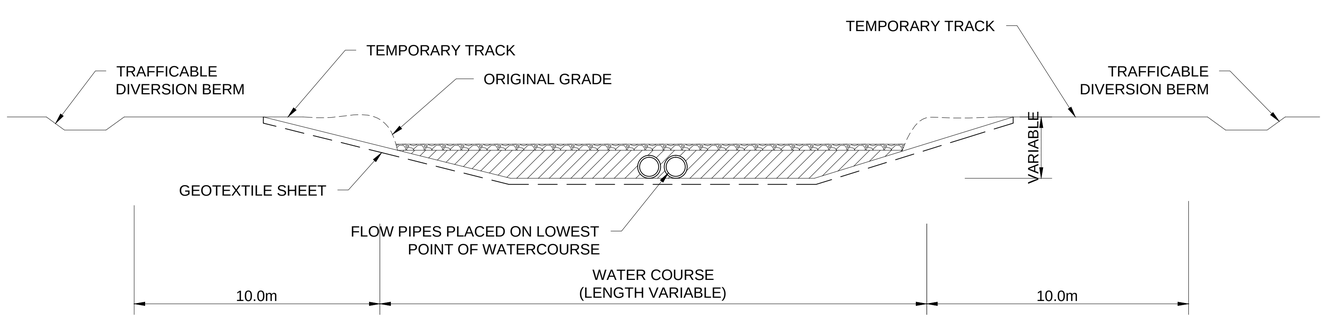
DATE: 06/10/12

DOCUMENT NAME:

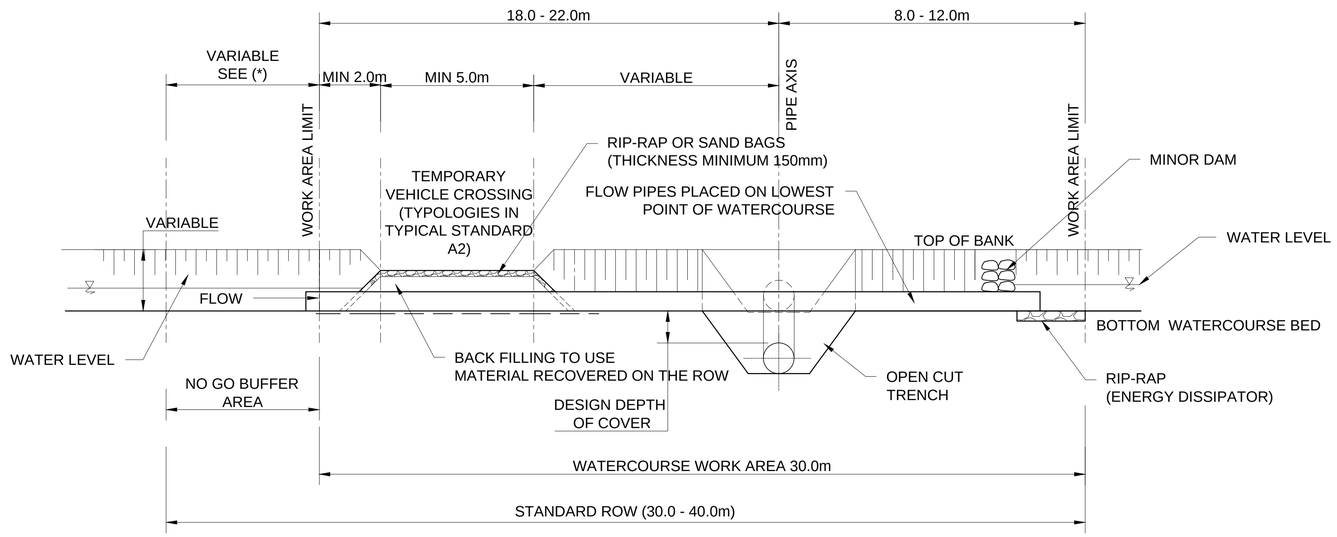
**TYPICAL STANDARD FOR WATERCOURSE PIPELINE CONSTRUCTION. MINOR DAM AND PUMP.**




# PLAN VIEW




# SECTION A-A'




# SECTION B - B'

## LEGEND

TEMPORARY ACCESS WAY. CONSTRUCTIVE TYPOLOGIES DESCRIBED IN THE TYPICAL STANDARD A1, A2, A3 AND A4 SHALL BE APPLIED.

TEMPORARY WORK AREAS AT THE TIME OF PIPELINE CROSSING CONSTRUCTION

"NO GO ZONE" BUFFER

(*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.DRAWING NOT TO SCALE.
2. THE WORKS DESCRIBED IN THIS TYPICAL STANDARD ARE APPLICABLE FOR WATERCOURSES FLOWING AS IDENTIFIED IN THE WATERCOURSE CROSSING REGISTER. IN-STREAM EROSION AND SEDIMENT CONTROLS SHALL BE PLACED IN THE WATERCOURSE BED AT THE TIME OF PIPELINE CROSSING CONSTRUCTION.
3. FLOW DIRECTION MAY BE OPPOSITE TO WHAT THE DRAWING SHOWS. THE LOWER DAM COULD NOT BE BUILT IF IT IS LOCATED DOWNSTREAM AND THE HYDRAULIC CONDITIONS OF THE WATERCOURSE ALLOWS.
4. THE AREA DOWNSTREAM TO CAUSEWAY WILL BE ABLE TO DE-WATERED, AND FLOWS ARE CONVEYED THROUGH / AROUND THE SITE VIA EITHER FLOW PIPES OR A FLUME.
5. THIS IS A TYPICAL (CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE ACCESS WAY, SEDIMENT CONTROL AND ETC. MAY VARY DUE TO SITE CONDITIONS.
6. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN.
7. CAUSEWAY TO BE INSTALLED DURING ROW CLEARING. REFER TO TYPICAL CAUSEWAY CROSSING DRAWING (A2).
8. MINOR DAMS SHALL BE CONSTRUCTED OF APPROPRIATE MATERIALS SO AS TO MINIMISE SEDIMENTATION (E.G. STEEL PLATES, SAND BAGS, GRAVEL BAGS, SHEET PILING OR INFLATABLE DAMS). THE USE OF UNPROTECTED EARTHEN DAMS SHALL BE AVOIDED.
9. DIVERTED FLOWS WILL BE PUMPED INTO A GEOFABRIC-LINED CONTAMINANT AREA AND SUBJECT TO A CONTROLLED RELEASE BACK INTO THE WATERCOURSE SO AS TO MINIMISE THE RISK OF SCOUR AND EROSION.
10. DE-WATERING SHOULD CEASE WHEN WATER LEVELS WITHIN THE WATERCOURSE REACH THE CRITICAL LEVEL NECESSARY TO SUSTAIN AQUATIC FAUNA SUCH AS FISH. ANY AQUATIC FAUNA (I.E. FISH, TURTLES OR FROGS) TRAPPED IN ANY IMPOUNDMENTS AREAS WILL BE SALVAGED IN ACCORDANCE WITH THE FAUNA HANDLING PROCEDURE (DOC. NO: 3380-SA1P-4-1.3-1965) AND THE DPIF (2004) FISH SALVAGE GUIDELINES, AFTER WHICH TIME, DE-WATERING MAY RE-COMMENCE.
11. ALL DE-WATERING, INCLUDING ANY WELL POINT DE-WATERING NECESSARY TO STABILIZE SATURATED SOILS, MUST BE CONDUCTED IN ACCORDANCE WITH THE PROCEDURE OUTLINED IN THE WATER QUALITY MANAGEMENT PLAN (DOC. NO: 3380-SAIP-4-1.34947).
12. THE AMOUNT OF TIME THE TRENCH IS OPEN WILL BE MINIMIZED. BACKFILL WILL COMMENCE AS SOON AS POSSIBLE AFTER PIPELAY.
13. THE TRENCH WIDTH AND DEPTH WILL BE MINIMIZED TO REDUCE SPOIL GENERATION WHERE POSSIBLE. TRENCH SHORING OR OTHER ALTERNATIVE. MEASURES SHOULD BE USED IF REQUIRED.
14. THE RISK OF FAUNA ENTRAPMENT IN THE TRENCH SHALL BE MINIMIZED IN ACCORDANCE WITH THE SPECIES MANAGEMENT PLAN (DOC. NO: . 3380-SAIP-4-1.3-1963) AND THE FAUNA HANDLING PROCEDURE (DOC. NO: 3380-SAIP-4-1.3-1965).
15. TRENCHING ON APPROACHES TO WET WATERCOURSES WILL CEASE, LEAVING HARD TRENCH PLUGS IN PLACE FOR THE MAXIMUM PERIOD POSSIBLE PENDING PIPE LAYING.
16. TRENCH PLUGS SHALL BE EXCAVATED AND REPLACED WITH TRENCH BLOCKS OR SACK BREAKERS ABOVE THE SLOPE AND, AS REQUIRED, DOWN THE SLOPE TO PREVENT TURBID WATER FROM DIRECTLY ENTERING WATERWAYS.
17. IN THE EVENT THAT A VISIBLE SEDIMENT PLUME IS OBSERVED OUTSIDE OF THE WORKS AREA THE WORKS SHALL CEASE, AND THE EROSION AND SEDIMENT CONTROLS WILL BE INSPECTED AND REPAIRED AND/OR UPGRADED AS REQUIRED.
18. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
19. IF THE CREEK IS FLOWING, SILT CURTAINS (OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW.
20. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE OF THE WORKS FOOTPRINT OR STOCKPILED LANDWARD OF THE TOP OF BANK,OUTSIDE OF THE BUFFER AREA FOR LATER REINSTATEMENT AS PART OF THE REHABILITATION WORKS.
21. THE EXISTING BED AND BANK MATERIAL MUST BE SALVAGED PRIOR TO THE CONSTRUCTION AND PLACED BACK INTO THE WATERCOURSE AT THE COMPLETION OF CONSTRUCTION. STOCKPILES OF SPOIL OR MATERIAL EXCAVATED FROM THE BED OR BANKS OF THE WATERCOURSE SHALL BE STOCKPILED AT LEAST 10m OR 50m ( FOR HIGH AQUATIC VALVE WATERCOURSE), LANDWARD OF THE TOP OF BANK AND PROTECTED ON THE DOWNSLOPE SIDE BY A SILT FENCE AND/OR AN ADEQUATE STOCKPILE BERM, UNTIL STABILIZED. ALL SALVAGED MATERIALS WILL BE STOCKPILED SEPARATELY WHERE POSSIBLE.
22. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 10m OR 50m FROM TOP OF BANK.
23. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE FOR MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN (3380-SAIP-4-L3-1993).
24. IF SUSPECTED ASS ARE ENCOUNTERED DURING THE WORKS, THEY SHALL BE MANAGED IN ACCORDANCE WITH THE ACID SULPHATE SOILS MANAGEMENT PLAN (3380-SAIP-4-1.3-1832).

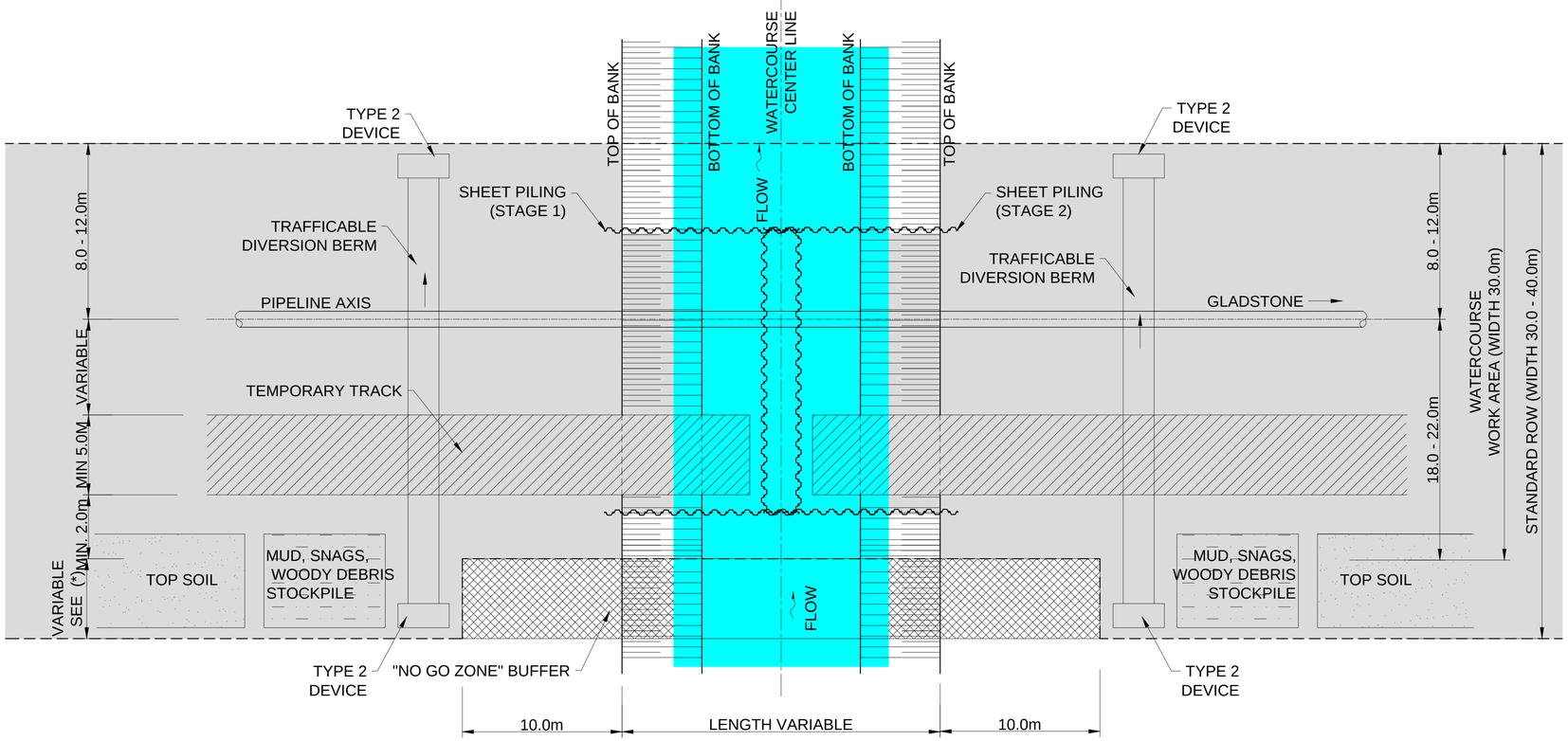
Saipem Australia Pty Ltd

APPENDIX: B3
(SHEET 1 OF 1)

DATE: 06/10/12

DOCUMENT NAME:

**TYPICAL STANDARD FOR WATERCOURSE PIPELINE CONSTRUCTION. MINOR DAM AND FLUME.**




# WORKING AREA PLAN VIEW

## NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE. DRAWING NOT TO SCALE. WATERCOURSE FLOW DIRECTION SHOWN ON THE DRAWING COULD BE REVERSED.
2. ALL WORKS SHALL BE CARRIED OUT IN ACCORDANCE WITH THE WATERCOURSE CROSSINGS MANAGEMENT PLAN (3380-SAIP-4-3.3-6040), WATERCOURSE CROSSING (OPEN CUT) PROCEDURE (3380-SAIP-4-3.3-6026) AND RELEVANT AQUATIC VALUES MANAGEMENT PLAN. WATERCOURSE FLOW DIRECTION SHOWN ON THE DRAWING COULD BE REVERSED.
3. THE METHOD IS APPLICABLE WHERE THERE ARE HIGH WATER FLOWS AND WHERE THE SAND BAGS COULD BE INADEQUATE. THIS APPROACH INVOLVES CONSTRUCTION OF COFFERDAMS ACROSS THE WATERCOURSE. IT WILL TYPICALLY INVOLVE THE INSTALLATION OF FLUMES USING TRENCHING GROUND OF SHEET PILING.
4. TWO COFFER DAMS ARE INSTALLED, ACROSS THE WATERCOURSE, TO PERMIT THE FLOW DIVERSION AND TO HAVE THE DE-WATERING AREAS FOR THE PIPELINE CONSTRUCTION. COFFER DAMS ARE INSTALLED IN TWO PHASES ( COFFER DAM IN A HALF SECTION OF WATERCOURSE AND FLOW DIVERSION IN THE OPPOSITE SECTION). TEMPORARY ACCESS WAY IN THE CREEK BED IS NOT EXPECTED.
5. SHEET PILING ONLY APPLICABLE FOR LOOSE AND COHESIVE SOILS.
6. THE AMOUNT OF TIME THE TRENCH IS OPEN WILL BE MINIMIZED, BACKFILL AND REINSTATEMENT WILL COMMENCE AS SOON AS POSSIBLE AFTER PIPELAY.
7. THE TRENCH WIDTH AND DEPTH WILL BE MINIMIZED TO REDUCE SPOIL GENERATION WHERE POSSIBLE. TRENCH SHORING OR OTHER ALTERNATIVE MEASURES SHOULD BE USED IF REQUIRED.
8. THE RISK OF FAUNA ENTRAPMENT IN THE TRENCH SHALL BE MINIMISED IN ACCORDING WITH SPECIES MANAGEMENT PLAN ( 3380-SAIP-4-1.3-1963) AND FAUNA HANDLING PROCEDURE ( 3380-SAIP-4-1.3-1965).
9. IN THE EVENT THAT A VISIBLE SEDIMENT PLUME IS OBSERVED OUTSIDE OF THE WORKS AREA THE WORKS SHALL CEASE , AND THE EROSION AND SEDIMENT CONTROLS WILL BE INSPECTED AND REPAIRED AND / OR UPGRADED AS REQUIRED.
10. EROSION AND SEDIMENT CONTROLS SHALL BE IMPLEMENTED IN ACCORDING WITH THE WATERCOURSE CROSSING MANAGEMENT PLAN (3380-SAIP-4-3.3-6040) AND THE RELEVANT AQUATIC VALUES MANAGEMENT PLAN AND EROSION AND SEDIMENT CONTROL PLAN.
11. SNAGS AND OTHER WOODY DEBRIS LOCATED IN THE WATERCOURSE SHALL BE RELOCATED OUTSIDE THE "NO GO BUFFER" AREA OF THE TOP OF BANK FOR LATER RE-INSTATEMENT AS PART OF THE REHABILITATION WORKS.
12. THE EXISTING BED AND BANKS MATERIAL SHOULD WHERE POSSIBLE BE SALVAGED PRIOR TO CONSTRUCTION AND PLACED BACK INTO THE WATERCOURSE AT THE COMPLETION OF CONSTRUCTION. STOCKPILES OF SPOIL OR MATERIAL EXCAVATED FROM THE BED OR BANKS OF THE WATERCOURSE SHALL BE STOCKPILED AT LEAST 50m LANDWARD OF THE TOP OF BANK FOR WATERCOURSE ASSESSED AS HAVING HIGH AQUATIC VALUES UNDER THE AQUATIC VALUES MANAGEMENT PLAN. FOR ALL OTHER WATERCOURSE WITH LESS THAN HIGH AQUATIC VALUES A 10m BUFFERS SHALL BE PROTECTED ON THE DOWNSLOPE SIDE BY A SILT FENCE AND / OR ADEQUATE STOCKPILE BERM, UNTIL STABILIZED.
13. ALL OTHER STOCKPILES WILL BE LOCATED NO LESS THAN 50 m FROM THE TOP OF BANK FOR HIGH VALUE WATERCOURSE ASSESSED UNDER THE AQUATIC VALUES MANAGEMENT PLAN AND 10m FROM TOP OF BANK FOR ALL WATERCOURSE ASSESSED AS HAVING LESS THAN HIGH AQUATIC VALUES.
14. DE-WATERING SHOULD CEASE WHEN WATER LEVELS WITHIN THE IMPOUNDMENT AREA REACH THE CRITICAL LEVEL NECESSARY TO SUSTAIN AQUATIC FAUNA SUCH AS FISH. ANY AQUATIC FAUNA ( I.E. FISH, TURTLES OR FROGS) TRAPPED IN ANY IMPOUNDMENTS AREA WILL BE SALVAGED IN ACCORDANCE WITH THE FAUNA HANDLING PROCEDURE ( DOC. No: 3380-SAIP-4-1.3-1965) AND THE DPIF ( 2004) FISH SALVAGE GUIDELINES, AFTER WHICH TIME, DE-WATERING MAY RE-COMMENCE.
15. ALL DE-WATERING, NECESSARY TO STABILIZE SATURATED SOILS, MUST BE CONDUCTED IN ACCORDANCE WITH THE PROCEDURE OUTLINED IN THE WATER QUALITY MANAGEMENT PLAN ( DOC. No. 3380-SAIP-4-1.3-1947).
16. TRENCHING ON APPROACHES TO WET WATERCOURSES WILL CEASE, LEAVING HARD TRENCH PLUGS IN PLACE FOR THE MAXIMUM PERIOD POSSIBLE PENDING PIPE LAYING.
17. TRENCH PLUGS SHALL BE EXCAVATED AND REPLACED WITH TRENCH BLOCKS OR SACK BREAKERS ABOVE THE SLOPE AND, AS REQUIRED, DOWN THE SLOPE TO PREVENT TURBID WATER FROM DIRECTLY ENTERING WATERWAYS.
18. IF THE CREEK IS FLOWING, SILT CURTAINS ( OR SIMILAR IN-STREAM CONTROLS) SHALL BE PLACED IN THE WATERCOURSE AT THE UPSTREAM AND DOWNSTREAM EXTENT OF THE ROW.
19. ANY SUSPECTED CONTAMINATED MATERIAL UNCOVERED DURING THE WORKS SHOULD BE MANAGED IN ACCORDANCE WITH THE PROCEDURE OF MANAGING UNEXPECTED CONTAMINATION CONTAINED WITHIN THE CONTAMINATED LAND MANAGEMENT PLAN ( 3380-SAIP-4-1.3-1993).
20. THIS IS A TYPICAL ( CONCEPT) DRAWING. THE SPECIFIC CONFIGURATION OF THE SEDIMENT CONTROLS AND ETC. MAY VARY DUE TO SITE CONDITIONS.

## LEGEND

- TEMPORARY ACCESS WAY.
- TEMPORARY WORK AREAS AT THE TIME OF PIPELINE CROSSING CONSTRUCTION
- "NO GO ZONE" BUFFER
- WATER ZONE

(*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

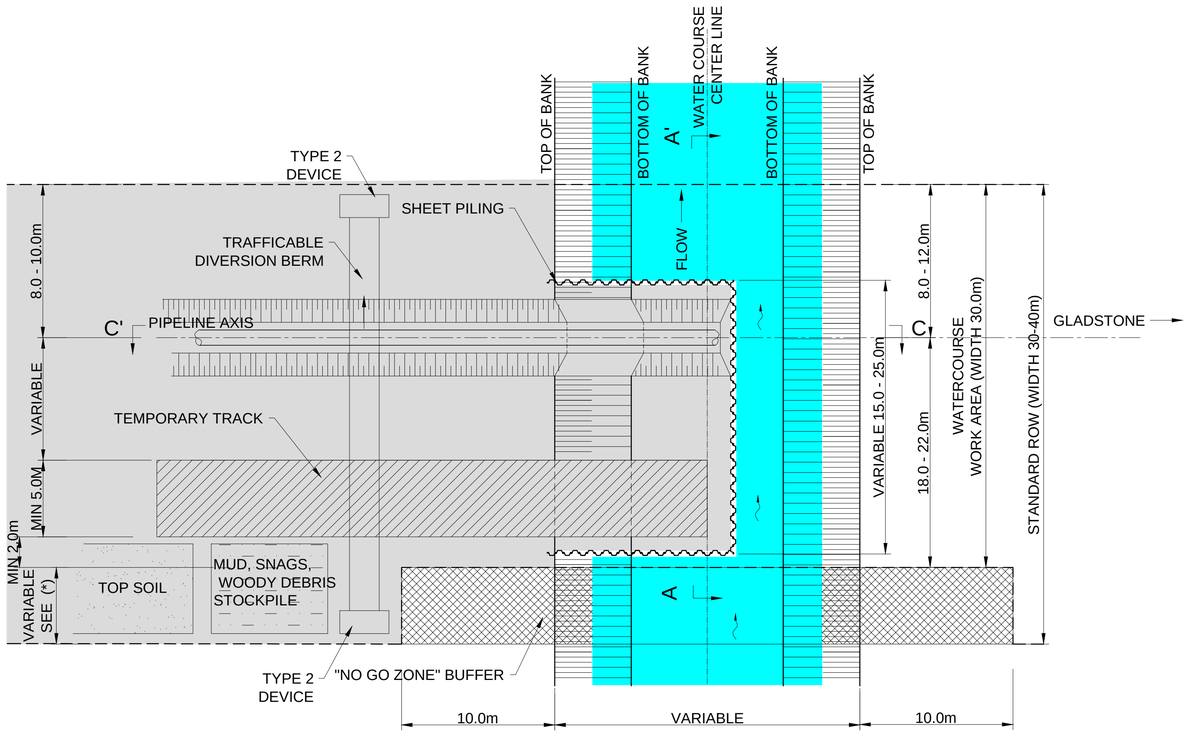
Saipem Australia Pty Ltd

APPENDIX: B4 (SHEET 1 OF 2)

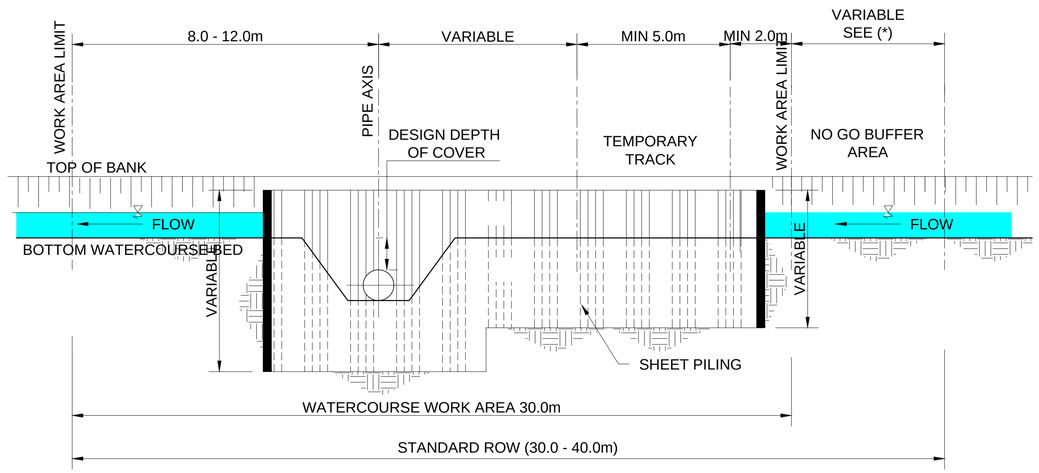
DATE: 06/10/12

DOCUMENT NAME:

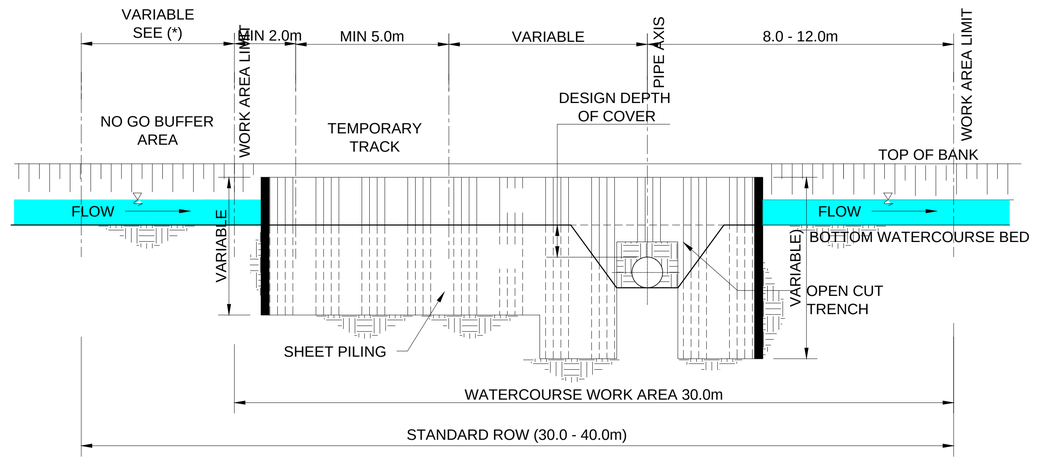
**TYPICAL STANDARD FOR WATERCOURSE PIPELINE CONSTRUCTION. COFFER DAM / FLOW DIVERSION**



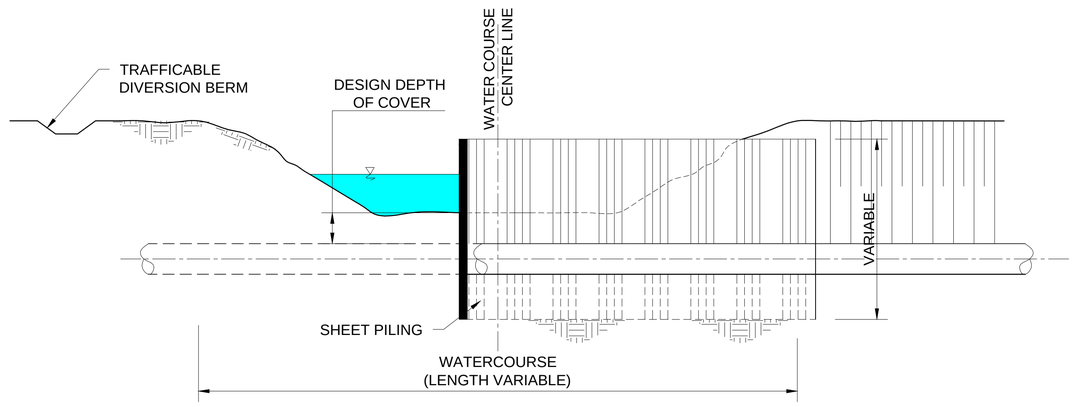

## STAGE 1 CONSTRUCTION( PLAN VIEW)



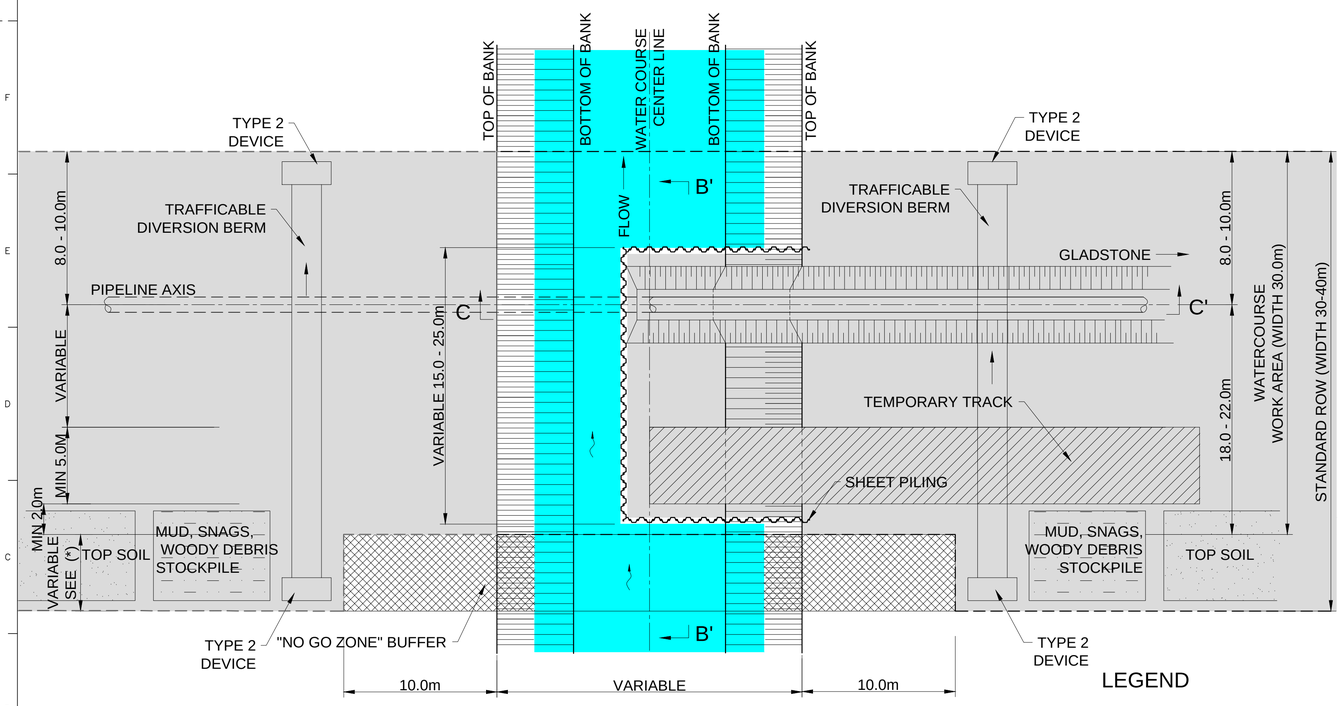

## SECTION A - A'




## SECTION B - B'




## SECTION C - C'




## STAGE 2 CONSTRUCTION( PLAN VIEW)

LEGEND

- TEMPORARY ACCESS WAY.
- TEMPORARY WORK AREAS AT THE TIME OF PIPELINE CROSSING CONSTRUCTION
- "NO GO ZONE" BUFFER
- WATER ZONE

(*) LENGTH = 0.00m FOR STANDARD ROW 30m WIDTH
LENGTH = 10.00m FOR STANDARD ROW 40m WIDTH

Saipem Australia Pty Ltd

APPENDIX: B4 (SHEET 2 OF 2)

DATE: 06/10/12

DOCUMENT NAME:

**TYPICAL STANDARD FOR WATERCOURSE PIPELINE CONSTRUCTION. COFFER DAM / FLOW DIVERSION**

Santos
GLNG Project

# APPENDIX G1 – Triple Bottom Line Assessment for Construction Methodology and Site Specific Methodology Assessments

| | Triple-Bottom Line Assessment | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Geology, Soils &/or Geomorphology | Geology Notes | Demand on Resources | Resources Notes | Waste Impacts | Waste Notes | Traffic and Transport Impacts | T&T Notes | Noise and Vibration Impacts | N&V Notes | Hydrological Impacts | Hydrology Notes | Terrestrial Flora & Fauna Impacts | Riparian Notes | Aquatic Flora & Fauna Impacts | AF&F Notes | Social Impacts | Social Notes |
| **Pipeline Crossing Construction Methodology** | | | | | | | | | | | | | | | | | | |
| *HDD* | L - M (-ve) | The construction works would not involve disturbance of the creek bed, however, this benefit would be offset somewhat by the additional invasive geotech investigations required pre-construction. Furthermore, it is noted that this benefit may be further offset by the requirement to construct a new access track for purposes of accessing the construction pads. | H (-ve) | Water and mud demand for drilling fluid make-up. Hazardous and other materials are also used to make up the drilling fluid. In addition, some of the specialist equipment required for the HDD may not be sourced locally, and may potentially be shipped from overseas, thereby consuming additional resources. | H (-ve) | The contaminated drilling mud generated during the works will require disposal. Potentially contaminated wastewater from the bore hole drilling will also require disposal. | H (-ve) | Due to requirement for larger and more plant and equipment, which will require transport to the site at construction commencement and de-mobilisation. In addition, the longer construction duration means that site workers will be travelling to and from the site for at least 3 months per crossing. | H (-ve) | The impacts are greater due to use of noisier equipment and longer construction duration, noting that construction would be 24 hours. | L (-ve) | There is no requirement to (partially or fully) obstruct flow, divert flow or de-watter a section of the creek for the HDD works. However, this benefit may be offset by the requirement to construct an additional access track to facilitate the works. | M - H (-ve) | There is a larger construction footprint, which will result in greater extent of clearing of riparian vegetation and associated loss of riparian and terrestrial habitat. | M (-ve) | The creek bed will not require disturbance and no de-watering will be required for the HDD works. It is noted that there is also potential for water quality impacts resulting from the identified engineering risks. In the event there is a loss of drilling fluid or bore hole collapse, there would be increases in turbidity and water pollution. These impacts would be more difficult to manage because it is only possible to predict a likelihood of occurrence, and the event would be otherwise unanticipated. | H (-ve) | The longer duration of construction, increased volume/duration of traffic impacts, and significantly increased noise and vibration impacts have potential to result in a significant increase in the magnitude and extent of social impacts, dependent upon the proximity to development and/or potential for interactions with landowner operations. |
| *Dry (Open) Trenching (see alternatives below)* | - | ALL: Requires disturbance of the creek banks and bed to excavate the trench. | - | ALL: There is no demand for water or other materials to undertake the works. | - | ALL: The excavated material from the trench will be used for backfilling. It is expected that there would be minimal, if any, spoil material generated. | | ALL: There would be some impacts associated with the transport of plant and equipment to the site at site establishment and de-mobilisation. During construction workers would travel to and from the site. However, when compared to HDD, the duration of impacts would be shorter due to | - | ALL: The impacts are lesser due to the quantity and type of plant and equipment required, the adopted construction methodology (i.e. no drilling) and the shorter duration of construction. | - | ALL: There is potential to undertake the construction works during low or no flow conditions. If the timing of construction does not permit this possibility, there may be a requirement to either temporarily partially obstruct or divert flow for the duration of construction. | - | ALL: There is a requirement to clear some vegetation to facilitate the works, however, the footprint is lesser than for HDD. In addition, the duration of works is shorter and the site may be re-instated sooner. | | ALL: There is a requirement to excavate the creek bed, which will disrupt aquatic fauna. It also has potential to result in localised, short term increases in turbidity, although it is considered that any impacts can be adequately mitigated. | | ALL: The social impacts are likely to be lesser in extent and magnitude relative to those anticipated for HDD works due to the shorter construction period, lesser footprint, lesser traffic impacts and lower noise and vibration impacts. Similarly, the level of impact is dependent upon the proximity to development and/or the potential for interactions with landowner operations. |
| - Standard Mainline Construction | M (-ve) | See row 5 above. | L - M (-ve) | | L (-ve) | | L (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | L - M (-ve) | There is potential for terrestrial fauna to fall into the open trench. | M - H (-ve) | See row 5 above. | L- M (-ve) | See row 5 above. |
| - Excavate from each Bank | M (-ve) | See row 5 above. | L - M (-ve) | | L (-ve) | | L (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | L - M (-ve) | There is potential for terrestrial fauna to fall into the open trench. | M - H (-ve) | See row 5 above. | L- M (-ve) | See row 5 above. |
| - Minor Dam / Pumping | M - H (-ve) | See row 5 above. | M (-ve) | This trenching method requires some additional demand on resources to power the pumps. | Mod (-ve) | There may be some additional dewatering from the watercourse required, which may necessitate some sort of treatment prior to discharge / disposal. Materials used to construct the dam will be removed and re-used on another construction site. | L (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | M (-ve) | Results in disruption of flow due to the presence of the dam. However, low flows would be conveyed through the obstruction via the flume pipes. | L - M (-ve) | There is potential for terrestrial fauna to fall into the open trench. | M - H (-ve) | The risk of increased turbidity and sedimentation is lower than for the previous two dry trenching methods due to diversion of flows around the works site. Aquatic fauna would need to be relocated from the dry, damned section of creek, as the dam would act as a barrier to fish passage. | L- M (-ve) | See row 5 above. |
| - Minor Dam / Flume | M - H (-ve) | See row 5 above. | L - M (-ve) | | Mod (-ve) | There may be some additional dewatering from the watercourse required, which may necessitate some sort of treatment prior to discharge / disposal. Materials used to construct the dam and flume pipes will be removed and re-used on another construction site. | L (-ve) | See row 5 above. | L - M (-ve) | See row 5 above. | M (-ve) | Results in disruption of flow due to the presence of the dam. However, low flows would be conveyed through the obstruction via the flume pipes. | L - M (-ve) | There is potential for terrestrial fauna to fall into the open trench. | M - H (-ve) | The risk of increased turbidity and sedimentation is lower than for the previous two dry trenching methods due to diversion of flows around the works site. Aquatic fauna would need to be relocated from the dry, damned section of creek, as the dam and flume would likely act as a barrier to fish passage. Many species would not likely travel along the flume. | L- M (-ve) | See row 5 above. |
| *Wet Trenching* | M (-ve) | Requires disturbance of the creek banks and bed to excavate the trench. | L (-ve) | Compared to HDD and open trenching, there is minimal demand for materials to undertake the works. | L (-ve) | | L (-ve) | | L - M (-ve) | When compared to HDD, the impacts are lesser due to the quantity and type of plant and equipment required, the adopted construction methodology (i.e. no drilling) and the shorter duration of construction. | L (-ve) | There would be minimal disruption to flows as the works are constructed "in the wet". | L - M (-ve) | There is a requirement to clear some vegetation to facilitate the works, however, the footprint is lesser than for either HDD or open trenching. | M (-ve) | There is a requirement to excavate the creek bed, which will partially disrupt fish passage. It also has potential to result in localised increases in turbidity, although it is considered possible to mitigate the impacts through the implementation of controls. | L- M (-ve) | The social impacts are likely to be lesser in extent and magnitude relative to those anticipated for HDD works due to the shorter construction period, lesser footprint, lesser traffic impacts and lower noise and vibration impacts. Similarly, the level of impact is dependent upon the proximity to development and/or the potential for interactions with landowner operations. |
| **Access Track Construction Methodologies** | | | | | | | | | | | | | | | | | | |
| Ford (e.g. with mats) | L (-ve) | Minimal disruption to bed and bank profile. Some re-grading of the banks may be required. | L (-ve) | Plastic mats or other materials will be used. These may be re-used on other sites after conclusion of the works. | Negligible | | L (+ve) | Permits access through the RoW and provides access to place the pipes during construction. | L (-ve) | | L (-ve) | Flows unaffected. | L (-ve) | | L - M (-ve) | There will likely be some compacting of the bed, and smothering of any biota living on the bed in the ford where the mats are placed. There is potential for erosion and sedimentation associated with the passage of vehicles, which can be managed effectively during construction. | L (-ve) | Some short term benefit associated with improved access across the waterway for the landowner. Some visual impact. |
| Causeway with Flume | M (-ve) | The placement of material in the bed of the creek has potential to alter the local bed and bank morphology due to altered hydrology. | M (-ve) | Requires the use of flume pipes and other material to construct the causeway, which can be re-used on another construction site. | Negligible | | L (+ve) | Permits access through the RoW and provides access to place the pipes during construction. | L (-ve) | | M (-ve) | Reduced hydraulic conveyance will impact on creek flows, however, this assumes that the creek is in flow at the time of construction and that the base flow cannot be conveyed through the flume pipes. There is potential for risk associated with rainfall events/floods. | L (-ve) | | M (-ve) | There will be some compacting and smothering of any biota on the bed. There is also potential for erosion and sedimentation during construction, however whilst the access way is in use, there may be reduction in erosion and sedimentation associated with the passage of vehicles (i.e. compared to the previous two open trench methods). The localised erosion and sedimentation can be managed through the use of appropriately sized scour protection works and other controls. | L (-ve) | Some short term benefit associated with improved access across the waterway for the landowner. Moderate visual impact. |
| Prefabricated Elevated Bridge / Steel Ramp | L (-ve) | Minimal disruption to bed and bank profile. Some re-grading of the banks will be required for the approaches. | M (-ve) | Requires the use of prefabricated structure, which can be re-used on another construction site. | Negligible | | L (+ve) | Permits access through the RoW and provides access to place the pipes during construction. | L (-ve) | | L (-ve) | Deck height to be set based on likely flow requirements during construction period. | L (-ve) | | L (-ve) | The structure will likely have no impacts on the bed, and is unlikely to impede fish passage. There is potential for localised erosion and sedimentation associated with the construction. | L (-ve) | Some short term benefit associated with improved access across the waterway for the landowner. Some visual impact. |
| **Interim Bank Stabilisation Works** | | | | | | | | | | | | | | | | | | |
| Do Nothing | M - H (-ve) | There is potential for erosion and sedimentation of the exposed banks. | N/A | No demand on resources. | N/A | No waste generation. | N/A | No traffic impacts. | N/A | No noise and vibration impacts. | N/A | No hydrological impacts. | M (-ve) | Failure to stabilise the soil may negatively impact on the re-establishment of riparian vegetation. | M (-ve) | Impacts result from high potential for erosion and sedimentation. In addition, water temperatures would be modified due to lack of shading. There would also be a lack of fringing habitat for aquatic species. | M (-ve) | Should erosion and sedimentation result, there would potentially be a significant visual impact associated with bank erosion and increased turbidity. |
| Mulching | L (+ve) | Effective measure for stabilising the banks. Short term maintenance requirement, e.g. after rainfall events. | L (-ve) | Some water required for application. | Negligible | | Negligible | | L (-ve) | Some noise associated with the use of a sprayer to apply the mulch. | Negligible | Impact on flows unlikely. | L (+ve) | Regulates soil temperate and increases humidity. | L (+ve) | Will effectively trap sediments that would otherwise make their way into the watercourse and impact on water quality. | Negligible / Neutral | Social impacts are primarily associated with noise from applying the mulch. Lower visual amenity than natural riparian vegetation. However, where the creek banks are currently unvegetated, the mulching will likely provide improved visual amenity. |
| Hydro-mulching | L (+ve) | Effective measure for stabilising the banks. Short term maintenance requirement, e.g. after rainfall events. | L (-ve) | Requires watering to apply and to become established. | Negligible | | Negligible | | L (-ve) | Some noise associated with the use of a sprayer to apply the mulch. | Negligible | Impact on flows unlikely. | L - M (+ve) | Regulates soil temperate and increases humidity. Also provides some interim habitat for some species, and provides an improved micro-climate for the germination and establishment of seedlings. | L (+ve) | Will effectively trap sediments that would otherwise make their way into the watercourse and impact on water quality. | Negligible / Neutral | Social impacts are primarily associated with noise from applying the mulch. Lower visual amenity than natural riparian vegetation. However, where the creek banks are currently unvegetated, the mulching will likely provide improved visual amenity. |
| Erosion Control Blanket / Mulching | M (+ve) | Effective measure for stabilising the banks. | L (-ve) | Some water required for application. | Negligible | | Negligible | | L (-ve) | Some noise associated with the use of a sprayer to apply the mulch. | Negligible | Impact on flows unlikely. | L - M (+ve) | Regulates soil temperate and increases humidity. Also provides some stabilisation at the roots, and provides an improved micro-climate for the germination and establishment of seedlings. | L (+ve) | Will effectively trap sediments that would otherwise make their way into the watercourse and impact on water quality. | Negligible / Neutral | Social impacts are primarily associated with noise from applying the mulch. Lower visual amenity than natural riparian vegetation. However, where the creek banks are currently unvegetated, the mulching will likely provide improved visual amenity. |
| Rip Rap (stone pitching) | L (+ve) | Effective measure for stabilising steep banks, but requires careful design to avoid impacts on hydrology and geomorphology. | M (-ve) | Requires suitable rock material. Requires ongoing maintenance. | L (-ve) | May result in the generation of some wastes. | L - M (-ve) | Depends upon the volume of material required and distance of transportation. | L - M (-ve) | Some noise associated with the use of machinery to position the rocks. | L - M (-ve) | Potential to deflect flows, thereby altering hydrology. | L (-ve) | Does not provide suitable substrate for the establishment of riparian vegetation. | L (-ve) | Higher potential for water quality impacts (erosion and sedimentation) during construction. Additionally, any resultant changes in local hydrology have potential to impact on aquatic species. Unlikely to provide suitable habitat. | L - M (-ve) | Social impacts are primarily associated with noise from construction. Poor visual amenity and may also prevent access between the land and the watercourse. |
| Reno Mattress | L (+ve) | Effective measure for stabilising steep banks, but requires careful design to avoid impacts on hydrology and geomorphology. | M (-ve) | Requires suitable rock material, as well as materials to construct the Reno mattresses. Requires ongoing maintenance. | L (-ve) | May result in the generation of some wastes, depending on the method of construction. | L - M (-ve) | Depends upon the volume of material required and distance of transportation. | L - M (-ve) | Some noise associated with the use of machinery to position the Reno mattresses and the rocks. | L - M (-ve) | Potential to deflect flows, thereby altering hydrology. | L (-ve) | Does not provide suitable substrate for the establishment of riparian vegetation. | L (-ve) | Higher potential for water quality impacts (erosion and sedimentation) during construction. Additionally, any resultant changes in local hydrology have potential to impact on aquatic species. Unlikely to provide suitable habitat. | L - M (-ve) | Social impacts are primarily associated with noise from construction. Poor visual amenity and may also prevent access between the land and the watercourse. |
| Bonded Fibre Matrix | M (+ve) | Effective measure for stabilising the banks. | L - M (-ve) | Requires water for application, and watering to become established. | Negligible | | Negligible | | L (-ve) | Some noise associated with the use of a sprayer to apply the mulch. | Negligible | Impact on flows unlikely. | L - M (+ve) | Regulates soil temperate and increases humidity. Also provides some interim habitat for some species, and provides an improved micro-climate for the germination and establishment of seedlings. | L (+ve) | Will effectively trap sediments that would otherwise make their way into the watercourse and impact on water quality. | Negligible / Neutral | Social impacts are primarily associated with noise from applying the mulch. Lower visual amenity than natural riparian vegetation. However, where the creek banks are currently unvegetated, the mulching will likely provide improved visual amenity. |
| Grass Seeding | L (+ve) | Effective measure for stabilising the banks. Short term maintenance requirement, e.g. After rainfall events. | L - M (-ve) | Requires water for application, and watering to become established. | Negligible | | Negligible | | L (-ve) | Some noise associated with the use of a sprayer to apply the mulch. | Negligible | Impact on flows unlikely. | L - M (+ve) | Regulates soil temperate and increases humidity. Also provides some interim habitat for some species, and provides an improved micro-climate for the germination and establishment of seedlings. | L (+ve) | Will effectively trap sediments that would otherwise make their way into the watercourse and impact on water quality. | Negligible / Neutral | Decline in visual amenity over natural riparian vegetation. |

# Hutton Creek - Crossing Method Selection Analysis

| Hutton Creek | KP 2.092 | Notes on Key Aquatic Values | Objectives |
|---|---|---|---|
| Stream order: | 6 | Considerable riparian vegetation. | Minimise vegetation clearing on the banks. |
| Avg. grade of the banks: | >23 degrees (left bank) | Sizeable watercourse prone to large flow events. | Minimise risk to construction staff, plant and equipment. |
| Height of banks: | 5m, 10m | Aquatic flora and fauna present, incl. fish (some exotic spp.) and crustaceans. Suitable breeding habitat for White throated snapping turtle. Marginal habitat for Fitzroy River turtle, however unlikely to occur this far upstream. Platypus burrows were observed in the vicinity of the ROW. Breeding season of white throated snapping turtle is Autumn and Winter. | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. |
| Bankfull width: | 66m | GEOLOGY: The geology at the proposed crossing is predominantly lower Jurassic age deposits of sandstone comprising quartzose sandstone, minor siltstone and shale, and easily decomposable and sub-labile sandstone, mudstone, occasional shale and coal. Borehole results can be typically summarised as alluvium (about 1m) overlying residual soil, in turn overlying slightly weathered rock comprising inter bedded sandstone and siltstone. The alluvium was also encountered to depths of 7.25m inter bedded very stiff sandy clay and dense clayey sand. New boreholes indicated highly fragmented (boulders) rocks in the borehole. | |
| Water present: | Y | | |
| Substrate type: | Silt/clay | | |
| Estimated date construction: | Mar-13 | | |
| Extra workspace requirements: | 9297.16m$^2$ | | |
| Aquatic value: | High | | |

| Access Way Construction Methodology | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | N | This approach is not feasible due to the amount of water contained within the creek. | | |
| Causeway + Flumes | Y | Moderate<br>A causeway would generally have a similar footprint as a bed level crossing, with the exception that it is higher than the creek bed and has the potential to obstruct flows. If the creek is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| **Trenching Methodology** | **Technical Feasibility?** | **Environmental Disturbance** | **Construction Risk / Safety** | **Preferred?** |
| Standard Mainline (Dry) Trenching | N | This approach is not feasible due to the amount of water contained within the creek. | | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>The adoption of a minor dam and flume approach would partially obstruct flows and thereby reduce biological connectivity. In addition, the de-watering process could trap fauna in the impoundment area, and the construction of the dam could mobilise sediments from the bed of the creek that would otherwise not be disturbed if dry trenching. Any fauna caught in the impoundment area would need to be relocated by a fauna handler. However, the flume pipes will be adequately sized and would provide for ongoing linear connectivity along the watercourse. | Low<br>This approach would permit pipe laying in wet conditions. However, the process of constructing the minor dam would involve some degree of risk to the safety of construction personnel associated with working in the wet during the construction/de-commissioning of the minor dam and the dewatering. | Preferred |
| Wet Trenching** | Y | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a small likelihood of trench collapse associated with wet trenching. | |
| HDD | Y - however extreme risk of failure | Extreme<br>The total length to be drilled would be 1700 m, with a high risk for HDD. This methodology also requires a lot of water and bentonite use.<br>Although HDD would avoid disturbance of the bed, this benefit may be offset by the high risk of frac out and the subsequent uncontrolled release of drilling mud to the environment. A geological assessment showed highly weathered and fractured heterogeneous strata consisting of mainly mudstone, shale and sandstone. This geology significantly increases the risk of HDD failure due to increased risk of frac out and subsequent release of drilling fluids to the environment. The drilling fluid contains hazardous materials that would represent a threat to environmental health, and could result in fish kills in the watercourse.<br>Due to the change in alignment of the ROW to the south of the crossing. HDD would require additional workspace areas outside the ROW for drill pads and stringing areas. This would result in the clearing of an additional 2.85ha of EPBC threatened ecological community - Brigalow.<br>The duration of works is estimated at up to 6 months due to the type of substrate, operating 24 hours a day, and coinciding with the breeding season of the turtles. During construction the local noise levels would increase significantly beyond those associated with typical construction activities due to the use of a drill rig. The lights and noise associated with the works are likely to result in disturbance of any fauna in the local area. | Extreme<br>Extreme risk of pipe blockage due to high frictional forces associated with the borehole length (1,700 m) and diameter (minimum 56" diameter required for 42" pipe).<br>Extreme risk of Borehole instability associated with elevation difference between the HDD entry and exit points (approximately 65 m). The borehole may collapse because the height difference and the difficulty in keeping the hole filled with drilling fluid.<br>High risk of Blow-out of bentonite due to the presence of variable soil type: up 14 m: clayey sand and clay / under 14m: weathered and fractured sandstone and siltstone rocks.<br>High sensitivity to variations in geotechnical conditions.<br>High/extreme risk of Bentonite leakage into the creek bed due to the relatively shallow depth of the borehole beneath the creek bed (approximately 10 m). To achieve a greater depth would require a longer HDD.<br>High risk of increased likelihood of blockage associated with the need to connect three pipe strings. There is not sufficient pipe stringing area for a single string.<br>Extreme risk of damage to the pipe coating due to presence of hard substrate | |
| Additional Mitigation Measures: | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Dawson River (upstream) - Crossing Method Selection Analysis

| Dawson River (upstream) | KP29.832 | Notes on Key Aquatic Values | Objectives |
|---|---|---|---|
| Stream order: | 5 | Dense riparian vegetation. | Minimise vegetation clearing on the banks. |
| Avg. grade of the banks: | >23 degrees | Watercourse with some potential for large flow events. | Minimise safety risk to construction staff, plant and equipment. |
| Height of banks: | 8m | Aquatic flora and fauna present, incl. fish and crustaceans. Habitat includes snags, pools and riffles. Potential habitat exists for White throated snapping turtle (breeding season - Autumn and winter) and Platypus (Breeding season August). Marginal habitat exists for Fitzroy River turtle (breeding season Sept-Oct), however not expected to occur this far upstream. | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. |
| Bankfull width: | 20m | GEOLOGY: The geology at the proposed crossing is Quaternary age alluvium comprising of clay, sand and gravel soil deposits overlying lower Triassic age formation consisting of mudstone, sandstone and occasional conglomerate. Boreholes indicate alluvium overlying residual soil or extremely weathered material and in turn highly or moderately weathered inter bedded siltstone and mudstone with some sandstone grading to slightly weathered and fresh rock. | |
| Water present: | Y | | |
| Substrate type: | Silt/clay | | |
| Estimated date construction: | May-13 | | |
| Extra workspace requirements: | 11954m2 | | |
| Aquatic value: | High | The alluvium was described as medium plasticity clay and sandy clay of very stiff consistency while the residual soil and extremely weathered material were described as low plasticity, indistinctly fissured sandy gravelly clay and sandy clay of very stiff to hard consistency. Highly and moderately weathered rock was encountered at depths ranging between 8.75m and 13m typically as very low and low strength. Slightly weathered and fresh rock was encountered at depths ranging between 18m and 18.36m and it is medium strength. | |

| Access Way Construction Methodology | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | N | This approach is not feasible due to the amount of water contained within the creek. | | |
| Causeway + Flumes | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| **Trenching Methodology** | **Technical Feasibility?** | **Environmental Disturbance** | **Construction Risk / Safety** | **Preferred?** |
| Standard Mainline (Dry) Trenching | N | This approach is not feasible due to the amount of water contained within the creek. | | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>The adoption of a minor dam and flume approach would partially obstruct flows and thereby reduce biological connectivity. In addition, the de-watering process could trap fauna in the impoundment area, and the construction of the dam could mobilise sediments from the bed of the creek that would otherwise not be disturbed if dry trenching. Any fauna caught in the impoundment area would need to be relocated by a fauna handler. However, the flume pipes will be adequately sized and would provide for ongoing linear connectivity along the watercourse. | Low<br>This approach would permit pipe laying in wet conditions. However, the process of constructing the minor dam would involve some degree of risk to the safety of construction personnel associated with working in the wet during the construction/de-commissioning of the minor dam and the dewatering. | Preferred |
| Wet Trenching** | Y | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a higher risk of trench collapse associated with wet trenching. | |
| HDD | Y | High<br>The total length to be drilled would be 680 m. Due to the change in the alignment of the ROW immediately to the west of the creek crossing, additional clearing (approx. 2.21 ha) would be required beyond the extent of the ROW for the launch pad and the stringing area. This would extend into ESA Cat C and Of Concern Veg areas RE 11.3.2.<br>Although HDD would avoid disturbance of the bed, this benefit may be offset by the risk of frac out and the subsequent uncontrolled release of drilling mud to the environment. The drilling fluid contains hazardous materials that would represent a threat to environmental health, and could result in fish kills in the watercourse.<br>HDD has an increased risk of failure due to fractured rock layers and heterogeneous substrate. Presence of gravel layers indicate potential of borehole collapse during drilling and pull-back operations. Presents high risk for safe and effective execution of HDD. The extension of the construction period due to the adoption of HDD would result in working during the wet season.<br>The estimated duration of works is estimated at 4 months min., operating 24 hours a day, during which time the local noise levels would increase significantly beyond those associated with typical construction activities due to the use of a drill rig. The lights and noise associated with the works are likely to result in disturbance of any fauna in the local area. | High<br>High risk of blockage during the pipe pull back operations due to the presence of two different soil types (up 13m: medium plasticity sandy clay of very stiff consistency, low plasticity. From 13m to 28m: Slightly/moderately weathered rock)<br>Moderate Risk Damage to the pipe coating due to presence of rocky soil.<br>HDD has a high risk of failure due to fractured rock layers and heterogeneous substrate. Presence of gravel layers indicate potential of borehole collapse during drilling and pull-back operations.<br>The increase in traffic volumes associated with mobilising and demobilising the drilling equipment, and long duration of construction, would result in an increase in the risk of traffic incident in the area, which is typically subject only to local traffic. | |
| Additional Mitigation Measures: | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Dawson River (downstream) - Crossing Method Selection Analysis

| Dawson River (downstream) | 233.969 | Notes on Key Aquatic Values | Objectives | |
|---|---|---|---|---|
| Stream order: | 8 | Well vegetated riparian zone present. | Minimise vegetation clearing on the banks | |
| Avg. grade of the banks: | <23 degrees | Wet watercourse with high likelihood of high flow events. | Minimise safety risk to construction staff, plant and equipment. | |
| Height of banks: | 5m | Very good aquatic habitat quality. Diverse aquatic flora, fish and crustaceans present. While Fitzroy River turtles were not caught, several recent surveys have noted the presence of critical habitat for Fitzroy River turtles at the site, including a large pool, riffles and rapids, and sandy banks with good riparian vegetation. Previous studies have also found the white-throated snapping turtle in the Dawson River to the north of the GTP ROW. Potential to support Platypus. | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. | |
| Bankfull width: | 100m | GEOLOGY: Geology at the site consists of alluvium clay, sand and gravel, with local occurrences of partly laterised soil overlying sandstone, siltstone, claystone, shale, conglomerate and intermediate volcanics. There are isolated beds comprising acidic and intermediate lava, tuff, and coarse to fine grained sedimentary rocks. Faulting is reported as the contact between the latter two formations. Alluvium was stiff to very stiff medium plasticity clay with some sand and gravel extending to 10m depth overlying inter bedded medium dense to very dense sand and gravelly sand to 20m depth and, in turn, hard sandy clay to 28m. The underlying residual soil was encountered to the termination depth of 35m. | | |
| Water present: | Y | | | |
| Substrate type: | Silt/clay, gravel. | | | |
| Extra workspace requirements: | 65,192m$^2$ | | | |
| Estimated Date Construction: | May-13 | | | |
| Aquatic Value: | High | | | |

| Access way Construction | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | N | This approach is not feasible due to the amount of water contained within the creek. | | |
| Causeway + Flumes | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| **Trenching Methodology** | **Technical Feasibility** | **Environmental Disturbance** | **Construction Risk / Safety** | **Preferred?** |
| Standard Mainline (Dry) Trenching | N | This approach is not feasible due to the amount of water contained within the creek | | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>The adoption of a minor dam and flume approach would partially obstruct flows and thereby reduce biological connectivity. In addition, the de-watering process could trap fauna in the impoundment area, and the construction of the dam could mobilise sediments from the bed of the creek that would otherwise not be disturbed if dry trenching. Any fauna caught in the impoundment area would need to be relocated by a fauna handler. However, the flume pipes will be adequately sized and would provide for ongoing linear connectivity along the watercourse. | Moderate<br>The process of constructing the minor dam would involve some degree of risk associated with working in the wet as it relates to the safety of the construction personnel. This would be the case primarily during construction and de-commissioning of the minor dam and de-watering. If the water flow is too high, it may not be possible to adequately convey the flow via the flume pipes. | Preferred |
| Coffer Dam/Berm* + Flow Diversion | Y | Low-Moderate<br>The adoption of a coffer dam and flow diversion approach would partially obstruct the watercourse and thereby reduce biological connectivity. In addition the de-watering process could trap fauna in the impoundment area, and construction of the dam could mobilise sediments from the bed of the watercourse that would otherwise not be disturbed if dry trenching. | Moderate<br>The process of constructing the coffer dam or berm would involve some degree of risk associated with working in the wet as it relates to the safety of the construction personnel. This would be the case primarily during construction and de-commissioning of the minor dam and de-watering. However, this approach would provide for conveyance of flows in the creek. | |
| Wet Trenching** | Y | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>The presence of water in the creek channel represents a hazard and would therefore increase the overall construction risk. | |
| HDD | Y | High<br>In order to HDD, it would be recommended to re-align the ROW further to the north to form a straight ROW. In this case, the HDD length would be 752 m. The required location for the launch pad would be located to the northwest of the crossing and would coincide with a low lying, boggy area. A stringing area of 752 m would also be required, likely on the northwest side of the crossing. This would necessitate additional engineering works, including the establishment of a coffer dam to provide a safe, dry working space. This would increase the net area of disturbance.<br>Extreme risk of failure of HDD due to presence of sand and gravel layers. Extreme risk for safe and effective execution of HDD due to potential for borehole collapse during drilling and pull-back operations<br>Duration of drilling works would be approx. 4 months of day and night work to conduct the drilling. This would require additional machinery to be shipped in from overseas, and would require a larger number of construction workers, thus increasing the traffic impacts over the construction period. Noise impacts would also be of a greater magnitude and duration for the HDD works. The NVMP identifies a sensitive receptor (residential) 2.3km distant from the site, which has potential to be impacted by the works. | Very High<br>Very high risk for Borehole instability associated with the presence of sandy gravel and gravelly strata<br>High risk of blockage during string pull back phase (a single string but unfavourable geotech conditions).<br>High risk of damage to the pipe coating (H.D.D. drilling in sand clay and andesite strata, very high strength).<br>The available geotechnical information for the crossing point indicates a very high risk of frac out, in which case there would be an uncontrolled release of hazardous drilling fluids to the environment. In addition, there is a very high risk of failure to complete (e.g. if a boulder is encountered during drilling), in which case the HDD would need to be abandoned and an alternative crossing methodology adopted. | |
| Additional Mitigation Measures: | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |
| In the event of high flows during the scheduled work period, the works should be put on hold until the water levels drop. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Calliope River - Crossing Method Selection Analysis

| Calliope River | 352.374 | Notes on Key Aquatic Values | Objectives | |
|---|---|---|---|---|
| Stream order: | 5 | Good quality riparian vegetation present along stream with heterogeneous RE consisting of RE11.3.4 and RE11.3.25. | Minimise vegetation clearing on the banks | |
| Avg. grade of the banks: | <23 degrees | Watercourse with constant low flows of water. | Minimise safety risk to construction staff, plant and equipment. | |
| Height of banks: | 6-15m | Diverse aquatic fauna including fish and crustaceans present. Potential habitat for the White Throated Snapping Turtle and platypus (but none captured). | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. | |
| Bankfull width: | 30m | | | |
| Water present: | Y | GEOLOGY: The geology at the proposed crossing is dominated by siltstone, mudstone, sandstone, limestone, conglomerate and tuff. On the surface alluvium composed of gravel, sand, silt and clay locally overlie conglomerate. The area consist several faults. The top 25 m consists of soils varying loose silty sand, clayey sand and sandy clay and below are weathered and fractured rocks including granite. Loose sand is a concern of drilling in which it can cause continuous collapse. It is also possible that upon withdrawal of the drill bit, loose sand may mix with drilling fluids. Actual rock layers may spread within 25 m depth and hard rock like granite may be encountered as boulders of thick layers. | | |
| Substrate type: | Sand, gravel and silt/clay. Underlain by bedrock. | | | |
| Extra workspace requirements: | 40,378m$^2$ | | | |
| Estimated Date Construction: | Jul-13 | | | |
| Aquatic Value: | High | | | |

| Access way Construction | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | Y | Low-Moderate<br>Direct impacts resulting from the clearing and grading works should be minimised where possible due to the presence of conservation significant flora.<br>Note: this approach may be adopted in the event the conditions at the time of construction suggest a low risk of flow events in the watercourse. | Moderate<br>There is a degree of risk associated with the possibility of flow events. It is apparent that the watercourse is subject to flow events periodically and it is conceivable that a flow event could occur during the 12 month period during which a crossing would be required to be in place for access. This would potentially cut off access along the ROW, and if the rate at which the water level rises is high, could result in the loss or damage of construction equipment. Construction personnel would also be at risk under these circumstances. | |
| Causeway + Flume | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| Trenching Methodology | Technical Feasibility | Environmental Disturbance | Construction Risk / Safety | Preferred? |
| Standard Mainline (Dry) Trenching | Y<br>(if dry) | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Low<br>Although there is a possibility of flows in the watercourse during construction, the duration of construction would be short (1-3 days) and the risk can be effectively managed through construction scheduling. | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| Wet Trenching** | Y<br>(if wet) | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a higher risk of trench collapse associated with wet trenching. | |
| HDD | Y | High<br>HDD would require additional workspaces beyond the ROW due to a bend in the alignment, however, due to the location of the crossing within the Callide Insfrastructure Corridor State Development Area and therefore substantial re-alignments are not permitted. Furthermore, the required work spaces would also infringe on another Proponent's ROW. Therefore, HDD is not feasible at this location.<br>Geology also suggests that HDD is not suitable due to presence of gravel and loose sand. Presents high risk for safe and effective execution of HDD due to potential for borehole collapse during drilling and pull-back operations | High<br>Extreme risk of Borehole instability associated with the High risk of Blow-out of bentonite due to the presence of sandy gravel and gravelly sand up 24.<br>High/extreme risk of Bentonite leakage into the creek bed due to the presence of gravel soil.<br>Extreme risk of blockage during the string pull back phase due to the presence of two different soil types (up 24/25m: gravel and clayey sandy gravel. Bellow 24/25m: andesite and granodiorite / granite very high strength, slightly weathered to fresh).<br>High sensitivity to variations in geotechnical conditions (very high strength rocky soil and gravel)<br>Moderate risk of damage to the pipe coating due to presence of hard substrate (rock). | |
| Additional Mitigation Measures: | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Harper Creek - Crossing Method Selection Analysis

| Harper Creek | 360.338 | Notes on Key Aquatic Values | Objectives | |
|---|---|---|---|---|
| Stream order: | 4 | Wide vegetated riparian zone on both banks. | Minimise vegetation clearing on the banks | |
| Avg. grade of the banks: | >23 degrees | Significant watercourse that was flowing at the time of inspection. Potential for high flow events periodically. | Minimise safety risk to construction staff, plant and equipment. | |
| Height of banks: | 12m | Diverse aquatic ecology comprising fish, crustaceans, macrophytes and (non-threatened) turtles. Potential for White Throated Snapping Turtle and Platypus to occur. Appears to be affected by poor water quality from periodically. | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. | |
| Bankfull width: | 26m | GEOLOGY: The geology at the proposed crossing indicates an early to middle age beds of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. The top 23 m is soils of varying layers – loose silty sand, gravels, sandy clay etc. Below is very high strength weathered rocks. Loose sand is a concern of drilling where they could continuously collapse and upon withdrawal of the drill bit, loose sand may mix with drilling fluids. Actual rock layers may spread within 23 m depth and are likely to be hard. Borehole HACBH01 indicates 3.2m of sandy clay followed by loose gravel up to 23.1m. Borehole HACBH02 indicates gravels almost from ground level up to 14.8m. From both these boreholes, rock layer is encountered below 23m. Trial pit indicates top soil with clay up to 4m. | | |
| Water present: | Y | | | |
| Substrate type: | N/A | | | |
| Extra workspace requirements: | 17,959m$^2$ | | | |
| Estimated Date Construction: | Jun-Jul 2013 | | | |
| Aquatic Value: | High | | | |
| | | | | |
| Access way Construction | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
| Bed Level Crossing | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW.<br>Note: this approach may be adopted in the event the conditions at the time of construction suggest a low risk of flow events in the creek. | Moderate<br>There is a degree of risk associated with the possibility of flow events. It is apparent that the creek is subject to flow events periodically and it is conceivable that a flow event could occur during the 3 month period during which a crossing would be required to be in place for access. This would potentially cut off access along the ROW, and if the rate at which the water level rises is high, could result in the loss or damage of construction equipment. Construction personnel would also be at risk under these circumstances. | |
| Causeway + Flume | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| Trenching Methodology | Technical Feasibility | Environmental Disturbance | Construction Risk / Safety | Preferred? |
| Standard Mainline (Dry) Trenching | Y<br>(if dry) | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Low<br>Although there is a possibility of flows in the creek during construction, the duration of construction would be short (1-3 days) and the risk can be effectively managed through construction scheduling. | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| Wet Trenching** | Y<br>(if flowing) | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a higher risk of trench collapse associated with wet trenching. | |
| HDD | Y | High<br>HDD would require additional workspaces beyond the ROW, however, due to the location of the crossing within the Callide Insfrastructure Corridor State Development Area substantial re-alignments are not permitted. Therefore, HDD is not feasible at this location.<br>Geology also suggests that HDD is not suitable due to presence of gravel and loose sand. Presents high risk for safe and effective execution of HDD due to potential for borehole collapse during drilling and pull-back operations | High<br>High risk for Borehole instability associated with the presence of sandy gravel and gravelly strata (Thickness 1,5 m).<br>Moderate risk of Bentonite leakage into the creek (sand clay from ground level to 14, 5m, minimum drilling cover 18m).<br>High risk of blockage during string pull back phase (a single string but unfavourable geotech conditions)<br>High risk of damage to the pipe coating (H.D.D. drilling in sand clay and andesite strata, very high strength) | |
| Additional Mitigation Measures | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Larcom Creek 1 - Crossing Method Selection Analysis

| Larcom Creek | 378.069 | Notes on Key Aquatic Values | Objectives | |
|---|---|---|---|---|
| Stream order: | 4 | Good quality, very wide riparian zone. | Minimise vegetation clearing on the banks | |
| Avg. grade of the banks: | N/A | Tributary of the Calliope River and likely to have permanent flows. | Minimise safety risk to construction staff, plant and equipment. | |
| Height of banks: | 2-5m | Complex instream habitat including riffles, runs, aquatic plant beds and snags. Diverse aquatic fauna including fish, turtle species and crustaceans. Potential habitat for white-throated snapping turtle | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. | |
| Bankfull width: | 54m | | | |
| Water present: | Y | GEOLOGY: The geology is comprised of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. Surface alluvium composed of gravel, sand; silt and clay locally overlie beds of conglomerate. Numerous faults are likely. Trial pits indicated moderately weathered sand stone with sandy gravel and clay. Sandy and gravelly clay is noticed from borehole with high strength and fractured rock below. | | |
| Substrate type: | Silt/clay, gravel and pebbles. | | | |
| Extra workspace requirements: | 13,121m$^2$ | | | |
| Estimated Date Construction: | Sep-13 | | | |
| Aquatic Value: | High | | | |

| Access way Construction | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Moderate<br>There is a degree of risk associated with the high probability that the creek would be flowing during the 3 month period during which a crossing would be required to be in place for access. Under these circumstances a bed level crossing would not be feasible due to the high risk to construction equipment and personnel, and the need to maintain access along the ROW. | |
| Causeway + Flume | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation. A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| **Trenching Methodology** | **Technical Feasibility** | **Environmental Disturbance** | **Construction Risk / Safety** | **Preferred?** |
| Standard Mainline (Dry) Trenching | Y<br>(if dry) | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Low<br>Although there is a possibility of flows in the creek during construction, the duration of construction would be short (1-3 days) and the risk can be effectively managed through construction scheduling. | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation. A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| Wet Trenching** | Y<br>(if flowing) | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a higher risk of trench collapse associated with wet trenching. | |
| HDD | Y | High<br>HDD would require additional workspaces beyond the ROW, however, due to the location of the crossing within the Callide Insfrastructure Corridor State Development Area substantial re-alignments are not permitted. Therefore, HDD is not feasible at this location.<br>Geology also suggest that HDD is not suitable due to loose gravel. Presents a high risk of safe and effective execution of HDD due to potential for borehole collapse during drilling a pull-back operations. | High<br>Extreme risk of Bentonite leakage into the creek bed due to the presence of very gravelly soil.<br>Extreme variations in geotechnical conditions of soil (sand clay and gravelly sand and andesite very high strength).<br>Extreme risk of pipe blockage during the pull back phase due to the presence of different soil types<br>Extreme risk of damage to the pipe coating due to presence of hard substrate (rock). | |
| Additional Mitigation Measures: | | | | |
| Prior to clearing activities, an experienced Aquatic Ecologist will inspect the area and ensure there are no active nests within the ROW. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

# Larcom Creek 2 - Crossing Method Selection Analysis

| Larcom Creek | 384.76 | Notes on Key Aquatic Values | Objectives | |
|---|---|---|---|---|
| Stream order: | 3 | Good quality, albeit narrow riparian zone. | Minimise vegetation clearing on the banks | |
| Avg. grade of the banks: | <23 degrees | Substantial watercourse flowing water at time of survey; likely to be perennial flow. | Minimise safety risk to construction staff, plant and equipment. | |
| Height of banks: | 2m | Complex instream habitat including aquatic plant beds and snags. Diverse aquatic fauna including fish, turtle species and crustaceans. Potential habitat for white-throated snapping turtle | Minimise disturbance of the watercourse (i.e. both duration and extent of disturbance). Maintain flows during construction. | |
| Bankfull width: | 28m | GEOLOGY: Geology is comprised of siltstone, mudstone, sandstone, limestone, conglomerate and tuff. Borehole BHLC01 indicates traces of gravel up to 7.2m followed gravelly mixed soil up to 12.6m. Below this depth, material is hard rock and drilling was refused at 17.7m. Conversely BH-LAR01 shows soil up to 5.6m and below fine grained siltstone and mudstone up to 17.66m. Further down is coarse grained sand stone. | | |
| Water present: | Y | | | |
| Substrate type: | Silt/clay | | | |
| Estimated Date Construction: | Sep-13 | | | |
| Extra work space required: | 17991m$^2$ | | | |
| Aquatic Value: | High | | | |

| Access way Construction | Technical Feasibility? | Environmental Disturbance | Construction Risk / Safety | Preferred? |
|---|---|---|---|---|
| Bed Level Crossing | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Moderate<br>There is a degree of risk associated with the high probability that the creek would be flowing during the 3 month period during which a crossing would be required to be in place for access. Under these circumstances a bed level crossing would not be feasible due to the high risk to construction equipment and personnel, and the need to maintain access along the ROW. | |
| Causeway + Flume | Y | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW, noting however, that this may also result in positive impacts due to the removal of weed species during clearing, and the subsequent rehabilitation.<br>A causeway has a similar footprint than a bed level crossing, due to a smaller amount of grading required on the banks. If the watercourse is wet, the impact of obstructing creek flows / biological connectivity can be mitigated to an extent by installing flume pipes. However, there is a requirement to use an additional workspace area to the left to construct the causeway. | Low<br>The crossing has relatively high water levels and a large number of tributary streams. In addition to the day to day base flows, it is conceivable that a higher flow event could occur during the use of the causeway. The causeway would be retained for up to 9 months for ongoing access along the ROW as per Fisheries Approval Reference No. 2012NA0527. It is beneficial to reduce the safety risk to construction personnel and ensure ongoing access by construction a causeway, particularly as the use of the crossing is to extend into the wet season. | Preferred |
| **Trenching Methodology** | **Technical Feasibility** | **Environmental Disturbance** | **Construction Risk / Safety** | **Preferred?** |
| Standard Mainline (Dry) Trenching | Y<br>(if dry) | Low-Moderate<br>Direct impacts relate to the removal of any riparian vegetation within the ROW. | Low<br>Although there is a possibility of flows in the creek during construction, the duration of construction would be short (1-3 days) and the risk can be effectively managed through construction scheduling. | |
| Minor Dam* + Flume + Standard Mainline Trenching | Y | Low-Moderate<br>The adoption of a minor dam and flume approach would partially obstruct and thereby reduce biological connectivity. In addition the de-watering process could trap fauna in the impoundment area, and construction of the dam could mobilise sediments from the bed of the creek that would otherwise not be disturbed if dry trenching. Any fauna caught in the impoundment area would need to be relocated by a fauna handler. However the flume pipes would provide ongoing linear connectivity along the watercourse. | Low<br>The process of constructing the minor dam would involve some degree of risk associated with working in the wet as it relates to the safety of the construction personnel. This would be the case primarily during construction and de-commissioning of the minor dam and de-watering. | Preferred |
| Wet Trenching** | Y<br>(if flowing) | Moderate<br>This approach would result in short term increases in erosion and sedimentation, as well as increases in turbidity levels. This could negatively impact on aquatic ecosystem health. | Low-Moderate<br>There is an inherently higher level of risk associated with working in the wet, particularly with respect to safety for personnel. Furthermore, there is a higher risk of trench collapse associated with wet trenching. | |
| HDD | Y | High<br>If HDD were proposed for this site it would require significant re-alignment due to the presence of a number of constraints in this location, including QG pipeline, future rail corridor, hilly land, commercial premises and a water pipeline. Substantial realignments are not permitted due to constraints associated with CICSDA. It is therefore not feasible to conduct HDD for this watercourse.<br>Geology also indicates that HDD is not suitable due to loose gravel. Presents a high risk of safe and effective execution of HDD due to potential for borehole collapse during drilling a pull-back operations. | High<br>Extreme risk of Bentonite leakage into the creek bed due to the presence of very gravelly soil.<br>Extreme variations in geotechnical conditions of soil (sand clay and gravelly sand and andesite very high strength).<br>Extreme risk of pipe blockage during the pull back phase due to the presence of different soil types<br>Extreme risk of damage to the pipe coating due to presence of hard substrate (rock). | |
| Additional Mitigation Measures: | | | | |
| Snags and other woody debris within the creek channel at the location of the crossing should be relocated or removed and replaced after the conclusion of works. | | | | |

*Can only be implemented with a causeway.

