Appendix F REMP Annual Reports

Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Geomorphological and Biological Monitoring Report, 2015

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos GLNG operates a number of gas fields in the Bowen and Surat Basins. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River Sub-catchment in central Queensland, is one of a number of Santos GLNG project areas in which coal seam gas (CSG) extraction activities are being conducted. The FAPA is an operating CSG field and includes Petroleum Leases 90, 91, 92, 99, 100, 232, 233, 234, 235, 236, 420, 421 and 440, Petroleum Pipeline Licences 76 and 92, and Authority to Prospect 526P, covering approximately 318, 297 ha.

The release of treated Coal Seam (CS) water from the Fairview Reverse Osmosis Plant (ROP) 2 to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713[1] (formerly PEN100178208). The release is known as the Dawson River Release Scheme (DRRS).

The FAPA EA authorises the release of reverse osmosis-treated CS water from ROP2, which is in the south-east of the FAPA, to a tributary gully of the Dawson River, which joins the Dawson River midway between "Dawson's Bend" and "Yebna Crossing" (Map 1.1). This area between the tributary gully of the Dawson River, which joins the Dawson River midway between "Dawson's Bend" and "Yebna Crossing" located 8.5 km downstream of the receiving wetland is known as the 'receiving environment' as defined by condition (B31) of the FAPA EA. The release includes the following elements:

- CS water produced in the Hub Compressor Station No. 4 (HCS4) gathering network will be collected from the well pads via gathering lines and transported to a coal seam water management pond of 200 ML capacity, sized for 10 days storage at peak production
- CS water will then be passed through ROP2 for treatment, and subsequently stored in a permeate pond of 340 ML capacity, sized for 15 days storage at peak production, before delivery at a maximum rate of 18 ML/day to the outfall pipeline (which is the total capacity of the pipe and the maximum design flow for the release scheme)
- treated CS water will be released to surface waters as defined by the FAPA EA, at the contaminant release point described in the FAPA EA as ROP2. The coordinates for the release location are those described in condition (B14) - Schedule B, Table 3 – Contaminant Release Points of the FAPA EA
- a 5.3 km outfall pipeline will transfer the treated CS water from the permeate pond to the proposed outfall at the tributary gully
- the released water will flow for 2.9 km down the tributary gully before discharging into the Waterbody, estimated to have a volume of approximately 500 ML, and

[1] EPPG00928713, dated 15 December 2015

- the Waterbody overflows into a downstream section of the tributary gully, which flows for a further 1.8 km before discharging to the Dawson River.

The receiving environment of the DRRS therefore contains two water types: the Waterbody (otherwise known as the Wetland by the FAPA EA conditions) and the Dawson River[2].

The EA requires that the release of contaminants from ROP2 must not cause adverse environmental impacts on the species richness or species abundance of aquatic fauna in the receiving environment (Condition B16). To monitor water quality, and the species richness and abundance of aquatic fauna within the receiving environment, the EA requires the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS Project (Condition B30).

1.1 Purpose and Scope

The REMP for DRRS (frc environmental 2015) has been developed to monitor and record the effects of the release water on the receiving environment whilst it is being discharged, as required by the conditions related to the DRRS within the EA.

This Annual Supplementary Geomorphological and Biological Monitoring Report presents the monitoring results of the 2015 post-wet (i.e. May) and pre-wet (i.e. November) surveys for aquatic habitat (including geomorphology – bed and bank stability), sediment quality, macroinvertebrates and fish as required under Conditions B33 (i), B33 (k), B33 (l), B33 (m), and A21 of the EA.

[2] Hutton Creek, upstream of the receiving environment for DRRS, is considered a third water type in the context of the REMP for DRRS

2 Monitoring Program

2.1 Background

Program Design

This Annual Supplementary Geomorphological and Biological Monitoring Report for 2015 presents monitoring results for aquatic habitat (including geomorphology – bed and bank stability), sediment quality, macroinvertebrates and fish. The report meets the requirements of the program design as detailed in the DRRS REMP (frc environmental 2015).

2.2 Timing

The 2015 post-wet survey was undertaken 18 to 20 May 2015 and the 2015 pre-wet survey was undertaken 3 to 4 November 2015.

2.3 Monitored Sites

The sites that are monitored for each monitoring component are shown in Table 2.1, and the geographic location of each site is shown in Table 2.2 and Map 2.1. Water quality and hydrology are monitored by Santos; therefore, reporting for these components is directly managed by Santos in accordance with the REMP design (frc environmental 2015).

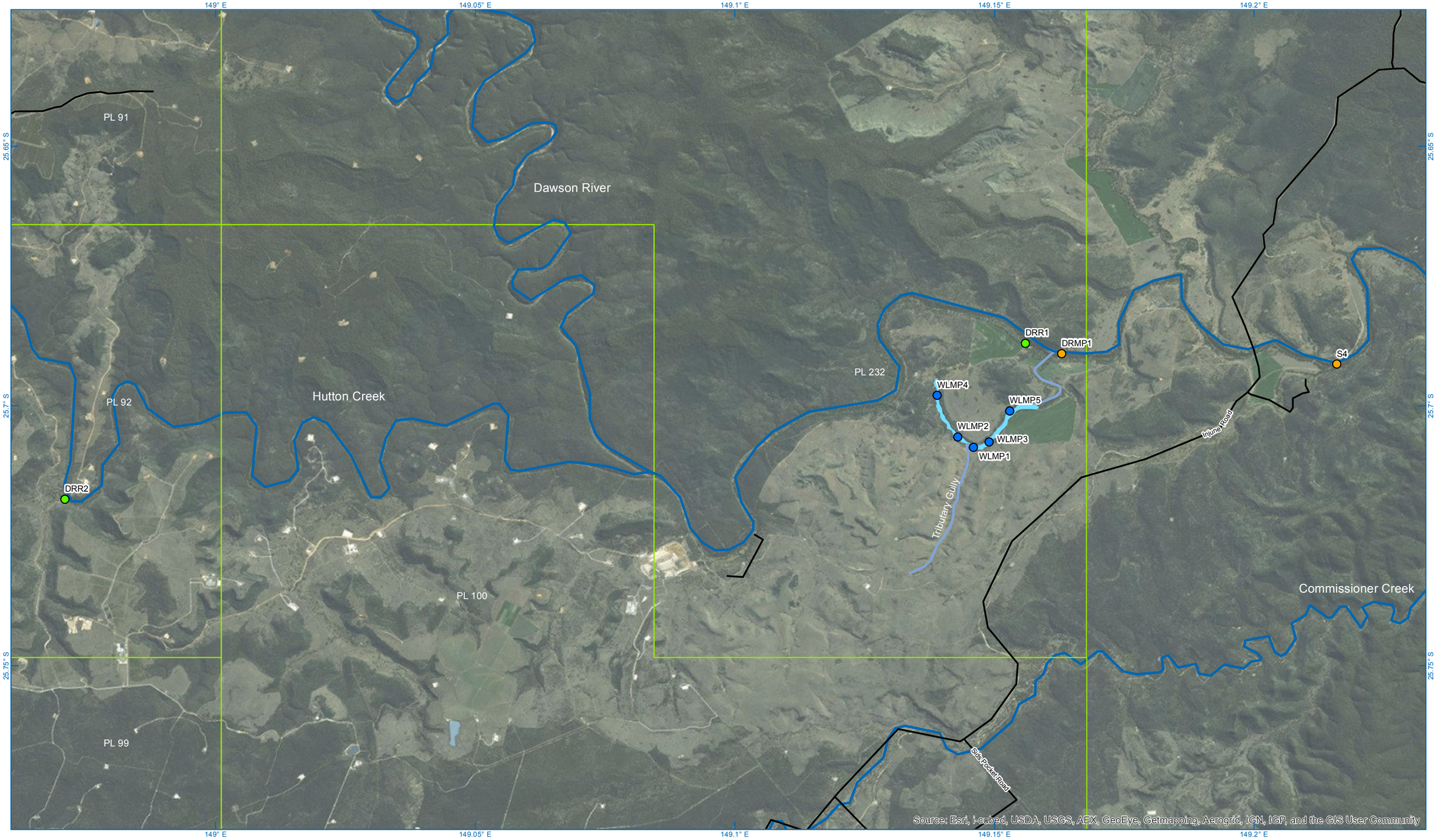
Table 2.1 Monitoring sites specified for each monitoring component.

REMP Monitoring Component	Monitoring Sites
Hydrology	Receiving environment sites: WLMP1, DRMP1 and S4 Control site: DRR1
Geomorphology	Receiving environment sites: WLMP1, WLMP4 and WLMP5 Control site: DRMP1
Water Quality	For parameters nominated in Schedule B, Table 4 of the EA: Receiving environment sites: WLMP1, WLMP2, WLMP3, WLMP4, WLMP5 and DRMP1 Control sites: DRR1 and DRR2
	For parameters nominated in Schedule B, Table 5 of the EA: Receiving environment site: S4 Control sites: DRR1 and DRR2
Sediment Quality	Receiving environment sites: WLMP1, WLMP4, WLMP5, DRMP1 and S4 Control sites: DRR1 and DRR2
Biological Parameters	Receiving environment sites: WLMP1, WLMP4, WLMP5, DRMP1 and S4 Control sites: DRR1 and DRR2

Table 2.2 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1 [a]	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP2 [b]	Waterbody; 450 m upstream of where the tributary gully discharges into the Waterbody.	-25.706	149.143
WLMP3 [c]	Waterbody; 300 m downstream of where the tributary gully discharges into the Waterbody.	-25.707	149.149
WLMP4 [d]	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5 [e]	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges into the Waterbody and 8 km downstream of the confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.	-25.692	149.216
Control Sites Upstream of the Receiving Environment			
DRR1 [f]	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2 [g]	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

Baseline site represented by: [a] = WMP1, [b] = WMP2, [c] = WMP3, [d] = WMP4, [e] =WMP5, [f] = RS1, [g] = RS2



frc environmental
AQUATIC ECOLOGISTS
deep thinking. science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme: Receiving Environment Monitoring Program

Map 2.1: Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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Document Path: Y:\Projects\2015\150908_SAN_Pre-wet-DRRS\Mapping\Workspaces\150908_monitoring_points.mxd

LEGEND

Monitoring Site

- Control Site
- Dawson River Site Within Receiving Environment
- Waterbody Site Within Receiving Environment
- Waterbody
- Tributary Gully
- Major Waterway
- Fairview Project Area
- Local Road

N

SCALE

0 1 2 4
Kilometres

Scale: 1:75,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2015-12-16

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VERSION
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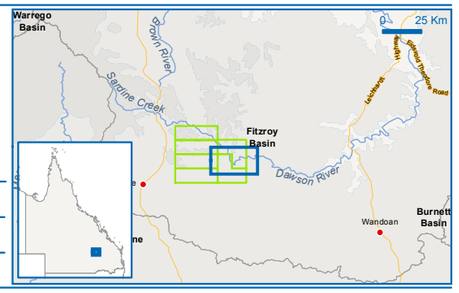

2.4 Quality Assurance

All monitoring was performed by suitably qualified persons, with sampling of sediment completed as per Australian / New Zealand Standard AS/NZ5667.12 *Guidance on Sampling of Bottom Sediments*, and the *Handbook for Sediment Quality Assessment* (Simpson et al. 2005). The sampling of aquatic habitat and biological parameters was as per the *Monitoring and Sampling Manual 2009 Environmental Protection (Water) Policy 2009* (EHP 2013).

The following quality assurance outcomes relate to the 2015 post-wet survey:

- high turbidity did not allow an accurate assessment of submerged habitat at Waterbody sites or site DRR2 on Hutton Creek. This is consistent with water quality conditions throughout the baseline monitoring program.

The following quality assurance outcomes relate to the 2015 pre-wet survey:

- all riverine sites (DRMP1, S4, DRR1 and DRR2) were in flood condition at the time of the survey, impacting the field team's ability to safely assess these sites and accurately assess submerged habitats, with the following outcomes:
  - fish were not sampled due to safety concerns
  - in-stream habitat (including bio-assessment) could not be assessed as all in-stream habitat was submerged under flood water
  - sediment samples were not collected at the Dawson River sites (i.e. DRR1, DRMP1 and S4) as bed sediments could not be accessed as a result of flood conditions, and
  - samples of edge habitat for macroinvertebrates were collected higher on the bank than usual; thus, samples were not directly comparable to samples collected during the baseline program.

3 Sediment Quality

3.1 Methods

Survey Procedure

Three sediment samples were collected from the top 0.30 m of the bed using a stainless steel trowel at each site for each survey, with the sediments transferred directly into the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids). The analytical limit of reporting was specified on the chain of custody documentation, and this was achieved for all parameters.

Data Analysis

The mean plus standard error was calculated for each parameter for each site across both surveys, and the mean values were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2015).

3.2 Results

Results for the laboratory analyses of sediment quality (Table 3.1; Appendix A) showed that:

- The concentration of manganese at control site DRR1 on the Dawson River was higher than the local sediment guideline value. While the mean concentration of iron was also slightly higher than the guideline value at site DRR1, the error around the mean overlapped with the guideline, indicating that the result is not statistically higher than the guideline. As site DRR1 is a control site, upstream from the release point, the high concentration of manganese and iron is not related to the release of treated CS water from ROP2. The concentration of manganese and iron complied with the applicable local sediment quality guideline at all other sites.
- While the mean concentration of Boron at Waterbody site WLMP4 was higher than the local sediment quality guideline, the error around the mean overlapped with the guideline, indicating that the result is not statistically higher than the guideline. The

baseline sediment data for Spring 2014 indicates that this site can have increased concentrations of boron (i.e. 23.1 mg/kg), similar to concentrations recorded at the Waterbody sites in the 2015 pre-wet survey (Appendix A). When the 2015 post- and pre- wet surveys are considered separately (Appendix A), the concentration of boron increased by an order of magnitude across most of the surveyed sites from the post-wet survey to the pre-wet survey. The increased concentrations of boron observed across all sites, but especially at the Waterbody sites, in the pre-wet survey is likely due to natural variation relating to rainfall and runoff patterns, especially considering that site WLMP4 was hydrologically isolated from all other Waterbody sites during the 2015 pre-wet survey.

- The concentration of all other parameters complied with the applicable local sediment quality guideline at all sites for both surveys.

Table 3.1 Sediment quality results (mean ± SE) for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2015 pre- and post- wet surveys combined.

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local Trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	0.5	13933	8053 (±1308)	7305 (±620)	8320 (±820)	5191	1575 (±602)	1468 (±397)	4917 (±240)	11800	4475 (±379)
Arsenic (As)	mg/kg	1	20	2.98 (±0.18)	2.30 (±0.13)	1.77 (±0.16)	20	1.07 (±0.30)	<1.00 (±0.23)	2.67 (±0.09)	20	2.72 (±0.63)
Boron (B)	mg/kg	5	18.8	19.82 (±5.73)	16.22 (±4.18)	15.95 (±3.90)	17.9	<5.00 (±0.00)	<5.00 (±0.00)	6.63 (±0.03)	25	15.40 (±2.98)
Cadmium (Cd)	mg/kg	0.5	1.5	<0.50 (±0.00)	<0.50 (±0.00)	<0.50 (±0.00)	1.5	<0.50 (±0.00)	<0.50 (±0.00)	<0.50 (±0.00)	1.5	<0.50 (±0.00)
Chromium (Cr)	mg/kg	1	80	10.27 (±2.08)	7.73 (±1.23)	10.02 (±1.55)	80	2.03 (±0.82)	1.57 (±0.32)	4.77 (±0.09)	80	6.85 (±0.88)
Copper(Cu)	mg/kg	1	65	11.45 (±1.85)	10.65 (±1.14)	11.97 (±1.20)	65	2.17 (±0.95)	1.73 (±0.63)	6.23 (±0.23)	65	5.65 (±0.68)
Iron (Fe)	mg/kg	2	17867	12678 (±1606)	10813 (±796)	10907 (±749)	9353	3843 (±1061)	2880 (±574)	9420 (±146)	20700	12872 (±3367)
Lead (Pb)	mg/kg	1	50	12.23 (±1.58)	10.75 (±1.11)	12.07 (±1.10)	50	2.87 (±1.28)	2.87 (±0.68)	7.80 (±0.38)	50	8.95 (±0.55)
Manganese (Mn)	mg/kg	1	648	454 (±54)	342 (±16)	369 (±30)	230.5	71 (±21)	53 (±24)	257 (±16)	337	256 (±31)
Mercury (Hg)	mg/kg	0.5	0.15	<0.50 (±0.00)	<0.50 (±0.00)	<0.50 (±0.00)	0.15	<0.50 (±0.00)	<0.50 (±0.00)	<0.50 (±0.00)	0.15	<0.50 (±0.00)
Nickel (Ni)	mg/kg	0.5	21	8.20 (±0.89)	7.17 (±0.51)	7.75 (±0.52)	21	2.43 (±0.79)	1.80 (±0.35)	5.57 (±0.07)	21	4.78 (±0.20)
Selenium (Se)	mg/kg	1	1	<1.00 (±0.00)	<1.00 (±0.00)	<1.00 (±0.00)	1.73	<1.00 (±0.00)	<1.00 (±0.00)	<1.00 (±0.00)	1	<1.00 (±0.00)
Zinc (Zn)	mg/kg	5	200	40.85 (±6.83)	41.27 (±4.73)	41.88 (±4.28)	200	9.47 (±3.57)	7.13 (±2.38)	23.63 (±0.64)	200	24.90 (±2.18)

LOR = analytical limit of reporting

grey shading indicates where the LOR is higher than the trigger value.

4 Aquatic Habitat, and Bed and Bank Stability

4.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers Method, as described in the REMP design document (frc environmental 2015).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons against baseline condition, as presented in the REMP design document (frc environmental 2015), have been made.

4.2 Results

Aquatic habitat summary sheets for each site and each survey are presented in Appendix B. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 4.1 and Table 4.2) showed:

- bed and bank stability at all sites and for all water types had not changed from baseline condition during both surveys
- flow habitat diversity at site DRR2 on Hutton Creek was higher than the baseline condition during the post-wet survey due to an increase in the water level after heavy rainfall in December 2014 / January 2015 (i.e. about 3 months prior to the survey); for most of the baseline surveys, this site consisted of a small isolated pool; flow habitat diversity remained low at DRR2 for the pre-wet survey, with the site instead in flood condition
- flow habitat diversity for the Dawson River water type was lower than the baseline condition during the pre-wet survey due to flood conditions at the time of the survey
- the physical habitat features at sites WLMP1 and WLMP5 in the Waterbody was higher than the baseline condition during the pre-wet survey, related to an increase in the cover of submerged macrophytes (*Potamogeton crispus*) in the water, and

- all other aquatic habitat features for all water types for both surveys had not changed since baseline condition.

Table 4.1 Habitat characteristics of each water type in the 2015 Post-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	*high*	*low to moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*moderate*
Physical habitat features	*low*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition
grey shading indicates a potential decline in habitat quality compared to baseline conditions
blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 4.2 Habitat characteristics of each water type in the 2015 Pre-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	–	–
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*low*	*low*
Physical habitat features	*low–moderate*	–	–

cells that are not shaded have current habitat quality that is the same as baseline condition
grey shading indicates a potential decline in habitat quality compared to baseline conditions
blue shading indicated a potential increase in habitat quality compared to baseline conditions
– habitat characteristics were not assessed due to flood conditions

5 Macroinvertebrate Communities

5.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site for each survey using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using methylated spirit and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a trained ecologists and in accordance with the Smartrivers methodology (Smart Rivers 2013).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual 2009* (DERM 2009). Enumeration and identification of samples was done by trained and accredited ecologists. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. An error rate of < 10% was considered acceptable as per the REMP, and this was achieved.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (in this assessment, generally 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

The mean (±SE) of these indices were calculated for each site across both surveys, and the mean for each index calculated for each site and water type was compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (frc environmental 2015). Where the mean for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the mean for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring (Appendix C), that is - is the survey result lower than the 5th (or the 1st) percentile of baseline data for that water type, and if it is, then:
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

5.2 Results

Results for macroinvertebrate indices showed that (Table 5.1, Table 5.2, Appendix D):

- site S4 on the Dawson River had the mean of all four macroinvertebrate indices below the local biological guidelines, although the standard error for taxonomic richness overlapped with the guideline, indicating that this index was not statistically lower than the guideline. The mean for SIGNAL-2 Score at site DRR1 (upstream of the release location), and for the Dawson River overall, was also below the guideline. These results are likely due to flood conditions in the Dawson River at the time of the pre-wet survey, with sampling completed higher up the bank than was completed during the baseline program
- site DRR2 on Hutton Creek had mean PET richness and SIGNAL-2 Score that was higher than the local biological guideline, indicating that the majority of invertebrate taxa sampled were from families sensitive to pollution and degraded conditions.
- at Waterbody sites WLMP4 and WLMP5, mean taxonomic richness was higher than the guideline, and at site WLMP5 mean PET richness was higher than the guideline. These results indicate habitat conditions in the Waterbody were similar to or better than, baseline condition for supporting macroinvertebrates, with the high abundance of submerged aquatic plants observed during the 2015 pre-wet survey potentially contributing to these macroinvertebrate results.

Table 5.1 Macroinvertebrate results for each site in the 2015 surveys.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	197.5 (±23.0)	244.4 (±26.9)	134.5 (±30.5)	39.9–152.0	71.4 (±10.3)	32.5 (±5.5)	119.6 (±14.9)	23.0–207.4	85.1 (±21.3)
Taxonomic Richness	5.67–10.8	14.7 (±1.8)	10.3 (±0.4)	12.1 (±0.6)	9.93–16.9	12.0 (±0.6)	9.6 (±0.8)	11.9 (±0.6)	4.0–10.0	8.8 (±1.0)
PET richness	0 – 1.2	1.1 (±0.2)	0.9 (±0.2)	1.4 (±0.2)	1.47–4.0	2.4 (±0.4)	1.0 (±0.3)	2.0 (±0.3)	0–1.0	1.4 (±0.3)
SIGNAL-2 Score	2.65 – 3.20	3.01 (±0.07)	3.10 (±0.05)	2.88 (±0.05)	3.46–4.00	3.63 (±0.12)	3.03 (±0.17)	3.23 (±0.08)	2.90–3.30	3.36 (±0.06)

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 5.2 Macroinvertebrate results for each water type in the 2015 surveys.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	192.1 (±16.7)	39.9 – 152.0	74.5 (±8.3)	23.0 – 207.4	85.1 (±21.3)
Taxonomic Richness	5.67–10.8	12.4 (±0.7)	9.93 – 16.9	11.2 (±0.4)	4.0 – 10.0	8.8 (±1.0)
PET richness	0 – 1.2	1.1 (±0.1)	1.47 – 4.0	1.8 (±0.2)	0 – 1.0	1.4 (±0.3)
SIGNAL-2 Score	2.65 – 3.20	2.99 (±0.04)	3.46 – 4.00	3.30 (±0.08)	2.90 – 3.30	3.36 (±0.06)

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

6 Fish

6.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 6.1 and Table 6.2). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under General Fisheries Permits (181742) and Animal Ethics Approvals (CA 2015/08/893) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded, and the apparent health of individuals noted. Identifications of fish were made in the field by experienced freshwater ecologists. Any exotic species caught was recorded and euthanized in accordance with ethics approvals.

Table 6.1 Effort used to catch freshwater fish in the 2015 Post-wet survey.

Site	Method	Habitat	Date	Time In	Time Out	Effort
Waterbody						
WLMP4	fyke net (2)	pool	18/05/15	12:00	7:30	39 h
WLMP1	fyke net (2)	pool	18/05/15	14:00	8:00	36 h
WMLP5	fyke net (2)	pool	18/05/15	15:00	9:00	36 h
Dawson River						
DRMP1	fyke net (2)	pool	19/05/15	11:00	10:30	47 h
S4	fyke net (2)	pool	19/05/15	15:00	7:30	33 h
DRR1 [1]	fyke net (2)	pool	19/05/15	12:00	11:30	47 h
Hutton Creek						
DRR2	fyke net (2)	pool	20/15/15	9:00	16:00	14 h

1 several fish were also caught at this site in cathedral traps set for turtles.

Table 6.2 Effort used to catch freshwater fish in the 2015 Pre-wet survey.

Site	Method	Habitat	Date	Time In	Time Out	Effort
Waterbody						
WLMP4	dip net	pool	03/11/15	13:15		3 x 2 m hauls
WLMP1	fyke net (2)	pool	03/11/15	14:45	08:15	35 h
WMLP5	fyke net (2)	pool	03/11/15	15:15	09:30	36.5 h
Dawson River						
DRMP1	–	–	–	–	–	–
S4	–	–	–	–	–	–
DRR1 [1]	–	–	–	–	–	–
Hutton Creek						
DRR2	–	–	–	–	–	–

– site was not fished due to flood conditions

Data Analysis

The richness of native and exotic fish species was determined for each water type on each survey (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was recommended.

The local guidelines for fish, as presented in the REMP design (frc environmental 2015) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

6.2 Results

Nine species of native fish were caught and / or observed during the post-wet survey (Table 6.3) and four species were caught during the pre-wet survey (Table 6.4). None of these species are conservation significant species under the EPBC Act or the NC Act. The number of native species caught at each site during the post-wet survey ranged from 2 (site S4 during the post-wet survey) to eight (site DRR1 during the post-wet survey). During the pre-wet survey, four native species were caught at sites WLMP1 and WLMP5 but no fish were caught at WLMP4, due to the very shallow depth and isolated condition of water at this site at the time of survey. Total abundance of fish at each site during the post-wet survey ranged from 15 (site S4) to 307 (site WLMP5), and 0 (WLMP4) to 177 (WLMP1) during the pre-wet survey. The range of fish abundances between surveys was due to differences in natural flow conditions and habitat size (i.e. pool dimensions and depth) between the surveys. The most commonly recorded species during the post-wet survey were carp gudgeons and Agassiz's glassfish, with and eastern rainbowfish the most abundant species during the pre-wet survey. Exotic species (goldfish) were only caught during the pre-wet survey at site WLMP1.

All water types for both surveys achieved the local biological guideline for fish (i.e. had an observed : expected ratio of species diversity that was ≥ 1) (Table 6.5 and Table 6.6). This indicates that the diversity of fish caught during the 2015 REMP surveys were the same as or higher than that caught during the baseline monitoring program. Increased water flow associated with heavy rainfall in December 2014 / January 2015 (i.e. 3 month prior to the post-wet survey) in the Dawson River and Hutton Creek may have created more favourable conditions for fish in these water types compared to baseline conditions for this survey.

A comparison with baseline conditions could not be made for the Dawson River or Hutton Creek water types for the pre-wet survey due to flood conditions.

Table 6.3 Total abundance of freshwater fish for each species at each site in 2015 Post-wet survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	3	139	132	5	0	4	0	**283**
Craterocephalus stercusmuscarum	flyspecked hardyhead	0	0	0	0	0	3	0	**3**
Hypseleotris spp.	carp gudgeon	63	110	172	0	0	24	22	**391**
Leiopotherapon unicolor	spangled perch	0	3	3	0	0	0	0	**6**
Macquaria ambigua	yellow belly	0	0	0	0	0	1	0	**1**
Melanotaenia splendida splendida	eastern rainbowfish	3	3	0	5	7	10	4	**32**
Nematalosa erebi	bony bream	0	0	0	0	0	2	3	**5**
Pseudomugil signifer	pacific blue eye	0	0	0	27	8	54	0	**89**
Tandanus tandanus	freshwater catfish	0	0	0	11	0	4	0	**15**
Total individuals		**69**	**255**	**307**	**48**	**15**	**102**	**29**	**825**
Total species		**3**	**4**	**3**	**4**	**2**	**8**	**3**	**9**

Table 6.4 Total abundance of freshwater fish for each species at each site in 2015 Pre-wet survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	0	28	9	–	–	–	–	**37**
Hypseleotris spp.	carp gudgeon	0	33	8	–	–	–	–	**41**
Leiopotherapon unicolor	spangled perch	0	27	23	–	–	–	–	**50**
Melanotaenia splendida splendida	eastern rainbowfish	0	89	15	–	–	–	–	**104**
Total individuals		**0**	**177**	**55**	**–**	**–**	**–**	**–**	**232**
Total species		**0**	**4**	**4**	**–**	**–**	**–**	**–**	**4**
Exotic Species									
Carassius auratus	goldfish	0	31	0	–	–	–	–	**31**

– site was not surveyed due to flood conditions

Table 6.5 Comparison of fish monitoring results with the local biological objective for fish for the 2015 Post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	4	1.0
Dawson River	5	8	1.6
Hutton Creek	2	3	1.5

Table 6.6 Comparison of fish monitoring results with the local biological objective for fish for the 2015 Pre-wet survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	4	1.0
Dawson River	–	–	–
Hutton Creek	–	–	–

– water type was not surveyed due to flood conditions

7 Macrocrustaceans – Exoskeleton Assessment

7.1 Methods

Survey Procedure

To satisfy condition B33 (m) in the EA individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded (frc environmental 2015). The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 7.1).

7.2 Results

The macrocrustaceans caught during the post wet and pre-wet surveys were of the same species caught during the baseline program, noting that only the Waterbody could be sampled during the 2015 pre-wet survey (Table 7.2 and Table 7.3). All specimens had exoskeletons that were robust and of good condition (Table 7.2 and Table 7.3). Although previous baseline surveys recorded macrocrustaceans in breeding condition in spring, no macrocrustaceans were in breeding condition during the pre-wet survey. This is most likely a result of the high flow conditions and limited sampling (sampling of Waterbody only), rather than an indication of a decline in macrocrustacean health.

Table 7.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 7.2 Macrocrustacean species and condition recorded during the 2015 Post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 7.3 Macrocrustacean species and condition recorded during the 2015 Pre-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	–	–
Breeding condition	not breeding	–	–
Exoskeleton condition	exoskeletons robust and in good condition	–	–

Macrobrachium australiense – long-armed river prawn (family Palaemonidae);

– water type was not surveyed due to flood conditions

8 Assessment of Environmental Changes

Monitoring results for 2015 indicated that the majority of components have not changed from baseline condition, with the exception of:

- The concentration of manganese in sediment at control site was higher than the local guideline. As site DRR1 is upstream of the release point, this result is not related to the discharge of treated CS water from ROP2. Rather, this result is likely due to natural variation.
- The concentration of boron in sediment, which increased from the post-wet survey to the pre-wet survey, although the mean concentration of boron was not statistically higher than the guideline at any site. The increased concentrations of boron observed across all sites, but especially at the Waterbody sites, in the pre-wet survey is likely due to natural variation relating to rainfall and runoff patterns, especially considering that site WLMP4, which had the highest mean concentration of boron in sediment, was hydrologically isolated from all other Waterbody sites during the 2015 pre-wet survey and was therefore upstream of the release location.
- Flow habitats, which had improved from baseline condition in Hutton Creek during the post-wet survey due to increased flow associated with high rainfall in December 2014 / January 2015 (i.e. about 3 months prior to the survey). Flow habitats had decreased from baseline conditions at Dawson River sites during the pre-wet survey due to flood conditions at the time of survey.
- Several results for the macroinvertebrate indices, which showed variation from baseline condition, but no evidence that the release of treated CS water from ROP2 had impacted aquatic ecology. The specific variations from baseline condition related to:
  - Low values (i.e. below guideline values) for most macroinvertebrate indices at site S4 on the Dawson River, and for SIGNAL-2 Scores at site DRR1 and the Dawson River overall. These results are likely due to flood conditions in the Dawson River at the time of the pre-wet survey, with sampling completed higher up the bank than was completed during the baseline program.
  - The abundance, taxonomic richness and PET richness of macroinvertebates at several sites on the Waterbody and Hutton Creek during the post-wet survey, which were higher than the applicable local biological objective for macroinvertebrates. These results were likely due to improved flow habitats at the time of survey compared to baseline condition in Hutton Creek. Similarly, water levels in the Waterbody increased with heavy rainfall in December

2014 / January 2015 (i.e. about 3 months prior to the survey), which may have created favourable conditions for recruitment by aquatic insects, such as the PET taxa, and increased the diversity and / or abundance of these sensitive taxa in the Waterbody compared to baseline conditions. The high abundance of submerged aquatic plants in the Waterbody during the pre-wet survey, including at site WLMP4 that was not hydrologically connected to the release water, may have also contributed to the high abundance and diversity of macroinvertebrates in the Waterbody compared to baseline condition.

Overall, the 2015 REMP survey results indicated that the release of treated CS water from ROP2 had not influenced aquatic ecology in the receiving environment.

9 References

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Appendix A Sediment Quality Results for Each Survey

Table A.1 Sediment quality results (mean ± SE) for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2015 Post-wet REMP survey.

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local Trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	0.5	13933	5307 (±307)	5983 (±318)	6917 (±296)	5191	1575 (±602)	1468 (±397)	4917 (±240)	11800	3830 (±467)
Arsenic (As)	mg/kg	1	20	2.7 (±0.2)	2.5 (±0.1)	2 (±0.1)	20	1.1 (±0.3)	<1 (±0.2)	2.7 (±0.1)	20	3.4 (±1.2)
Boron (B)	mg/kg	5	18.8	7 (±0.3)	6.9 (±0.3)	7.5 (±0.1)	17.9	<5 (±0)	<5 (±0)	6.6 (±0)	25	10.9 (±4.9)
Cadmium (Cd)	mg/kg	0.5	1.5	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	1.5	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	1.5	<0.5 (±0)
Chromium (Cr)	mg/kg	1	80	5.6 (±0.2)	5 (±0.4)	6.9 (±0.2)	80	2 (±0.8)	1.6 (±0.3)	4.8 (±0.1)	80	5.6 (±1.5)
Copper(Cu)	mg/kg	1	65	7.5 (±0.3)	8.2 (±0.6)	9.7 (±0.3)	65	2.2 (±1)	1.7 (±0.6)	6.2 (±0.2)	65	4.4 (±0.7)
Iron (Fe)	mg/kg	2	17867	9157 (±479)	9160 (±399)	9780 (±362)	9353	3843 (±1061)	2880 (±574)	9420 (±146)	20700	15527 (±7041)
Lead (Pb)	mg/kg	1	50	8.8 (±0.2)	8.3 (±0.4)	10.1 (±0.4)	50	2.9 (±1.3)	2.9 (±0.7)	7.8 (±0.4)	50	9.2 (±1.2)
Manganese (Mn)	mg/kg	1	648	338.7 (±5)	313.3 (±12.7)	306.7 (±17.7)	230.5	71.2 (±21)	53 (±23.9)	257 (±15.5)	337	202.3 (±32.9)
Mercury (Hg)	mg/kg	0.5	0.15	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	0.15	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	0.15	<0.5 (±0)
Nickel (Ni)	mg/kg	0.5	21	6.3 (±0.2)	6.1 (±0.4)	7.1 (±0.1)	21	2.4 (±0.8)	1.8 (±0.3)	5.6 (±0.1)	21	4.6 (±0.3)
Selenium (Se)	mg/kg	1	1	<1 (±0)	<1 (±0)	<1 (±0)	1.73	<1 (±0)	<1 (±0)	<1 (±0)	1	<1 (±0)
Zinc (Zn)	mg/kg	5	200	26.7 (±1.8)	30.9 (±1.6)	34.2 (±0.7)	200	9.5 (±3.6)	7.1 (±2.4)	23.6 (±0.6)	200	24.1 (±4.6)

LOR = analytical limit of reporting

grey shading indicates where the LOR is higher than the trigger value.

Table A.2 Sediment quality results (mean ± SE) for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2015 Pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local Trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	0.5	13933	8626 (±268)	10800 (±953)	9723 (±1141)	5191	–	–	–	11800	5120 (±289)
Arsenic (As)	mg/kg	1	20	2.13 (±0.20)	3.27 (±0.23)	1.53 (±0.23)	20	–	–	–	20	2 (±0.06)
Boron (B)	mg/kg	5	18.8	25.53 (±0.66)	32.6 (±0.67)	24.43 (±2.03)	17.9	–	–	–	25	19.9 (±0.15)
Cadmium (Cd)	mg/kg	0.5	1.5	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	1.5	–	–	–	1.5	<0.5 (±0)
Chromium (Cr)	mg/kg	1	80	10.47 (±0.15)	14.9 (±0.40)	13.17 (±1.45)	80	–	–	–	80	8.13 (±0.178)
Copper(Cu)	mg/kg	1	65	13.13 (±0.20)	15.43 (±1.07)	14.23 (±1.42)	65	–	–	–	65	6.93 (±0.38)
Iron (Fe)	mg/kg	2	17867	12467 (±524)	16200 (±513)	12033 (±1184)	9353	–	–	–	20700	10217 (±249)
Lead (Pb)	mg/kg	1	50	13.17 (±0.45)	15.67 (±0.82)	14.03 (±1.44)	50	–	–	–	50	8.73 (±0.12)
Manganese (Mn)	mg/kg	1	648	369.67 (±18.68)	570 (±36.01)	430.67 (±21.18)	230.5	–	–	–	337	310.33 (±27.69)
Mercury (Hg)	mg/kg	0.5	0.15	<0.5 (±0)	<0.5 (±0)	<0.5 (±0)	0.15	–	–	–	0.15	<0.5 (±0)
Nickel (Ni)	mg/kg	0.5	21	8.23 (±0.18)	10.13 (±0.45)	8.37 (±0.97)	21	–	–	–	21	5 (±0.25)
Selenium (Se)	mg/kg	1	1	<1 (±0)	<1 (±0)	<1 (±0)	1.73	–	–	–	1	<1 (±0)
Zinc (Zn)	mg/kg	5	200	51.67 (±1.13)	55.03 (±5.39)	49.6 (±5.62)	200	–	–	–	200	25.73 (±1.33)

LOR = analytical limit of reporting

grey shading indicates where the LOR is higher than the trigger value.

– sites were not sampled due to flood conditions

Appendix B Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson; Waterbody
Date surveyed:	18/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*33 (poor)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	>10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	high		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	low, stepped		pebble	0 %		large woody debris	**Weed species**	herbaceous species
			gravel	0 %		emergent aquatic plants	**Adjacent land use**	light grazing
Hydrology			sand	0 %				native vegetation
Flow regime	intermittent		silt / clay	100 %				
Water depth	1.0 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	26 m	**Bed stability**	stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	50 m							

Comments: some pig damage along water's edge (not extensive)

Site	WLMP4	**Region**	Upper Dawson; Waterbody
Date surveyed:	04/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	*40 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	>10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	high		cobble	0 %		large woody debris	**Dominant species**	native species
Bank shape	low, stepped		pebble	0 %		submerged macrophytes	**Weed species**	herbaceous species
			gravel	0 %		emergent aquatic plants		including thistle
Hydrology			sand	0 %		algal clumps	**Adjacent land use**	light grazing
Flow regime	–		silt / clay	100 %				native vegetation
Water depth	0.1 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	50 m							

Comments: site was ~50% dry with a single isolated shallow pool present; submerged macrophytes (*Potamogeton crispus*) was observed for the first time at the site; some benthic algae, surface scum and cattle disturbance was also observed.

Site	WLMP1	**Region**	Upper Dawson; Waterbody
Date surveyed:	18/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*33 (poor)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	low, stepped		pebble	0 %		large woody debris	**Weed species**	herbaceous species
			gravel	0 %		emergent aquatic plants	**Adjacent land use**	native vegetation
Hydrology			sand	0 %				light grazing
Flow regime	intermittent		silt / clay	100 %				
Water depth	1.3 m	**Deposits**	silt		In-stream disturbance			
Wetted width	20 m	**Bed stability**	bed stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	25 m							

Comments: row of *Juncus* less defined/obvious than in baseline surveys; *Persicaria orientalis* in water in poor condition; large woody debris both in and adjacent to water; very little *Ludwigia* at site; green tinge to water suggesting high concentration of chlorophyll *a*.

Site	WLMP1	**Region**	Upper Dawson; Waterbody
Date surveyed:	04/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	*47 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	deep pool	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		large woody debris	**Dominant species**	native species
Bank shape	low, stepped		pebble	0 %		emergent aquatic plants	**Weed species**	herbaceous species
			gravel	0 %		submerged aquatic plants	**Adjacent land use**	native vegetation
Hydrology			sand	0 %		floating aquatic plants		light grazing
Flow regime	–		silt / clay	100 %				
Water depth	2.5 m	**Deposits**	silt		In-stream disturbance			
Wetted width	25 m	**Bed stability**	bed stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	25 m							

Comments:	water level was higher than all previous surveys, but not up to the top of the bank; water was clear and free of surface scum; aquatic plants were abundant with *Potamogeton crispus*, *Azolla* and *Spirodela* in the water and *Ludwigia peploides* and *Persicaria* sp. on the bank; wildlife was healthy with frogs abundant upstream and a black swan nest observed

Site	WLMP5	**Region**	Upper Dawson; Waterbody
Date surveyed:	19/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*35 (poor)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	5, 10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	flat / moderate, stepped		pebble	0 %		large woody debris	**Weed species**	herbaceous species
			gravel	0 %		emergent aquatic plants	**Adjacent land use**	light grazing
Hydrology			sand	0 %				native vegetation
Flow regime	intermittent		silt / clay	100 %				
Water depth	1.5 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	50 m	**Bed stability**	bed stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	70 m							

Comments: minor pig damage near water edge.

Site	WLMP5	**Region**	Upper Dawson; Waterbody
Date surveyed:	07/11//15 (Pre-wet survey)	**Habitat Bioassessment Score**	*44 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low	**Riparian width**	5, 10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	flat / moderate, stepped		pebble	0 %		emergent aquatic plants	**Weed species**	herbaceous species
			gravel	0 %		submerged macrophytes	**Adjacent land use**	light grazing
Hydrology			sand	0 %		floating macrophytes		native vegetation
Flow regime	–		silt / clay	100 %				
Water depth	2.5 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	40 m	**Bed stability**	bed stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	70 m							

Comments:	water level was higher than all previous surveys, and up to the top of the bank with some terrestrial herbs now submerged; water was clear and free of surface scum; aquatic plants were abundant with *Potamogeton crispus*, *Ludwigia peploides* and *Juncus usitatus* in the water; wildlife was relatively healthy with frogs heard in the area

Site	DRR1	**Region**	Upper Dawson; Dawson River
Date surveyed:	19/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*41 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	good	**Riparian width**	>20 m
Pattern	mildy sinuous		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	low
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	vertical / steep, concave		pebble	0 %		large woody debris	**Weed species**	herbaceous species e.g. thistle, grasses
			gravel	5 %		aquatic plants	**Adjacent land use**	native forest
Hydrology			sand	15%		undercut banks		light grazing
Flow regime	intermittent		silt / clay	80%		substrate diversity		
Water depth	1.25 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	stable		Flow modification	none		
Flow	0.01 m / s				Waterway barrier	none		
Channel width	25 m							

Comments: *Vallisneria* present only in very low and patchy cover. Little filamentous algae near water's edge.

Site	DRR1	**Region**	Upper Dawson; Dawson River
Date surveyed:	04/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	–

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	–	**Habitat diversity**	low	**Riparian width**	>20 m
Pattern	mildy sinuous		boulder	–	**Habitat present**	deep run	**Disturbance**	low
Bank stability	moderate		cobble	–		undercut banks	**Dominant species**	native species
Bank shape	vertical / steep, concave		pebble	–		large woody debris	**Weed species**	herbaceous species
			gravel	–		emergent aquatic plants		thistle
Hydrology			sand	–				grasses
Flow regime	perennial		silt / clay	–			**Adjacent land use**	native forest
Water depth	2.5 m	**Deposits**	–		**In-stream disturbance**			light grazing
Wetted width	12 m	**Bed stability**	–		Flow modification	none		
Flow	0.6 m / s				Waterway barrier	none		
Channel width	25 m							

Comments:	water level was very high, fast and turbid and was almost to the top of the bank (sediment deposit on the right bank from swelling a few days prior); high water level and turbidity limited the assessment of bed and in-stream habitat features; some plants (*Persicaria* sp.) in water due to high water level

Site	DRR2	**Region**	Upper Dawson; Hutton Creek
Date surveyed:	20/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	31 (poor)

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	good	**Riparian width**	>10 m
Pattern	mildly sinuous, braided, irregular meanders		boulder	10 %	**Habitat present**	shallow pool	**Disturbance**	low
						deep pool		
Bank stability	moderate		cobble	10%		large woody debris	**Dominant species**	native species
Bank shape	Low / moderate / steep, stepped / concave		pebble	5 %			**Weed species**	herbaceous weeds e.g. minor grass
			gravel	5 %			**Adjacent land use**	native forest
Hydrology			sand	5 %				light grazing
Flow regime	intermittent		silt / clay	65 %				
Water depth	0.8 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	severe aggradation		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	20 m							

Comments: pool disconnected at downstream end of site. Very thick and extensive layer of silt over whole bed – notable silt bar near downstream end of site.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	04/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	–

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology	
Stream order	6
Pattern	mildly sinuous, irregular
Bank stability	moderate
Bank shape	Low / moderate / steep, stepped / concave
Hydrology	
Flow regime	intermittent
Water depth	1.5 m
Wetted width	12 m
Flow	0.3 m / s
Channel width	20 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	0 %
	pebble	0 %
	gravel	20 %
	sand	10 %
	silt / clay	70 %
Deposits	silt	
Bed stability	moderate aggradation	

Aquatic Habitat	
Habitat diversity	moderate
Habitat present	deep pool
	deep run
	large woody debris
	undercut banks
In-stream disturbance	
Flow modification	none
Waterway barrier	none

Riparian Zone	
Riparian width	>10 m
Disturbance	low
Dominant species	native species
Weed species	herbaceous weeds e.g. minor grass
Adjacent land use	native forest
	light grazing

Comments: water level was high, with moderate flow and turbid water; abundant levels of silt, large woody debris and fine organic particulate matter has also been deposited on the banks from the flow.

Site	DRMP1	**Region**	Upper Dawson; Dawson River
Date surveyed:	19/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*67 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	15 m, > 10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	low
Bank stability	stable		cobble	10 %		deep pool	**Dominant species**	native species
Bank shape	vertical /steep, concave		pebble	5 %		large woody debris	**Weed species**	noogoora burr
			gravel	5 %		undercut banks		herbaceous weeds
Hydrology			sand	55 %		aquatic plants (low cover)		grasses
Flow regime	intermittent		silt / clay	25 %			**Adjacent land use**	native forest
Water depth	0.8 m	**Deposits**	sand		**In-stream disturbance**			light grazing
Wetted width	6 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.02 m / s				Waterway barrier	none		
Channel width	30 m							

Comments: sand aggradation at upstream end of site exposed as mid-channel sand bar.

Site	DRMP1	**Region**	Upper Dawson; Dawson River
Date surveyed:	04/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	–

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	–	**Habitat diversity**	low	**Riparian width**	15 m, > 10 m
Pattern	mildly sinuous		boulder	–	**Habitat present**	deep run	**Disturbance**	low
Bank stability	stable		cobble	–		large woody debris	**Dominant species**	native species
Bank shape	vertical /steep, concave		pebble	–		undercut banks	**Weed species**	noogoora burr
			gravel	–		aquatic plants (bank only)		herbaceous weeds
Hydrology			sand	–				grasses
Flow regime	perennial		silt / clay	–			**Adjacent land use**	native forest,
Water depth	2.5 m	**Deposits**	–		**In-stream disturbance**			light grazing
Wetted width	15 m	**Bed stability**	–		Flow modification	none		
Flow	0.8 m / s				Waterway barrier	none		
Channel width	30 m							

Comments: water level was very high, fast and turbid and was almost to the top of the bank (was over the bank a few days prior); high water level and turbidity limited the assessment of bed and in-stream habitat features; some plants (*Persicaria hydropiper*, *Juncus usitatus*, *Lomandra sp*.) in water due to high water level

Site	S4	**Region**	Upper Dawson; Dawson River
Date surveyed:	20/05/15 (Post-wet survey)	**Habitat Bioassessment Score**	*48 (moderate)*

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 / 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	low
Bank stability	high		cobble	0 %		deep pool	**Dominant species**	native species
Bank shape	low / steep / vertical, concave		pebble	0 %		large woody debris	**Weed species**	herbaceous weeds e.g. noogoora burr
			gravel	5 %		undercut banks	**Adjacent land use**	native forest /
Hydrology			sand	55 %		aquatic plants		light grazing
Flow regime	intermittent		silt / clay	40 %				
Water depth	0.8 m	**Deposits**	sand, silt		**In-stream disturbance**			
Wetted width	8 m	**Bed stability**	moderate aggradation		Flow modification	road culvert		
Flow	0.08 m / s				Waterway barrier	road culvert (partial barrier)		
Channel width	40 m							

Comments: Sandbar at downstream end on left bank has not started reforming. Slow pools have been mostly in-filled with sand – bed now fairly uniform with minor undulations, thus only minor changes to depth throughout site.

Site	S4	**Region**	Upper Dawson
Date surveyed:	03/11/15 (Pre-wet survey)	**Habitat Bioassessment Score**	–

Downstream view

Upstream view

Left bank view

Right bank view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	–	**Habitat diversity**	moderate	**Riparian width**	10 / 15 m
Pattern	mildly sinuous		boulder	–	**Habitat present**	deep run	**Disturbance**	low
Bank stability	high		cobble	–		undercut banks	**Dominant species**	native species
Bank shape	low / steep / vertical, concave		pebble	–		large woody debris	**Weed species**	herbaceous weeds
			gravel	–		aquatic plants (bank only)		noogoora burr
Hydrology			sand	–			**Adjacent land use**	native forest
Flow regime	intermittent		silt / clay	–				light grazing
Water depth	> 3 m	**Deposits**	–		**In-stream disturbance**			
Wetted width	20 m	**Bed stability**	–		Flow modification	road culvert		
Flow	0.75 m / s				Waterway barrier	road culvert (partial barrier)		
Channel width	40 m							

Comments: water level was very high, fast and turbid; high water level and turbidity limited the assessment of bed and in-stream habitat features; some plants (*Persicaria hydropiper*) in water due to high water level

Appendix C Historical Synthesis Data for Macroinvertebrates

Table C.1 Baseline monitoring range for the abundance macroinvertebrate index at each site and water type.

Macroinvertebrate Index	Water type	Percentile						
		Min	5th	20th	Median	80th	95th	Max
Abundance	Waterbody	41.7	59.8	92.3	165.8	252.8	329.0	439.0
	Dawson River	17.3	25.5	39.9	80.7	152.0	256.0	316.0
	Hutton Creek	1.0	12.0	23.0	128.0	207.4	484.7	590.0
Taxonomic Richness	Waterbody	4.0	4.3	5.7	7.7	10.8	15.5	16.7
	Dawson River	6.7	7.1	9.9	12.7	16.9	20.9	21.7
	Hutton Creek	1.0	3.0	4.0	7.0	10.0	15.7	20.0
PET-Richness	Waterbody	0.00	0.00	0.00	0.00	1.20	2.00	2.33
	Dawson River	0.33	0.33	1.47	2.67	4.00	4.58	5.33
	Hutton Creek	0.00	0.00	0.00	0.00	1.00	3.00	3.00
SIGNAL-2 Score	Waterbody	2.35	2.46	2.65	2.93	3.16	3.35	3.54
	Dawson River	2.89	3.06	3.46	3.77	4.03	4.23	4.35
	Hutton Creek	2.00	2.63	2.90	3.13	3.33	3.75	3.85

Appendix D Macroinvertebrate Results of Each Survey

Table D.1 Macroinvertebrate results for each site in the 2015 Post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	324.3	223.3	231.6	39.9–152.0	69.4	47.9	84.4	23.0–207.4	151.4
Taxonomic Richness	5.67–10.8	10.9	10.0	11.9	9.93–16.9	11.3	11.4	11.7	4.0–10.0	11.6
PET richness	0 – 1.2	1.57	0.86	1.43	1.47–4.0	3.00	1.71	2.00	0–1.0	2.14
SIGNAL-2 Score	2.65 – 3.20	3.14	3.01	2.87	3.46–4.00	3.97	3.60	3.41	2.90–3.30	3.26

– Blue shading indicates where the macroinvertebrate index is higher than the local biological objective
– Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table D.2 Macroinvertebrate results for each water type in the 2015 Post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	259.7	39.9 – 152.0	67.2	23.0 – 207.4	151.4
Taxonomic Richness	5.67–10.8	10.9	9.93 – 16.9	11.5	4.0 – 10.0	11.6
PET richness	0 – 1.2	1.29	1.47 – 4.0	2.24	0 – 1.0	2.14
SIGNAL-2 Score	2.65 – 3.20	3.01	3.46 – 4.00	3.66	2.90 – 3.30	3.26

– Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Table D.3 Macroinvertebrate results for each site in the 2015 Pre-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	164.4	171.7	37.4*	39.9–152.0	73.4	17.1*	154.9	23.0–207.4	18.7
Taxonomic Richness	5.67–10.8	9.7	19.4*	12.3	9.93–16.9	12.7	7.9	12.1	4.0–10.0	6.0
PET richness	0 – 1.2	0.29	1.29	1.43	1.47–4.0	1.86	0.29*	2.00	0–1.0	0.71
SIGNAL-2 Score	2.65 – 3.20	3.06	3.00	2.89	3.46–4.00	3.29	2.46*	3.05	2.90–3.30	3.46

– Blue shading indicates where the macroinvertebrate index is higher than the local biological objective
– Grey shading indicates where the macroinvertebrate index is lower than the local biological objective
– * macroinvertebrate index is also outside the full range from the baseline monitoring program for that water type

Table D.4 Macroinvertebrate results for each water type in the 2015 Pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	124.5	39.9 – 152.0	81.8	23.0 – 207.4	18.7
Taxonomic Richness	5.67–10.8	13.8	9.93 – 16.9	10.9	4.0 – 10.0	6.0
PET richness	0 – 1.2	1.00	1.47 – 4.0	1.38	0 – 1.0	0.71
SIGNAL-2 Score	2.65 – 3.20	2.98	3.46 – 4.00	2.93	2.90 – 3.30	3.46

– Blue shading indicates where the macroinvertebrate index is higher than the local biological objective
– Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Santos GLNG Project

Santos Fairview REMP

2016 Supplementary Biological and Geomorphological Report

January 2017

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1. Introduction

1.1 Background

Santos GLNG (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos GLNG project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of treated water from the Fairview Reverse Osmosis Plant 2 to the Dawson River is authorised under the FAPA Environmental Authority EPPG00928713 (formerly PEN100178208). The release is known as the Dawson River Release Scheme (DRRS).

The DRRS became operational in May 2015, which initiated the development and implementation of a Receiving Environment Monitoring Program (REMP) as required by the Environmental Authority. REMP monitoring and reporting is guided by the REMP design documentation, entitled *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program* (frc environmental 2015a). Under the REMP, biological and geomorphological monitoring is required to be carried out biannually. This monitoring is to be carried out during the Pre- and Post-wet season each year. This is the second year the REMP has been implemented.

1.2 Purpose and scope

Santos commissioned GHD to undertake the DRRS REMP in 2016. The scope of works included the sampling of seven study sites (defined by the REMP) on two occasions: once during the Post-wet season period; and once during the Pre-wet season period. Sampling was based on methods nominated in the REMP and included macroinvertebrate, fish, water and sediment quality, aquatic habitat and bed and bank stability monitoring.

The purpose of this report is to describe the biological and geomorphological monitoring methodologies used to conduct the Post-wet and Pre-wet season DRRS REMP sampling and to provide a summary of the results. This report is the deliverable nominated as the *Supplementary Biological and Geomorphological Report*, under Blanket Release 945122-290 and forms a key requirement under the FAPA Environmental Authority EPPG00928713.

Note that water quality and stream hydrology are monitored by Santos and the reporting of water and sediment quality data collected in conjunction with biological and geomorphological monitoring is managed directly Santos. Therefore, results for these REMP components are not included as part of this report.

The work presented in this report was carried out by suitably qualified persons, as detailed in Appendix A.

This report should be read in conjunction with the study limitations outlined in the disclaimer.

2. Monitoring program

2.1 Monitored sites

The seven monitoring sites nominated in the REMP were sampled as part of the 2016 DRRS REMP study. Site location details are provided in Table 2-1 and Figure 2-1. Under the REMP, three waterways are sampled. These include:

- Hutton Creek, which is the nominated reference system
- Waterbody, which represents the immediate receiving environment and is constituted by backwater habitat off the Dawson River main channel
- Dawson River main channel.

Study sites have been allocated to each of these waterways as part of the REMP study design. The Dawson River includes sites both upstream and downstream of confluence with the Waterbody. Sites within the Waterbody and downstream of confluence between the Waterbody and the Dawson River are regarded as potentially impacted sites.

Table 2-1 Site locations surveyed during 2016 Post-wet and Pre-wet surveys

Site	Waterway/treatment	Latitude	Longitude
DRR2	Hutton Creek site (Control)	25.718	148.971
WLMP1	Waterbody site (Potentially Impacted)	25.708	149.146
WLMP4	Waterbody site (Potentially Impacted)	25.698	149.139
WLMP5	Waterbody site (Potentially Impacted)	25.701	149.153
DRR1	Dawson River site (Control)	25.688	149.156
DRMP1	Dawson River site (Potentially Impacted)	25.688	149.156
S4	Dawson River site (Potentially Impacted)	25.692	149.216

Paper Size A3

0 0.5 1 2 3

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Monitoring Site

- Control Site
- Dawson River Site Within Receiving Environment
- Waterbody Site Within Receiving Environment
- Major Watercourse
- Street/Local Road
- Private or Restricted Road
- 4WD and Track
- Unconstructed Road

Santos Limited
Santos GLNG Fairview REMP

Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

Job Number	41-29864
Revision	0
Date	17 Jan 2017

Figure 2-1

G:\41\29864\GIS\Maps\MXD\4129864_001_Rev0.mxd

145 Ann Street Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

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Data source: Santos: Monitoring Site (2016); DNRM: Watercourse (2014); Road (2016); GE: Imagery Extracted 13/12/2016. Created by:rbannister

2.2 Timing

The Post-wet season REMP monitoring was carried out between 30 May 2016 and 2 June 2016, while the Pre-wet season sampling was carried out between 15 and 19 November 2016.

2.3 Monitoring completed

As part of the Post-wet season survey, six sites were surveyed across three waterways (Table 2-2). A seventh site (S4) was unable to be accessed at the time of that survey due to logistical issues caused by inclement weather conditions (i.e. access issues due to rainfall). The full complement of REMP sampling was only completed at two sites during the Post-wet season sampling round. Rainfall and, the associated potential increase in stream flow, precluded the deployment of nets at all sites except DRR2 and WLMP1.

All seven nominated REMP sites were sampled as part of the Pre-wet season survey and, apart from fish sampling at DRR1, all REMP monitoring components were completed at all sites (Table 2-3). The water level and steep stream bed gradient precluded the safe deployment of fyke nets at DRR1 for fish sampling.

Table 2-2 Summary of REMP sampling components completed during the 2016 Post-wet survey

Site	Water quality sampling	Sediment quality Sampling	Macroinvertebrate sampling	Macrocrustacean exoskeleton examination	Fish sampling	Habitat/geomorphic assessment
DRR2	✓	✓	✓	✓	✓	✓
WLMP1	✓	✓	✓	✓	✓	✓
WLMP4	✓	✓	✓	×	×	✓
WLMP5	✓	✓	✓	×	×	✓
DRR1	✓	✓	✓	×	×	✓
DRMP1	✓	✓	✓	×	×	✓
S4	×	×	×	×	×	×

✓ = completed

× = planned, but unable to be completed due to weather restriction on site access

Table 2-3 Summary of REMP sampling components completed during the 2016 Pre-wet survey

Site	Water quality sampling	Sediment quality Sampling	Macroinvertebrate sampling (surber and AusRivAS)	Macrocrustacean exoskeleton examination	Fish sampling	Habitat/geomorphic assessment
DRR2	✓	✓	✓	✓	✓	✓
WLMP1	✓	✓	✓	✓	✓	✓
WLMP4	✓	✓	✓	✓	✓	✓
WLMP5	✓	✓	✓	✓	✓	✓
DRR1	✓	✓	✓	✓	×	✓
DRMP1	✓	✓	✓	✓	✓	✓
S4	✓	✓	✓	✓	✓	✓

✓ = completed

× = planned, but unable to be completed due to safety reasons

2.4 Quality assurance

- All monitoring was performed by suitably qualified persons (see Appendix A)
- Sediment sampling was completed as per Australian/New Zealand Standard AS/NZ5667.12 Guidance on Sampling of Bottom Sediments and the Handbook for Sediment Quality Assessment (Simpson *et al.* 2005)
- Water quality sampling was as per the Monitoring and Sampling Manual 2009 Environmental Protection (Water) Policy 2009 (EHP 2013)
- Biological and Geomorphological surveys were completed as per the methods outlined in the REMP (frc environmental 2015a).

The following quality assurance outcomes relate to the 2016 Post-wet survey:

- Fish and macrocrustacean survey components not completed at sites WLMP4, WLMP5, DRR1, DRMP1 and S4 due to potential risk of gear loss and/or injury to fauna associated with a prospective increase in flow linked to rainfall on site
- S4 was not sampled at all due to logistical issues affecting site access linked to inclement weather conditions (i.e. access issues due to rainfall).

The following quality assurance outcomes relate to the 2016 Pre-wet survey:

- Fish sampling was not completed at DRR1 for safety reasons related to water depth and bank stability
- The location of sampling was adjusted at WLMP4 by 400 m for safety reasons due to the presence of a back burning fire at the nominated sampling location. Habitat sampled at the revised location, was however, considered to be equivalent of that of the nominated location.

3. Aquatic habitat

3.1 Methods

Instream habitat diversity and condition and the stability of bed and banks were assessed at each site using the Smart Rivers method detailed in the REMP (frc environmental 2015a).

State of Rivers assessment field sheets for the Post-wet season sampling round are provided in Appendix B covering results for each site. Site photos for each site covering both sampling rounds are presented in Appendix C.

3.2 Data analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. As such, assessment was based on qualitative comparisons of results in this study against the baseline condition range detailed in the REMP (frc environmental 2015a).

A comparison of habitat features and bed and bank stability between waterway types is provided below in Table 3-1 and Table 3-2. For this, results have been pooled across sites within waterway types. Where ratings for particular attributes differed among sites within a given waterway type, the range in ratings has been provided. Reference to specific site conditions have been made where appropriate.

3.3 Results

3.3.1 Overview

A representative photograph of each site in the Pre- and Post-wet season sampling rounds is presented in in Appendix D.

3.3.2 Bank and bed stability

Post-wet season

Bank and bed stability in the Waterbody were rated high during the 2016 Post-wet season survey. Previously bank stability for this waterway type has been rated as moderate (Table 3-1). Our reasoning for the high rating for bank stability for the waterbody in the Post-wet season survey was that banks were very shallow and therefore less prone to erosion than steep gradient banks and that the erosion at individual sites was either minor or confined to a single bank.

Bank stability in the Dawson River varied widely between the two sites assessed. There was clearly more erosion at the downstream site DRMP1, though this related to erosion seepage points rather than being represented by bank slumps. Bed stability was rated as moderate in the Dawson River, which differs from the low rating achieved during the baseline monitoring period and the frc environmental (2015b) Biological and Geomorphology Monitoring study. In the 2016 Post-wet season sampling round, the degree of bed scouring at both sites was rated as minor. Aggradation at DRMP1 was only associated with point bars, so was considered to be minor. Aggradation was more apparent at the upstream site DRR1 than DRMP1 due to the presence of mid channel bars and terrestrial vegetation encroachment, so bed stability was considered to be lower at the upstream Dawson River site than the downstream Dawson River site.

Hutton Creek bank stability was rated low to moderate in the 2016 Post-wet survey, as opposed to the moderate rating achieved previously. This assessment relates to erosion at regular intervals on the lower banks and at seepage points, combined with erosion due to flood scouring and cattle access to the bank. Bed stability in this waterway type was low, consistent with previous results.

Pre-wet season

Bank stability in the Pre-wet season survey ranged from low to high. Bank stability was highest (high) in the Waterbody and lowest in the Dawson River (low to moderate). Bank stability was assessed as being moderate in Hutton Creek, which was consistent with all previous surveys (Table 3-2). However, bed stability was lowest for Hutton Creek, moderate for the Dawson River, and highest for the Waterbody. These findings were consistent with those of the 2016 Post-wet season survey (Table 3-1), indicating that conditions had remained unchanged during this time.

Table 3-1 Habitat characteristics of each waterway type in the 2016 Post-wet REMP survey

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Bank stability	High	Moderate	Moderate
Bed stability	High	Moderate	Low

Blue shading indicates a higher rating than assigned during the baseline period

Table 3-2 Habitat characteristics of each waterway type in the 2016 Pre-wet REMP survey

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Bank stability	High	Low to Moderate	Moderate
Bed stability	High	Moderate	Low

Blue shading indicates a higher rating than assigned during the baseline period

Grey shading indicates a lower rating than assigned during the baseline period

4. Macroinvertebrates

4.1 Methods

Macroinvertebrate sampling was undertaken in accordance with the Smart Rivers methodology (Smart Rivers 2013) outlined in the REMP (frc environmental 2015a).

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site for each survey using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. As 'clean' edge habitat was not readily available during the Post-wet season sampling round, samples contained a relatively high portion of detritus material.

The substrate within the Surber sampler frame was disturbed by gentling wafting the water by hand. Where present, large rocks were 'cleaned' by hand to dislodge macroinvertebrate fauna. Samples were collected from the survey cod end, transferred into a labelled screw top jar containing ethanol as a preservative and transported back to the laboratory for enumeration and identification.

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in the Monitoring and Sampling Manual (EHP 2013). Specimens were identified to the lowest practical taxonomic level (family in most cases).

Sorting, enumeration and data entry was cross checked for 10% of the samples. An error rate of <10% was considered acceptable as per the REMP. Macroinvertebrate sample processing QA/QC results are shown in Appendix E.

4.2 Data analysis

As per the REMP (frc environmental 2015a), the following indices were calculated for the assessment of macroinvertebrate communities:

- Abundance – the total number of individuals in a sample
- Taxa richness – the number of taxa in a sample based on the taxonomic level of identification applied in this study (generally family level)
- PET richness – the number of combined Plecoptera (stonefly), Ephemeroptera (mayfly) and Trichoptera (caddisfly) larval taxa in a given sample
- SIGNAL2 (Stream Invertebrate Grade Number – Average Level) scores – based on the sensitivity of each macroinvertebrate taxa family recorded in a sample to pollution and habitat degradation as per the 1 to ratings given in Chessman (2003). As per the REMP methodology, SIGNAL2 scores calculated in this study were weighted for abundance.

For each of these indices, the mean (±SE) was calculated across both surveys at both the site and waterway type level. Results were then compared to the local biological objectives for macroinvertebrates given in the REMP (frc environmental 2015). Where the mean for an index complied with, or was higher than, the relevant local biological objective range, then it was concluded that there was no impact to macroinvertebrate communities, and no further assessment was required. Where results for a given index were below the local biological objective range, a qualitative assessment of site conditions was carried out to determine if habitat, flow condition or other factors might explain this result.

4.3 Results

Macroinvertebrate indices results for the 2016 surveys are presented for each site and for each waterway type in Table 4-1 and Table 4-2, respectively. Abundance for most sites was found to be within the relevant biological objectives outlined in frc environmental (2015a). However, abundance at WLMP5 was 301.1 (± 25.5), above the objective, and 32.7 (± 5.6) at S4, which was below the objective. The value for S4 was similar to that calculated for the 2015 surveys of 32.5 (± 5.5) (frc environmental 2015b), so indicates that site conditions have remained consistent over the past year. Abundance at WLMP5 was greater than that previously observed by frc environmental (2015b), of 134.5 (± 30.5). Despite variation from baseline condition at the site level, the combined results according to waterway type show that all three waterway types had abundances within the baseline range (Table 4-2).

For all three Waterbody sites, taxa richness and PET richness were above the biological objective, whereas these indices were within the biological objective at all three Dawson River sites (Table 4-1). PET richness was also above the objective at DRR2 (Hutton Creek). This meant that taxa richness and PET richness were also higher than baseline levels for the Waterbody as a whole and that PET richness was higher than baseline levels for Hutton Creek as a whole (Table 4-2). Frc environmental (2015b) also found higher than baseline taxa richness in the Waterbody and a higher than baseline PET richness in Hutton Creek, so the 2016 results are not inconsistent with previous REMP monitoring.

In contrast, the SIGNAL2 values from 2016 were below the objective at all sites with the exception of S4 (Table 4-1). This meant that all waterway types recorded SIGNAL2 values below the objective (Table 4-2). This finding also differed to the results of the frc environmental (2015b) survey, which found the SIGNAL2 values to be within the objective for the Waterbody, below the objective for the Dawson River and above the objective for Hutton Creek. Given the 2016 finding of low SIGNAL2 values across all sites except the most downstream site (S4):

- There may be localised stressors within the catchment (including upstream of the DRRS) that may be affecting sensitive taxa
- Low flow habitats tend to have lower SIGNAL2 scores as ‘flow-loving’ (rheophilic) species are generally pollution sensitive – consequently, this result may be a reflection of low flow conditions within the catchment.

It should also be pointed out that the 2016 results for Dawson River at the waterway level only take into account one round of sampling. Given the higher SIGNAL2 result recorded for this site during the Pre-wet season survey (Table 4-1), it is possible that the lack of Post-wet season data for S4 contributed to the lower than baseline SIGNAL2 result for the Dawson River shown in Table 4-2.

Table 4-1 Macroinvertebrate combined season results for each site in 2016

Index	Waterbody local biological objective	WLMP1	WLMP4	WLMP5	Dawson River local biological objective	DRMP1	DRR1	S4	Hutton Creek local biological objective	DRR2
Abundance	92.3 – 252.8	209.8 (± 27.2)	123.4 (± 50.2)	301.1 (± 25.5)	39.9 – 152.0	106.6 (± 11.9)	78.8 (± 1.3)	32.7 (± 5.6)	23.0 – 207.4	45.1 (± 6.7)
Taxa richness	5.67 – 10.8	15.7 (± 0.6)	13.0 (± 1.5)	18.1 (± 1.4)	9.93 – 16.9	16.4 (± 0.6)	14.9 (± 1.2)	10.6 (± 1.3)	4.0 – 10.0	9.8 (± 0.8)
PET richness	0 – 1.2	2.2 (± 0.3)	2.1 (± 0.4)	2.4 (± 0.4)	1.47 – 4.0	3.7 (± 0.3)	3.1 (± 0.3)	3.0 (± 0.3)	0.0 – 1.0	2.5 (± 0.4)
SIGNAL2	2.65 – 3.20	1.1 (± 0.1)	2.1 (± 0.2)	1.6 (± 0.1)	3.46 – 4.0	2.7 (± 0.2)	2.9 (± 0.2)	4.2 (± 0.3)	2.9 – 3.3	2.8 (± 0.2)

Blue shading denotes values above the local biological objective range

Dark grey shading denotes values below the local biological objective range

Table 4-2 Macroinvertebrate combined season results for each waterway type in 2016

Index	Waterbody local biological objective	Waterbody	Dawson River local biological objective	Dawson River	Hutton Creek local biological objective	Hutton Creek
Abundance	92.3 – 252.8	211.4 (± 23.3)	39.9 – 152.0	80.7 (± 8.0)	23.0 – 207.4	45.1 (± 6.7)
Taxa richness	5.67 – 10.8	15.6 (± 0.8)	9.93 – 16.9	14.6 (± 0.7)	4.0 – 10.0	9.8 (± 0.8)
PET richness	0 – 1.2	2.2 (± 0.2)	1.47 – 4.0	3.3 (± 0.2)	0.0 – 1.0	2.5 (± 0.4)
SIGNAL2	2.65 – 3.20	1.6 (± 0.1)	3.46 – 4.0	3.1 (± 0.1)	2.9 – 3.3	2.8 (± 0.2)

Blue shading represents values above the local biological objective range

Dark grey represents values below the local biological objective range

5. Fish

5.1 Methods

Fish sampling was conducted using two fyke nets at each site – one approximately 4 mm mesh and one approximately 10 mm mesh. Nets were set facing upstream and downstream directions at all sites, and floats were used to provide a surface chamber such that air breathing species (e.g. turtles, platypus, snakes and water dragons) were provided access to the surface at all times.

Surveys were conducted in accordance with the Queensland *Animal Care and Protection Act 2001*, the GHD Department of Employment, Economic Development and Innovation Scientific Users Registration Certificate (Registration Number 132), and the GHD General Fisheries Permit (permit number 171785).

At each site where sampling was conducted, the species captured and their abundance and life history stage (i.e. juvenile, adult) was recorded. Identifications of fish were made in the field using relevant field guides. Large numbers of fish were caught in 2016 relative to previous surveys. With agreement from Santos, abundance classes were used for particularly abundant species (e.g. *Hypseleotris* spp.). Note that this has no bearing on fish survey data interpretation as there is no objective for fish abundance in the REMP (frc environmental 2015a). As well as this, an indicator of fish health was noted based on visual observation of external condition (e.g. presence or absence of lesions, ulcer, parasites, fin damage).

Fish captured in this study were released unharmed, except for exotic species, which were euthanised in accordance with ethics approvals.

Table 5-1 Fishing effort during the 2016 Post-wet survey

Site	Method	Habitat	Date	Time In	Time Out	Effort
Waterbody						
WLMP1	Fyke net (x2)	Pool	30/05/2016	12:00	13:40	51 h
WLMP4	Not sampled due to inclement weather					
WLMP5	Not sampled due to inclement weather					
Dawson River						
DRMP1	Not sampled due to inclement weather					
DRR1	Not sampled due to inclement weather					
S4	Not sampled due to inclement weather					
Hutton Creek						
DRR2	Fyke net (x2)	Pool	30/05/2016	16:30	07:30	30 h

Table 5-2 Fishing effort during the 2016 Pre-wet survey

Site	Method	Habitat	Date	Time In	Time Out	Effort
Waterbody						
WLMP1	Fyke net (x2)	Pool	16/11/2016	10:30	07:30	42 h
WLMP4	Fyke net (x2)	Pool	16/11/2016	13:30	08:30	38 h
WLMP5	Fyke net (x2)	Pool	17/11/2016	15:30	09:30	36 h
Dawson River						
DRR1	Not sampled for safety reasons					
DRMP1	Fyke net (x2)	Pool	17/11/2016	13:30	08:00	37 h
S4	Fyke net (x2)	Pool	15/11/2016	13:30	07:00	35 h
Hutton Creek						
DRR2	Fyke net (x2)	Pool	18/11/2016	15:00	07:30	33 h

5.2 Data analysis

The taxonomic richness of native and exotic fish species was determined for each waterway type on each survey occasion. Any captured individuals from the genus *Hypseleotris* were recorded as *Hypseleotris* spp., so as to be consistent with the level of identification used in the frc environmental baseline survey monitoring, upon which, trigger values relating to fish taxa richness are based. These results were then compared to the expected number of species for the relevant waterway type (i.e. the local biological guideline for fish) as a ratio.

Where the ratio was ≥ 1, then it was considered that there has been no impact to fish. Where the ratio was < 1, then the diversity of fish was lower than expected and an investigation of the factors affecting fish communities is recommended in frc environmental (2015a), though in this case, further investigation was not necessary. The local guidelines for fish, as presented in the REMP design (frc environmental 2015a) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5)
- Hutton Creek: two species (i.e. ≥ 2).

5.3 Results

A total of 5,459+ individual fish from 11 species were captured and identified during the 2016 field surveys (Table 5-3; Table 5-4). None of these species are of conservation significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* or the Queensland *Nature Conservation Act 1992*.

The goldfish (*Carassius auratus*), an exotic species, was captured in very low abundances during the Pre- and Post-wet season sampling within the waterbody sites WLMP1, WLMP4 and WLMP5.

During the Post-wet season sampling round, a total of four native species were detected at WLMP1 and DRR2. Hence, the number of native fish species observed in the Waterbody during the Post-wet season sampling round matched the objective for this waterway type and the number of native fish species observed in Hutton Creek exceeded the objective for this waterway type (Table 5-3).

For the Pre-wet season sampling round, fish were captured at all sampled sites. For the Waterbody, a total of six native species were recorded, which is above the number expected based on baseline conditions (Table 5-3). At Hutton Creek (DRR2), a total of 4 native species were detected, which was also above number expected based on baseline conditions. The five species recorded from Dawson River sites matched the number of species expected for this waterway type. However, that number included a species new to the study (*Neosiluris hyrtlii*).

Table 5-3 Abundance of fish species captured during the 2016 Post-wet season sampling round

Site	Waterbody	Hutton Creek	Total
Species	WLMP1	DRR2	
Ambassis agassizii	297	0	297
Anguilla reinhardtii	0	1	1
*Carassius auratus**	1	0	1
Craterocephalus stercusmuscarum	0	0	0
Hypseleotris spp.	932	0	932
Leiopotherapon unicolor	0	0	0
Macquaria ambigua oriens	0	5	5
Melanotaenia splendida splendida	3	0	3
Nematalosa erebi	1	2	3
Neosilurus hyrtlii	0	0	0
Tandanus tandanus	0	4	4
Total abundance	1274	12	1286
Total native species observed (per site)	4	4	8
Total native species observed (per waterway type)	4	4	
Total native species expected	4	2	
Observed: Expected ratio	1.0	2.0	

exotic species

Table 5-4 Abundance of fish species captured during the 2016 Pre-wet season sampling round

Site	Waterbody			Dawson River		Hutton Creek	Total
Species	WLMP1	WLMP4	WLMP5	DRMP1	S4	DRR2	
Ambassis agassizii	273	558	205	0	0	0	1036
Anguilla reinhardtii	0	0	0	0	0	0	0
*Carassius auratus**	5	2	1	0	0	0	8
Craterocephalus stercusmuscarum	2	10	0	0	0	0	12
Hypseleotris spp.	1000+	72	1000+	0	0	500+	2572+
Leiopotherapon unicolor	0	3	2	2	4	0	11
Macquaria ambigua oriens	0	0	0	0	0	1	1
Melanotaenia splendida splendida	10	453	0	7	1	7	478
Nematalosa erebi	1	0	0	4	3	0	8
Neosilurus hyrtlii#	0	0	0	2	0	0	2
Tandanus tandanus	0	0	0	32	5	8	45
Total abundance	1291+	1098	1208+	47	13	516+	4173+
Total native species observed (per site)	5	5	3	5	4	4	10
Total native species observed (per waterway type)	6			5		4	
Total native species expected	4			5		2	
Observed: Expected ratio	1.5			1.0		2.0	

#new to survey

****exotic species***

6. Macrocrustacean exoskeleton assessment

6.1 Methods

Condition B33 (m) of the EA stipulates '*monitoring of a selection of invertebrate species (minimum of three from the local receiving environment) to assess ecosystem health (e.g. exoskeleton density) in respect to the availability of calcium and magnesium*'. Consequently, three commonly occurring macrocrustacean species (the freshwater prawn (*Macrobrachium australiense*), the Queensland crayfish (*Cherax destructor*), and the freshwater shrimp (*Caridina* spp.)) were targeted for visual inspection to support assessment and meeting of this condition. Note that *Cherax destructor* had not been recorded during previous surveys, but were captured in both surveys in 2016. Macrocrustaceans captured in fyke nets were visually examined upon capture for signs of potential calcium and magnesium deficiency, based on observations of the strength, apparent thickness and condition of the exoskeleton. Assessment of the reproductive status of females was also made in conjunction with exoskeleton condition assessment.

6.2 Results

During the Post-wet season survey, only two species (freshwater prawn and Queensland crayfish) were detected. The Queensland crayfish has not been captured during previous REMP baseline monitoring events. While all captured freshwater prawns appeared to be of normal colour and exoskeleton condition, there were unusual traits observed in two Queensland crayfish captured at WLMP1. Both these individuals' exoskeletons appeared to be of normal colour and thickness; however, both were very soft, with the exoskeleton yielding to gentle fingertip pressure. No berried females of either detected species was recorded during the 2016 Post-wet season survey, though this aligns with results presented in frc environmental (2015b).

During the Pre-wet season survey, the exoskeleton of all captured macrocrustaceans (freshwater prawn, freshwater shrimp and Queensland crayfish) was observed to be robust and in good condition. There were also numerous berried female freshwater prawns captured.

Table 6-1 Macrocrustacean exoskeleton assessment – 2016 Post-wet survey

Recorded Attribute	Waterway type		
	Waterbody	Dawson River	Hutton Creek
Species present	*Macrobrachium australiense* *Cherax destructor**	N/A	*Macrobrachium australiense*
Breeding condition	No berried individuals recorded.	N/A	No berried individuals recorded.
Exoskeleton condition	Exoskeleton of both *Cherax destructor* individuals soft and pale. Exoskeleton condition of *Macrobrachium australiense* robust and in good condition.	N/A	Exoskeleton robust and in good condition.

***new to survey**

Table 6-2 Macrocrustacean exoskeleton assessment, 2016 Pre-wet survey

Recorded Attribute	Waterway type		
	Waterbody	Dawson River	Hutton Creek
Species present	*Macrobrachium australiense* *Cherax destructor*[*] *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp.
Breeding condition	Multiple berried *Macrobrachium australiense* recorded.	Multiple berried *Macrobrachium australiense* recorded.	Multiple berried *Macrobrachium australiense* recorded.
Exoskeleton condition	Exoskeleton of all species robust and in good condition.	Exoskeleton of all species robust and in good condition.	Exoskeleton of all species robust and in good condition.

new to survey, though sampled during the Post-wet season sampling round

7. Assessment of environmental changes

Overall, the monitoring results of the 2016 surveys were consistent with previous findings. The following key observations on the site environmental conditions were made:

- Bed and bank stability ratings in the Waterbody improved from moderate (in 2015) to high, and there were overall improvements in bed stability ratings for the Dawson River. Bed and bank stability was rated lowest in Hutton Creek, which is a control site.
- Macroinvertebrate indices showed some change from the previous results, although there was no evidence to suggest that the DRRS is having a negative impact on the macroinvertebrate community in the receiving environment. The combined results show abundance to be within the objectives at each waterway type. For all Waterbody sites, taxa richness and PET richness was above the biological objective. PET richness was also above the objective at DRR2. The high taxa richness observed in the Waterbody in 2016 is consistent with observation made by frc environmental (2015b) and could potentially relate to greater water level stability in this system as a result on Santos FAPA releases. SIGNAL2 values were below the objective at most sites and all waterway types. Given this was wide-ranging and not restricted to receiving waters, it is likely that other factors were responsible. These could include localised stressors associated with the sites that are affective pollution-sensitive taxa. However, it is more likely that the low SIGNAL2 scores observed in 2016 were due to lower flow conditions, which favour taxa that prefer still water. Those taxa also tend to be more pollution tolerant.
- A total of 5,459+ individual fish from 11 species were captured and identified during the 2016 field surveys, none of which are of conservation significance. Only one exotic species was recorded (*Carassius auratus*)) and this species was only recorded from the Waterbody. Native fish species richness matched or was above the predicted value for each waterway type and each sampling round, demonstrating that releases have had no impact on native fish species richness.
- During the Post-wet season sampling round, two Queensland crayfish were captured at WLMP1 which were observed to have very soft exoskeletons. However, the following Pre-wet season survey showed all captured macrocrustaceans to have robust exoskeletons in good condition and many females were also berried, which indicates that releases are not leading to adverse impacts on the health of macrocrustaceans in the receiving waters.

Based on the results presented above, there is no evidence to suggest that Santos FAPA releases have led to the following impacts in the receiving environment:

- Reduced bed and bank stability
- Reduced macroinvertebrate diversity and abundance
- Reduced native fish diversity
- Reduced health of macrocrustaceans.

As noted previously, water and sediment monitoring carried out by GHD as part of this scope of works will be reported separately by Santos with data compared against relevant guidelines and trigger levels. Based on macrocrustacean exoskeleton results from this study and a review of water quality data (specifically calcium and magnesium concentration data) by Santos, Tier 2 monitoring was not required in 2016.

8. 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.

EHP, 2013. *Monitoring and Sampling Manual 2009*, Queensland Department of Environment and Heritage Protection, Brisbane.

frc environmental 2015a. Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program, report prepared for Santos.

frc environmental, 2015b. *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program*, report prepared for Santos.

Simpson, S.L., Batley, G.E., Chariton, A.A., Stauber, J.L., King, C.K., Chapman, J.C., Hyne, R.V., Gale, S.A., Roach, A.C. and Maher, W.A., 2005. *Handbook for Sediment Quality Assessment*, CSIRO, Lucas Heights, NSW.

Smart Rivers, 2013. Smart Rivers, http://www.smartrivers.com/riverscience.html, accessed 20 December 2016.

Appendices

Appendix A Statutory declaration

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: Supplementary Biological and Geomorphological Report, dated January 2017

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions B32 and B33(i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 29 September 2015, as detailed in the Receiving Environment Monitoring Program

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Jamie Lawson Corfield

(Insert full name of person making this declaration)

of, Brisbane City

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the requirements of conditions B32, B33 (i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 24 June 2015
3. All relevant material has been considered in preparing the Supplementary Biological and Geomorphological Report, dated January 2017
4. The content of the Supplementary Biological and Geomorphological Report, dated January 2017 is accurate and true.
5. The Supplementary Biological and Geomorphological Report, dated January 2017 meets the requirements of the conditions B32, B33 (i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 24 June 2015.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at 145 Ann Street, Brisbane

(Insert name of town or city and suburb)

this 17th day of January in the year 2017

(Insert day, e.g. 18th) (Insert month) (Insert year)

Signed

(Person making this declaration)

Signed

(Cross out whichever is not applicable)

~~Justice of the Peace / Commissioner for Declarations~~ /
Solicitor / ~~Barrister~~

Susan Elizabeth Cleary
~~*Solicitor*~~

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following:
"This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature

Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867*. This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: Supplementary Biological and Geomorphological Report, dated January 2017

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions B32 and B33(i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 29 September 2015, as detailed in the Receiving Environment Monitoring Program

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Courtenay Elyse Mills

(Insert full name of person making this declaration)

of, Brisbane City

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the requirements of conditions B32, B33 (i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 24 June 2015
3. All relevant material has been considered in preparing the Supplementary Biological and Geomorphological Report, dated January 2017
4. The content of the Supplementary Biological and Geomorphological Report, dated January 2017 is accurate and true.
5. The Supplementary Biological and Geomorphological Report, dated January 2017 meets the requirements of the conditions B32, B33 (i), B33 (k) and B33 (m) of environmental authority EPPG00928713 dated 24 June 2015.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at 145 Ann Street, Brisbane
(Insert name of town or city and suburb)

this 19th (Insert day, e.g. 18th) day of January (Insert month) in the year 2017 (Insert year)

Signed
(Person making this declaration)

Signed
(Cross out whichever is not applicable)

~~Justice of the Peace / Commissioner for Declarations~~ / Solicitor / ~~Barrister~~

Susan Elizabeth Cleary
Solicitor

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature

Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B Habitat assessment field sheets

FIELD SHEETS

PROJECT NAME: Santos KEMP **SITE CODE:** DRMP1

SITE NAME: DRMP1

DATE: 2 / 6 / 16 **TIME (24hrs):** [12.30] **PARTY:** CM + KM

LATITUDE: 25.690291 **LONGITUDE:** 149.167359

EASTING: – **NORTHING:** – **Mobile Coverage:** Y / N

MAP NAME: – **MAP SCALE:** – **Sat. Phone Coverage:** Y / N

PHOTO #'s: Red camera **KEY NEEDED (Details) :** –

COMMENTS: Pretty reach, but impacted by cattle.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	~~6.46~~	~~127.4~~ 11.6
Gauge Height (m)	—		DO (% sat)	~~65.9~~	~~12.4~~ 119
Water Temperature (°C)	16.27		Turbidity (NTU)	10.4	
Conductivity ~~(µS/cm)~~	0.226 m/s		Total Alkalinity (mg/L)	115	
pH	7.35		**Time Collected**	12.30	
TDS	0.175		REDOX	148.4	

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5. Riffle 6. LWD 7. Macrophyte 8. Other

Stream Width Max 7 m Min 2.5 m Mode 6 m

Water Level 1. No Flow 2. Dry/Isolated 3. <Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details……

Bank Erosion 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details……

Hydrological Variation 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Hydrological Variation details: Flood debris to ~6m

Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cleared paddock adjacent

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle +

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse: Cattle grazing. Dry land cropping?

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other……

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) 710 m 40%

Trees<10m 30 % cover *Shrubs/Vines/Rushes* 2 % cover *Grasses/Ferns/Herbs* 70 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME pkm01	DATE: 2 / 6 / 16				
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES					
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.02				
Mean Sample Depth (m)	0.15				
Mean Wetted Width (m)	7m				
% Bedrock	–				
% Boulder (>soccer ball)	–				
% Cobble (tennis ball - soccer ball)	–				
% Pebble (marble - tennis ball)	2				
% Gravel (2 - 4mm)	13				
% Sand (0.005 - 2mm)	15				
% Silt/Clay (< 0.005 mm)	70				
% Detritus (leaves/twigs)	30				
% Sticks (<2cm)	10				
% Branches	5				
% Logs (>15cm)					
% Algae	10				
% Macrophytes					
% Overhanging habitat (e.g. vegetation, roots)	30				
% Blanketing silt (indicated by plume)	40				
% Shading	15				
Sampled By:	AM				
Picked By:					

Comments:

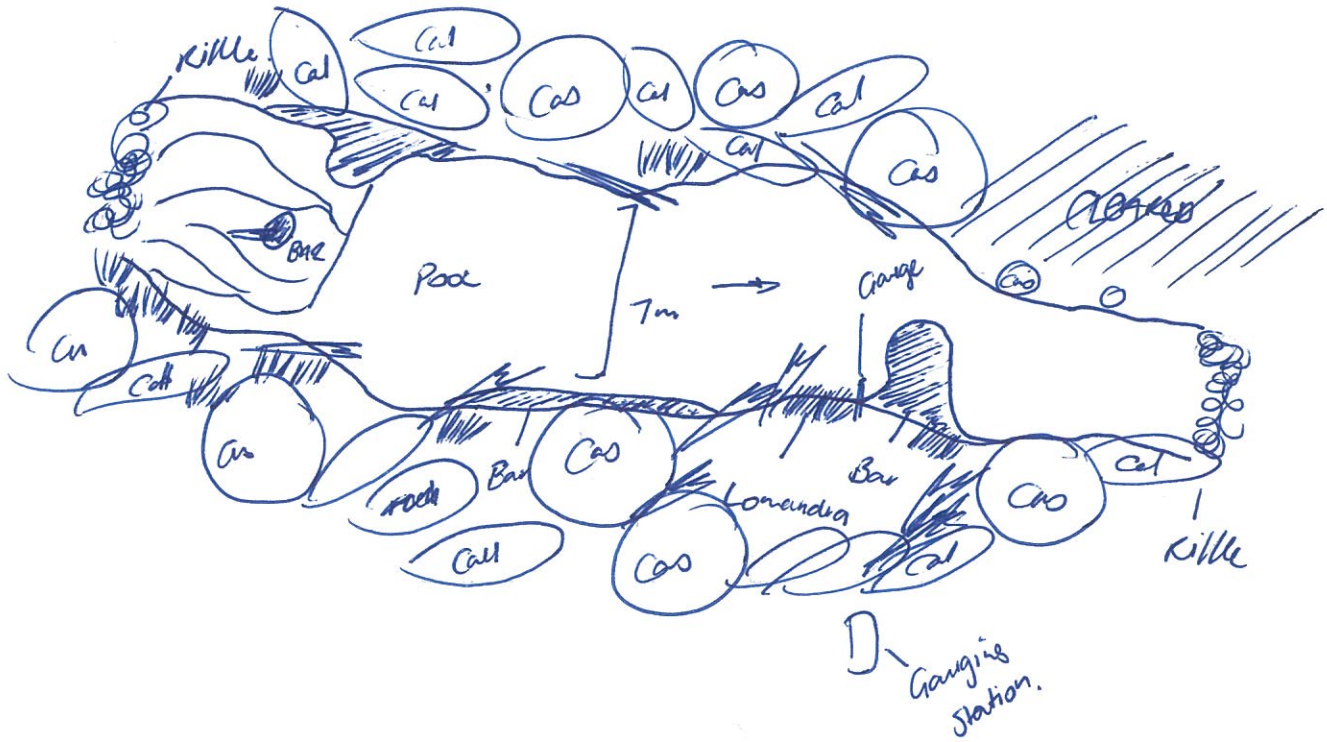
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME DRMP1 **DATE:** 2 / 6 / 16

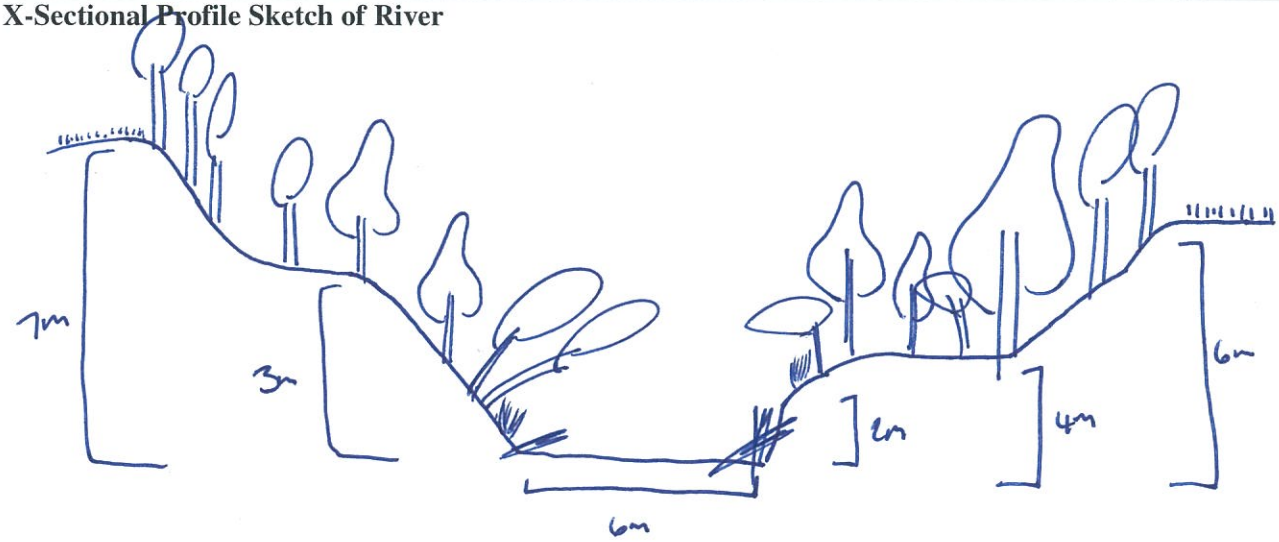
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

Depth 0.10 — 0.5m.

REFERENCE CONDITION SELECTION SHEET

SITE CODE: DRMP1 **Date:** 2.6.16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious		
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction		
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation		
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged		
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment		
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified		
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification		
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion		
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration		
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats		
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [|D|K|M|P|1|] **SITE NAME:** DRMP1

Date: 2 / 6 / 16 **Time (24 hrs):** [1 3 1 6] **GPS:** 25.690210, 149.167377 **Project Name:** Santos Kenp.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (LM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	30	43	11	0

Score 84

STATE OF THE RIVERS --- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 02/06/16 Recorder am

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Basin | Sub-section | Site: DRMP | Tributary Name: Dawson River

SITE CODE

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- 1 Completely dry
- 2 Isolated pools, no flow
- 3 Low Flow/ low level
- 4 Moderate < water mark
- [X] 5 Normal at water mark
- 6 High > water mark
- 7 Flood > bankfull
- 8 Within 1 hr of High Tide
- 9 Within 1 hr of Low Tide
- 10 Incoming/between Tide
- 11 Out-going/between Tide

3 Channel Pattern

Map Scale → | Not Determined (0) | ← Local Scale

- 1 Straight
- 2 Mildly sinuous
- 3 Irregular
- 4 Reg. Meanders
- 5 Irreg. Meanders
- 6 Tortuous
- 7 Braided
- 8 Swampy
- 9 Channelised
- 10 Overland Flow

4 Local Land Use

- 1 Sugar Cane
- 2 Horticulture small crops/ vines
- 3 Horticulture tree crops/ fruit
- 4 Irrigated broadacre row crops
- [X] 4 Rainfed broadacre row crops ?
- [X] 5 Grazing - sown pasture
- [X] 6 Grazing -native --- cleared
- [X] 7 Grazing -native --- thinned
- [X] 8 Grazing -native --- virgin timber
- 9
- 10 Intensive Livestock-pig,fowl,cow
- 11 Urban residential
- 12 Urban manufact/ processing
- 13 Park or Reserve / National, envir
- 14 Urban Park or Reserve
- 15 Rural Residential / hobby farm
- 16 Other _____

5 Local Disturbance

- 1 Sand / gravel mine
- 2 Other mine
- 3 Road
- 4 Bridge / culvert / wharf
- 5 Ford / ramp
- 6 Discharge Pipe
- 7 Forestry activities
- 8 Sugar Mill
- 9 Sewerage Effluent
- 10 Irrig. runoff, pipe outlet
- 11 Channelisation
- 12 River improvement
- 13 Water Extraction
- 14 Dredging
- [X] 15 Grazing
- [X] 16 Other Clearing

6 Record Present Vegetation in Local Vacinity

- 1 Rainforest
- 2 Eucalypt Wet Sclerophyl
- 3 Eucalypt Open Forest
- [X] 4 Eucalypt woodland
- [X] 5 Eucalypt open woodland
- 6 Cypruss Pine forest
- 7 Belah/ Brigalow/ Gidgee
- 8 Mulga scrub-open forest
- 9 Mulga Shrubland
- 10 Bendee/lancewood scrub
- 11 Softwood Scrub
- 12 Melaleuca forest
- [X] 13 Grassland(isolated trees)
- 14 Other Shrubland
- 15 Heathland
- 16 Mangrove
- 17 Salt marsh / salt pans
- 18 Freshwater marsh
- 19 Pine plantation
- 20 Banana plantation
- 21 Sugar Cane
- 22 Other _____

7 Floodplain features

- [X] 1 Oxbows / billabongs
- 2 Remnant Channels
- [X] 3 Floodplain scours
- [X] 4 Floodplain deposits
- 5 Prominent flood channels

8 Local Land Tenure

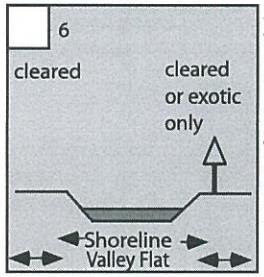
- [X] 1 Freehold/ leasehold
- 2 National Park
- 3 State Park
- 4 Reserve-timber,envir P
- 5 State Forest
- 6 Urban Reserve
- 7 Urban
- 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

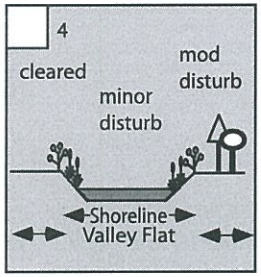


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[ ] 4



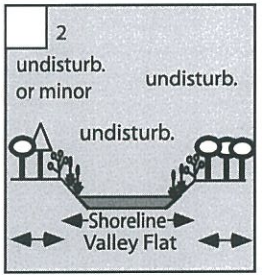
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

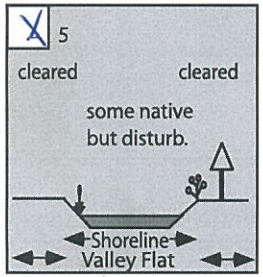


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[X] 5

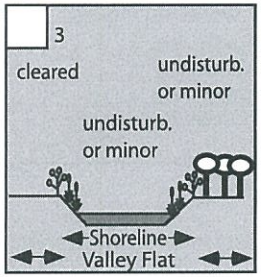


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[ ] 3

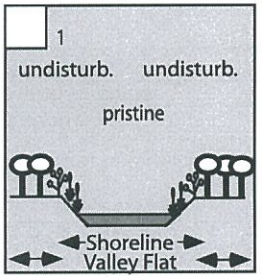


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

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Basin	Sub-section	Site	Tributary Name
		0 K m P1 (SITE CODE)	Dawson River

Date (dd/mm/yy): 02/06/16

Recorder: CM

1 Channel Habitat Types

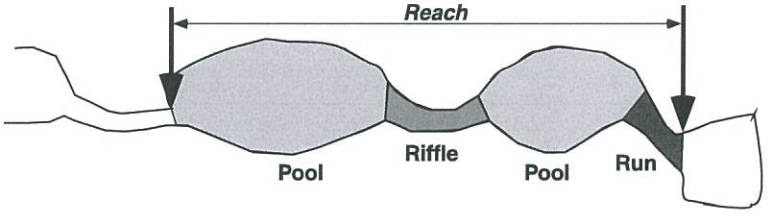
Habitat	Description	% of section	Est. Av. length (m)	Est. Av. height (m) / Est. Av. depth (m)	Est. Av. Gradient (deg.) / Est. Av. Width (m)
Waterfall	Height > 1m; Gradient > 60 deg				
Cascade	Step Height < 1m; Gradient 5 - 60 deg; Strong Currents				
Rapid	Depth > 0.3 m; Gradient 3 - 5 deg; Strong Currents; Rocks break surface				
Riffle	Depth 0.1 - 0.3 m; Gradient 1- 3 deg; Moderate Currents; Surface unbroken but unsmooth	10			
Glide	Depth < 0.1 m; Gradient 1- 3 deg; Small Currents; Surface unbroken and smooth	5			
Run	Depth > 0.3 m; Gradient 1- 3 deg; Small but distinct & uniform current; Surface unbroken	20			
Pool	Depth > 0.5 m where stream widens or deepens and current declines	60			
Backwater	Depth < 0.3m; a reaonable size (>20% of channel width) cut-off section away from the channel	5			

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m): 100

3 Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

See KNSRIVRS assessment.

STATE OF THE RIVERS --- SHEET 6 Cross- Sections

Page __ of __

Date (dd/mm/yy) 02/06/16

Recorder: am

© 1992 J. Anderson

Basin | Sub-section | Site: Dann 1 (SITE CODE) | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.

Upper bank = water mark to inflexion point on the bank

1 TYPE

Pool	X	1
Riffle	X	2
Run	X	3
Glide	X	4
Cascade		5
Rapid		6
Backwater		7
Other ____		8

2 Length of Type (m) | Av. Width of Type (m) | Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		

salt 0.1mm; sugar grain 0.5mm; raw sugar 2mm; pea 5mm; 10 cent coin 20mm; tennis ball 60 mm; Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

8 Left — Lower | Upper

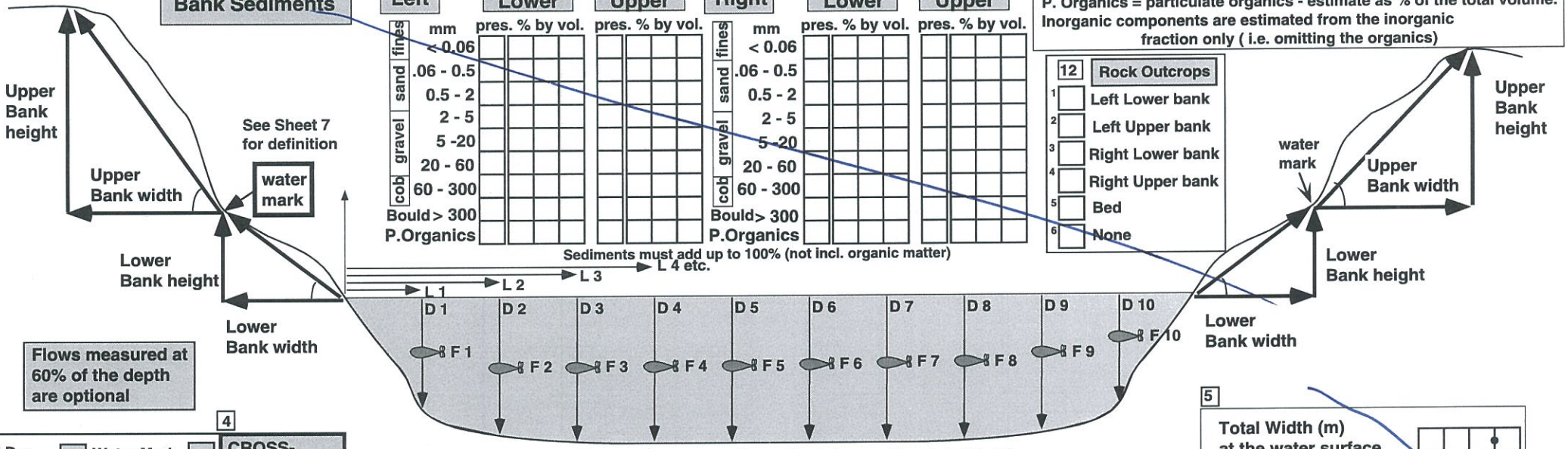
11 Right — Lower | Upper

	mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines	< 0.06				
sand	.06 - 0.5				
sand	0.5 - 2				
gravel	2 - 5				
gravel	5 -20				
gravel	20 - 60				
cob	60 - 300				
Bould	> 300				
P.Organics					

Sediments must add up to 100% (not incl. organic matter)

12 Rock Outcrops

1. Left Lower bank
2. Left Upper bank
3. Right Lower bank
4. Right Upper bank
5. Bed
6. None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark | Water Mark covered -no lower bank

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

	mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines	< 0.06								
sand	.06 - 0.5								
sand	0.5 - 2								
gravel	2 - 5								
gravel	5 -20								
gravel	20 - 60								
cob	60 - 300								
Bould	> 300								
P.Organics (out of 100%)									

6 LEFT LOWER BANK

Width (m)	1
Height (m)	0.6
Slope (deg.)	45

7 LEFT UPPER BANK

Width (m)	3
Height (m)	4
Slope (deg.)	60

9 RIGHT LOWER BANK

Width (m)	2
Height (m)	3
Slope (deg.)	10

10 RIGHT UPPER BANK

Width (m)	15
Height (m)	7
Slope (deg.)	40

STATE OF THE RIVERS --- SHEET 7 BankCondition

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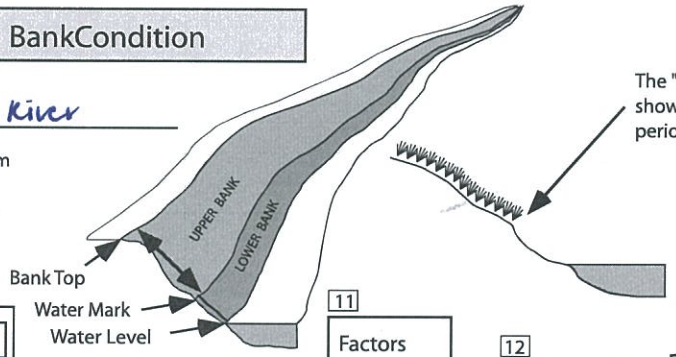
Basin | Sub-section | Site (SITE CODE): DRMP | Tributary Name: Dawson River

Date (dd/mm/yy): 02/06/16 | Recorder: CM

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width
1 Natural				
2 Man-made				
3 Absent	X			

LEFT BANK

Record % of bank length

LOCATION for Instability

1 LOWER BANK

Bare of Veg: 35

NOTE: The 4 % figures below must = 100%

Stable: 30

Eroding: 65 | Aggrading: | Slumping: 5 | where

2 UPPER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding: | Aggrading: | Slumping: | where

Location	1 LOWER BANK	2 UPPER BANK
bends		
At floodplain scours	X	
at obstacles		
at seepage & runoff points		
Irregular		
all along	X	

3 LEFT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60-80 deg. Steep	2
Slope 30-60 deg. Moderate	3 X
Slope 10-30 deg. Low	4
Slope < 10 deg. Flat	5

4 LEFT BANK Shape (RANK types)

Concave	1
Convex	2
Stepped	3 X
Wide lower bench	4
Undercut	5

11 Factors Affecting Stability

Flow & Waves	1
Seepage	2
Runoff	3 X
Floodplain Scours	4 X
Stock	5 X
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8
Clearing of Vegetation	9 X
Gravel/sand extraction	10
Mining	11
Other	

** RANKS **

12 Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other	9
Other	10
None	11 X

RIGHT BANK

Record % of bank length

LOCATION for Instability

6 LOWER BANK

Bare of Veg: 20

NOTE: The 4 % figures below must = 100%

Stable: 10

Eroding: 20 | Aggrading: 30 | Slumping: 40 | where

7 UPPER BANK

Bare of Veg: 20

NOTE: The 4 % figures below must = 100%

Stable: 40

Eroding: 20 | Aggrading: | Slumping: | where

Location	6 LOWER BANK	7 UPPER BANK
bends		
At floodplain scours		
at obstacles	X	
at seepage & runoff points	X	
Irregular		X
all along	X	

8 RIGHT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	X 1
Slope 60-80 deg. Steep	2
Slope 30-60 deg. Moderate	3
Slope 10-30 deg. Low	4
Slope < 10 deg. Flat	5

9 RIGHT BANK Shape (RANK types)

Concave	1
Convex	2
Stepped	3
Wide lower bench	4
Undercut	X 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	X			
Susceptibility to erosion (1 / 2 / 3 / 4)		X		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability		X		
Susceptibility to erosion (1 / 2 / 3 / 4)		X		

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Date (dd/mm/yy) 2 / 6 / 96 Recorder DM

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Basin | Sub-section | Site (DRDP) | Tributary Name Dawson R.