**Must be implemented with a causeway unless alternative access around the creek is available.

Santos
GLNG Project

**APPENDIX G2 – Baffle Creek Crossing: Analysis of Open Cut and Horizontal Directional Drilling and Open Cut and Horizontal Directional Drilling Options Technical and Geotechnical Assessment**

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**Table 4: Environmental Management Plan**

The Environmental Management Plan (EMP) for the Project is presented in the following table.

| Environmental Aspect | Management Measures |
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| Disturbance to benthic habitat and communities from dredging and seabed disposal of dredged material | Dredging and seabed disposal of dredged material will be undertaken in accordance with the Dredging and Spoil Disposal Management Plan (DSDMP) and the Marine Operations Environmental Management Plan (MOEMP). |
| Disturbance to benthic habitat and communities from anchoring and jack-up barge operations | |
| Disturbance to benthic habitat and communities from dredging and seabed disposal of dredged material<br>Disturbance to benthic habitat and communities from anchoring and jack-up barge operations | Dredging and seabed disposal of dredged material will be undertaken in accordance with the DSDMP and the MOEMP. Dredging and seabed disposal of dredged material will be undertaken in accordance with the *Fisheries Act 1994* and the Regulations. Dredging and seabed disposal of dredged material will be undertaken in accordance with the *Fisheries Act 1994* and the Regulations. |
| Disturbance to benthic habitat and communities from anchoring and jack-up barge operations | Anchoring and jack-up barge operations will be undertaken in accordance with the MOEMP. |
| Disturbance to benthic habitat and communities from anchoring and jack-up barge operations | Anchoring and jack-up barge operations will be undertaken in accordance with the MOEMP. |
| Disturbance to benthic habitat and communities from dredging and seabed disposal of dredged material<br>Disturbance to benthic habitat and communities from anchoring and jack-up barge operations | Dredging and seabed disposal of dredged material will be undertaken in accordance with the DSDMP and the MOEMP. Anchoring and jack-up barge operations will be undertaken in accordance with the MOEMP. |

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BAFFLE CREEK

BAFFLE CREEK

BAFFLE CREEK

**Location of Baffle Creek crossing**

Santos
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# GLNG GAS TRANSMISSION PIPELINE

## Figure 2
## Location of Baffle Creek crossing

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Pipe String area

Lot 4 on WT217

Lot 1 on WT87

Temporary work area (1000 m2 max.)

KP20

KP21

KP22

KP19

AT021

AT022

# GLNG GAS TRANSMISSION PIPELINE

## Figure 3 - Proposed location for watercourse crossing: H.D.D. or Open Cut

Santos GLNG Project

eni saipem

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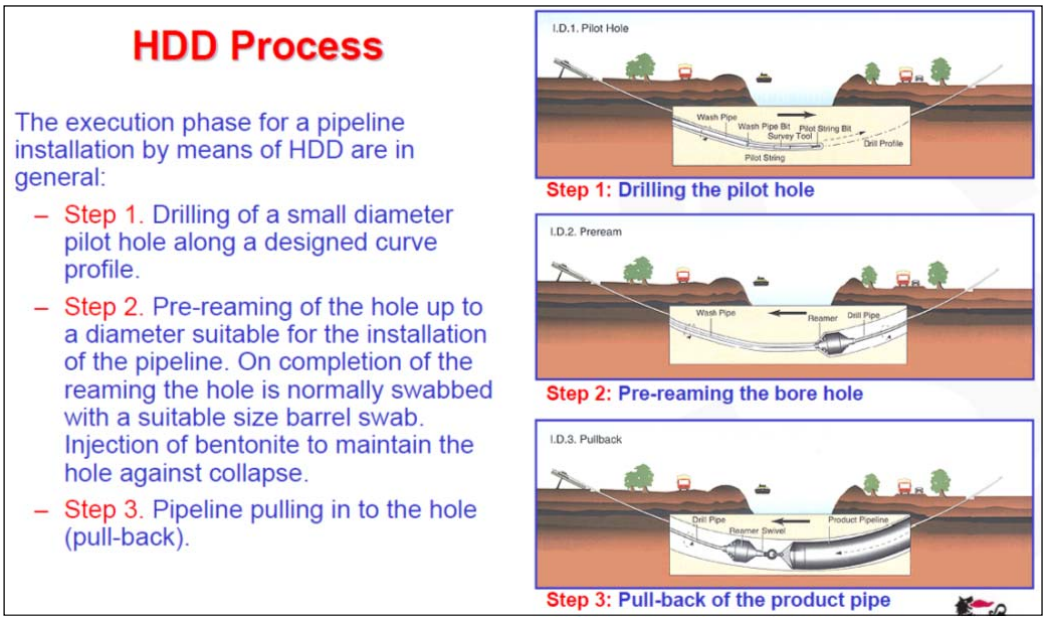


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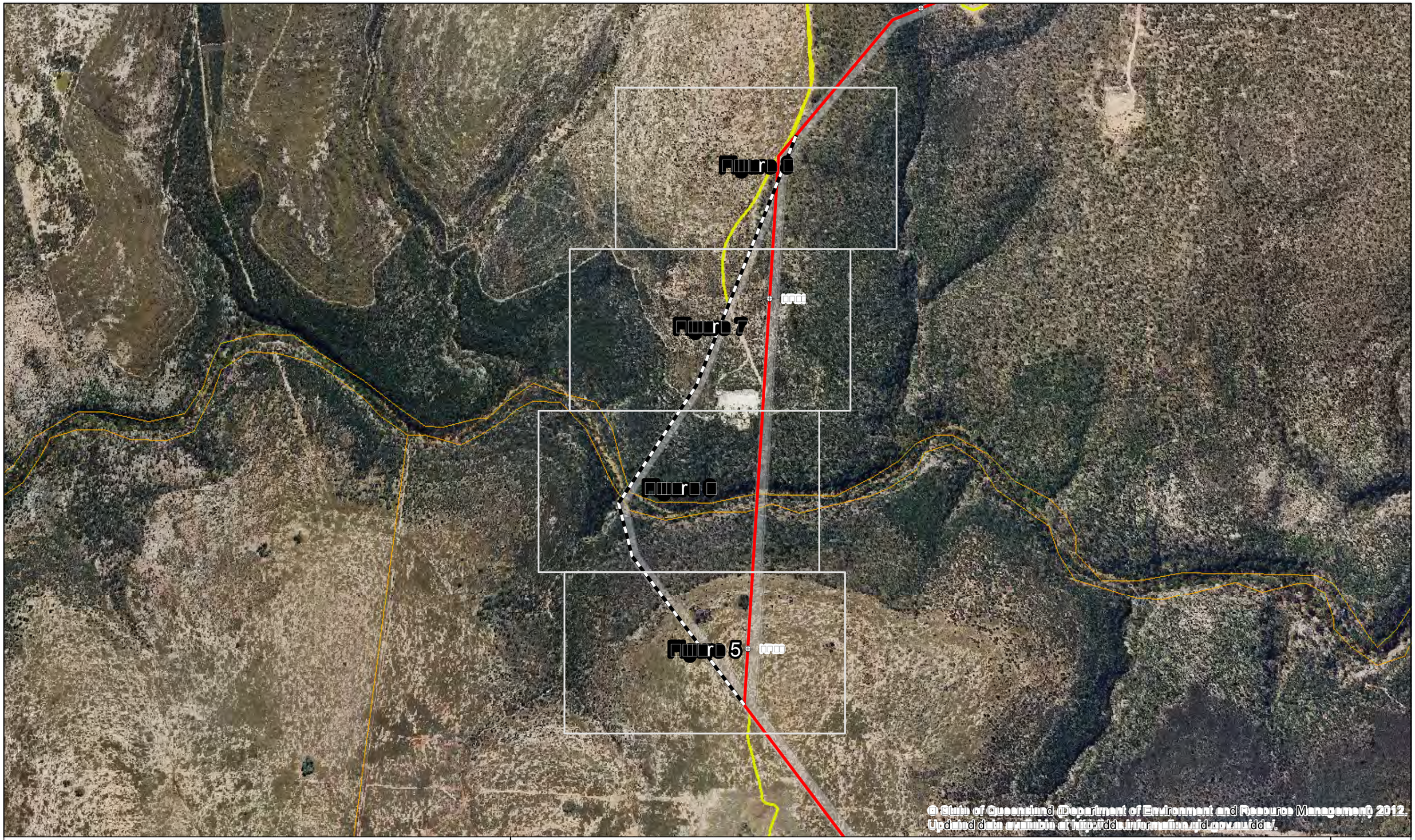


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# GLNG GAS TRANSMISSION PIPELINE

## Figure 4

## Route Change Request - Baffle Creek

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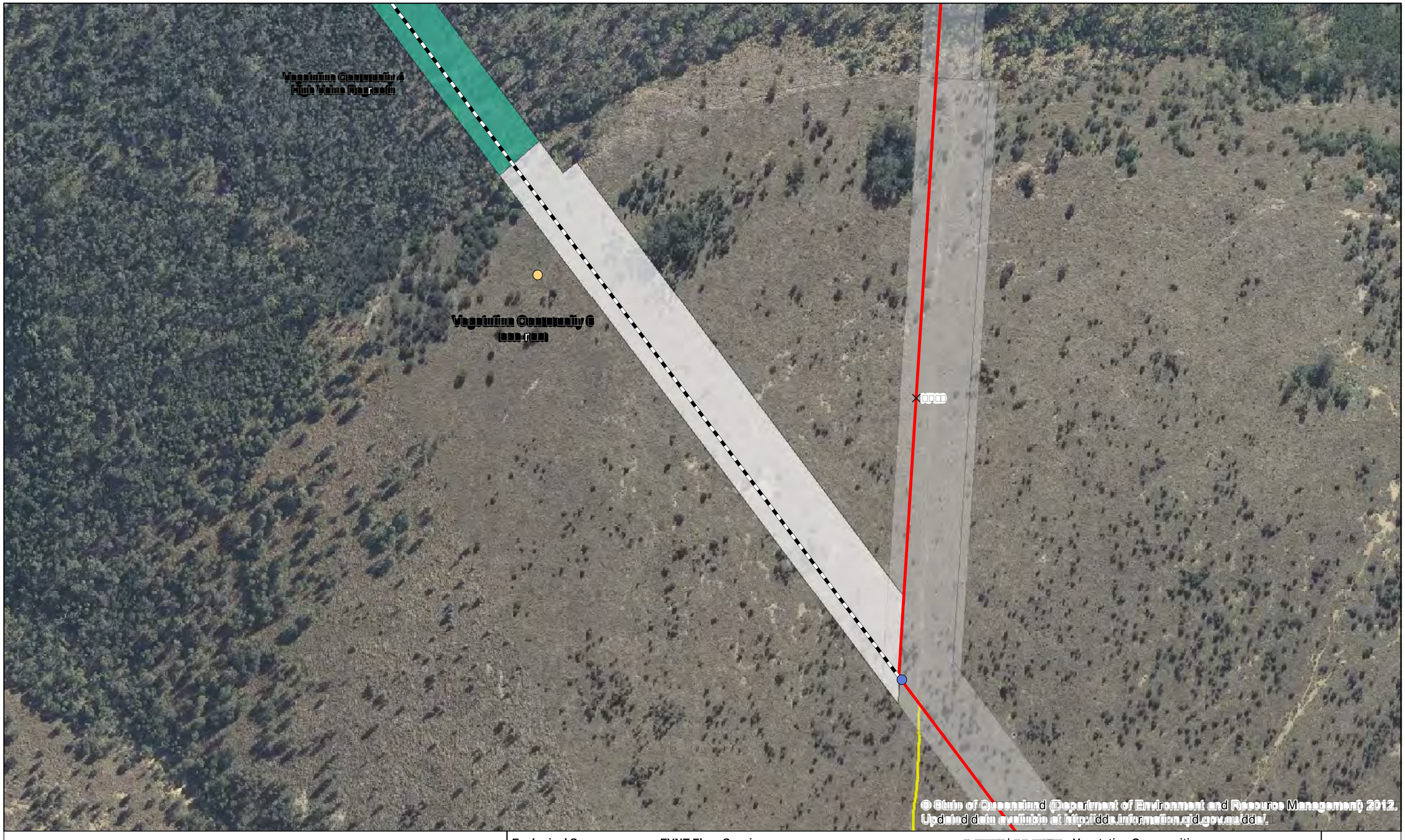


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# GLNG GAS TRANSMISSION PIPELINE

## Figure 5

## Route Change Request - Baffle Creek

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**Ecological Survey**

**Type A Species**

- *Brachychiton australis*
- *Brachychiton populneus*
- *Brachychiton rupestris*
- *Macrozamia moorei*
- *Platycerium veitchii*
- *Sarcochilus ceciliae*
- *Xanthorrhoea johnsonii*

**EVNT Flora Species**

- *Acacia sp. Boyd Creek*
- *Apatophyllym teretifolium*
- *Wahlenbergia islensis*

**EVNT Fauna Species**

- *Chalinolobus dwyeri*
- *Chalinolobus picatus*
- *Strophurus taenicauda*

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**Weed Species**

- *Opuntia stricta**
- *Opuntia tomentosa**

*N.B. a white outline depicts a survey point captured by GLNG*

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**Vegetation Communities**

**Biodiversity Status**

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**High Value Regrowth**

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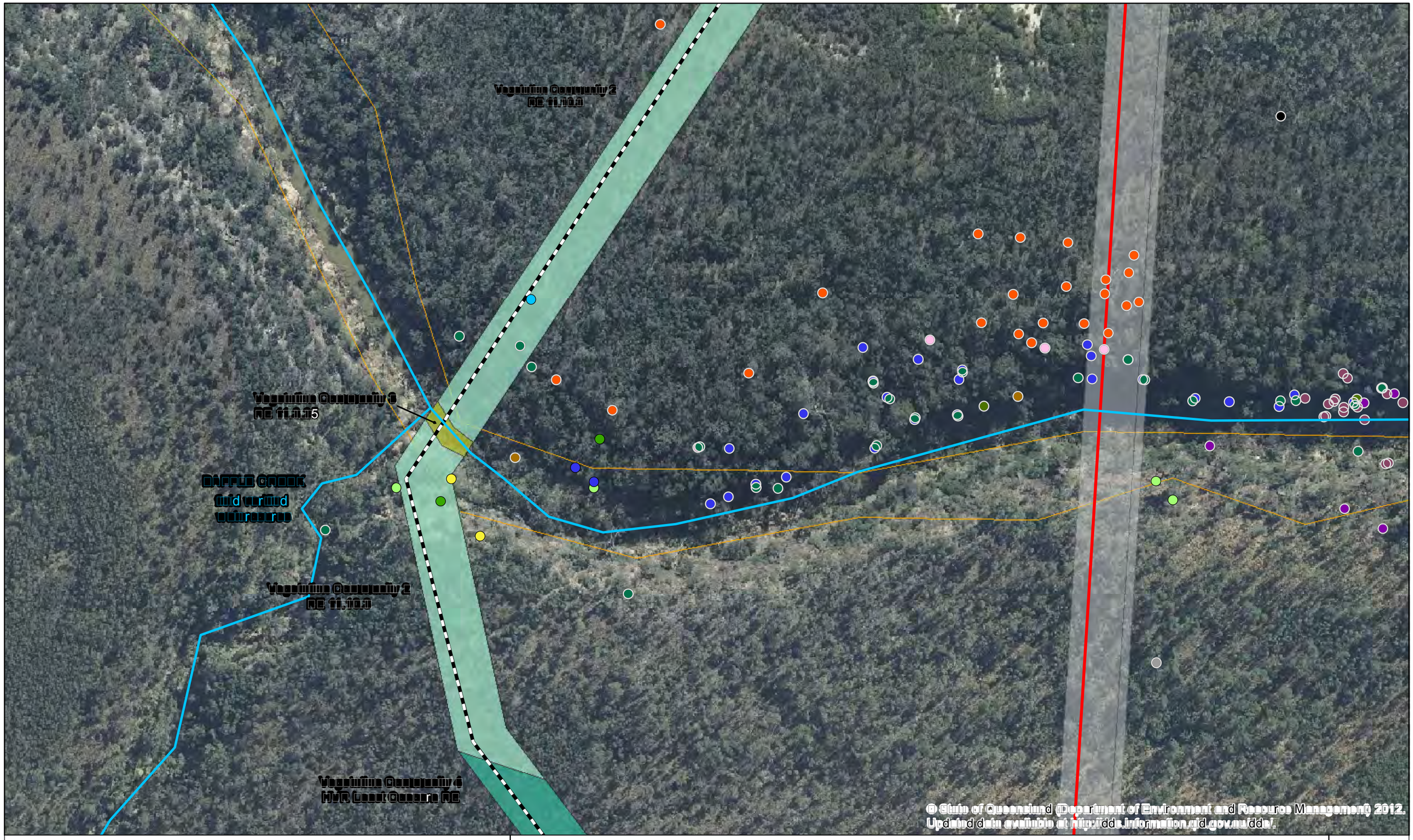


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# GLNG GAS TRANSMISSION PIPELINE

## Figure 6

## Route Change Request - Baffle Creek

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**Ecological Survey**

**Type A Species**

- *Brachychiton australis*
- *Brachychiton populneus*
- *Brachychiton rupestris*
- *Macrozamia moorei*
- *Platycerium veitchii*
- *Sarcochilus ceciliae*
- *Xanthorrhoea johnsonii*

**EVNT Flora Species**

- *Acacia sp. Boyd Creek*
- *Apatophyllym teretifolium*
- *Wahlenbergia islensis*

**EVNT Fauna Species**

- *Chalinolobus dwyeri*
- *Chalinolobus picatus*
- *Strophurus taenicauda*

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**Weed Species**

- *Opuntia stricta**
- *Opuntia tomentosa**

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*N.B. a white outline depicts a survey point captured by GLNG*

**Vegetation Communities**

**Biodiversity Status**

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**High Value Regrowth**

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# GLNG GAS TRANSMISSION PIPELINE
## Figure 7
## Route Change Request - Baffle Creek

5 5 M

**Ecological Survey**

**Type A Species**
- *Brachychiton australis*
- *Brachychiton populneus*
- *Brachychiton rupestris*
- *Macrozamia moorei*
- *Platycerium veitchii*
- *Sarcochilus ceciliae*
- *Xanthorrhoea johnsonii*

**EVNT Flora Species**
- *Acacia sp. Boyd Creek*
- *Apatophyllym teretifolium*
- *Wahlenbergia islensis*

**EVNT Fauna Species**
- *Chalinolobus dwyeri*
- *Chalinolobus picatus*
- *Strophurus taenicauda*

**Weed Species**
- *Opuntia stricta**
- *Opuntia tomentosa**

*N.B. a white outline depicts a survey point captured by GLNG*

**Vegetation Communities**

**Biodiversity Status**

**High Value Regrowth**

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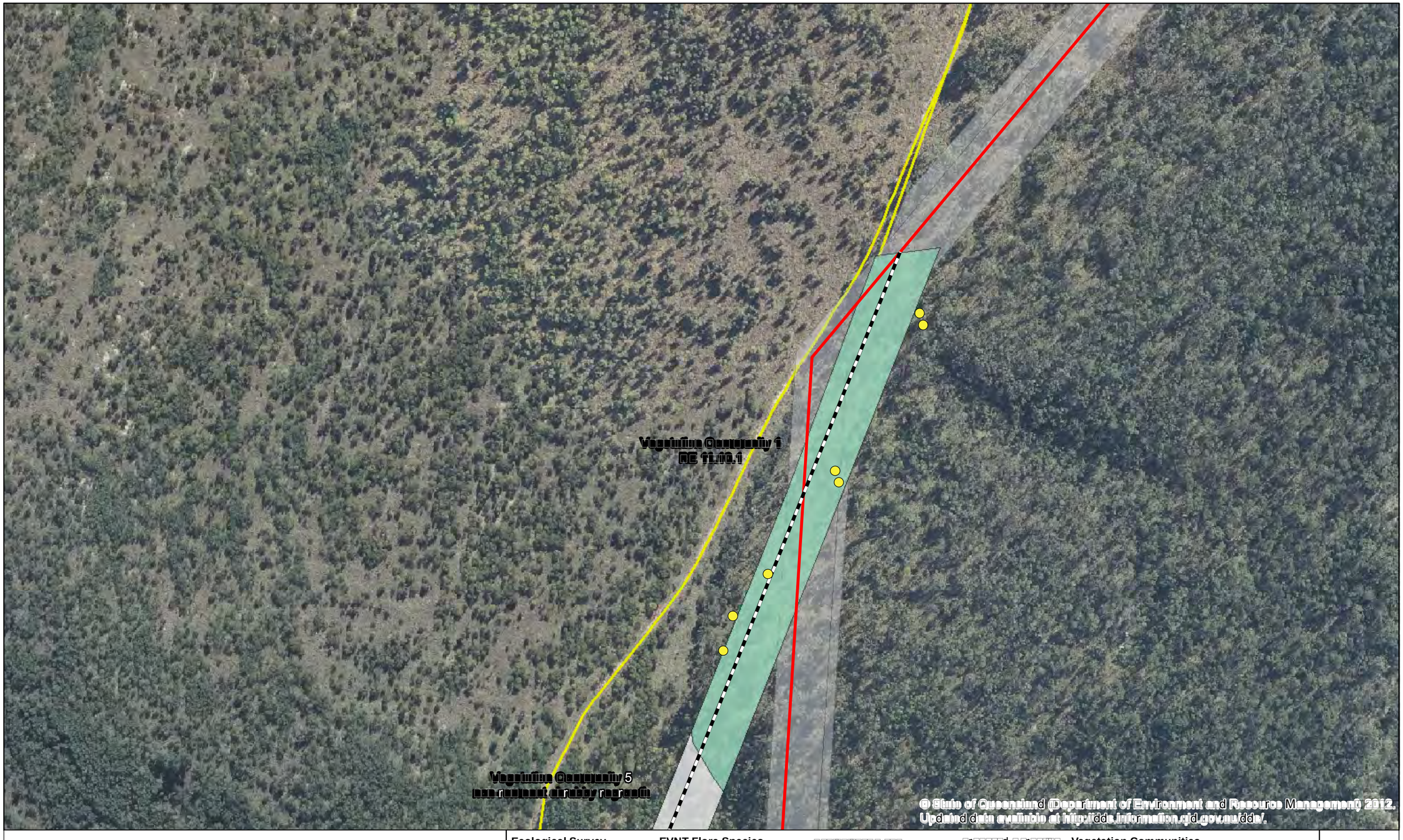


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# GLNG GAS TRANSMISSION PIPELINE
## Figure 8
## Route Change Request - Baffle Creek

5 5 M

**Ecological Survey**
**Type A Species**
- *Brachychiton australis*
- *Brachychiton populneus*
- *Brachychiton rupestris*
- *Macrozamia moorei*
- *Platycerium veitchii*
- *Sarcochilus ceciliae*
- *Xanthorrhoea johnsonii*

**EVNT Flora Species**
- *Acacia sp. Boyd Creek*
- *Apatophyllym teretifolium*
- *Wahlenbergia islensis*

**EVNT Fauna Species**
- *Chalinolobus dwyeri*
- *Chalinolobus picatus*
- *Strophurus taenicauda*

**Weed Species**
- *Opuntia stricta**
- *Opuntia tomentosa**

*N.B. a white outline depicts a survey point captured by GLNG*

**Vegetation Communities**
**Biodiversity Status**

**High Value Regrowth**

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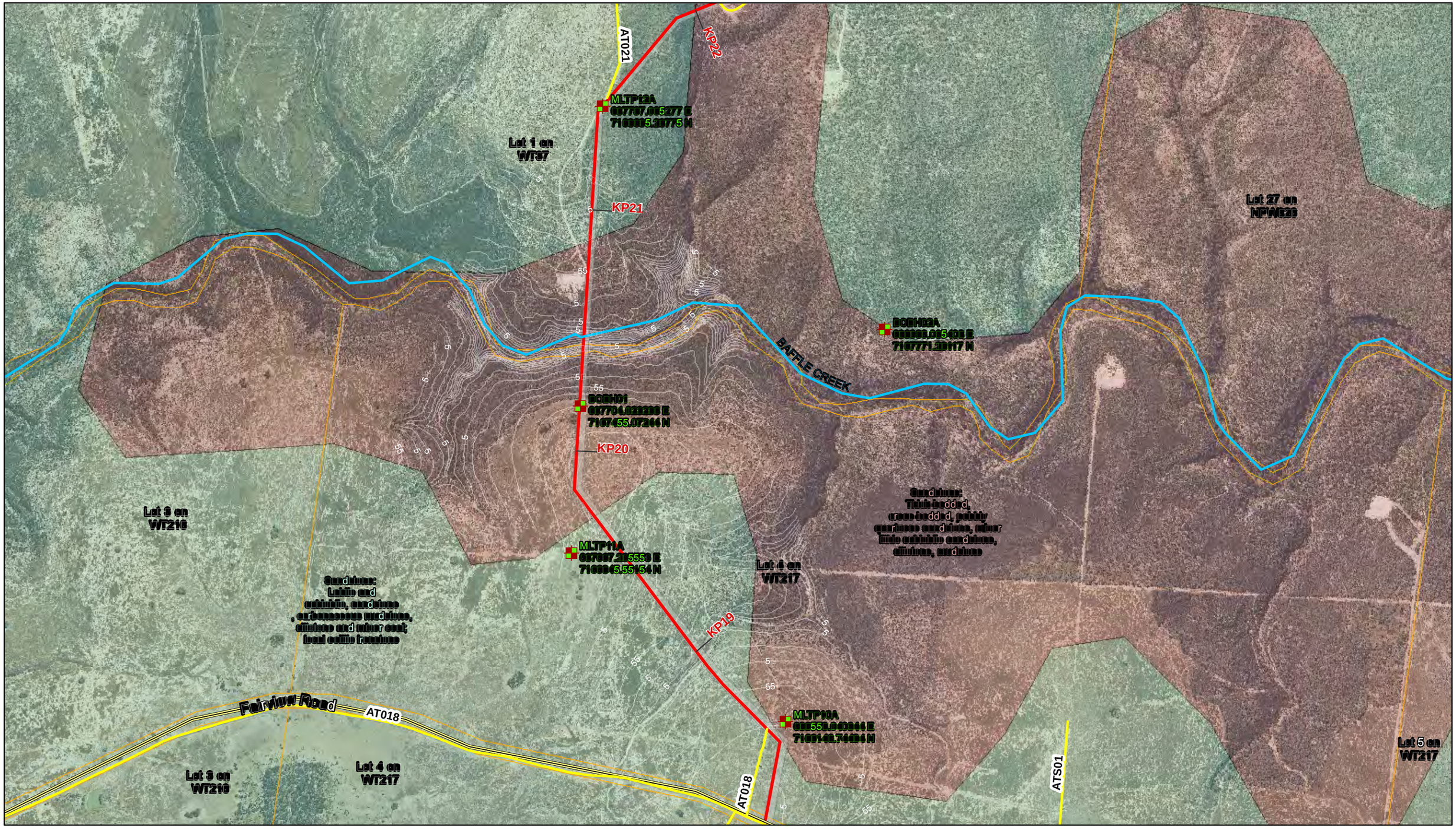


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# GLNG GAS TRANSMISSION PIPELINE

**Figure 9**

**Location of boreholes and test pits**

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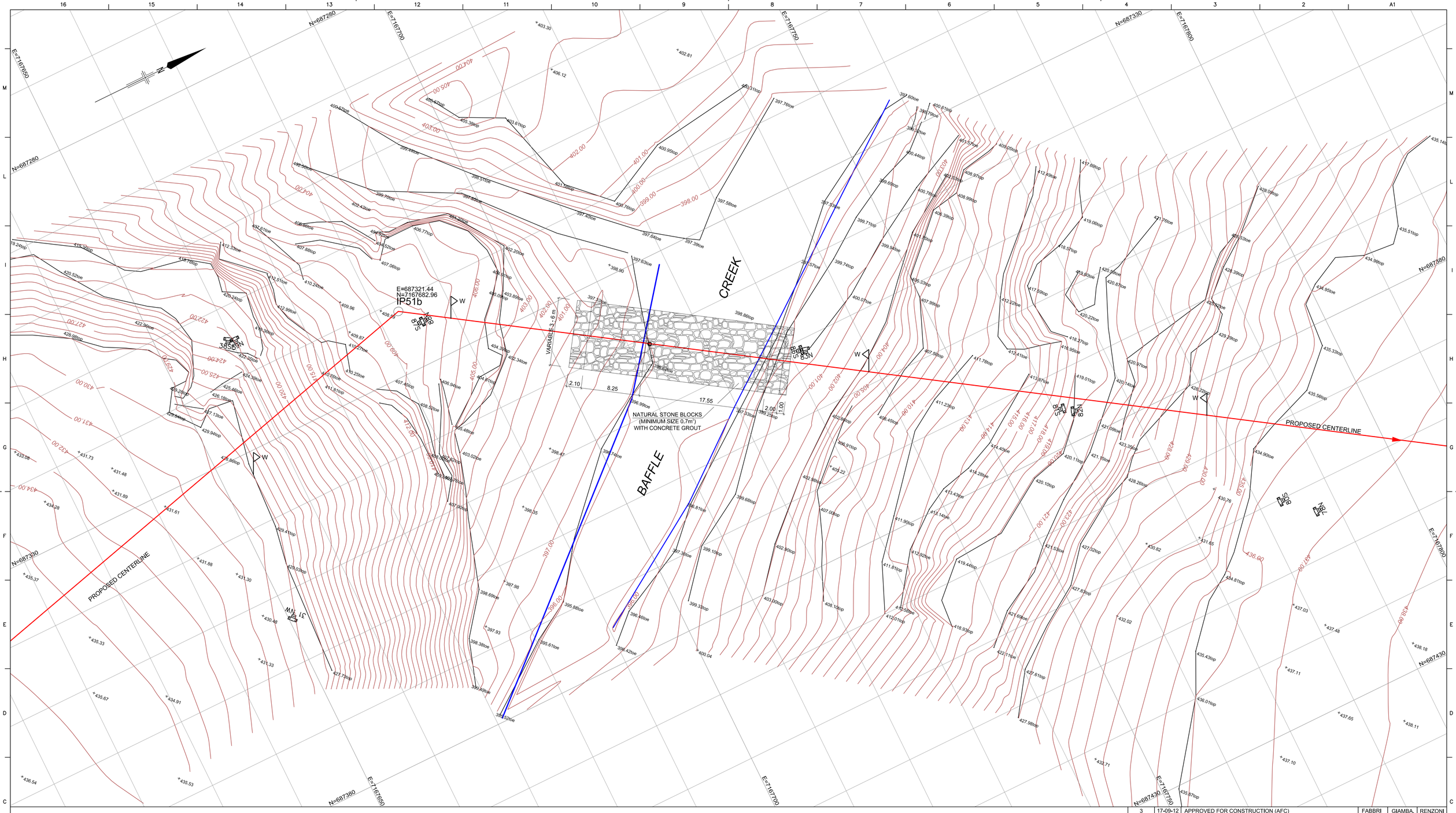


## ELEVATION

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VERTICAL SCALE 1:250
VERTICAL DATUM AHD
A1

## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
- CENTRELINE STAKE
- MARKER
- TRENCH BREAKER

NOTE:

1. BANKS SHALL BE RESTORED BY GRADING AND REVEGETATING, AND BY METHODS REQUIRED BY THE EROSION CONTROL PHILOSOPHY (GLNG DOC. 3381-GHD-3-3.3-0220).
2. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE STATED.
3. FOR METHODOLOGY OF CONSTRUCTION, EROSION CONTROL AND FINAL REINSTATED PROFILE SEE DOC. 3380-SAIP-4-3.3-6040 WATERCOURSE CROSSING MANAGEMENT PLAN
4. ALL COORDINATES REFER TO:
   HORIZONTAL DATUM MGA94 ZONE 55
   VERTICAL DATUM AHD

| REFERENCE DRAWING | |
|---|---|
| DOC No. | DOC Title |
| 3381-40-3300-009 | ALIGNMENT SHEET n°9 (ROUTE A8) FROM KP 20.000 TO KP 22.500 |
| 3381-40-3705 | WARNING SIGN FOR WATERCOURSE CROSSINGS |
| 3381-40-3707 | WATERCOURSE CROSSING |
| 3381-40-3711 | MARKER POST INSTALLATION DETAILS |
| 3381-40-3717 | BUOYANCY CONTROL WITH CONCRETE COATING |
| 3381-40-3727 | WATERCOURSE BANKS RESTORATION |
| 3381-40-3730 | TRENCH BREAKERS |
| 3381-40-3732 | BANK PROTECTION RENO MATRESSES |