SITE CODE

Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point [X]
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 5

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size: _____

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening [X]
- Bank Erosion [X]
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other _____

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other _____
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted (< 0.1 m deep & narrow)	2
3	Moderately Restricted (< 0.3 m deep & narrow)	3
4	Partly Restricted (< 0.5 m deep & narrow)	4
5	Good Passage (0.5 -1 m deep wide no torrent)	5
[X] 6	Unrestricted (> 1 m deep & almost channel wide)	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall	1	2	3	4	5	6	7
Cascade rapid or log jam	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge	1	2	3	4	5	6	7
Single log branch pile, rock	1	2	3	4	5	6	7
Low feature easily by-passed	1	2	3	4	5	6	7
None / Other	1	2	3	4	5	6	7

m

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) ___/___/___ Recorder _____ 22.9.94 D.Telfer

Basin ___ Sub-section ___ Site D R M P 1 (SITE CODE) Tributary Name Dawson R.

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

See photo

Refer definition of the Riparian Zone

- 5 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 5 Width of Riparian Vegetation (m)
- 15 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	15	
Trees 10 - 30 m	25	
Trees < 10 m	5	
Woody Shrubs (> 2m)	2	
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	30	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

4 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ___ (1) No ___ (2)

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width (1) X
- Disturbed & non-grass species extend only to the bank top (2)
- Disturbed & non-grass species extend partially into the original zone (floodplain) (3)
- Thinned, semi-natural in cover and width (4)
- Virtually natural cover & width (5)

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width (1)
- Disturbed & non-grass species extend only to the bank top (2) X
- Disturbed & non-grass species extend partially into the original zone (floodplain) (3)
- Thinned, semi-natural in cover and width (4)
- Virtually natural cover & width (5)

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

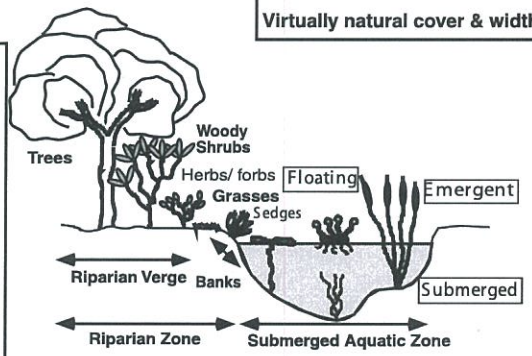
Visible depth (m)	3
Too turbid - pres only	X
% Bare - no vegetation	
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other _____	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 40 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 6 Width of Riparian Vegetation (m)
- 25 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	15	
Trees 10 - 30 m	10	
Trees < 10 m	30	
Woody Shrubs (> 2m)	5	
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	25	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ___ (1) No ___ (2)

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

FIELD SHEETS

PROJECT NAME: Santos Kemp **SITE CODE:** DRK1

SITE NAME: DRK1

DATE: 2 / 6 / 16 **TIME (24hrs):** [10.00] **PARTY:** CM + AM

LATITUDE: 25.687721 **LONGITUDE:** 149.155920

EASTING: - **NORTHING:** - **Mobile Coverage:** (Y) N

MAP NAME: - **MAP SCALE:** - **Sat. Phone Coverage:** (Y) N

PHOTO #'s: Red camera **KEY NEEDED (Details) :** -

COMMENTS: Turbid incised channel. Turtle (sp unknown) observed. Yellowbelly + T. tandanus both observed. Large saratoga.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	~~59.4~~	8.61
Gauge Height (m)	-		DO (% sat)	~~5.64~~	89.4
Water Temperature (°C)	16.44		Turbidity (NTU)	12.6	
Conductivity (µS/cm)	0.223 mS		Total Alkalinity (mg/L)	110	
pH	6.89		**Time Collected**	10.00	
TDS	0.173		Redox	158.0	

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 10 m Min 4 m Mode 10 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low + Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: Flood debris to ~6m above water mark.

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle.

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse Cattle grazing. Potentially dryland cropping - paddock cleared but not sown.

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) >10m 50%

Trees<10m 45 % cover *Shrubs/Vines/Rushes* 5 % cover *Grasses/Ferns/Herbs* 80 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME DRR1 DATE: 2 / 6 / 16

HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)

KEY HABITAT FEATURES	Edge														
Vel count															
Vel depth															
Vel m/sec															
Vel (average) (m/sec)	0.05														
Mean Sample Depth (m)	0.25														
Mean Wetted Width (m)	8 m														
% Bedrock															
% Boulder (>soccer ball)															
% Cobble (tennis ball - soccer ball)															
% Pebble (marble - tennis ball)															
% Gravel (2 - 4mm)															
% Sand (0.005 - 2mm)	5														
% Silt/Clay (< 0.005 mm)	95														
% Detritus (leaves/twigs)	60														
% Sticks (<2cm)	20														
% Branches	5														
% Logs (>15cm)															
% Algae	40														
% Macrophytes															
% Overhanging habitat (e.g. vegetation, roots)	30														
% Blanketing silt (indicated by plume)	20														
% Shading	40														
Sampled By:	AMJ														
Picked By:															

Comments:

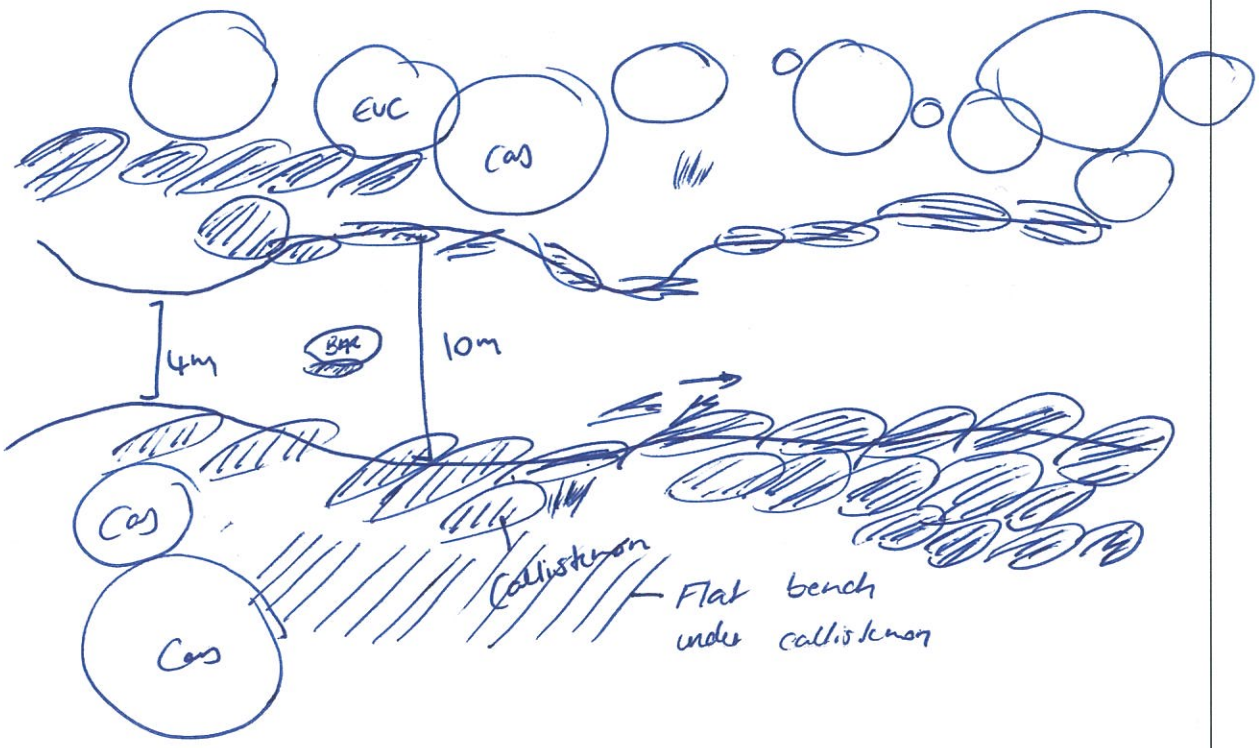
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME DKR1 **DATE:** 2 / 6 / 16

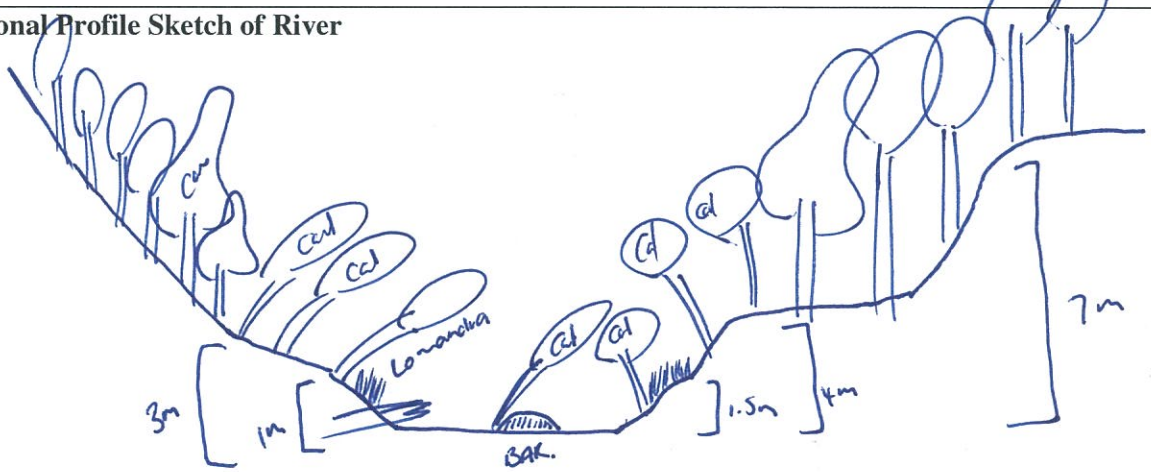
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

.....

.....

.....

REFERENCE CONDITION SELECTION SHEET

SITE CODE: DDR1 **Date:** 2.6.16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	1	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	3	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	4	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	2	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	3	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	5	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	38	

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [D|R|R|1| | |] **SITE NAME:** DRR 1

Date: 2 / 6 / 16 **Time (24 hrs):** [1|0|3|0] **GPS:** 25.687505, 149.156053 **Project Name:** Santos Kenya

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (IM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	30	8	27	2

Score 67

STATE OF THE RIVERS --- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 02/06/16 Recorder CM

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Basin | Sub-section | Site DRR1 | Tributary Name Dawson River

SITE CODE

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- Completely dry
- Isolated pools, no flow
- Low Flow/ low level
- Moderate < water mark
- [X] Normal at water mark
- High > water mark
- Flood > bankfull
- Within 1 hr of High Tide
- Within 1 hr of Low Tide
- Incoming/between Tide
- Out-going/between Tide

3 Channel Pattern

Map Scale → | Not Determined | ← Local Scale

- 1 Straight
- 2 Mildly sinuous
- 3 Irregular
- 4 Reg. Meanders
- 5 Irreg. Meanders
- 6 Tortuous
- 7 Braided
- 8 Swampy
- 9 Channelised
- 10 Overland Flow

4 Local Land Use

- 1 Sugar Cane
- 2 Horticulture small crops/ vines
- 3 Horticulture tree crops/ fruit
- 4 Irrigated broadacre row crops
- [X] 5 Rainfed broadacre row crops
- [X] 6 Grazing - sown pasture
- [X] 7 Grazing -native --- cleared
- 8 Grazing -native --- thinned
- 9 Grazing -native --- virgin timber
- 10 Intensive Livestock-pig,fowl,cow
- 11 Urban residential
- 12 Urban manufact/ processing
- 13 Park or Reserve / National, envir
- 14 Urban Park or Reserve
- 15 Rural Residential / hobby farm
- 16 Other _____

5 Local Disturbance

- 1 Sand / gravel mine
- 2 Other mine
- 3 Road
- 4 Bridge / culvert / wharf
- 5 Ford / ramp
- 6 Discharge Pipe
- 7 Forestry activities
- 8 Sugar Mill
- 9 Sewerage Effluent
- 10 Irrig. runoff, pipe outlet
- 11 Channelisation
- 12 River improvement
- 13 Water Extraction
- 14 Dredging
- [X] 15 Grazing
- [X] 16 Other Clearing

6 Record Present Vegetation in Local Vacinity

- 1 Rainforest
- 2 Eucalypt Wet Sclerophyl
- 3 Eucalypt Open Forest
- [X] 4 Eucalypt woodland
- [X] 5 Eucalypt open woodland
- 6 Cypruss Pine forest
- 7 Belah/ Brigalow/ Gidgee
- 8 Mulga scrub-open forest
- 9 Mulga Shrubland
- 10 Bendee/lancewood scrub
- 11 Softwood Scrub
- 12 Melaleuca forest
- [X] 13 Grassland(isolated trees)
- 14 Other Shrubland
- 15 Heathland
- 16 Mangrove
- 17 Salt marsh / salt pans
- 18 Freshwater marsh
- 19 Pine plantation
- 20 Banana plantation
- 21 Sugar Cane
- 22 Other _____

7 Floodplain features

- [X] 1 Oxbows / billabongs
- 2 Remnant Channels
- 3 Floodplain scours
- [X] 4 Floodplain deposits
- 5 Prominent flood channels

8 Local Land Tenure

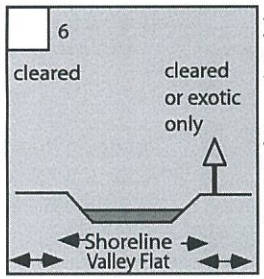
- [X] 1 Freehold/ leasehold
- 2 National Park
- 3 State Park
- 4 Reserve-timber,envir P
- 5 State Forest
- 6 Urban Reserve
- 7 Urban
- 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

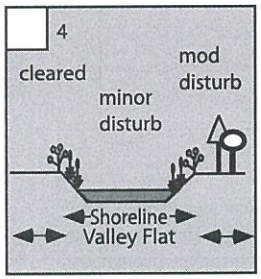


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[ ] 4



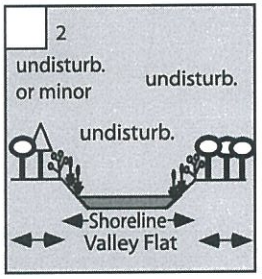
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

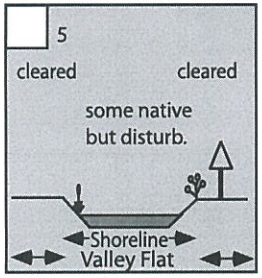


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[ ] 5

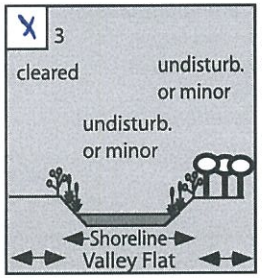


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[X] 3

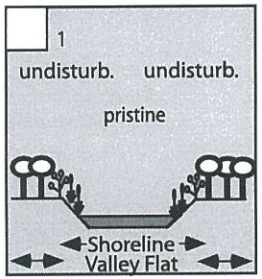


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

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Date (dd/mm/yy) 02/06/16

Recorder OM

Basin | Sub-section | Site DKR1 (SITE CODE) | Tributary Name Dawson River

1 Channel Habitat Types

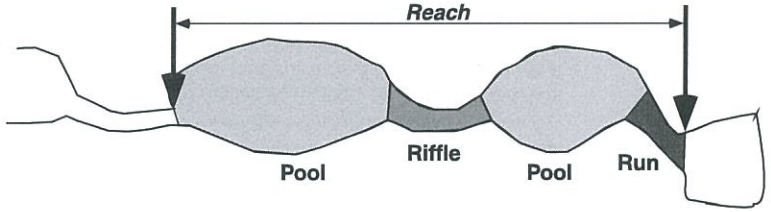
Habitat	Height / Gradient	% of section	Est. Av. length (m)	Est. Av. height (m) / Est. Av. depth (m)	Est. Av. Gradient (deg.) / Est. Av. Width (m)
Waterfall	Height > 1m, Gradient > 60 deg				
Cascade	Step Height < 1m, Gradient 5 - 60 deg, Strong Currents				
Rapid	Depth > 0.3 m, Gradient 3 - 5 deg, Strong Currents, Rocks break surface				
Riffle	Depth 0.1 - 0.3 m, Gradient 1- 3 deg, Moderate Currents, Surface unbroken but unsmooth				
Glide	Depth < 0.1 m, Gradient 1- 3 deg, Small Currents, Surface unbroken and smooth				
Run	Depth > 0.3 m, Gradient 1- 3 deg, Small but distinct & uniform current, Surface unbroken	20			
Pool	Depth > 0.5 m where stream widens or deepens and current declines	~~80~~ 75			
Backwater	Depth < 0.3m a reaonable size (>20% of channel width) cut-off section away from the channel	5			

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m) 100

3 Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

See KNSRIVAS assessment.

STATE OF THE RIVERS --- SHEET 6 Cross- Sections

Page __ of __

Date (dd/mm/yy) 02/06/16

Recorder CM

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Basin | Sub-section | Site DRR1 (SITE CODE) | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.
Upper bank = water mark to inflexion point on the bank

1 TYPE

Pool	X	1
Riffle		2
Run	X	3
Glide		4
Cascade		5
Rapid		6
Backwater	X	7
Other ____		8

2 Length of Type (m) | Av. Width of Type (m) | Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		
salt 0.1mm	sugar grain 0.5mm		raw sugar 2mm	pea 5mm	10 cent coin 20mm	tennis ball 60 mm	Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

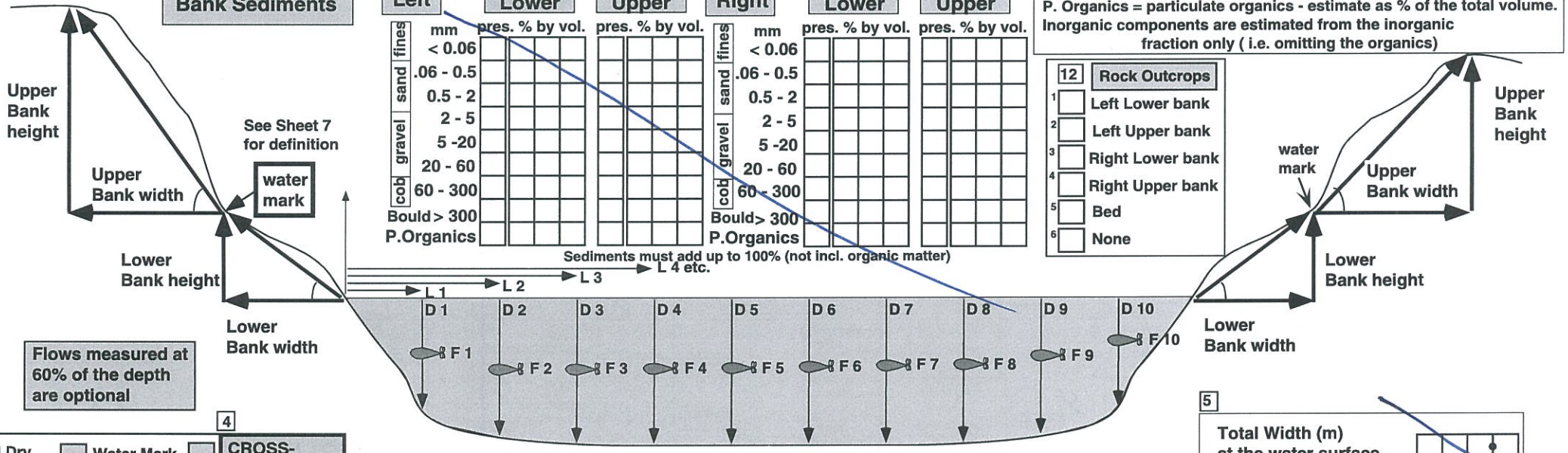
8 Left: Lower | Upper — **11** Right: Lower | Upper

	mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines	< 0.06				
sand	.06 - 0.5				
sand	0.5 - 2				
gravel	2 - 5				
gravel	5 -20				
gravel	20 - 60				
cob	60 - 300				
Bould	> 300				
P.Organics					

Sediments must add up to 100% (not incl. organic matter)

12 Rock Outcrops

1. Left Lower bank
2. Left Upper bank
3. Right Lower bank
4. Right Upper bank
5. Bed
6. None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark ☐ Water Mark covered -no lower bank ☐

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

	mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines	< 0.06								
sand	.06 - 0.5								
sand	0.5 - 2								
gravel	2 - 5								
gravel	5 -20								
gravel	20 - 60								
cob	60 - 300								
Bould	> 300								
P.Organics (out of 100%)									

6 LEFT LOWER BANK

Width (m)	1
Height (m)	0.8
Slope (deg.)	60

7 LEFT UPPER BANK

Width (m)	11.2
Height (m)	3.0
Slope (deg.)	40

9 RIGHT LOWER BANK

Width (m)	1
Height (m)	2.5
Slope (deg.)	80

10 RIGHT UPPER BANK

Width (m)	3
Height (m)	3
Slope (deg.)	45

STATE OF THE RIVERS --- SHEET 7 BankCondition

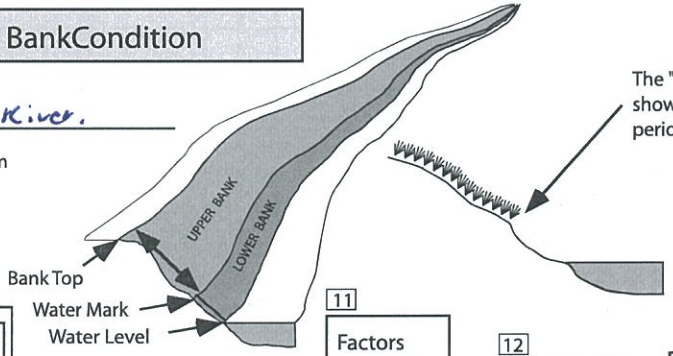
© 1992 J. Anderson

Basin | Sub-section | Site: DKR1 | Tributary Name: Dawson River.

SITE CODE

Date (dd/mm/yy): 02/06/16 Recorder: CM

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width
1 Natural				
2 Man-made				
X 3 Absent				

LEFT BANK

Record % of bank length

LOCATION for Instability

1 LOWER BANK

Bare of Veg: 20

NOTE: The 4 % figures below must = 100%

Stable: 70

Eroding: 25 Aggrading: 5

Slumping: where / where

2 UPPER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding: Aggrading:

Slumping: where / where

	1 LOWER BANK	2 UPPER BANK
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		X
all along	X	

3 LEFT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60-80 deg. Steep	2
Slope 30-60 deg. Moderate	X 3
Slope 10-30 deg. Low	4
Slope < 10 deg. Flat	5

4 LEFT BANK Shape (RANK types)

Concave	X 1
Convex	2
Stepped	X 3
Wide lower bench	4
Undercut	5

11 Factors Affecting Stability

Flow & Waves	1
Seepage	2
Runoff	X 3
Floodplain Scours	4
Stock	X 5
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8
Clearing of Vegetation	X 9
Gravel/sand extraction	10
Mining	11
Other	

** RANKS **

12 Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other	9
Other	10
None	X 11

RIGHT BANK

Record % of bank length

LOCATION for Instability

6 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 95

Eroding: 5 Aggrading:

Slumping: where / where

7 UPPER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 95

Eroding: Aggrading: 5

Slumping: where / where

	6 LOWER BANK	7 UPPER BANK
bends		
At floodplain scours		
at obstacles		X
at seepage & runoff points	X	
Irregular		
all along		

8 RIGHT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60-80 deg. Steep	X 2
Slope 30-60 deg. Moderate	3
Slope 10-30 deg. Low	4
Slope < 10 deg. Flat	5

9 RIGHT BANK Shape (RANK types)

Concave	1
Convex	2
Stepped	X 3
Wide lower bench	4
Undercut	X 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	X	X		
Susceptibility to erosion		X		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability		X		
Susceptibility to erosion	X	X		

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

© 1992 J. Anderson

Basin | Sub-section | Site: D R R 1 (SITE CODE) | Tributary Name: Dawson R.

Date (dd/mm/yy): 02/06/16 | Recorder: CM

Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular [X]
- Mid-channel Island [X]
- Encroaching Vegetation [X]
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 8

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:
(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2 [X]

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening [X]
- Bank Erosion [X]
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

	Now	@ Water Mark
No Passage	1	1
Very Restricted (< 0.1 m deep & narrow)	2	2
Moderately Restricted (< 0.3 m deep & narrow)	3	3
Partly Restricted (<0.5 m deep & narrow)	4	4
Good Passage (0.5 -1 m deep wide no torrent)	5	5
Unrestricted (> 1 m deep & almost channel wide)	6 [X]	6 [X]

	m	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall		1	2	3	4	5	6	7
Cascade rapid or log jam		1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge		1	2	3	4	5	6	7
Single log branch pile, rock		1	2	3	4	5	6	7
Low feature easily by-passed		1	2	3	4	5	6	7
None		1	2	3	4	5	6	7
Other		1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2 [X]	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 2/6/16 Recorder CM

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) DKR1

Tributary Name: Dawson River.

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 750 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 10 Width of Riparian Vegetation (m)
- 10 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	10	
Trees 10 - 30 m	30	
Trees < 10 m	5	
Woody Shrubs (> 2m)	5	
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	35	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

4 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		X
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

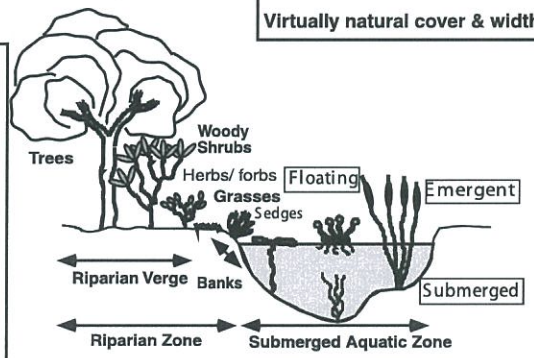
2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 X

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 X
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐



12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

Visible depth (m)	
Too turbid - pres only	X
% Bare - no vegetation	
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other	

Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	X 2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	1
Total % exotic emergents	0
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 Lomandra	0.8
Local Sp. 2 Schoen	0.2
Local Sp. 3	
Local Sp. 4	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 40 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 8 Width of Riparian Vegetation (m)
- 15 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	10	
Trees 10 - 30 m	35	
Trees < 10 m	5	
Woody Shrubs (> 2m)		
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	40	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		X
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

FIELD SHEETS

PROJECT NAME: Santos KGMP **SITE CODE:** DRR2

SITE NAME: DKR2

DATE: 30 / 5 /16 **TIME (24hrs):** [14.30] **PARTY:** CM & AM

LATITUDE: 25 718094 **LONGITUDE:** 148.971815

EASTING: – **NORTHING:** – **Mobile Coverage: Y / (N)**

MAP NAME: – **MAP SCALE:** – **Sat. Phone Coverage: (Y) / N**

PHOTO #'s: RS300135 – 183 **KEY NEEDED (Details) :** –

COMMENTS: Cattle present at time of sampling. Site frequented by cattle as a key watering point.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.25		DO (mg/L)	6.54	
Gauge Height (m)	–		DO (% sat)	68.2	
Water Temperature (°C)	17.19		Turbidity (NTU)	25.3	
Conductivity (µS/cm)	228		Total Alkalinity (mg/L)	120	
pH	6.12		**Time Collected**	15.00	
Redox	235.2		TDS	0.175	

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5. Riffle when flowing 6. LWD 7. Macrophyte 8. Other

Stream Width Max 15 m Min 0 m Mode 6 m

Water Level 1. No Flow 2. Dry/Isolated 3. <Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details....Road crossing (back).....

Hydrological Variation 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Hydrological Variation details:...Flood depths to ~6m.....

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details...Cattle.....

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse....Cattle grazing & crops.....

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) >10m 30

Trees<10m 30 % cover *Shrubs/Vines/Rushes* 5 % cover *Grasses/Ferns/Herbs* 50 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME DRR2													**DATE:** 30 / 5 / 16		
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)															
KEY HABITAT FEATURES															
Vel count															
Vel depth															
Vel m/sec	0														
Vel (average) (m/sec)	0														
Mean Sample Depth (m)	0.1														
Mean Wetted Width (m)	~6m														
% Bedrock	5														
% Boulder (>soccer ball)	15														
% Cobble (tennis ball - soccer ball)	25														
% Pebble (marble - tennis ball)	10														
% Gravel (2 - 4mm)	5														
% Sand (0.005 - 2mm)	2														
% Silt/Clay (< 0.005 mm)	38														
% Detritus (leaves/twigs)	5														
% Sticks (<2cm)	0														
% Branches	0														
% Logs (>15cm)	5														
% Algae	100														
% Macrophytes	0														
% Overhanging habitat (e.g. vegetation, roots)	10														
% Blanketing silt (indicated by plume)	40														
% Shading	30														
Sampled By:	AM														
Picked By:															

Comments:

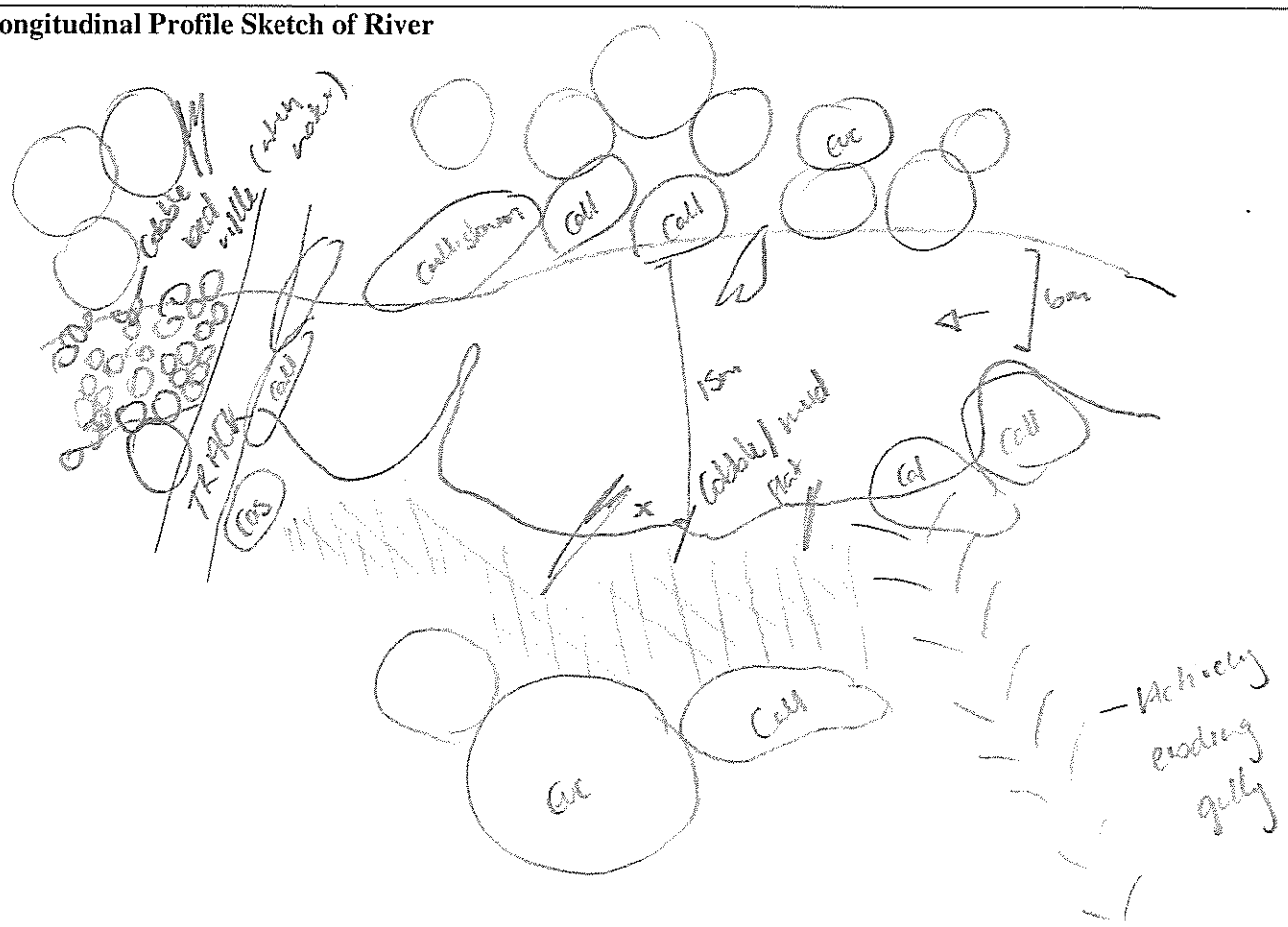
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME DRKZ DATE: 30 / 5 / 16

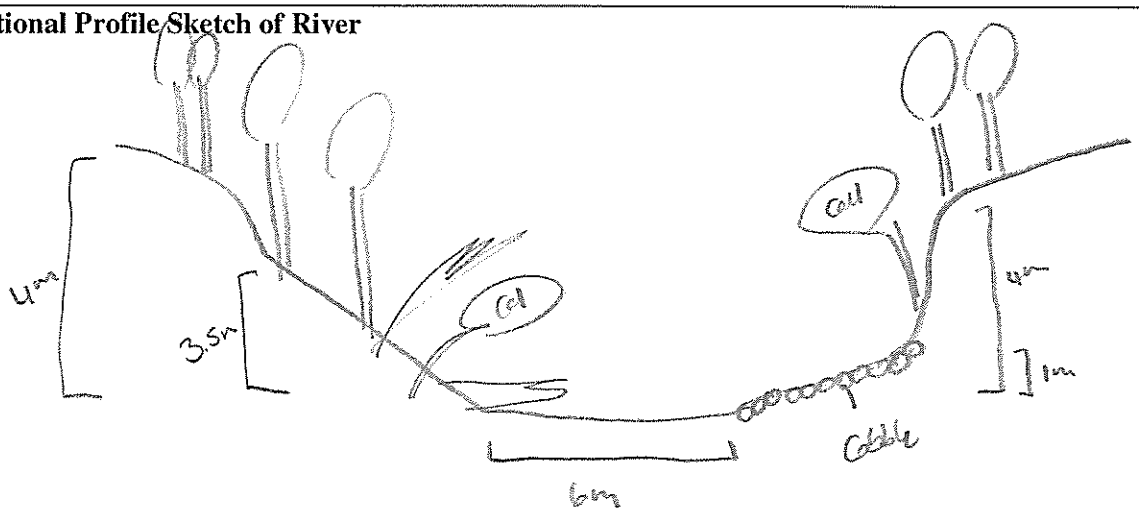
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments: lots of pondweed & algae in water channel & substrate. moderate traffic through site.

REFERENCE CONDITION SELECTION SHEET

SITE CODE: DRR2 **Date:** 30.5.16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	1	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	3	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	4	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	1	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	3	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	4	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	36	

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [ ] **SITE NAME:** DRK2

Date: 30 / 5 / 16 **Time (24 hrs):** [1 5 0 0] **GPS:** 25.717937 , 148.971295 **Project Name:** Santos KEMP

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (LM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	25	0	18	9

Score 52

STATE OF THE RIVERS ---- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 30/05/16 Recorder CM

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Basin | Sub-section | Site: DRK2 (SITE CODE)

Tributary Name DRR2 Dawson River

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- [ ] Completely dry
- [x] Isolated pools, no flow
- [ ] Low Flow/ low level
- [ ] Moderate < water mark
- [ ] Normal at water mark
- [ ] High > water mark
- [ ] Flood > bankfull
- [ ] Within 1 hr of High Tide
- [ ] Within 1 hr of Low Tide
- [ ] Incoming/between Tide
- [ ] Out-going/between Tide

3 Channel Pattern

	Map Scale	Local Scale
Not Determined	[ ] 0	[ ] 0
Straight	[ ] 1	[ ] 1
Mildly sinuous	[ ] 2	[ ] 2
Irregular	[ ] 3	[x] 3
Reg. Meanders	[ ] 4	[ ] 4
Irreg. Meanders	[ ] 5	[ ] 5
Tortuous	[ ] 6	[ ] 6
Braided	[ ] 7	[ ] 7
Swampy	[ ] 8	[ ] 8
Channelised	[ ] 9	[ ] 9
Overland Flow	[ ] 10	[ ] 10

4 Local Land Use

- [ ] 1 Sugar Cane
- [ ] 2 Horticulture small crops/ vines
- [ ] 3 Horticulture tree crops/ fruit
- [ ] 4 Irrigated broadacre row crops
- [ ] 5 Rainfed broadacre row crops
- [x] 6 Grazing - sown pasture
- [x] 7 Grazing -native --- cleared
- [x] 8 Grazing -native --- thinned
- [ ] 9 Grazing -native --- virgin timber
- [ ] 10 Intensive Livestock-pig,fowl,cow
- [ ] 11 Urban residential
- [ ] 12 Urban manufact/ processing
- [ ] 13 Park or Reserve / National, envir
- [ ] 14 Urban Park or Reserve
- [ ] 15 Rural Residential / hobby farm
- [x] 16 Other CSG

5 Local Disturbance

- [ ] 1 Sand / gravel mine
- [ ] 2 Other mine
- [x] 3 Road
- [ ] 4 Bridge / culvert / wharf
- [x] 5 Ford / ramp
- [ ] 6 Discharge Pipe
- [ ] 7 Forestry activities
- [ ] 8 Sugar Mill
- [ ] 9 Sewerage Effluent
- [ ] 10 Irrig. runoff, pipe outlet
- [x] 11 Channelisation
- [ ] 12 River improvement
- [ ] 13 Water Extraction
- [ ] 14 Dredging
- [x] 15 Grazing
- [ ] 16 Other

6 Record Present Vegetation in Local Vacinity

- [ ] 1 Rainforest
- [ ] 2 Eucalypt Wet Sclerophyl
- [ ] 3 Eucalypt Open Forest
- [ ] 4 Eucalypt woodland
- [x] 5 Eucalypt open woodland
- [ ] 6 Cypruss Pine forest
- [ ] 7 Belah/ Brigalow/ Gidgee
- [ ] 8 Mulga scrub-open forest
- [ ] 9 Mulga Shrubland
- [ ] 10 Bendee/lancewood scrub
- [ ] 11 Softwood Scrub
- [ ] 12 Melaleuca forest
- [x] 13 Grassland(isolated trees)
- [ ] 14 Other Shrubland
- [ ] 15 Heathland
- [ ] 16 Mangrove
- [ ] 17 Salt marsh / salt pans
- [ ] 18 Freshwater marsh
- [ ] 19 Pine plantation
- [ ] 20 Banana plantation
- [ ] 21 Sugar Cane
- [ ] 22 Other

7 Floodplain features

- [ ] 1 Oxbows / billabongs
- [ ] 2 Remnant Channels
- [ ] 3 Floodplain scours
- [ ] 4 Floodplain deposits
- [ ] 5 Prominent flood channels

8 Local Land Tenure

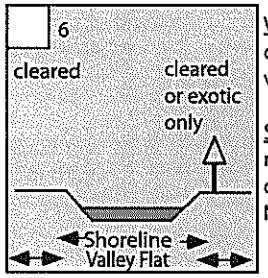
- [x] 1 Freehold/ leasehold
- [ ] 2 National Park
- [ ] 3 State Park
- [ ] 4 Reserve-timber,envir P
- [ ] 5 State Forest
- [ ] 6 Urban Reserve
- [ ] 7 Urban
- [ ] 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

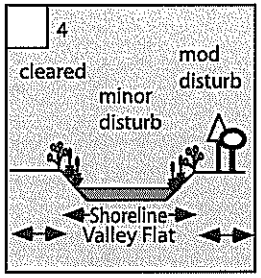


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[ ] 4



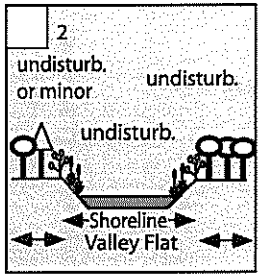
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

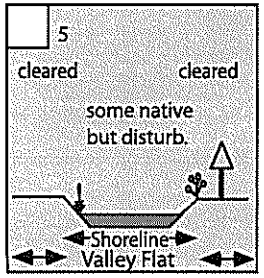


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[ ] 5

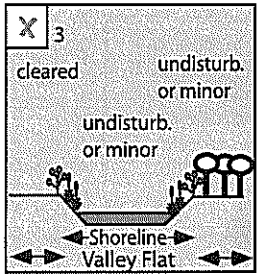


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[x] 3

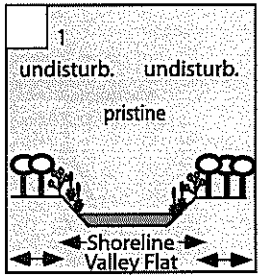


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

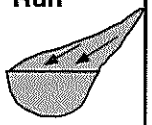
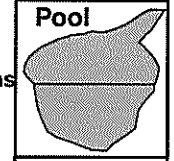
© 1992 J. Anderson

Date (dd/mm/yy) 30/05/16

Recorder AM

Basin | Sub-section | Site DR2 (SITE CODE) | Tributary Name Dawson River

1 Channel Habitat Types

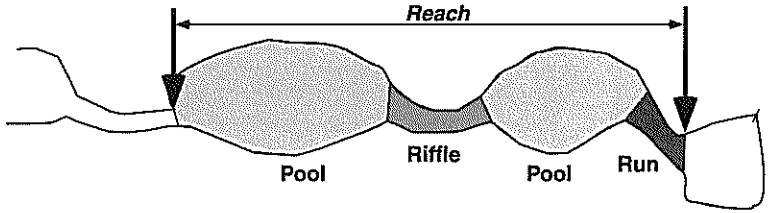
Height > 1m Gradient > 60 deg	Waterfall	% of section Est. Av. length (m) Est. Av. height (m) Est. Av. Gradient (deg.)
Step Height < 1m Gradient 5 - 60 deg Strong Currents	Cascade	% of section Est. Av. length (m) Est. Av. height (m) Est. Av. Gradient (deg.)
Depth > 0.3 m Gradient 3 - 5 deg Strong Currents Rocks break surface	Rapid	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Depth 0.1 - 0.3 m Gradient 1- 3 deg Moderate Currents Surface unbroken but unsmooth	Riffle	% of section: 10 Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Depth < 0.1 m Gradient 1- 3 deg Small Currents Surface unbroken and smooth	Glide	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Depth > 0.3 m Gradient 1- 3 deg Small but distinct & uniform current Surface unbroken	Run 	% of section: 10 Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Depth > 0.5 m where stream widens or deepens and current declines	Pool 	% of section: 80 Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Depth < 0.3m a reaonable size (>20% of channel width) cut-off section away from the channel	Backwater	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m) 100

3

Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

See AUSRIVAS sketches.

STATE OF THE RIVERS --- SHEET 6 Cross-Sections

Page __ of __

Date (dd/mm/yy) 30/05/16

Recorder rm

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Basin | Sub-section | Site (SITE CODE) | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.
Upper bank = water mark to inflexion point on the bank

1 TYPE

Pool	X
Riffle	X
Run	X
Glide	
Cascade	
Rapid	
Backwater	
Other ____	

2 Length of Type (m) / Av. Width of Type (m) / Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		

salt 0.1mm; sugar grain 0.5mm; raw sugar 2mm; pea 5mm; 10 cent coin 20mm; tennis ball 60 mm; Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

8 Left — Lower / Upper

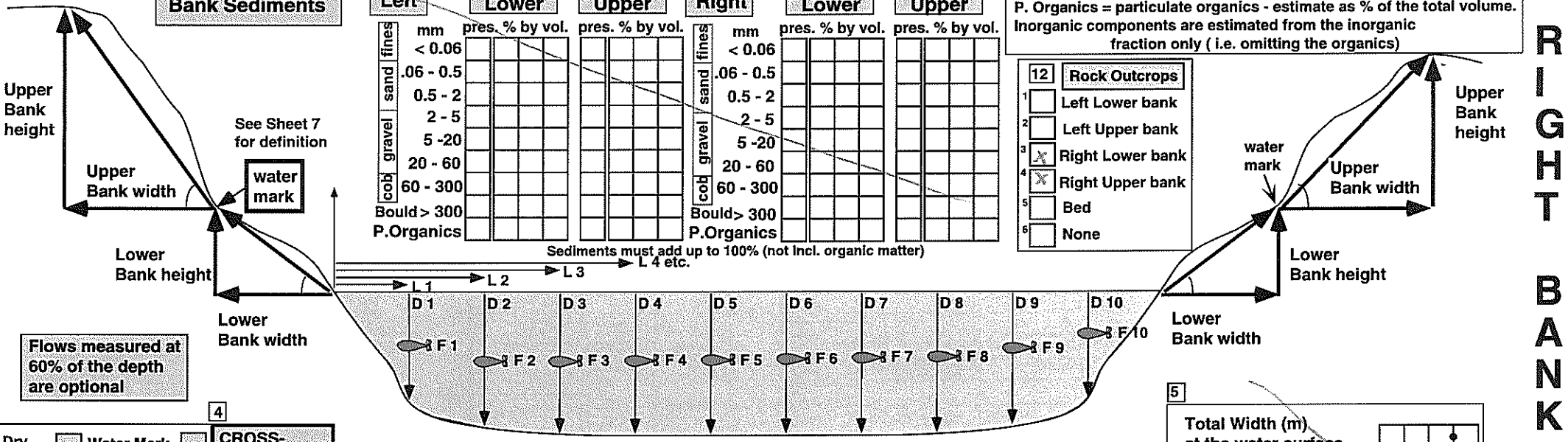
11 Right — Lower / Upper

	mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines	< 0.06				
sand	.06 - 0.5				
sand	0.5 - 2				
gravel	2 - 5				
gravel	5 -20				
gravel	20 - 60				
cob	60 - 300				
	Bould > 300				
	P.Organics				

Sediments must add up to 100% (not incl. organic matter)

12 Rock Outcrops

1	Left Lower bank
2	Left Upper bank
3	X Right Lower bank
4	X Right Upper bank
5	Bed
6	None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark ☐ Water Mark covered -no lower bank ☐

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

	mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines	< 0.06								
sand	.06 - 0.5								
sand	0.5 - 2								
gravel	2 - 5								
gravel	5 -20								
gravel	20 - 60								
cob	60 - 300								
	Bould > 300								
	P.Organics (out of 100%)								

6 LEFT LOWER BANK

Width (m)	10
Height (m)	6
Slope (deg.)	10

7 LEFT UPPER BANK

Width (m)	20
Height (m)	3
Slope (deg.)	20

9 RIGHT LOWER BANK

Width (m)	2
Height (m)	1
Slope (deg.)	60

10 RIGHT UPPER BANK

Width (m)	12
Height (m)	6
Slope (deg.)	60

STATE OF THE RIVERS --- SHEET 7 BankCondition

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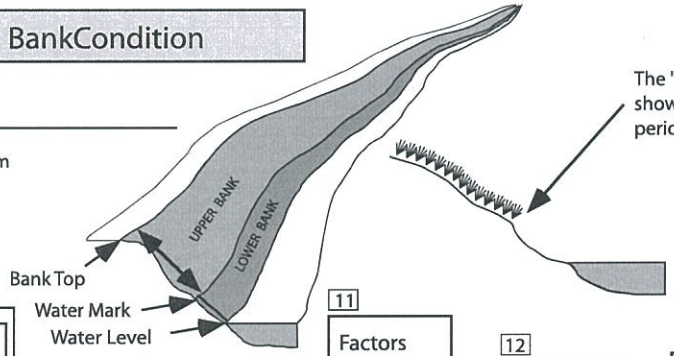
Basin | Sub-section | Site (SITE CODE): DR2 | Tributary Name: Dawson R.

Date (dd/mm/yy): 30/05/16 | Recorder: CM

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

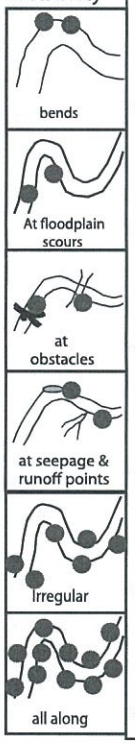
13 Levee Banks

		LEFT Height	LEFT Width	RIGHT Height	RIGHT Width
	1 Natural				
	2 Man-made				
X	3 Absent				

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 75

NOTE: The 4 % figures below must = 100%

Stable: 5

Eroding: 25 | Aggrading: | Slumping: 70

	where		where
bends			
At floodplain scours			
at obstacles			
at seepage & runoff points		X	
Irregular			
all along	X		

2 UPPER BANK

Bare of Veg: 10

NOTE: The 4 % figures below must = 100%

Stable: 40

Eroding: 60 | Aggrading: | Slumping:

	where		where
bends			
At floodplain scours			
at obstacles	X		
at seepage & runoff points			
Irregular			
all along			

3 LEFT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60- 80 deg. Steep	2 X
Slope 30-60 deg. Moderate	3 X
Slope 10 -30 deg. Low	4
Slope < 10 deg. Flat	5

4 LEFT BANK Shape (RANK types)

Concave	1 X
Convex	2
Stepped	3
Wide lower bench	4
Undercut	5

11 Factors Affecting Stability

Flow & Waves	1
Seepage	2
Runoff	3
Floodplain Scours	4 X
Stock	5 X
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8
Clearing of Vegetation	9
Gravel/sand extraction	10
Mining	11
Other	

** RANKS **

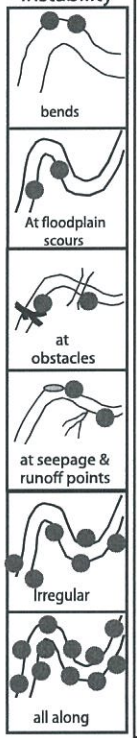
12 Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other	9
Other	10
None	11 X

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 45

NOTE: The 4 % figures below must = 100%

Stable: 70

Eroding: 30 | Aggrading: | Slumping:

	where		where
bends			
At floodplain scours			
at obstacles			
at seepage & runoff points			
Irregular			
all along	X		

7 UPPER BANK

Bare of Veg: 40

NOTE: The 4 % figures below must = 100%

Stable: 80

Eroding: 20 | Aggrading: | Slumping:

	where		where
bends			
At floodplain scours			
at obstacles			
at seepage & runoff points			
Irregular			
all along	X		

8 RIGHT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60- 80 deg. Steep	2
Slope 30-60 deg. Moderate	3 X
Slope 10 -30 deg. Low	4
Slope < 10 deg. Flat	5

9 RIGHT BANK Shape (RANK types)

Concave	1 X
Convex	2
Stepped	3
Wide lower bench	4
Undercut	5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	X			
Susceptibility to erosion (1 / 2 / 3 / 4)	X			

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability		X		
Susceptibility to erosion (1 / 2 / 3 / 4)	X			

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE) | Tributary Name: Dawson R.

Date (dd/mm/yy): 30 / 5 / 96 Recorder: CM

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Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 40

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size: _____

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing
- Other _____

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other _____
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

	Now	@ Water Mark
No Passage	1	1
Very Restricted (< 0.1 m deep & narrow)	2	2
Moderately Restricted (< 0.3 m deep & narrow)	3	3
Partly Restricted (0.5 m deep & narrow)	4	4
Good Passage (0.5 -1 m deep wide no torrent)	5	5
Unrestricted (> 1 m deep & almost channel wide)	6	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall							
m	1	2	3	4	5	6	7
Cascade rapid or log jam							
m	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge							
m	1	2	3	4	5	6	7
Single log branch pile, rock							
m	1	2	3	4	5	6	7
Low feature easily by-passed							
m	1	2	3	4	5	6	7
None Other _____							
m	1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 30/05/96 Recorder CM

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) DAR2 | Tributary Name Dawson R.

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

7 200 Width of Existing Vegetation (m) (riparian & non riparian vegetation)

40 Width of Riparian Vegetation (m)

30 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3 Type	% Cover	% Exotic spp.
Trees > 30 m	5	
Trees 10 - 30 m	30	
Trees < 10 m	20	
Woody Shrubs (> 2m)	5	
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	50	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

4 10 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

5	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.	X		Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☒
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☒
- Virtually natural cover & width 5 ☐

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

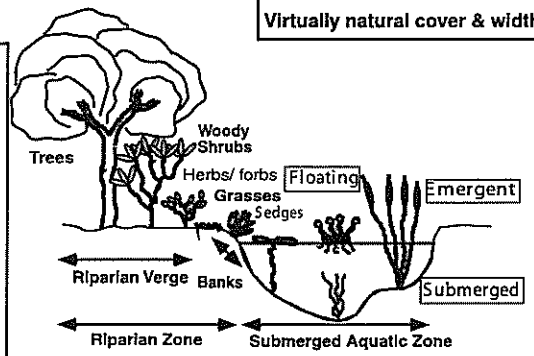
Visible depth (m)	0.5
Too turbid - pres only	
% Bare - no vegetation	100
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	100
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	100
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	X 2
Rhodes grass	1	2
Red natal grass	1	X 2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	0
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1	
Local Sp. 2	
Local Sp. 3	
Local Sp. 4	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

7 200 Width of Existing Vegetation (m) (riparian & non riparian vegetation)

50 Width of Riparian Vegetation (m)

25 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8 Type	% Cover	% Exotic spp.
Trees > 30 m		
Trees 10 - 30 m	40	
Trees < 10 m	10	
Woody Shrubs (> 2m)	2	
Woody Shrubs (< 2m)	3	
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses	50	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

10	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.	X		Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

FIELD SHEETS

PROJECT NAME: Sahtos Kemp **SITE CODE:** WLMP1

SITE NAME: WLMP1

DATE: 30 / 5 / 16 **TIME (24hrs):** [09 20] **PARTY:** CM + AM

LATITUDE: 25.708185 **LONGITUDE:** 149.145772

EASTING: – **NORTHING:** – **Mobile Coverage:** Y / (N)

MAP NAME: **MAP SCALE:** – **Sat. Phone Coverage:** (Y) / N

PHOTO #'s: P5300110 → 134, 184 → 194 iPhone **KEY NEEDED (Details) :** –

COMMENTS: Site at bend in river where widens. Numerous water birds including pelicans, ducks + grebes. Cattle + pigs present. Some damage caused by pig activity.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	7.98	
Gauge Height (m)	–		DO (% sat)	81.3	
Water Temperature (°C)	16.31		Turbidity (NTU)	15.4	
Conductivity (µS/cm)	135		Total Alkalinity (mg/L)	100	
pH	6.84		**Time Collected**	9.50	
Redox	137.4	TDS 0.106 g/L			

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 60 m Min 15 m Mode 40 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details……

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details……

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: Very little flood debris to show height outfall

Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Outfall

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle + pigs.

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse: Cattle grazing + CSG

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other……

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) 710 m 15%

Trees<10m 15 % cover *Shrubs/Vines/Rushes* 5 % cover *Grasses/Ferns/Herbs* 60 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME WLMP1					DATE: 30 / 5 / 16
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	Edge				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0				
Mean Sample Depth (m)	0.2				
Mean Wetted Width (m)	>80m				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	5				
% Silt/Clay (< 0.005 mm)	95				
% Detritus (leaves/twigs)	75				
% Sticks (<2cm)	5				
% Branches	12				
% Logs (>15cm)	8				
% Algae	50				
% Macrophytes	0				
% Overhanging habitat (e.g. vegetation, roots)	0				
% Blanketing silt (indicated by plume)	20				
% Shading	0				
Sampled By:	AM				
Picked By:	–				

Comments:

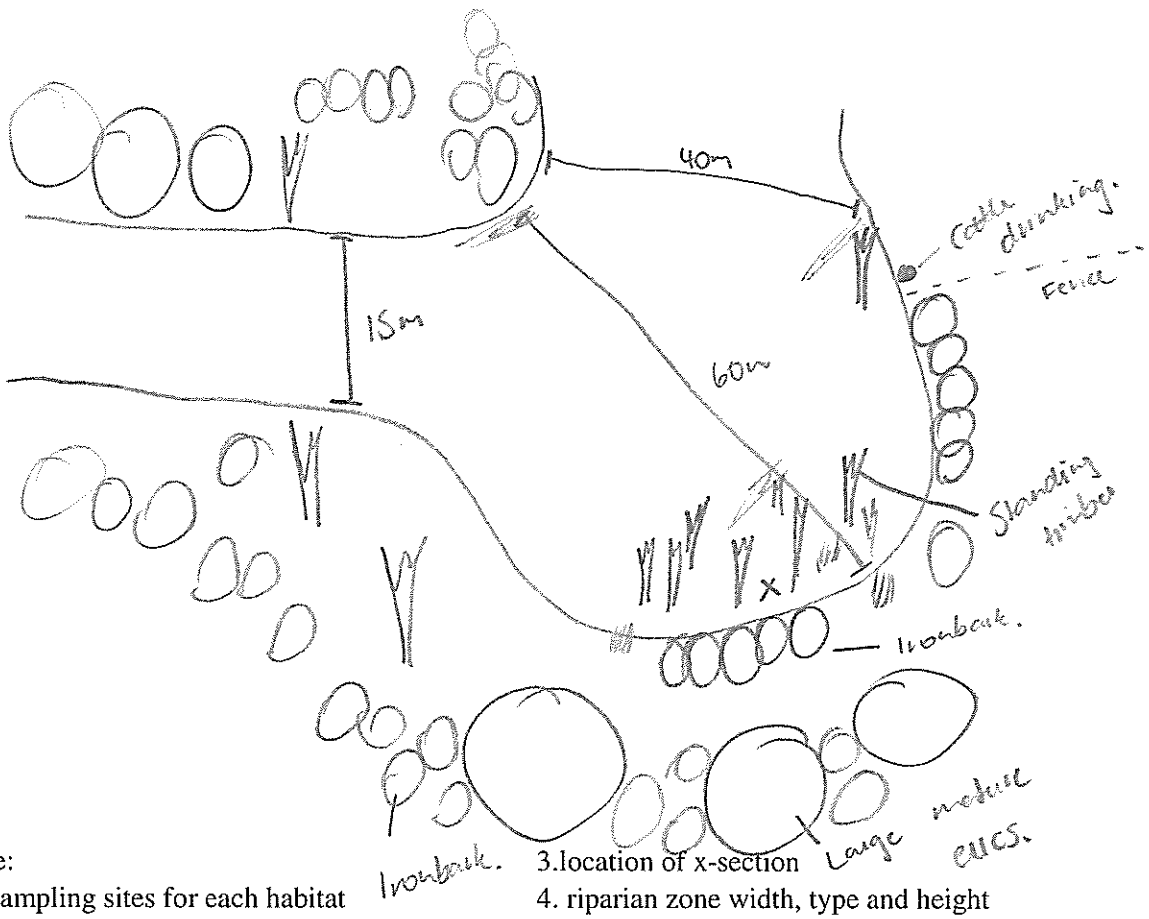
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME LEMP1 **DATE:** 30 / 5 / 16

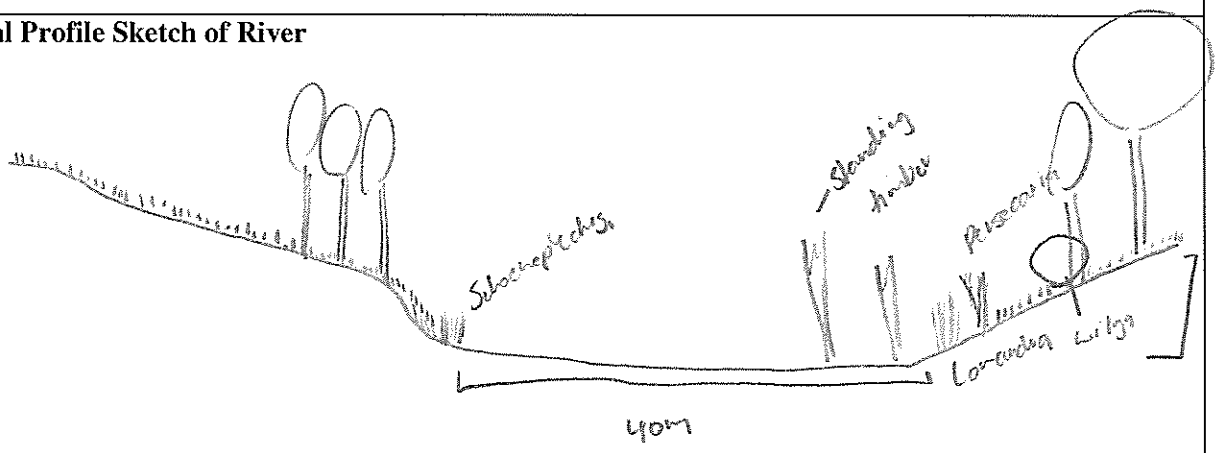
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

Little paspalum, lomandra + cyperus. Patchy schoenoplectus.

REFERENCE CONDITION SELECTION SHEET

SITE CODE: CLMP1 **Date:** 30 5 16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	2	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	2	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	2	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	4	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	5	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	3	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	35	

COMMENTS

SC1:
SC2:
SC3:
SC4: Outfall / discharge
SC5:
SC6: "
SC7: Channel
SC8:
SC9:
SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | |] **SITE NAME:** KEMP1

Date: 30/5/16 **Time (24 hrs):** [110106] **GPS:** 25.708071, 149.145785 **Project Name:** Santos KEMP

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU50340RSC.P65 (UA3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	9	17	17	0

Score 43

STATE OF THE RIVERS --- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 30/05/16 Recorder CM

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Basin | Sub-section | Site: WLMP | Tributary Name: Dawson R - WLMP

SITE CODE

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- [ ] Completely dry
- [ ] Isolated pools, no flow
- [ ] Low Flow/ low level
- [ ] Moderate < water mark
- [ ] Normal at water mark
- [x] High > water mark
- [ ] Flood > bankfull
- [ ] Within 1 hr of High Tide
- [ ] Within 1 hr of Low Tide
- [ ] Incoming/between Tide
- [ ] Out-going/between Tide

3 Channel Pattern

Map Scale → [ ] Not Determined [ ] ← Local Scale

- [ ] 1 Straight
- [ ] 2 Mildly sinuous
- [ ] 3 Irregular
- [x] 4 Reg. Meanders
- [ ] 5 Irreg. Meanders
- [ ] 6 Tortuous
- [ ] 7 Braided
- [ ] 8 Swampy
- [ ] 9 Channelised
- [ ] 10 Overland Flow

4 Local Land Use

- [ ] 1 Sugar Cane
- [ ] 2 Horticulture small crops/ vines
- [ ] 3 Horticulture tree crops/ fruit
- [ ] 4 Irrigated broadacre row crops
- [ ] 5 Rainfed broadacre row crops
- [ ] 6 Grazing - sown pasture
- [x] 7 Grazing -native --- cleared
- [ ] 8 Grazing -native --- thinned
- [ ] 9 Grazing -native --- virgin timber
- [ ] 10 Intensive Livestock-pig,fowl,cow
- [ ] 11 Urban residential
- [ ] 12 Urban manufact/ processing
- [ ] 13 Park or Reserve / National, envir
- [ ] 14 Urban Park or Reserve
- [ ] 15 Rural Residential / hobby farm
- [ ] 16 Other _____

5 Local Disturbance

- [ ] 1 Sand / gravel mine
- [ ] 2 Other mine
- [x] 3 Road
- [ ] 4 Bridge / culvert / wharf
- [ ] 5 Ford / ramp
- [x] 6 Discharge Pipe
- [ ] 7 Forestry activities
- [ ] 8 Sugar Mill
- [ ] 9 Sewerage Effluent
- [ ] 10 Irrig. runoff, pipe outlet
- [ ] 11 Channelisation
- [ ] 12 River improvement
- [ ] 13 Water Extraction
- [ ] 14 Dredging
- [x] 15 Grazing
- [ ] 16 Other _____

6 Record Present Vegetation in Local Vacinity

- [ ] 1 Rainforest
- [ ] 2 Eucalypt Wet Sclerophyl
- [ ] 3 Eucalypt Open Forest
- [ ] 4 Eucalypt woodland
- [x] 5 Eucalypt open woodland
- [ ] 6 Cypruss Pine forest
- [ ] 7 Belah/ Brigalow/ Gidgee
- [ ] 8 Mulga scrub-open forest
- [ ] 9 Mulga Shrubland
- [ ] 10 Bendee/lancewood scrub
- [ ] 11 Softwood Scrub
- [ ] 12 Melaleuca forest
- [x] 13 Grassland(isolated trees)
- [ ] 14 Other Shrubland
- [ ] 15 Heathland
- [ ] 16 Mangrove
- [ ] 17 Salt marsh / salt pans
- [ ] 18 Freshwater marsh
- [ ] 19 Pine plantation
- [ ] 20 Banana plantation
- [ ] 21 Sugar Cane
- [ ] 22 Other _____

7 Floodplain features

- [x] 1 Oxbows / billabongs
- [ ] 2 Remnant Channels
- [ ] 3 Floodplain scours
- [ ] 4 Floodplain deposits
- [ ] 5 Prominent flood channels

8 Local Land Tenure

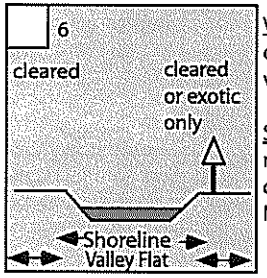
- [x] 1 Freehold/ leasehold
- [ ] 2 National Park
- [ ] 3 State Park
- [ ] 4 Reserve-timber,envir P
- [ ] 5 State Forest
- [ ] 6 Urban Reserve
- [ ] 7 Urban
- [ ] 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

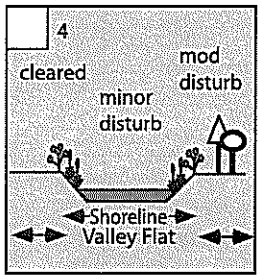


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[ ] 4



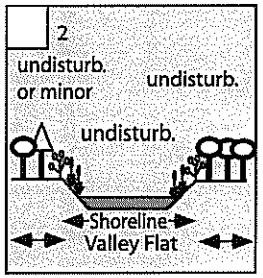
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

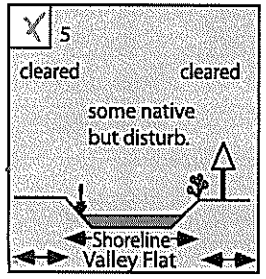


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[x] 5

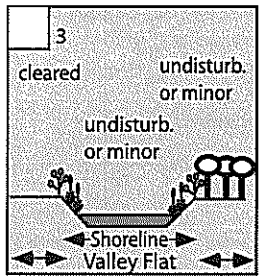


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[ ] 3

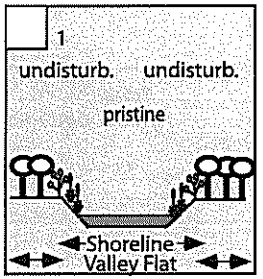


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

© 1992 J. Anderson

Date (dd/mm/yy) 30/05/16

Recorder: m

Basin | Sub-section | Site: WCMP1 (SITE CODE)

Tributary Name: Dawson River WCMP1

1 Channel Habitat Types

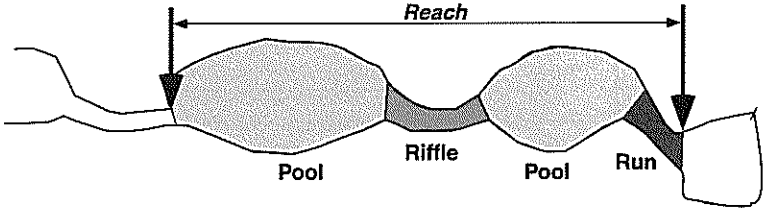
Habitat	Height / Gradient / Flow	% of section	Est. Av. length (m)	Est. Av. height (m) / depth (m)	Est. Av. Gradient (deg.) / Width (m)
Waterfall	Height > 1m; Gradient > 60 deg				
Cascade	Step Height < 1m; Gradient 5 - 60 deg; Strong Currents				
Rapid	Depth > 0.3 m; Gradient 3 - 5 deg; Strong Currents; Rocks break surface			Est. Av. depth (m)	Est. Av. Width (m)
Riffle	Depth 0.1 - 0.3 m; Gradient 1- 3 deg; Moderate Currents; Surface unbroken but unsmooth			Est. Av. depth (m)	Est. Av. Width (m)
Glide	Depth < 0.1 m; Gradient 1- 3 deg; Small Currents; Surface unbroken and smooth			Est. Av. depth (m)	Est. Av. Width (m)
Run	Depth > 0.3 m; Gradient 1- 3 deg; Small but distinct & uniform current; Surface unbroken			Est. Av. depth (m)	Est. Av. Width (m)
Pool	Depth > 0.5 m where stream widens or deepens and current declines	100	100	5	40
Backwater	Depth < 0.3m; a reaonable size (>20% of channel width) cut-off section away from the channel				

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m): 100

3 Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

Refer to MISRIVAS sketch

STATE OF THE RIVERS --- SHEET 6 Cross- Sections

Page __ of __

Date (dd/mm/yy) 30/05/16

Recorder CM

© 1992 J. Anderson

Basin | Sub-section | Site (W L M P) SITE CODE | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.
Upper bank = water mark to inflexion point on the bank

1 TYPE

Pool	X	1
Riffle		2
Run		3
Glide		4
Cascade		5
Rapid		6
Backwater	X	7
Other ____		8

2 Length of Type (m); Av. Width of Type (m); Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		
salt 0.1mm	sugar grain 0.5mm		raw sugar 2mm	pea 5mm	10 cent coin 20mm	tennis ball 60 mm	Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

8 Left: Lower | Upper

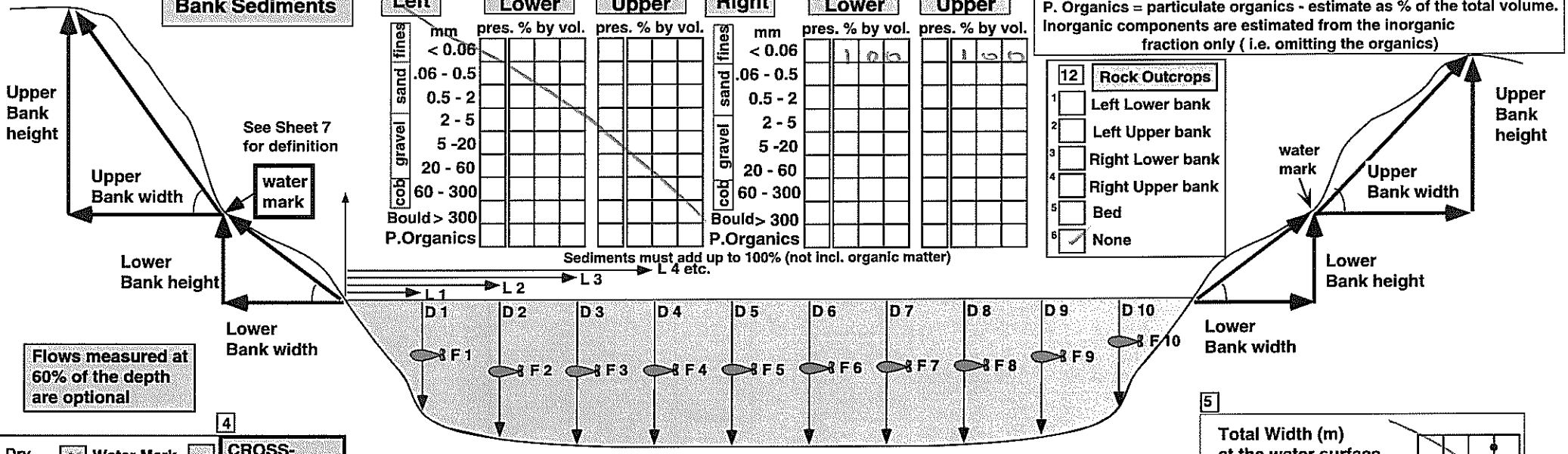
11 Right: Lower | Upper

	mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines	< 0.06			100	100
sand	.06 - 0.5				
sand	0.5 - 2				
gravel	2 - 5				
gravel	5 -20				
gravel	20 - 60				
cob	60 - 300				
Bould > 300					
P.Organics					

Sediments must add up to 100% (not incl. organic matter)

12 Rock Outcrops

1. [ ] Left Lower bank
2. [ ] Left Upper bank
3. [ ] Right Lower bank
4. [ ] Right Upper bank
5. [ ] Bed
6. [✓] None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark [X] Water Mark covered -no lower bank [ ]

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

	mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines	< 0.06								
sand	.06 - 0.5								
sand	0.5 - 2								
gravel	2 - 5								
gravel	5 -20								
gravel	20 - 60								
cob	60 - 300								
Bould > 300									
P.Organics (out of 100%)									

6 LEFT LOWER BANK

Width (m)	3
Height (m)	1.2
Slope (deg.)	20

7 LEFT UPPER BANK

Width (m)	6
Height (m)	0.5
Slope (deg.)	25

9 RIGHT LOWER BANK

Width (m)	25
Height (m)	0.5
Slope (deg.)	5

10 RIGHT UPPER BANK

Width (m)	5
Height (m)	3
Slope (deg.)	30

STATE OF THE RIVERS --- SHEET 7 BankCondition

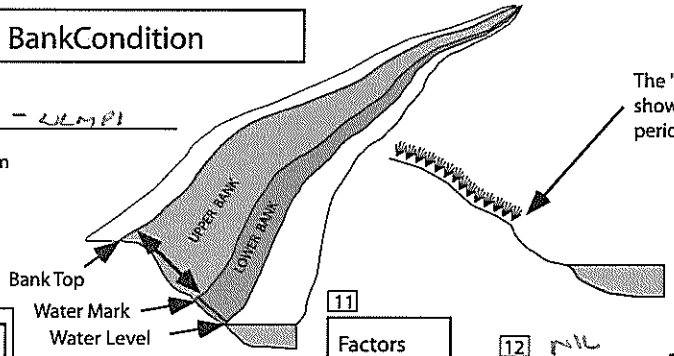
© 1992 J.Anderson

Basin: 4 | Sub-section: | Site: WLMP | Tributary Name: Dawson R - WLMP1

SITE CODE

Date (dd/mm/yy): 30/05/16 | Recorder: CM

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

- 1 Natural
- 2 Man-made
- 3 Absent: X

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability: bends; At floodplain scours; at obstacles; at seepage & runoff points; Irregular; all along

1 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable	Eroding	Aggrading	Slumping
100	0	0	0

2 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

Stable	Eroding	Aggrading	Slumping
100	0	0	0

3 LEFT BANK Slope (RANK types)

- Slope 80-90 deg. Vertical — 1
- Slope 60-80 deg. Steep — 2
- Slope 30-60 deg. Moderate — 3
- Slope 10-30 deg. Low — X 4
- Slope < 10 deg. Flat — 5

4 LEFT BANK Shape (RANK types)

- Concave — X 1
- Convex — 2
- Stepped — 3
- Wide lower bench — 4
- Undercut — 5

11 Factors Affecting Stability

- Flow & Waves — 1
- Seepage — 2
- Runoff — 3
- Floodplain Scours — X 4
- Stock — X 5
- People tracks — 6
- Vermin, Ferals — X 7
- Ford, road culvert, bridge, Weir — 8
- Clearing of Vegetation — X 9
- Gravel/sand extraction — 10
- Mining — 11
- Other

** RANKS **

12 Artificial Bank Protection Measures: nil

- Trees & Other Plants — 1
- Rock wall or layer — 2
- Fence Structures — 3
- Fenced watering points — 4
- Fenced human access — 5
- Logs strapped to bank — 6
- Concrete Wall — 7
- Break-water — 8
- Other — 9
- Other — 10
- None — 11

RIGHT BANK

Record % of bank length

LOCATION for Instability: bends; At floodplain scours; at obstacles; at seepage & runoff points; Irregular; all along

6 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable	Eroding	Aggrading	Slumping
85	15		0

7 UPPER BANK

Bare of Veg: 15

NOTE: The 4 % figures below must = 100%

Stable	Eroding	Aggrading	Slumping
85	15		

8 RIGHT BANK Slope (RANK types)

- Slope 80-90 deg. Vertical — 1
- Slope 60-80 deg. Steep — 2
- Slope 30-60 deg. Moderate — 3
- Slope 10-30 deg. Low — X 4
- Slope < 10 deg. Flat — X 5

9 RIGHT BANK Shape (RANK types)

- Concave — X 1
- Convex — X 2
- Stepped — 3
- Wide lower bench — X 4
- Undercut — 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	X			
Susceptibility to erosion		X		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability			X	
Susceptibility to erosion		X		

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Date (dd/mm/yy) 30/05/16 Recorder CM

T. Anderson

Basin | Sub-section | Site: W L M P | Tributary Name: Dawson R WLMP1

SITE CODE

Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed. at the water

1 BAR TYPE

- Bars Absent [X]
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1 [X]
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion [X]
- Channelisation [X]
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted (< 0.1 m deep & narrow)	2
3	Moderately Restricted (< 0.3 m deep & narrow)	3
4	Partly Restricted (< 0.5 m deep & narrow)	4
5	Good Passage (0.5 -1 m deep wide no torrent)	5
6	Unrestricted (> 1 m deep & almost channel wide)	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall	1	2	3	4	5	6	7
Cascade rapid or log jam	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge	1	2	3	4	5	6	7
Single log branch pile, rock	1	2	3	4	5	6	7
Low feature easily by-passed	1	2	3	4	5	6	7
None [X]	1	2	3	4	5	6	7
Other	1	2	3	4	5	6	7

m

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3 [X]	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 30/05/16 Recorder CM

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) WLMP

Tributary Name Dawson R. WLMP1

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 7 260 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 5 Width of Riparian Vegetation (m)
- 0 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3 Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	20	
Trees < 10 m	2	
Woody Shrubs (> 2m)	0	
Woody Shrubs (< 2m)	0	
Vines	0	
Rushes & Sedges	2	
Herbs/Forbs (NOT WOODY)	5	
Grasses	61	10
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 10 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes [ ] No [X]

5	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width [1] [ ]
- Disturbed & non-grass species extend only to the bank top [2] [ ]
- Disturbed & non-grass species extend partially into the original zone (floodplain) [3] [X]
- Thinned, semi-natural in cover and width [4] [ ]
- Virtually natural cover & width [5] [ ]

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width [1] [ ]
- Disturbed & non-grass species extend only to the bank top [2] [ ]
- Disturbed & non-grass species extend partially into the original zone (floodplain) [3] [ ]
- Thinned, semi-natural in cover and width [4] [X]
- Virtually natural cover & width [5] [ ]

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

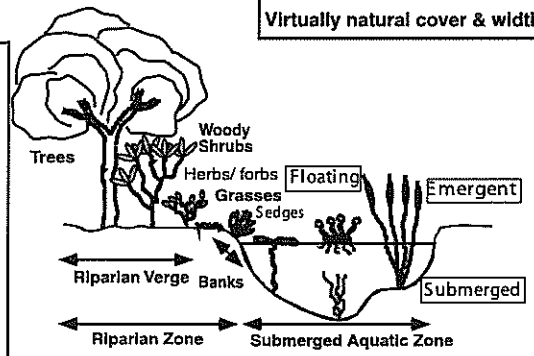
Visible depth (m)	2
Too turbid - pres only	
% Bare - no vegetation	
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	20
Total % exotics	0
Filamentous algae	20
Freshwater Algae (Blue-green Algae)	0
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	X 2
Rhodes grass	1	2
Red natal grass	1	X 2
	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	5
Total % exotic emergents	0
Phragmites p. 168	0
Typha (bull rush) p. 182	0
Para Grass p. 125	0
Other Rushes & Sedges	5
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 Schoenoplectus	1
Local Sp. 2 Cyperus	1
Local Sp. 3 Persicaria	3
Local Sp. 4	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 7 200 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 40 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8 Type	% Cover	% Exotic spp.
Trees > 30 m	5	
Trees 10 - 30 m	20	
Trees < 10 m	5	
Woody Shrubs (> 2m)	10	
Woody Shrubs (< 2m)	2	
Vines	0	
Rushes & Sedges	5	
Herbs/Forbs (NOT WOODY)	5	
Grasses	60	10
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 10 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes [ ] No [ ]

10	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

FIELD SHEETS

PROJECT NAME: Santos KEMP **SITE CODE:** WLMP4

SITE NAME: WLMP4

DATE: 2 / 6 / 16 **TIME (24hrs):** [16.15] **PARTY:** CM & AM.

LATITUDE: 25.697888 **LONGITUDE:** 149.138650

EASTING: – **NORTHING:** – **Mobile Coverage:** Y / N

MAP NAME: – **MAP SCALE:** – **Sat. Phone Coverage:** Y / N

PHOTO #'s: Red camera **KEY NEEDED (Details) :**

COMMENTS: Small amount of Azolla. Water very clear.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	10.95	
Gauge Height (m)	–		DO (% sat)	120.5%	
Water Temperature (°C)	20.03		Turbidity (NTU)	5.48	
Conductivity (µS/cm)	295		Total Alkalinity (mg/L)	135	
pH	7.64		**Time Collected**	16.05	
Redox	119.7		TDS	0.212%	

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 90 m Min 50 m Mode 70 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details……

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details……

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details:…… Don't know – estimate 5 m. ……

Point Source Pollution 1. Yes 2. No 3. Don't Know Details……

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details… Cattle ……

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse…… Cattle grazing. ……

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other……

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) 710m 40%

Trees<10m 10 % cover *Shrubs/Vines/Rushes* 5 % cover *Grasses/Ferns/Herbs* 100 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME LILMP9													**DATE:** 2 / 6 / 16		
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)															
KEY HABITAT FEATURES	Edge														
Vel count															
Vel depth															
Vel m/sec															
Vel (average) (m/sec)	0														
Mean Sample Depth (m)	0.20														
Mean Wetted Width (m)	50														
% Bedrock	–														
% Boulder (>soccer ball)	–														
% Cobble (tennis ball - soccer ball)	–														
% Pebble (marble - tennis ball)	–														
% Gravel (2 - 4mm)	2														
% Sand (0.005 - 2mm)	3														
% Silt/Clay (< 0.005 mm)	95														
% Detritus (leaves/twigs)	80														
% Sticks (<2cm)	10														
% Branches	5														
% Logs (>15cm)	5														
% Algae	–														
% Macrophytes	–														
% Overhanging habitat (e.g. vegetation, roots)	5														
% Blanketing silt (indicated by plume)	60														
% Shading	5														
Sampled By:	PM														
Picked By:	–														

Comments:

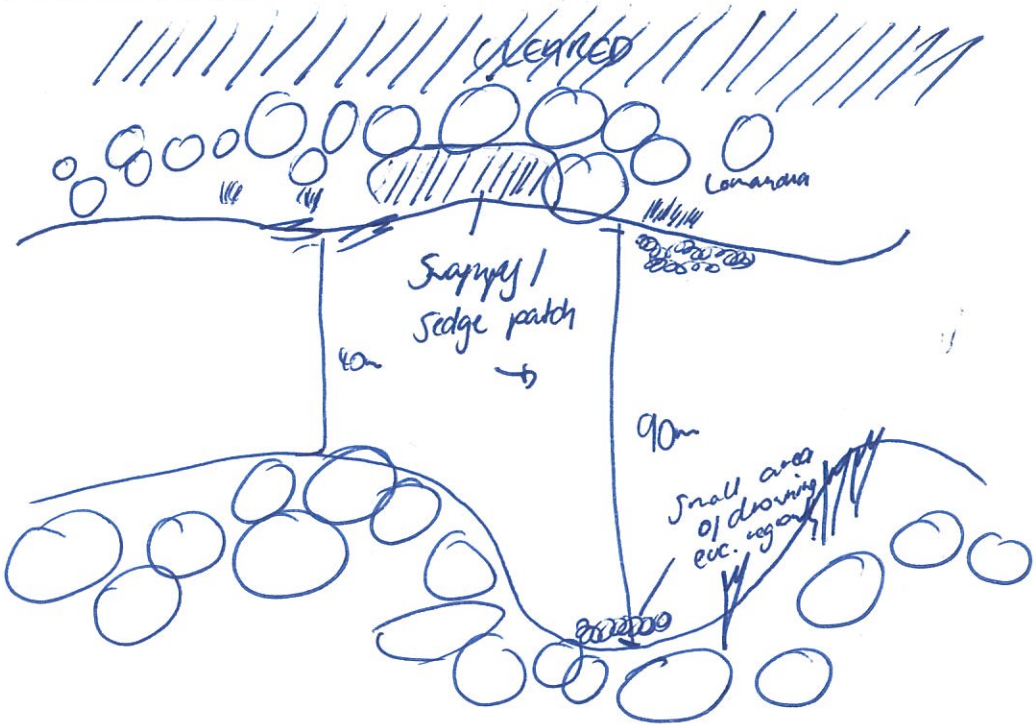
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME LEMP4 DATE: 2 / 6 / 16

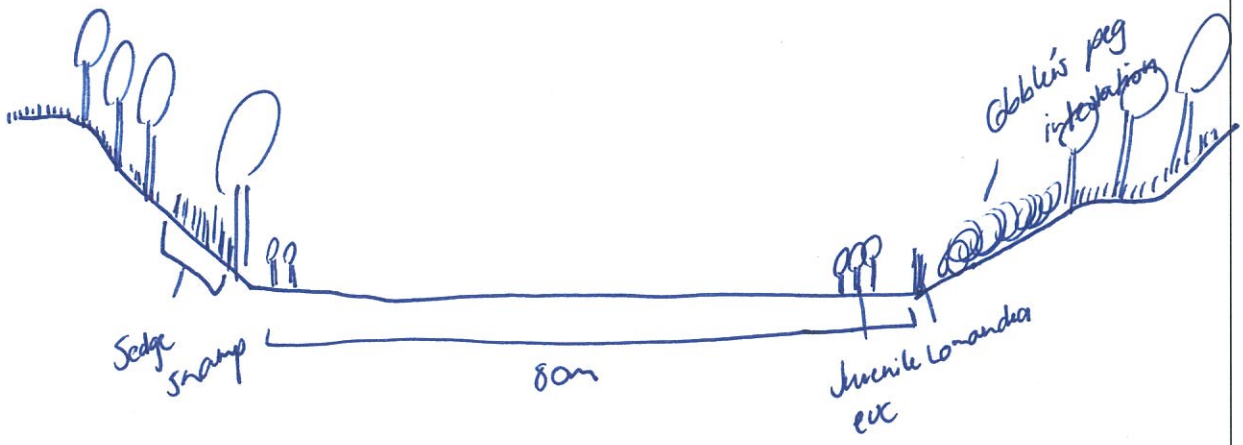
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

.....

.....

.....

REFERENCE CONDITION SELECTION SHEET

SITE CODE: WLMP4 **Date:** 6.2.16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious		
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction		
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation		
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged		
5. Dam/weir*	No artificial barriers in basin which will affect the site ?	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment		
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified		
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification		
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion		
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration		
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats		
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [W | L | M | P | 4 | |] **SITE NAME:** WLMP4

Date: 2 / 6 / 16 **Time (24 hrs):** [1 | 6 | 4 | 0] **GPS:** 25.697885, 149.138652 **Project Name:** San Los REMP

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.965 (LM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	75	0	12	1

Score 88

STATE OF THE RIVERS --- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 02/06/16 Recorder CM

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Basin	Sub-section	Site	Tributary Name
		WLMP 4	Dawson River

SITE CODE

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- [ ] Completely dry
- [x] Isolated pools, no flow
- [ ] Low Flow/ low level
- [ ] Moderate < water mark
- [ ] Normal at water mark
- [ ] High > water mark
- [ ] Flood > bankfull
- [ ] Within 1 hr of High Tide
- [ ] Within 1 hr of Low Tide
- [ ] Incoming/between Tide
- [ ] Out-going/between Tide

3 Channel Pattern

Not Determined [ ] 0

Map Scale		Local Scale
[ ] 1	Straight	[ ] 1
[ ] 2	Mildly sinuous	[ ] 2
[ ] 3	Irregular	[ ] 3
[ ] 4	Reg. Meanders	[ ] 4
[ ] 5	Irreg. Meanders	[ ] 5
[ ] 6	Tortuous	[x] 6
[ ] 7	Braided	[ ] 7
[ ] 8	Swampy	[ ] 8
[ ] 9	Channelised	[ ] 9
[ ] 10	Overland Flow	[ ] 10
[ ] 11		

4 Local Land Use

- [ ] 1 Sugar Cane
- [ ] 2 Horticulture small crops/ vines
- [ ] 3 Horticulture tree crops/ fruit
- [ ] 4 Irrigated broadacre row crops
- [ ] 5 Rainfed broadacre row crops
- [x] 6 Grazing - sown pasture
- [x] 7 Grazing -native --- cleared
- [x] 8 Grazing -native --- thinned
- [x] 9 Grazing -native --- virgin timber
- [ ] 10 Intensive Livestock-pig,fowl,cow
- [ ] 11 Urban residential
- [ ] 12 Urban manufact/ processing
- [ ] 13 Park or Reserve / National, envir
- [ ] 14 Urban Park or Reserve
- [ ] 15 Rural Residential / hobby farm
- [ ] 16 Other _____

5 Local Disturbance

- [ ] 1 Sand / gravel mine
- [ ] 2 Other mine
- [ ] 3 Road
- [ ] 4 Bridge / culvert / wharf
- [ ] 5 Ford / ramp
- [ ] 6 Discharge Pipe
- [ ] 7 Forestry activities
- [ ] 8 Sugar Mill
- [ ] 9 Sewerage Effluent
- [ ] 10 Irrig. runoff, pipe outlet
- [ ] 11 Channelisation
- [ ] 12 River improvement
- [ ] 13 Water Extraction
- [ ] 14 Dredging
- [x] 15 Grazing
- [ ] 16 Other _____

6 Record Present Vegetation in Local Vacinity

- [ ] 1 Rainforest
- [ ] 2 Eucalypt Wet Sclerophyl
- [ ] 3 Eucalypt Open Forest
- [ ] 4 Eucalypt woodland
- [x] 5 Eucalypt open woodland
- [ ] 6 Cypruss Pine forest
- [ ] 7 Belah/ Brigalow/ Gidgee
- [ ] 8 Mulga scrub-open forest
- [ ] 9 Mulga Shrubland
- [ ] 10 Bendee/lancewood scrub
- [ ] 11 Softwood Scrub
- [ ] 12 Melaleuca forest
- [x] 13 Grassland(isolated trees)
- [ ] 14 Other Shrubland
- [ ] 15 Heathland
- [ ] 16 Mangrove
- [ ] 17 Salt marsh / salt pans
- [ ] 18 Freshwater marsh
- [ ] 19 Pine plantation
- [ ] 20 Banana plantation
- [ ] 21 Sugar Cane
- [ ] 22 Other _____

7 Floodplain features

- [x] 1 Oxbows / billabongs
- [ ] 2 Remnant Channels
- [ ] 3 Floodplain scours
- [ ] 4 Floodplain deposits
- [ ] 5 Prominent flood channels

8 Local Land Tenure

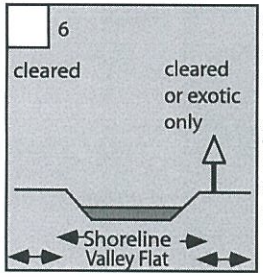
- [x] 1 Freehold/ leasehold
- [ ] 2 National Park
- [ ] 3 State Park
- [ ] 4 Reserve-timber,envir P
- [ ] 5 State Forest
- [ ] 6 Urban Reserve
- [ ] 7 Urban
- [ ] 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

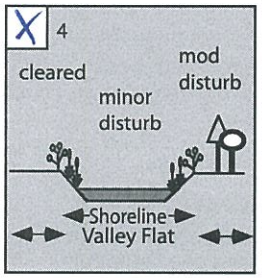


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[x] 4



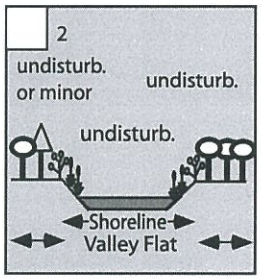
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

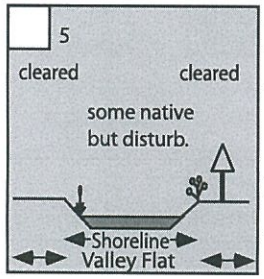


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[ ] 5

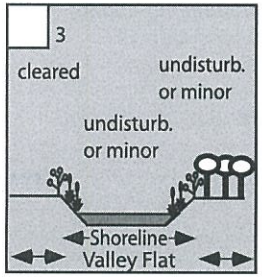


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[ ] 3

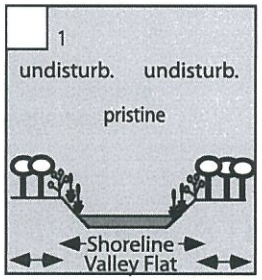


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

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Date (dd/mm/yy) 02/06/16

Recorder am

Basin | Sub-section | Site: WLMP4 (SITE CODE) | Tributary Name: Dawson River

1 Channel Habitat Types

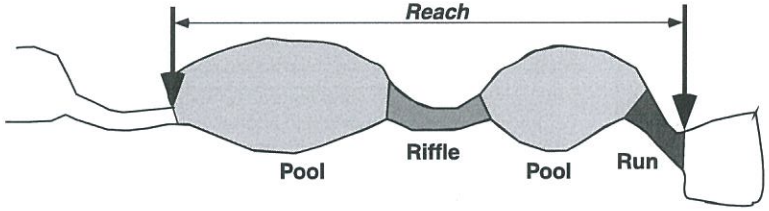
Habitat	Criteria	% of section	Est. Av. length (m)	Est. Av. height (m)	Est. Av. Gradient (deg.)	Est. Av. depth (m)	Est. Av. Width (m)
Waterfall	Height > 1m, Gradient > 60 deg						
Cascade	Step Height < 1m, Gradient 5 - 60 deg, Strong Currents						
Rapid	Depth > 0.3 m, Gradient 3 - 5 deg, Strong Currents, Rocks break surface						
Riffle	Depth 0.1 - 0.3 m, Gradient 1- 3 deg, Moderate Currents, Surface unbroken but unsmooth						
Glide	Depth < 0.1 m, Gradient 1- 3 deg, Small Currents, Surface unbroken and smooth						
Run	Depth > 0.3 m, Gradient 1- 3 deg, Small but distinct & uniform current, Surface unbroken						
Pool	Depth > 0.5 m where stream widens or deepens and current declines	80					
Backwater	Depth < 0.3m a reaonable size (>20% of channel width) cut-off section away from the channel	20					

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m) 100

3

Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

See KUSKIVAS assessment.

STATE OF THE RIVERS --- SHEET 6 Cross- Sections

Page __ of __

Date (dd/mm/yy) 1 / 6 / 16

Recorder OM

© 1992 J. Anderson

Basin | Sub-section | Site: WCMP4 SITE CODE | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.

Upper bank = water mark to inflexion point on the bank

1 TYPE

1 Pool
2 Riffle
3 Run
4 Glide
5 Cascade
6 Rapid
7 Backwater
8 Other _____

2 Length of Type (m)

Av. Width of Type (m)

Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		
salt 0.1mm	sugar grain 0.5mm		raw sugar 2mm	pea 5mm	10 cent coin 20mm	tennis ball 60 mm	Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

8 Left — Lower | Upper

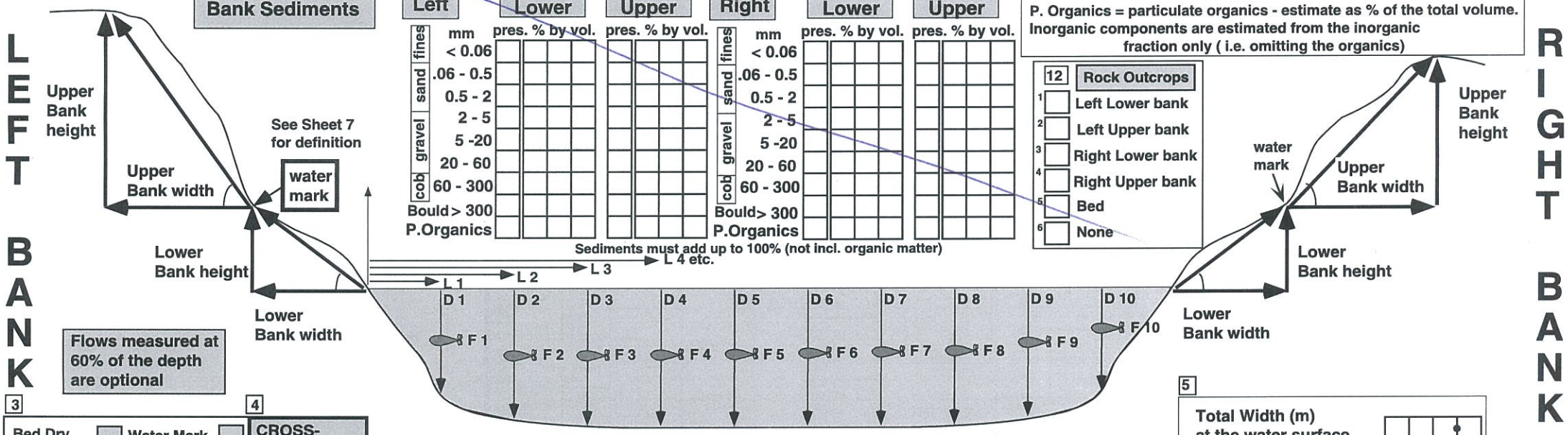
11 Right — Lower | Upper

	mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines	< 0.06				
sand	.06 - 0.5				
sand	0.5 - 2				
gravel	2 - 5				
gravel	5 -20				
gravel	20 - 60				
cob	60 - 300				
Bould	> 300				
P.Organics					

Sediments must add up to 100% (not incl. organic matter)

12 Rock Outcrops

1 Left Lower bank
2 Left Upper bank
3 Right Lower bank
4 Right Upper bank
5 Bed
6 None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark ☐ Water Mark covered -no lower bank ☐

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

	mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines	< 0.06								
sand	.06 - 0.5								
sand	0.5 - 2								
gravel	2 - 5								
gravel	5 -20								
gravel	20 - 60								
cob	60 - 300								
Bould	> 300								
P.Organics (out of 100%)									

6 LEFT LOWER BANK

Width (m) 10
Height (m) 2
Slope (deg.) 25

7 LEFT UPPER BANK

Width (m) 5
Height (m) 1.5
Slope (deg.) 30

9 RIGHT LOWER BANK

Width (m) 80
Height (m) 4
Slope (deg.) 30

10 RIGHT UPPER BANK

Width (m)
Height (m)
Slope (deg.)

STATE OF THE RIVERS --- SHEET 7 BankCondition

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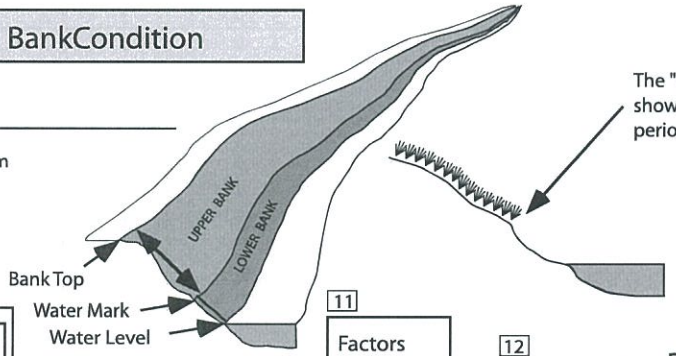
Date (dd/mm/yy) 02/06/16 Recorder OM

Basin | Sub-section | Site | Tributary Name

SITE CODE

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

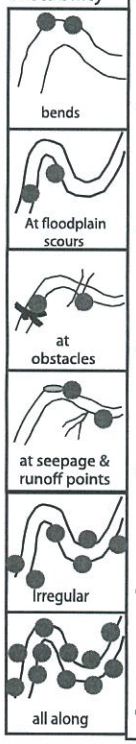
1 Natural
2 Man-made
3 Absent

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg 0

NOTE: The 4 % figures below must = 100%

Stable 100

Eroding | Aggrading | Slumping | where | where

2 UPPER BANK

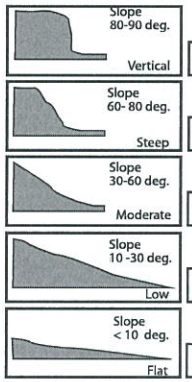
Bare of Veg 0

NOTE: The 4 % figures below must = 100%

Stable 100

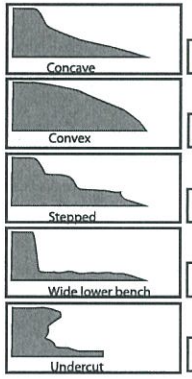
Eroding | Aggrading | Slumping | where | where

3 LEFT BANK Slope (RANK types)



1 2 3 4 X 5

4 LEFT BANK Shape (RANK types)



X 1 X 2 3 4 5

11 Factors Affecting Stability

Flow & Waves		1
Seepage		2
Runoff	X	3
Floodplain Scours		4
Stock	X	5
People tracks		6
Vermin, Ferals		7
Ford, road culvert, bridge, Weir		8
Clearing of Vegetation	X	9
Gravel/sand extraction		10
Mining		11
Other ____		

** RANKS **

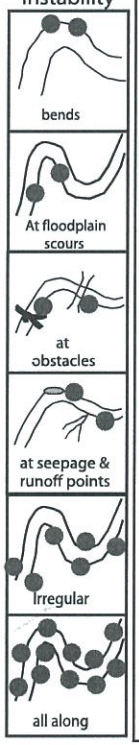
12 Artificial Bank Protection Measures

Trees & Other Plants		1
Rock wall or layer		2
Fence Structures		3
Fenced watering points		4
Fenced human access		5
Logs strapped to bank		6
Concrete Wall		7
Break-water		8
Other ____		9
Other ____		10
None	X	11

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg 0

NOTE: The 4 % figures below must = 100%

Stable

Eroding | Aggrading | Slumping | where | where

7 UPPER BANK

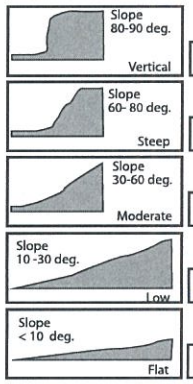
Bare of Veg 0

NOTE: The 4 % figures below must = 100%

Stable

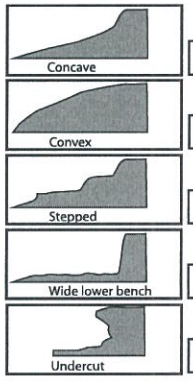
Eroding | Aggrading | Slumping | where | where

8 RIGHT BANK Slope (RANK types)



1 2 3 X 4 5

9 RIGHT BANK Shape (RANK types)



X 1 2 3 4 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability				X
Susceptibility to erosion	1	2	3	X 4

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability				X
Susceptibility to erosion	1	2	3	X 4

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Basin | Sub-section | Site | Tributary Name: Dawson K.

SITE CODE

Date (dd/mm/yy) 2 / 6 / 16 Recorder: CM

© 1992 J. Anderson

Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted < 0.1 m deep & narrow	2
3	Moderately Restricted < 0.3 m deep & narrow	3
4	Partly Restricted 0.5 m deep & narrow	4
5	Good Passage 0.5 -1 m deep wide no torrent	5
X 6	Unrestricted > 1 m deep & almost channel wide	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall	m	1	2	3	4	5	6	7
Cascade rapid or log jam	m	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge	m	1	2	3	4	5	6	7
Single log branch pile, rock	m	1	2	3	4	5	6	7
Low feature easily by-passed	m	1	2	3	4	5	6	7
None	m	1	2	3	4	5	6	7
Other	m	1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable X 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 12/6/96 Recorder [illegible]

22.9.94 D.Telfer

Basin | Sub-section | Site WLMP 4 (SITE CODE) | Tributary Name Dawson

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- Width of Existing Vegetation (m) (riparian & non riparian vegetation): 5
- Width of Riparian Vegetation (m): 5
- % Bare - no vegetation: 60

Vegetation Cover of the Riparian Zone -*overlaps allowed*
record presence for rare types % cover for abundant sp.

3 Type	% Cover	% Exotic spp.
Trees > 30 m	10	
Trees 10 - 30 m	5	
Trees < 10 m	10	
Woody Shrubs (> 2m)	15	
Woody Shrubs (< 2m)	25	
Vines		
Rushes & Sedges	10	
Herbs/Forbs (NOT WOODY)	60	
Grasses	40	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

4 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes [ ] 1 No [ ] 2

5	rare 1	common 2		rare 1	common 2
Rainforest			Lantana		
Eucalyptus spp.		X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 [X]
- Disturbed & non-grass species extend only to the bank top 2 [ ]
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 [ ]
- Thinned, semi-natural in cover and width 4 [ ]
- Virtually natural cover & width 5 [ ]

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 [ ]
- Disturbed & non-grass species extend only to the bank top 2 [X]
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 [ ]
- Thinned, semi-natural in cover and width 4 [ ]
- Virtually natural cover & width 5 [ ]

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- Width of Existing Vegetation (m) (riparian & non riparian vegetation): 20
- Width of Riparian Vegetation (m): 10 [illegible]
- % Bare - no vegetation: 2

Vegetation Cover of the Riparian Zone -*overlaps allowed*
record presence for rare types % cover for abundant sp.

8 Type	% Cover	% Exotic spp.
Trees > 30 m	10	
Trees 10 - 30 m	10	
Trees < 10 m	5	
Woody Shrubs (> 2m)	5	
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges	5	
Herbs/Forbs (NOT WOODY)		
Grasses	40	
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes [ ] 1 No [ ] 2

10	rare 1	common 2		rare 1	common 2
Rainforest			Lantana		
Eucalyptus spp.		X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)	X		Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

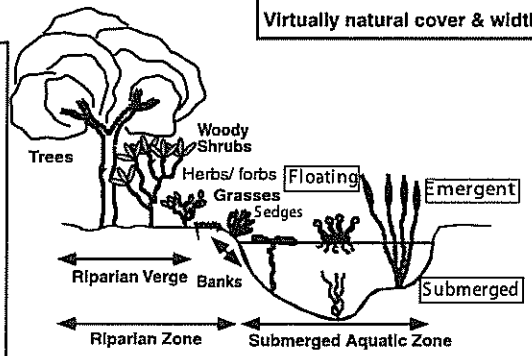
Visible depth (m)	1
Too turbid - pres only	
% Bare - no vegetation	100
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other _____	



Other species identified L= left R= right

	rare 1	common 2
Gomphrena		
Buffel Grass		X
Rhodes grass		
Red natal grass		

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

FIELD SHEETS

PROJECT NAME: Santos . Remp **SITE CODE:** WLMPS

SITE NAME: WLMPS

DATE: 31 / 5 / 16 **TIME (24hrs): [** 13.20 **]** **PARTY:** CM & AM

LATITUDE: 25.701627 **LONGITUDE:** 149.153589

EASTING: _____ **NORTHING:** _____ **Mobile Coverage:** Y / N

MAP NAME: _____ **MAP SCALE:** _____ **Sat. Phone Coverage:** Y / N

PHOTO #'s: See red camera **KEY NEEDED (Details) :** —

COMMENTS: Waterbirds - swans, WF heron, grebes, cormorants

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.3		DO (mg/L)	6.47	
Gauge Height (m)	—		DO (% sat)	66.2	
Water Temperature (°C)	17.27		Turbidity (NTU)	14.7	
Conductivity (µS/cm)	~~100~~ 139		Total Alkalinity (mg/L)	100	
pH	7.34		**Time Collected**	15.20	
TDS	0.106		Redox	145.1	

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 80 m Min 20 m Mode 80 m

Water Level 1. No Flow 2.Dry/Isolated 3. <Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details……

Bank Erosion 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details……

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: Inputs from CSG.