**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
| 2 | Revise as noted and re-submit. | |
| 3 | Revise as directed and re-submit. Works may NOT proceed. | |
| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

**Signed:** **Dated:**

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 17-09-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
| 1 | 27-07-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 0 | 18-11-11 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| A | 05-09-11 | ISSUE FOR REVIEW (IFR) | FABBRI | GIAMBA. | RENZONI |

CONTRACTOR: eni saipem — Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

PROJECT: GLNG GAS TRANSMISSION PIPELINE

DOCUMENT NAME: BAFFLE CREEK CROSSING KP 20.569

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3403

CONTRACTOR DOC No.: 10-LC-B-81403

CONT No.: 897315

REV.: 3

SHEET: 1 OF 3

SCALE: 1:250

## PLAN

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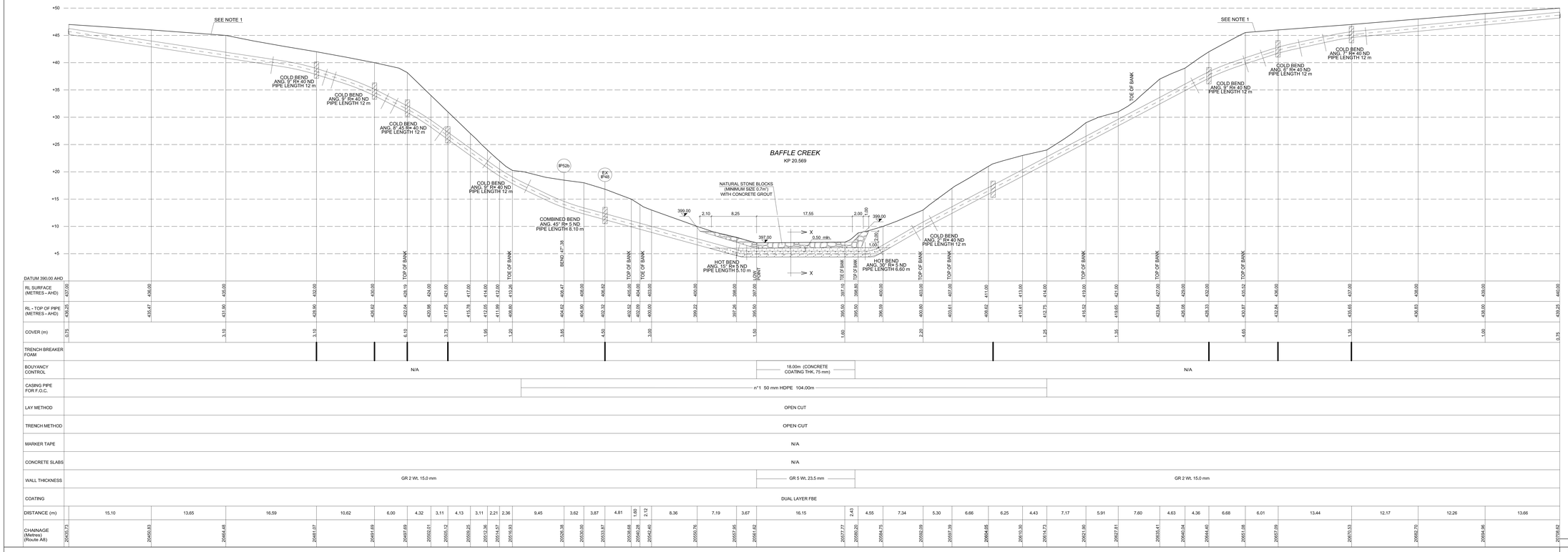
HORIZONTAL SCALE 1:250
HORIZONTAL DATUM MGA94 ZONE 55


SEE NOTE 1
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
IP52b
EX IP45
BAFFLE CREEK
KP 20.589
NATURAL STONE BLOCKS (MINIMUM SIZE 0.7m³) WITH CONCRETE GROUT
COMBINED BEND ANG. 45° R/r 5 ND PIPE LENGTH 6.10 m
HOT BEND ANG. 15° R/r 5 ND PIPE LENGTH 6.10 m
HOT BEND ANG. 30° R/r 5 ND PIPE LENGTH 6.60 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
SEE NOTE 1
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
COLD BEND ANG. 9° R/r 40 ND PIPE LENGTH 12 m
TOE OF BANK
399.00
2.10
8.25
17.55
2.00
399.00
397.00
0.50 min.
1.00
2.00
1.00
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TOP OF BANK
TOE OF BANK
BEND 47° 38'
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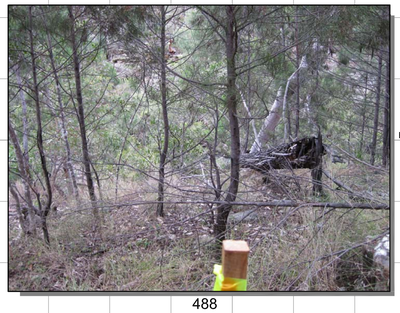

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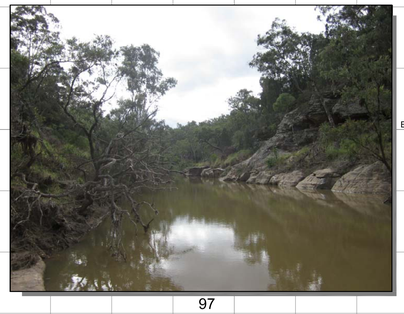

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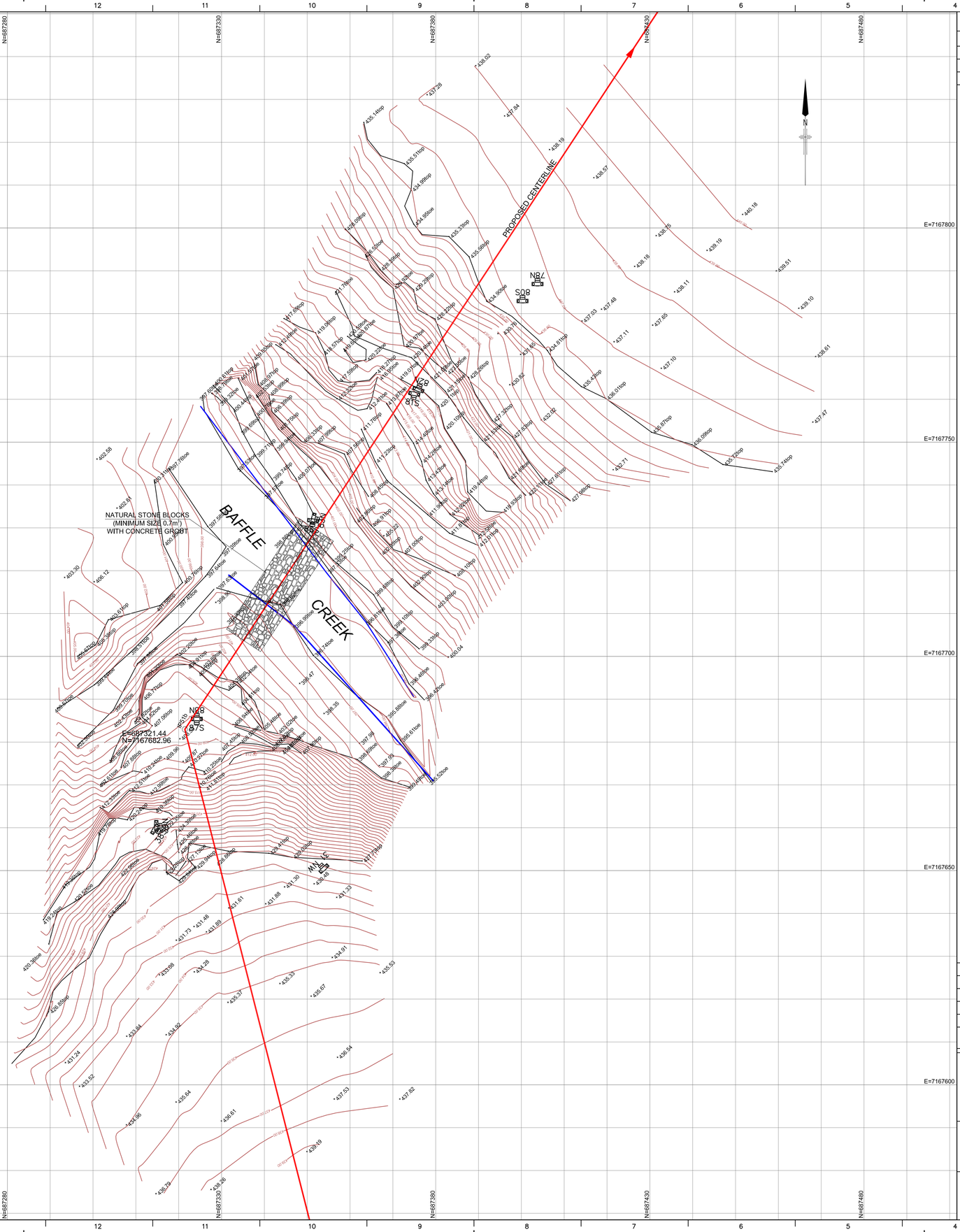


REFERENCE DRAWING

| DOC No. | DOC Title |
|---|---|
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## LEGEND

- PROPOSED ROUTE ND 42"
- FENCE
- TOP OF BANK
- TOE OF BANK
- EDGE OF WATER
- CONTOUR (INTERVAL 0.25m)
- GROUND SURFACE RL
- UNDERWATER SURFACE RL
- PHOTOGRAPH LOCATION / NUMBER
- SIGN
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**COMPANY REVIEW CODE**

| Code | Description | Tick |
|---|---|---|
| 1 | No comment. Proceed to AFC. | |
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| 4 | Information Only. Re-submission not required. | |
| 5 | Approved for Construction (AFC) | |

**Signed:** **Dated:**

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

Horizontal Datum MGA94 Zone 55
Vertical Datum AHD

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1:500

| Revision | Date | Reasons For Issue | Prepared | Checked | Approved |
|---|---|---|---|---|---|
| 3 | 17-09-12 | APPROVED FOR CONSTRUCTION (AFC) | FABBRI | GIAMBA. | RENZONI |
| 2 | 26-08-12 | APPROVED FOR CONSTRUCTION (AFC) | SIM | GIAMBA. | RENZONI |
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CONTRACTOR: Saipem Australia Pty Ltd

CLIENT: Santos GLNG Project

SAIPEM JOB: 032118 AREA: 3381

Doc. Class.: 2

COMPANY DOC No.: 3381-40-3403

PROJECT: GLNG GAS TRANSMISSION PIPELINE

CONTRACTOR DOC No.: 10-LC-B-81403

CONT No.: 897315

DOCUMENT NAME: BAFFLE CREEK CROSSING KP 20.569

REV.: 3

SHEET: 3 OF 3

SCALE: 1:500

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|---|---|---|---|
| Saipem Australia Pty Ltd | SAIPEM JOB 032118 | AREA 3381 | Santos GLNG Project |
| | SPC. 10-AZ-E-80657 | | |
| | Sh. 1 of 35 | Doc. class: 1 | |
| | Rev. B | | |
| Contract No. 897315 | GLNG GAS TRANSMISSION PIPELINE | | |
| | Company Doc. No. 3381-SAIP-4-3.2-3287 | | |
| | Document Title: Baffle Creek Crossing - Open Cut And Horizontal Directional Drilling Options - Technical And Geotechnical Assessment | | |

# BAFFLE CREEK CROSSING
# OPEN CUT AND HORIZONTAL DIRECTIONAL DRILLING OPTIONS
# TECHNICAL AND GEOTECHNICAL ASSESSMENT

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| B | Iussed for Approval (IFA) | Morgante | Polloni | Parlato | 01/11/2012 |
| A | Iussed for Review (IFR) | Morgante | Polloni | Parlato | 04/10/2012 |
| **Revision** | **Reason For Issue** | **Prepared** | **Checked** | **Approved** | **Date** |

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|---|---|

Contractor remains responsible for the due and proper performance in accordance with the Contract. Comments do not limit or relieve Contractor of any obligation or liability under the Contract or give rise to any claim.

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## EXECUTIVE SUMMARY


Based on the assessment of technical and construction risks, the HDD option for Baffle River Crossing, at the Eastern Alignment (original ROW), is considered associated with an EXTREME RISK profile for the following reasons:

- Extreme risk of drilling blockage/upsets due to the length of the HDD, the large diameter of the hole and to the discontinuous pipe pull back operation due to the welding operations.
- High risk for frac-out of bentonite at the banks due to the presence of weathered and fractured sandstone. The section in correspondace of creek bed is considered at extreme risk of frac-out due to the reduced hole coverage. This could lead to bentonite leakage in surface.
- The primary and secondary permeability associated respectively with the presence of granular conglomerate layers low cemented, and with the presence of fractured rocks confirmed by the outcrop and by the boreholes, can represent a significant risk in terms of blow-out, loss of circulation and bentonitic mud loss.
- The geotechnical laboratory analysis describe rock with low mechanical strength. The bore has to pass through layers with a lower resistance. In this case a risk of soil collapse couldn't be excluded.
- Extreme risk of damage to the pipe coating due to presence of rock soil.
- HDD Methodology requires large amounts of water to make up the drilling mud: water supply mud treatment and disposal are critical.

From a technical and constructability perspective, the crossing of Baffle Creek with Open Cut method on the Western Alignment should not be subject to relevant risks. In particular:

- Installation option is not subjet to extra safety risks.
- No risks related to unspected geotechnical condition of soil.
- The method is not as sensitive to variation in the geotechnical conditions of the soil as HDD.
- Instalaltion methodology is not critical for installation failure.
- Safer and more friendly for pipe coating.

The crossing of Baffle Creek with HDD methodology is considered technically not acceptable because associated to an EXTREME RISK profile. The crossing of Baffle Creek with Open Cut method is the preferred option proposed because associated to a LOW RISK profile.

This report has not taken into consideration the environmental impacts, the health and safety risks, detailed engineering scoping, scheduling of work and costing of options.

# 1. INTRODUCTION

## 1.1 Project Description

GLNG Operations Pty Ltd is planning a large scale development to extract coal seam gas (**CSG**) from existing and future fields in the Roma, Fairview and Arcadia Valley area (Upstream) and to supply that gas for commercial sale and/or conversion to liquefied natural gas (**LNG**).

A gas transmission pipeline (**GTP**) called the “GLNG Pipeline” is a major component of the development.

The GLNG Pipeline will be approximately 420 km in length and will be used to transport CSG from the existing and future fields in the Roma, Fairview and Arcadia Valley area to an LNG processing facility (LNG Plant) at Curtis Island near Gladstone. Figure 1 shows the GTP route.




**Figure 1: Gas Transmission Pipeline Route**

## 1.2 Scope and purpose

Construction of the GTP involves crossing numerous watercourses. Watercourses considered of high environmental value, including Baffle Creek, require careful consideration of potential crossing locations and methods.

Although the selected construction method for Baffle Creek Crossing is open cut on the alternative route RCR 47B, due to outstanding environmental constraints, GLNG requested Saipem investigate on alternative Horizontal Directional Drilling (HDD) execution techniques.

Baffle Creek crossing is approximately located between kilometre point (KP) 19 and KP 22.

The scope of this report is to:

- Collect the geotechnical data available in the Baffle creek area.
- Describe the outcrop in the area around the crossing point, from a geotechnical and hydro-geological point of view.
- Conduct a geotechnical assessment of the open cut trench for construction of the Baffle Creek crossing.
- Conduct a geotechnical assessment of the potential use of Horizontal Directional Drilling (HDD) as an alternative to open cut trench.
- Assess potential risks associated with construction of the HDD Baffle Creek crossing.

The two options for the location and methods for the pipeline crossing of Baffle Creek are detailed in the “Baffle Creek Crossing Analysis of Open Cut and Horizontal Direction Drilling” (Doc No: 3380-SAIP-4-1.3-7071).

A detailed description of the works to be carried out by utilising open cut trenching method is provided in the “Baffle Creek Crossing Procedure (Open Cut)” (doc No:3380-SAIP-4-3.3-6074).

This report has not taken into consideration the environmental impacts, the health and safety risks, detailed engineering scoping, scheduling of work and costing of options.

## 1.3 GTP Route Options

The original ROW alignment encountered very steep creek embankments that presented a number of engineering constraints for crossing Baffle Creek by open cut. Further assessment of Baffle Creek identified an alternative route alignment located approximately 350 m upstream (west) of the original ROW, which encountered less steep embankments.

Hence two alignments (see Figure 2) are under consideration to achieve the pipeline crossing of Baffle Creek:

- The original Right of Way (ROW A8) for HDD crossing option.
- The proposed Route Change Request (RCR 47B) for Open Cut crossing option.

Both crossings are located between KP 19 and KP 22 on Lot 4 on WT217 to the south of Baffle Creek, and Lot 1 on WT37 to the north.

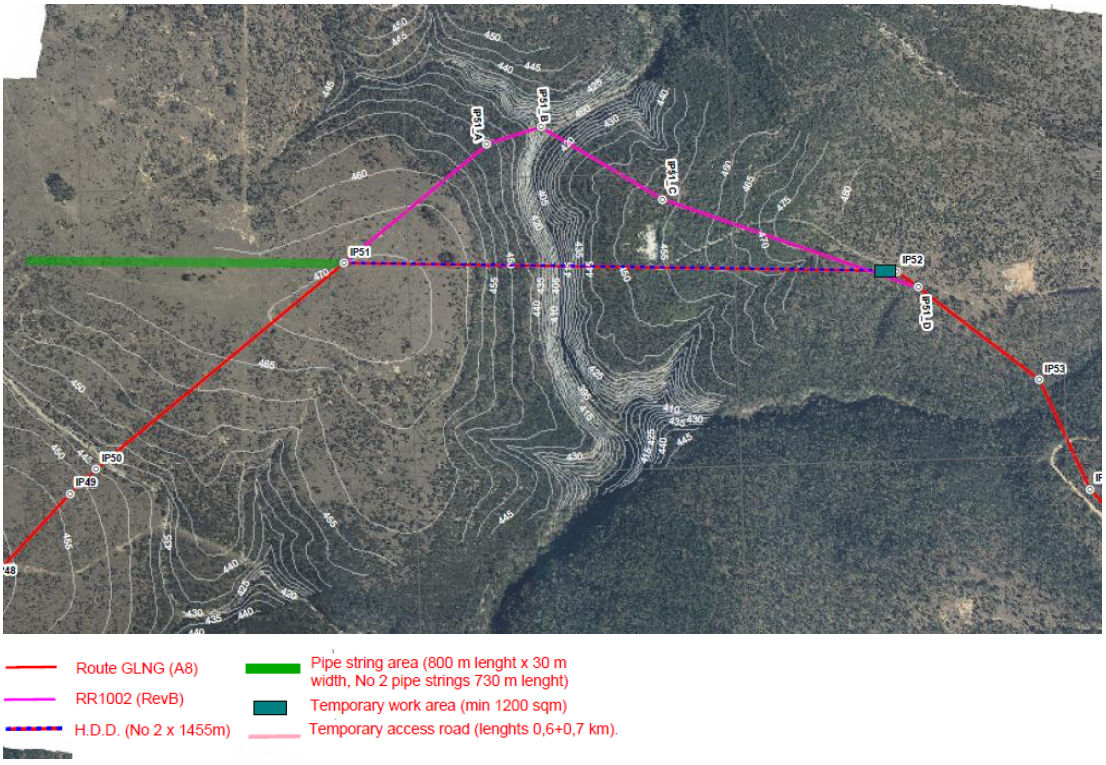



**Figure 2 - Open Trench (RCR 47B) and HDD alignments (ROW A8)**

## 2. REFERENCE DOCUMENTS

### 2.1 Codes & Standards

| | |
|---|---|
| AS 2885.1 | Pipelines – Gas and liquid petroleum – Design and construction |
| AS/NZS 4801 | Occupational health and safety management systems |

### 2.2 Project Documentation

| | |
|---|---|
| 3380-GLNG-3-1.1-0001 | Specification for EPC Contractor: Health, Safety and Security Requirements |
| 3380-GLNG-3-1.3-0006 | Weed Management Plan |
| 3380-GLNG-3-1.3-0007 | Environmental Management Plan |
| 3381-GHD-3-3.3-0186 | Specification for Pipeline Construction |
| 3381-GHD-3-3.3-0247 | Specification – Fibre Optic Cable Detailed Design & Installation |
| 3381-GHD-3-3.3-0260 | Scope of Work for GLNG Pipeline EPC |
| QA/QC Requirements (Schedule 21) | |
| HS&S Requirements (Schedule 22) | |
| Environmental Requirements (Schedule 23) | |

### 2.3 Contractor Project Documentation, Plans & Procedures

| | |
|---|---|
| 3380-SAIP-4-1.3-7071 | Baffle Creek Crossing Analysis of Open Cut and Horizontal Direction Drilling |
| 3380-SAIP-4-3.3-6074 | “Baffle Creek Crossing Procedure (Open Cut)” |
| 3380-SAIP-4-1.2-1836 | Project Specific Health & Safety Management Plan |
| 3380-SAIP-4-1.2-1859 | Ground Disturbance & Excavation Procedure |
| 3380-SAIP-4-1.2-1903 | SWMS Trenching/ Ploughing of Water Crossing |
| 3380-SAIP-4-1.3-1806 | Waste Management Plan |
| 3380-SAIP-4-1.3-1814 | Project Specific Contractor Construction Environmental Management Plan (CEMP) |
| 3380-SAIP-4-1.3-7038 | Erosion & Sedimentation Control Plan – Pipeline Construction – KP0 to KP70 |

| | |
|---|---|
| 3380-SAIP-4-2.1-6001 | Construction Management Plan |
| 3380-SAIP-4-3.3-6008 | Rock Blasting Procedure |
| 3380-SAIP-4-3.3-6009 | Survey Works Procedure |
| 3380-SAIP-4-3.3-6015 | Field Joint Coating Procedure |
| 3380-SAIP-4-3.3-6016 | ROW Clear and Grade Procedure |
| 3380-SAIP-4-3.3-6017 | Welding and NDT Procedure |
| 3380-SAIP-4-3.3-6019 | Line Pipes Stringing Procedure |
| 3380-SAIP-4-3.3-6020 | Line Pipes Cold Bending Procedure |
| 3380-SAIP-4-3.3-6021 | Pipeline Lowering Procedure |
| 3380-SAIP-4-3.3-6022 | Bedding-Padding-Backfilling Procedure |
| 3380-SAIP-4-3.3-6023 | Tie-In Procedure |
| 3380-SAIP-4-3.3-6025 | Trenching And Excavation Procedure |
| 3380-SAIP-4-3.3-6033 | Clean-Up & Marker Installation Procedure |
| 3380-SAIP-4-3.3-6040 | Watercourse Crossing Management Plan |
| 3380-SAIP-4-3.3-6066 | Installation of FOC |
| 3380-SAIP-4-6.6-1251 | Project Quality Management Plan |
| 3380-SAIP-4-6.6-1331 | Quality Control Plan for Pipeline Construction |
| 3381-SAIP-4-3.3-4607 | Technical Specification for the Installation and Testing of Fibre Optic Cable |
| 3381-SAIP-4-3.3-3113 | Specification for Pipeline Construction |

## 2.4 Contractor Drawings

| | |
|---|---|
| 3381-40-3403 | Baffle Creek Crossing KP 20.569; Sheets 1 to 3 |
| 3381-40-3300-009 | Alignment Sheet N°9 (Route A8) (From KP 20+000 To KP 22+500) |
| 3381-40-3701 | Typical Right of Way – 30m Wide |
| 3381-40-3704 | Marker Post Locations |
| 3381-40-3705 | Warning Sign for Watercourse Crossings |
| 3381-40-3707 | Watercourse Crossings |
| 3381-40-3711 | Marker Post Installation Details |
| 3381-40-3713 | Pipeline Marker Sign |
| 3381-40-3714 | Trench and Marker Tape Details |

| | |
|---|---|
| 3381-40-3715 | Optical Fibre Cable Join Installation Details |
| 3381-40-3717 | Buoyancy Control with Concrete Coating |
| 3381-40-3721 | Temporary Sediment Fence |
| 3381-40-3723 | Diversion Berm |
| 3381-40-3727 | Water Course Banks Restoration |
| 3381-40-3728 | Bank Protection with Boulders |
| 3381-40-3730 | Trench Breaker |
| 3381-40-3735 | Open Cut Watercourse Crossing (Working Area) |

## 3. DEFINITIONS AND ABBREVIATIONS

| | |
|---|---|
| Company | GLNG Operations Pty Ltd |
| Contractor | Saipem Australia Pty Ltd |
| Subcontractor | The individual, partnership firm or corporation, qualified to practice professional work under the laws of country in which the site lies and is contractually obligate to perform the work specified in this document and referenced documents. |
| Project Name | Gladstone LNG Pipeline |
| CEMP | Construction Environmental Management Plan |
| DOC | Depth of Cover |
| ESC | Erosion and Sedimentation Control |
| ESCMP | Erosion and Sedimentation Control Management Plan |
| FOC | Fibre Optic Cable |
| FOPS | Falling Object Protective Structures |
| GIS | Geographic Information System |
| HDD | Horizontal Directional Drilling |
| ITP | Inspection and Test Plan |
| KP | Kilometre Point |
| ROW | Right of Way |
| SWMS | Safe Work Method Statement |

| | |
|---|---|
| WCMP | Watercourse Crossing Management Plan |

# 4. GEOLOGICAL OVERVIEW AND GEOTECHNICAL INVESTIGATIONS

## 4.1 Site geographical background

The Baffle Creek crossing is located at approximately Kp 20.500, at approximately 25 km north-east to the town of Injune, along the pipeline route, in the Fairview area: 687711E, 7167724N (Datum GDA94, projection MGA55).

The topography of the area is characterized by flat sandstone plateaus intersected by incised gullies with meanders that in the low velocity parts created large valleys.

The main plateaus of the area are the Fairview and the Springwater with range in the elevations between 400 and 500 m AHD.

The hydrology of the area is regulated by the Springwater plateau and the south side of the Fairview plateau that drain into Hatton Creek and by the northern part of the Fairview plateau that drain into the Baffle Creek.

## 4.2 Geological overview

The geology of the area at Baffle creek crossing is characterized by Early Jurassic fluviatile-lacustrine deposits of the Precipice sandstone formation, consisting of a basal quartzose sandstones, from fine to medium grained, with minor inclusion of labile and sublabile siltstones. The presence of a cover of alluvium associated with Hutton and Baffle Creeks, concludes the geological picture of the zone.

In Figure 3, the map shows the location of geotechnical investigation performed by Coffey Geotechnics in 2009 and the geology of the area.

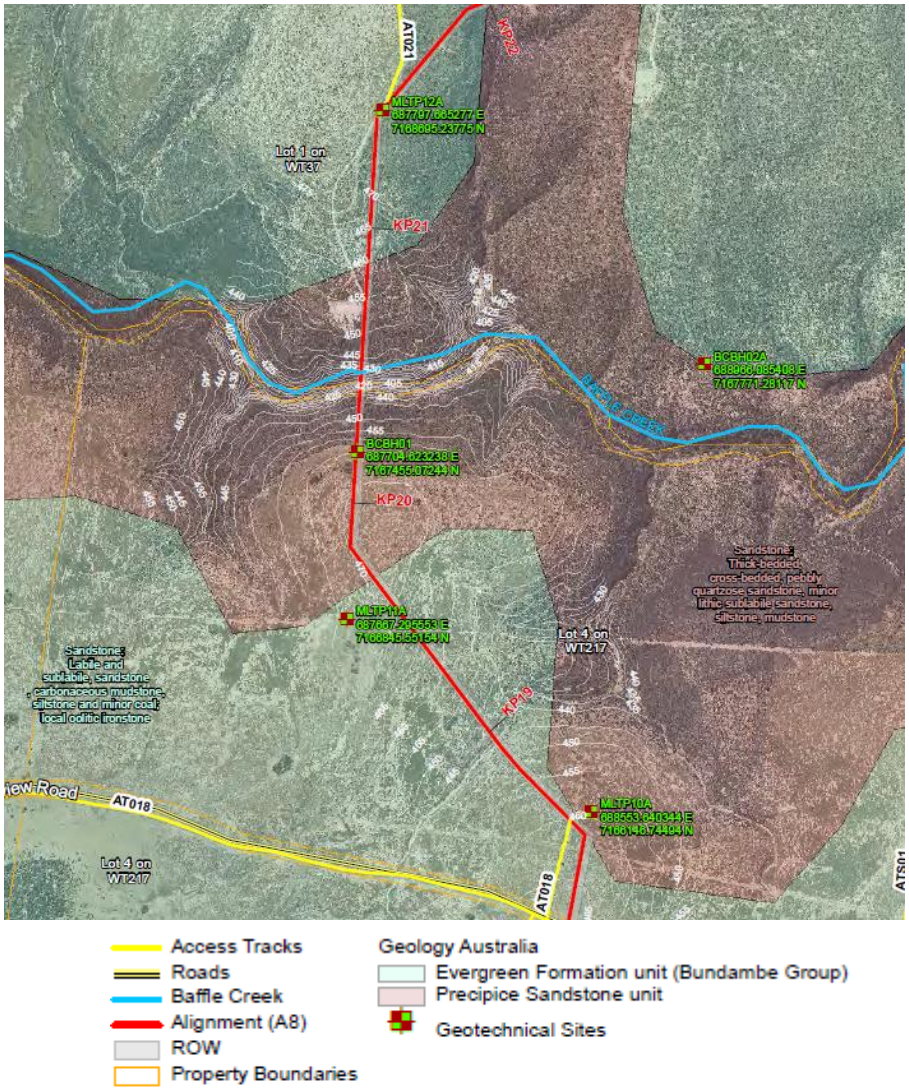



**Figure 3 - Location of boreholes and test pits**

## 4.3 Overview of the Geotechnical Investigation performed during FEED

The data presented in this section are relevant to the geotechnical investigation performed by Coffey Geotechnics in 2009 (ref. document no: GEOTNEWS20400AB-AG, “Factual report on main land geotechnical investigation, QLD”).

The boreholes and trial pits which will be discussed in the following paragraphs have been selected based on their closeness to the Baffle creek crossing (as per RCR no. RR1002).

**Boreholes BCBH01 and BCBH02A - Baffle Creek**

Boreholes BCBH01 and BCBH02A show the same geological formation.

Below relatively thin layers of topsoil and/or residual soil, boreholes BCBH01 and BCBH02A intersected moderately and slightly weathered sandstone near the surface which continued to the termination depth of the boreholes of 60.55 m (RL 402.1m AHD) and 59.8 m (RL 393.72m AHD) respectively. The sandstone included occasional thin beds of interlaminated sandstone and siltstone. The strength of the moderately weathered rock was typically assessed as medium or high strength, while the slightly weathered rock was typically assessed as high strength.

The sandstone included occasional thin beds of interlaminated sandstone and siltstone

**Table 1 Summary of Materials – Boreholes BCBH01 and BCBH02A – Baffle Creek**

| Borehole | Materials Encountered Depth, D (m) and Reduced Level, RL (m AHD) | | |
|---|---|---|---|
| | Topsoil | Residual Soil | MW/SW Sandstone |
| BCBH01 | D: 0 – 0.3<br>RL: 462.65 – 462.35 | D: 0.3 – 1.7<br>RL: 462.35 – 460.95 | D: 0 - 60.55<br>RL: 460.95 - 402.1 |
| BCBH02A | D: 0 - 0.6<br>RL: 453.52 - 452.92 | | D: 0.6 - 59.8<br>RL: 452.92 – 393.72 |

Notes: XW=Extremely Weathered, HW = Highly Weathered, MW = Moderately Weathered, SW = Slightly Weathered, * = Includes some MW material and XW/HW material of very low strength

The Engineering Log - Cored Borehole BCBH02A and BCBH02A are show in Attachment A.

Profile drawing showing the depth of the boreholes performed with respect to baffle creek bottom is described in Figure 4.

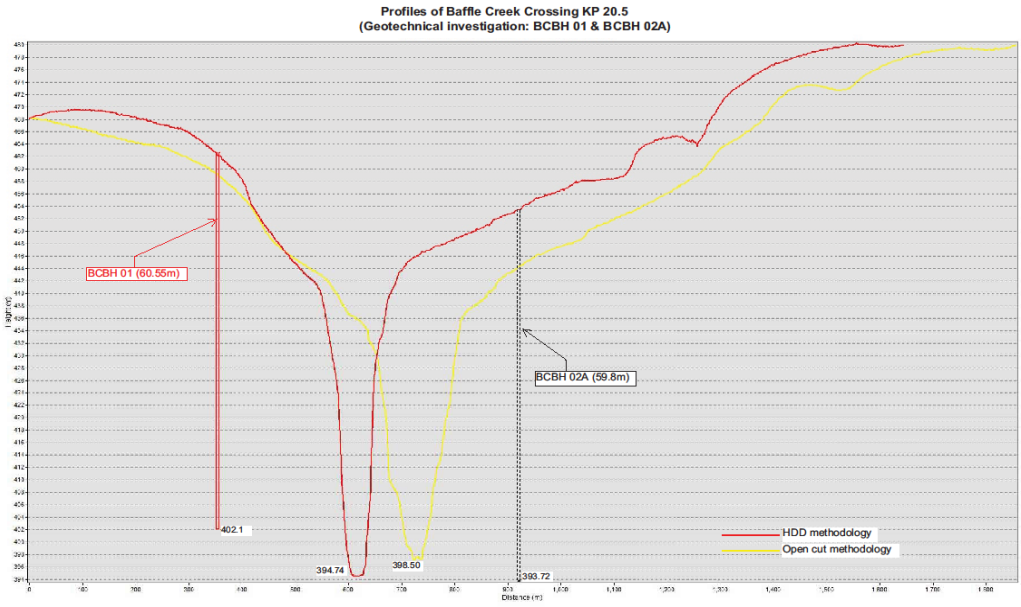



**Figure 4 - Profile drawing showing the depth of the boreholes performed with respect to baffle creek bottom.**

Borehole FRBH01A is not part of the same geological formation which characterize Baffle creek crossing.

The materials encountered in borehole FRBH01A can be summarised as a thin layer of topsoil overlying extremely weathered material and in turn highly to moderately weathered sandstone grading to slightly weathered siltstone.

**Table 2 Summary of Materials – Borehole FRBH01A – Fairview Road**

| Borehole | Materials Encountered Depth, D (m) and Reduced Level, RL (m AHD) | | | |
|---|---|---|---|---|
| | Topsoil | XW Material* | HW/MW Sandstone | SW Sandstone |
| | D: 0 - 0.7 | D: 0.7 - 7.2 | D: 7.2 - 11.9 | D: 11.9 - 20.8 |
| FRBH01A | RL: 467.5 - 466.8 | RL: 466.8 - 460.3 | RL: 460.3 - 455.6 | RL: 455.61 - 446.7 |

Notes: XW=Extremely Weathered, HW = Highly Weathered, MW = Moderately Weathered, SW = Slightly Weathered,
* = Includes some MW material and XW/HW material of very low strength

Sampling of soils consisted of standard penetration (SPT) tests or relatively undisturbed thin walled tube (U63) samples taken at typical depth intervals of 1.5m to help assess the relative density or consistency of the soil and to obtain samples for examination and laboratory testing.

Sampling of hard soils and rock consisted of continuous NMLC or NQ core which was logged and photographed on site.

**Test pits**

No.4 Test pits were performed in the area of Baffle creek crossing, and will be analysed in this report: MLTP009A, MLTP0010A, MLTP011A, MLTP012A.

The materials encountered in the test pits can be summarised as generally consisting of topsoil overlying residual soil and/or extremely weathered materials that typically graded into highly weathered sandstone and siltstone (ref. Table 3).

**Table 3 Summary of Materials – Test pits**

| Test Pit / Material | Material Encountered, Depth (m) | | | | |
|---|---|---|---|---|---|
| Fill | Topsoil | Alluvium | Residual Soil and/or XW Material | HW Sandstone, Siltstone, Claystone | MW Sandstone, Siltstone |
| MLTP009A | | 0 - 0.6 | | 0.6 - 4 | |
| MLTP010A | | 0 - 0.1 | | 0.1 - 1.6 | 1.6 - 1.9 |
| MLTP011A | | 0 - 0.1 | | 0.1 - 1.7 | 1.7 - 1.9 |
| MLTP012A | | 0 - 0.7 | | | 0.7 - 1.1 |

Notes: XW=Extremely Weathered, HW = Highly Weathered, MW = Moderately Weathered, SW = Slightly Weathered, * = Includes some MW material and XW/HW material of very low strength

The Engineering Log - Excavation of test-pits are show in Attachment B.

Sampling in the test pits consisted of bulk samples, typically taken at 0.25m below ground level and subsequently at 1m depth intervals or less if a change in lithology was observed. Tactile assessment was used to characterise the nature of the soil and rock substances. In situ tests included hand vane shear and pocket penetrometer tests to help assess the consistency of cohesive soils.

Laboratory tests performed in rock soil show the characteristics below:

| | |
|---|---|
| Wet density | from 2 to 2,6 t/m$^3$. |
| Dry density | from 1,9 to 2,5 t/m$^3$. |
| USC | from 19 to 35 MPa |
| Point Load Index | Is50 ≤ 2,8 MPa |
| Youngs Mod. | from 10 to 21 GPa |

The summary of the laboratory tests performed both boreholes and test pits is shows in Attachment C.

For further details on the laboratory/site tests and engineer log performed, refer to the document no: GEOTNEWS20400AB-AG “Factual report on main land geotechnical investigation, QLD”.

## 4.4 Geological site reconnaissance survey

A Geological survey has been carried out all along the two pipeline routes in order to describe the outcrop in the area around the crossings (see Figure 2: overview map).