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.. Cleared land on right bank with no cover

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details.... Cattle

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse Cattle grazing & cropping?

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other……

Riparian Zone (zone extends for 100m upstream and downstream from sampled area) >10m 60 %

Trees<10m 20 % cover *Shrubs/Vines/Rushes* 20 % cover *Grasses/Ferns/Herbs* 80 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME WLMP5															DATE: 31 / 5 / 06
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)															
KEY HABITAT FEATURES	Edge														
Vel count	0														
Vel depth		0.15													
Vel m/sec		0													
Vel (average) (m/sec)	–														
Mean Sample Depth (m)	0.15														
Mean Wetted Width (m)	60m														
% Bedrock	–														
% Boulder (>soccer ball)	–														
% Cobble (tennis ball - soccer ball)	–														
% Pebble (marble - tennis ball)	–														
% Gravel (2 - 4mm)	5														
% Sand (0.005 - 2mm)	15														
% Silt/Clay (< 0.005 mm)	85														
% Detritus (leaves/twigs)	85														
% Sticks (<2cm)	10														
% Branches	5														
% Logs (>15cm)	–														
% Algae	–														
% Macrophytes	–														
% Overhanging habitat (e.g. vegetation, roots)	10														
% Blanketing silt (indicated by plume)	60														
% Shading	5														
Sampled By:	AM														
Picked By:															

Comments:

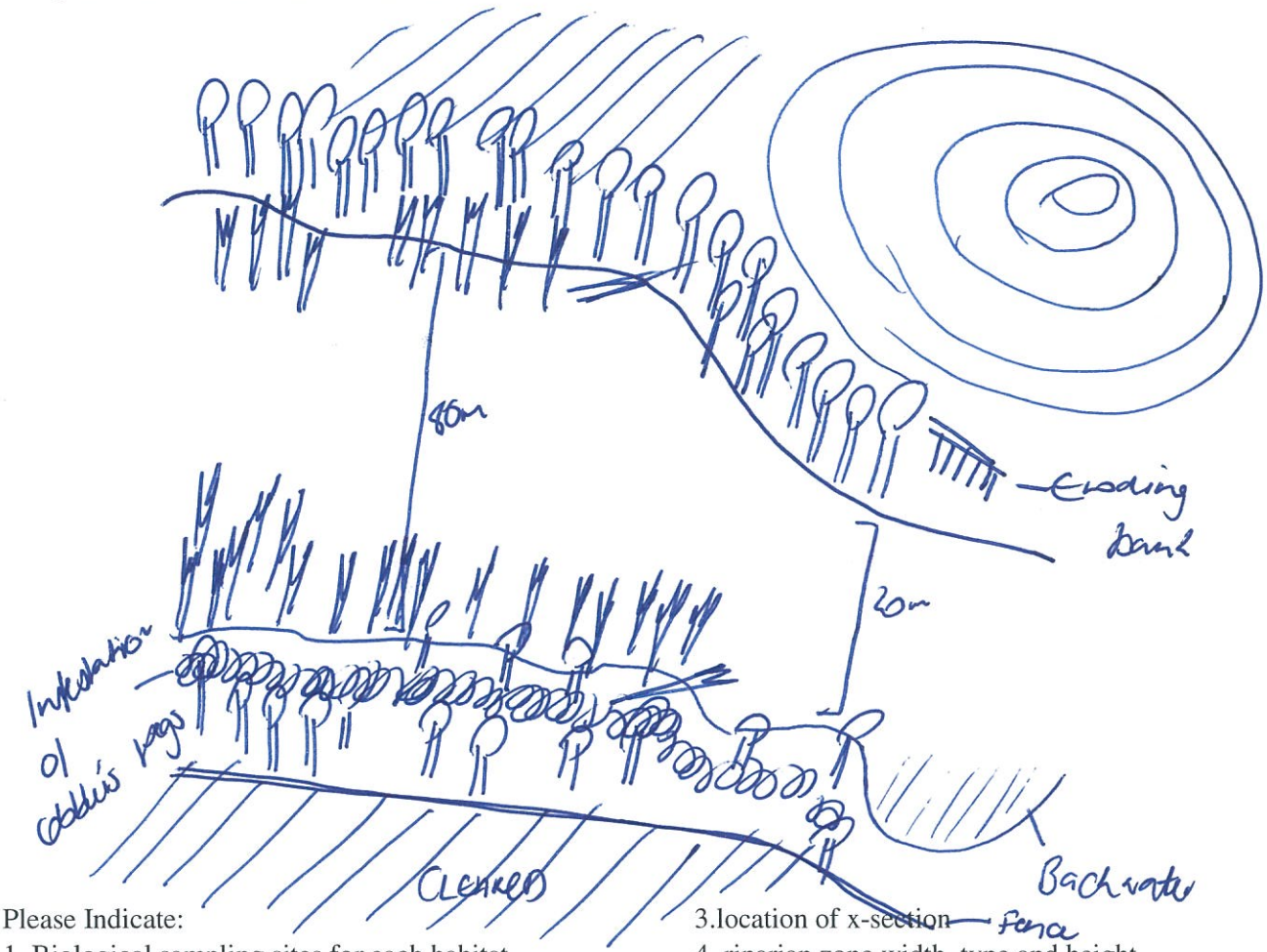
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME WLMP35 **DATE:** 2 / 6 / 16

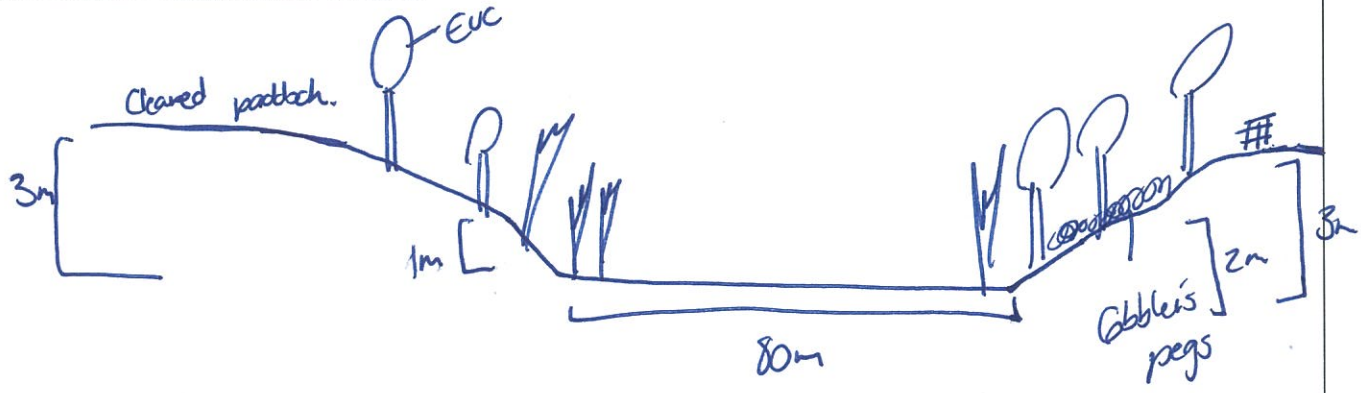
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

.....

.....

.....

REFERENCE CONDITION SELECTION SHEET

SITE CODE: WLMP5 **Date:** 2.6.16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious		
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction		
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation		
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged		
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment		
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified		
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification		
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion		
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration		
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats		
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [W|L|M|P|5| |] **SITE NAME:** WLMP5

Date: 2 / 6 / 16 **Time (24 hrs):** [| | |] **GPS:** 25.701627, 149.159589 **Project Name:** Santos Kemp

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (LM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score

○ ○ ○ ○

STATE OF THE RIVERS --- SHEET 4 Reach Envions -temporal & spatial

Date (dd/mm/yy) 31/05/16 Recorder CM

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Basin | Sub-section | Site | Tributary Name

SITE CODE: W L M P 5 — Dawson River

Record information about the local land adjacent to the reach on each side and about the conditions prevailing at the time of the sampling. The assessment should be restricted to the immediate vicinity of the reach-- i.e. not beyond the land bordering the riparian zone

1 Water Level at sampling time

- [ ] Completely dry
- [ ] Isolated pools, no flow
- [ ] Low Flow/ low level
- [ ] Moderate < water mark
- [ ] Normal at water mark
- [x] High > water mark
- [ ] Flood > bankfull
- [ ] Within 1 hr of High Tide
- [ ] Within 1 hr of Low Tide
- [ ] Incoming/between Tide
- [ ] Out-going/between Tide

3 Channel Pattern

	Map Scale	Local Scale
	Not Determined	
1	Straight	
2	Mildly sinuous	
3	Irregular	
4	Reg. Meanders	x
5	Irreg. Meanders	
6	Tortuous	x
7	Braided	
8	Swampy	
9	Channelised	
10	Overland Flow	

4 Local Land Use

- [ ] 1 Sugar Cane
- [ ] 2 Horticulture small crops/ vines
- [ ] 3 Horticulture tree crops/ fruit
- [ ] 4 Irrigated broadacre row crops
- [ ] 5 Rainfed broadacre row crops
- [x] 6 Grazing - sown pasture
- [x] 7 Grazing -native --- cleared
- [x] 8 Grazing -native --- thinned
- [ ] 9 Grazing -native --- virgin timber
- [ ] 10 Intensive Livestock-pig,fowl,cow
- [ ] 11 Urban residential
- [ ] 12 Urban manufact/ processing
- [ ] 13 Park or Reserve / National, envir
- [ ] 14 Urban Park or Reserve
- [ ] 15 Rural Residential / hobby farm
- [ ] 16 Other _____

5 Local Disturbance

- [ ] 1 Sand / gravel mine
- [ ] 2 Other mine
- [ ] 3 Road
- [ ] 4 Bridge / culvert / wharf
- [ ] 5 Ford / ramp
- [x] 6 Discharge Pipe
- [ ] 7 Forestry activities
- [ ] 8 Sugar Mill
- [ ] 9 Sewerage Effluent
- [ ] 10 Irrig. runoff, pipe outlet
- [ ] 11 Channelisation
- [ ] 12 River improvement
- [ ] 13 Water Extraction
- [ ] 14 Dredging
- [x] 15 Grazing
- [ ] 16 Other _____

6 Record Present Vegetation in Local Vacinity

- [ ] 1 Rainforest
- [ ] 2 Eucalypt Wet Sclerophyl
- [ ] 3 Eucalypt Open Forest
- [x] 4 Eucalypt woodland
- [x] 5 Eucalypt open woodland
- [x] 6 Cypruss Pine forest
- [ ] 7 Belah/ Brigalow/ Gidgee
- [ ] 8 Mulga scrub-open forest
- [ ] 9 Mulga Shrubland
- [ ] 10 Bendee/lancewood scrub
- [ ] 11 Softwood Scrub
- [ ] 12 Melaleuca forest
- [x] 13 Grassland(isolated trees)
- [ ] 14 Other Shrubland
- [ ] 15 Heathland
- [ ] 16 Mangrove
- [ ] 17 Salt marsh / salt pans
- [ ] 18 Freshwater marsh
- [ ] 19 Pine plantation
- [ ] 20 Banana plantation
- [ ] 21 Sugar Cane
- [ ] 22 Other _____

7 Floodplain features

- [x] 1 Oxbows / billabongs
- [ ] 2 Remnant Channels
- [ ] 3 Floodplain scours
- [x] 4 Floodplain deposits
- [ ] 5 Prominent flood channels

8 Local Land Tenure

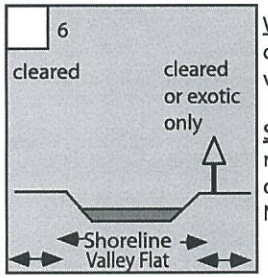
- [x] 1 Freehold/ leasehold
- [ ] 2 National Park
- [ ] 3 State Park
- [ ] 4 Reserve-timber,envir P
- [ ] 5 State Forest
- [ ] 6 Urban Reserve
- [ ] 7 Urban
- [ ] 8 Other / Unknown

9 OVERALL DISTURBANCE RATING

Tick one box for the overall rating

EXTREME DISTURBANCE

[ ] 6

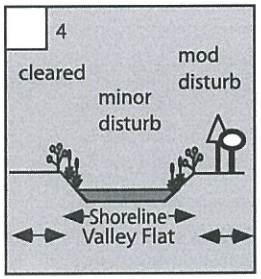


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines etc.)

Shoreline Vegetation - Absent or severely reduced. Vegetation present is extremely disturbed - i.e. dominated by exotic species. Native species rare or completely absent.

HIGH DISTURBANCE

[ ] 4



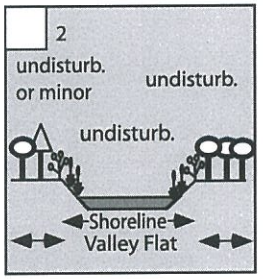
Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other clearly disturbed or with a high percentage of introduced species present.

Shoreline Vegetation - Bank vegetation moderately disturbed by stock or through the intrusion of introduced species, though native species remain.

Note: Sites with valley flat vegetaion cleared BOTH sides, but with shoreline vegetation in good condition, for example when it is fenced off, should be included in this category.

LOW DISTURBANCE

[ ] 2

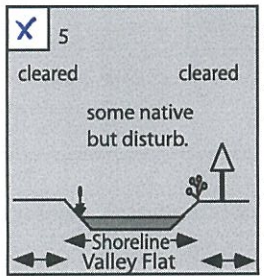


Valley Flat Vegetation - Native vegetation present on BOTH sides of the river with a virtually intact canopy. Minor disturbances present through introduced species.

Shoreline Vegetation - Native vegetation on BOTH sides of the river is generally in good condition with few introduced species present. Any disturbance is minor.

VERY HIGH DISTURBANCE

[x] 5

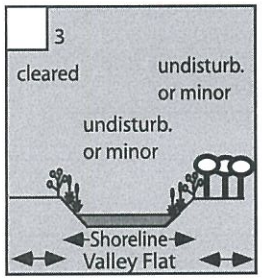


Valley Flat Vegetation - Agriculture and/or cleared land BOTH sides. Plants present are virtually all exotic species (willows, pines, etc.).

Shoreline Vegetation - Some native vegetation present, but it is severely modified BOTH sides by grazing or the intrusion of introduced species. Native species severely reduced in numbers and cover.

MODERATE DISTURBANCE

[ ] 3

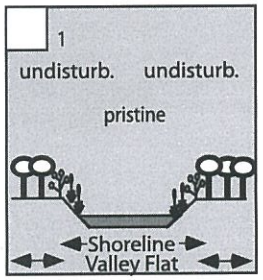


Valley Flat Vegetation - Agricultural land and/or cleared on ONE side; native vegetation on the other in reasonably undisturbed state.

Shoreline Vegetation - Native vegetation on BOTH sides with canopy intact or with native species widespread and common in the shoreline zone. The intrusion of introduced species is minor and of moderate impact.

V. LOW DISTURBANCE

[ ] 1



Valley Flat Vegetation - Native vegetation present on both sides of the river with an intact canopy. Introduced species are absent or insignificant. No evidence of outside interference. Representative of natural vegetation in excellent condition.

Shoreline Vegetation - Native vegetation on both sides of the river in an undisturbed state. Introduced species are rare or insignificant. Representative of natural vegetation in excellent condition.

STATE OF THE RIVERS --- SHEET 5 Channel Habitat

© 1992 J. Anderson

Date (dd/mm/yy) 31/05/16

Recorder CM

Basin | Sub-section | Site: WLMP5 (SITE CODE) | Tributary Name: Dawson R.

1 Channel Habitat Types

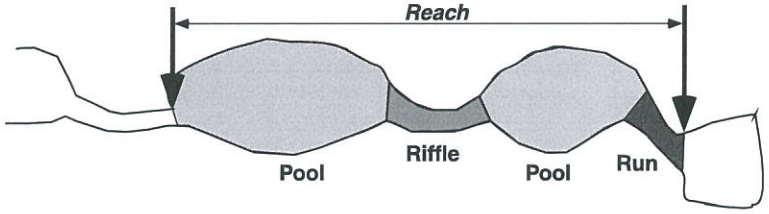
Waterfall	Height > 1m Gradient > 60 deg	% of section Est. Av. length (m) Est. Av. height (m) Est. Av. Gradient (deg.)
Cascade	Step Height < 1m Gradient 5 - 60 deg Strong Currents	% of section Est. Av. length (m) Est. Av. height (m) Est. Av. Gradient (deg.)
Rapid	Depth > 0.3 m Gradient 3 - 5 deg Strong Currents Rocks break surface	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Riffle	Depth 0.1 - 0.3 m Gradient 1- 3 deg Moderate Currents Surface unbroken but unsmooth	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Glide	Depth < 0.1 m Gradient 1- 3 deg Small Currents Surface unbroken and smooth	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)
Run	Depth > 0.3 m Gradient 1- 3 deg Small but distinct & uniform current Surface unbroken	% of section: 10 Est. Av. length (m): 10 Est. Av. depth (m) Est. Av. Width (m)
Pool	Depth > 0.5 m where stream widens or deepens and current declines	% of section: 90 Est. Av. length (m): >90 Est. Av. depth (m) Est. Av. Width (m)
Backwater	Depth < 0.3m a reaonable size (>20% of channel width) cut-off section away from the channel	% of section Est. Av. length (m) Est. Av. depth (m) Est. Av. Width (m)

Selecting a Reach

Choose an appropriate *Reach* for the remaining assessment. It should:-

1. Preferably contains at least 2 complete pools and riffle / run habitats
2. The whole length of the reach should be visible at one location.
3. The pool should be the largest and deepest in the area.

Sketch the reach showing the location and dimensions of the major habitat types. Measure the length width of each channel habitat type and take a transect across each type located at right angles to the shoreline and passing over the point of maximum depth in a pool (low flow area) and maximum flow / bed height for a run or riffle habitat i.e. the transect where flows would be expected to be maximal.



REACH DETAILS

2 Total Length of reach (m) 100

3

Sketch the reach showing the channel pattern and the distribution of channel habitat types and key features. A cross-section profile showing the bank shape and vegetation types would also be helpful if there is time

See RUSRIVAS fieldsheets.

STATE OF THE RIVERS --- SHEET 6 Cross- Sections

Page __ of __

Date (dd/mm/yy) 31/05/16

Recorder CM

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Basin | Sub-section | Site WLMP 5 SITE CODE | Section Number for This reach

One or more cross-sections (separate sheets) are required for each channel habitat type within the reach. Begin at the water's margin on the left bank and take a series of distance and depth measurements. A minimum of 3 measurements is required for each cross-section including the width of stream. Also measure the width, height and slope for the left and right banks.

Lower bank = surface to water mark. If bed dry measure depth at water mark level.
Upper bank = water mark to inflexion point on the bank

1 TYPE

Pool	X	1
Riffle		2
Run	X	3
Glide		4
Cascade		5
Rapid		6
Backwater		7
Other ____		8

2 Length of Type (m) | Av. Width of Type (m) | Av. Depth of Type (m)

Sediment Classification

Sediment classes are those of the SAA which are easier to estimate visually - estimate % of total inorganic volume occupied by each catgeory. Estimate organics as % of total vol. Record presence of each type (esp. max. and min. sizes) and % vols for major fractions.

Fines	Sand		Gravel			Cobbles	Boulder+Rock
	fine	medium	fine	medium	course		

salt 0.1mm; sugar grain 0.5mm; raw sugar 2mm; pea 5mm; 10 cent coin 20mm; tennis ball 60 mm; Head 300 mm

P. Organics = particulate organics - estimate as % of the total volume. Inorganic components are estimated from the inorganic fraction only (i.e. omitting the organics)

Bank Sediments

8

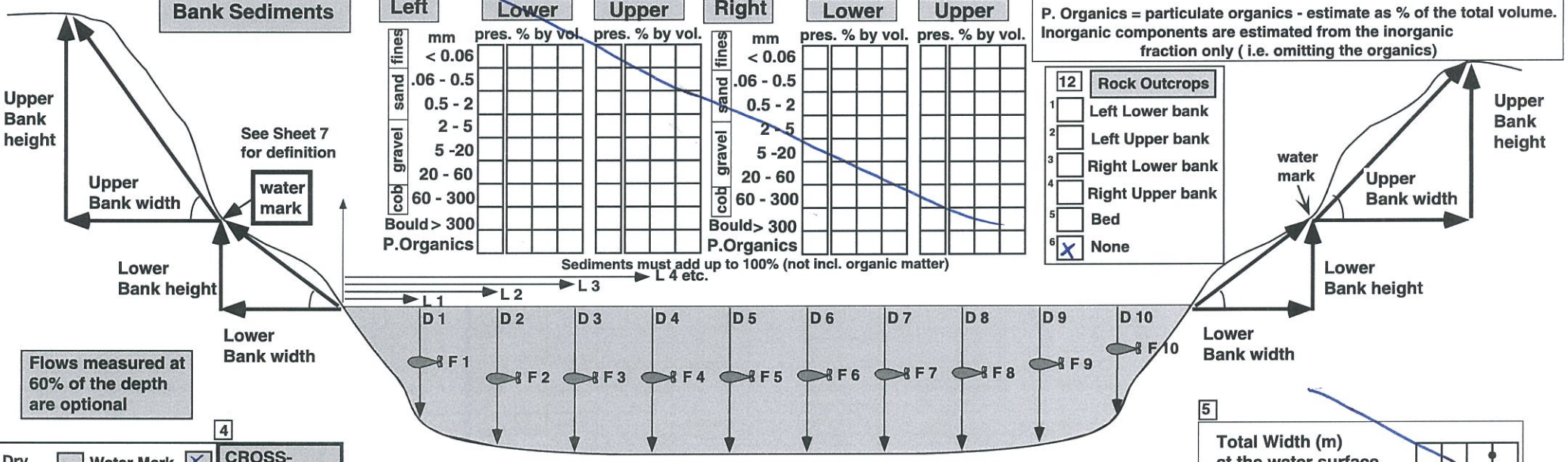
mm	Left Lower pres. % by vol.	Left Upper pres. % by vol.	Right Lower pres. % by vol.	Right Upper pres. % by vol.
fines < 0.06				
sand .06 - 0.5				
0.5 - 2				
2 - 5				
gravel 5 -20				
20 - 60				
cob 60 - 300				
Bould> 300				
P.Organics				

Sediments must add up to 100% (not incl. organic matter)

11

12 Rock Outcrops

1. [ ] Left Lower bank
2. [ ] Left Upper bank
3. [ ] Right Lower bank
4. [ ] Right Upper bank
5. [ ] Bed
6. [X] None



Flows measured at 60% of the depth are optional

3 Bed Dry - Depths @ water mark | Water Mark covered -no lower bank [X]

4 CROSS-SECTION AT SURFACE

Cross- section readings across the bed (minimum of 3, maximum 15)

5 Total Width (m) at the water surface or where transect taken

	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8
Dist (m)								
Depth (m)								

Page No. for Extra Readings

Sediments must add up to 100% (not incl. organic matter)

mm	Reading 1 pres. % by vol.	Reading 2 pres. % by vol.	Reading 3 pres. % by vol.	Reading 4 pres. % by vol.	Reading 5 pres. % by vol.	Reading 6 pres. % by vol.	Reading 7 pres. % by vol.	Reading 8 pres. % by vol.
fines < 0.06								
sand .06 - 0.5								
0.5 - 2								
2 - 5								
gravel 5 -20								
20 - 60								
cob 60 - 300								
Bould> 300								
P.Organics (out of 100%)								

6 LEFT LOWER BANK

Width (m)	0.5
Height (m)	0.2
Slope (deg.)	20

7 LEFT UPPER BANK

Width (m)	5.0
Height (m)	4.0
Slope (deg.)	50

9 RIGHT LOWER BANK

Width (m)	8.0
Height (m)	0.4
Slope (deg.)	

10 RIGHT UPPER BANK

Width (m)	10.
Height (m)	1.0
Slope (deg.)	10

STATE OF THE RIVERS --- SHEET 7 BankCondition

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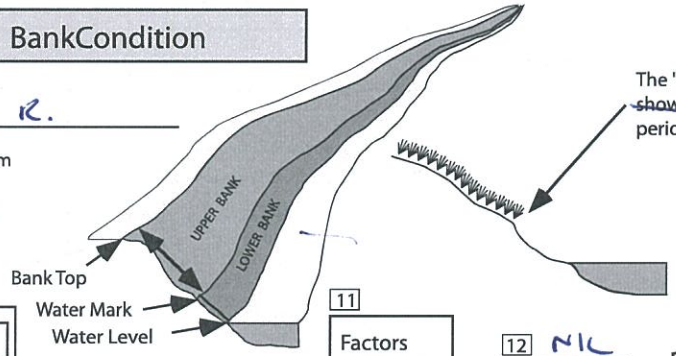
Date (dd/mm/yy) 31/05/16 Recorder CM

Basin | Sub-section | Site (SITE CODE) H L M P S | Tributary Name Dawson R.

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width
1 Natural				
2 Man-made				
3 Absent				

LEFT BANK

Record % of bank length

LOCATION for Instability

1 LOWER BANK — Bare of Veg 40

NOTE: The 4 % figures below must = 100%

Stable 90 | Eroding 10 | Aggrading | Slumping

2 UPPER BANK — Bare of Veg 12

NOTE: The 4 % figures below must = 100%

Stable 88 | Eroding 12 | Aggrading | Slumping

	1 LOWER BANK	2 UPPER BANK
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		X
Irregular	X	
all along		

3 LEFT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60-80 deg. Steep	2
Slope 30-60 deg. Moderate	3
Slope 10-30 deg. Low	X 4
Slope < 10 deg. Flat	5

4 LEFT BANK Shape (RANK types)

Concave	X 1
Convex	2
Stepped	3
Wide lower bench	4
Undercut	5

11 Factors Affecting Stability — ** RANKS **

Flow & Waves	1
Seepage	2
Runoff	X 3
Floodplain Scours	X 4
Stock	X 5
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8
Clearing of Vegetation	X 9
Gravel/sand extraction	10
Mining	11
Other	

12 NIL Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other	9
Other	10
None	11

RIGHT BANK

Record % of bank length

LOCATION for Instability

6 LOWER BANK — Bare of Veg 40

NOTE: The 4 % figures below must = 100%

Stable 100 | Eroding | Aggrading | Slumping

7 UPPER BANK — Bare of Veg 0

NOTE: The 4 % figures below must = 100%

Stable 100 | Eroding | Aggrading | Slumping

	6 LOWER BANK	7 UPPER BANK
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		

8 RIGHT BANK Slope (RANK types)

Slope 80-90 deg. Vertical	1
Slope 60-80 deg. Steep	2
Slope 30-60 deg. Moderate	3
Slope 10-30 deg. Low	4
Slope < 10 deg. Flat	X 5

9 RIGHT BANK Shape (RANK types)

Concave	1
Convex	X 2
Stepped	3
Wide lower bench	4
Undercut	5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability			X	
Susceptibility to erosion (1 2 3 4)		X		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability				X
Susceptibility to erosion (1 2 3 4)			X	

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

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Basin | Sub-section | Site: WLMP 5 | Tributary Name: Dawson R.

SITE CODE

Date (dd/mm/yy): 31/05/16 | Recorder: CM

Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent [X]
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:
(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1 [X]
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion [X]
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted: < 0.1 m deep & narrow	2
3	Moderately Restricted: < 0.3 m deep & narrow	3
4	Partly Restricted: < 0.5 m deep & narrow	4
5	Good Passage: 0.5 -1 m deep wide no torrent	5
6 [X]	Unrestricted: > 1 m deep & almost channel wide	6 [X]

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall	m						
Cascade rapid or log jam	m						
Low weir, pipe culvert, ford, bridge	m						
Single log branch pile, rock	m						
Low feature easily by-passed	m						
None [X]							
Other	m						

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3 [X]	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

22.9.94
D.Telfer

Date (dd/mm/yy) 31/05/16

Recorder CM

Basin | Sub-section | Site (SITE CODE) WLMP5

Tributary Name Dawson R.

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

7 200	Width of Existing Vegetation (m) (riparian & non riparian vegetation)
40	Width of Riparian Vegetation (m)
10	% Bare - no vegetation

Vegetation Cover of the Riparian Zone *-overlaps allowed record presence for rare types % cover for abundant sp.*

3 Type	% Cover	% Exotic spp.
Trees > 30 m	60	
Trees 10 - 30 m	5	
Trees < 10 m	10	
Woody Shrubs (> 2m)	5	
Woody Shrubs (< 2m)	5	
Vines		
Rushes & Sedges	10	
Herbs/Forbs (NOT WOODY)	60	100
20 Grasses	40	50
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

4 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No 1 ☒ 2

5	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

Highly disturbed, distinct boundary on vegetation edge Width less than bank width	1 ☒
Disturbed & non-grass species extend only to the bank top	2 ☐
Disturbed & non-grass species extend partially into the original zone (floodplain)	3 ☐
Thinned, semi-natural in cover and width	4 ☐
Virtually natural cover & width	5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

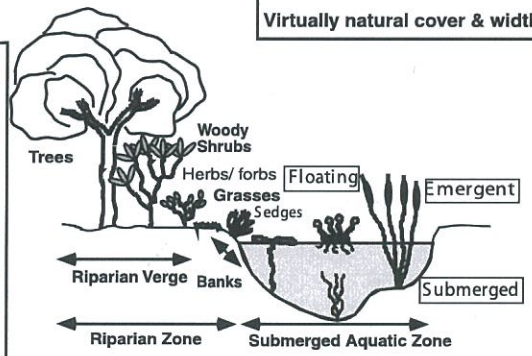
Visible depth (m)	1
Too turbid - pres only	
% Bare - no vegetation	100
Tot.% Exotic spp.	

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other ___	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other ___	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2 ☒
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None	☐	☐
Major	☐	☐
Minor	☒	☒

15 Emergent Veg.

	% Submerged lands
Total emergents	
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 ___	
Local Sp. 2 ___	
Local Sp. 3 ___	
Local Sp. 4 ___	

7 Right Bank Scaling Factor

Highly disturbed, distinct boundary on vegetation edge Width less than bank width	1 ☐
Disturbed & non-grass species extend only to the bank top	2 ☒
Disturbed & non-grass species extend partially into the original zone (floodplain)	3 ☐
Thinned, semi-natural in cover and width	4 ☐
Virtually natural cover & width	5 ☐

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

20	Width of Existing Vegetation (m) (riparian & non riparian vegetation)
12	Width of Riparian Vegetation (m)
5	% Bare - no vegetation

Vegetation Cover of the Riparian Zone *-overlaps allowed record presence for rare types % cover for abundant sp.*

8 Type	% Cover	% Exotic spp.
Trees > 30 m	60	
Trees 10 - 30 m	10	
Trees < 10 m	5	
Woody Shrubs (> 2m)		
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses		
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No 1 ☒ 2

10	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)		X	Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

FIELD SHEETS

PROJECT NAME: SANTOS PFE WET 16 **SITE CODE:** WLMP1

SITE NAME: WLMP1

DATE: 16 / 11 / 16 **TIME (24hrs): [** 1020 **]** **PARTY:** TS / AM

LATITUDE: _____ **LONGITUDE:** _____

EASTING: _____ **NORTHING:** _____ **Mobile Coverage: Y / N**

MAP NAME: _____ **MAP SCALE:** _____ **Sat. Phone Coverage: Y / N**

PHOTO #'s: 106-0680 – 106-[redacted] 0705 **KEY NEEDED (Details) :** N

COMMENTS: _____

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.15		DO (mg/L)	4.67	
Gauge Height (m)			DO (% sat)	60.8	
Water Temperature (°C)	28.68		Turbidity (NTU)	35.8	
Conductivity (µS/cm)	154		Total Alkalinity (mg/L)	<50	
pH	7.70		**Time Collected**	1025	

ORP - 41

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S
5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 70 m Min 50 m Mode 60 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know
Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive
Hydrological Variation details:.....

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....R.I.O. Plant

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....Cattle.....

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse..Cattle.....

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 70 % cover *Shrubs/Vines/Rushes* 80 % cover *Grasses/Ferns/Herbs* 90 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME_____ DATE: ____/____/____					
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.1				
Mean Wetted Width (m)	60m				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	0				
% Silt/Clay (< 0.005 mm)	100				
% Detritus (leaves/twigs)	100				
% Sticks (<2cm)	80				
% Branches	0				
% Logs (>15cm)	10				
% Algae	35				
% Macrophytes	90				
% Overhanging habitat (e.g. vegetation, roots)	0				
% Blanketing silt (indicated by plume)	100				
% Shading	30				
Sampled By:	TS				
Picked By:	—				

Comments:

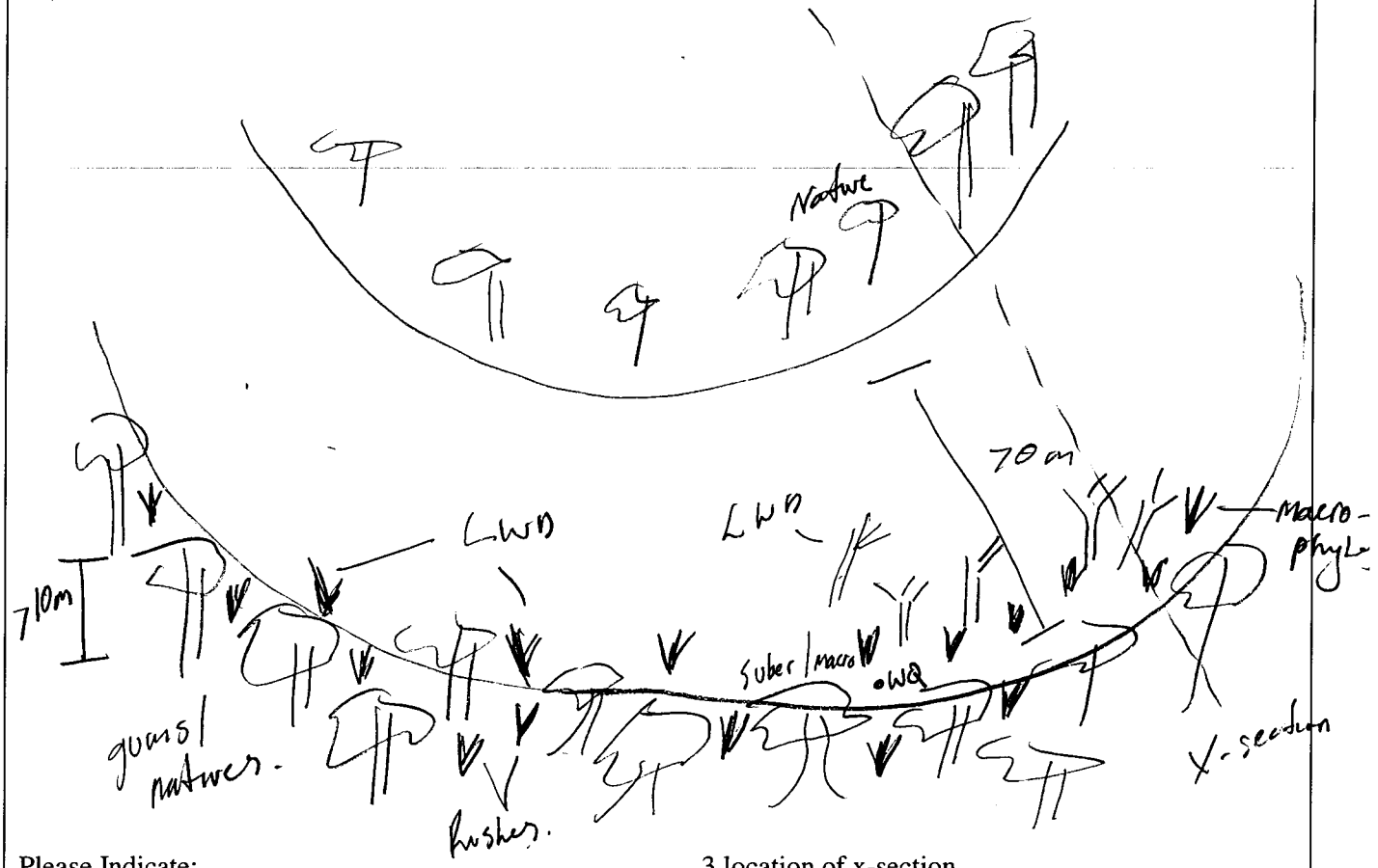
.....

.....

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME_____**DATE:** ____/____/____

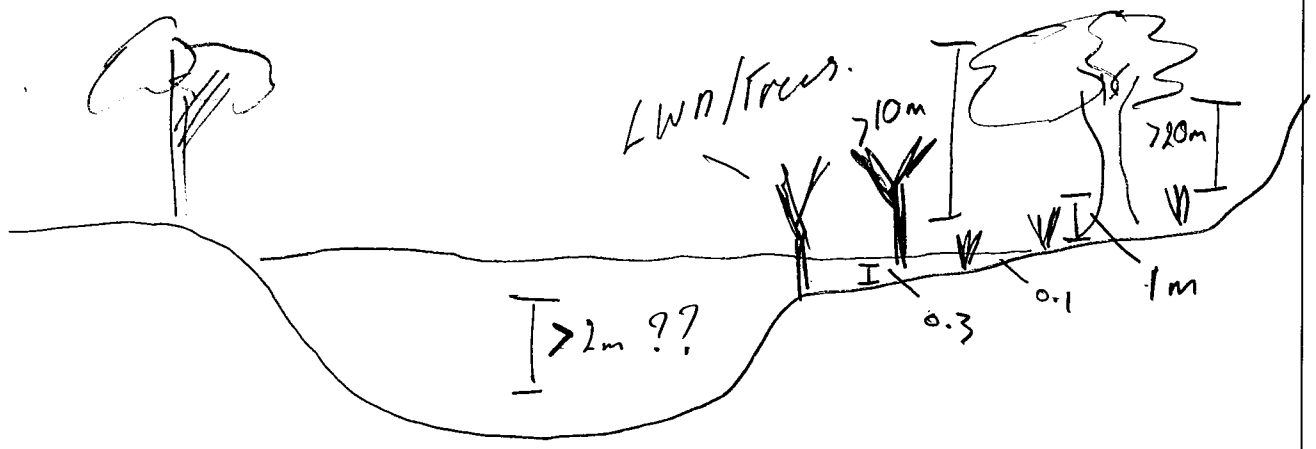
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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REFERENCE CONDITION SELECTION SHEET

SITE CODE: _____ **Date:** _____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious		
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction		
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation		
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged		
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment		
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified		
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification		
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion		
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration		
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats		
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS

SC1: Cattle
SC2:
SC3:
SC4: R/O plant
SC5:
SC6: R/O Plant
SC7: clearing / roads / farms etc.
SC8:
SC9: Due to flow alteration - flooding of banks.
SC10: LWD / macrophytes.

FIELD SHEETS

PROJECT NAME: SANTOS PW 16 **SITE CODE:** WLMP4

SITE NAME: WLMP4

DATE: 16 / 11 / 16 **TIME (24hrs):** [1321] **PARTY:** TS / AM

LATITUDE: _____ **LONGITUDE:** _____

EASTING: _____ **NORTHING:** _____ **Mobile Coverage:** Y / (N)

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage:** (Y) / N

PHOTO #'s: 106-709 — 106-728 **KEY NEEDED (Details) :** N/A

COMMENTS: _____

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	4.28	
Gauge Height (m)			DO (% sat)	54.9	
Water Temperature (°C)	27.74		Turbidity (NTU)	6.7	
Conductivity (µS/cm)	287		Total Alkalinity (mg/L)	95	
pH	7.54		**Time Collected** ORP 168		

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7.Macrophyte 8. Other

Stream Width Max 50 m Min 40 m Mode 35 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5.>Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive Associated with Roads

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: R10 Plant DISCHARGE

Point Source Pollution 1. Yes 2. No 3. Don't Know Details: R10 Plant D/S

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse Cattle

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 15 % cover *Shrubs/Vines/Rushes* 10 % cover *Grasses/Ferns/Herbs* 80 % cover

Bare Ground	1. None	2. Little	3. Some (Road / Track)	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

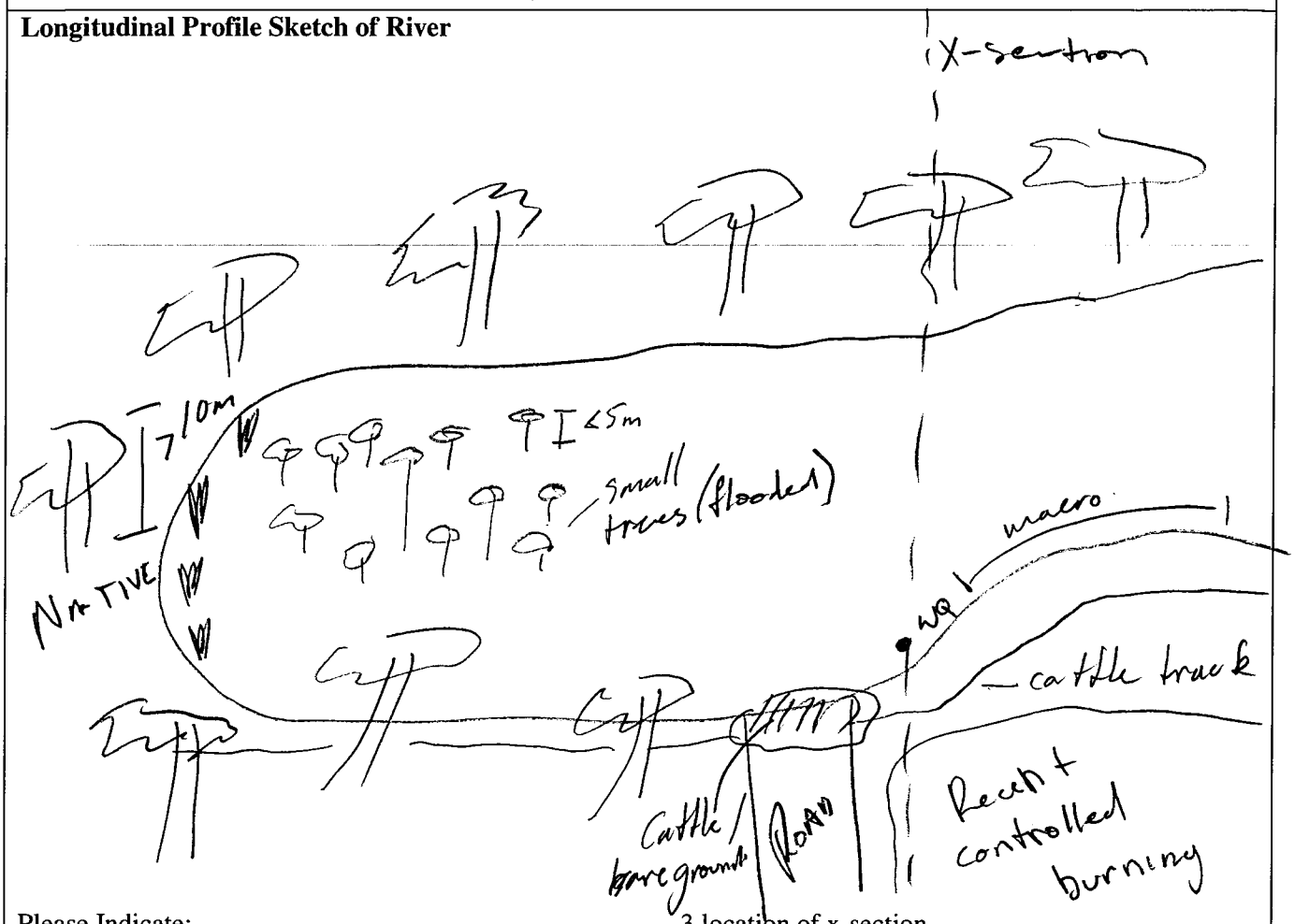
SITE CODE/NAME_____ DATE: ____/____/____					
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.1				
Mean Wetted Width (m)	40				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	0				
% Silt/Clay (< 0.005 mm)	100				
% Detritus (leaves/twigs)	80				
% Sticks (<2cm)	20				
% Branches	0				
% Logs (>15cm)	0				
% Algae	40				
% Macrophytes	60				
% Overhanging habitat (e.g. vegetation, roots)	0				
% Blanketing silt (indicated by plume)	100				
% Shading	30				
Sampled By:	TS				
Picked By:	—				

Comments: Sampling macrophyte was undable

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME WCMP4 **DATE:** ___/___/___

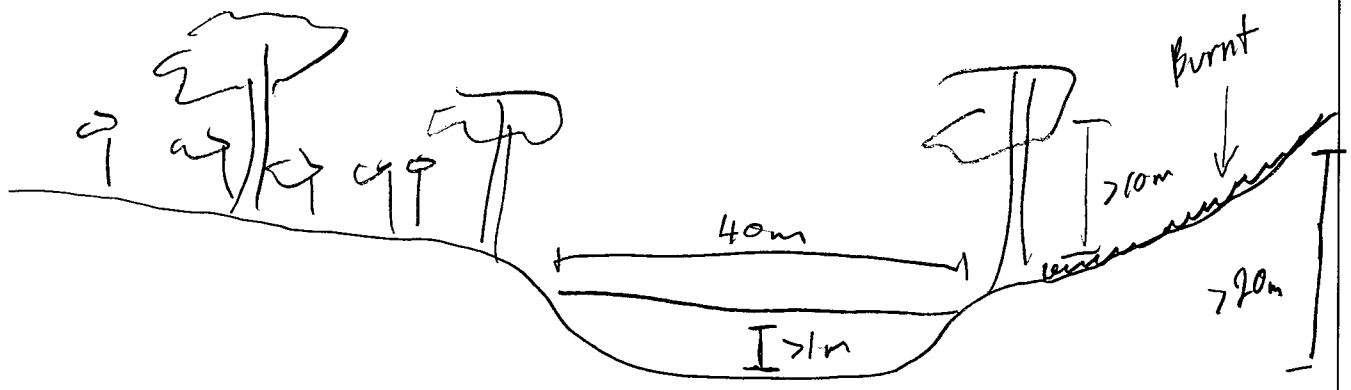
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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REFERENCE CONDITION SELECTION SHEET

SITE CODE: _____ **Date:** _____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	3	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	4	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	1	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	2	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	4	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	2	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	4	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS

SC1:	CATTLE
SC2:	
SC3:	
SC4:	
SC5:	
SC6:	R/O Plant discharge / flooding
SC7:	Clearing for grazing / cattle
SC8:	
SC9:	R/O Plant discharge & flooding of banks.
SC10:	

FIELD SHEETS

PROJECT NAME: SANTOS PRE WET 1'16 **SITE CODE:** WLUP5

SITE NAME:

DATE: 16/11/16 **TIME (24hrs): [** 14:10 **]** **PARTY:** TS + AM

LATITUDE: **LONGITUDE:**

EASTING: **NORTHING:** **Mobile Coverage: Y / N**

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage: Y / N**

PHOTO #'s: **KEY NEEDED (Details) :** N

COMMENTS: OX BOW FILLED W RELEASE WATER

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.25		DO (mg/L)	2.37	
Gauge Height (m)	—		DO (% sat)	30.5	
Water Temperature (°C)	21.43		Turbidity (NTU)	353	
Conductivity (µS/cm)	159		Total Alkalinity (mg/L)	<50	
pH	7.22		**Time Collected**	14:25	

ORP: 169

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 100 m Min 85 m Mode 90 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: RD RELEASES

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details.... GRAZING

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse..... GRAZING & CROPPING

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 10 % cover *Shrubs/Vines/Rushes* 40 % cover *Grasses/Ferns/Herbs* 50 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

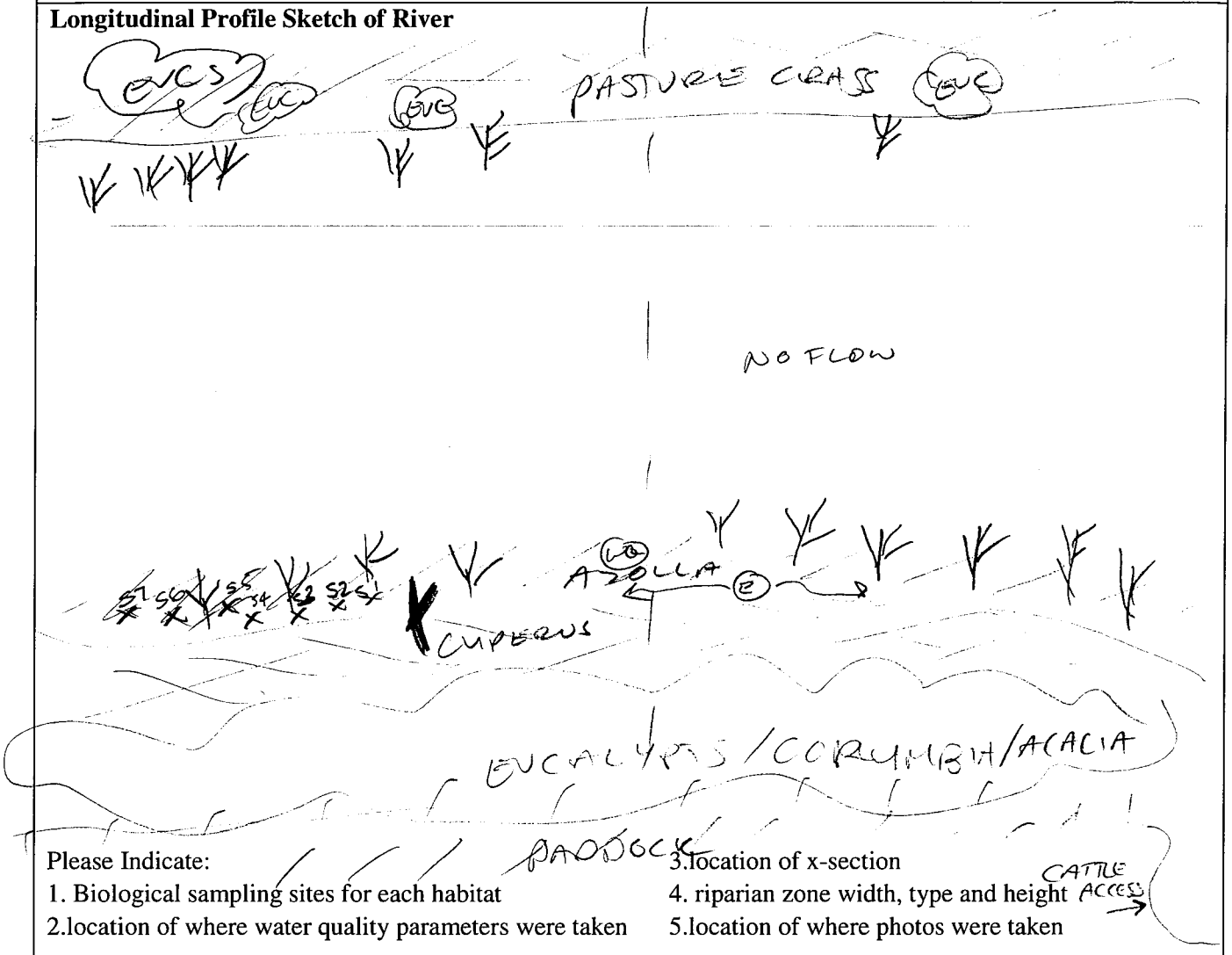
SITE CODE/NAME WCMP5	DATE: 17/11/16				
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.05				
Mean Wetted Width (m)	90				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	0				
% Silt/Clay (< 0.005 mm)	100				
% Detritus (leaves/twigs)	80				
% Sticks (<2cm)	70				
% Branches	0				
% Logs (>15cm)	0				
% Algae	0				
% Macrophytes	100				
% Overhanging habitat (e.g. vegetation, roots)	0				
% Blanketing silt (indicated by plume)	100				
% Shading	0				
Sampled By:	TS				
Picked By:					

Comments: Macrophyte sampling unavoidable.

MACROINVERTEBRATE FIELD SHEET 2

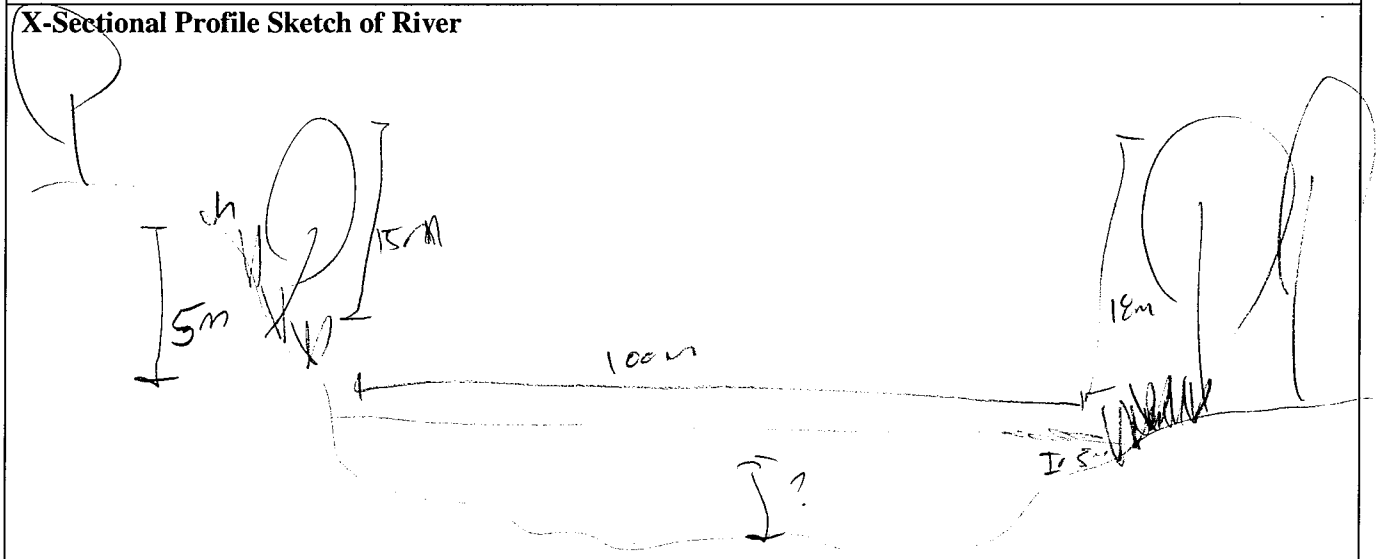
SITE CODE/NAME WLMR5 **DATE:** 16/11/16

Longitudinal Profile Sketch of River



Please Indicate:
1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:
1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments: LOTS OF BIRDS: DUCKS, SWANS, PELICANS ETC

REFERENCE CONDITION SELECTION SHEET

SITE CODE: WLMP5 **Date:** 16/11/16 **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	4	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	1	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	3	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	5	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	4	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	3	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	37	

COMMENTS	
	SC1:
	SC2:
	SC3:
	SC4:
	SC5:
	SC6:
	SC7:
	SC8:
	SC9:
	SC10:

FIELD SHEETS

PROJECT NAME: Santos Pre W 16. **SITE CODE:** DRR1

SITE NAME: DRR1

DATE: 17/11/16 **TIME (24hrs):** [1100] **PARTY:** AM, TS

LATITUDE: _____ **LONGITUDE:** _____

EASTING: _____ **NORTHING:** _____ **Mobile Coverage:** Y / N

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage:** Y / N

PHOTO #'s: Alex's phone **KEY NEEDED (Details) :** N/A.