The river bed of Baffle Creek shows a clear section for a complete surface rock relief where can be observed the presence of a moderately weathered and fractured brown and grey sandstone, medium and fine grained with inclusion of grained gravel crystal of quartz see photo 1).

Presence of fine grained from light grey to orange-brown sandstone, thinly sub horizontal laminated (see photo 2 and 3) has been identified locally.

At irregular intervals, there are cent metrics layers of granular conglomerate low cemented, formed by prevalently crystalline material that attested episode of deposits of high energy (see photo 4).

Occasionally it is possible to observe the presence of interlaminated layers 20-50mm thickness of dark brown labile (easily decomposable) siltstones (see photo 5).

The conglomerate layers and thin siltstone layers determine surface alterations spaced layers due to the decomposition of the material (see photo 6).

The fractures within the rock are sub vertical with little relative sliding (see photo 7).

Considering both the geotechnical investigation (boreholes) and the surface rock relief, it cab be stated that the rock formation is uniformly represented in the area and the same rocks characteristics will likely be maintained far below form the bottom of the pipeline excavation trench, as confirmed also by the boreholes.

**Photo 1 Sandstone, medium and fine grained with inclusion of grained gravel crystal of quartz**



**Photo 2 Fine grained from light grey to orange-brown sandstone, thinly sub horizontal laminated (fractured rock).**

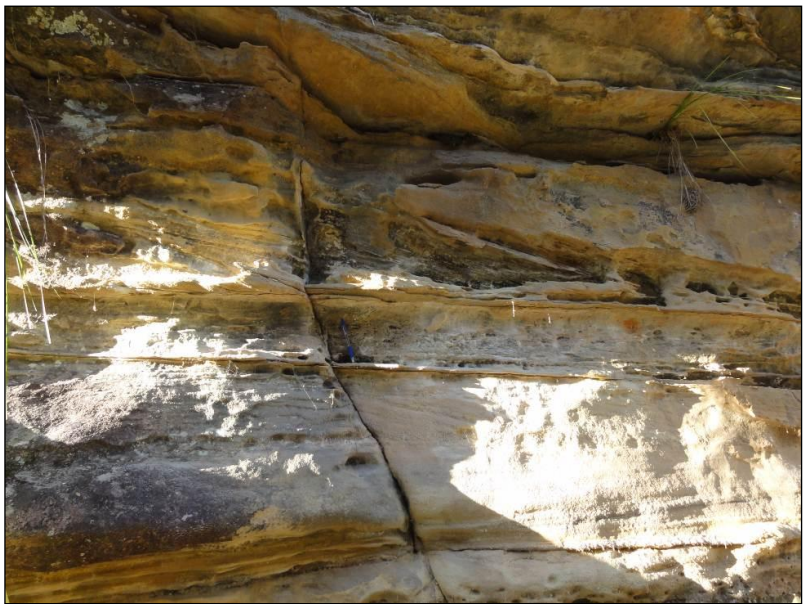


**Photo 3 Fine grained from light grey to orange-brown sandstone, thinly sub horizontal laminated**



**Photo 4 Layers of granular conglomerate low cemented**



**Photo 5 Presence of interlaminated layers 20-50mm thickness of dark brown labile**



**Photo 6 Surface alterations spaced layers**



**Photo 7 Sub vertical fractured sandstone**



**Photo 8 Overview: re-routing open trench alignment**

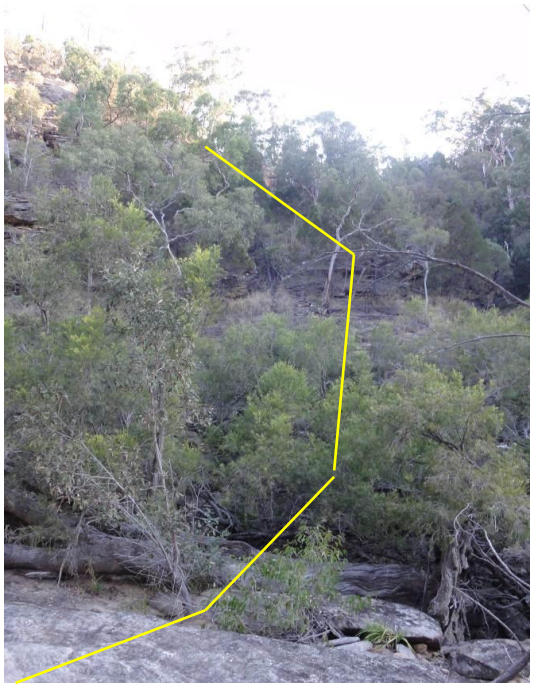


**Photo 9 Looking backwards from the river bed (open cut alignment)**



**Photo 10 Looking forward: trough crossing river bed**

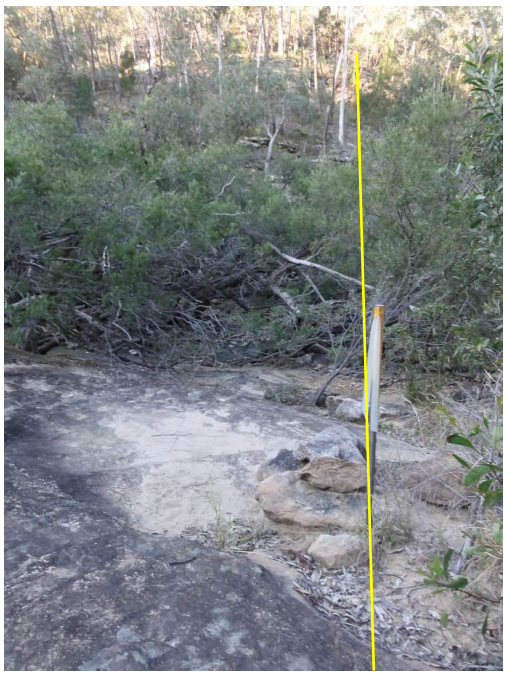
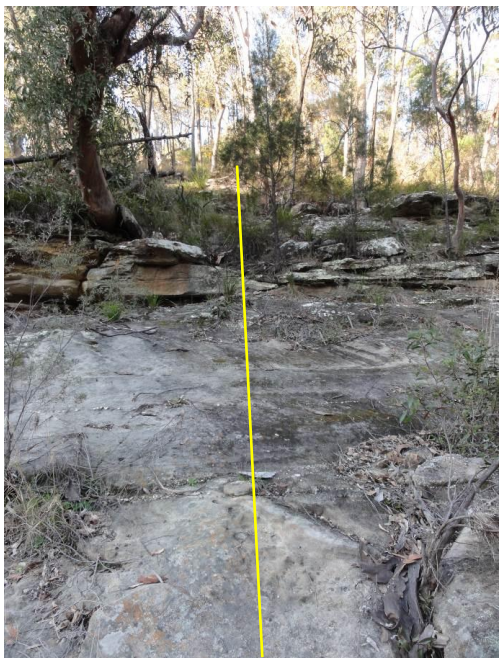


**Photo 11 Looking forward from river bed**



## 4.5 Geotechnical and hydro-geological considerations

The geotechnical investigations together with the site reconnaissance geological survey carried out, have led to the following conclusions:

- The area presents a lithological homogeneity that can exclude the possibility of stratigraphy change within the excavation range related to both the Open Cut or HDD alignments.
- The primary and secondary permeability associated respectively with the presence of granular conglomerate layers low cemented, (see photo 4) and with the presence of fractured rocks, (see photo 7), confirmed by the outcrop and by the boreholes, can represent a significant risk, in case of HDD option, in terms of blow-out, loss of circulation and drilling mud loss.
- The presence of granular conglomerate in certain layers could create difficulty in controlling the drill direction, in case of HDD application. A chance of experiencing drilling fluid loss, due to voids within the change of soil mixture, is also very high.
- The Geotechnical Laboratory Analysis shows that the values of the UCS (Uniaxial Compressive Strength), are ≤ 35 MPa and on the borehole logs, the Point Load Index Is50 are ≤ 2,8 MPa. Those values, associated to a

weathered grained sandstone, describe rock with low mechanical strength. In the HDD option the bore has to pass through layers with a lower resistance (UCS = 19 MPa), where the bore depth is about 10 m. In this case a risk of soil collapse couldn't be excluded.

- The layers of siltstone which have been identified on site and in the boreholes, are too thin and easily alterable to cause a modification of the hydrological asset in the area and therefore underflows, during the Open Cut construction method.
- Referring to the Open Cut method, both from the boreholes logs examined, and the outcrops which are clearly visible in the river bed as well as in the banks, the presence of remarkable low permeability layers that can be easily disturbed during the excavation has been excluded.
- The Open Cut method will not alter, in any way, the hydrological asset of the area, considering the homogeneity of the subsoil which will be affected by construction, and the absence of low permeability layers that could be disturbed during construction.
- In case of Open Cut methodology, based on the investigations considered so far, further direct or indirect investigations, would not add any additional knowledge respect to the information already acquired.
- Due to the high sensitivity of the HDD methodology to variations of the geotechnical conditions and considering the uncertain setting of the Baffle HDD Creek crossing, further direct and indirect geological and geotechnical investigations are necessary to delineate the eventual best drilling profile.

## 5. OPEN CUT OPTION

### 5.1 Open Cut Option Characteristics

The main characteristics of Open Cut Crossing Option are listed bellow:

- Blasting required.
- Optimum trenching time April (prior to wet season).
- If water present will require construction of causeway/minor dam and flume.
- Space required for Storage of excavated soil and rock. In the Baffle River crossing area, the ROW width is 30 m, the additional space required is 45,950 $m^2$. Figure 5 shows the localization of the these areas.
- Access tracks to both banks.
- No drilling muds required.




**Figure 5 - Additional temporay work areas for Open Trench Option**

## 5.2 Open Cut Method statement

For Open Cut Method statement refer to document No. 3380-SAIP-4-3.3-6074 “Baffle Creek Crossing Procedure (Open Cut)”

## 5.3 Open Cut Construction Risks

The installation methodology is not subject to risks. In particular:

- Installation option is not subjet to extra safety risks
- No risks related to unspected geotechnical condition of soil.
- The method is not as sensitive to variation in the geotechnical conditions of the soil as HDD.
- Instalaltion methodology is not critical for installation failure. Safer and more friendly for pipe coating.

# 6. HORIZONTAL DIRECTIONAL DRILLING OPTION

## 6.1 Characteristics of HDD option

The main characteristics of HDD of Baffle Creek crossing are listed below:

*Profile characteristics*

The preliminary design of the HDD crossing is based on the drawing profile attached in Attachment D. The main geometrical characteristics are the following:

- Entry angle: 8°
- Exit angle: 9°
- Radius of curvature: 1800 m
- Length: 1455 m
- Minimum cover in the creek bed: 10 m

*Bentonite mud amounts*

HDD methodology requires large amounts of bentonite. Based on typical mud requirements (volume per linear meter of HDD of 4 m3/m in gravel and sand, and 2.5 $m^3$/m in compact soil and rock), a preliminary estimate indicate that approximately 5,500 $m^3$ to 9,000 $m^3$ of drilling fluid will be required. Typically, approximately 30% of drilling fluid is recovered in silt and sand, and 70% in compact soil and hard rock. Hence, a large volume of drilling fluid and drill cuttings will require disposal at the conclusion of drilling.

*Water amounts*

Methodology requires large amounts of water to make up the drilling mud and buoyancy control system. This quantity is variable from 7,000 to 10,000 $m^3$.

Water supply mud treatment and disposal are critical.

*Mud returns line*

A steel line will be pulled across the Baffle Creek at first and used as mud return line for drilling the main line. A HDPE duct will be pulled across the Steel line, after the works and will be used to protect the fibre optic cable.

*Drilling*

The pilot holes will be drilled with a mud motor and a milled tooth bit. There will be more or less six reaming passes (e.g.: 18", 24", 34", 40", 48" and 56“, for the installation of OD 42” pipeline, 56” is the minimum diameter of the hole).

*Temporary work areas*

We have considered at this stage, that the pilot holes for all crossings will be drilled from downstream to upstream (see Figure 2). Prior to mobilization, the temporary

work areas is prepared and enclosed. Typical temporary working areas for H.D.D. are the following:

- Rig pad area: from 1200 $m^2$ to 4000 $m^2$
- String prefabrication area (on the H.D.D. alignment): 800 m x 30 m (ROW width). String length is a half of the HDD length, pipe pull-back must be stopped for one welding work.

Two mud pits of 200/500 $m^3$ capacity each will be excavated for mud storage purpose.

The rig will be anchored using sheet-piles or concrete wall, perpendicular to the drill axis, near the entry point.

*Temporary access tracks*

The access to the Rig area from the exiting road will be built strong enough for heavy trucks circulation, even during bad weather. The 400-700 tons drilling rig will be transported at site by trailer.

## 6.2 Method statement of HDD drilling works

*Pilot hole*

The pilot hole will be drilled with a with a jet assembly or/and a mud motor, using a milled tooth bit. The direction of the drilling can be controlled.
A down hole steering probe positioned behind the bit in a non-magnetic housing monitors the position of the drill. The signal will be then transmitted up the drill string to a read-out in the control unit. Data collected to be made to record the progress and position of the pilot hole.
An additional positioning system could be is used for better accuracy of the drilling (Para-Track system).

*Reaming*

Upon completion of the pilot hole, the down-hole assembly will be disconnected and a reaming tool will be connected to the wash pipe. The hole will be back reamed by rotating the down-hole assembly using the drilling rig. Drill pipes will be continuously added behind the tool so that there are always drill pipes in the hole.
During reaming, the mud recovered at the pipe side will be pumped back to the rig site using the mud return line in order to be cleaned and re-used.

*Pull back*

A swabbing will be carried out prior to the pullback operation. The pulling head will be welded to the extremity of the product pipe. A launching ramp will be made using

rollers so that the pipe string will gets the proper entry angle before entering into the hole.
The pulling head will be connected to a swivel bearing (to prevent the pipeline turning), a barrel reamer (to ensure that the hole is clear) and to the drill strings.
The pipe string will be continuously pulled back from the rig side by rotating the drill string into the reamed hole, fully lubricated with the drilling mud. In the meantime, water will be pumped inside the pipeline, for buoyancy control.

*Drilling fluid*

The drilling mud has physical characteristics designed to preserve the integrity of the drilled hole, remove cuttings, and lubricate the bit and the down-hole tools. Bentonite is used and the mud is fabricated with sweet water (about 40/50 Kg/$m^3$).
During the pilot hole phase, the mud returns at the rig side and is pumped into the first mud pit. The recycling unit separates the cuttings from the fluid, which is than transferred into the second pit. The cleaned mud is available again to be pumped into the hole.
During the back-reaming and pulling operations, most of the fluid returns to the pipe side. The fluid is cleaned from the sand and pumped back to the rig site using the mud return line installed prior starting drilling for the pipeline products.
Bentonite is naturally occurring swelling clay, which contains mineral montmorilonite as a major component. During HDD works, the drilling fluid is carrying away the soil cuttings. At the end of the job, the remaining fluid and the dry cuttings will be transported to a rubbish dump.

## 6.3 Equipment

The following equipment will be mobilised:

*Drilling equipment*

- Drilling Rig: It consists of a centre beam rack with a carriage moving by pinions powered by hydraulic motors. Hydraulic rotary motors located on the carriage provide the necessary rotary power to a power sub. A specially designed thrust box is incorporated to isolate the rotary motors from the pull and thrust forces required to drill and install pipelines. The soundproofed Power Packs provides sufficient horsepower to the Rig.
- Control Unit: The Control Unit is specially designed and manufactured to serve as the operator's station for the Drill Rig system. A Control Unit consists of a container. The driller's console consists of controllers to operate the drilling carriage, hydraulic pressure gauges for monitoring torque, pull and push, speed, mud flow and mud pressure.
- Drilling Fluid Mixing Unit: it is specially designed and manufactured to mix and supply drilling fluid for the Drill Rig. The Drilling Fluid Mixing Unit consists of a tank complete with piping, manifolds, electrical submersible pumps, agitating

fans, and mixing hoppers complete with all necessary piping. The unit, skid mounted is designed and piped to mix and pump drilling fluid simultaneously.

- Two High Pressure Pumping Units: The Drilling Fluid Pumping Unit consists of two triplex pumps, powered by a diesel engine. Each unit is container mounted, and comes complete with an electrical panel, automatic shutdown system, torque converter etc.
- Pumps: In order to insure all fluid transfers. The pumps are capable of a maximum flow rate. They are also used in case of frac-out.
- Drilling Fluid Recycling Unit: The Drilling Fluid Recycling Unit is specially designed and manufactured to clean and reprocess the drilling fluids. This Recycling Unit consists of desanding and desilting units. These self-contained units utilise electric powered centrifugal pump to process the drilling fluid through the various stages.
- Mud return pumps
- Crane for handling the drill pipes.
- Rollers
- Container workshop.
- Container with spare parts

*Down-hole equipment*

- Guidance system: Consisting of a magnetic guidance system probe, with remote units, a driller's console, a computer and a printer.
- Non-magnetic drill pipe: Consisting of two stainless steel non-magnetic joints, and one non-magnetic collar, these pipes will be used as housings for the guidance probe.

- Drill pipe: Drill pipes are necessary to achieve these crossings.
- Drilling assembly: consists of a jetting assembly and/or a mud motor, equipped with Milled Tooth / rock drilling bit and one pressure sub.
- Reamers: Specific Barrel Reamers are necessary to enlarge the holes and pull the pipe strings.
- Swivel: Swivel are used for the connection between the pull head and the drilling string to avoid the product pipe rotation during pulling.

## 6.4 Horizontal Directional Drilling Construction Risks (General)

*[extract from: North American Society for Trenchless Technology, No-Dig Show 2012, Nashville TN March 11-15, 2012 Paper E-4-01 "Investigation of Horizontal Directional Drilling Construction Risks"]*

Referring to the bibliography published, in general, the most important risk events than can be verified during the HDD construction are the following:

1. **Frac-out**. An event in which drilling fluid has escaped the confines of the borehole and has come to surface.
2. **Collapsing Soil / Lost Hole.** An event in which a section of the borehole has collapsed resulting in a loss of a section of the borehole.
3. **Loss of Circulation.** An event in which drilling fluid has stopped flowing to either the entry or exit point but is being lost into the ground with no inadvertent flow to surface (frac-out).
4. **High Annular Pressure.** An event in which the drill bit is tripped back or completely out of the borehole in an attempt to clean the borehole and lower the annular pressure.
5. **Tripping to Clean/Gauge Hole.** An event in which the drill bit or reamer was tripped out of the borehole to mechanically clean the cuttings from the borehole and/or gauge the borehole.
6. **Stuck in hole**. An event in which the drill pipe is stuck in the borehole.
7. **Flow to Exit**. An event in which remedial action is taken in response to drilling fluid flowing to exit.
8. **Drilling Fluid / Solids Control Work.** An event in which production or event remediation cannot proceed until the drilling fluid in built or modified, or until solids (cuttings) have been cleaned out of the holding area.
9. **Hung Up on Casing.** An event in which the BHA or the product line will not enter the casing when casing has been installed.

10. **Damaged Product line.** An event in which the product line or product line coating has been damaged to the point that redial action must be taken.
11. **Product line Stuck in Hole.** An event in which the product line has become stuck in the hole and cannot be pulled any further toward the entry point.

Other events depend on the errors in the positional data, failures in the equipment, wait on equipment / services, etc. Some of those events are listed below:

- **Inspect/change Bottom Hole Assembly.** An event which the bottom hole assembly (BHA) was ripped out of the borehole to inspect or change some aspect of the Bottom Hole Assembly, usually the drill bit or reamer.
- **Wait on Vacuum Truck**. An event in which production (active drilling or reaming operations for example) have been stopped while waiting for drilling fluid to be recovered from a frac location or from exit side. This event may also apply to waiting for a vacuum truck to empty holding pits or holding tanks that are full of water, drilling fluid or solids that have been produced from the borehole.
- **Wireline/Steering/Pressure Tools Failure**. An event in which a component of the navigation or annular pressure system has stopped working and has to be tripped out of the borehole for repair or replacement.
- **Downhole Tooling Failure**. An event in which the drill pipe or a component of the BHA has suffered a catastrophic failure or rapid degradation failure that does not represent normal and managed wear and tear.
- **Unscheduled Maintenance / Repair of surface Equipment**
- **Wait on Others**.
- **Wait on Equipment / Services**.
- **Pilot Hole Out of Specification / Directional Rework**.
- **Wait on Water.**
- **Weather related Delay**
- **Water production**

## 6.5 Risk assessment for HDD Baffle River crossing

With reference to the items described in section 4.5 and 5.1 and the potential risk events described in the above section, the HDD methodology for Baffle River crossing is considered associated with an EXTREME RISK profile because of the high possibility that the following events may occur.

*Events: Product line Stuck in Hole / Stuck in hole*

- Extreme risk of drilling blockage/upsets due to the length of the HDD (L= 1455 m minimum) and large diameter of the hole (minimum 56").
- High Risk of blockage due to discontinuous pipe pull back operation due to the welding operations to connect the two string sections and to relevant length of the pipe string. Contingency measures could be adopted (eg.: Provision of a Pipe Thruster)

*Events: Frac-out / Loss of Circulation*

- High risk for blow-out of bentonite at the banks due to the presence of weathered and fractured sandstone.
- The section in correspondance of creek bed is considered at extreme risk of blow-out due to the reduced hole coverage. This could lead to bentonite leakage in surface. Higher depth require longer HDD lengths.
- The primary and secondary permeability associated respectively with the presence of low cemented granular conglomerate layers, and with the presence of fractured rocks confirmed by the outcrop and by the boreholes, can represent a significant risk in terms of blow-out, loss of circulation and bentonitic mud loss.

*Events: Stuck in hole Lost / Collapsing Soil / Lost Hole*

- The presence of granular conglomerate in certain layers could create difficulty in controlling the drill direction.

*Events: Loss of circulation / Drilling Fluid / Solids Control Work*

- A chance of experiencing loss of drilling fluid, due to the voids within the change of soil mixture, is also very high.

*Events: Collapsing Soil*

- The geotechnical laboratory analysis describe rock with low mechanical strength. The bore has to pass through layers with a lower resistance (UCS = 19 Mpa). In this case a risk of soil collapse couldn't be excluded.

*Event: Damaged Product line*

- Extreme risk of damage to the pipe coating when crossing rocky soil.

*Event: Wait on Water / Water production*

- HDD Methodology requires large amounts of water to make up the drilling mud: water supply and treatment are critical.

In addition, other criticalities are:

- Two HDD drilling are required (the first for pipeline installation and the second for FOC cable installation).
- HDD method is very sensitive to variations in the geotechnical conditions. Additional geotechnical investigations are necessary to delineate the eventual best drilling profile.

## 7 RECOMANDATIONS

Based on the assessment of technical and construction risks, the HDD option for Baffle River Crossing, at the Eastern Alignment (original ROW), is considered associated with an EXTREME RISK profile for the following reasons:

- Extreme risk of drilling blockage/upsets due to the length of the HDD, to the large diameter of the hole and to the discontinuous pipe pull back operation due to the welding operations.
- High risk of bentonite frac-out at the banks due to the presence of weathered and fractured sandstone. The depth below the creek bed is considered at extreme risk of frac-out with bentonite leakage in surface of the creek bed.
- The primary and secondary permeability associated respectively with the presence of low cemented granular conglomerate layers, and with the presence of fractured rocks confirmed by the outcrop and by the boreholes, can represent a significant risk in terms of blow-out, loss of circulation and bentonitic mud loss.
- The geotechnical laboratory analysis describe rock with low mechanical strength. The bore has to pass through layers with a lower resistance. In this case couldn't be excluded a risk of soil collapse.
- Extreme risk of damage to the pipe coating due to presence of rock.
- HDD Methodology requires large amounts of water to make up the drilling mud: water supply and treatment are critical.

In addition, other criticalities are:

- Two HDD drilling are required (one being for FOC installation).

From a technical and constructability perspective, the crossing of Baffle Creek with Open Cut method on the Western Alignment is not subject to relevant risks. In particular:

- No risks related to unspected geotechnical condition of soil.
- The method is not as sensitive to variability ofthe geotechnical conditions as HDD.
- Instalaltion methodology is not critical for installation failure.
- Safer and more friendly for pipe coating.

Table 4 summarizes the identified potential and residual construction risks associated with each potential watercourse crossing methods (open cut and HDD).

In conclusion, the HDD methodology is considered technically not acceptable because associated to an EXTREME RISK profile. The crossing of Baffle Creek with Open Cut method is the preferred option proposed.

This report has not taken into consideration the environmental impacts, the health and safety risks, detailed engineering scoping, scheduling of work and costing of options.

| Risks | Open Trench | H.D.D. |
|---|---|---|
| Suitability of soil geotechnical conditions | | |
| Block drilling risk due to the trenchless lenght | | |
| Blow out risk due to soil geomechanical characteristics | | |
| Unexpected geotechnal conditions | | |
| Temporary Environmental impact in the working areas | | |
| Working safety | | |
| Pipeline installation failure (coating damage) | | |
| Permit / Approval | | |
| Re-routing of pipeline route | | |
| Suitablity of pipe string temporary area | | |
| Difficulty of access to yard area (Drilling Rig side) | | |
| Suitability of Pipeline ailigment | | |
| Equpments procurement (mounths) | | (6?) |
| Timeframes (mounths) | (3) | (3,5) |
| Presence of water on the river in dry season | | |
| Complexity construction using open cut | | |
| Synthetic Degree of Criticality | | |

KEY (Degree of Criticality)
- Low
- Moderate
- High
- Extreme

**Table 4 - Qualitative risk analysis for HDD and Open Cut options**

## 8 ATTACHMENTS

| | |
|---|---|
| Attachment A | Engineering Log - Cored Boreholes BCBH01 and BCBH02A |
| Attachment B | Engineering Log - Excavation of test-pits. |
| Attachment C | Summary of the laboratory tests performed both boreholes and test pits. |
| Attachment D | Baffle Creek Crossing KP 20.569. Horizontal Directional Drilling preliminary profile. |

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# Engineering Log - Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 1 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model and mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648
hole diameter: 100 mm | Northing 7167449 | bearing: 005° | datum: AHD

| drilling information | | | | | | | material substance | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL | depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetrometer kPa 100 200 300 400 | structure and additional observations |
| RR | | N | | | | | | CH | **TOPSOIL; CLAY:** high plasticity, brown, some organic matter. | D | Fb | | TOPSOIL |
| | | | | | | | | CH | **CLAY:** high plasticity, brown, some sand. | D | H | | RESIDUAL SOIL |
| | | | | | 462 | 1 | | | | | | | |
| | | | | | 461 | 2 | | | Borehole BCBH01 continued as cored hole | | | | |
| | | | | | 460 | 3 | | | | | | | |
| | | | | | 459 | 4 | | | | | | | |
| | | | | | 458 | 5 | | | | | | | |
| | | | | | 457 | 6 | | | | | | | |
| | | | | | 456 | 7 | | | | | | | |
| | | | | | | 8 | | | | | | | |

**method**
HA hand auger
DT diatube
AD auger drilling*
W washbore*
R rotary drilling*
CT cable tool
V V bit
T TC bit
CB claw/drag/blade bit
RR roller/tricone bit
*bit shown by suffix e.g. ADT, WCB

**support**
M mud N nil
C casing

**penetration**
1 2 3 4
no resistance ranging to refusal

**water**
10/1/98 water level on date shown
water inflow
water outflow

**notes, samples, tests**
$U_{50}$ undisturbed sample 50mm diameter
$U_{63}$ undisturbed sample 63mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
V vane shear (kPa)
P pressuremeter
Bs bulk sample
E environmental sample
R refusal

**classification symbols and soil description**
based on unified classification system

**moisture**
D dry
M moist
W wet
Wp plastic limit
$W_L$ liquid limit

**consistency/density index**
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFGEOTECHVER7REV2.GDT FRAME TITLE: BOREHOLE DATE: 14.12.09
Form GEO 5.3 Issue 3 Rev.2

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 2 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular / general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 462 | 1 | | Continued from non-cored borehole | | | | | | |
| NMLC | | | 461 | 2 | | **SANDSTONE:** coarse grained, grey with black and white speckling, some pale brown staining, massive. ... becoming indistinctly bedded below 2m depth | MW | | | 93 | | PT2<br>PT2 |
| | | | 460 | 3 | | ... becoming distinctly bedded below 3m depth. Beds typically less than 10mm thick. | | | | | | PT2<br>PT2<br>JT1<br>JT, 70°, PL, RO, SN<br>JT1<br>PT1<br>PT, 50°, PL, Ro, CO 15mm fine sand<br>Fractured zone, 70mm thick, 0-15mm |
| | | | | 4 | | | | | | 37 | | PT1<br>Fractured zone, 80mm thick, 0-30mm<br>JT, 10°, IR, RO, CN<br>PT, 45°, PL, RO, CL, gravel infill<br>PT, 45°, CU, Ro, SN, gravel infill<br>PT, 45°, RO, CN |
| | | | 459 | | | **MUDSTONE:** grey with some pale brown staining, residual clay. | XW | | | | | |
| | | | | 5 | | **SILTSTONE:** grey, ~30° bedding about 40mm thick, pale brown. | MW | | | 88 | | PT, 45°, PL, RO, SN<br>PT, 45°, PL, RO, SN<br>PT, 30°, PL, RO, SN, sand & gravel infill<br>JT, 60°, ST, IR<br>JT, 10°, IR, RO, clay infill |
| | | | 458 | | | **SANDSTONE:** medium grained, grey with regular pale brown bedding ~30°. | | | D 3.11 | | | PT1<br>PT1<br>PT1<br>PT1 (clay infill) |
| | | | | 6 | | | | | D 0.74 A 0.95 | 89 | | PT1<br>Fracture zone, 90mm thick<br>PT1<br>PT1<br>PT2<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1 |
| | | | 457 | 7 | | | | | D 1.44 | | | PT1<br>PT1 (20mm clay infill) |
| | | | | | | **SILTSTONE:** grey, bedding ~30°. | SW | | | 96 | | PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1 |
| | | | 456 | 8 | | **SANDSTONE:** medium to coarse grained, orange-brown, bedding ~30°, spacing typically less than 10mm. | MW | | | | | |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°. PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used; barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material; no core recovered

**water**
10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; water pressure test result (lugeons) for depth interval shown (25)

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

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# Engineering Log - Cored Borehole

Borehole No. **BCBH01**
Sheet 3 of 9
Project No: **GEOTNEWS20400AA**

Client: **GLNG OPERATIONS PTY LTD**
Date started: **31.8.2009**
Principal:
Date completed: **4.9.2009**
Project: **GLNG PIPELINE PROJECT**
Logged by: **GKW**
Borehole Location: **BAFFLE CREEK**
Checked by: **ZT**

drill model & mounting:HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648
hole diameter: 100 mm Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | Is(50) MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness (particular / general) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 455 | 9 | | **SANDSTONE:** medium to coarse grained, orange-brown, bedding ~30°, spacing typically less than 10mm. *(continued)* | MW | | | | | PT1 |
| | | | | | | **SILTSTONE:** grey with dark grey bedding ~30°. | | | | | | PT1 |
| | | | | | | **SANDSTONE:** fine grained, grey with pale brown staining, distinctly bedded, spacing typicall less than 10mm. ... becoming coarse grained and indistinctly bedded. | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | JT1 |
| | | | | | | | | | | | | PT1 (5mm clay infill) |
| | | | | | | | | | | | | PT1 (4mm clay infill) |
| | | | | | | | | | | 96 | | PT2 (8mm fine sand infill) |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | Fracture zone, 160mm thick |
| | | | 454 | 10 | | ... with coarse grained quartz inclusions. | | | | | | |
| | | | | | | | | | | 100 | | |
| | | | 453 | 11 | | | | | | | | |
| | | | | | | ... becoming distinctly bedded, typically spaced less than 15mm. ... with 30mm inclusions of fine to medium subrounded gravel. | | | | | | JT, 65°, PL, closed (healed), SN |
| | | | | 12 | | ... becoming indistinctly bedded. | | | | | | PT2 |
| | | | 452 | | | ... becoming distinctly bedded, spacing typically less than 15mm. | | | | | | PT1 |
| | | | | | | | | | | 100 | | PT1 |
| | | | | 13 | | | | | D 0.89 A 1.68 | | | PT1 |
| | | | | | | | | | | | | PT2 (IR) |
| | | | 451 | | | ... becoming medium grained. Small void in core ~15mm, and locally red brown. | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | 14 | | | | | D 3.13 | | | PT1 |
| | | | | | | | | | | | | PT1 (2mm clay inclusion) |
| | | | | | | | | | | | | PT1 |
| | | | 450 | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | 15 | | | | | D 1.92 | 94 | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | 449 | | | | | | | | | PT1 |
| | | | | 16 | | | | | | | | PT1 |

**method**
DT diatube
AD auger drilling*
W washbore*
CB claw/drag/blade bit
RR roller/tricone bit
NMLC NMLC core
NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used
barrel withdrawn

**graphic log/core recovery**
core recovered
- graphic symbols indicate material
no core recovered

**water**
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
water pressure test result (lugeons) for depth interval shown (25)

**weathering**
FR fresh
SW slightly weathered
MW moderately weathered
HW highly weathered
XW extremely weathered
DW distinctly weathered (covers MW and HW)

**strength**
VL very low
L low
M medium
H high
VH very high
EH extremely high

**defect type**
JT joint
PT parting
SM seam
SZ sheared zone
SS sheared surface
CS crushed seam

**roughness**
VR very rough
RO rough
SO smooth
SL slickensided

**planarity**
PL planar
CU curved
UN undulating
ST stepped
IR irregular

**coating**
CN clean
SN stained
VN veneer
CO coating

Form GEO 5.5 Issue 3 Rev. 3 PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE DATE: 5.2.10

coffey geotechnics

# Engineering Log - Cored Borehole

| | | | |
|---|---|---|---|
| Borehole No. | **BCBH01** | | |
| Sheet | 4 of 9 | | |
| Project No: | **GEOTNEWS20400AA** | | |
| Client: | **GLNG OPERATIONS PTY LTD** | Date started: | **31.8.2009** |
| Principal: | | Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** | Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** | Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness (particular / general) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 448 | 17 | | **SANDSTONE:** fine grained, grey with pale brown staining, distinctly bedded, spacing typicall less than 10mm. *(continued)* ... becoming medium to coarse grained. | MW | | | 94 | | PT2<br>PT2<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1 |
| | | | | | | ... becoming coarse grained. | | | | | | PT1, 5mm fractured zone<br>PT1, 12mm fractured zone<br>PT1, 10mm fractured zone<br>JT1<br>PT1 |
| | | | 447 | 18 | | ... with red speckling. | | | | | | PT1<br>PT1<br>JT1 |
| | | | | | | ... becoming fine grained, grey with dark grey and pale brown bedding ~30°, spacing typically less than 15mm. | | | | 84 | | PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1<br>PT1 |
| | | | 446 | 19 | | | SW | | | | | |
| | | | 445 | 20 | | | | | | | | PT1<br>PT1<br>PT1 |
| | | | | 21 | | ... becoming light grey with some light brown staining. | | | | | | PT1<br>PT1<br>PT1<br>PT1 |
| | | | 444 | | | | | | | 92 | | PT1 |
| | | | | 22 | | | | | | | | PT1<br>PT1 spaced every 2mm to 5mm up to 22.14m depth<br>PT1<br>PT1<br>JT1 |
| | | | 443 | 23 | | | | | | | | PT1 |
| | | | | | | | | | | 87 | | JT1<br>PT2<br>PT2 |
| | | | 442 | 24 | | | | | | | | |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°, PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**: casing used; barrel withdrawn

**graphic log/core recovery**: core recovered - graphic symbols indicate material; no core recovered

**water**: 10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; 25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 5 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular / general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 441 | 25 | | **SANDSTONE:** fine grained, grey with pale brown staining, distinctly bedded, spacing typicall less than 10mm. *(continued)* | SW | | | 87 | | JT1 |
| | | | | | | | | | | | | JT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | Fracture zone, 60mm thick |
| | | | | | | | | | | | | PT1 |
| | | | | | | ... becoming fine grained. | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1, (3mm fine sand infill) |
| | | | | 26 | | | | | | | | PT1 |
| | | | 440 | | | | | | | | | Fractured zone, 130mm thick |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | JT1 |
| | | | | 27 | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | 439 | | | | | | | 95 | | PT1 |
| | | | | | | | | | | | | JT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | 28 | | | | | D 1.48 A 2.64 | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | 438 | | | | | | | | | PT1 |
| | | | | | | | | | | | | Fractured zone, 40mm thick |
| | | | | 29 | | | | | D 1.26 | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1, 5mm infill |
| | | | 437 | | | ... becoming medium to coarse grained. | | | D 1.44 | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | | 30 | | | | | | 94 | | PT1 |
| | | | | | | | | | | | | JT1 |
| | | | 436 | | | | | | | | | JT1 |
| | | | | 31 | | | | | | | | JT1 |
| | | | | | | | | | | | | PT1 |
| | | | | | | | | | | | | PT1 |
| | | | 435 | 32 | | | | | | | | JT1 |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°, PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**

- casing used
- barrel withdrawn

**graphic log/core recovery**

- core recovered - graphic symbols indicate material
- no core recovered

**water**

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

coffey geotechnics

# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 6 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: **GLNG OPERATIONS PTY LTD** | Date started: **31.8.2009** |
| Principal: | Date completed: **4.9.2009** |
| Project: **GLNG PIPELINE PROJECT** | Logged by: **GKW** |
| Borehole Location: **BAFFLE CREEK** | Checked by: **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength VL L M H VH EH | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm 30 100 300 1000 3000 | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 434 | 33 | | ... coarse grained band 70mm wide. | MW/SW | | | 71 | | JT | |
| | | | | | | **SANDSTONE:** fine grained, pale grey with some pale brown bedding ~30°, spacing typically less than 10mm. | | | | | | PT1 | |
| | | | | | | ... with 10mm coarse subangular grained SAND, red-brown. | | | | | | PT1, (fine rounded gravel infill, 5mm) | |
| | | | 433 | 34 | | ... 33.70-33.82m: with some fine subangular grained gravel. | | | | | | PT1 | |
| | | | | | | **SANDSTONE:** medium to coarse grained, angular, pale grey with some pale brown bedding ~30°, spacing typically less than 10mm; and fine grained subangular gravel of sandstone, bedding ~30°. | SW | | | | | PT1 | |
| | | | 432 | 35 | | ... becoming coarse grained | MW/SW | | | 100 | | PT1 | |
| | | | | 36 | | ... 35.8-36.0m: with pale brown staining. ... 35.95-36.45m: with angular gravel, bedding ~30° 15-40mm spacings, 5-10mm wide. | | | | | | PT1 | |
| | | | 431 | 37 | | | | | | | | PT1 | |
| | | | 430 | 38 | | ... with some purple staining. | | | | | | PT1 | |
| | | | | | | ... 38.42-38.51m: with pale brown staining. | | | | 100 | | PT1 | |
| | | | 429 | 39 | | | | | | | | PT1 | |
| | | | | 40 | | ... 39.56-40.05m: with pale brown staining. | | | | | | PT1 | |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°, PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**: casing used; barrel withdrawn

**graphic log/core recovery**: core recovered - graphic symbols indicate material; no core recovered

**water**: 10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; water pressure test result (lugeons) for depth interval shown (25)

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

coffey geotechnics

# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 7 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 427 | 41 | | **SANDSTONE:** medium to coarse grained, angular, pale grey with some pale brown bedding ~30°, spacing typically less than 10mm; and fine grained subangular gravel of sandstone, bedding ~30°. *(continued)* | MW/SW | | | 100 | | PT1 | |
| | | | 426 | 42 | | ... 41.40-43.01m: some red stained bedding at ~30°, typically spaced 20mm to 300mm apart.<br>... with coarse grained bands. | | | | 100 | | | |
| | | | 425 | 43 | | | | | | | | | |
| | | | 424 | 44 | | ... 43.95-43.98m: with bedding ~30° of fine angular gravel of quartz.<br>... 44.05-44.12: with bedding ~30° of fine angular gravel of quartz.<br>... 44.15-44.31m: with orange staining.<br>**SANDSTONE:** medium grained, pale grey, subangular grains with some 30° bedding, typically less than 20mm apart. Some beds of coarse grained angular sand of quartz.<br>... 44.42-44.61m: with bedding ~30° of fine angular gravel of quartz, typically less than 15mm apart.<br>... 44.7-44.81m: with bedding ~30° of fine angular gravel of quartz, typically less than 20mm apart.<br>... 44.91-45.85m: with 30° red staining.<br>... 46.0-46.40m: with some red mottling. | | | | | PT1<br>JT1<br>PT1<br>PT1 | |
| | | | 423 | 45 | | | | | | 100 | | | |
| | | | 422 | 46 | | | | | | | | | |
| | | | | 47 | | ... 47.25-47.30m: brown staining. | | | D 0.54 | 96 | | PT1<br>PT1<br>PT1 | |
| | | | | 48 | | | | | | | | | |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°, PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used
barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material
no core recovered

**water**
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 8 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering / alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 421 | | | **SANDSTONE:** medium grained, pale grey, subangular grains with some 30° bedding, typically less than 20mm apart. Some beds of coarse grained angular sand of quartz. *(continued)* | MW/SW | | D 1.28 | | | PT1, JT1, PT1 | |
| | | | | 49 | | ... 48.42-48.62m: bedding ~30°, coarse sandstone, spacing typically less than 30mm. | | | | | | PT1, PT1 | |
| | | ◁ | 420 | | | ... with fine grained angular gravel of sandstone. | | | D 1.06 | 96 | | PT1, PT1 | |
| | | | | | | ... with coarse sandstone and fine angular gravels with grey clay infill. | | | | | | | |
| | | | | | | ... no water return. | | | | | | | |
| | | | | 50 | | ... with some pale brown staining. | | | | | | PT2 | |
| | | | 419 | | | | | | | | | PT2 | |
| | | | | 51 | | ... 51.05-51.20m: with black mottling. | | | | | | PT1 | |
| | | | | | | ... 51.35-53.60m: with some 30° bedded pale brown staining, typically less than 20mm apart. | | | | 100 | | PT2 | |
| | | | 418 | | | | | | | | | PT1 | |
| | | | | 52 | | | | | | | | | |
| | | | | | | | | | | | | PT1 | |
| | | | 417 | | | | | | | | | PT1 | |
| | | | | 53 | | | | | | | | | |
| | | | | | | ... 53.24-53.45m: with fine to medium angular and subangular gravels of sandstone cemented into medium grained sandstone. | | | | | | PT1, PT1, PT1 | |
| | | | 416 | | | | | | | | | | |
| | | | | 54 | | | | | | | | | |
| | | | | | | ... 54.25-54.30m: fine subangular gravels of sandstone, well cemented. | | | | 99 | | PT1, PT1, PT1 | |
| | | | 415 | 55 | | | | | | | | PT1 | |
| | | | | | | | | | | | | PT1 | |
| | | | | | | ... 55.40-59.75m: with regular 30° bedded coarse sand, spacing typically less than 20mm, well cemented, subangular, 5-45mm thick. | | | | | | PT2 | |
| | | | | 56 | | | | | | | | | |

Generally defects are: PT1: PT, 20° to 40°, PL, RO, CN or SN, PT2: PT, 0° to 20°, PL, RO, CN, or JT1: JT, 45°, PL, RO, SN

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**

- casing used
- barrel withdrawn

**graphic log/core recovery**

- core recovered - graphic symbols indicate material
- no core recovered

**water**

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- water pressure test result (lugeons) for depth interval shown (e.g. 25)

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

coffey geotechnics

# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH01** |
| Sheet | 9 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **31.8.2009** |
| Principal: | |
| Date completed: | **4.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **GKW** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 687704 | slope: -60° | R.L. Surface: 462.648

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167449 | bearing: 005° | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | | 414 | 57 | | **SANDSTONE:** medium grained, pale grey, subangular grains with some 30° bedding, typically less than 20mm apart. Some beds of coarse grained angular sand of quartz. *(continued)* | MW/SW | | | | | PT1 | |
| | | | | | | ... 56.0-56.48m: with 30-45° bedding, spacing typically less than 15mm, dark brown staining 2-15mm thick. | | | | | | PT1 | |
| | | | 413 | | | ... with regular 30° bedding, spacing typically less than 20mm, pale red, 10-25mm thick. | | | | | | PT1 | |
| | | | | 58 | | | | | | 94 | | JT1 | |
| | | | | | | | | | | | | PT1 | |
| | | | 412 | | | | | | | | | PT1 | |
| | | | | 59 | | | | | | | | PT1 | |
| | | | | | | | | | | | | PT1 | |
| | | | 411 | | | | | | | | | PT1 | |
| | | | | 60 | | **SANDSTONE:** coarse angular to subangular grained, pale brown, distincly bedded at about 25°, spacing typically less than 20mm. With some fine grained subangular gravel of quartz. | | | | 100 | | PT1 | |
| | | | | | | BCBH01 terminated at 60.55m | | | | | | | |
| | | | 410 | 61 | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | 409 | 62 | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | 63 | | | | | | | | | |
| | | | 408 | | | | | | | | | | |
| | | | | 64 | | | | | | | | | |

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**

- casing used
- barrel withdrawn

**graphic log/core recovery**

- core recovered - graphic symbols indicate material
- no core recovered

**water**

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE DATE: 5.2.10

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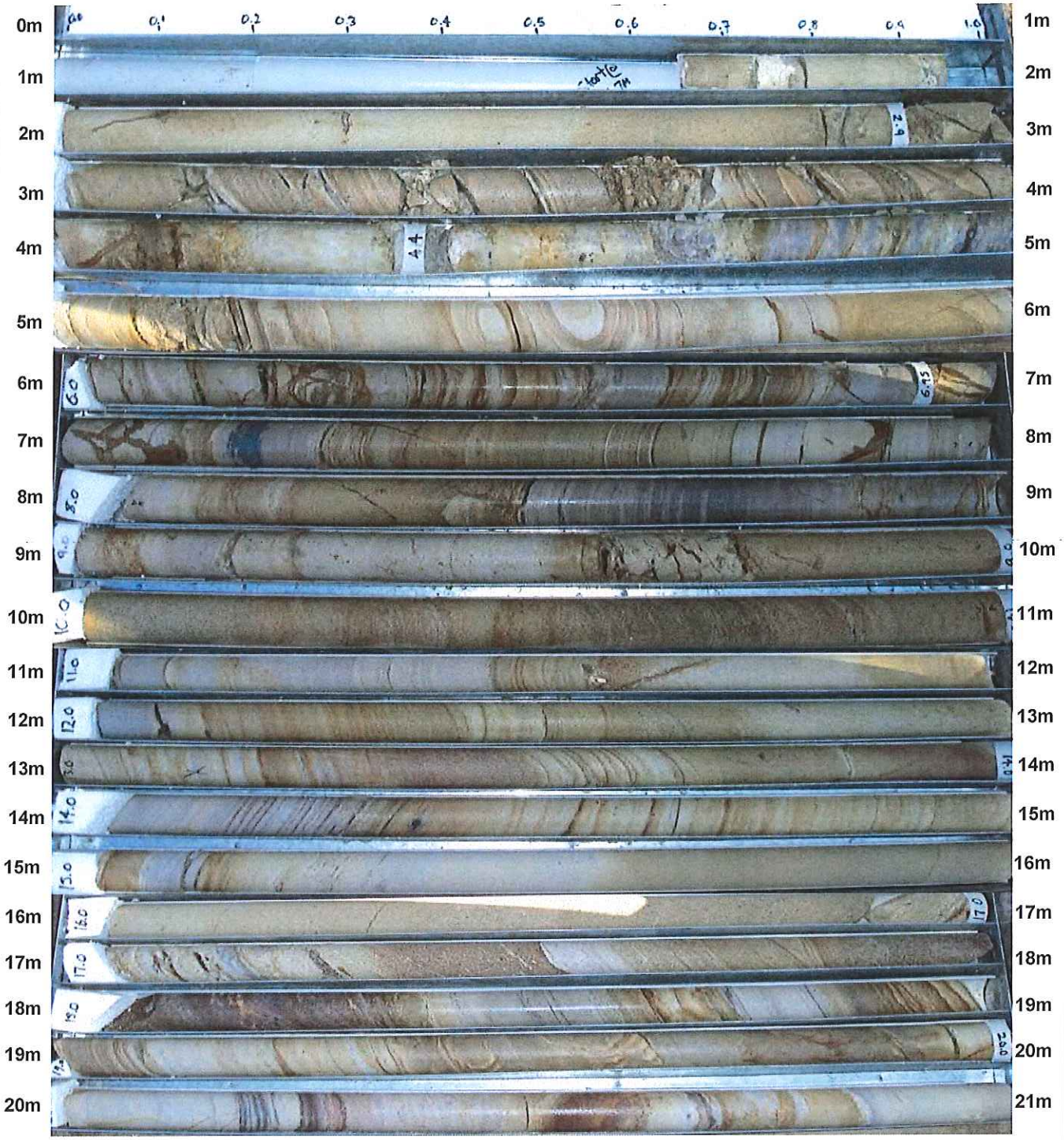
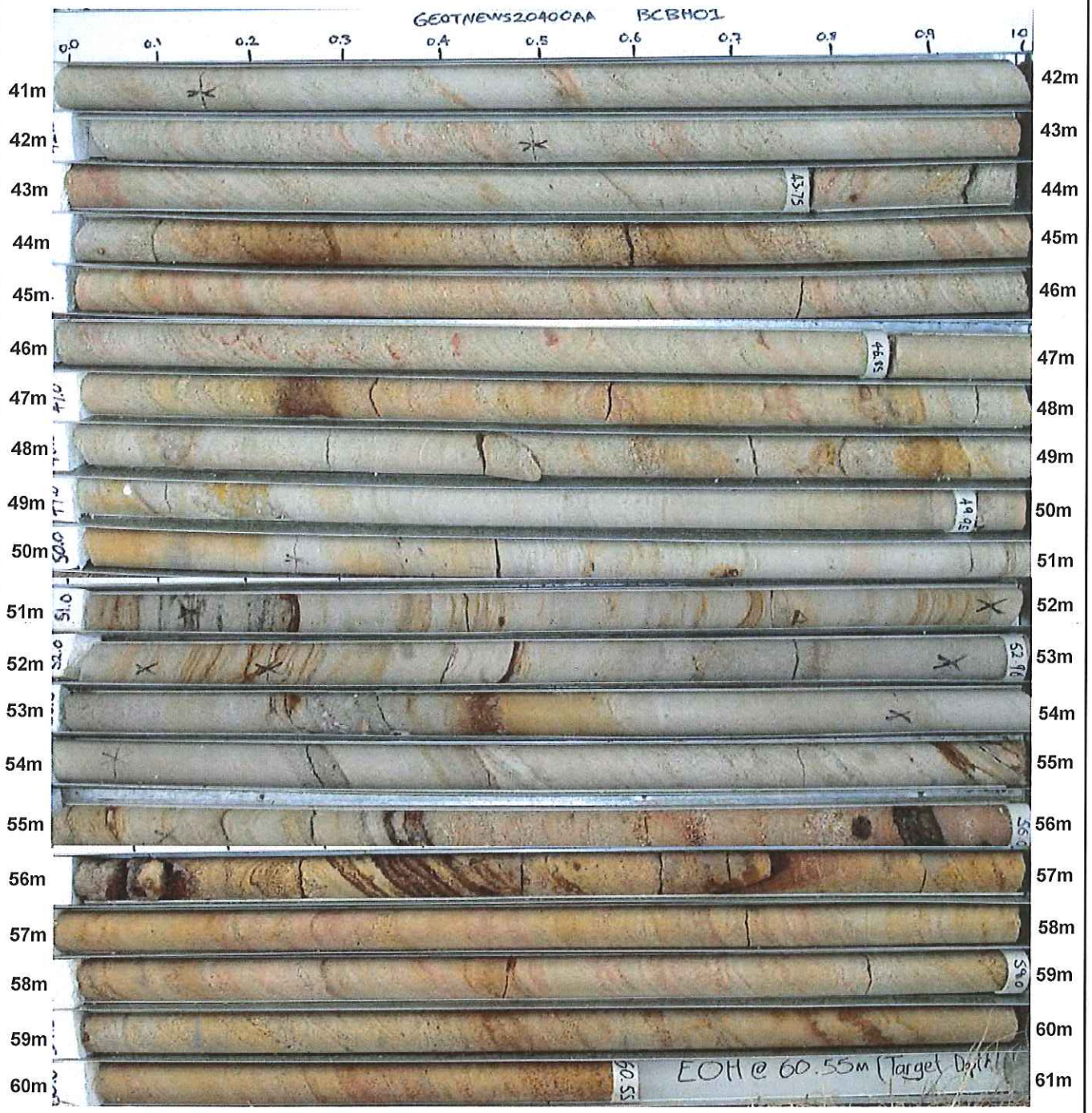



| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB01, 1.7m - 21m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |




| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB01, 21m - 41m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |




| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB01, 41m - 60.55m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |

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# Engineering Log - Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 1 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model and mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516
hole diameter: 100 mm | Northing 7167772 | bearing: | datum: AHD

**drilling information** | **material substance**

| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL | depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetro-meter kPa 100 200 300 400 | structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADT | | C | | | 453 | 1 | | SP | **TOPSOIL; Silty SAND:** Low plasticity, yellow brown. Angular and subangular fine to coarse grained sand. Some medium grained low strength gravel of sandstone | D | D-VD | | TOPSOIL |
| | | M | | | | | | | **SANDSTONE:** medium grained, indistinctly bedded, sub-horizontal, typically <5mm thick, pale grey, locally mottled orange brown, moderately weathered, assessed as low to medium strength. | | | | MW/SW SANDSTONE |
| | | | NONE OBSERVED | | 452 | 2 | | | Borehole BCBH02A continued as cored hole | | | | |
| | | | | | 451 | 3 | | | | | | | |
| | | | | | 450 | 4 | | | | | | | |
| | | | | | 449 | 5 | | | | | | | |
| | | | | | 448 | 6 | | | | | | | |
| | | | | | 447 | 7 | | | | | | | |
| | | | | | 446 | 8 | | | | | | | |

**method**
HA hand auger
DT diatube
AD auger drilling*
W washbore*
R rotary drilling*
CT cable tool
V V bit
T TC bit
CB claw/drag/blade bit
RR roller/tricone bit
*bit shown by suffix e.g. ADT, WCB

**support**
M mud N nil
C casing

**penetration**
1 2 3 4 — no resistance ranging to refusal

**water**
10/1/98 water level on date shown
water inflow
water outflow

**notes, samples, tests**
$U_{50}$ undisturbed sample 50mm diameter
$U_{63}$ undisturbed sample 63mm diameter
D disturbed sample
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
V vane shear (kPa)
P pressuremeter
Bs bulk sample
E environmental sample
R refusal

**classification symbols and soil description**
based on unified classification system

**moisture**
D dry
M moist
W wet
Wp plastic limit
$W_L$ liquid limit

**consistency/density index**
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ. LIBRARY FILE: COFGEOTECHVER7REV3.GLB. TEMPLATE FILE: COFGEOTECHVER7REV2.GDT FRAME TITLE: BOREHOLE. DATE: 14.12.09

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 2 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness (particular / general) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Continued from non-cored borehole | | | | | | |
| NMLC | | NONE OBSERVED | 452 | 2 | | **SANDSTONE:** medium grained, pale grey with localised orange brown mottling, distinct bedding. | SW | | | 91 | | SET 3<br>SET 1<br>JT,60°-90°,UN-CU<br>JT,90°,UN,RO,CN<br>SET 3<br>SET 1<br>1.80-2.16m: JT,90°,UN,RO,CN<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1, ST<br>SET 2<br>SET 2 |
| | | | 451 | 3 | | | | | | | | |
| | | | 450 | 4 | | | | | | | | |
| | | | 449 | 5 | | ... becoming interbedded with fine grained thinly subhorizontally laminated sandstone (bedding between 50mm and 300mm, laminae tyipcally 5mm thick) | | | | 97 | | SET 1,PL,SO<br>4.57-4.90m: JT,80°,UN,RO,CO(CLAY,HP,brown) 2mm<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 2<br>SET 1<br>SET 1,PL,SO<br>SET 1,PL,SO/ JT,45°,UN-CU,VN (CLAY)<br>SET 1<br>5.70-5.80m: JT,60°-90°,UN-CU,RO,CO (CLAY)<br>SET 1<br>SET 1<br>5.88-6.30m: JT,90°,UN,RO,CO (CLAY) 1mm<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>JT,45°,UN,RO<br>SET 1,PL,SO<br>6.39-6.62m: JT,90°,UN,RO,CO (CLAY)<br>SET 1,SO<br>SET 1,ST<br>SET 2<br>SET 2,PL,SO<br>SET 1,PL,SO<br>SET 1<br>SET 1 |
| | | | 448 | 6 | | | | | D 0.73 | | | |
| | | | 447 | 7 | | | | | D 4.61 | 96 | | |
| | | | 446 | 8 | | | | | D 2.02 | | | |
| | | | 445 | 9 | | **SILTSTONE and SANDSTONE:** Fine grained, pale grey and dark grey, distinctly thinly laminated. | | | D | 88 | | |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**
DT diatube
AD auger drilling*
W washbore*
CB claw/drag/blade bit
RR roller/tricone bit
NMLC NMLC core
NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used
barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material
no core recovered

**water**
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh
SW slightly weathered
MW moderately weathered
HW highly weathered
XW extremely weathered
DW distinctly weathered (covers MW and HW)

**strength**
VL very low
L low
M medium
H high
VH very high
EH extremely high

**defect type**
JT joint
PT parting
SM seam
SZ sheared zone
SS sheared surface
CS crushed seam

**roughness**
VR very rough
RO rough
SO smooth
SL slickensided

**planarity**
PL planar
CU curved
UN undulating
ST stepped
IR irregular

**coating**
CN clean
SN stained
VN veneer
CO coating

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ. LIBRARY FILE: COFGEOTECHVER7REV3.GLB. TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE. DATE: 14.12.09
Form GEO 5.5 Issue 3 Rev. 3

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 3 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

## drilling information

| method | core-lift | water | RL | depth metres |
|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 444 | 10 |
| | | | 443 | 11 |
| | | | 442 | 12 |
| | | | 441 | 13 |
| | | | 440 | 14 |
| | | | 439 | 15 |
| | | | 438 | 16 |
| | | | 437 | 17 |

## material substance

| graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial |
|---|---|---|---|---|
| | **SILTSTONE and SANDSTONE:** Fine grained, pale grey and dark grey, distinctly thinly laminated. *(continued)* | SW | | 0.65 |
| | ... becoming interbedded with medium grained sandstone, bedding <200mm | MW/SW | | D 2.03 |
| | **SANDSTONE:** medium grained, orange brown. Subhorizontal distinct bedding (0°-10°) | | | D 2.36 |
| | **Interlaminated SILTSTONE and SANDSTONE:** Fine grained, pale grey and dark grey. Distinctly laminated. | SW | | |
| | **SANDSTONE:** medium grained locally coarse grained, orange brown. Subhorizontal distinct bedding (0-10°) | MW | | |
| | ... locally conglomeratic with rounded and | SW | | |

## rock mass defects

| RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness (particular / general) |
|---|---|---|
| 88 | | SET 1<br>SET 1,PL,SO<br>JT,45°,UN,RO,CN<br>SET 2<br>SET 2<br>SET 1<br>SET 1,PL,SO<br>SET 1<br>SET 1<br>SET 1,PL,SO<br>SET 1,PL,SO<br>9.90-10.23m: JT,90°,UN,RO,VN (SAND, medium grained)<br>SET 1<br>SET 1<br>SET 2<br>SET 1,PL,SO<br>SET 1<br>SET 1<br>SET 2, CO<br>SET 1<br>SET 2<br>SET 2<br>SET 1<br>SET 1<br>12.04-12.57 Fracture sets: SET 1,VN, (CLAY, HP, grey) 10mm-100mm spacing<br>SET 1<br>SET 2 |
| 81 | | SET 1,CU-UN<br>13.32-14.0: JT,90°,UN,RO,VN (SAND, medium grained)<br>SET 2<br>SET 2<br>SET 2<br>SET 2<br>SET 1<br>SET 1<br>SET 1 |
| 93 | | SET 3<br>SET 1,SN (FE)<br>JT,40°,UN,RO,SN (Fe)<br>SET 1<br>SET 1<br>SET 1<br>SET 1 |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used; barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material; no core recovered

**water**
10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; water pressure test result (lugeons) for depth interval shown (25)

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE DATE: 14.12.09
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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 4 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness (particular / general) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 436 | 18 | | subrounded fine and medium grained quartz gravel (16.80-17.15m) **SANDSTONE:** medium grained locally coarse grained, orange brown. Subhorizontal distinct bedding (0-10°) *(continued)* | MW/SW | | | 93 | | VOIDS: 3X30mm, CN<br>SET 1,ST<br>SET 1<br>SET 3<br>SET 1<br>SET 2<br>SET 2<br>SET 1<br>SET 1 |
| | | | 435 | 19 | | ... becoming pale grey locally mottled orange brown | SW<br>MW/SW<br>SW | | | 95 | | SET 1/SET 3<br>SET 3<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1 |
| | | | 434 | 20 | | | | | | | | SET 1/SET3<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1,CO (CLAY) 2mm<br>SET 1,ST |
| | | | 433 | 21 | | **SANDSTONE:** fine to coarse grained, grey, mottled yellow, red-brown. Some interbedded minor conglomerate horizons. Repeating fining upward sequences (~300mm). | | | | | | |
| | | | 432 | 22 | | | | | | 100 | | SET 1<br>SET 2,CO (CLAY) 20mm<br>SET 1<br>SET 1 |
| | | | 431 | 23 | | | | | | | | SET 1 |
| | | | 430 | 24 | | | | | D<br>1.23 | 98 | | SET 1 |
| | | | 429 | 25 | | | | | | | | SET 1<br>SET 1 |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**: casing used; barrel withdrawn

**graphic log/core recovery**: core recovered - graphic symbols indicate material; no core recovered

**water**: 10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; water pressure test result (lugeons) for depth interval shown (25)

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

coffey geotechnics

# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 5 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular / general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 428 | 26 | | **SANDSTONE:** fine to coarse grained, grey, mottled yellow, red-brown. Some interbedded minor conglomerate horizons. Repeating fining upward sequences (~300mm). *(continued)* | SW | | D 1.4 | 98 | | SET 1<br>SET 1, CO (SAND, medium grained) 2mm<br>SET 2,CO (CLAY)<br>SET 1<br>SET 2 |
| | | | 427 | 27 | | | | | D 1.21 | | | SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1 |
| | | | 426 | 28 | | | | | | | | |
| | | | 425 | 29 | | ... becoming mottled red brown | | | | 99 | | SET 1<br>SET 1<br>SET 1 |
| | | | 424 | 30 | | | | | | | | SET 3<br>SET 1<br>SET 2<br>SET 1 |
| | | | 423 | 31 | | | | | | | | SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1 |
| | | | 422 | 32 | | | | | | 95 | | SET 1<br>SET 2 |
| | | | 421 | 33 | | **Interbedded SILTSTONE and SANDSTONE:** Fine grained, pale grey and dark grey. Distinctly laminated. | MW | | | 88 | | SET 1<br>SET 1,CO (CLAY) 2mm<br>SET 1<br>SET 1 |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used; barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material; no core recovered

**water**
10/1/98 water level on date shown; water inflow; partial drill fluid loss; complete drill fluid loss; 25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 6 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength VL L M H VH EH | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm 30 100 300 1000 3000 | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 420 | 34 | | **SANDSTONE:** medium grained, locally coarse grained, grey, some orange brown mottling, distinctly bedded. | MW | | | 88 | | SET 1<br>SET 1<br>SET 2<br>SET 1<br>SET 2<br>VOIDS: 3X50mm, CN<br>SET 1<br>SET 1<br>SET 1<br>SET 1,ST<br>JT,45°,UN,RO,CN<br>SET 2<br>SET 2,CO (CLAY) 2mm<br>SET 1 | |
| | | | 419 | 35 | | **Interbedded SILTSTONE and SANDSTONE:** Fine and medium grained, pale grey and dark grey, distinctly bedded.<br>**SANDSTONE:** medium grained, locally coarse grained, grey, some orange brown mottling, distinctly bedded. | SW | | | | | SET 1 | |
| | | | 418 | 36 | | | MW | | | | | SET 1,CO | |
| | | | 417 | 37 | | | SW | | | 100 | | SET 1,CO (CLAY) 1mm<br>SET 1,CO (CLAY) 1mm<br>SET 1<br>SET 1 | |
| | | | 416 | 38 | | | | | | | | SET 1,PL,SO<br>SET 1,PL,SO<br>SET 1,PL,SO | |
| | | | 415 | 39 | | ... becoming coarse grained, locally medium grained, pale grey with pink and orange brown bands | MW/SW | | D 2.16 | | | SET 1<br>SET 1,CO (CLAY) 2mm<br>SET 1 | |
| | | | 414 | 40 | | | SW | | | 100 | | SET 1 | |
| | | | 413 | 41 | | | | | D | | | SET 2 | |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used
barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material
no core recovered

**water**
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE DATE: 14.12.09
Form GEO 5.5 Issue 3 Rev. 3

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 7 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular / general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 412 | 42 | | **SANDSTONE:** medium grained, locally coarse grained, grey, some orange brown mottling, distinctly bedded. *(continued)* | SW | | 1.13 | 100 | | SET 1 |
| | | | | | | | MW/SW | | D 0.8 | | | |
| | | | 411 | 43 | | | SW | | | | | SET 1<br>SET 3<br>SET 1<br>SET 1<br>SET 3<br>SET 1<br>SET 2 |
| | | | 410 | 44 | | ... becoming with interbedded conglomerate. Fining up sequences (~300mm). | | | | 94 | | SET 2<br>SET 2 |
| | | | 409 | 45 | | | | | | | | SET 1, Infilled (SAND, course grained and GRAVEL, fine and medium grained sandstone and quartz) 40mm |
| | | | 408 | 46 | | | | | | | | SET 1 |
| | | | 407 | 47 | | | | | | 98 | | SET 1 |
| | | | | | | | MW | | | | | |
| | | | 406 | 48 | | | SW | | | | | SET 3, Infilled (SAND, course grained and GRAVEL, fine and medium grained sandstone and quartz) 40mm<br>SET 1<br>SET 1 |
| | | | 405 | 49 | | | | | | 93 | | SET 1<br>SET 1<br>SET 1<br>SET 1,VR |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**
DT diatube; AD auger drilling*; W washbore*; CB claw/drag/blade bit; RR roller/tricone bit; NMLC NMLC core; NQ, HQ, PQ wireline core
*bit shown by suffix e.g. WRR

**core-lift**
casing used
barrel withdrawn

**graphic log/core recovery**
core recovered - graphic symbols indicate material
no core recovered

**water**
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

**weathering**
FR fresh; SW slightly weathered; MW moderately weathered; HW highly weathered; XW extremely weathered; DW distinctly weathered (covers MW and HW)

**strength**
VL very low; L low; M medium; H high; VH very high; EH extremely high

**defect type**
JT joint; PT parting; SM seam; SZ sheared zone; SS sheared surface; CS crushed seam

**planarity**
PL planar; CU curved; UN undulating; ST stepped; IR irregular

**roughness**
VR very rough; RO rough; SO smooth; SL slickensided

**coating**
CN clean; SN stained; VN veneer; CO coating

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 8 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: | **GLNG OPERATIONS PTY LTD** |
| Date started: | **19.9.2009** |
| Principal: | |
| Date completed: | **22.9.2009** |
| Project: | **GLNG PIPELINE PROJECT** |
| Logged by: | **CN** |
| Borehole Location: | **BAFFLE CREEK** |
| Checked by: | **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(50)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular | general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 404 | 50 | | **SANDSTONE:** medium grained, locally coarse grained, grey, some orange brown mottling, distinctly bedded. *(continued)* | SW | | | 93 | | SET 1,VR<br>SET 1<br>SET 1<br>JT,45°,UN,RO,CN<br>SET 1<br>SET 1,CU-UN<br>SET 1 | |
| | | | 403 | 51 | | | | | | | | | |
| | | | 402 | 52 | | ... becoming coarse grained, locally medium grained | | | | | | SET 1<br>SET 1,VR<br>SET 1 | |
| | | | 401 | 53 | | | | | | 96 | | SET 1 | |
| | | | 400 | 54 | | | MW | | | | | JT,45°,UN,RO,VN (SAND, coarse grained)<br>SET 1,VN (SAND, coarse grained)<br>SET 1 | |
| | | | | | | **SANDSTONE:** fine grained, pale grey locally mottled orange brown. Thinly subhorizontally laminated (0°-10°). | SW | | | | | JT,45°,UN,RO,VN (CLAY)<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1<br>SET 1 | |
| | | | 399 | 55 | | | | | | | | | |
| | | | 398 | 56 | | | | | | 72 | | SET 2 | |
| | | | 397 | 57 | | ... becoming mottled orange brown | MW | | | | | SET 2,VN (CLAY)<br>SET 2,VN (CLAY)<br>SET 2<br>SET 2<br>SET 1<br>SET 1<br>SET 1 | |
| | | | | | | | | | | 90 | | SET 1 | |

Generally defects are partially closed to fully healed: SET 1: PT,0°,UN,RO,CN, SET 2: PT,10°,UN,RO,CN and SET 3: JT,60°,UN,RO,CN

**method**

| | |
|---|---|
| DT | diatube |
| AD | auger drilling* |
| W | washbore* |
| CB | claw/drag/blade bit |
| RR | roller/tricone bit |
| NMLC | NMLC core |
| NQ, HQ, PQ | wireline core |

*bit shown by suffix e.g. WRR

**core-lift**

- casing used
- barrel withdrawn

**graphic log/core recovery**

- core recovered - graphic symbols indicate material
- no core recovered

**water**

- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

**weathering**

| | |
|---|---|
| FR | fresh |
| SW | slightly weathered |
| MW | moderately weathered |
| HW | highly weathered |
| XW | extremely weathered |
| DW | distinctly weathered (covers MW and HW) |

**strength**

| | |
|---|---|
| VL | very low |
| L | low |
| M | medium |
| H | high |
| VH | very high |
| EH | extremely high |

**defect type**

| | |
|---|---|
| JT | joint |
| PT | parting |
| SM | seam |
| SZ | sheared zone |
| SS | sheared surface |
| CS | crushed seam |

**planarity**

| | |
|---|---|
| PL | planar |
| CU | curved |
| UN | undulating |
| ST | stepped |
| IR | irregular |

**roughness**

| | |
|---|---|
| VR | very rough |
| RO | rough |
| SO | smooth |
| SL | slickensided |

**coating**

| | |
|---|---|
| CN | clean |
| SN | stained |
| VN | veneer |
| CO | coating |

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# Engineering Log - Cored Borehole

| | |
|---|---|
| Borehole No. | **BCBH02A** |
| Sheet | 9 of 9 |
| Project No: | **GEOTNEWS20400AA** |
| Client: **GLNG OPERATIONS PTY LTD** | Date started: **19.9.2009** |
| Principal: | Date completed: **22.9.2009** |
| Project: **GLNG PIPELINE PROJECT** | Logged by: **CN** |
| Borehole Location: **BAFFLE CREEK** | Checked by: **ZT** |

drill model & mounting: HYDROPWR SCT TRUCK | Easting: 688963 | slope: -90° | R.L. Surface: 453.516

hole diameter: 100 mm | Drilling fluid: WATER | Northing: 7167772 | bearing: | datum: AHD

**drilling information** | **material substance** | **rock mass defects**

| method | core-lift | water | RL | depth metres | graphic log / core recovery | material: rock type; grain characteristics, colour, structure, minor components | weathering alteration | estimated strength (VL L M H VH EH) | $Is_{(60)}$ MPa D- diametral A- axial | RQD % | defect spacing mm (30 100 300 1000 3000) | defect description: type, inclination, planarity, roughness, coating, thickness — particular / general |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMLC | | NONE OBSERVED | 396 | 58 | | **SANDSTONE:** medium to coarse grained, orange brown. Thinly laminated with bedding <200mm between 0°-10°. Trace of rounded and subrounded fine to coarse grained gravel inclusions of chrystalline high strength rock. Some dark iron staining | MW | | | | | SET 2<br>SET 1<br>SET 1,SN (Fe)<br>SET 1,SN (Fe)<br>SET 1,SN (Fe)<br>SET 1 |
| | | | 395 | | | ... becoming pale grey | SW | | | 90 | | VOIDS: 6X15mm,VN (CLAY)<br>SET 1,SN (Fe)<br>SET 1<br>SET 1 |
| | | | | 59 | | ... becoming pale grey and orange brown | MW/SW | | | | | SET 1<br>SET 1,VR<br>SET 2 |
| | | | 394 | | | **Interlaminated SILTSTONE and SANDSTONE:** fine grained, pale grey and dark grey | SW | | | | | SET 1,CO (CLAY) 2mm<br>SET 1,ST<br>SET 2<br>SET 2 |
| | | | | 60 | | BCBH02A terminated at 59.8m | | | | | | |
| | | | 393 | | | | | | | | | |
| | | | | 61 | | | | | | | | |
| | | | 392 | | | | | | | | | |
| | | | | 62 | | | | | | | | |
| | | | 391 | | | | | | | | | |
| | | | | 63 | | | | | | | | |
| | | | 390 | | | | | | | | | |
| | | | | 64 | | | | | | | | |
| | | | 389 | | | | | | | | | |
| | | | | 65 | | | | | | | | |

**method**
- DT diatube
- AD auger drilling*
- W washbore*
- CB claw/drag/blade bit
- RR roller/tricone bit
- NMLC NMLC core
- NQ, HQ, PQ wireline core

*bit shown by suffix e.g. WRR

**core-lift**
- casing used
- barrel withdrawn

**graphic log/core recovery**
- core recovered - graphic symbols indicate material
- no core recovered

**water**
- 10/1/98 water level on date shown
- water inflow
- partial drill fluid loss
- complete drill fluid loss
- 25 water pressure test result (lugeons) for depth interval shown

**weathering**
- FR fresh
- SW slightly weathered
- MW moderately weathered
- HW highly weathered
- XW extremely weathered
- DW distinctly weathered (covers MW and HW)