COMMENTS:

- Site heavily silted, evidence of high flow evident.
- macrobrachium in AUSRIVAS sample
- possible seratoga sighted.
- fyking not possible with depth.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	3.61	
Gauge Height (m)			DO (% sat)	43.3	
Water Temperature (°C)	23.84		Turbidity (NTU)	15	
Conductivity (µS/cm)	302		Total Alkalinity (mg/L)	100	
pH	7.25		**Time Collected**	1115	

ORP 159

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 25 m Min 10 m Mode 20 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: possible influence from R10 / farm extraction

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse: Cattle

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 70 % cover *Shrubs/Vines/Rushes* 10 % cover *Grasses/Ferns/Herbs* 60 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

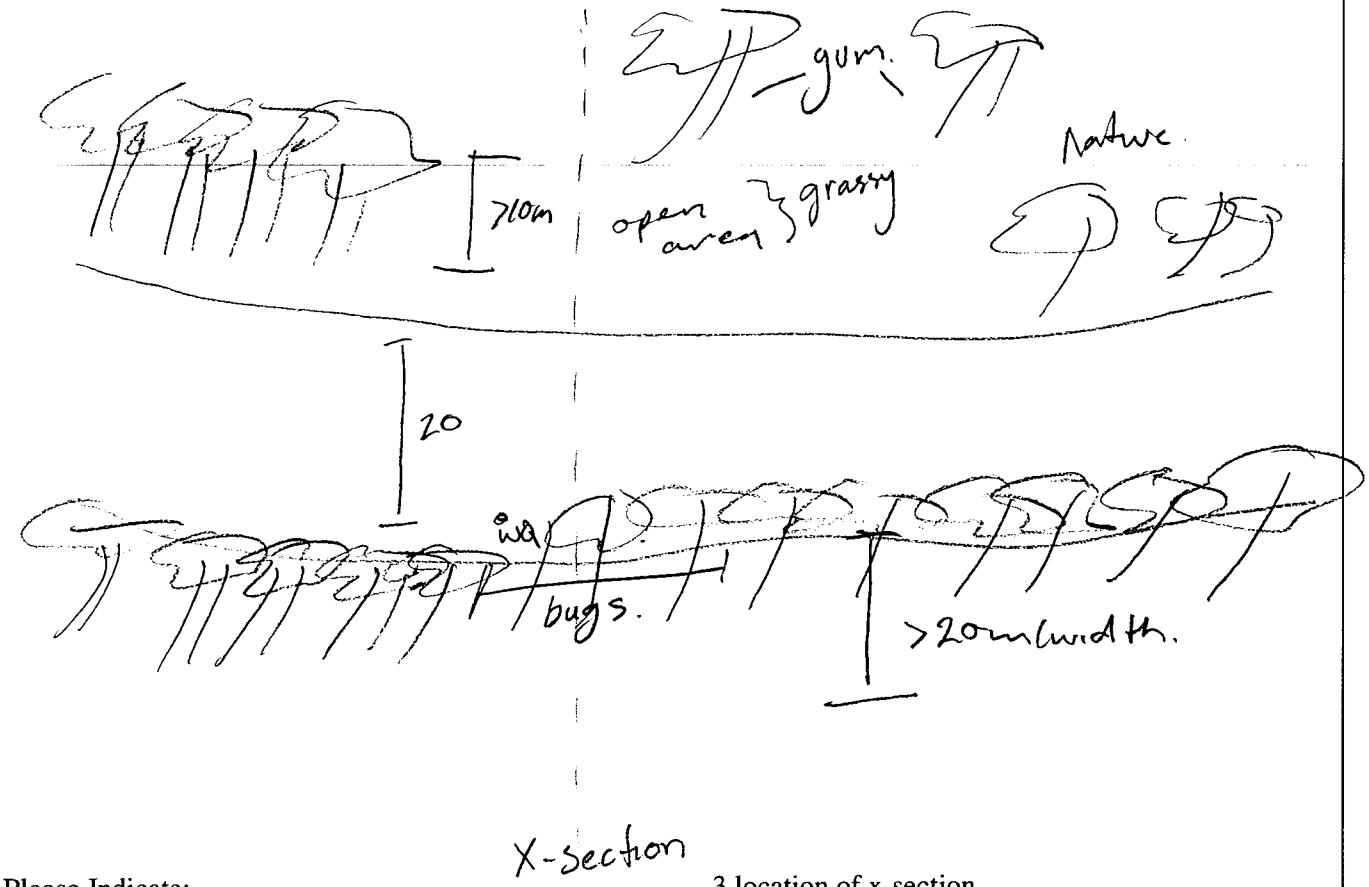
SITE CODE/NAME_____ DATE: ____/____/____					
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.15				
Mean Wetted Width (m)	20				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	5				
% Silt/Clay (< 0.005 mm)	95				
% Detritus (leaves/twigs)	85				
% Sticks (<2cm)	30				
% Branches	20				
% Logs (>15cm)	5				
% Algae	0				
% Macrophytes	5				
% Overhanging habitat (e.g. vegetation, roots)	10				
% Blanketing silt (indicated by plume)	100				
% Shading	100				
Sampled By:	JS				
Picked By:					

Comments: macrobrachian in sample in good condition

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME_____ **DATE:** ____/____/____

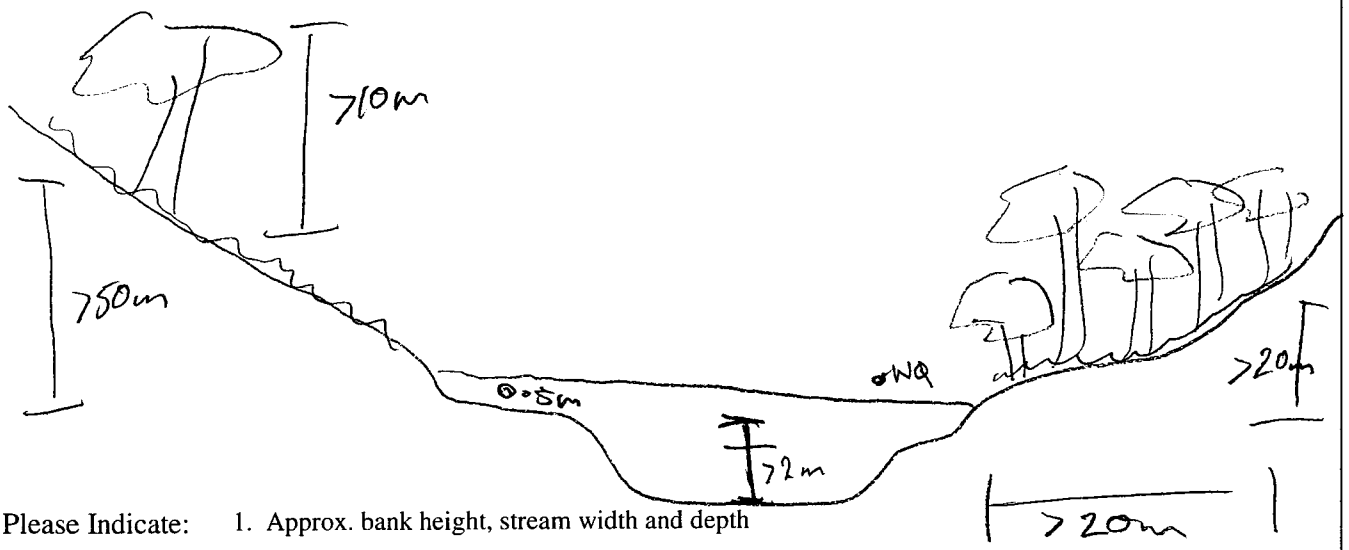
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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REFERENCE CONDITION SELECTION SHEET

SITE CODE: DRR1 **Date:**_____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	3	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	3	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	2	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	4	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	5	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**		

COMMENTS

SC1: cattle.
SC2:
SC3:
SC4:
SC5:
SC6: R/O plant / possible farm extraction.
SC7: clearing.
SC8: cattle.
SC9:
SC10:

FIELD SHEETS

PROJECT NAME: SANTOS PRE WET 16 **SITE CODE:** DRR2

SITE NAME:

DATE: 18 / 11 / 16 **TIME (24hrs):** [1430] **PARTY:** AM, TS

LATITUDE: **LONGITUDE:**

EASTING: **NORTHING:** **Mobile Coverage:** Y / N

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage:** Y / N

PHOTO #'s: ALEX'S phone **KEY NEEDED (Details) :** —

COMMENTS: • lots of large cobbles unlike D/S sites.
• isolated / no flow
• lots of erosion (due to cattle).

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.2		DO (mg/L)	3.92	
Gauge Height (m)			DO (% sat)	50.1	
Water Temperature (°C)	27.62		Turbidity (NTU)	24.6	
Conductivity (µS/cm)	255		Total Alkalinity (mg/L)	85	
pH	7.37		**Time Collected**	1435	

ORP 207

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 20 m Min 2 m Mode 10 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....ROAD.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details:.....possible farm extraction.....

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....Cattle.....

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse.....Cattle.....

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 40 % cover *Shrubs/Vines/Rushes* 40 % cover *Grasses/Ferns/Herbs* 80 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

SITE CODE/NAME DRR2	DATE: 18/11/16				
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.3				
Mean Wetted Width (m)	10				
% Bedrock	0				
% Boulder (>soccer ball)	5				
% Cobble (tennis ball - soccer ball)	45				
% Pebble (marble - tennis ball)	10				
% Gravel (2 - 4mm)	20				
% Sand (0.005 - 2mm)	10				
% Silt/Clay (< 0.005 mm)	10				
% Detritus (leaves/twigs)	95				
% Sticks (<2cm)	20				
% Branches	0				
% Logs (>15cm)	15				
% Algae	80				
% Macrophytes	0				
% Overhanging habitat (e.g. vegetation, roots)	15				
% Blanketing silt (indicated by plume)	100				
% Shading	70				
Sampled By:	TS				
Picked By:	BULK				

Comments:

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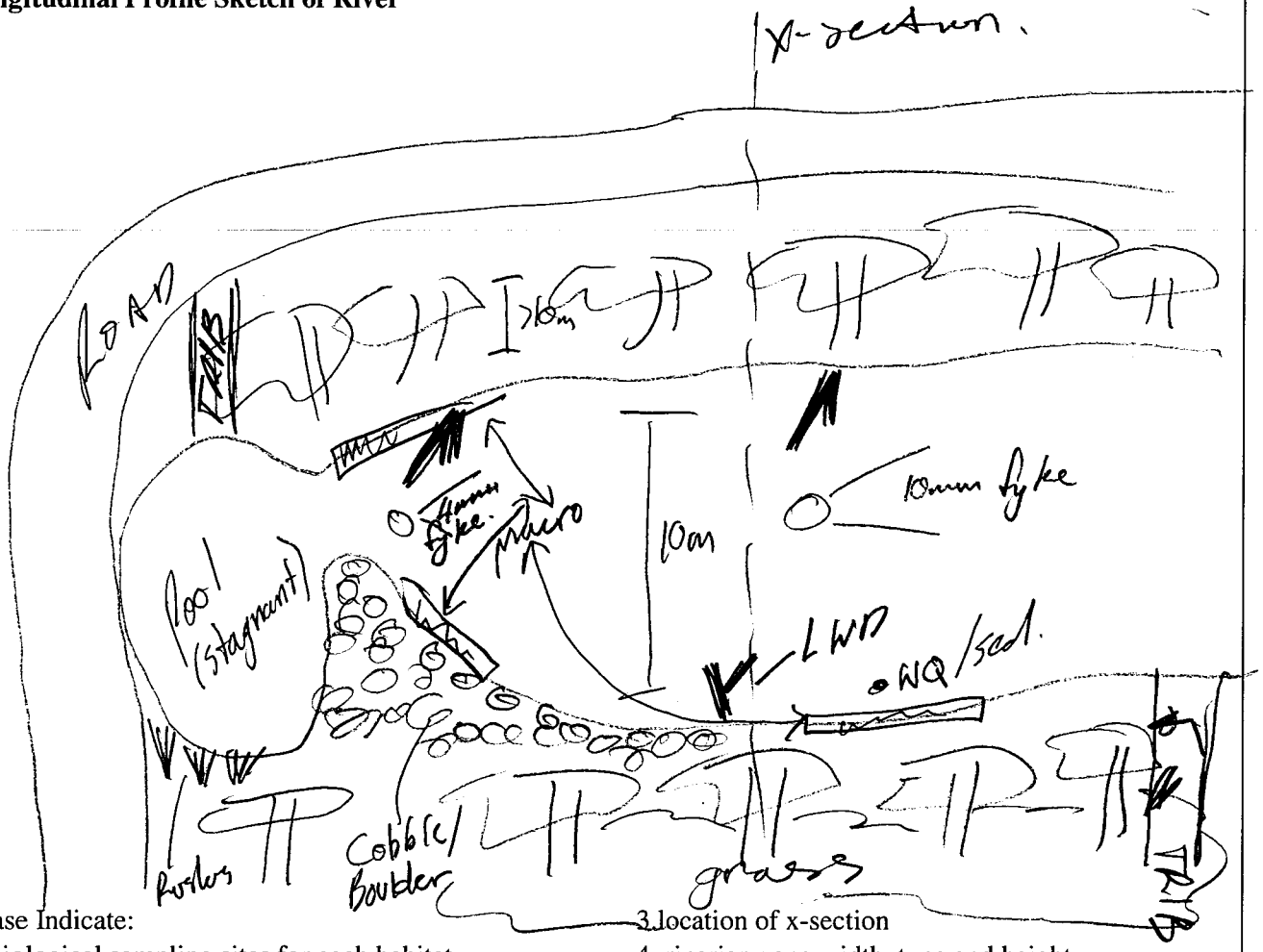
MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME DRR2 **DATE:** 18/11/16

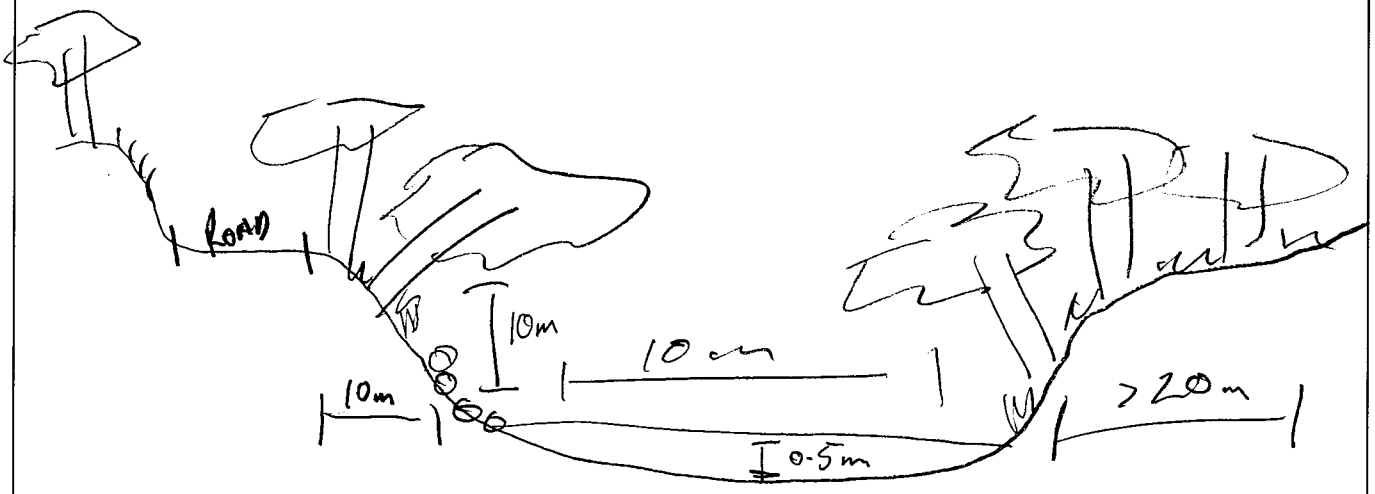
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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REFERENCE CONDITION SELECTION SHEET

SITE CODE: _____ **Date:** _____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	4	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	4	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	3	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	1	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	3	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	4	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	36	

COMMENTS

SC1: Cattle.
SC2:
SC3:
SC4:
SC5:
SC6:
SC7: Clearing.
SC8: cattle.
SC9: cattle.
SC10:

FIELD SHEETS

PROJECT NAME: SANTOS PN 16 **SITE CODE:** DRMP1

SITE NAME:

DATE: 17/11/16 **TIME (24hrs): [** 1315 **]** **PARTY:**

LATITUDE: **LONGITUDE:**

EASTING: **NORTHING:** **Mobile Coverage: Y / N**

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage: Y / N**

PHOTO #'s: Alex's phone **KEY NEEDED (Details) :** N

COMMENTS:

- small amount of flow
- evidence of high flow evident.

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0.1		DO (mg/L)	3.39	
Gauge Height (m)			DO (% sat)	41.4	
Water Temperature (°C)	25.02		Turbidity (NTU)	12.2	
Conductivity (µS/cm)	311		Total Alkalinity (mg/L)	95	
pH	7.40		**Time Collected**	1320	

ORP 213

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5.Riffle 6.LWD 7. Macrophyte 8. Other

Stream Width Max 15 m Min 8 m Mode 10 m

Water Level 1. No Flow 2.Dry/Isolated 3.<Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details.....

Bank Erosion 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details.....

Hydrological Variation 1. None 2. Little 3.Some 4. Moderate 5. Extensive

Hydrological Variation details: R/O plant

Point Source Pollution 1. Yes 2. No 3. Don't Know Details.....

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details: Cattle.

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse cattle.

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other.....

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 80 % cover *Shrubs/Vines/Rushes* 20 % cover *Grasses/Ferns/Herbs* 90 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

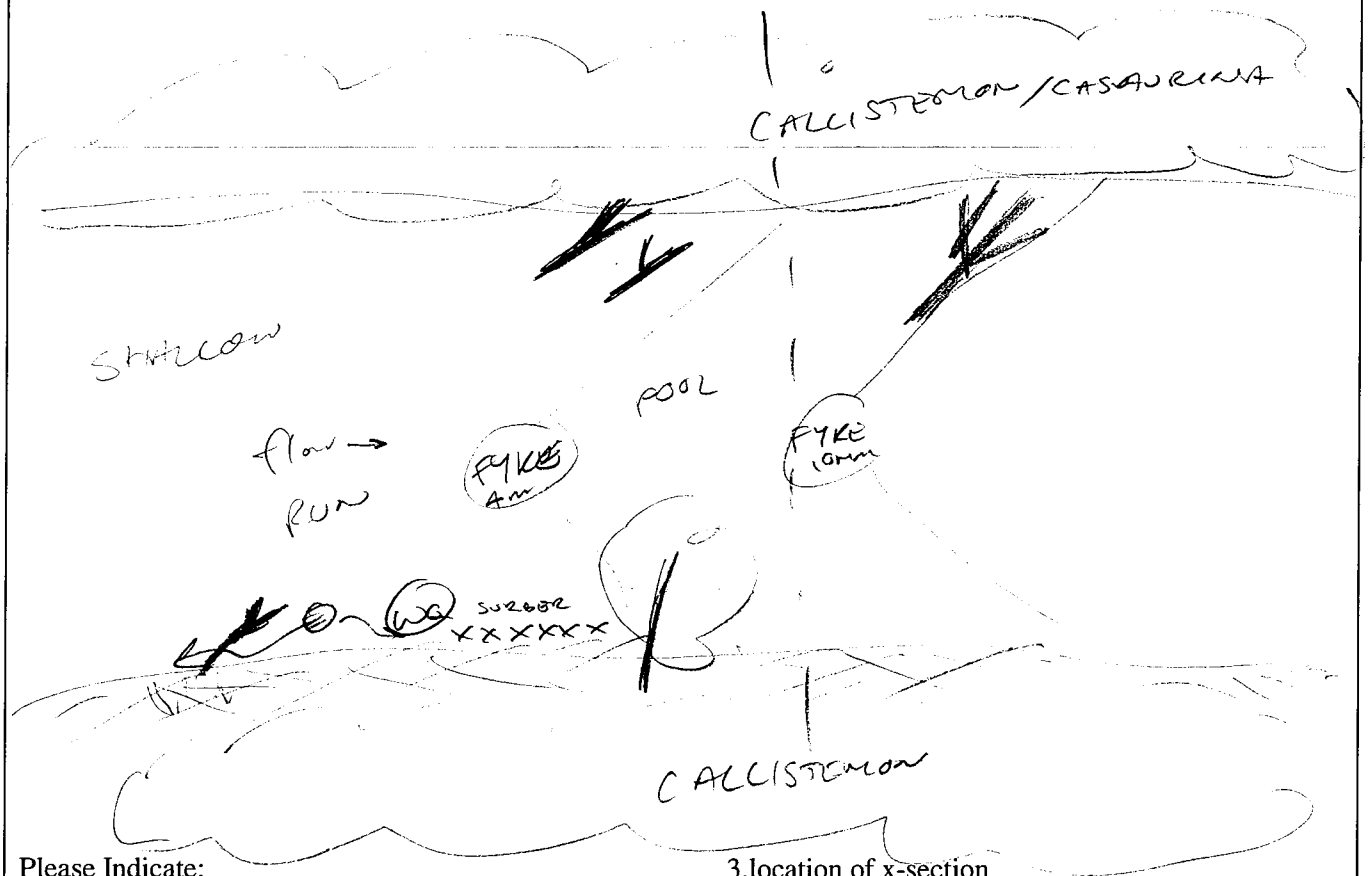
SITE CODE/NAME DRMP1	DATE: 17/11/16				
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.2				
Mean Wetted Width (m)	10				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	40				
% Silt/Clay (< 0.005 mm)	60				
% Detritus (leaves/twigs)	70				
% Sticks (<2cm)	5				
% Branches	0				
% Logs (>15cm)	5				
% Algae	0				
% Macrophytes	0				
% Overhanging habitat (e.g. vegetation, roots)	10				
% Blanketing silt (indicated by plume)	100				
% Shading	90				
Sampled By:	TS				
Picked By:					

Comments: SURBER SAMPLING UNABLE TO AVOID HEAVY DETRITUS FROM CASUARINA

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME DRMP1 **DATE:** 17/11/16

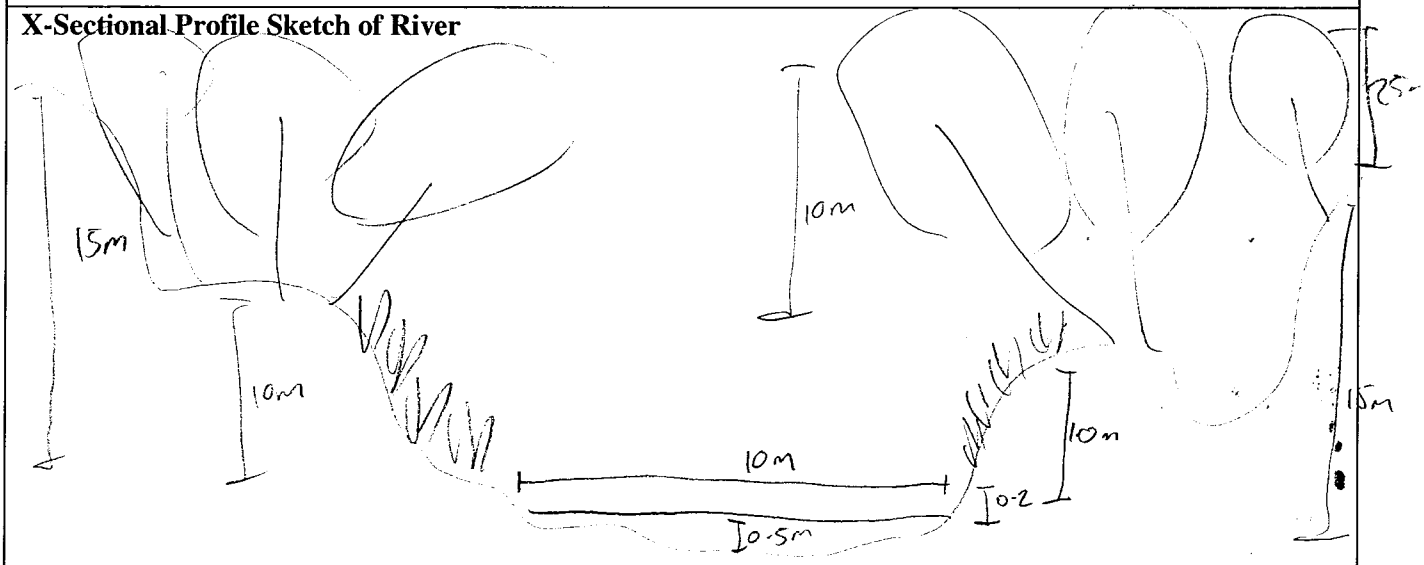
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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REFERENCE CONDITION SELECTION SHEET

SITE CODE: _____ **Date:** _____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream, moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	5	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	3	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	4	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	1	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	4	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	4	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	38	

COMMENTS

SC1: Cattle.
SC2:
SC3:
SC4:
SC5:
SC6: RO plant
SC7: Clearing.
SC8: Cattle.
SC9:
SC10:

FIELD SHEETS

PROJECT NAME: SANTOS PRE WET 2016 **SITE CODE:** S4

SITE NAME: DAWSON RIVER @ YEBNA CROSSING

DATE: 15/11/16 **TIME (24hrs):** [13:30] **PARTY:** TS+AM

LATITUDE: _____ **LONGITUDE:** _____

EASTING: _____ **NORTHING:** _____ **Mobile Coverage: Y / N**

MAP NAME: — **MAP SCALE:** — **Sat. Phone Coverage: Y / N**

PHOTO #'s: 106-0645 – 106-0654 **KEY NEEDED (Details) :** _____

COMMENTS: _____

WQ Parameter	Edge	Riffle	WQ Parameter	Edge	Riffle
Sample Depth (m)	0-1		DO (mg/L)	6.30	
Gauge Height (m)	—		DO (% sat)	77.5	
Water Temperature (°C)	25.16		Turbidity (NTU)	19.8	
Conductivity (µS/cm)	335		Total Alkalinity (mg/L)		
pH	7.32		**Time Collected**	13:45	

ORP 134

Habitat's Present (circle if present) 1. Pool-K 2. Pool-S 3. Run-K 4. Run-S 5. Riffle 6. LWD 7. Macrophyte 8. Other

Stream Width Max 10 m Min 2 m Mode 6 m

Water Level 1. No Flow 2. Dry/Isolated 3. <Watermark 4. Normal 5. >Watermark

Shading of River None Low Moderate High

Type of River System Intermittent Permanent Details... UNSURE?

Bank Erosion 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Dams/Barriers 1. Yes - Upstream 2. Yes - Downstream 3. No 4. Don't Know

Dam/Barrier details... ROAD CULVERT PIPED CULVERT

Hydrological Variation 1. None 2. Little 3. Some 4. Moderate 5. Extensive

Hydrological Variation details:... RELEASES U/S FROM R/O PLANT

Point Source Pollution 1. Yes 2. No 3. Don't Know Details...

Non Point Source Pollution 1. Yes 2. No 3. Don't Know Details. TRUCKS EXTRACTING WATER

Position in Catchment 1. Upland 2. Midland 3. Lowland

Adjacent Landuse... CATTLE

Geomorphology 1. Steep Valley 2. Broad Valley 3. Floodplain 4. Other...

Riparian Zone (zone extends for 100m upstream and downstream from sampled area)

Trees<10m 50 % cover *Shrubs/Vines/Rushes* 0 % cover *Grasses/Ferns/Herbs* 80 % cover

Bare Ground	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Grass	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Shrubs	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees<10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive
Trees>10m	1. None	2. Little	3. Some	4. Moderate	5. Extensive

MACROINVERTEBRATE FIELD SHEET 1

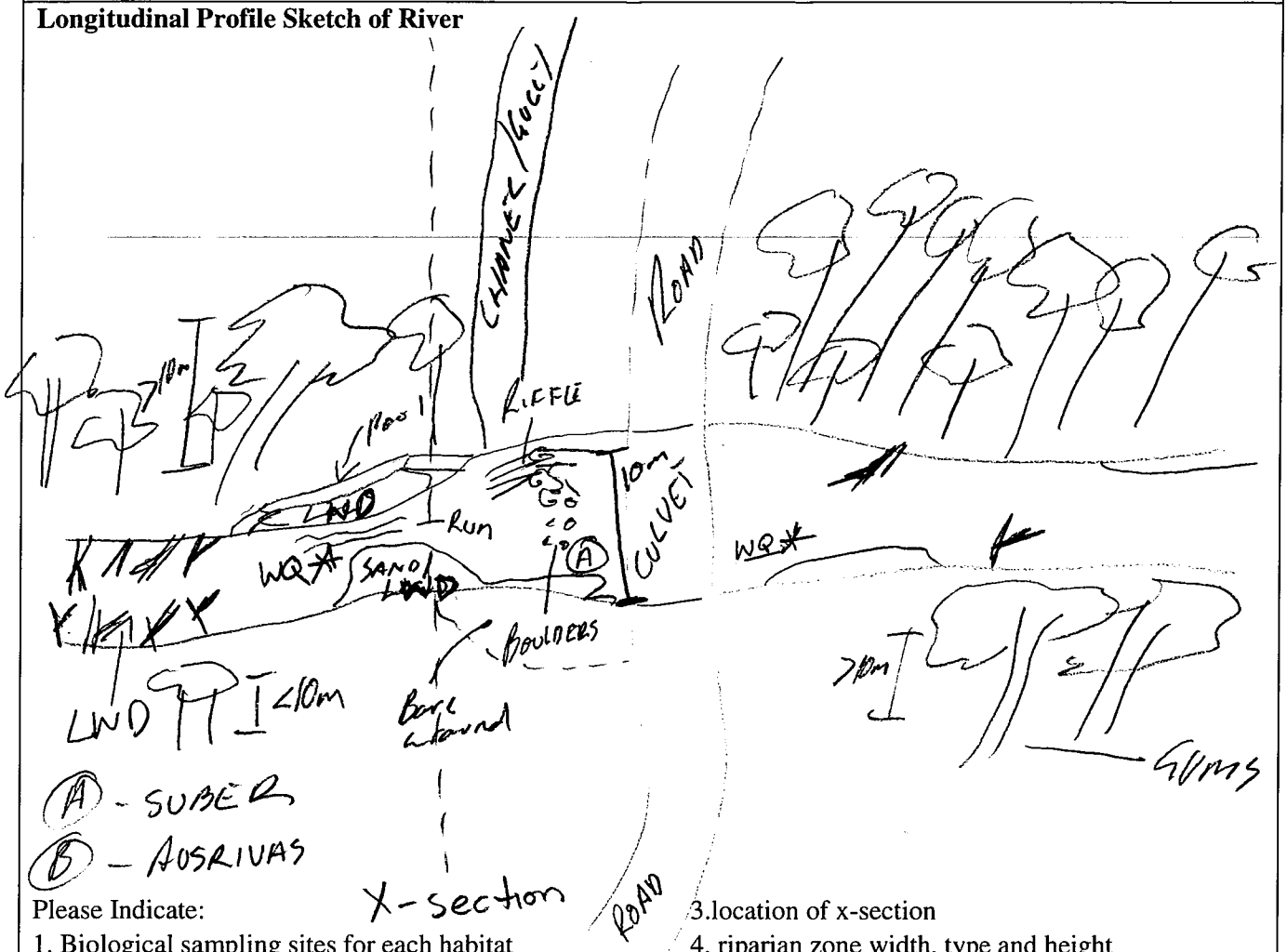
SITE CODE/NAME_____ DATE: ____/____/____					
HABITAT TYPE (E=Edge; R=Riffle; K=Rocky Bed; S=Sandy Bed; M=Macrophytes; N=Run; C=Composite)					
KEY HABITAT FEATURES	E				
Vel count					
Vel depth					
Vel m/sec					
Vel (average) (m/sec)	0.05				
Mean Sample Depth (m)	0.2				
Mean Wetted Width (m)	6 m				
% Bedrock	0				
% Boulder (>soccer ball)	0				
% Cobble (tennis ball - soccer ball)	0				
% Pebble (marble - tennis ball)	0				
% Gravel (2 - 4mm)	0				
% Sand (0.005 - 2mm)	70				
% Silt/Clay (< 0.005 mm)	30				
% Detritus (leaves/twigs)	40				
% Sticks (<2cm)	20				
% Branches	20				
% Logs (>15cm)	15				
% Algae	5				
% Macrophytes	0				
% Overhanging habitat (e.g. vegetation, roots)	40				
% Blanketing silt (indicated by plume)	100				
% Shading	90				
Sampled By:	TS				
Picked By:	—				

Comments: THICK / FIRM SHELL OF MACROBRACHIUM.

MACROINVERTEBRATE FIELD SHEET 2

SITE CODE/NAME_____**DATE:** ____/____/____

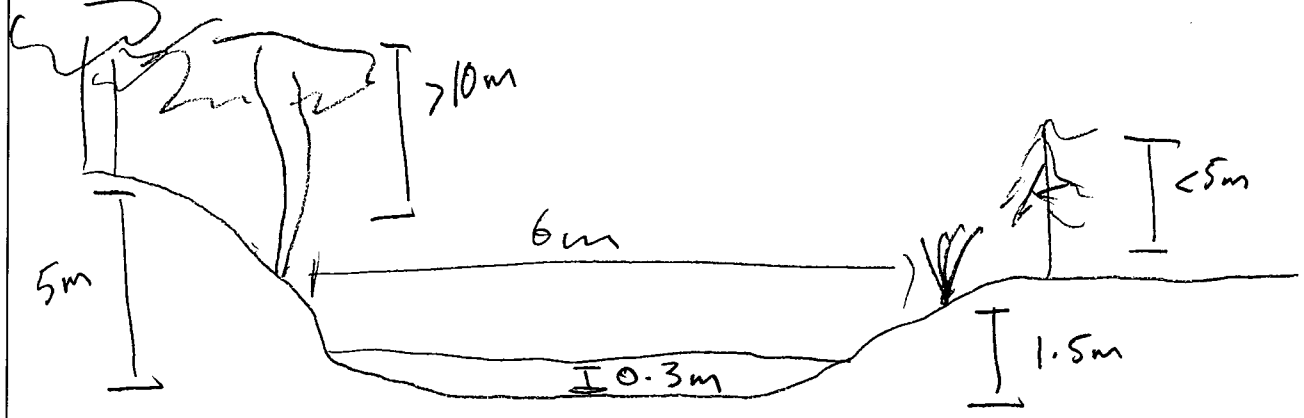
Longitudinal Profile Sketch of River



Please Indicate:

1. Biological sampling sites for each habitat
2. location of where water quality parameters were taken
3. location of x-section
4. riparian zone width, type and height
5. location of where photos were taken

X-Sectional Profile Sketch of River



Please Indicate:

1. Approx. bank height, stream width and depth
2. Approx. riparian vegetation height

General Comments:

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.....

REFERENCE CONDITION SELECTION SHEET

SITE CODE: S4 **Date:**_____ **(If the impacts are unknown, seek further information before scoring; more than one person must complete this form)**

Possible Impacts	5 (No Impact)	4 (Minor Impact)	3 (Moderate Impact)	2 (Major Impact)	1 (Extreme Impact)	Score	Previous Score
1. Agriculture and forestry*	No impact	Present but level of impact is barely discernible	Evident, however, not severe and/or widespread	Obvious impact to stream; moderate and/or widespread	Severe and widespread, impact obvious	2	
2. Sand/gravel extraction*	No evidence or prior knowledge of extraction	Small scale historical extraction	No current extraction; large historical extraction	Current small scale/localised extraction	Current and widespread extraction	5	
3. Upstream urban areas*	No impacts from urbanisation	Possible impacts caused from urbanisation	Definite impacts caused from urbanisation	High impacts caused from urbanisation	Extreme impacts caused from urbanisation	5	
4. Point source pollution*	Nil point source pollution	Low volumes of point source pollution discharged	Low to moderate volumes of point source pollution discharged	Moderate to high volumes of point source pollution discharged	High to extreme volumes of point source pollution discharged	5	
5. Dam/weir*	No artificial barriers in basin which will affect the site	Few small upstream barriers; not within impoundment	Many small barriers; site not within impoundment	Multiple small barriers; Large barriers upstream; within small impoundment	Large barriers upstream; within large impoundment	3	
6. Flow regime alteration*	Seasonal flow regime natural	Seasonal flow regime not obviously altered	Flow regime altered	Flow regime obviously altered	Flow regime highly modified	3	
7. Streamside veg. alteration@	Streamside vegetation unaltered	Vegetation slightly modified	Obvious modification	Highly modified vegetation	Severe modification	2	
8. Riparian zone/ streambank erosion	No evidence of erosion beyond natural	Slightly more than natural levels of erosion	Moderate levels of unnatural erosion	High levels of erosion	Extreme erosion	3	
9. Geomorphic change@	No evidence	Slight geomorphic change	Moderate change	High changes	Extreme alteration	3	
10. Instream habitat alteration@	Instream habitats of natural appearance and diversity	Barely discernible impacts	Moderate modifications to instream habitats	Highly modified modifications to instream habitats	Severe modification of instream habitats	3	
NOTE: When applicable, write down in the comments section the type and approx. distances from the impact If a score given differs from the previous score, state the reason why they are different in the comments section					**Total**	34	

COMMENTS

SC1: Cattle
SC2:
SC3:
SC4:
SC5: ROAD CULVET @ SITE
SC6: DISHARGE FROM R/O PLANT (WATER EXTRACTION FROM FARMERS)
SC7: CLEARING FOR ROAD ACCES
SC8: EROSION ASSOCIATED WITH BARE GROAD
SC9: ROAD CULVET / EROSION / R/O DISCARGE
SC10: ROAD CULVET / TYRE / BOULDERS.

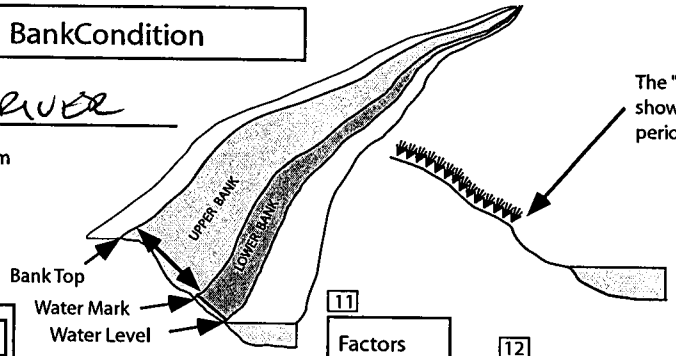
STATE OF THE RIVERS --- SHEET 7 BankCondition

© 1992 J. Anderson

Basin | Sub-section | Site (SITE CODE): D R 1 1 | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 17/11/16 | Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

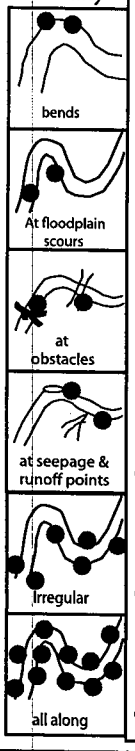
- [X] 1 Natural
- [ ] 2 Man-made
- [ ] 3 Absent

	LEFT		RIGHT	
	Height	Width	Height	Width
	00	00	20	35

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 20

NOTE: The 4 % figures below must = 100%

Stable: 0

Eroding: 00 | Aggrading: 10

Slumping: 10 (where / where / where)

2 UPPER BANK

Bare of Veg: 10

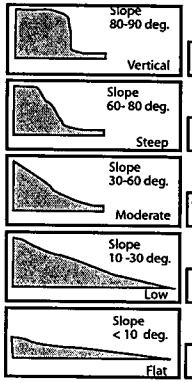
NOTE: The 4 % figures below must = 100%

Stable: 20

Eroding: 10 | Aggrading: 60

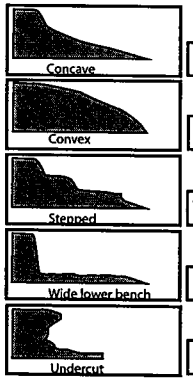
Slumping: 10 (where / where / where)

3 LEFT BANK Slope (RANK types)



- [ ] 1
- [ ] 2
- [X] 3
- [ ] 4
- [ ] 5

4 LEFT BANK Shape (RANK types)



- [ ] 1
- [ ] 2
- [X] 3
- [ ] 4
- [ ] 5

11 Factors Affecting Stability

RANKS

- 1 Flow & Waves
- 2 Seepage
- 3 Runoff [X]
- 4 Floodplain Scours [X]
- 5 Stock [X]
- 6 People tracks
- 7 Vermin, Ferals [X]
- 8 Ford, road culvert, bridge, Weir
- 9 Clearing of Vegetation [X]
- 10 Gravel/sand extraction
- 11 Mining
- Other _____

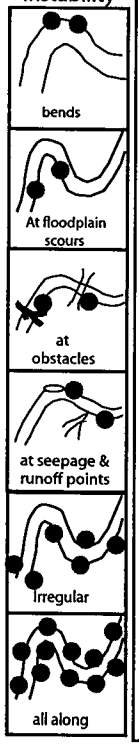
12 Artificial Bank Protection Measures

- 1 Trees & Other Plants
- 2 Rock wall or layer
- 3 Fence Structures
- 4 Fenced watering points
- 5 Fenced human access
- 6 Logs strapped to bank
- 7 Concrete Wall
- 8 Break-water
- 9 Other _____
- 10 Other _____
- 11 None

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 30

NOTE: The 4 % figures below must = 100%

Stable: 0

Eroding: 90 | Aggrading: 10

Slumping: 0 (where / where / where)

7 UPPER BANK

Bare of Veg: 10

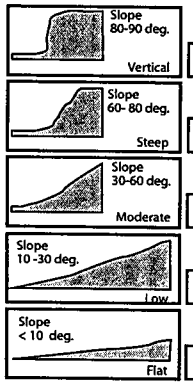
NOTE: The 4 % figures below must = 100%

Stable: 20

Eroding: 30 | Aggrading: 50

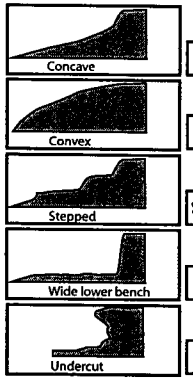
Slumping: 0 (where / where / where)

8 RIGHT BANK Slope (RANK types)



- [ ] 1
- [X] 2
- [ ] 3
- [ ] 4
- [ ] 5

9 RIGHT BANK Shape (RANK types)



- [ ] 1
- [ ] 2
- [X] 3
- [ ] 4
- [ ] 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	[ ]	[X]	[ ]	[ ]
Susceptibility to erosion (1 / 2 / 3 / 4)	[ ]	[X]	[ ]	[ ]

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability	[X]	[ ]	[ ]	[ ]
Susceptibility to erosion (1 / 2 / 3 / 4)	[ ]	[X]	[ ]	[ ]

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE) | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 17/11/16 | Recorder: JS

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Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 10

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:
(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion [X]
- Channelisation [X]
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted: < 0.1 m deep & narrow	2
3	Moderately Restricted: < 0.3 m deep & narrow	3
4	Partly Restricted: 0.5 m deep & narrow	4
5 [X]	Good Passage: 0.5 -1 m deep wide no torrent	5
6	Unrestricted: > 1 m deep & almost channel wide	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall							
Cascade rapid or log jam							
Low weir, pipe culvert, ford, bridge							
Single log branch pile, rock							
Low feature easily by-passed							
None / Other							

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2 [X]	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 17/11/16 Recorder JS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) DRR1 | Tributary Name DAWSON RIVER

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

150 Width of Existing Vegetation (m) (riparian & non riparian vegetation)

300 Width of Riparian Vegetation (m)

0 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	10	
Trees < 10 m	15	
Woody Shrubs (> 2m)	20	
Woody Shrubs (< 2m)	20	
Vines	0	
Rushes & Sedges	5	
Herbs/Forbs (NOT WOODY)	10	80
Grasses	100	20
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 2 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - *Yes* ☐ 1 *No* ☐ 2

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		X
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)	X		Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

Highly disturbed, distinct boundary on vegetation edge Width less than bank width	1 ☒
Disturbed & non-grass species extend only to the bank top	2 ☐
Disturbed & non-grass species extend partially into the original zone (floodplain)	3 ☐
Thinned, semi-natural in cover and width	4 ☐
Virtually natural cover & width	5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

Highly disturbed, distinct boundary on vegetation edge Width less than bank width	1 ☐
Disturbed & non-grass species extend only to the bank top	2 ☒
Disturbed & non-grass species extend partially into the original zone (floodplain)	3 ☐
Thinned, semi-natural in cover and width	4 ☐
Virtually natural cover & width	5 ☐

12 All Aquatic Vegetation - submerged bed, within the wetted perimeter of the stream

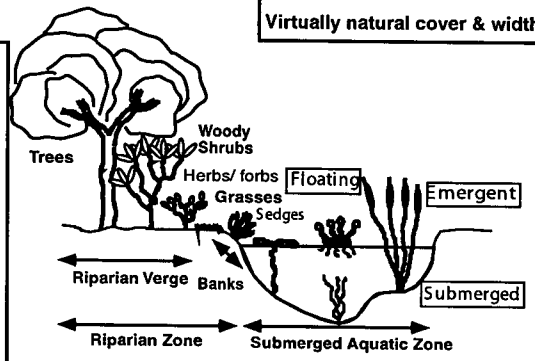
Visible depth (m)	00
Too turbid - pres only	
% Bare - no vegetation	100
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other _____	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None	☐	☐
Major	☐	☐
Minor	☒	☒

15 Emergent Veg.

	% Submerged lands
Total emergents	
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

200 Width of Existing Vegetation (m) (riparian & non riparian vegetation)

400 Width of Riparian Vegetation (m)

0 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	1	
Trees 10 - 30 m	10	
Trees < 10 m	15	
Woody Shrubs (> 2m)	30	
Woody Shrubs (< 2m)	5	
Vines	0	
Rushes & Sedges	5	
Herbs/Forbs (NOT WOODY)	20	
Grasses	100	
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 5 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - *Yes* ☐ 1 *No* ☐ 2

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		X
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)		X	Parthenium weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

STATE OF THE RIVERS --- SHEET 7 BankCondition

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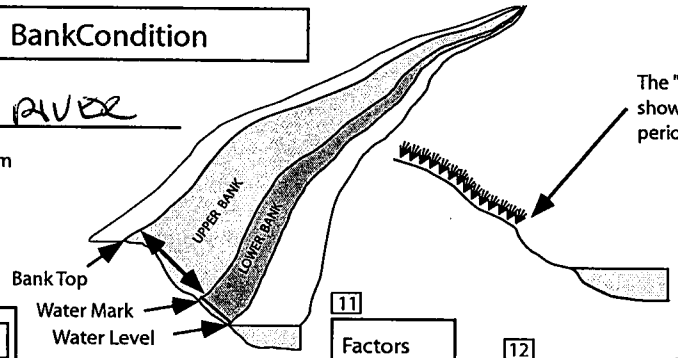
Basin | Sub-section | Site (SITE CODE) | Tributary Name: DAWSON RIVER

Site: ORMP

Date (dd/mm/yy): 17/11/16

Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

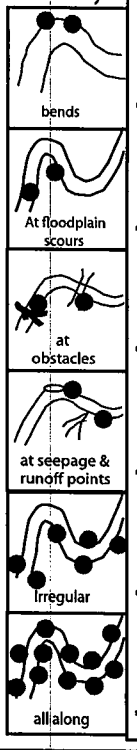
- [ ] 1 Natural
- [ ] 2 Man-made
- [x] 3 Absent

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 20

NOTE: The 4 % figures below must = 100%

	Stable	Eroding	Aggrading	Slumping (where)
	0	60	30	10

2 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

	Stable	Eroding	Aggrading	Slumping (where)
	10	35	35	20

3 LEFT BANK Slope (RANK types)

- [ ] 1 Slope 80-90 deg. Vertical
- [ ] 2 Slope 60-80 deg. Steep
- [x] 3 Slope 30-60 deg. Moderate
- [ ] 4 Slope 10-30 deg. Low
- [ ] 5 Slope < 10 deg. Flat

4 LEFT BANK Shape (RANK types)

- [ ] 1 Concave
- [ ] 2 Convex
- [x] 3 Stepped
- [ ] 4 Wide lower bench
- [ ] 5 Undercut

11 Factors Affecting Stability

** RANKS **

- 1 Flow & Waves
- 2 Seepage
- 3 Runoff [x]
- 4 Floodplain Scours
- 5 Stock [x]
- 6 People tracks [x]
- 7 Vermin, Ferals [x]
- 8 Ford, road culvert, bridge, Weir
- 9 Clearing of Vegetation [x]
- 10 Gravel/sand extraction
- 11 Mining
- Other

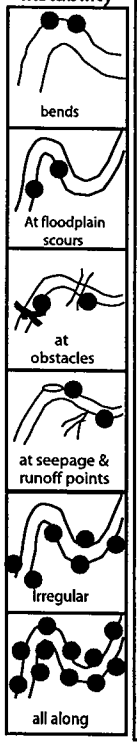
12 Artificial Bank Protection Measures

- 1 Trees & Other Plants
- 2 Rock wall or layer
- 3 Fence Structures
- 4 Fenced watering points
- 5 Fenced human access
- 6 Logs strapped to bank
- 7 Concrete Wall
- 8 Break-water
- 9 Other
- 10 Other
- 11 None [x]

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 10

NOTE: The 4 % figures below must = 100%

	Stable	Eroding	Aggrading	Slumping (where)
	0	10	80	10

7 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

	Stable	Eroding	Aggrading	Slumping (where)
	60	10	30	0

8 RIGHT BANK Slope (RANK types)

- [ ] 1 Slope 80-90 deg. Vertical
- [ ] 2 Slope 60-80 deg. Steep
- [x] 3 Slope 30-60 deg. Moderate
- [ ] 4 Slope 10-30 deg. Low
- [ ] 5 Slope < 10 deg. Flat

9 RIGHT BANK Shape (RANK types)

- [ ] 1 Concave
- [ ] 2 Convex
- [x] 3 Stepped
- [ ] 4 Wide lower bench
- [ ] 5 Undercut

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability		[x]		
Susceptibility to erosion		[x]		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability		[x]		
Susceptibility to erosion			[x]	

STATE OF THE RIVERS --- SHEET 8 — Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE): DRMP1 | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 17/11/16 | Recorder: TS

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Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point ☒
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 5

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size: SAND/SILT

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere — short= interm, interm = long 1
- Disc — short < interm, interm = long 2
- Blade — short << interm, interm < long 3
- Rod — short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured — array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured — array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction — array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction — poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction — loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion ☒
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing ☒
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other ____
- None ☒

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted (< 0.1 m deep & narrow)	2
3	Moderately Restricted (< 0.3 m deep & narrow)	3
4	Partly Restricted (< 0.5 m deep & narrow)	4
5	Good Passage (0.5 -1 m deep wide no torrent)	5
☒ 6	Unrestricted (> 1 m deep & almost channel wide)	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall							
m	1	2	3	4	5	6	7
Cascade rapid or log jam							
m	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge							
m	1	2	3	4	5	6	7
Single log branch pile, rock							
m	1	2	3	4	5	6	7
Low feature easily by-passed							
m	1	2	3	4	5	6	7
None							
Other							
m	1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated ☒ 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 17/11/16 Recorder TS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) 0RMP1 | Tributary Name DAWSON RIVER

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 50 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 300 Width of Riparian Vegetation (m)
- 10 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3 Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	10	0
Trees < 10 m	5	0
Woody Shrubs (> 2m)	20	0
Woody Shrubs (< 2m)	5	0
Vines	0	
Rushes & Sedges	0	
Herbs/Forbs (NOT WOODY)	20	30
Grasses	100	50
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

5	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.	X	X	Lomandra		X
Casuarina spp.	X	X	Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)	X	X	Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 [X]
- Disturbed & non-grass species extend only to the bank top 2 [ ]
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 [ ]
- Thinned, semi-natural in cover and width 4 [ ]
- Virtually natural cover & width 5 [ ]

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

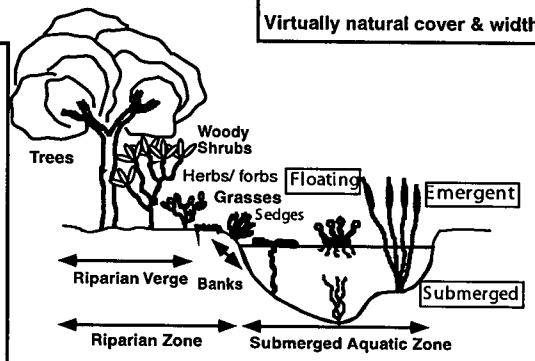
Visible depth (m)	0	5
Too turbid - pres only		1
% Bare - no vegetation	100	0
Tot.% Exotic spp.		0

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	0
Filamentous algae	0
Freshwater Algae (Blue-green Algae)	0
Marine / estuarine algae	0
Chara / Nitella p. 57	0
Vallisneria/strap like forms p. 108-111	0
Herb like forms	0
Myriophyllumspp. p. 62-73	0
Potamogeton spp. p. 46-49 96-105	0
Triglochin spp. p. 178-181	0
Water Primrose p. 27	0
Other ___	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other ___	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None	☐	☐
Major	☐	X
Minor	X	☐