**strength**
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

**defect type**
- JT joint
- PT parting
- SM seam
- SZ sheared zone
- SS sheared surface
- CS crushed seam

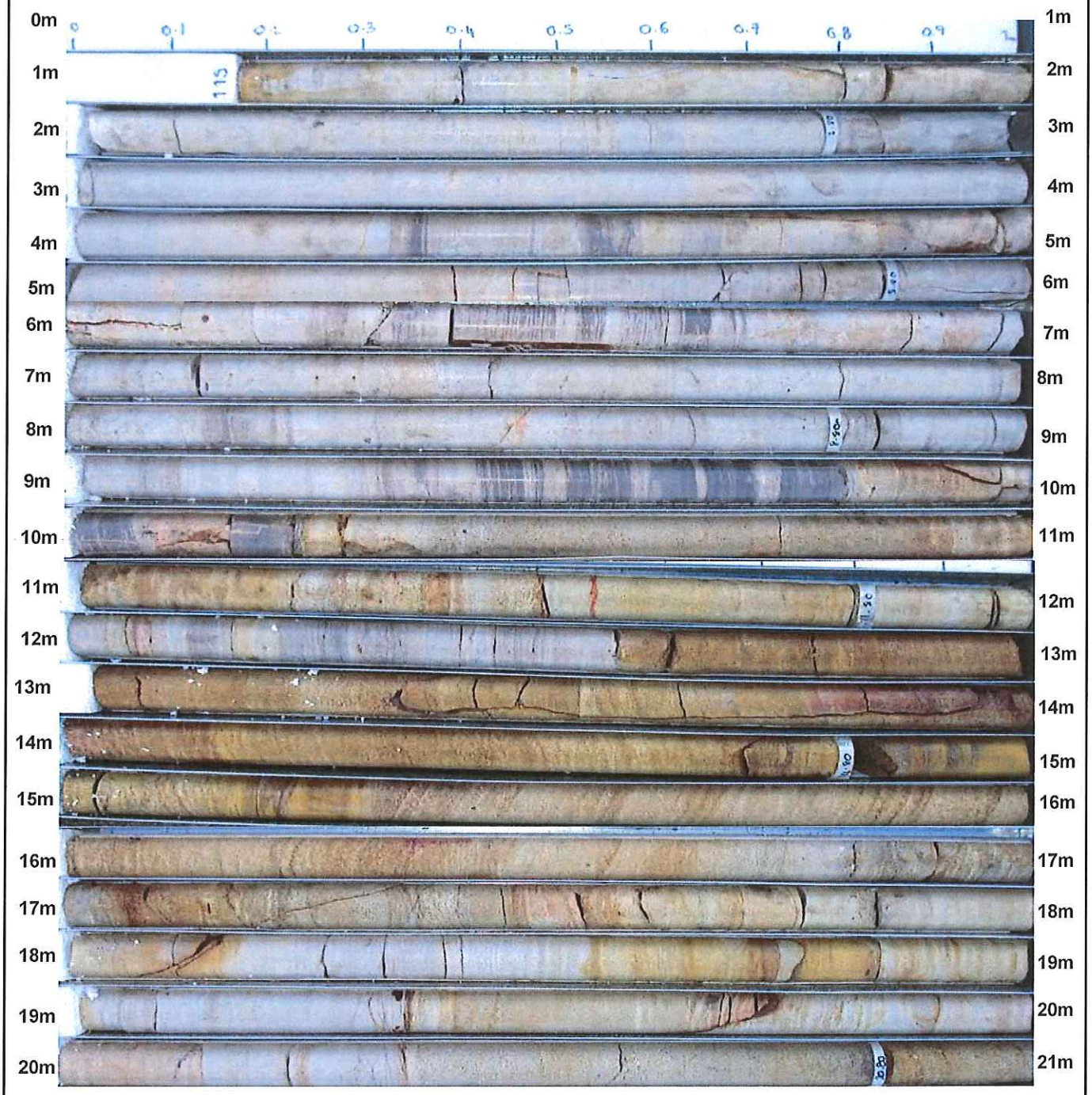
**planarity**
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR irregular

**roughness**
- VR very rough
- RO rough
- SO smooth
- SL slickensided

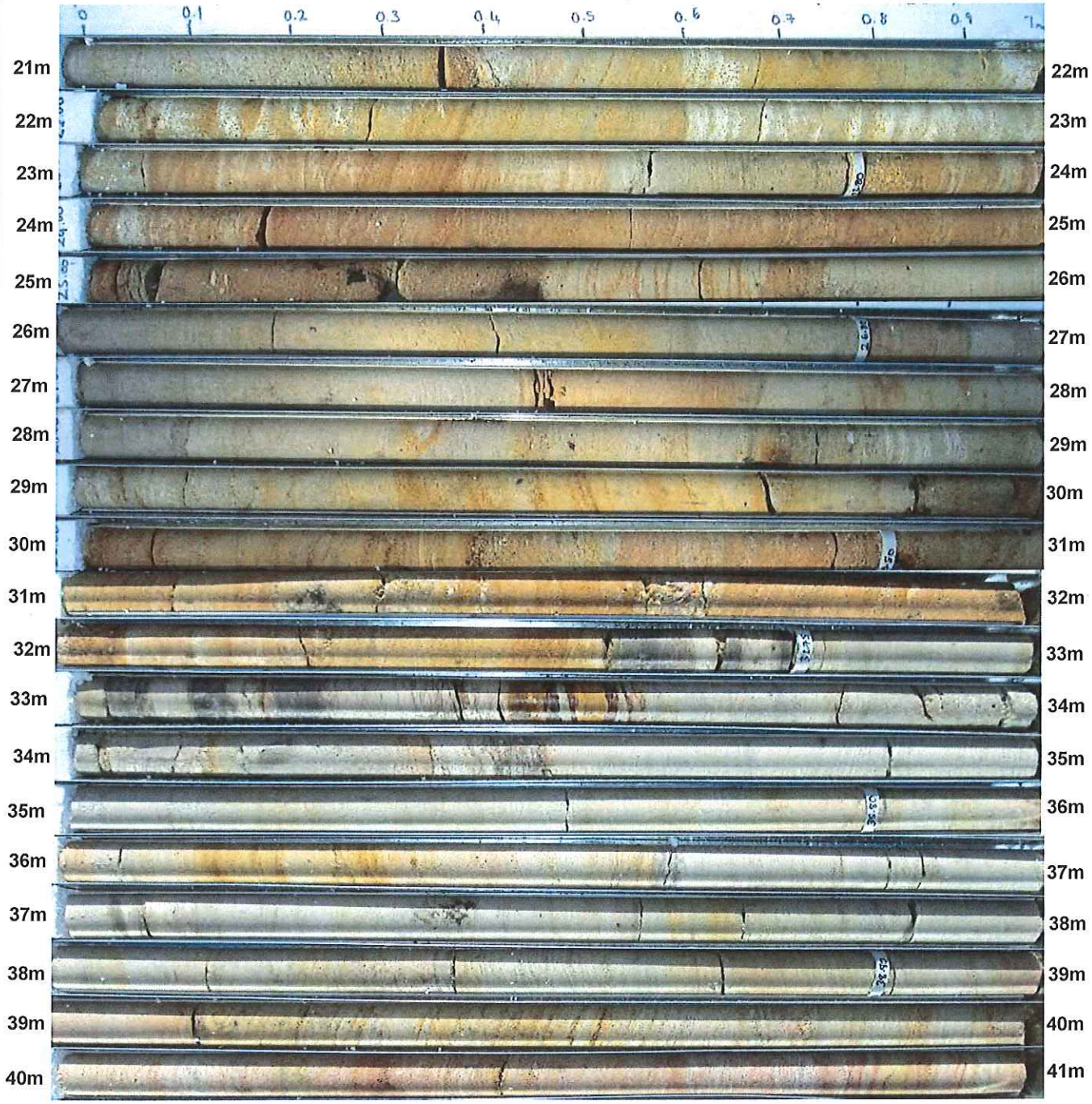
**coating**
- CN clean
- SN stained
- VN veneer
- CO coating

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_BOREHOLES.GPJ LIBRARY FILE: COFGEOTECHVER7REV3.GLB TEMPLATE FILE: COFFEY.GDT FRAME TITLE: CORED BOREHOLE DATE: 14.12.09

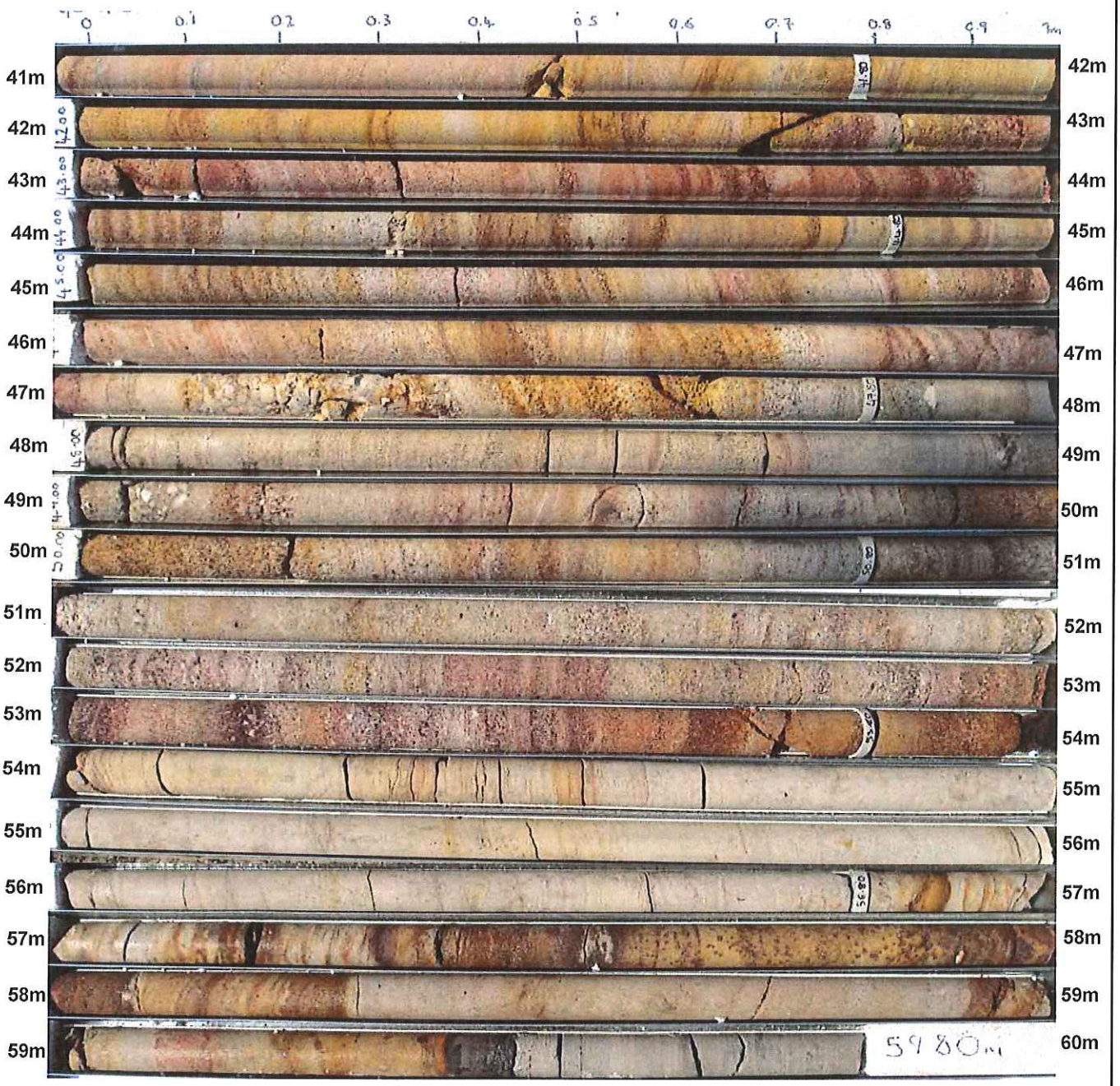
Form GEO 5.5 Issue 3 Rev. 3




| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB02A, 1.15m - 21m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |




| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB02A 21m - 41m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |




| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | ZT | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 9/11/2009 | | title: | CORE PHOTOS: BCB02A, 41m - 59.80m |
| scale | NTS | | project no: GEOTNEWS20400AA | figure no: |
| original size | A4 | | | |

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# Engineering Log - Excavation

Excavation No. **MLTP009A**

Sheet 1 of 1

Project No: **GEOTNEWS20400AA**

Client: **GLNG OPERATIONS PTY LTD**

Date started: **28.8.2009**

Principal:

Date completed: **28.8.2009**

Project: **GLNG PIPELINE PROJECT**

Logged by: **GKW**

Test pit location: **MLTP009A**

Checked by: **RP**

equipment type and model: Hyundai 140 w-7 | Pit Orientation: 0° | Easting: 688377 m | R.L. Surface: 478.300

excavation dimensions: 4.2m long 1.6m wide | Northing: 7164962 m | datum: AHD

| excavation information | | | | | | material substance | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL / depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetrometer kPa 100 200 300 400 | structure and additional observations |
| E | | N | NONE OBSERVED | Bs | 478.0 / 0.5 | | CL | **TOPSOIL; Sandy CLAY:** low plasticity, dark brown, fine grained sand, some fine grained subrounded gravel, some rootlets. | D | Fb | | TOPSOIL |
| | | | | Bs | 477.5 / 1.0 | | SC | **Clayey SAND:** fine to coarse grained, orange-brown with white mottling and some white and orange streaking, low to medium plasticity clay. | | MD | | RESIDUAL SOIL |
| | | | | | 477.0 / 1.5 | | | | | | | ×pp>600kPa |
| | | | | Bs | 476.5 / 2.0 | | GC | **Clayey GRAVEL:** fine to medium grained, grey/dark grey, high plasticity clay, grey/dark grey with some brown horizontal banding and pale brown streaking, trace sand. | M | VD | | EXTREMELY WEATHERED MATERIAL |
| | | | | | 476.0 / 2.5 | | | | | | | |
| | | | | | 475.5 / 3.0 | | | | | | | ×pp>600kPa |
| | | | | | 475.0 / 3.5 | | | | | | | |
| | | | | | 474.5 / 4.0 | | | | | | | ×pp>600kPa |
| | | | | | 474.0 / 4.5 | | | MLTP009A terminated due to reach limit of machinery at 4m | | | | Excavation Time (Min): 45<br>Compacted Spoil Height (m): 0.3<br>Excavator Bucket (0.6m width):<br>0-1.8m: Smooth<br>1.8-4m: Toothed |
| | | | | | 473.5 / 5.0 | | | | | | | |

Sketch

**method**
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

**support**
- S shoring
- N nil

**penetration** 1 2 3 4 — no resistance ranging to refusal

**water**
- water level on date shown
- water inflow
- water outflow

**notes, samples, tests**
- $U_{50}$ undisturbed sample 50mm diameter
- $U_{63}$ undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

**classification symbols and soil description** based on unified classification system

**moisture**
- D dry
- M moist
- W wet
- Wp plastic limit
- $W_L$ liquid limit

**consistency/density index**

| | |
|---|---|
| VS | very soft |
| S | soft |
| F | firm |
| St | stiff |
| VSt | very stiff |
| H | hard |
| Fb | friable |
| VL | very loose |
| L | loose |
| MD | medium dense |
| D | dense |
| VD | very dense |

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ LIBRARY FILE: GN20400_TESTPIT_LIB.GLB TEMPLATE FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ FRAME TITLE: TESTPIT DATE: 15.12.09
Form GEO 5.2 Issue 3 Rev.2





| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | NA | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 11/12/2009 | | title: | TEST PIT PHOTOS: MLTP009A, Depth 0-4m, Width 1.6m |
| scale | NTS | | project no: | GEOTNEWS20400AA |
| original size | A4 | | figure no: | |

coffey geotechnics

# Engineering Log - Excavation

Excavation No. **MLTP010A**

Sheet 1 of 1

Project No: **GEOTNEWS20400AA**

Client: **GLNG OPERATIONS PTY LTD**

Date started: **29.8.2009**

Principal:

Date completed: **29.8.2009**

Project: **GLNG PIPELINE PROJECT**

Logged by: **GKW**

Test pit location: **MLTP010A**

Checked by: **RP**

equipment type and model: Hyundai 140 w-7 | Pit Orientation: 0° | Easting: 688560 m | R.L. Surface: 458.124

excavation dimensions: 5m long 1.5m wide | Northing: 7166153 m | datum: AHD

**excavation information** | **material substance**

| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL | depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetrometer kPa 100 200 300 400 | structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | | N | NONE OBSERVED | | 458.0 | 0 | | CL | **TOPSOIL; Sandy CLAY:** low plasticity, brown-grey, fine grained sand, some rootlets. | D | H | | TOPSOIL |
| | | | | | | | | CL | **Sandy CLAY:** medium plasticity, brown, fine grained sand, some orange streaking. | | | | RESIDUAL SOIL |
| | | | | Bs | 457.5 | 0.5 | | | | | | | |
| | | | | | 457.0 | 1.0 | | | | | | | ×pp>600kPa |
| | | | | Bs | | | | CL | **Gravelly CLAY:** medium plasticity, grey-brown, fine to coarse grained gravel of sandstone, trace fine to coarse grained sand, some pale brown streaking. | | | | EXTREMELY WEATHERED MATERIAL |
| | | | | | 456.5 | 1.5 | | | | | | | ×pp>600kPa |
| | | | | Bs | | | | | **SANDSTONE:** fine grained, dark grey with orange staining, indistinct thin horizontal bedding, slight shale texture, highly weathered, medium estimated strength. | | | | HIGHLY WEATHERED SANDSTONE |
| | | | | | 456.0 | 2.0 | | | MLTP010A terminated due to bucket refusal on sandstone at 1.9m | | | | Excavation Time (Min): 25<br>Compacted Spoil Height (m): 0.3<br>Excavator Bucket (0.6m width):<br>0-1.0m: Smooth<br>1.0-1.9m: Toothed |
| | | | | | 455.5 | 2.5 | | | | | | | |
| | | | | | 455.0 | 3.0 | | | | | | | |
| | | | | | 454.5 | 3.5 | | | | | | | |
| | | | | | 454.0 | 4.0 | | | | | | | |
| | | | | | 453.5 | 4.5 | | | | | | | |
| | | | | | | 5.0 | | | | | | | |

Sketch

**method**
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

**support**
- S shoring
- N nil

**penetration**
1 2 3 4 — no resistance ranging to refusal

**water**
- water level on date shown
- water inflow
- water outflow

**notes, samples, tests**
- $U_{50}$ undisturbed sample 50mm diameter
- $U_{63}$ undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

**classification symbols and soil description**
based on unified classification system

**moisture**
- D dry
- M moist
- W wet
- Wp plastic limit
- $W_L$ liquid limit

**consistency/density index**

| | |
|---|---|
| VS | very soft |
| S | soft |
| F | firm |
| St | stiff |
| VSt | very stiff |
| H | hard |
| Fb | friable |
| VL | very loose |
| L | loose |
| MD | medium dense |
| D | dense |
| VD | very dense |

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ LIBRARY FILE: GN20400_TESTPIT_LIB.GLB TEMPLATE FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ FRAME TITLE: TESTPIT DATE: 15.12.09
Form GEO 5.2 Issue 3 Rev.2






| | | | | |
|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD |
| approved | NA | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND |
| date | 11/12/2009 | | title: | TEST PIT PHOTOS: MLTP010A, Depth 0-1.9m, Width 1.5m |
| scale | NTS | | project no: | GEOTNEWS20400AA |
| original | A4 | | figure no: | |

coffey geotechnics

# Engineering Log - Excavation

Excavation No. **MLTP011A**

Sheet 1 of 1

Project No: **GEOTNEWS20400AA**

Client: **GLNG OPERATIONS PTY LTD**

Date started: **29.8.2009**

Principal:

Date completed: **29.8.2009**

Project: **GLNG PIPELINE PROJECT**

Logged by: **GKW**

Test pit location: **MLTP011A**

Checked by: **RP**

equipment type and model: Hyundai 140 w-7 | Pit Orientation: 0° | Easting: 687664 m | R.L. Surface: 464.344

excavation dimensions: 4.5m long 1.5m wide | Northing: 7166849 m | datum: AHD

**excavation information** | **material substance**

| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL | depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetrometer kPa 100 200 300 400 | structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | | N | NONE OBSERVED | Bs | 464.0 | 0.5 | | CL | **TOPSOIL; Sandy CLAY:** low plasticity, brown, fine grained sand. Some rootlets. | D | H | | TOPSOIL |
| | | | | | | | | CL | **CLAY:** low plasticity, brown-black, some fine grained sand. | | | | EXTREMELY WEATHERED MATERIAL |
| | | | | Bs | 463.5 | 1.0 | | CL | **CLAY:** low plasticity, pale grey with pale brown streaking. | | | | pp>600kPa<br>pp>600kPa<br>pp>600kPa<br>pp>600kPa |
| | | | | Bs | 463.0 | 1.5 | | | | | | | pp>600kPa |
| | | | | Bs | 462.5 | 2.0 | | | **SANDSTONE:** coarse grained, grey with pale brown staining, massive, highly weathered, low estimated strength. | | | | HIGHLY WEATHERED SANDSTONE |
| | | | | | 462.0 | 2.5 | | | MLTP011A terminated due to bucket refusal on sandstone at 1.9m | | | | Excavation Time (Min): 20<br>Compacted Spoil Height (m): 0.2<br>Excavator Bucket (0.6m width):<br>0-0.9m: Smooth<br>0.9-1.9m: Toothed |
| | | | | | 461.5 | 3.0 | | | | | | | |
| | | | | | 461.0 | 3.5 | | | | | | | |
| | | | | | 460.5 | 4.0 | | | | | | | |
| | | | | | 460.0 | 4.5 | | | | | | | |
| | | | | | 459.5 | 5.0 | | | | | | | |

Sketch

**method**
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

**support**
- S shoring
- N nil

**penetration**
1 2 3 4 — no resistance ranging to refusal

**water**
- water level on date shown
- water inflow
- water outflow

**notes, samples, tests**
- $U_{50}$ undisturbed sample 50mm diameter
- $U_{63}$ undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

**classification symbols and soil description**
based on unified classification system

**moisture**
- D dry
- M moist
- W wet
- Wp plastic limit
- $W_L$ liquid limit

**consistency/density index**

| | |
|---|---|
| VS | very soft |
| S | soft |
| F | firm |
| St | stiff |
| VSt | very stiff |
| H | hard |
| Fb | friable |
| VL | very loose |
| L | loose |
| MD | medium dense |
| D | dense |
| VD | very dense |

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ LIBRARY FILE: GN20400_TESTPIT_LIB.GLB TEMPLATE FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ FRAME TITLE: TESTPIT DATE: 15.12.09
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| | | | | | |
|---|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD | |
| approved | NA | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND | |
| date | 11/12/2009 | | title: | TEST PIT PHOTOS: MLTP011A, Depth 0-1.9m, Width 1.5m | |
| scale | NTS | | project no: | GEOTNEWS20400AA | figure no: |
| original | A4 | | | | |

coffey geotechnics

# Engineering Log - Excavation

Excavation No. **MLTP012A**

Sheet 1 of 1

Project No: **GEOTNEWS20400AA**

Client: **GLNG OPERATIONS PTY LTD**

Date started: **29.8.2009**

Principal:

Date completed: **29.8.2009**

Project: **GLNG PIPELINE PROJECT**

Logged by: **GKW**

Test pit location: **MLTP012A**

Checked by: **RP**

equipment type and model: Hyundai 140 w-7 | Pit Orientation: 0° | Easting: 687796 m | R.L. Surface: 479.535

excavation dimensions: 4m long 1.5m wide | Northing: 7168697 m | datum: AHD

**excavation information** | **material substance**

| method | penetration 1 2 3 | support | water | notes samples, tests, etc | RL | depth metres | graphic log | classification symbol | material: soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency/ density index | pocket penetrometer kPa 100 200 300 400 | structure and additional observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | | N | NONE OBSERVED | Bs | 479.0 | 0.5 | | CL | **TOPSOIL; Sandy CLAY:** low plasticity, black-brown, fine grained sand, many rootlets. | D | H/Fb | × | TOPSOIL pp>600kPa |
| | | | | Bs | 478.5 | 1.0 | | | | | | × | pp>600kPa |
| | | | | | | | | | **SANDSTONE:** coarse grained, grey with regular pale brown and orange staining, massive, highly weathered, assessed as low to medium strength. Excavated as fine to coarse grained Clayey SAND (SC), medium plasticity clay, trace gravel. | | | | HIGHLY WEATHERED SANDSTONE |
| | | | | | 478.0 | 1.5 | | | ... sandstone becoming high estimated strength. | | | | Excavation Time (Min): 14 |
| | | | | | 477.5 | 2.0 | | | MLTP012A terminated due to bucket refusal on sandstone at 1.1m | | | | Compacted Spoil Height (m): 0.2 |
| | | | | | 477.0 | 2.5 | | | | | | | Excavator Bucket (0.6m width): |
| | | | | | 476.5 | 3.0 | | | | | | | 0-0.7m: Smooth |
| | | | | | 476.0 | 3.5 | | | | | | | 0.7-1.1m: Toothed |
| | | | | | 475.5 | 4.0 | | | | | | | |
| | | | | | 475.0 | 4.5 | | | | | | | |
| | | | | | | 5.0 | | | | | | | |

Sketch

**method**
- N natural exposure
- X existing excavation
- BH backhoe bucket
- B bulldozer blade
- R ripper
- E excavator

**support**
- S shoring
- N nil

**penetration** 1 2 3 4 — no resistance ranging to refusal

**water**
- water level on date shown
- water inflow
- water outflow

**notes, samples, tests**
- $U_{50}$ undisturbed sample 50mm diameter
- $U_{63}$ undisturbed sample 63mm diameter
- D disturbed sample
- V vane shear (kPa)
- Bs bulk sample
- E environmental sample
- R refusal

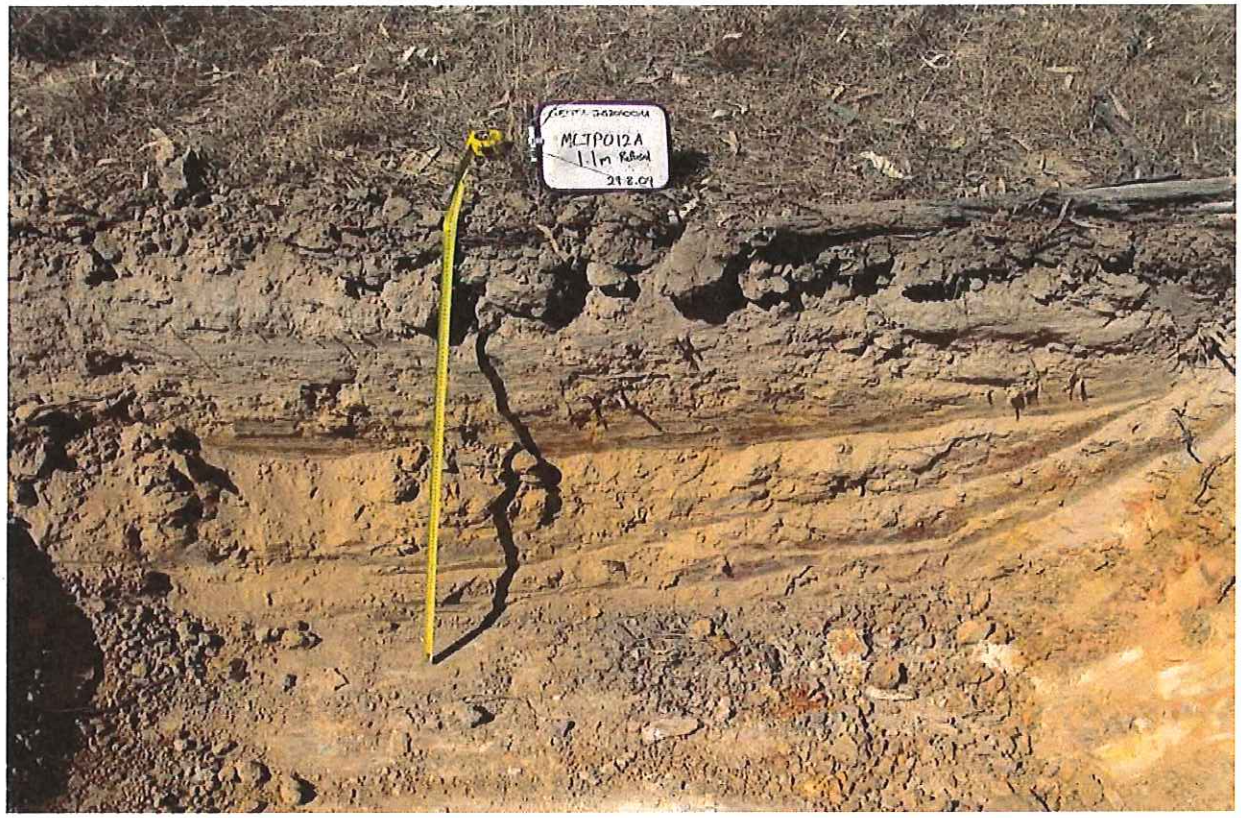
**classification symbols and soil description** based on unified classification system

**moisture**
- D dry
- M moist
- W wet
- Wp plastic limit
- $W_L$ liquid limit

**consistency/density index**

| | |
|---|---|
| VS | very soft |
| S | soft |
| F | firm |
| St | stiff |
| VSt | very stiff |
| H | hard |
| Fb | friable |
| VL | very loose |
| L | loose |
| MD | medium dense |
| D | dense |
| VD | very dense |

PROJECT FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ LIBRARY FILE: GN20400_TESTPIT_LIB.GLB TEMPLATE FILE: GEOTNEWS20400AA_MAINLAND_TESTPITS.GPJ FRAME TITLE: TESTPIT DATE: 15.12.09
Form GEO 5.2 Issue 3 Rev.2



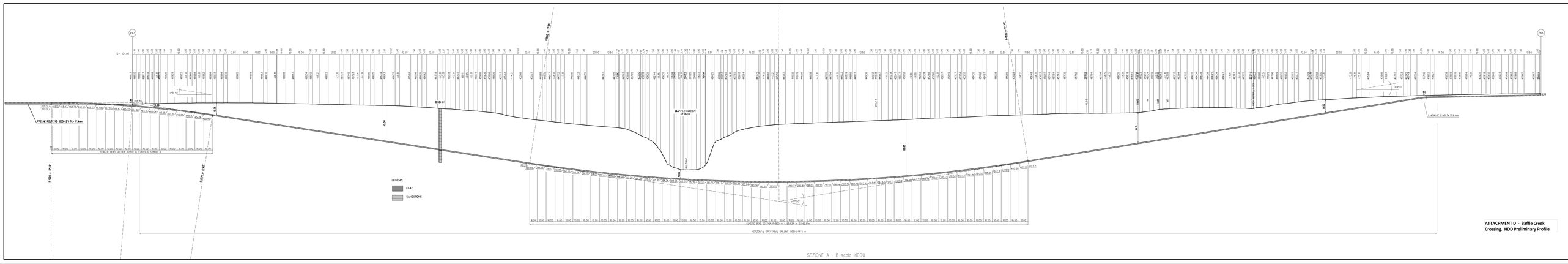



| | | | | | |
|---|---|---|---|---|---|
| drawn | DG | coffey geotechnics SPECIALISTS MANAGING THE EARTH | client: | GLNG OPERATIONS PTY LTD | |
| approved | NA | | project: | GLNG PIPELINE PROJECT<br>MAIN LAND | |
| date | 11/12/2009 | | title: | TEST PIT PHOTOS: MLTP012A, Depth 0-1.1m, Width 1.5m | |
| scale | NTS | | project no: | GEOTNEWS20400AA | figure no: |
| original size | A4 | | | | |

| Borehole / Test Pit | Sample Depth (m) | Sample Description[2] | USC | Moisture Content (%) | Atterberg Limits | | | | Particle Size Distribution[1] | | | | MDD-Moisture Relation | | CBR (%) | Emerson Class No. | Soil Particle Density (t/m³) | Wet Density (t/m³) | Dry Density (t/m³) | CU Triaxial | | Chemical Tests | | | | | | | | Rock Tests | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Plasticity Index (%) | Liquid Limit (%) | Plastic Limit (%) | Linear shrinkage (%) | Clay (%) | Silt (%) | Sand (%) | Gravel (%) | MDD (t/m³) | OMC (%) | | | | | | ϕ' (°) | c' (kPa) | EC (dS/m) | pH | Cl (%) | S (mg/kg) | $SO_4$ (%) | $SO_3$ (%) | Organic C (%) | Organic Matter (%) | Porosity (%) | Density (t/m3) | Point Load, $Is_{50}$ (MPa) | USC (MPa) | Ave.Youngs Mod.(GPa) | Poissions Ratio, μ |
| HCBH06 | 50 | MUDSTONE (SW-Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.22[D] | | | | |
| HCBH06 | 51.1 | MUDSTONE (SW-Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.3[S] | | | | |
| HCBH06 | 52.66 | MUDSTONE (SW-Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.66[S] | | | | |
| HCBH06 | 52.72 | SANDSTONE (SW-Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.80[S] | | | | |
| HCBH06 | 75-75.53 | SANDSTONE (SW-Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | 15.2 | 2.244 | | | | | |
| HCBH06 | 75.31-75.46 | SANDSTONE (SW-Fr) | | 5.8 | | | | | | | | | | | | | | 2.4 | | | | | | | | | | | | | 14.3 | | | |
| FRBH01A | 3.21 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.15[S] | | | | |
| FRBH01A | 3.21 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.26[S] | | | | |
| FRBH01A | 3.53 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.15[S] | | | | |
| FRBH01A | 3.57 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.21[S] | | | | |
| FRBH01A | 3.92 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.52[S] | | | | |
| FRBH01A | 9.26 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.23[S] | | | | |
| FRBH01A | 9.31 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.58[S] | | | | |
| FRBH01A | 3.77 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.34[S] | | | | |
| FRBH01A | 6.0-6.32 | SANDSTONE (MW) | | 8.2 | | | | | | | | | | | | | | 2.4 | | | | | | | | | | | 11.4 | 1.874 | | 1.45 | | |
| FRBH01A | 10.46 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.30[S] | | | | |
| FRBH01A | 10.46 | SILTSTONE (XW/HW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.49[S] | | | | |
| FRBH01A | 13.3-13.6 | SANDSTONE (SW) | | 2 | | | | | | | | | | | | | | 2.61 | 2.56 | | | | | | | | | | 8.3 | 2.415 | | 63.3 | 15.3 | 0.18 |
| BCBH01 | 5.63 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3.11[S] | | | | |
| BCBH01 | 6.12 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.74[S] | | | | |
| BCBH01 | 6.15 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.95[S] | | | | |
| BCBH01 | 6.95 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.44[S] | | | | |
| BCBH01 | 10.0-10.4 | SANDSTONE (MW) | | 6.4 | | | | | | | | | | | | | | 2.35 | 2.21 | | | | | | | | | | 14.4 | 2.239 | | 19.9 | 10.2 | 0.16 |
| BCBH01 | 13.1 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.89[S] | | | | |
| BCBH01 | 13.1 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.68[S] | | | | |
| BCBH01 | 13.95 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3.13[S] | | | | |
| BCBH01 | 14.9 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.92[S] | | | | |
| BCBH01 | 16.3-16.8 | SANDSTONE (MW) | | 6 | | | | | | | | | | | | | | 2.3 | | | | | | | | | | | 16 | 2.195 | | 20.4 | | |
| BCBH01 | 23.2-23.55 | SANDSTONE (SW) | | 6 | | | | | | | | | | | | | | 2.18 | 2.06 | | | | | | | | | | 14.5 | 2.104 | | 22.6 | 13.2 | 0.16 |
| BCBH01 | 28 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.48[S] | | | | |
| BCBH01 | 28.04 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.64[S] | | | | |
| BCBH01 | 29.66 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.26[S] | | | | |
| BCBH01 | 34.0-34.40 | SANDSTONE (SW) | | 7.1 | | | | | | | | | | | | | | 2.2 | | | | | | | | | | | 20.8 | 2.019 | | 30.1 | | |
| BCBH01 | 40.65-41.00 | SANDSTONE (MW/SW) | | 9.6 | | | | | | | | | | | | | | 2.17 | 1.98 | | | | | | | | | | 24.9 | 1.977 | | 23.1 | 21.5 | 0.3 |
| BCBH01 | 47.0-50.0 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.44[S] | | | | |
| BCBH01 | 47.45 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.54[S] | | | | |
| BCBH01 | 48.35 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.28[S] | | | | |
| BCBH01 | 49 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.06[S] | | | | |
| BCBH01 | 54.40-54.80 | SANDSTONE (MW/SW) | | 6.3 | | | | | | | | | | | | | | 2.2 | | | | | | | | | | | 20.6 | 2.038 | | 20 | | |
| BCBH02A | 3.00-3.40 | SANDSTONE (SW) | | 6.9 | | | | | | | | | | | | | | 2.03 | 1.9 | | | | | | | | | | 18.2 | 2.076 | | 19.7 | 13.5 | 0.32 |
| BCBH02A | 6.33 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.73[S] | | | | |
| BCBH02A | 6.88 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4.61[S] | | | | |
| BCBH02A | 7.9 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.02[S] | | | | |

| Borehole / Test Pit | Sample Depth (m) | Sample Description[2] | USC | Moisture Content (%) | Atterberg Limits | | | | Particle Size Distribution[1] | | | | MDD-Moisture Relation | | CBR (%) | Emerson Class No. | Soil Particle Density (t/m$^3$) | Wet Density (t/m$^3$) | Dry Density (t/m$^3$) | CU Triaxial | | Chemical Tests | | | | | | | | Rock Tests | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Plasticity Index (%) | Liquid Limit (%) | Plastic Limit (%) | Linear shrinkage (%) | Clay (%) | Silt (%) | Sand (%) | Gravel (%) | MDD (t/m$^3$) | OMC (%) | | | | | | ϕ' (°) | c' (kPa) | EC (dS/m) | pH | Cl (%) | S (mg/kg) | $SO_4$ (%) | $SO_3$ (%) | Organic C (%) | Organic Matter (%) | Porosity (%) | Density (t/m3) | Point Load, $Is_{50}$ (MPa) | USC (MPa) | Ave.Youngs Mod.(GPa) | Poissions Ratio, μ |
| BCBH02A | 9 | SANDSTONE/ SILTSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.65[S] | | | |
| BCBH02A | 9.88 | SANDSTONE/ SILTSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.03[S] | | | |
| BCBH02A | 10.27 | SANDSTONE/ SILTSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.35[S] | | | |
| BCBH02A | 14.0-14.4 | SANDSTONE (HW) | | 7.8 | | | | | | | | | | | | | | 2.1 | | | | | | | | | | | 21.6 | 1.998 | | 34.7 | | |
| BCBH02A | 21.0-21.35 | SANDSTONE (MW) | | 7.8 | | | | | | | | | | | | | | 2.23 | 2.07 | | | | | | | | | | 21.9 | 2.059 | | 20.7 | 13.9 | 0.19 |
| BCBH02A | 24.0-27.0 | SANDSTONE (MW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BCBH02A | 24.1 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.23[S] | | | | |
| BCBH02A | 25.87 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.40[S] | | | | |
| BCBH02A | 26.32 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.21[S] | | | | |
| BCBH02A | 35.0-35.5 | SANDT SONE (SW) | | 8 | | | | | | | | | | | | | | 2.14 | 1.98 | | | | | | | | | | 24.1 | 1.994 | | 29.1 | 21.3 | 0.3 |
| BCBH02A | 39.1 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2.16[S] | | | | |
| BCBH02A | 40.9 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.13[S] | | | | |
| BCBH02A | 41.9 | SANDSTONE (MW/SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.80[S] | | | | |
| BCBH02A | 45.35-45.80 | SANDSTONE (MW) | | 7.4 | | | | | | | | | | | | | | 2.2 | | | | | | | | | | | 21 | 2.039 | | 31.4 | | |
| BCBH02A | 50.2-50.8 | SANDSTONE (MW) | | 6.6 | | | | | | | | | | | | | | 2.17 | 2.03 | | | | | | | | | | 18.9 | 2.115 | | 24.5 | 18.2 | 0.69 |
| BCBH02A | 55.45-55.9 | SANDSTONE (MW) | | 6.2 | | | | | | | | | | | | | | 2.2 | | | | | | | | | | | 17.5 | 2.027 | | 45.5 | | |
| ESCBH01 | 1.06-1.21 | SANDSTONE (SW) | | 5.3 | | | | | | | | | | | | | | 2.3 | | | | | | | | | | | | | | 12.9 | | |
| ESCBH01 | 1.23-1.35 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 12.1 | 2.183 | | | | |
| ESCBH01 | 10 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.7[S] | | | | |
| ESCBH01 | 11 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.2[S] | | | | |
| ESCBH01 | 12.87 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.99[S] | | | | |
| ESCBH01 | 18.74-18.8 | SANDSTONE (SW) | | 5 | | | | | | | | | | | | | | 2.21 | 2.11 | | | | | | | | | | | | | 17.2 | 8.81 | 0.24 |
| ESCBH01 | 18.89-19 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 22.5 | 1.973 | | | | |
| ESCBH01 | 23.1-23.11 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 19 | 2.121 | | | | |
| ESCBH01 | 23.24-23.38 | SANDSTONE (SW) | | 6.4 | | | | | | | | | | | | | | 2.2 | | | | | | | | | | | | | | 23.2 | | |
| ESCBH01 | 32.1 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.8[S] | | | | |
| ESCBH01 | 33 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.91[S] | | | | |
| ESCBH01 | 33.82 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.56[S] | | | | |
| ESCBH01 | 42.0 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.97[S] | | | | |
| ESCBH01 | 42.0 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.9[S] | | | | |
| ESCBH01 | 43.69 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.65[S] | | | | |
| ESCBH01 | 44.49 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.38[S] | | | | |
| ESCBH01 | 48.4-48.8 | MUDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 13.8 | 2.287 | | | | |
| ESCBH01 | 48.59-48.74 | SILTSTONE (SW) | | 6.1 | | | | | | | | | | | | | | 2.46 | 2.32 | | | | | | | | | | | | | 8.38 | 1.28 | 0.35 |
| ESCBH01 | 54.08-24.20 | SILTSTONE (SW) | | 5.6 | | | | | | | | | | | | | | 2.5 | | | | | | | | | | | | | | 3.47 | | |
| ESCBH01 | 54.23-54.35 | SILTSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 12 | 2.392 | | | | |
| ESCBH01 | 56.33 | MUDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.2[S] | | | | |
| ESCBH01 | 57 | SILTSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.6[S] | | | | |
| ESCBH01 | 57.59 | MUDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.48[S] | | | | |
| ESCBH01 | 65.35-65.7 | SANDSTONE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | 17.5 | 2.157 | | | | |

| Borehole / Test Pit | Sample Depth (m) | Sample Description[2] | USC | Moisture Content (%) | Atterberg Limits | | | | Particle Size Distribution[1] | | | | MDD-Moisture Relation | | CBR (%) | Emerson Class No. | Soil Particle Density (t/m³) | Wet Density (t/m³) | Dry Density (t/m³) | CU Triaxial | | Chemical Tests | | | | | | | | Rock Tests | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Plasticity Index (%) | Liquid Limit (%) | Plastic Limit (%) | Linear shrinkage (%) | Clay (%) | Silt (%) | Sand (%) | Gravel (%) | MDD (t/m³) | OMC (%) | | | | | | ϕ' (°) | c' (kPa) | EC (dS/m) | pH | Cl (%) | S (mg/kg) | $SO_4$ (%) | $SO_3$ (%) | Organic C (%) | Organic Matter (%) | Porosity (%) | Density (t/m3) | Point Load, $Is_{50}$ (MPa) | USC (MPa) | Ave.Youngs Mod.(GPa) | Poissions Ratio, μ |
| CALESCBH01A | 11.06 | GRANITE (SW) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1.1[S] | | | | |
| CALESCBH01A | 14.34-14.49 | GRANITE (Fr) | | 0.3 | | | | | | | | | | | | | | 2.75 | 2.74 | | | | | | | | | | | | 143 | 69.9 | 0.29 |
| CALESCBH01A | 14.49-14.59 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.6 | 2.733 | | | | |
| CALESCBH01A | 22 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9.6[S] | | | | |
| CALESCBH01A | 23 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5.5[S] | | | | |
| CALESCBH01A | 24.1 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9.9[S] | | | | |
| CALESCBH01A | 33.38-33.53 | GRANITE (Fr) | | 0.1 | | | | | | | | | | | | | | 2.75 | 2.75 | | | | | | | | | | | | 76.9 | 84.9 | 0.29 |
| CALESCBH01A | 33.53-33.6 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.4 | 2.738 | | | | |
| CALESCBH01A | 45.29-45.44 | GRANITE (Fr) | | 0.2 | | | | | | | | | | | | | | 2.7 | | | | | | | | | | | | | 87.0 | | |
| CALESCBH01A | 45.46-45.48 | GRANITE (Fr) | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.5 | 2.719 | | | | |
| MLTP001 | 1.8- 2.1 | Clayey GRAVEL, (HW SILTSTONE) | GC | 17.8 | 26 | 52 | 26 | 15.5 | 22 | | 9 | 58[3] | 1.66 | 19.5 | 1.0 | 1 | | | | | | 0.87 | 6.6 | 0.12 | 29 | <0.1 | <0.1 | | | | | | | |
| MLTP002A | 0.6- 4 | Sandy CLAY | CL | 7.3 | 16 | 28 | 12 | 7 | 24 | 27 | 49 | | 1.76 | 13 | 6 | 3 | | | | | | 0.03 | 7.5 | <0.01 | 18 | <0.1 | <0.1 | | | | | | | |
| MLTP003 | 0.25- 1.5 | CLAY, trace sand | CL-CH | 20.2 | 55 | 71 | 16 | 18.5 | 66 | 25 | 6 | 3 | 1.63 | 22.5 | 1.5 | | | | | | | 0.74 | 6.2 | 0.1 | 78 | <0.1 | <0.1 | | | | | | | |
| MLTP004 | 1- 1.6 | Sandy Clayey GRAVEL (HW SANDSTONE) | GC | 9.8 | 18 | 30 | 12 | 8.5 | 25 | | 14 | 58[3] | 13.8 | 1.81 | 2 | | | | | | | 0.25 | 6.7 | 0.04 | 32 | <0.1 | <0.1 | | | | | | | |
| MLTP006 | 0.9- 1.6 | Sandy Clayey GRAVEL | GC | 11.5 | 22 | 35 | 13 | 15 | 24 | 8 | 25 | 43 | 1.89 | 15.5 | 3.5 | | | | | | | | | | | | | | | | | | | |
| MLTP007 | 0.5- 1.9 | CLAY, some sand | CH | 18.6 | 38 | 53 | 15 | 14 | 47 | 24 | 20 | 9 | 1.69 | 19.5 | 1 | 1 | | | | | | | | | | | | | | | | | | |
| MLTP008 | 0.7- 1 | Sandy GRAVEL (HW SANDSTONE) | GP-GM | 3 | 4 | 19 | 15 | 2.5 | 4 | 4 | 24 | 68 | 1.88 | 8 | 60 | | | | | | | | | | | | | | | | | | | |
| MLTP009A | 1.6- 4 | Clayey GRAVEL | GC | 20.4 | 44 | 65 | 21 | 18 | 12 | 17 | 4 | 67 | 1.54 | 25 | 4 | 2 | | | | | | 0.63 | 6.3 | 0.09 | 25 | <0.1 | <0.1 | | | | | | | |
| MLTP010A | 1.2- 1.6 | CLAY and GRAVEL | CL-CH/GP | | 35 | 49 | 14 | 16.5 | 26 | 24 | 14 | 36 | 1.78 | 14.5 | 3.5 | 2 | | | | | | 0.28 | 6.7 | 0.04 | 39 | <0.1 | <0.1 | | | | | | | |
| MLTP012A | 0.7- 1 | Clayey SAND, MP fines (HW SANDSTONE) | SC | 9.1 | 24 | 36 | 12 | 12 | 28 | 14 | 56 | 2 | 1.88 | 12 | 12 | | | | | | | | | | | | | | | | | | | |
| MLTP013A | 2.2- 2.6 | Clayey GRAVEL (MW SANDSTONE) | GC | 8.6 | 25 | 40 | 15 | 11 | 17 | | 6 | 77 | 1.84 | 13 | 11 | | | | | | | | | | | | | | | | | | | |
| MLTP014A | 0.4- 2.1 | Clayey GRAVEL (HW SILTSTONE) | GC | | 28 | 44 | 16 | 11 | 2 | 11 | 5 | 77[3] | 1.84 | 13 | 8 | | | | | | | | | | | | | | | | | | | |
| MLTP015A | 0.3- 2.2 | Sandy Clayey GRAVEL | GC | 15.9 | 38 | 52 | 14 | 16.5 | 14 | 30 | 18 | 38 | 1.67 | 19 | 2.0 | 2 | | | | | | 0.58 | 6.5 | 0.08 | 38 | <0.1 | <0.1 | | | | | | | |
| MLTP017A | 1.2- 2.5 | Clayey GRAVEL (HW MUDSTONE) | GC | 9.7 | 29 | 44 | 15 | 13.5 | 10 | 13 | 8 | 69 | 1.81 | 13.5 | 4.5 | | | | | | | 0.36 | 6.8 | 0.03 | 18 | <0.1 | <0.1 | | | | | | | |
| MLTP020A | 1.4- 2.2 | Silty SAND | SM | 5.1 | 7 | 23 | 16 | 4.5 | 18 | 24 | 58 | | 1.86 | 11 | 20 | 3 | | | | | | 0.03 | 6.8 | <0.01 | 14 | <0.1 | <0.1 | | | | | | | |
| MLTP022 | 1.7- 4 | CLAY, some sand | CL | 7.9 | 18 | 31 | 13 | 10.5 | 23 | 59 | 17 | 1 | 1.82 | 12 | 6 | 2 | | | | | | 0.11 | 6.2 | <0.01 | 25 | <0.1 | <0.1 | | | | | | | |
| MLTP024 | 0.3- 1.1 | CLAY, trace sand | CH | 12.7 | 36 | 51 | 15 | 16.5 | 44 | 48 | 6 | 2 | 1.74 | 17.5 | 3.5 | 2 | | | | | | | | | | | | | | | | | | |
| MLTP026 | 0.7- 2.6 | Cobbly GRAVEL | GP | 8 | 22 | 37 | 15 | 7 | 1 | 3 | 5 | 57[3] | 1.86 | 13 | 8 | | | | | | | | | | | | | | | | | | | |
| MLTP027 | 0- 1.5 | CLAY, some sand/gravel | CL-CH | 10.7 | 32 | 46 | 14 | 14.5 | 72 | | 15 | 13 | 1.68 | 16 | 3.5 | 2 | | | | | | 0.64 | 6.1 | 0.07 | 53 | <0.1 | <0.1 | | | | | | | |
| MLTP030 | 1.6- 3.5 | Sandy CLAY | CL-CH | 9.5 | 23 | 38 | 15 | 13 | 30 | 20 | 33 | 17 | 1.85 | 14 | 3.5 | | | | | | | | | | | | | | | | | | | |
| MLTP031 | 0.3- 1 | Sandy Clayey GRAVEL | GC | 9.9 | 37 | 52 | 15 | 17.5 | 17 | 11 | 11 | 52[3] | 1.76 | 14.5 | 1.5 | | | | | | | | | | | | | | | | | | | |
| MLTP033 | 1.1- 1.9 | Clayey SAND, LP fines | SC | 6.2 | 13 | 24 | 11 | 6 | 19 | 28 | 53 | | 1.92 | 10 | 9 | | | | | | | 0.04 | 6.4 | <0.01 | 17 | <0.1 | <0.1 | | | | | | | |
| MLTP034 | 1.8- 3.5 | Sandy CLAY | CL-CH | 10.1 | 25 | 37 | 12 | 14 | 37 | 23 | 36 | 4 | 1.85 | 14 | 3.5 | | | | | | | | | | | | | | | | | | | |
| MLTP035 | 1.7- 2.4 | Sandy CLAY | CL | 7.8 | 16 | 28 | 12 | 9 | 23 | 34 | 35 | 8 | 1.87 | 12 | 8 | | | | | | | | | | | | | | | | | | | |
| MLTP036 | 0.6- 2.2 | Sandy GRAVEL (XW/HW SANDSTONE) | GP | 7.6 | 12 | 33 | 21 | 5 | 1 | 4 | 23 | 72 | 1.75 | 13 | 28 | | | | | | | 0.21 | 7.3 | 0.01 | 28 | <0.1 | <0.1 | | | | | | | |
| MLTP037 | 2.5- 3.8 | Gravelly Clayey Sand | SC | 7.4 | 15 | 30 | 15 | 8.5 | 22 | 20 | 45 | 13 | 1.87 | 12 | 5 | | | | | | | | | | | | | | | | | | | |

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**ATTACHMENT D - Baffle Creek Crossing. HDD Preliminary Profile**

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**APPENDIX H – Field Monitoring Sheets**

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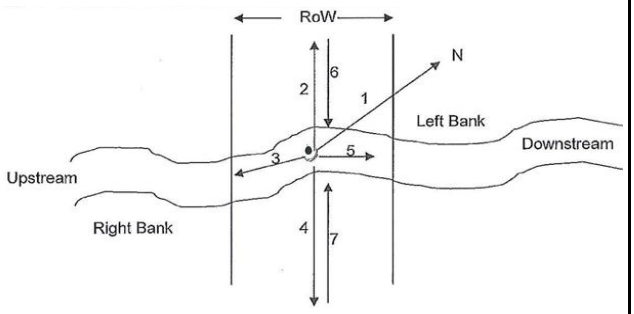


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**APPENDIX I – Addendum Aquatic Assessment for Revised Dawson River (Downstream) Crossing**

frc environmental
AQUATIC ECOLOGISTS
deep thinking. science.

ACN 002 895 007
ABN 72 002 895 007

Unit 1/7 Grant Street
Cleveland Q 4163
Australia

P 07 3286 3850
F 07 3821 7936
E info@frcenv.com.au

www.frcenv.com.au

1 August 2013 Our Reference: 130422Lii

Nicole Gibson
Environmental Consultant Pipeline
Santos GLNG
GPO Box 1010
Brisbane QLD 4001

Dear Nicole,

Re: Aquatic Values Assessment at KP234 – Dawson River

frc environmental were commissioned by Santos GLNG to undertake an assessment of aquatic ecosystem values at site KP234 on the Dawson River, where there is a proposed field design change to the gas transmission pipeline (GTP) crossing location. The aquatic ecology survey included an assessment of:

- aquatic habitat
- water quality measured in situ
- aquatic plants
- macroinvertebrates
- fish, and
- turtles.

The methods used for this survey were the same as those used in previous surveys of aquatic ecology for the Santos GTP project (frc environmental 2012). An assessment of the aquatic values of the Dawson River region are also presented in frc environmental 2012. This report presents the findings of the aquatic values assessment at the revised KP234 crossing on the Dawson River, and includes the site assessment sheet for this location (Attachment A).

## Aquatic Habitat

The condition of aquatic habitat was assessed using two approaches:

- the Australian River Assessment System (AUSRIVAS) protocol described in the Queensland AUSRIVAS Sampling and Processing Manual (DNRM 2001), and
- the habitat bioassessment scoring method (DNRM 2001).

Results for the habitat condition assessment, along with photographs, are presented in Attachment A, and show that:

- grazing was the dominant land use surrounding the site, and there was evidence of cattle access to the watercourse and some minor localised erosion
- water flow was moderate, and the site consisted of a flowing section of river connected to a large pool upstream and flowing reaches downstream
- the channel pattern at the site was mildly sinuous
- the substrate was a mix of silt / clay and sand, with an extensive sandy bank on the eastern side (right bank)
- the riparian vegetation was dominated by native trees (e.g. eucalypts) with an understorey of grasses and introduced weeds, including parthenium weed (*Parthenium hysterophorus*), which is a declared Class 2 pest in Queensland and a Weed of National Significance, and
- in-stream habitat included deep and shallow pools, riffles and runs, large woody debris and undercut banks.

The bioassessment score was 103 out of a possible 135, which indicates good habitat condition. This was due to:

- excellent available habitat cover
- excellent flow and depth variation at the site
- excellent stream side vegetation cover
- good bank stability, and
- limited scouring and deposition of the bed.

## Water Quality

Water quality was measured in situ, for the following parameters:

- pH
- electrical conductivity
- dissolved oxygen, and
- turbidity.

The water quality results were compared with the water quality objectives (WQOs) scheduled under the Environmental Protection (Water) Policy 2009 (EPP Water) for waterways in the Dawson River Sub-basin (DERM 2011).

Most water quality parameters complied with the WQO, with the exception of electrical conductivity, which was 70 µS/cm higher than the WQO (Table 1) .

Table 1 Results for water quality measured in situ at site KP234.

| Sampling date | Temperature (°C) | DO (% saturation) | Electrical Conductivity (µS/cm) | Turbidity (NTU) | pH |
|---|---|---|---|---|---|
| **WQO** | **–** | **85–110** | **< 340** | **< 50** | **6.5–8.5** |
| 22/06/13 | 13.4 | 102 | 410 | 14.7 | 7.8 |

Grey shading indicates where the result exceeded the WQO

## Aquatic Plants

The aquatic plant community at the site was assessed along a 100 m reach of the stream and adjacent bank (50 m upstream and downstream of the proposed pipeline crossing).

Plants were identified to species where possible, and the following were recorded:

- taxonomic richness
- percent cover (% of substrate (bed or bank) covered by each aquatic species)
- growth form of each species (submerged, floating (free-floating or rooted) and emergent)
- whether the plant was native or introduced to Australia, and

- whether the plant was listed under State or Commonwealth legislation.

The aquatic plant survey showed that:

- no aquatic plants were recorded from within the water
- five species of native emergent aquatic plant had moderate cover on the banks (adjacent to water):
  - common rush, *Juncus usitatus* (25 % cover)
  - mat rush, *Lomandra* sp. (18 % cover)
  - sedge, *Cyperus* sp. (8 % cover)
  - yellow eclipta, *Eclipta platyglosaa* (3 % cover)
  - smart weed, *Persicaria* sp. (1 % cover), and
- no introduced or conservation significant aquatic plants were at the site.

## Macroinvertebrates

Benthic macroinvertebrates were assessed by collecting five quantitative samples in both bed and edge habitats. Samples were sorted and macroinvertebrates were identified to the family level, and the following indices were calculated:

- total abundance
- total taxonomic richness
- total PET richness, and
- total SIGNAL 2 scores.

Taxonomic richness, PET richness and SIGNAL 2 scores, based on data pooled for all five samples, were assessed against the biological WQOs scheduled under the Environmental Protection (Water) Policy 2009 (EPP Water) for waterways in the Dawson River Sub-basin (DERM 2011). While the WQOs are based on samples collected using AUSRIVAS techniques, meaning the results are not directly comparable, this still provides a good indication of the current condition of the site.

Results of the macroinvertebrate survey (Table 2) showed:

- total taxonomic richness was higher than the WQO in bed and edge habitats, indicating a very diverse macroinvertebrate community at the site, including insects, crustaceans and molluscs
- PET richness complied with the WQO in bed and edge habitats
- the total SIGNAL-2 score for edge habitat complied with the WQO, and
- the total SIGNAL-2 score for bed habitat was above the WQO, indicating that the macroinvertebrate community has a relatively high number of sensitive taxa.

Table 2 Results for macroinvertebrate communities at site KP234.

| Index | Bed Habitat | | Edge Habitat | |
|---|---|---|---|---|
| | WQO | Total | WQO | Total |
| Total abundance | – | 470 | – | 338 |
| Total taxonomic richness | 12–21 | 29 | 23–33 | 34 |
| Total PET richness | 2–5 | 5 | 2–5 | 5 |
| Total SIGNAL-2 | 3.33–3.85 | 4.40 | 3.31–4.20 | 3.75 |

Blue shading indicates where the result is higher than the WQO

## Fish

Freshwater fish communities were surveyed using a combination of boat electrofishing (1212 seconds) and baited traps (17.5 hours) (Table 4). The following indices were calculated at each site:

- total abundance (total number of individuals caught at the site)
- species richness (total number of species caught at the site)
- abundance at each life-history stage
- proportion and abundance of exotic species, and
- abundance of listed protected species.

The fish survey (Table 3, Figure 1) showed:

- five species of native fish were caught, and each had low abundance
- adult, intermediate and juvenile life history stages were caught, but no one species had individuals of all life history stage, and

- no introduced or conservation significant species were caught.

Table 3 Results for species richness and abundance of fish at site KP234.

| Species | Common name | Boat electrofishing | Baited box traps | Total |
|---|---|---|---|---|
| *Hypseleotris* sp. | carp gudgeon | – | 1 | **1** |
| *Macquaria ambigua* | golden perch | 3 | – | **3** |
| *Amniataba percoides* | barred grunter | 2 | – | **2** |
| *Leiopotherapon unicolor* | spangled perch | 1 | – | **1** |
| *Mogurnda adspersa* | purple spotted gudgeon | 1 | – | **1** |
| **Total** | **–** | **7** | **1** | **8** |

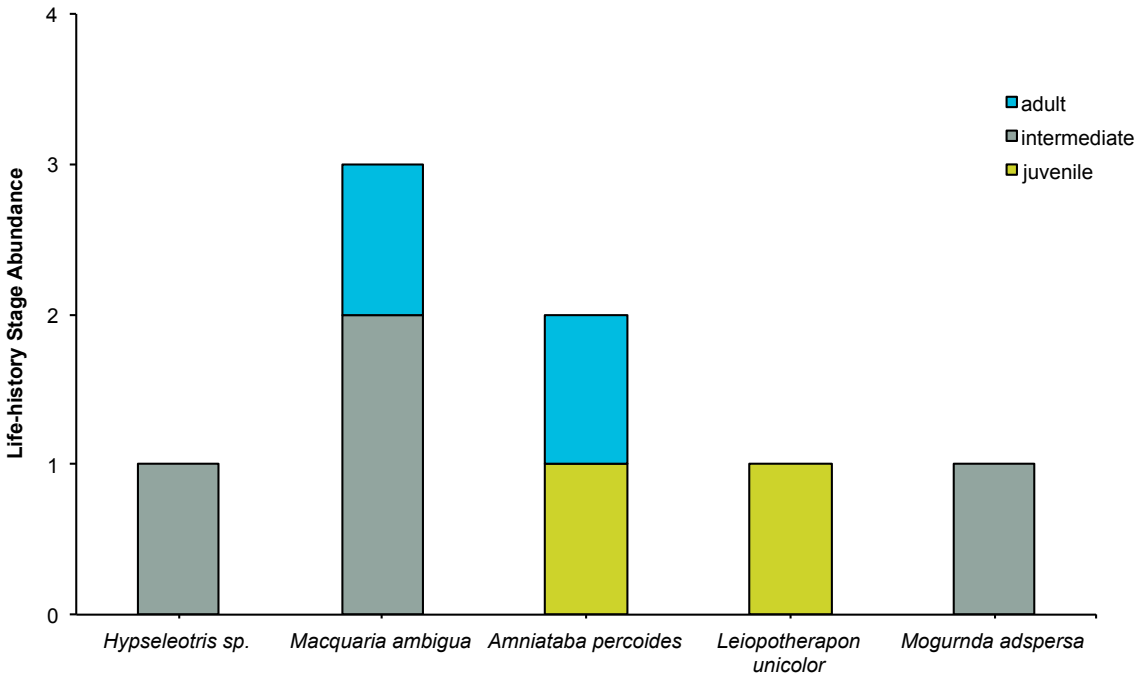



Figure 1 Life history stage of fish at site KP234.

Table 4 Fishing and fish trapping effort at site KP234.

| Site | Method | Habitat | Date | Time In | Time Out | Settings | Effort |
|---|---|---|---|---|---|---|---|
| KP234a | box | pool | 22/06/13 | 9:00 | 12:30 | – | 17.5 h |
| | opera | pool | 22/06/13 | 9:15 | 12:30 | – | 17.5 h |
| | boat electrofishing | pool | 22/06/13 | 10:00 | 10:45 | 200 V<br>30 Hz<br>12% | 1212 s |

## Turtles

Five baited turtle traps (cathedral traps) were set at the site for four hours (20 hours total effort) and no turtles were caught. However, Krefft's River Turtle (*Emydura macquarii krefftii*) was caught in the 2012 survey in the large pool immediately upstream of the site, and it is likely that saw shelled turtle (*Myuchelys latisternum*) inhabits this section of the Dawson River, as they are widespread and common in the region. Furthermore, the field survey showed that preferred habitat types of Fitzroy River turtle (*Rheodytes leukops*), including preferred breeding habitats (i.e. large sandy banks adjacent to pool and riffle habitats) occurred at the site (although the sandy bank at the site was moderately impacted by cattle trampling.

## Description of Aquatic Values

The field survey, literature reviews and database searches were used to inform the assessment of aquatic value for site KP234. Four categories of aquatic value (High, Moderate, Low, Negligible) were used in the Aquatic Values Assessment, as described in frc environmental 2012 and shown in Attachment B.

Site KP234 was assessed as having High Aquatic Value, because:

- database searches show that conservation significant aquatic species (i.e. Fitzroy River turtle, *Rheodytes leukops*) could occur at the site
- the field survey showed that preferred habitat types of Fitzroy River turtle, including preferred breeding habitats (i.e. large sandy banks adjacent to pool and riffle habitats) occurred at the site (although the sandy bank at the site was moderately impacted by cattle trampling), and

- database searches showed that endangered Regional Ecosystems (REs) occurred in the riparian zone (i.e. REs 11.3.2 and 11.3.1).

The proposed crossing location at site KP234 has the same Aquatic Value as the original crossing location, which is located a short distance upstream from site KP234 (i.e. both the original and the proposed crossing locations have High Aquatic Values).

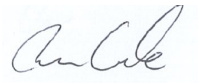
## Recommendations

While site KP234 contains preferred breeding habitat for Fitzroy River turtle, impacts to Fitzroy River turtle can be mitigated were the breeding season (September to October) is avoided during construction. Furthermore, as the sandy bank is currently impacted by cattle trampling, there is an opportunity to consider fencing cattle off from the likely nesting sites of Fitzroy River turtle to off-set potential impacts to these habitats caused by construction.

It is recommended that the generic impact mitigation measures, as outlined in Section 4.2 of frc environmental 2012, are implemented, in accordance with the Aquatic Values Management Plan. Mitigating measures for complex crossings, outlined in frc environmental 2012 should also be implemented, including pre-clearance surveys for Fitzroy River turtle prior to construction.

Nicole, please don't hesitate to contact me if you have any questions.

Yours sincerely



Dr Ben Cook,
on behalf of frc environmental

## References

DERM, 2010, *Fitzroy Natural Resource Management Region, Back on Track Actions for Biodiversity*, Department of Environment and Resource Management, Brisbane.

DERM, 2011. *Environmental Protection (Water) Policy 2009 – Dawson River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Dawson River Sub-basin except the Callide Creek Catchment September 2011*. Department of Environment and Resource Management.

DNRM, 2001. *Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual*. Queensland Department of Natural Resources and Mines, Rocklea.

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# Attachment A: Site Assessment Sheet

| **KP234.0**<br>Catchment: Dawson River | **Coordinates (Zone 55J, WGS 84)** | |
|---|---|---|
| | **Easting**<br>788651.15 | **Northing**<br>7294513.71 |

*Stream Order and Geomorphology*
Stream Order 8
Mildly sinuous channel, average 8 m wide with grazing the dominant surrounding land use. Flow is perennial, and had moderate flow at the time of survey although water level was below the watermark (about 1.5 – 2.0 m deep). The left bank was high and steep with convex slopes; the right bank was steep in sections though not has high, and it also had extensive areas of sandy bank. Overall bank stability was moderate. The channel substrate had low compaction and was composed of predominantly sand, silt / clay and some gravel and pebbles. Moura weir approximately 10 km upstream of site.

*Erosion Risk*
Moderate. Moderate channel disturbance. Evidence of cattle access and clearing of vegetation from erosion prone soils.

*Riparian Vegetation*
Relatively wide riparian zone, 20 m on both the left and right bank, composed of extensive shrubs, small and large trees, moderate grass and some bare ground. Native trees consisted of eucalypts and *Callistemon* sp. and there were some exotic species present (mainly pastoral weeds, parthenium and Mexican daisy). Half the wetted area of the river channel was shaded by riparian vegetation, and there was little trailing bank vegetation.

*Aquatic Flora and Fauna, Including Breeding Habitat*
Moderate diversity of aquatic flora including *Juncus* sp., *Cyperus* sp. and *Persicaria* sp.. Native fish included *Hypseleotris* sp. (carp gudgeon), *Macquaria ambigua* (golden perch), *Amniataba percoides* (barred grunter), *Leiopotherapon unicolor* (spangled perch), and *Mogurnda adspersa* (purple spotted gudgeon). Some freshwater prawns were caught. Structural habitat included aquatic plants, deep pools, riffles, large woody debris and undercut banks.

*Endangered / Vulnerable / Rare (EVR) Flora and Fauna*
Likely habitat, including breeding habitat, for Fitzroy River turtle (*Rheodytes leukops*)

*Aquatic Values*
Habitat Bioassessment Score: 103 (Good)
Macroinvertebrate Richness: 29 (bed); 34 (edge)
Macroinvertebrate PET Richness: 5 (bed); 5 (edge)
Macroinvertebrate SIGNAL 2 Score: 4.40 (bed); 3.75 (edge)
Level of Disturbance: moderate

Overall Aquatic Values:
Dry Season: High
Wet Season: High

Waterway Barrier Works:
4 - Major (Purple) – will require development approval from DAFF

*Mitigation and Management Measures*
Apply all standard mitigation and management measures as summarised in the AVMP.

Apply the following specific management measures:

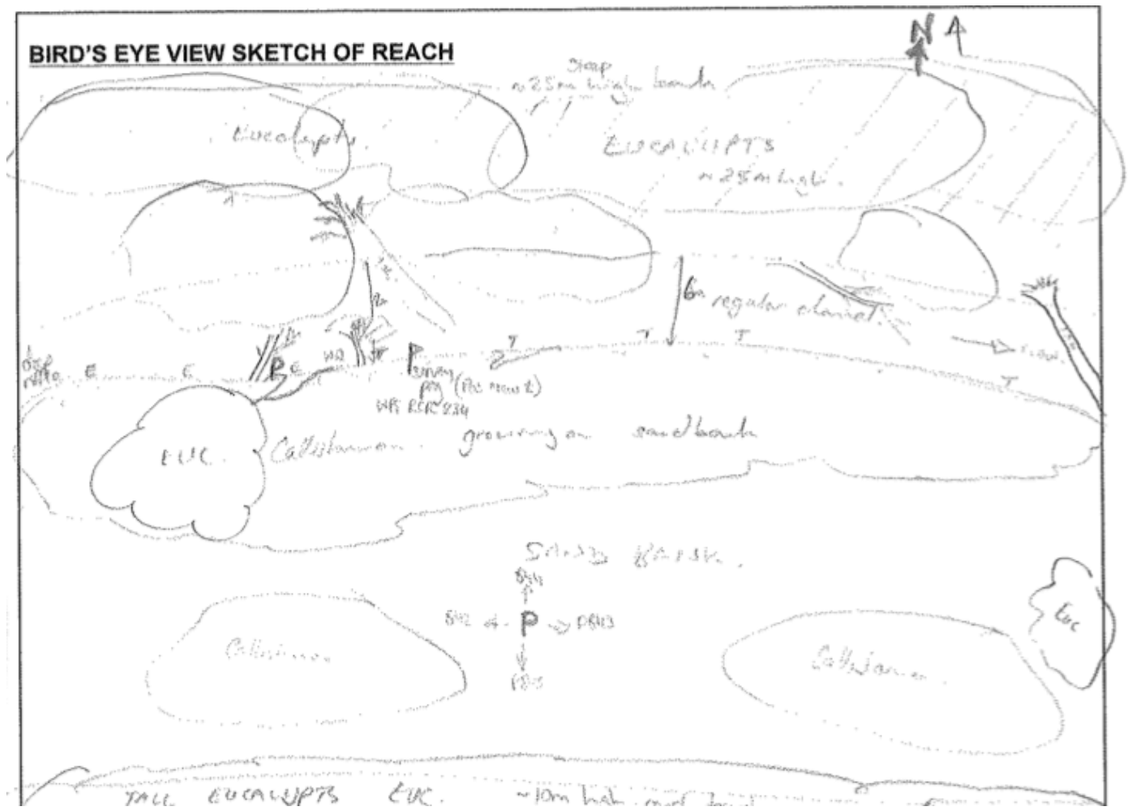
*Timing Constraints*
Dry season works (Avoid during Fitzroy River turtle breeding season, i.e. September / October)

*Site-specific Pipeline Construction Methods and Mitigation Measures*
If workspace is isolated and there is water present, fish and other aquatic fauna salvage required. Implement water quality monitoring (temperature, pH, electrical conductivity, dissolved oxygen and turbidity). Replace bed material and in-stream habitat (e.g. large woody debris) when construction complete.

*Site-specific Access Track Construction Methods and Mitigation Measures*
Avoid if possible. Multi-span bridge or large box culverts. Implement temporary and permanent erosion control measures and rehabilitate as per the AVMP.

**Aerial Photograph of KP**





| Downstream | Upstream |
| --- | --- |
|  |  |
| **Left Bank** | |
|  | |
| **Right Bank** | |
|  | |

# Attachment B: Categories and Descriptions of Aquatic Value

## *High Value*

Where field investigations and / or literature searches indicated that conservation significant species were present. Conservation significant species are those listed in the *Environment Protection and Biodiversity Conservation Act 1999* and / or the *Nature Conservation Act 1992*, and / or those species listed as priority species in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity document (DERM 2010).

Where field investigations and / or literature searches indicated that preferred habitats for conservation species were present. The preferred habitat for conservation significant species was assessed using a combination of:

- habitat condition [e.g. the Bioassessment scores method (DNRM 2001)
- levels of disturbance (e.g. erosion, riparian vegetation condition)
- likely occurrence based on distribution (e.g. using appropriate literature and database searches, e.g. the Protected Matters Report Tool, DEHPs Wildlife Online database, and HERBRECS), and
- relevant habitat features (e.g. pools, riffles and sandy banks for Fitzroy River turtle, Tucker et al. 2001; in-stream habitat and connectivity for freshwater fish, including undercut banks, substrate characteristics, large woody debris).

## *Moderate Value*

Where field investigations indicated the presence of aquatic habitat and non-conservation significant aquatic life, but where field investigations and / or literature searches indicated no conservation significant species or habitats for conservation significant species were present.

Aquatic life included:

- submerged and / or floating attached aquatic plants
- native freshwater fish (such as rainbowfish, spangled perch, glass perchlets, purple spotted gudgeons), and
- aquatic invertebrates (including crayfish, shrimps, snails, mussels, and insects).

Life history stage (i.e. juvenile, intermediate, adult) was recorded for freshwater fish to indicate if the site provided breeding habitat.

Aquatic habitat was assessed using:

- habitat condition (e.g. the Bioassessment scores method (DNRM 2001))
- levels of disturbance (e.g. erosion, riparian vegetation condition), and
- habitat features (e.g. pools, riffles, undercut banks, substrate characteristics, large woody debris).

### *Low Value*

Where field investigations indicated the presence of dry seam beds, without aquatic fauna and submerged aquatic plants.

Emergent aquatic plants, such as sedges and nardoo, may be have been present.

Field investigations also indicated the presence of structural habitat elements, including:

- woody debris
- cobbles, and / or
- undercut banks.

Habitat condition was determined using:

- the Bioassessment scores method (DNRM 2001), noting that this method was developed for perennial streams, and
- levels of disturbance (e.g. erosion, riparian vegetation condition).

### *Negligible Value*

Where field investigations indicated:

- an absence of aquatic habitats, and
- an absence of aquatic life (e.g. no aquatic fauna or aquatic plants, including no sedges).

Habitat condition was typically poor:

- Low Bioassessment Scores (DNRM 2001), and
- High levels of disturbance (e.g. extensive erosion, no riparian vegetation).