15 Emergent Veg.

	% Submerged lands
Total emergents	0
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 ___	
Local Sp. 2 ___	
Local Sp. 3 ___	
Local Sp. 4 ___	

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 [X]
- Disturbed & non-grass species extend only to the bank top 2 [ ]
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 [ ]
- Thinned, semi-natural in cover and width 4 [ ]
- Virtually natural cover & width 5 [ ]

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 150 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 800 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8 Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	15	0
Trees < 10 m	5	0
Woody Shrubs (> 2m)	50	0
Woody Shrubs (< 2m)	10	0
Vines	0	
Rushes & Sedges	10	0
Herbs/Forbs (NOT WOODY)	20	70
Grasses	100	20
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 ___ Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

10	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.			Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

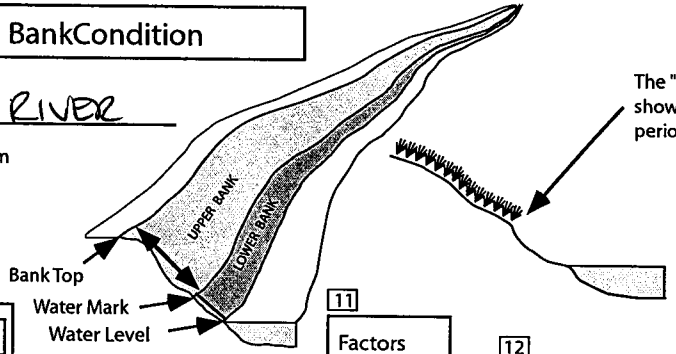
STATE OF THE RIVERS --- SHEET 7 BankCondition

© 1992 J. Anderson

Basin | Sub-section | Site (SITE CODE): DR22 | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 18/11/16 | Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

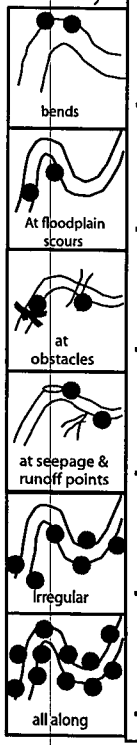
- [X] 1 Natural
- [ ] 2 Man-made
- [ ] 3 Absent

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width
	210	110	-010	000

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 60

NOTE: The 4 % figures below must = 100%

Stable: 50

Eroding: 10 | Aggrading: 40

Slumping: 0 (where)

2 UPPER BANK

Bare of Veg: 0

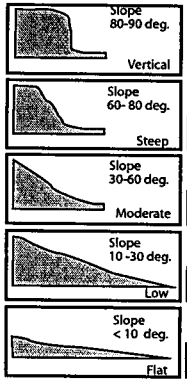
NOTE: The 4 % figures below must = 100%

Stable: 70

Eroding: 0 | Aggrading: 30

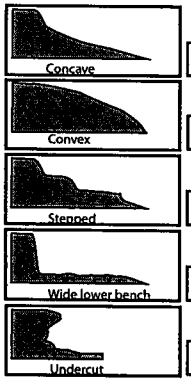
Slumping: 0 (where)

3 LEFT BANK Slope (RANK types)



- 1 [ ]
- 2 [ ]
- 3 [ ]
- 4 [X]
- 5 [ ]

4 LEFT BANK Shape (RANK types)



- 1 [ ]
- 2 [X]
- 3 [/]
- 4 [ ]
- 5 [ ]

11 Factors Affecting Stability

Flow & Waves	[ ] 1
Seepage	[ ] 2
Runoff	[ ] 3
Floodplain Scours	[ ] 4
Stock	[X] 5
People tracks	[ ] 6
Vermin, Ferals	[X] 7
Ford, road culvert, bridge, Weir	[X] 8
Clearing of Vegetation	[ ] 9
Gravel/sand extraction	[ ] 10
Mining	[ ] 11
Other ____	[ ]

** RANKS **

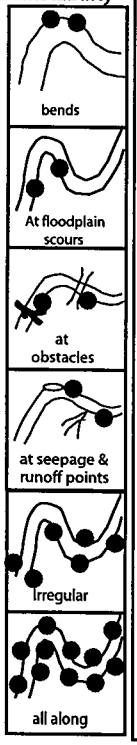
12 Artificial Bank Protection Measures

Trees & Other Plants	[ ] 1
Rock wall or layer	[ ] 2
Fence Structures	[ ] 3
Fenced watering points	[ ] 4
Fenced human access	[ ] 5
Logs strapped to bank	[ ] 6
Concrete Wall	[ ] 7
Break-water	[ ] 8
Other ____	[ ] 9
Other ____	[ ] 10
None	[X] 11

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 70

NOTE: The 4 % figures below must = 100%

Stable: 10

Eroding: 10 | Aggrading: 80

Slumping: 0 (where)

7 UPPER BANK

Bare of Veg: 5

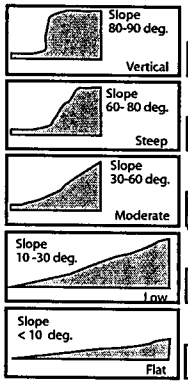
NOTE: The 4 % figures below must = 100%

Stable: 10

Eroding: 20 | Aggrading: 50

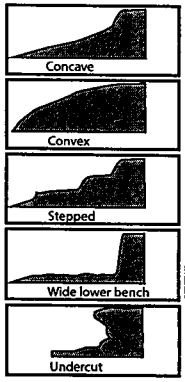
Slumping: 20 (where)

8 RIGHT BANK Slope (RANK types)



- 1 [ ]
- 2 [ ]
- 3 [X]
- 4 [ ]
- 5 [ ]

9 RIGHT BANK Shape (RANK types)



- 1 [ ]
- 2 [ ]
- 3 [X]
- 4 [ ]
- 5 [ ]

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	[ ]	[ ]	[X]	[ ]
Susceptibility to erosion	[ ] 1	[X] 2	[ ] 3	[ ] 4

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability	[ ]	[X]	[ ]	[ ]
Susceptibility to erosion	[ ] 1	[X] 2	[ ] 3	[ ] 4

STATE OF THE RIVERS --- SHEET 8 — Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE): DRR2 | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 18/11/16 | Recorder: TS

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Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point ☒
- Alternate / side Irregular ☒
- Mid-channel Island ☒
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

40 % of bed surface forming a bar

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size: SAND/GRAVEL

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere — short= interm, interm = long 1
- Disc — short < interm, interm = long 2
- Blade — short << interm, interm < long 3
- Rod — short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured — array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured — array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction — array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction — poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction — loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing ☒
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops ☒
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other _____
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted < 0.1 m deep & narrow	2
3	Moderately Restricted < 0.3 m deep & narrow	3
4	Partly Restricted 0.5 m deep & narrow	4
5	Good Passage 0.5 -1 m deep wide no torrent	5
6	Unrestricted > 1 m deep & almost channel wide	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall ☐ m	1	2	3	4	5	6	7
Cascade rapid or log jam ☐ m	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge ☐ m	1	2	3	4	5	6	7
Single log branch pile, rock ☐ m	1	2	3	4	5	6	7
Low feature easily by-passed ☐ m	1	2	3	4	5	6	7
None ☐ / Other ☐ ☐ m	1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2 ☒	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 18/11/16 Recorder JS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) 0222 | Tributary Name DAWSON RIVER

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 80 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 250 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	20	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	50	0
Woody Shrubs (< 2m)	0	
Vines	0	
Rushes & Sedges	0	
Herbs/Forbs (NOT WOODY)	60	80
Grasses	90	40
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 10 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - *Yes* ☐ 1 *No* ☐ 2

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.	X	
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☒
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☒
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

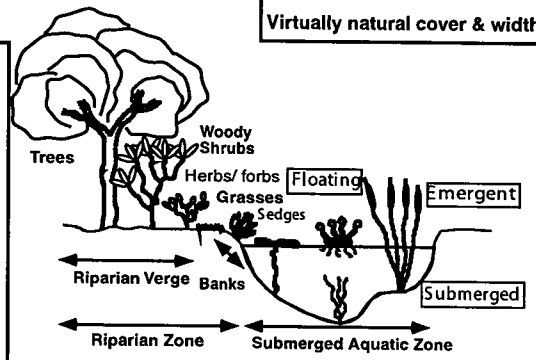
Visible depth (m)	0.5
Too turbid - pres only	
% Bare - no vegetation	100
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2 X
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		X
Major	X	
Minor		

15 Emergent Veg.

	% Submerged lands
Total emergents	0
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1	
Local Sp. 2	
Local Sp. 3	
Local Sp. 4	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 170 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 30 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	10	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	45	0
Woody Shrubs (< 2m)	5	0
Vines	0	
Rushes & Sedges	0	
Herbs/Forbs (NOT WOODY)	20	60
Grasses	80	15
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 5 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - *Yes* ☐ 1 *No* ☐ 2

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.	X		Palms		
Melaleuca spp. (paperbark)	X		Parthenium weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

STATE OF THE RIVERS --- SHEET 7 BankCondition

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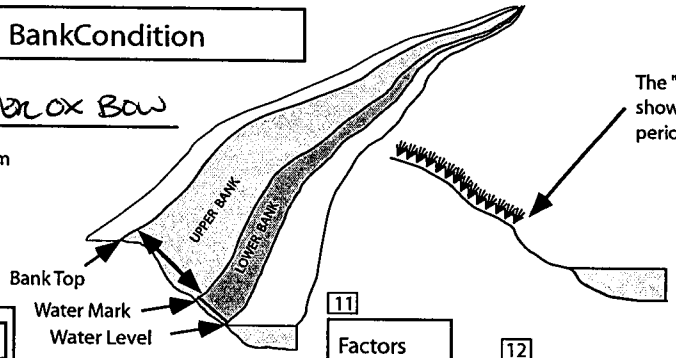
Basin | Sub-section | Site (SITE CODE): WLMP | Tributary Name: DAWSON RIVER OX BOW

Date (dd/mm/yy): 16/11/16 | Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

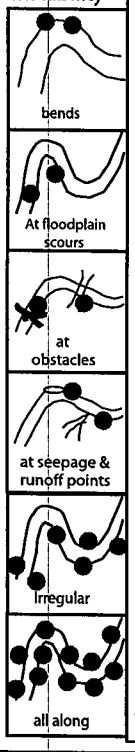
- [ ] 1 Natural
- [ ] 2 Man-made
- [x] 3 Absent

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding: 0 | Aggrading: 0

Slumping: 0

	where	where
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		

2 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

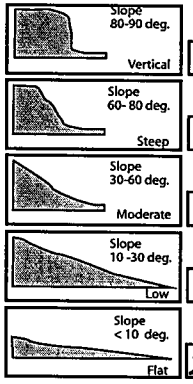
Stable: 100

Eroding: 0 | Aggrading: 0

Slumping: 0

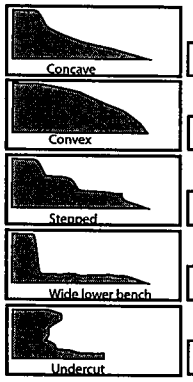
	where	where
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		

3 LEFT BANK Slope (RANK types)



- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [x] 5

4 LEFT BANK Shape (RANK types)



- [x] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

11 Factors Affecting Stability

Flow & Waves	1
Seepage	2
Runoff	3 [x]
Floodplain Scours	4
Stock	5 [x]
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8 [x]
Clearing of Vegetation	9
Gravel/sand extraction	10
Mining	11
Other ____	

** RANKS **

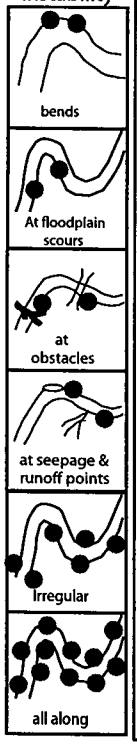
12 Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other ____	9
Other ____	10
None	11 [x]

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding | Aggrading

Slumping

	where	where
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		

7 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

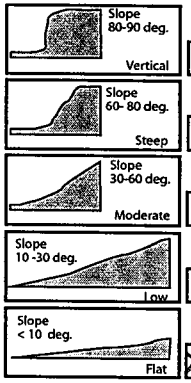
Stable: 100

Eroding | Aggrading

Slumping

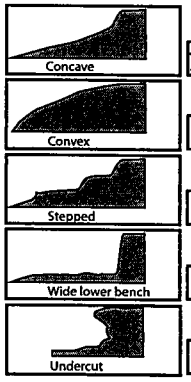
	where	where
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		

8 RIGHT BANK Slope (RANK types)



- [ ] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [x] 5

9 RIGHT BANK Shape (RANK types)



- [x] 1
- [ ] 2
- [ ] 3
- [ ] 4
- [ ] 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability			[x]	
Susceptibility to erosion	1	2 [x]	3	4

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability			[x]	
Susceptibility to erosion	1	2 [x]	3	4

STATE OF THE RIVERS --- SHEET 8 — Bed and Bar Condition

Date (dd/mm/yy) 16/11/16 Recorder TS

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Basin | Sub-section | Site (SITE CODE) WLMP1 | Tributary Name DAWSON RIVER OX BOW

Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent [X]
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:
(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long 1
- Disc: short < interm, interm = long 2
- Blade: short << interm, interm < long 3
- Rod: short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials [X]
- Mining
- Grazing
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted: < 0.1 m deep & narrow	2
3	Moderately Restricted: < 0.3 m deep & narrow	3
4	Partly Restricted: < 0.5 m deep & narrow	4
5	Good Passage: 0.5 -1 m deep wide no torrent	5
6 [X]	Unrestricted: > 1 m deep & almost channel wide	6 [X]

	m	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall		1	2	3	4	5	6	7
Cascade rapid or log jam		1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge		1	2	3	4	5	6	7
Single log branch pile, rock		1	2	3	4	5	6	7
Low feature easily by-passed		1	2	3	4	5	6	7
None		1	2	3	4	5	6	7
Other _____		1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3 [X]	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over-bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 16/11/16 Recorder TS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) WLMP1 | Tributary Name DAWSON RIVER OX BOW

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 500 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 50 Width of Riparian Vegetation (m)
- 2 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3 Type	% Cover	% Exotic spp.
Trees > 30 m	5	0
Trees 10 - 30 m	5	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	5	0
Woody Shrubs (< 2m)	0	
Vines	0	
Rushes & Sedges	10	0
Herbs/Forbs (NOT WOODY)	30	50
Grasses	100	80
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 30 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

5	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☒
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

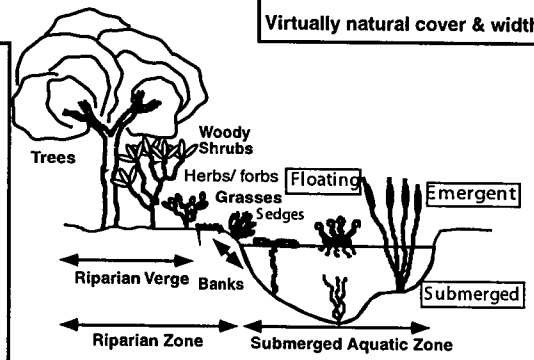
Visible depth (m)	0.3
Too turbid - pres only	
% Bare - no vegetation	50
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	20
Total % exotics	0
Filamentous algae	0
Freshwater Algae (Blue-green Algae)	0
Marine / estuarine algae	0
Chara / Nitella p. 57	0
Vallisneria/strap like forms p. 108-111	0
Herb like forms	0
Myriophyllumspp. p. 62-73	0
Potamogeton spp. p. 46-49 96-105	10 0
Triglochin spp. p. 178-181	0
Water Primrose p. 27	0
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	2
Total % Exotic Floating	0
Water Hyacinth p. 57	0
Azolla p. 3	10 0
Water Lilies p.32-41	0
Duckweeds p. 7	0
Other _____	0



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2 X
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None	X	X
Major		
Minor		

15 Emergent Veg.

	% Submerged lands
Total emergents	3
Total % exotic emergents	0
Phragmites p. 168	0
Typha (bull rush) p. 182	0
Para Grass p. 125	0
Other Rushes & Sedges	10 0
Encroaching willows	0
Other Shrubs & Trees	0
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☒
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 1000 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 200 Width of Riparian Vegetation (m)
- 10 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8 Type	% Cover	% Exotic spp.
Trees > 30 m	10	0
Trees 10 - 30 m	20	0
Trees < 10 m	5	0
Woody Shrubs (> 2m)	10	0
Woody Shrubs (< 2m)	10	0
Vines	0	
Rushes & Sedges	5	0
Herbs/Forbs (NOT WOODY)	35	60
Grasses	90	90
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 30 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

10	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)	X		Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		X
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

STATE OF THE RIVERS --- SHEET 7 BankCondition

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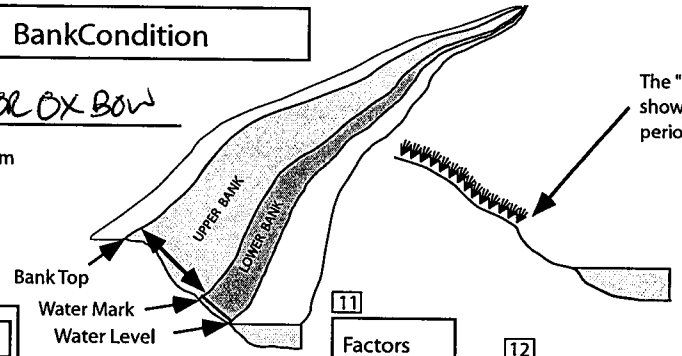
Basin | Sub-section | Site (SITE CODE) | Tributary Name: WLMP7 DAWSON RIVER OX BOW

Date (dd/mm/yy): 16/11/16 Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

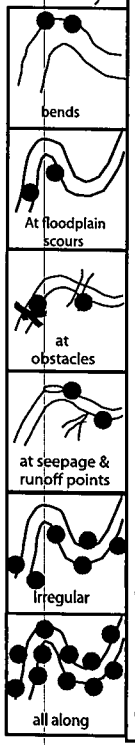
13 Levee Banks: 1 Natural; 2 Man-made; X 3 Absent

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding: 0 | Aggrading: 0

Slumping: 0 (where / where)

2 UPPER BANK

Bare of Veg: 0

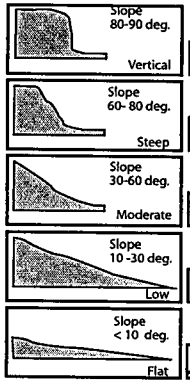
NOTE: The 4 % figures below must = 100%

Stable: 100

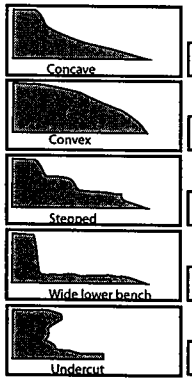
Eroding: 0 | Aggrading: 0

Slumping: 0 (where / where)

3 LEFT BANK Slope (RANK types)



4 LEFT BANK Shape (RANK types)



11 Factors Affecting Stability

Flow & Waves (1); Seepage (2); Runoff (3) X; Floodplain Scours (4); Stock (5) X; People tracks (6); Vermin, Ferals (7); Ford, road culvert, bridge, Weir (8); Clearing of Vegetation (9); Gravel/sand extraction (10); Mining (11); Other ____

** RANKS **

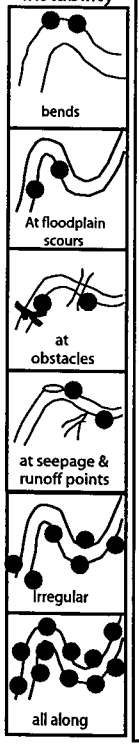
12 Artificial Bank Protection Measures

Trees & Other Plants (1); Rock wall or layer (2); Fence Structures (3); Fenced watering points (4); Fenced human access (5); Logs strapped to bank (6); Concrete Wall (7); Break-water (8); Other ____ (9); Other ____ (10); None (11) X

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding: 0 | Aggrading: 0

Slumping: 0 (where / where)

7 UPPER BANK

Bare of Veg: 0

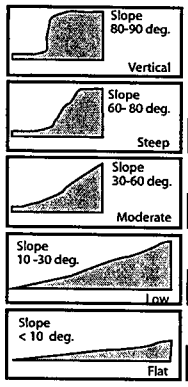
NOTE: The 4 % figures below must = 100%

Stable: 100

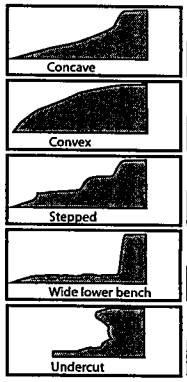
Eroding: 0 | Aggrading: 0

Slumping: 0 (where / where)

8 RIGHT BANK Slope (RANK types)



9 RIGHT BANK Shape (RANK types)



5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability			X	
Susceptibility to erosion		X		

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability			X	
Susceptibility to erosion		X		

STATE OF THE RIVERS --- SHEET 8 Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE) | Tributary Name

Site: WUMP7 Tributary Name: DANSON RIVER OX BOW

Date (dd/mm/yy): 16/11/16 Recorder: TS

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Record the total % of bed surface along the reach protruding out of the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent [X]
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 0

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:

(e.g fine sand, medium gravel, large boulders)

Angularity	Shape
Very Angular 1	Sphere: short= interm, interm = long 1
Angular 2	Disc: short < interm, interm = long 2
Sub Angular 3	Blade: short << interm, interm < long 3
Rounded 4	Rod: short << interm, interm = long 4
Well Rounded 5	

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None [X]

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted < 0.1 m deep & narrow	2
3	Moderately Restricted < 0.3 m deep & narrow	3
4	Partly Restricted < 0.5 m deep & narrow	4
5	Good Passage 0.5 -1 m deep wide no torrent	5
6 [X]	Unrestricted > 1 m deep & almost channel wide	6 [X]

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall							
m	1	2	3	4	5	6	7
Cascade rapid or log jam							
m	1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge							
m	1	2	3	4	5	6	7
Single log branch pile, rock							
m	1	2	3	4	5	6	7
Low feature easily by-passed							
m	1	2	3	4	5	6	7
None / Other							
m	1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3 [X]	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

RIGHT BANK BURNING, COULD NOT BE ASSESSED

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 16/11/16 Recorder TS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) WLMP4 | Tributary Name DAWSON RIVER OX BOW

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 150.0 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 150 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	15	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	5	0
Woody Shrubs (< 2m)	5	0
Vines	0	
Rushes & Sedges	10	0
Herbs/Forbs (NOT WOODY)	30	0
Grasses	75	50
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 35 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.	X		Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☑
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

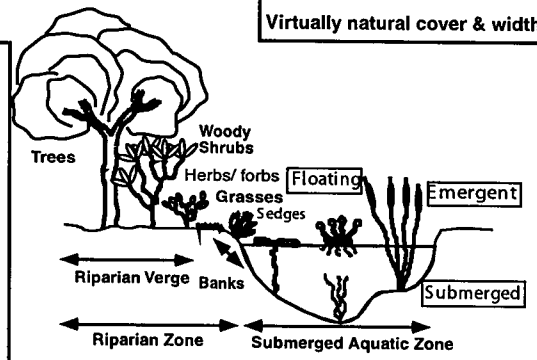
Visible depth (m)	2.0
Too turbid - pres only	–
% Bare - no vegetation	70
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	90
Total % exotics	0
Filamentous algae	0
Freshwater Algae (Blue-green Algae)	0
Marine / estuarine algae	0
Chara / Nitella p. 57	0
Vallisneria/strap like forms p. 108-111	0
Herb like forms	0
Myriophyllumspp. p. 62-73	0
Potamogeton spp. p. 46-49 96-105	100
Triglochin spp. p. 178-181	0
Water Primrose p. 27	0
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	10
Total % Exotic Floating	0
Water Hyacinth p. 57	0
Azolla p. 3	100
Water Lilies p.32-41	0
Duckweeds p. 7	0
Other _____	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	X 1	2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None	X	X
Major		
Minor		

15 Emergent Veg.

	% Submerged lands
Total emergents	30
Total % exotic emergents	0
Phragmites p. 168	0
Typha (bull rush) p. 182	0
Para Grass p. 125	0
Other Rushes & Sedges	100
Encroaching willows	0
Other Shrubs & Trees	0
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☐
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- Width of Riparian Vegetation (m)
- % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m		
Trees 10 - 30 m		
Trees < 10 m		
Woody Shrubs (> 2m)		
Woody Shrubs (< 2m)		
Vines		
Rushes & Sedges		
Herbs/Forbs (NOT WOODY)		
Grasses		
Tree Ferns		
Ferns / Bracken		
Mosses		
Mangroves		
Salt Marsh		
Coastal Heath		

9 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.	X		Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr		
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles		
Camphor Laurel			Mexican Poppy		
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

STATE OF THE RIVERS --- SHEET 7 BankCondition

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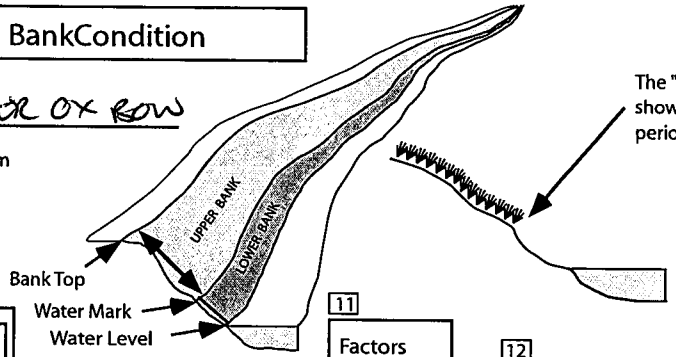
Basin | Sub-section | Site | Tributary Name

SITE CODE: WLMP S DAWSON RIVER OX BOW

Date (dd/mm/yy): 16/11/16 Recorder: JS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

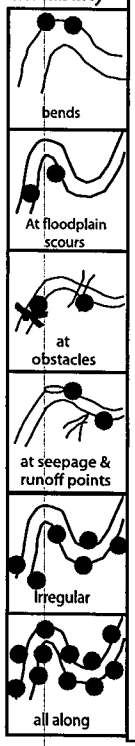
1 Natural
2 Man-made
3 Absent [X]

LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 10

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding | Aggrading

Slumping: where | where

2 UPPER BANK

Bare of Veg: 0

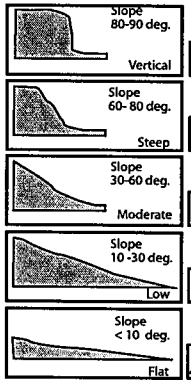
NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding | Aggrading

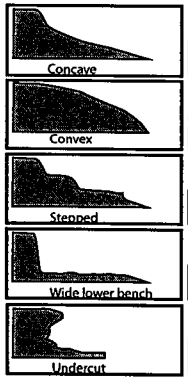
Slumping: where | where

3 LEFT BANK Slope (RANK types)



1 2 3 4 5 [X]

4 LEFT BANK Shape (RANK types)



1 [X] 2 3 4 5

11 Factors Affecting Stability

Flow & Waves	1
Seepage	2
Runoff	3
Floodplain Scours	4
Stock	5 [X]
People tracks	6
Vermin, Ferals	7
Ford, road culvert, bridge, Weir	8
Clearing of Vegetation	9 [X]
Gravel/sand extraction	10
Mining	11
Other ____	

** RANKS **

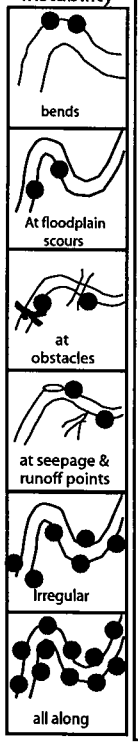
12 Artificial Bank Protection Measures

Trees & Other Plants	1
Rock wall or layer	2
Fence Structures	3
Fenced watering points	4 [X]
Fenced human access	5
Logs strapped to bank	6
Concrete Wall	7
Break-water	8
Other ____	9
Other ____	10
None	11

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 5

NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding | Aggrading

Slumping: where | where

7 UPPER BANK

Bare of Veg: 0

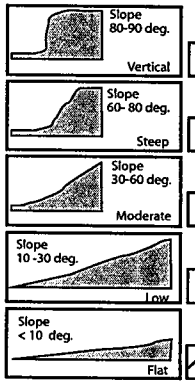
NOTE: The 4 % figures below must = 100%

Stable: 100

Eroding | Aggrading

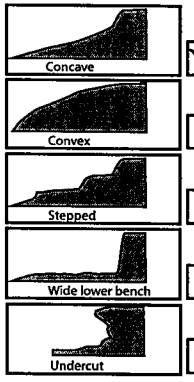
Slumping: where | where

8 RIGHT BANK Slope (RANK types)



1 2 3 4 5 [X]

9 RIGHT BANK Shape (RANK types)



1 [X] 2 3 4 5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability		[X]		
Susceptibility to erosion			[X]	

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability			[X]	
Susceptibility to erosion		[X]		

STATE OF THE RIVERS --- SHEET 8 — Bed and Bar Condition

Basin | Sub-section | Site: WUMP5 | Tributary Name: DANSON RIVER OX BOW

SITE CODE

Date (dd/mm/yy): 16/11/16 | Recorder: TS

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Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular
- Mid-channel Island
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 0

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size:

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere: short= interm, interm = long — 1
- Disc: short < interm, interm = long — 2
- Blade: short << interm, interm < long — 3
- Rod: short << interm, interm = long — 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured: array of sizes, tightly packed, overlapping, hard to dislodge — 1
- Packed, but not armoured: array of sizes, tightly packed, overlapping, can be dislodged — 2
- Moderate Compaction: array of sizes, some packing, little overlapping, can be dislodged — 3
- Low Compaction: poor grading, some packing & structure, little overlap, can be dislodged easily — 4
- Loose Compaction: loose array, no packing or structure, no overlap, easily moved — 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing ✓
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert
- Rock Outcrops
- Fallen Trees
- Vegetation
- Bed stabilising structures
- Laid Stone
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted (< 0.1 m deep & narrow)	2
3	Moderately Restricted (< 0.3 m deep & narrow)	3
4	Partly Restricted (< 0.5 m deep & narrow)	4
5	Good Passage (0.5 -1 m deep wide no torrent)	5
6	Unrestricted (> 1 m deep & almost channel wide)	6

	m	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall		1	2	3	4	5	6	7
Cascade rapid or log jam		1	2	3	4	5	6	7
Low weir, pipe culvert, ford, bridge		1	2	3	4	5	6	7
Single log branch pile, rock		1	2	3	4	5	6	7
Low feature easily by-passed		1	2	3	4	5	6	7
None		1	2	3	4	5	6	7
Other _____		1	2	3	4	5	6	7

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3 ✓	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 16/11/16 Recorder JS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) WCMP5 | Tributary Name DAWSON RIVER OX BOW

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 500 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 50 Width of Riparian Vegetation (m)
- 0 % Bare - no vegetation

Vegetation Cover of the Riparian Zone - *overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	5	0
Trees 10 - 30 m	10	0
Trees < 10 m	5	0
Woody Shrubs (> 2m)	0	
Woody Shrubs (< 2m)	0	
Vines	0	
Rushes & Sedges	5	
Herbs/Forbs (NOT WOODY)	30	60
Grasses	100	80
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 70 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

5

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.	X	X	Lomandra		
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)			Noogoora burr	X	
Native Pine (Callitris)			Burrs		
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)			Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- 1 Highly disturbed, distinct boundary on vegetation edge Width less than bank width ☒
- 2 Disturbed & non-grass species extend only to the bank top ☐
- 3 Disturbed & non-grass species extend partially into the original zone (floodplain) ☐
- 4 Thinned, semi-natural in cover and width ☐
- 5 Virtually natural cover & width ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

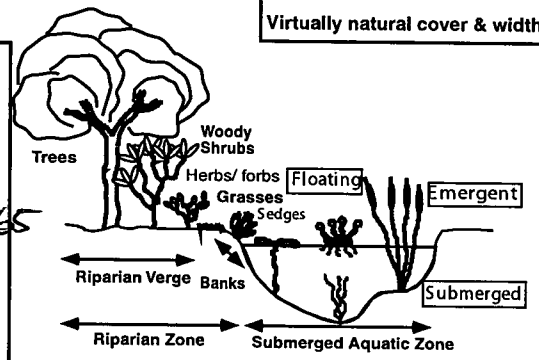
Visible depth (m)	30
Too turbid - pres only	
% Bare - no vegetation	65
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	35
Total % Exotic Floating	0
Water Hyacinth p. 57	0
Azolla p. 3	100
Water Lilies p.32-41	0
Duckweeds p. 7	0
Other _____	



Other species identified L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	1	2 X
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor		

15 Emergent Veg.

	% Submerged lands
Total emergents	5
Total % exotic emergents	0
Phragmites p. 168	0
Typha (bull rush) p. 182	0
Para Grass p. 125	0
Other Rushes & Sedges	100
Encroaching willows	0
Other Shrubs & Trees	0
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

7 Right Bank Scaling Factor

- 1 Highly disturbed, distinct boundary on vegetation edge Width less than bank width ☒
- 2 Disturbed & non-grass species extend only to the bank top ☐
- 3 Disturbed & non-grass species extend partially into the original zone (floodplain) ☐
- 4 Thinned, semi-natural in cover and width ☐
- 5 Virtually natural cover & width ☐

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 700 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 350 Width of Riparian Vegetation (m)
- 10 % Bare - no vegetation

Vegetation Cover of the Riparian Zone - *overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	20	0
Trees < 10 m	30	0
Woody Shrubs (> 2m)	15	0
Woody Shrubs (< 2m)	20	0
Vines	0	
Rushes & Sedges	10	0
Herbs/Forbs (NOT WOODY)		
Grasses	20	50
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 25 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ No ☐

10

	rare	common		rare	common
Rainforest	1	2	Lantana	1	2
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.			Palms		
Melaleuca spp. (paperbark)			Parthenium weed		
Callistemon spp. (bottlebrush)			Noogoora burr	X	
Native Pine (Callitris)			Burrs	X	
Exotic Pine			Milky weed spp.	X	
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)		X	Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

STATE OF THE RIVERS --- SHEET 7 BankCondition

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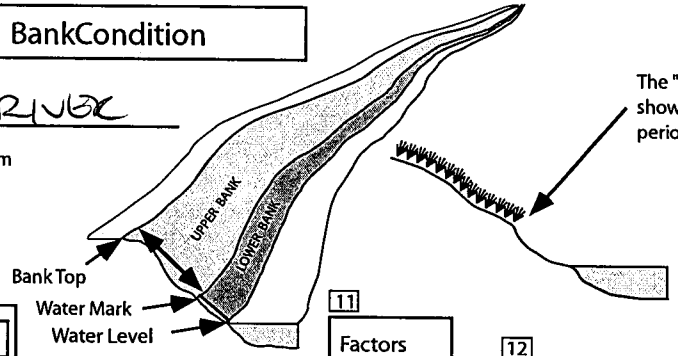
Basin | Sub-section | Site (SITE CODE) | Tributary Name: DAWSON RIVER

Date (dd/mm/yy): 16/11/16 Recorder: TS

Assess the condition of the banks on the left and right side of the stream (facing downstream). Identify the major types of instability (eroding, slumping & aggrading) and mark the location where they occur on the lower and upper banks. Also record and the slope and shape of the banks, and make nn overall assessment of instability.



The "Water Mark" is left at the normal inundation level in the stream. It's location is shown by the limit of the terrestial grasses etc. which can only withstand short periods of inundation, or by an eroded area or boundary in the bank sediment types.

13 Levee Banks

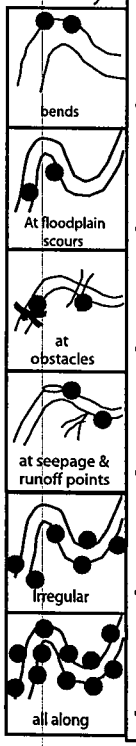
- 1 Natural
- 2 Man-made
- 3 Absent ✗

	LEFT Height	LEFT Width	RIGHT Height	RIGHT Width

LEFT BANK

Record % of bank length

LOCATION for Instability



1 LOWER BANK

Bare of Veg: 15

NOTE: The 4 % figures below must = 100%

Stable: 0

Eroding: 5 | Aggrading: 80

Slumping: 10

	where	where
bends	✗	✗
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		✗
all along		

2 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

Stable: 85

Eroding: 0 | Aggrading: 15

Slumping: 0

	where	where
bends		
At floodplain scours		
at obstacles		
at seepage & runoff points		
Irregular		
all along		✗

3 LEFT BANK Slope (RANK types)

Slope 80-90 deg. Vertical		1
Slope 60-80 deg. Steep		2
Slope 30-60 deg. Moderate		3
Slope 10-30 deg. Low	✗	4
Slope < 10 deg. Flat		5

4 LEFT BANK Shape (RANK types)

Concave	✗	1
Convex		2
Stepped		3
Wide lower bench		4
Undercut		5

11 Factors Affecting Stability

Flow & Waves		1
Seepage		2
Runoff	✗	3
Floodplain Scours		4
Stock	✗	5
People tracks		6
Vermin, Ferals		7
Ford, road culvert, bridge, Weir	✗	8
Clearing of Vegetation	✗	9
Gravel/sand extraction		10
Mining		11
Other ____		

** RANKS **

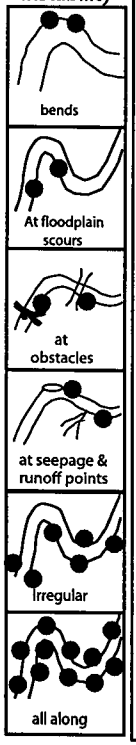
12 Artificial Bank Protection Measures

Trees & Other Plants		1
Rock wall or layer	✗	2
Fence Structures		3
Fenced watering points		4
Fenced human access		5
Logs strapped to bank		6
Concrete Wall		7
Break-water		8
Other ____		9
Other ____		10
None		11

RIGHT BANK

Record % of bank length

LOCATION for Instability



6 LOWER BANK

Bare of Veg: 55

NOTE: The 4 % figures below must = 100%

Stable: 20

Eroding: 25 | Aggrading: 50

Slumping: 5

	where	where
bends		
At floodplain scours	✗	✗
at obstacles	✗	
at seepage & runoff points	✗	
Irregular		✗
all along		

7 UPPER BANK

Bare of Veg: 0

NOTE: The 4 % figures below must = 100%

Stable: 50

Eroding: 5 | Aggrading: 45

Slumping: 0

	where	where
bends		
At floodplain scours	✗	
at obstacles	✗	
at seepage & runoff points		
Irregular		✗
all along		✗

8 RIGHT BANK Slope (RANK types)

Slope 80-90 deg. Vertical		1
Slope 60-80 deg. Steep	✗	2
Slope 30-60 deg. Moderate		3
Slope 10-30 deg. Low		4
Slope < 10 deg. Flat		5

9 RIGHT BANK Shape (RANK types)

Concave		1
Convex	✗	2
Stepped		3
Wide lower bench		4
Undercut		5

5 Rate the Overall Condition of the Left Bank

	High	Mod	Low	Min
Overall Instability	✗			
Susceptibility to erosion	✗ (1)	(2)	(3)	(4)

10 Rate the Overall Condition of the Right Bank

	High	Mod	Low	Min
Overall Instability		✗		
Susceptibility to erosion	(1)	✗ (2)	(3)	(4)

STATE OF THE RIVERS --- SHEET 8 — Bed and Bar Condition

Basin | Sub-section | Site (SITE CODE: SH)

Tributary Name: DANSON RIVER

Date (dd/mm/yy): 13/11/16

Recorder: TS

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Record the total % of bed surface along the reach protruding out of the water at the water mark and forming a bar. Identify its type, the features of the bed & gravel if present, the overall stability of the bed and the controls and factors affecting the stability of the bed.

1 BAR TYPE

- Bars Absent
- Point
- Alternate / side Irregular [X]
- Mid-channel Island [X]
- Encroaching Vegetation
- Around Obstructions
- Channel bar plain
- Low flow Meander infilled channel
- High Flow deposits

2 BAR SIZE

% of bed surface forming a bar: 30

3 Bed Features

(Only if dominant particle size > 2mm)

Most Common Substrate Type & Size: SAND

(e.g fine sand, medium gravel, large boulders)

Angularity

- Very Angular 1
- Angular 2
- Sub Angular 3
- Rounded 4
- Well Rounded 5

Shape

- Sphere — short= interm, interm = long 1
- Disc — short < interm, interm = long 2
- Blade — short << interm, interm < long 3
- Rod — short << interm, interm = long 4

4 Bed Surface

- Gravel covered by algae / silt 1
- Gravel - 'clean' 2

5 Bed Compaction

- Tightly packed, armoured — array of sizes, tightly packed, overlapping, hard to dislodge 1
- Packed, but not armoured — array of sizes, tightly packed, overlapping, can be dislodged 2
- Moderate Compaction — array of sizes, some packing, little overlapping, can be dislodged 3
- Low Compaction — poor grading, some packing & structure, little overlap, can be dislodged easily 4
- Loose Compaction — loose array, no packing or structure, no overlap, easily moved 5

6 Factors Affecting Stability

- Sand & Gravel extraction
- Bed deepening
- Bank Erosion [X]
- Channelisation
- Cut-off of supply of alluvial materials
- Mining
- Grazing [X]
- Other

7 Controls Stabilising the Bed

- Bridge Ford or Culvert [X]
- Rock Outcrops [X]
- Fallen Trees [X]
- Vegetation [X]
- Bed stabilising structures
- Laid Stone [X]
- Concrete Lining
- Other
- None

9 PASSAGE FOR FISH AND OTHER ORGANISMS

1. Score the general passage for the prevailing conditions (now) and for the stage equivalent to the water mark.
2. For Obstructions give type, height from bed level and stage when by-passed or over-topped.

Now		@ Water Mark
1	No Passage	1
2	Very Restricted (< 0.1 m deep & narrow)	2
3	Moderately Restricted (< 0.3 m deep & narrow)	3
4	Partly Restricted (< 0.5 m deep & narrow)	4
5	Good Passage (0.5 - 1 m deep wide no torrent)	5
6	Unrestricted (> 1 m deep & almost channel wide)	6

	@ WM	1/3	2/3	bank full	flood	extreme flood	never
High dam weir, or waterfall							
Cascade rapid or log jam							
Low weir, pipe culvert, ford, bridge							
Single log branch pile, rock							
Low feature easily by-passed							
None / Other							

8 Overall Bed Stability Rating

Unstable / Eroding ← Stable → Unstable / Aggrading

Severe Erosion	Moderate Erosion	Bed Stable	Mod. Aggradation	Severe Aggrad.
Bed scoured of sand Signs of deepening Bare eroded banks Erosion heads Erosion causes Steep bed 1	Little alluvium Signs of deepening Eroded banks Bed deep & narrow Steep bed Unconsoildated 2 [X]	Bed consolidated algae covered Bed & bar material the same size Alluvium balanced Banks stable 3	Mod. build-up at obstructions & bars Bed flat and uniform Bed wide & shallow Some minor over- bank siltation 4	Flat bed, channel blocked & wide but shallow. Bars large, covering most of bed / bank bed loose, unconsolidated 5

STATE OF THE RIVERS --- SHEET 9 Vegetation

Date (dd/mm/yy) 16/11/16 Recorder TS

22.9.94 D.Telfer

Basin | Sub-section | Site (SITE CODE) 54

Tributary Name DAWSON RIVER

The Riparian Zone The Riparian Zone is the corridor of vegetation along the edge of a stream or river which is immediately linked with the stream both in providing leaf and branch litter to the stream and being affected by the extra moisture available. It is the distinct vegetation zone along the stream. The strip chosen should be relatively homogeneous. Disturbed zones may be very thin.

1 LEFT BANK VEGETATION

Refer definition of the Riparian Zone

- 80 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 10.0 Width of Riparian Vegetation (m)
- 20 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

3

Type	% Cover	% Exotic spp.
Trees > 30 m	10	0
Trees 10 - 30 m	10	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	30	0
Woody Shrubs (< 2m)	5	0
Vines	0	
Rushes & Sedges	0	
Herbs/Forbs (NOT WOODY)	10	50
Grasses	60	25
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

4 10 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

5

	rare 1	common 2		rare 1	common 2
Rainforest			Lantana		
Eucalyptus spp.		X	Lomandra	X	
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)			Parthenium Weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs	X	
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil		
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)	X		Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats claw creeper		

2 Left Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☒
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

Assessment is made in terms of the % cover of the surface area for the zone specified for each type (submerged lands, banks or riparian verge)

7 Right Bank Scaling Factor

- Highly disturbed, distinct boundary on vegetation edge Width less than bank width 1 ☐
- Disturbed & non-grass species extend only to the bank top 2 ☒
- Disturbed & non-grass species extend partially into the original zone (floodplain) 3 ☐
- Thinned, semi-natural in cover and width 4 ☐
- Virtually natural cover & width 5 ☐

12 All Aquatic Vegetation

- submerged bed, within the wetted perimeter of the stream

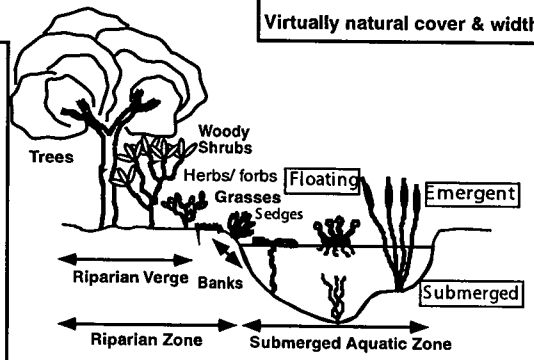
Visible depth (m)	0.5
Too turbid - pres only	✓
% Bare - no vegetation	100
Tot.% Exotic spp.	0

13 Submerged / Floating leaf

Total Cover	0
Total % exotics	
Filamentous algae	
Freshwater Algae (Blue-green Algae)	
Marine / estuarine algae	
Chara / Nitella p. 57	
Vallisneria/strap like forms p. 108-111	
Herb like forms	
Myriophyllumspp. p. 62-73	
Potamogeton spp. p. 46-49 96-105	
Triglochin spp. p. 178-181	
Water Primrose p. 27	
Other _____	

14 Floating Vegetation

	% Submerged lands
Total Floating	0
Total % Exotic Floating	
Water Hyacinth p. 57	
Azolla p. 3	
Water Lilies p.32-41	
Duckweeds p. 7	
Other _____	



Other species identified

L= left R= right

	rare	common
Gomphrena	1	2
Buffel Grass	✓ 1	2
Rhodes grass	1	2
Red natal grass	1	2
	1	2
	1	2
	1	2
	1	2

11 Signs of Regeneration (natives)

	Left	Right
None		
Major		
Minor	X	X

15 Emergent Veg.

	% Submerged lands
Total emergents	0
Total % exotic emergents	
Phragmites p. 168	
Typha (bull rush) p. 182	
Para Grass p. 125	
Other Rushes & Sedges	
Encroaching willows	
Other Shrubs & Trees	
Local Sp. 1 _____	
Local Sp. 2 _____	
Local Sp. 3 _____	
Local Sp. 4 _____	

6 RIGHT BANK VEGETATION

Refer Definition of the Riparian Zone

- 30.0 Width of Existing Vegetation (m) (riparian & non riparian vegetation)
- 15.0 Width of Riparian Vegetation (m)
- 5 % Bare - no vegetation

Vegetation Cover of the Riparian Zone -*overlaps allowed record presence for rare types % cover for abundant sp.*

8

Type	% Cover	% Exotic spp.
Trees > 30 m	0	
Trees 10 - 30 m	15	0
Trees < 10 m	10	0
Woody Shrubs (> 2m)	50	0
Woody Shrubs (< 2m)	35	0
Vines	0	
Rushes & Sedges	0	
Herbs/Forbs (NOT WOODY)	20	50
Grasses	70	25
Tree Ferns	0	
Ferns / Bracken	0	
Mosses	0	
Mangroves	0	
Salt Marsh	0	
Coastal Heath	0	

9 15 Total % Exotic spp. in zone

Local Species Checklist - *Recorded* - Yes ☐ 1 No ☐ 2

10

	rare 1	common 2		rare 1	common 2
Rainforest			Lantana		
Eucalyptus spp.		X	Lomandra		
Casuarina spp.		X	Palms		
Melaleuca spp. (paperbark)		X	Parthenium weed		
Callistemon spp. (bottlebrush)		X	Noogoora burr	X	
Native Pine (Callitris)			Burrs	X	
Exotic Pine			Milky weed spp.		
Native vines			Castor Oil	X	
Exotic vines			Thistles	X	
Camphor Laurel			Mexican Poppy	X	
Acacia spp. (native)	X		Rubber vine		
Grevillia spp.			Wild Tobacco		
Ficus spp. (figs)			Cats Claw Creeper		

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** WCMP1

Date: 16/11/16 **Time (24 hrs):** [1 0130] **GPS:** _____ **Project Name:** SANTOS PW 16

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

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River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score 55

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** WLMP4

Date: 16/11/16 **Time (24 hrs):** [113139] **GPS:** _____ **Project Name:** SANTOS PW 16.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (UM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score 50

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [WLMP151 1] **SITE NAME:** _____

Date: 16/11/16 **Time (24 hrs):** [1430] **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

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River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals	33	0	5	1

Score 39

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** DRR1

Date: 17/11/16 **Time (24 hrs):** [1130] **GPS:** _____ **Project Name:** SANTOS PRE W16.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 [UM3883] 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score 52

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** DRRZ

Date: 18/11/16 **Time (24 hrs):** [1 1 4 1 5 1 0] **GPS:** _____ **Project Name:** SATOS FAIRVIEW REM

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 [UM3883] 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score 60

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| | | | | |] **SITE NAME:** DRMP 1

Date: 17 / 11 / 16 **Time (24 hrs):** [1310] **GPS:** _____ **Project Name:** Santos Pre Wet 16.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU503400RSC.P65 (UM3883) 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score 23

AEF007

River Bioassessment Program

Queensland Government
Natural Resources and Mines

HABITAT ASSESSMENT FIELD SHEET

SITE NUMBER: [| S|4 | |] **SITE NAME:** S4

Date: 15/11/16 **Time (24 hrs):** [0439] **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

DU50340ORSC.P65 [LM3883] 20/8/98

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

NATURAL RESOURCES Queensland Government

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score

○ ○ ○ ○

Appendix C Site photographs

Representative images for Pre- and Post-wet season sampling rounds

Site	Pre-wet season	Post-wet season
DRR2		
WLMP1		
WLMP4		
WLMP5		
DRR1		

Site	Pre-wet season	Post-wet season
DRMP1		
S4	N/A	

Appendix D Habitat characteristics

Habitat characteristics of each waterway type in the 2016 Post-wet REMP survey

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Bank stability	***High*** • Shallow gradient and stable banks • Some minor bank erosion at WLMP1 and WLMP5, but confined to only one bank	***Low to high*** • Bank slope moderate to high at both sites • Erosion of lower banks at regular intervals at both sites, though minor at DRR1 • Slumping at seepage points at DRMP1 • Some erosion due to cattle access at both sites • Clearly higher bank stability at DRR1	***Low to moderate*** • Bank slope moderate to high • Erosion of lower banks at regular intervals on both banks • Slumping at seepage points on left bank • Some erosion due to cattle access and flood scouring • Lower left bank high degree of erosion
Bed stability	***High*** • Bank erosion and channel deepening only minor at WLMP1 • No aggradation observed	***Moderate*** • Some scouring leading to channel deepening, combined with bank erosion at both sites • Aggradation as point bars at DRMP1 and associated with mid-channel and vegetation-encroachment bars at DRR1	***Low*** • Severe scouring leading to channel deepening, combined with bank erosion • Aggradation on alternate sides and around obstacles

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Substrate diversity	***Low*** • Heavily dominated by silt-clay • Sand and gravel the only other particle sizes present (<5%) • High degree of compaction at WLMP1 and WLMP5	***Low to high*** • Ranging from silt to pebbles at DRMP1 • Heavily dominated by silt and clay at DRR1	***High*** • Ranges from silt and clay to boulders and bedrock (silt clay and cobble dominated) • Moderate level of compaction of sediment
Riparian vegetation condition	***Moderate*** • Some clearing for creating pasture at both sites • Nature species dominate canopy and understorey at both sites • Noogoora burr common on both banks • Native emergent macrophytes and filamentous algae present at WLMP1	***Moderate*** • Some clearing for creating pasture at both sites • Nature species dominate canopy and understorey at both sites • Native emergents present at DRR1	***Moderate*** • Some clearing for creating pasture at both sites • Nature species dominate canopy and understorey at both sites • Noogoora burr present on both banks in low abundance

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Flow habitats	***Low*** • Pool habitat only at WLMP1 • Backwater present at WLMP4	***Moderate to high*** • Riffle, glides, runs, pool habitat present at DRMP1 (pools and runs dominate) • Pools, runs and backwaters present at DRR1	***Low*** • Only run and pool habitat present • Pool habitat heavily dominant
Physical habitat features	***Low to moderate*** • Limited woody debris • Some aquatic plant cover (including filamentous algae) at WLMP1 • No bank undercuts • Little variation in substrate types • Limited variation in hydraulic habitat	***Moderate to high*** • Habitat included large woody debris, bank undercuts, limited macrophyte cover at both sites • A greater range of substrate and hydraulic habitat types at DRMP1 than DRR1	***Low*** • Limited large woody debris • Some undercuts • No macrophytes present but bed had 100% algal cover • Limited hydraulic habitat diversity

Habitat characteristics of each waterway type in the 2016 Pre-wet REMP survey

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Bank stability	***High*** • Shallow gradient and stable banks	***Low to moderate*** • Bank slope moderate to high at both sites • Erosion of lower banks at regular intervals at both sites, though minor at DRR1 • Slumping at seepage points at DRMP1 • Some erosion due to cattle access at both sites • DRR1 has high erosion of lower banks, but less aggradation than DRMP1 • High degree of aggradation observed at S4	***Moderate*** • Bank slope moderate to high • Erosion of lower banks at regular intervals on both banks • Minor slumping at seepage points on left bank • Some erosion due to cattle access and flood scouring • Lower left bank high degree of erosion • Moderate levels of aggradation on both banks
Bed stability	***High*** • No bars observed and only minor erosion	***Moderate*** • Some scouring leading to channel deepening at DRR1 • Some bank erosion at all three sites • Aggradation as point bars at DRR1 and DRMP1 • Aggradation associated with mid-channel bars and alternate bars at S4	***Low*** • Aggradation on alternate sides and as point bars and mid-channel islands

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Substrate diversity	***Low*** • Almost completed dominated by silt-clay	***Low to moderate*** • Sand and silt-clay dominated substrate at DRMP1 and S4 • Heavily dominated by silt and clay at DRR1	***High*** • Ranges from silt and clay to boulders and bedrock (silt clay and cobble dominated)
Riparian vegetation condition	***Moderate*** • Some clearing for creating pasture at both sites • Nature species dominate canopy and understorey at both sites • Noogoora burr common and other weed species including Mexican Poppy and Milky Weed also present • Native floating macrophyte (*Azolla* spp.) present at WLMP5	***Moderate*** • Some minor clearing at all sites • Nature species dominate canopy and understorey at all sites	***Moderate*** • Some minor clearing • Nature species dominate canopy and understorey • Noogoora burr present on both banks in low abundance and other weed species including Mexican Poppy and Milky Weed also present

Habitat attribute	Habitat characteristics		
	Waterbody	Dawson River	Hutton Creek
Flow habitats	***Low*** • Pool habitat only	***Moderate to high*** • Riffle, glides, runs, pool habitat present at S4 (pools and runs dominate) • Pools and runs present at DRR1 and DRMP1	***Low*** • Pool habitat only
Physical habitat features	***Low to moderate*** • Limited woody debris • Some aquatic plant cover (including filamentous algae) at WLMP1 • No bank undercuts • Little variation in substrate types • Limited variation in hydraulic habitat	***Moderate to high*** • Habitat included large woody debris, bank undercuts, limited macrophyte cover at all three sites • Minor coverage of macrophytes at DRR1	***Low*** • Limited large woody debris • Some undercuts • No macrophytes present but bed had 80% algal cover • Limited hydraulic habitat diversity

Appendix E Macroinvertebrate QA/QC

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Sofie Bernays **Processing Date:** 10/10/16

Project #: 41298605 **LIMS/Sample #:** SAN02/25 **Sample Code:** WLMP1 - rep 7

Site Name: Waterbody site 1 **Site Code:** WLMP1

Collection Date: 30/6/16 **Method/Habitat:** Surber - Edge **Collected By:** Alex Moore

Taxonomic Id Level: Family - QLD PRESERVAS level **Pass/Fail Rate (if set):** 90% **QA/QC By:** Zac Billingham

Incorrect Identification	Correct Identification	Error Code
Gastropoda sp.	Physidae	3
Gastropoda sp.	Planorbidae	3
Epiproctophora	Lestidae	3
Trichoptera sp.	Not in sample for QA - missing due to transfer or damaged	N/A

Number of Taxa (species/families): 16
Number Identified Incorrectly: 3
Percentage Correct: 81.25%
Pass or Fail: Fail
Comments: Provisional pass as identifier instructed not to take identifications further if not all features present by P.M.

Training Received For Incorrect Taxa? (Yes/No) **QA Date:** 11/11/16
Senior Taxonomist (min. 5yrs training) Zac Billingham
Identifier Sofie Bernays

Notes:
Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Zac Billingham **Processing Date:** 7/11/16

Project #: 41298640S **LIMS/Sample #:** SAN02/29 **Sample Code:** WLMP4-rep4

Site Name: Waterbody site 4 **Site Code:** WLMP4

Collection Date: 2/6/16 **Method/Habitat:** Surber-Edge **Collected By:** Alex Moore

Taxonomic Id Level: Family-Ausrivas level **Pass/Fail Rate (if set):** 90% **QA/QC By:** ~~Zac Billi~~ Laura Bateson

Incorrect Identification	Correct Identification	Error Code
Leptoceridae	Trichoptera sp.	4

Number of Taxa (species/families): 17
Number Identified Incorrectly: 1
Percentage Correct: 94.11%
Pass or Fail: pass
Comments: N/A

Training Received For Incorrect Taxa? (Yes/No) **QA Date:** 21/11/16

Senior Taxonomist (min. 5yrs training) Laura Bateson

Identifier Zac Billingham

Notes:

Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Zac Billingham Processing Date: 18/11/16

Project #: 41286405 LIMS/Sample #: SAN02/39 Sample Code: WLMPS-rep7

Site Name: Waterbody site 5 Site Code: WLMP 5

Collection Date: 31/5/16 Method/Habitat: Surber-Edge Collected By: Alex Moore

Taxonomic Id Level: Family - AusRIVAS level Pass/Fail Rate (if set): 90% QA/QC By: Laura Bateson

Incorrect Identification	Correct Identification	Error Code

Number of Taxa (species/families): 15

Number Identified Incorrectly: 0

Percentage Correct: 100%

Pass or Fail: Pass

Comments:

Training Received For Incorrect Taxa? (Yes/No) QA Date: 21/11/16

Senior Taxonomist (min. 5yrs training) Laura Bateson

Identifier Zac Billingham

Notes:

Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Zac Billingham **Processing Date:** 8/11/16

Project #: 41298640S **LIMS/Sample #:** SRN02/40 **Sample Code:** DRR1 - rep1

Site Name: Dawson River u/s of waterbody **Site Code:** DRR1

Collection Date: 2/6/16 **Method/Habitat:** Surber - Edge **Collected By:** Alesc Moore

Taxonomic Id Level: Family - Australian level **Pass/Fail Rate (if set):** 90% **QA/QC By:** Laura Bateson

Incorrect Identification	Correct Identification	Error Code
Sphaeridae	Bivalvia sp.	4
Baetidae	Ephemeroptera sp.	4

Number of Taxa (species/families): 23
Number Identified Incorrectly: 21
Percentage Correct: 91.3%
Pass or Fail: Pass
Comments:

Training Received For Incorrect Taxa? (Yes/No) **QA Date:** 21/11/16

Senior Taxonomist (min. 5yrs training) Laura Bateson

Identifier Zac Billingham

Notes:

Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Maria Bavins Processing Date: 2/12/16

Project #: 4129864606 LIMS/Sample #: SAN03/15 Sample Code: WLMPS - rep1

Site Name: Waterbody site 1 Site Code: WLMPS

Collection Date: 17/11/16 Method/Habitat: Surber - Edge Collected By: Tara Steele

Taxonomic Id Level: Family - AUSRIVAS level Pass/Fail Rate (if set): 90% QA/QC By: ~~Zac Bettington~~ Simon Harrow

Incorrect Identification	Correct Identification	Error Code
Ephemeroptera sp.	Baetidae	3
Ephemeroptera sp.	Caenidae	3
Gastropoda sp.	Not present in sample. Likely damaged or lost during transfer	N/A
Leptoceridae	Not in QA sample. Likely lost during transfer	N/A

Number of Taxa (species/families): 19

Number Identified Incorrectly: 2

Percentage Correct: 90%

Pass or Fail: Pass

Comments: Differences in numbers indicates loss of specimens during transfer to QA vial.

Training Received For Incorrect Taxa? (Yes/No) QA Date: 19/12/16

Senior Taxonomist (min. 5yrs training) Simon Harrow

Identifier Maria Bavins

Notes:

Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Maria Bavins **Processing Date:**

Project #: 412986406 **LIMS/Sample #:** SAN03/25 **Sample Code:** DRR1-rep 4

Site Name: Dawson River u/s of Waterbody **Site Code:** DRR1

Collection Date: 17/11/16 **Method/Habitat:** Surber-Edge **Collected By:** Tara Steele

Taxonomic Id Level: Family - AUSRIVAS level **Pass/Fail Rate (if set):** 90% **QA/QC By:** Simon Harrow

Incorrect Identification	Correct Identification	Error Code
Sphaeridae	Bivalvia	4
Atyidae	Palaemonidae	2
Orthocladiinae	Not in QA vial - likely lost during transfer	N/A

Number of Taxa (species/families): 19
Number Identified Incorrectly: 17
Percentage Correct: 90%
Pass or Fail: Pass
Comments: Sphaeridae may have been intact before being transferred to vial

Training Received For Incorrect Taxa? (Yes/No) **QA Date:** 19/12/16
Senior Taxonomist (min. 5yrs training) Simon Harrow
Identifier Maria Bavins

Notes:
Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

WSG-AEF003

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Maria Bavins **Processing Date:** 7/12/16

Project #: **LIMS/Sample #:** SAN03/32 **Sample Code:** DRMPL1-rep4

Site Name: Dawson River d/s Waterbody **Site Code:** DRMPL1

Collection Date: 17/11/16 **Method/Habitat:** Surber-Edge **Collected By:** Tara Steele

Taxonomic Id Level: Family-AUSRIVAS level **Pass/Fail Rate (if set):** 90% **QA/QC By:** Simon Harrow

Incorrect Identification	Correct Identification	Error Code
Chironomidae	Not in QA sample - likely lost during transfer	N/A
Chironominae	Not in QA sample - likely lost during transfer	N/A
Gastropoda sp	Not in QA sample. likely lost during transfer	N/A
Leptoceridae	Trichoptera Sp.	4

Number of Taxa (species/families): 15
Number Identified Incorrectly: 14
Percentage Correct: 93.33%
Pass or Fail: Pass.
Comments: Differences in counts and absence of some taxa in QA vial most likely represent losses during transfer to QA vial

Training Received For Incorrect Taxa? (Yes/No) **QA Date:** 19/12/16

Senior Taxonomist (min. 5yrs training) Simon Harrow

Identifier Maria Bavins

Notes:

Please refer N\AU\Canberra\Service\Water Sciences Group\ALS Folders\Consulting\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified (where required)
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount (These are NOT included in error rate calculations)
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

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Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Sediment Quality, Geomorphological and Biological Monitoring Report, 2017

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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freshwater estuarine marine

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1 Introduction

Santos GLNG (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos GLNG project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP design document, titled *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program* (frc environmental 2016). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the third year the REMP has been implemented.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake the DRRS REMP in 2017.

The purpose of this report is to present and record the methods and results of the 2017 post-wet and pre-wet REMP surveys, and provide an assessment of potential adverse effects of the release on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP) during each season. Sampling utilised the methods nominated in the REMP and included sediment quality, aquatic habitat, macroinvertebrate, fish and geomorphological (i.e. bed and bank stability) monitoring.

The work presented in this report was carried out by suitably qualified persons (Dr Ben Cook and Dr Andrew Bentley who are professional aquatic ecologists with Ph.D qualifications in freshwater biology and a combined total of over 28 years of industry experience as aquatic ecologists) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 2 – 5 May 2017; the pre-wet survey was implemented 14 – 17 November 2017.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are shown in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two watertypes: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As prescribed by the REMP, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and one (DRMP1) on the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges into the Waterbody and 8 km downstream of the	-25.692	149.216

Site	Description	GDA94	
		Latitude	Longitude
	confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.		
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2017 REMP surveys:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek on both surveys. This is consistent with water quality conditions throughout the baseline monitoring program,
- sediment quality data was not available from the control site on Hutton Creek (site DRR2) for the post-wet survey, and
- the release of desalinated produced water from ROP2 was continuous during the post-wet survey, but there were no releases made during the pre-wet survey.

149° E

149.2° E

Dawson River

Harris Creek

Boyd Creek

Belington Hut State Forest

Injune-Road

Expedition Resources Reserve

Beilba State Forest

Expedition (Limited Depth) National Park

Hutton Creek

Fitzroy Basin

DRR1

DRMP1

S4

WLMP4

WLMP5

WLMP1

DRR2

Stephenton State Forest

Commissioner Creek

Hallett State Forest

Sids Pocket Road

149° E

149.2° E

frc environmental
AQUATIC ECOLOGISTS
deep thinking.science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme Receiving Environment Program

Map 2.1:
Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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Document Path: Y:\Projects\2017\170307_SAN-DRRS_2017_REMPMapping\Workspaces\170307_Monitoring_Sites_17-06-20_AB.mxd

LEGEND

Monitoring Site
- Control sites upstream of receiving environment
- Waterbody sites within receiving environment
- Dawson River sites within receiving environment
- Watercourse
- Lake/Reservoir
- Basin

Road Network
- Local Road

Protected Area
- National Park
- Other Reserve

N

SCALE

0 2.25 4.5
Kilometres

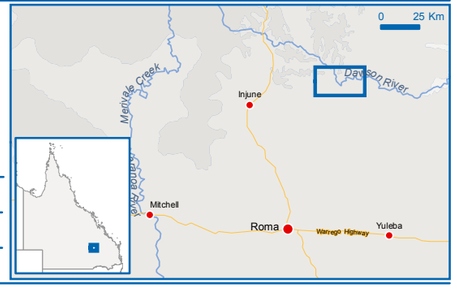
Scale: 1:80,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2017-06-20

DRAWN BY
AB

VERSION
01



3 Sediment Quality

3.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site except site DRR2 on Hutton Creek, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids). The analytical limit of reporting was specified on the chain of custody documentation, and this was achieved for all parameters except boron and selenium in both the post-wet and pre-wet surveys.

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2016).

3.2 Results

Results for the laboratory analyses of sediment quality (Table 3.1 and Table 3.2) showed that:

- The concentration of aluminium was higher than the local trigger value at sites WLMP1 and WLMP5 in the Waterbody in the post-wet survey. However, the 95th percentile of baseline data for the concentration of aluminium in sediment at site WLMP1 is 15,600 mg/kg, demonstrating that the recorded concentration of aluminium in sediment in May 2017 is consistent with ambient baseline conditions.
- The concentration of iron was higher than the local trigger value at sites WLMP4 and WLMP1 in the Waterbody in the post-wet survey, and at site WLMP1 in the pre-wet survey. The concentration of iron was also higher than the local trigger value at site DRR1 on the Dawson River on the pre-wet survey. However, the 95th percentile of baseline data for the concentration of iron in sediment in the Waterbody is 20,367 mg/kg, demonstrating that the recorded concentration of iron in sediment in the Waterbody is consistent with ambient baseline conditions. Site DRR1 is an

upstream control site, and is therefore not influenced by the release; furthermore, the 95th percentile concentration of baseline data for iron for the Dawson River is 12,053 mg/kg, demonstrating that results from the pre-wet survey were consistent with ambient baseline conditions.

- The concentration of manganese was higher than the local trigger value at site WLMP4 in the Waterbody in the post-wet survey, and at site DRR1 on the Dawson River in both the post-wet and pre-wet surveys. Site DRR1 is a control site upstream of the receiving environment, and therefore not influenced by the release of desalinated produced water from ROP2, with the recorded values also lower than the 95th percentile of baseline concentrations of manganese in sediment in the Dawson River (i.e. 346 mg/kg). The 95th percentile of baseline data for the concentration of manganese in sediment at site WLMP4 is 923 mg/kg, demonstrating that the recorded concentration of manganese in sediment in the post-wet survey is consistent with ambient baseline conditions.
- The concentration of all other parameters complied with the applicable local sediment quality guideline at all sites, noting that boron and selenium could not be assessed because the limit of reporting (LOR) was higher than the local trigger value.

Table 3.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2017 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River		
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1
Aluminium (Al)	mg/kg	50	13933	12600	15300	15400	5191	4080	580	4150
Arsenic (As)	mg/kg	5	20	< 5	6	< 5	20	< 5	< 5	< 5
Boron (B)	mg/kg	50	18.8	< 50	< 50	< 50	17.9	< 50	< 50	< 50
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1
Chromium (Cr)	mg/kg	2	80	11	11	13	80	4	< 2	4
Copper(Cu)	mg/kg	5	65	13	15	16	65	< 5	< 5	6
Iron (Fe)	mg/kg	50	17867	17900	19700	16600	9353	6770	1910	9120
Lead (Pb)	mg/kg	5	50	15	17	17	50	7	< 5	8
Manganese (Mn)	mg/kg	5	648	770	468	370	230.5	68	16	233
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1
Nickel (Ni)	mg/kg	2	21	11	12	12	21	4	< 2	6
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5
Zinc (Zn)	mg/kg	5	200	59	66	63	200	22	< 5	23

LOR = analytical limit of reporting

grey shading indicates where the LOR is higher than the trigger value.

Green shading indicated where the LOR was higher than the trigger value.

Table 3.2 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2017 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local Trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	10600	13900	12500	5191	2340	2930	5270	11800	3370
Arsenic (As)	mg/kg	5	20	7	8	<5	20	<5	<5	<5	4.5	<5
Boron (B)	mg/kg	50	18.8	<50	<50	<50	17.9	<50	<50	<50	25	<50
Cadmium (Cd)	mg/kg	1	1.5	<1	<1	<1	1.5	<1	<1	<1	<0.25	<1
Chromium (Cr)	mg/kg	2	80	10	11	12	80	3	<2	5	15	4
Copper(Cu)	mg/kg	5	65	13	17	16	65	<5	<5	7	11	<5
Iron (Fe)	mg/kg	50	17867	15900	20300	17600	9353	5860	5340	10700	20700	8390
Lead (Pb)	mg/kg	5	50	17	20	18	50	<5	6	9	16	8
Manganese (Mn)	mg/kg	5	648	586	593	373	230.5	136	45	277	337	129
Mercury (Hg)	mg/kg	0.1	0.15	–	–	–	0.15	–	–	–	<0.25	–

Parameter	Unit	LOR	Local trigger - Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local Trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Nickel (Ni)	mg/kg	2	21	12	14	12	21	4	<2	7	9	4
Selenium (Se)	mg/kg	5	1	<5	<5	<5	1.73	<5	<5	<5	1	<5
Zinc (Zn)	mg/kg	5	200	53	66	59	200	14	6	30	45	20

LOR = analytical limit of reporting

grey shading indicates where the LOR is higher than the trigger value.

Green shading indicated where the LOR was higher than the trigger value.

4 Aquatic Habitat, and Bed and Bank Stability

4.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP design document (frc environmental 2015).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons against baseline condition, as presented in the REMP design document (frc environmental 2016), have been made.

4.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 4.1 and Table 4.2) showed:

- bed and bank stability at all sites and for all water types had not changed from baseline condition
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with rainfall leading up to each survey increasing the water level and the number of submerged large woody debris and submerged aquatic plants, and
- all other aquatic habitat features for all water types had not changed from baseline condition.

Table 4.1 Habitat characteristics of each water type in the 2017 post-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	*high*	*low to moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 4.2 Habitat characteristics of each water type in the 2017 pre-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	*high*	*low to moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

5 Macroinvertebrate Communities

5.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2016).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual 2009* (DEHP 2013). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. An error rate of < 10% was considered acceptable as per the REMP, and this was achieved.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (in this assessment, generally 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each site, and the median for each index calculated for each water type, and compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP design document; frc environmental 2016). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range , then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

5.2 Results

Results for macroinvertebrate indices showed that (Table 5.1, Table 5.2, Table 5.3 and Table 5.4):

- Several sites in the Waterbody and site DRR2 on Hutton Creek, had taxonomic richness, PET richness and SIGNAL-2 Scores that were higher than the local biological guideline in the post-wet survey, with sites on the Waterbody, Dawson River and Hutton Creek also having taxonomic richness, PET richness and / or SIGNAL-2 score higher than the local biological guideline in the pre-wet survey. Generally results were not consistent across the two surveys, with only site WLMP5 having taxonomic richness, PET richness and SIGNAL-2 Scores higher than the local biological objective on both surveys. The Waterbody and Hutton Creek water types overall also had high taxonomic richness, PET richness and SIGNAL-2 Scores compared to the guideline value in the post-wet survey, with the Waterbody having high values for these metrics in the pre-wet survey. Of these, taxonomic richness at site WLMP4 in the pre-wet survey, and PET richness at site WLMP5 in the pre-wet survey and for the Waterbody overall in the pre-wet survey, were higher than the baseline range. These high values were likely due to an increase in water level at the time of the surveys compared to baseline condition, with heavy rainfall leading up to the surveys creating favourable conditions for recruitment by aquatic insects, such as the PET taxa, and increased the diversity and / or abundance of these sensitive taxa compared to baseline conditions;
- Taxonomic richness complied with the local biological guideline at all sites (and all water types), except at the Dawson River site DRMP1 in the post-wet survey, where it was below the local guideline. Further analysis of the taxonomic richness for site DRMP1 showed that it is higher than the 5th percentile of baseline taxonomic richness for the Dawson River water type, indicating that the 2017 post-wet REMP survey monitoring result was within the baseline range of variation; and
- The abundance of macroinvertebrates complied with the local biological guideline at all sites (and all water types), except at site DRMP1 on the Dawson River in the post-wet survey, site WLMP1 in the Waterbody in both surveys, and overall for the Waterbody water type in the post-wet survey. Further analyses showed that the abundance of macroinvertebrates at site DRMP1 and for the Waterbody water type were higher than the 5th percentile of baseline macroinvertebrate abundance scores for their water type, indicating that the results were within the baseline range of variation. Furthermore, the abundance at site WLMP1 in the waterbody was higher than the 5th percentile of baseline abundance scores for site WLMP1 on both surveys and all other macroinvertebrate indices complied with the local biological guideline for the site on both surveys. Therefore these results are consistent with the baseline range of variation.

Table 5.1 Macroinvertebrate results for each site in the 2017 post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	132.00	46.00	136.00	39.9–152.0	34.00	51.00	115.00	23.0–207.4	117.00
Taxonomic Richness	5.67–10.8	12.00	9.00	10.00	9.93–16.9	9.00	11.00	13.00	4.0–10.0	15.00
PET richness	0 – 1.2	2.00	1.00	2.00	1.47–4.0	2.00	3.00	2.00	0–1.0	2.00
SIGNAL-2 Score	2.65 – 3.20	3.48	3.25	3.39	3.46–4.00	3.74	3.86	3.46	2.90–3.30	3.54

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 5.2 Macroinvertebrate results for each water type in the 2017 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	92.00	39.9 – 152.0	66.00	23.0 – 207.4	117.00
Taxonomic Richness	5.67–10.8	11.00	9.93 – 16.9	11.00	4.0 – 10.0	15.00
PET richness	0 – 1.2	2.00	1.47 – 4.0	2.00	0 – 1.0	2.00
SIGNAL-2 Score	2.65 – 3.20	3.39	3.46 – 4.00	3.71	2.90 – 3.30	3.54

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 5.3 Macroinvertebrate results for each site in the 2017 pre-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	177.0	63.0	189.0	39.9–152.0	85.0	119.0	181.0	23.0–207.4	104.0
Taxonomic Richness	5.67–10.8	21.0	12.0	14.0	9.93–16.9	11.0	14.0	18.0	4.0–10.0	11.0
PET richness	0 – 1.2	3.0	2.0	4.0	1.47–4.0	2.0	4.0	5.0	0–1.0	1.0
SIGNAL-2 Score	2.65 – 3.20	3.20	3.27	3.50	3.46–4.00	3.81	3.92	3.98	2.90–3.30	3.16

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 5.4 Macroinvertebrate results for each water type in the 2017 pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	161.0	39.9 – 152.0	119.0	23.0 – 207.4	104.0
Taxonomic Richness	5.67–10.8	14.0	9.93 – 16.9	15.0	4.0 – 10.0	11.0
PET richness	0 – 1.2	3.0	1.47 – 4.0	4.0	0 – 1.0	1.0
SIGNAL-2 Score	2.65 – 3.20	3.32	3.46 – 4.00	3.92	2.90 – 3.30	3.16

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

6 Fish

6.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 6.1 and Table 6.2). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 181742) and Animal Ethics Approval (CA 2015/08/893) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 6.1 Effort used to catch freshwater fish in the 2017 post-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	14:00	8:00	36 h
	cathedral (2)	pool	14:00	8:00	36 h
WLMP1	fyke net (2)	pool	15:30	9:30	36 h
	cathedral (2)	pool	15:30	9:30	36 h
WMLP5 [1]	fyke net (2)	pool	16:30	11:30	38 h
	cathedral (2)	pool	16:30	11:30	38 h
Dawson River					
DRMP1	fyke net (2)	pool	14:00	8:00	36 h
	cathedral (2)	pool	14:00	8:00	36 h
S4	fyke net (2)	pool	15:00	10:00	38 h
	cathedral (2)	pool	15:00	10:00	38 h

Site	Method	Habitat	Time In	Time Out	Effort
DRR1	fyke net (2)	pool	16:00	12:30	41 h
	cathedral (2)	pool	16:00	12:30	41 h
Hutton Creek					
DRR2	fyke net (2)	pool	15:30	6:30	30 h
	cathedral (2)	pool	15:30	6:30	30 h

[1] several fish were also caught at this site in cathedral traps set for turtles.

Table 6.2 Effort used to catch freshwater fish in the 2017 pre-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	15:30	8:30	34 h
	cathedral (2)	pool	15:30	8:30	34 h
WLMP1	fyke net (2)	pool	16:00	11:00	38 h
	cathedral (2)	pool	16:00	11:00	38 h
WMLP5	fyke net (2)	pool	17:00	13:00	40 h
	cathedral (2)	pool	17:00	13:00	40 h
Dawson River					
DRMP1	fyke net (2)	pool	14:30	8:30	36 h
	cathedral (2)	pool	14:30	8:30	36 h
S4 [1]	fyke net (2)	pool	16:00	12:30	37 h
	cathedral (2)	pool	16:00	12:30	37 h
DRR1	fyke net (2)	pool	15:00	10:30	45 h
	cathedral (2)	pool	15:00	10:30	45 h
Hutton Creek					
DRR2	fyke net (2)	pool	17:00	15:00	44 h
	cathedral (2)	pool	17:00	15:00	44 h

[1] several fish were also caught at this site in cathedral traps set for turtles.

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2016) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

6.2 Results

Thirteen species of native fish were caught and / or observed during the 2017 REMP surveys (Table 6.3 and Table 6.4). None of these species are conservation significant species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act). The number of native species caught at each site ranged from four (site WLMP1 in the post-wet survey and site DRR2 in the pre-wet survey) to ten (site S4 in the pre-wet survey). Total abundance of fish at each site ranged from 11 (site DRR1 in the post-wet survey) to 2,372 (site WLMP1 in the pre-wet survey). The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites. The most commonly recorded species were carp gudgeons, Agassiz's glassfish and eastern rainbowfish. One exotic species was caught (goldfish) from sites WLMP4 and WLMP5 in the post-wet survey, with no exotic species caught in the pre-wet survey.

All water types achieved the local biological guideline for fish on each survey (i.e. had an observed : expected ratio of species diversity that was ≥ 1) (Table 6.5 and Table 6.6). This indicates that the diversity of fish caught during the 2017 REMP surveys was the same as or higher than that recorded during the baseline monitoring program. Increased water levels associated with heavy rainfall in March and October 2017 (i.e. within six weeks prior to each survey) may have created favourable conditions for fish in these water types compared to baseline conditions.

All sites also achieved the biological guideline for exotic fish, indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 6.3 Total abundance of freshwater fish for each species at each site in 2017 post-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	agassiz's glassfish	105	388	636	3	10	1	–	**1143**
Craterocephalus stercusmuscarum	flyspecked hardyhead	13	–	11	–	–	–	–	**24**
Hypseleotris compressa	empire gudgeon	–	–	–	–	12	–	–	**12**
Hypseleotris spp.	carp gudgeon	165	155	541	–	20	2	70	**953**
Leiopotherapon unicolor	spangled perch	2	–	2	1	–	1	1	**7**
Macquaria ambigua	yellow belly	–	–	–	1	–	1	1	**3**
Melanotaenia splendida splendida	eastern rainbowfish	18	37	48	73	86	1	91	**354**
Nematalosa erebi	bony bream	1	2	1	1	3	1	8	**17**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	–	1	–	–	–	**1**
Philypnodon grandiceps	flathead gudgeon	–	–	–	–	–	–	1	**1**
Pseudomugil signifer	Pacific blue eye	–	–	–	–	32	3	–	**35**
Tandanus tandanus	freshwater catfish	–	–	–	17	–	1	3	**21**
Total native individuals		**304**	**582**	**1239**	**97**	**163**	**11**	**175**	**2571**
Total native species		**6**	**4**	**6**	**7**	**6**	**8**	**7**	**12**
Exotic Species									
Carassius auratus	goldfish	3	–	1	–	–	–	–	**4**

– not caught

Table 6.4 Total abundance of freshwater fish for each species at each site in 2017 pre-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	agassiz's glassfish	240	980	455	1	8	26	–	**1710**
Craterocephalus stercusmuscarum	flyspecked hardyhead	59	53	47	1	5	1	–	**166**
Hypseleotris spp.	carp gudgeon	71	1185	620	–	97	429	71	**2473**
Leiopotherapon unicolor	spangled perch	1	1	–	–	–	–	–	**2**
Macquaria ambigua	yellow belly	–	–	–	–	1	1	–	**2**
Melanotaenia splendida splendida	eastern rainbowfish	124	152	488	15	168	179	1	**1127**
Nematalosa erebi	bony bream	3	1	1	–	1	–	3	**9**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	1	–	3	1	1	**6**
Philypnodon grandiceps	flathead gudgeon	–	–	–	–	–	1	–	**1**
Pseudomugil signifer	Pacific blue eye	–	–	–	2	12	7	–	**21**
Tandanus tandanus	freshwater catfish	–	–	–	5	26	3	–	**34**
Porochilus rendahli	Rendahl's catfish	1	–	–	–	5	–	–	**6**
Total native individuals		**499**	**2372**	**1612**	**24**	**324**	**646**	**76**	**5557**
Total native species		**7**	**6**	**6**	**5**	**10**	**9**	**4**	**12**

– not caught

Table 6.5 Comparison of fish monitoring results with the local biological objective for fish for the 2017 post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	6	1.5
Dawson River	5	10	2.0
Hutton Creek	2	7	3.5

Table 6.6 Comparison of fish monitoring results with the local biological objective for fish for the 2017 pre-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	8	2.0
Dawson River	5	11	2.2
Hutton Creek	2	4	2.0

7 Macrocrustaceans – Exoskeleton Assessment

7.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 7.1).

7.2 Results

The macrocrustaceans caught during the 2017 post-wet REMP survey were of the same species caught from each water type during the baseline monitoring program (Table 7.2), although yabbies (Cherax destructor) were caught at sites WLMP1 and WLMP4 in the pre-wet survey. All specimens had exoskeletons that were of robust and good condition (Table 7.2 and Table 7.3). No macrocrustacean was recorded in breeding condition during the post-wet season, which is consistent with the results of baseline surveys implemented in Autumn, although macrocrustaceans in the Waterbody and Dawson River were breeding (i.e. gravid) in the pre-wet survey, which is consistent with the results of baseline surveys implemented in Spring.

Table 7.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 7.2 Macrocrustacean species and condition recorded during the 2017 post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp.
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 7.3 Macrocrustacean species and condition recorded during the 2017 pre-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
	Cherax destructor	*Caridina* spp.	*Caridina* spp.
Breeding condition	*M. australiense* breeding	both taxa breeding	Neither taxa breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae); *Cherax destructor* – yabbie (family Parastacidae)

8 Assessment of Environmental Changes

The monitoring results for the 2017 post-wet and pre-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- Physical habitat features in the Waterbody, which had improved from baseline condition due to high water levels associated with heavy rainfall leading up to the surveys. The high water levels increased submerged aquatic plant cover and cover of large woody debris in water.
- Several results for the macroinvertebrate indices in the pre-wet survey (i.e. taxonomic richness at site WLMP4, PET richness at site WLMP5, and for the Waterbody overall), which were higher than the baseline range. These high values were likely due to an increase in water level at the time of the surveys compared to baseline condition, with heavy antecedent rainfall prior to the surveys creating favourable conditions for recruitment by aquatic insects, such as the PET taxa, and increased the diversity and / or abundance of these sensitive taxa compared to baseline conditions.
- The diversity of native fish was higher than the baseline range in some instances, especially for the Hutton Creek site (DRR2) in the post-wet survey. As for the habitat and macroinvertebrate results, this observed increase in fish diversity is likely due to higher water levels during the 2017 REMP surveys compared to water levels during the baseline surveys (site DRR2 was near-dry on a number of the baseline surveys).

Overall, the 2017 post-wet and pre-wet REMP survey results indicated that the release of desalinated produced water from ROP2 had not influenced aquatic ecology in the receiving environment.

9 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. User Manual Version 4 ed. Canberra: Commonwealth of Australia.

DEHP 2013. Monitoring and Sampling Manual 2009, Environmental Protection (Water) Policy 2009, Version 1. Department of Environment and Resource Management.

EHMP 2007. Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report. Brisbane: South East Queensland Healthy Waterways Partnership.

frc environmental 2016. Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program, Santos.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994.*

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Sediment Quality, Geomorphological and Biological Monitoring Report, 2017, frc environmental 9 February 2018

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions (B44), (B45)(i), (B45)(k) and (B45)(m) of environmental authority EPPG00928713 dated 19th September 2017, as detailed in the Receiving Environment Monitoring Program, dated 7th November 2016

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Ben Cook

(Insert full name of person making this declaration)

of, 157 Prospect St, Wynnum, Brisbane, QLD.

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the requirements of conditions (B44), (B45)(i), (B45)(k) and (B45)(m) of environmental authority EPPG00928713 dated 19th September 2017;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Sediment Quality, Geomorphological and Biological Monitoring Report, 2017,frc environmental, 9 February 2018;
4. The content of Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Sediment Quality, Geomorphological and Biological Monitoring Report, 2017,frc environmental, 9 February 2018is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Sediment Quality, Geomorphological and Biological Monitoring Report, 2017,frc environmental, 9 February 2018 meets the requirements of conditions ((B44), (B45)(i), (B45)(k) and (B45)(m) of environmental authority EPPG00928713 dated 19th September 2017.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at Cleveland, Brisbane Qld.
(Insert name of town or city and suburb)

this 09 (Insert day, e.g. 18th) day of February (Insert month) in the year 2018. (Insert year)

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No.: 78010 DEPT. OF JUSTICE & ATTORNEY-GENERAL

Signed (Person making this declaration)

Signed (Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations / Solicitor / Barrister~~

Pauline May Kilburn
JP (Qual)

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature	Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – current)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Lady Annie Operations Receiving Environment Monitoring Program 2017. CST Minerals Lady Annie Pty Ltd.
- Poitrel Mine 2017 Receiving Environment Monitoring Program. BHP BMC.
- South Walker Creek Mine 2017 Receiving Environment Monitoring Program. BHP BMC.
- Oaky Creek Coal Mine 2017 Receiving Environment Monitoring Program. Glencore. 2017.
- Newlands Coal Project 2017 In-stream Monitoring Program. Glencore Coal Queensland.
- Clermont Open Cut Receiving Environment Monitoring Program. Clermont Open Cut. 2014 – 2017.
- Chinchilla Beneficial Use Scheme: Receiving Environment Monitoring Program. SunWater. 2013 – ongoing.
- Glebe Beneficial Use Scheme Receiving Environment Monitoring Program. SunWater. 2015-ongoing.

Andrew Bentley

B.Sci., B.Sc. (Hons.), Ph.D.

Ecologist | Freshwater

andrewbentley@frcenv.com.au

With over ten years of industry and academic experience across a range of disciplines, Andrew brings a strong set of skills and knowledge to each project he works on. He has a Ph.D. in freshwater biology and has a thorough understanding of the biogeography, ecology and management of freshwater ecosystems. Andrew joined frc environmental after working on both academic and government projects, most recently for Griffith University, Monash University, National Parks Queensland and the Queensland Department of Environment and Resource Management.

Andrew's key expertise lies in the design and implementation of research on aquatic environments, specifically the ecological assessment, connectivity and biodiversity of freshwater ecosystems. He has extensive experience in the assessment and delivery of advice in relation to waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs) and the protection of aquatic Matters of National Environmental Significance (MNES) and aquatic Matters of State Environmental Significance (MSES).

Andrew has extensive field experience throughout Australia using a range of sampling techniques, has a wide range of laboratory skills (including microscopy, DNA barcoding), a strong set of computer and analytical skills, and prolific knowledge in the analysis of ecological data using univariate and multivariate approaches. He has extensive field experience across a range of disciplines with experience in the collection and identification of freshwater biota, trapping and banding of birds, tracking of mammals and measuring and monitoring of aquatic and riparian health pre- and post- rehabilitation.

Andrew has communicated the results of his work in peer-reviewed journals, technical reports for the Queensland Government and the Australian Rivers Institute and international and Australian conference presentations. He also utilises his strong communication skills to educate others through tutoring both academically and privately. Andrew is known by his colleagues as a highly approachable diligent worker that goes above and beyond to produce good quality science.

Specialisations

- Aquatic ecological assessment and management
- Molecular ecology and DNA barcoding of freshwater fish, crustaceans and invertebrates
- Water and sediment quality
- Experimental design and statistical analysis

Employment History

- Ecologist (Freshwater), frc environmental, Brisbane (2015 – current)
- Research Assistant, Australian Rivers Institute, Brisbane (2007 – 2016)
- Fieldwork Assistant, Griffith University, Brisbane (2006 – 2016)
- Academic Tutor, Griffith University, Brisbane (2008 – 2012)
- Fieldwork Assistant, Department of Environment and Resource Management (2006 – 2006)

Relevant Project History

During previous university-based employment, Andrew both lead and collaborated on a number of projects relating to freshwater ecology, and contributed to a number of published peer-reviewed journal articles, some of which he was lead author.

In his current role, Andrew has worked at different capacities on approximately 50 commercial water quality and / or freshwater ecology projects, including as Project Manager and Field Trip Leader. Andrew is currently the Project Manager for several ongoing Receiving Environment Monitoring Programs, and has a keen eye for data quality assurance and interrogating data using a range of statistical approaches. As a field ecologist, he is highly skilled in the identification of aquatic fauna and flora, a stickler for correct sample collection and preservation procedures, and comprehensive with respect to health and safety.

Some recent project examples include:

- Dawson River Release Scheme: Receiving Environment Monitoring Program. Santos. 2017.
- Blyth Creek Baseline Biological Monitoring Program. Santos. 2015 – 2017
- Yuleba Creek Baseline Biological Monitoring Program. Santos. 2016 – ongoing.
- Glebe Beneficial Use Scheme: Receiving Environment Monitoring Program. Sunwater. 2015 – ongoing.
- Chinchilla Beneficial Use Scheme: Receiving Environment Monitoring Program. SunWater. 2015 – ongoing.
- Kirar Weir Fishway Monitoring, SunWater. 2016 – ongoing
- Ambient and Event Water Quality Monitoring Programs. Redland City Council. 2015 – ongoing.
- Poitrel Mine 2017 Receiving Environment Monitoring Program, BHP BMC.
- South Walker Creek Mine 2017 Receiving Environment Monitoring Program, BHP BMC.
- Clermont Open Cut Receiving Environment Monitoring Program 2017. Glencore
- Olive Downs North Receiving Environment Monitoring Program 2017. Peabody
- Post-construction Aquatic Values Assessment for Gas Transmission Pipeline Crossings of Watercourses. E2M on behalf of Origin Energy. 2015.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	02/05/17 (post-wet)	**Habitat Bioassessment Score**	56

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	25-30 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	deep pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		large woody debris	**Dominant species**	Eucalypt
Bank shape	moderate, concave		pebble	0 %		emergent aquatic plants	**Weed species**	*Parthenium*
			gravel	0 %		trailing roots		*Bidens pilosa*
Hydrology			sand	5 %		submerged aquatic plants	**Adjacent land use**	light grazing
Flow regime	intermittent		silt / clay	95 %				native vegetation
Water depth	4 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	100 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	200 m							

Comments: Water level was higher than usual with bank vegetation in water and dead tree saplings observed in-stream downstream; banks lined with aquatic plants, predominantly *Cyperus* spp., *Carex* sp., and *Juncus usitatus* but with small patches of *Persicaria decipiens* and *Persicaria hydropiper*; high abundance and diversity of in-stream aquatic plants with *Ludwigia peploides*, *Azolla* sp., duckweed, *Hydrilla verticillata* and *Potamogeton crispus* all present; large woody debris present both in and out of the water.

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	15/11/17 (pre-wet)	**Habitat Bioassessment Score**	56

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	20-30 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	deep pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		large woody debris	**Dominant species**	Eucalypt
Bank shape	low to moderate, concave		pebble	0 %		emergent aquatic plants	**Weed species**	*Parthenium*
			gravel	0 %		trailing roots		*Xanthium*
Hydrology			sand	2 %		submerged aquatic plants		Prickly Pear
Flow regime	intermittent		silt / clay	98 %				Thistle
Water depth	4 m	**Deposits**	silt		**In-stream disturbance**			Creeping Lantana
Wetted width	60 m	**Bed stability**	moderate aggradation		Flow modification	none	**Adjacent land use**	grazing
Flow	no flow				Waterway barrier	none		
Channel width	150 m							

Comments: Site is a waterbody choked with Hydrilla and Potamogeton. Banks were lined with *Juncus* sp. and *Carex* sp.. Large woody debris present in stream. Water level was higher than in the baseline surveys but lower than the post-wet survey. Dead eucalyptus upstream. Bird life prevalent.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	03/05/17 (post-wet)	**Habitat Bioassessment Score**	53

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	20 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	emergent aquatic plants	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	Eucalypt
Bank shape	low, concave		pebble	0 %		large woody debris	**Weed species**	*Bidens pilosa*
			gravel	0 %		trailing roots	**Adjacent land use**	native vegetation
Hydrology			sand	3 %		submerged aquatic plants		light grazing
Flow regime	intermittent		silt / clay	97 %				
Water depth	5 m	**Deposits**	silt		In-stream disturbance			
Wetted width	80 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	130 m							

Comments: Large abundance of aquatic plants both in and out of the water; row of *Juncus* less defined/obvious than in baseline surveys but high abundance of *Cyperus gymnocaulos* and *Carex* sp. present on the banks with small patches of *Persicaria hydropiper* and *Persicaria prostrata*; *Ludwigia peploides*, *Azolla* sp., duckweed, *Hydrilla verticillata* and *Potamogeton crispus* all present in high abundance within the water near the banks; large woody debris both in and adjacent to water; water was very clear possibly due to recent rainfall and the release occurring ~200m upstream on the right bank at the time of the survey; numerous dead tree saplings present in-stream upstream of the survey point.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	15/11/17 (pre-wet)	**Habitat Bioassessment Score**	55

Downstream view

Upstream view

Channel Morphology		Substrate			Aquatic Habitat		Riparian Zone	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10-20 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	emergent aquatic plants	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	Eucalypt
Bank shape	flat, concave		pebble	0 %		large woody debris	**Weed species**	Thistle
			gravel	0 %		trailing roots		Creeping Lantana
Hydrology			sand	2 %		submerged aquatic plants		Sida
Flow regime	intermittent		silt / clay	98 %			**Adjacent land use**	grazing
Water depth	4 m	**Deposits**	silt		In-stream disturbance			
Wetted width	60 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	150 m							

Comments: This site is in the center of the Waterbody with the release point located upstream. Large woody debris present on the right bank. The banks lined with *C. Gymnocaulos*, *Juncus* sp. and *Carex* sp.. Azolla is present in large patches at the water's edge with small patches of Hydrilla and blade grass. Dead tree stumps in water and dead eucalyptus saplings upstream.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	03/05/17 (post-wet)	**Habitat Bioassessment Score**	57

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	deep pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		submerged aquatic plants	**Dominant species**	Eucalypt
Bank shape	flat-steep, concave		pebble	0 %		large woody debris	**Weed species**	*Bidens pilosa*
			gravel	0 %		trailing roots		noogoora burr
Hydrology			sand	2 %		emergent aquatic plants	**Adjacent land use**	light grazing
Flow regime	intermittent		silt / clay	98 %				native vegetation
Water depth	5 m	**Deposits**	silt		**In-stream disturbance**			cropping
Wetted width	110 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	150 m							

Comments: Site is located on a straight section of the waterbody with riparian vegetation on the right bank and scattered trees on the left bank; dense weeds (*Bidens pilosa*) were present behind the riparian vegetation on the right bank with cropping also present behind the weeds; dead trees were present in-stream near the right bank and a large patch of *Azolla* sp. covered the water surface near the left bank; *Cyperus gymnocaulos* and *Carex* sp. lined the right bank with small patches of Persicaria hydropiper and Persicaria prostrata; *Ludwigia peploides*, *Azolla* sp., duckweed, *Hydrilla verticillata* and *Potamogeton crispus* were all present in high abundance in-stream; large woody debris from the dead trees provided habitat for aquatic organisms.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	15/11/17 (pre-wet)	**Habitat Bioassessment Score**	49

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5-8 m
Pattern	oxbow lake		boulder	0 %	**Habitat present**	deep pool	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		submerged aquatic plants	**Dominant species**	Eucalypt
Bank shape	flat-moderate, concave		pebble	0 %		large woody debris	**Weed species**	thistle
			gravel	0 %		trailing roots		noogoora burr
Hydrology			sand	2 %		emergent aquatic plants		*Parthenium*
Flow regime	intermittent		silt / clay	98 %				cobbler's pegs
Water depth	4 m	**Deposits**	silt		**In-stream disturbance**			sida
Wetted width	100 m	**Bed stability**	moderate aggradation		Flow modification	none	**Adjacent land use**	grazing
Flow	no flow				Waterway barrier	none		cropping
Channel width	120 m							
Comments:	Site is at the downstream end of the Waterbody. Right bank is lined with dead trees. Large woody debris and Hydrilla provide in-stream habitat. Some hydrocarbons noted on the water's surface. *Carex sp.*, *Cyperus gymnocaulos* and *Ludwigia peploides* line the banks.							

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	04/05/17 (post-wet)	**Habitat Bioassessment Score**	63

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	good	**Riparian width**	20 m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	Eucalypt
Bank shape	moderate-steep, convex		pebble	0 %		large woody debris	**Weed species**	noogoora burr
			gravel	2 %		undercut banks		*Commelina* sp.
Hydrology			sand	60 %		submerged and emergent aquatic plants (low cover)		*Bidens pilosa*
Flow regime	intermittent		silt / clay	38 %			**Adjacent land use**	native vegetation
Water depth	1 m	**Deposits**	sand		**In-stream disturbance**			light grazing
Wetted width	15 m	**Bed stability**	moderate aggradation		Flow modification	none		cropping
Flow	0.25 m / s				Waterway barrier	none		
Channel width	50 m							

Comments: Water was flowing at the time of the survey; large logjam was present at the bend upstream producing a riffled surface in and around the logjam and bend; a mid-channel sand bar was present in the middle of the site; large woody debris, trailing roots and overhanging branches provide habitat; small cover of emergent (*Lomandra longifolia*), floating (duckweed) and submerged (*Vallisneria australis*) present at upstream end of site; high cover of *Cyperus* spp. on banks with some *Lomandra longifolia*, *Persicaria hydropiper* and *Persicaria decipiens*.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	16/11/17 (pre-wet)	**Habitat Bioassessment Score**	75

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	good	**Riparian width**	15 m
Pattern	irregular meanders		boulder	2 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	moderate		cobble	3 %		deep pool	**Dominant species**	Melaleuca
Bank shape	moderate-steep, convex		pebble	3 %		large woody debris	**Weed species**	*Xanthium*
			gravel	0 %		undercut banks		*Commelina* sp.
Hydrology			sand	80 %		submerged aquatic plants	**Adjacent land use**	grazing
Flow regime	perennial		silt / clay	12 %		trailing roots		
Water depth	1.2 m	**Deposits**	sand		**In-stream disturbance**			
Wetted width	8 m	**Bed stability**	moderate erosion		Flow modification	none		
Flow	0.08 m / s				Waterway barrier	none		
Channel width	20 m							

Comments: This site is a flowing reach of the Dawson River. There was high cover of overhanging branches with a log jam at the upstream end of the site. The site comprised a series of deeper pools interconnected by shallow sandy riffles/runs. Some exposed sandy bars on the left bank. Some oily residue/build up upstream on the right bank. Some rocky substrate on the right bank.

Site	S4	**Region**	Upper Dawson
Date surveyed:	04/05/17 (post-wet)	**Habitat Bioassessment Score**	65

Downstream view

Upstream view

Channel Morphology	
Stream order	6
Pattern	mildly sinuous
Bank stability	moderate
Bank shape	moderate-steep, convex

Hydrology	
Flow regime	intermittent
Water depth	1 m
Wetted width	15 m
Flow	0.25 m / s
Channel width	80 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	0 %
	pebble	0 %
	gravel	0 %
	sand	75 %
	silt / clay	25 %
Deposits	sand	
Bed stability	moderate aggradation	

Aquatic Habitat	
Habitat diversity	good
Habitat present	shallow / deep pool
	run
	large woody debris
	undercut banks
	emergent aquatic plants
	submerged aquatic plants

In-stream disturbance	
Flow modification	road culvert
Waterway barrier	road culvert (partial barrier)

Riparian Zone	
Riparian width	10-30 m
Disturbance	moderate
Dominant species	Eucalypt
	Melaleuca
Weed species	noogoora burr
Adjacent land use	native vegetation
	light grazing
	cropping

Comments: Site is separated by a large vegetated side sand bar on the left bank; Vallisneria and Potamogeton crispus was growing in a large patch immediately upstream of the sand bar with some algal matts on top; large woody debris and overhanging branches provide habitat throughout the site; some run/glide flow was present where the channel narrows adjacent to the sand bar; site is ~100m upstream of a road box culvert; duckweed and *Chara* spp. was present in patches in-stream and *Persicaria hydropiper*, *Persicaria decipiens*, *Cyperus* spp. and *Lomandra longifolia* lined the banks.

Site	S4	**Region**	Upper Dawson
Date surveyed:	16/11/17 (pre-wet)	**Habitat Bioassessment Score**	58

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	good	**Riparian width**	20 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow / deep pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		run	**Dominant species**	Melaleuca
Bank shape	moderate, convex		pebble	0 %		trailing roots	**Weed species**	noogoora burr
			gravel	5 %		undercut banks		*Commelina* sp.
Hydrology			sand	80 %		emergent aquatic plants		rumex
Flow regime	perennial		silt / clay	15 %		submerged aquatic plants	**Adjacent land use**	grazing
Water depth	1.1 m	**Deposits**	sand		**In-stream disturbance**			
Wetted width	25 m	**Bed stability**	moderate aggradation		Flow modification	road culvert		
Flow	0.05 m / s				Waterway barrier	road culvert (partial barrier)		
Channel width	100 m							
Comments:	Site comprised a series of pools connected by shallow sections and narrowed by large sandy bars. Sandy bars are covered in *Paspalum* sp. and *Persicaria* sp.. Some submerged blade grass in water.							

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	04/05/17 (post-wet)	**Habitat Bioassessment Score**	60

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate-good	**Riparian width**	30 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	Eucalypt
Bank shape	moderate-steep, stepped		pebble	0 %		large woody debris		Casuarina
			gravel	0 %		trailing roots	**Weed species**	herbaceous species
Hydrology			sand	30 %		undercut banks		pastoral grasses
Flow regime	intermittent		silt / clay	70 %		submerged aquatic plants	**Adjacent land use**	native forest
Water depth	1 m	**Deposits**	silt		**In-stream disturbance**			light grazing
Wetted width	18 m	**Bed stability**	moderate aggradation		Flow modification	none		cropping
Flow	0.02 m / s				Waterway barrier	none		
Channel width	80 m							

Comments: Site located on a reasonably straight reach of the Dawson River; side point and mid-channel bars present upstream and downstream with aquatic plants and trees present; low cover of *Vallisneria* near right bank and *Ottelia ovalifolia* mid-channel; water was turbid with low flow; silt deposition was present on the right bank and at all obstructions; *Cyperus* spp., *Persicaria hydropiper* and *Lomandra longifolia* lined the banks and bars.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	16/11/17 (pre-wet)	**Habitat Bioassessment Score**	53

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate-good	**Riparian width**	25-30 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow pool	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep pool	**Dominant species**	Casuarina
Bank shape	moderate-steep,		pebble	0 %		submerged aquatic plants	**Weed species**	*Commelina* sp.
	stepped / convex		gravel	0 %		trailing roots		*Xanthium*
Hydrology			sand	85 %		undercut banks		sida
Flow regime	perennial		silt / clay	15 %			**Adjacent land use**	grazing
Water depth	1 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	12 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.02 m / s				Waterway barrier	none		
Channel width	100 m							

Comments: Site is a large connected pool with slow flow. Some emergent trees (melaleuca) in-stream. Submerged blade grass in patches on the banks. Left bank has a large bar.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	04/05/17 (post-wet)	**Habitat Bioassessment Score**	67

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	low-moderate	**Riparian width**	15-25 m
Pattern	braided, irregular meanders		boulder	3 %	**Habitat present**	shallow pool	**Disturbance**	moderate
Bank stability	low		cobble	40 %		large woody debris	**Dominant species**	Eucalypt
Bank shape	steep-vertical, concave / convex		pebble	20 %		deep pool	**Weed species**	pastoral grasses
			gravel	10 %			**Adjacent land use**	native vegetation
Hydrology			sand	10 %				light grazing
Flow regime	ephemeral		silt / clay	17 %				road easement
Water depth	1.5 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	20 m	**Bed stability**	moderate aggradation		Flow modification	bed level crossing downstream		
Flow	no flow		moderate erosion		Waterway barrier	bed level crossing downstream		
Channel width	60 m							

Comments: Pool disconnected at downstream end of site by a raised bed at a bed level road crossing; a side channel is present on the left bank; rocky substrate present along a majority of the left bank; water surface has a algal scum layer on surface; evidence of recent high flows with logjam and high erosion in side channel; fallen dead trees and large woody debris provide habitat in the pool; *Cyperus* sp., *Persicaria hydropiper*, *Persicaria decipiens*, *Juncus* and *Lomandra longifolia* is present in patches along the banks.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	16/11/17 (pre-wet)	**Habitat Bioassessment Score**	63

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	low-moderate	**Riparian width**	10-20 m
Pattern	irregular meanders		boulder	5 %	**Habitat present**	shallow pool	**Disturbance**	very high
Bank stability	moderate		cobble	10 %		deep pool	**Dominant species**	Callistemon
Bank shape	steep, concave		pebble	10 %		large woody debris	**Weed species**	*Commelina* sp.
			gravel	15 %		trailing roots		rumex
Hydrology			sand	20 %				sida
Flow regime	intermittent		silt / clay	40 %			**Adjacent land use**	grazing
Water depth	1.2 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	30 m	**Bed stability**	moderate aggradation		Flow modification	bed level crossing downstream		
Flow	no flow				Waterway barrier	bed level crossing downstream		
Channel width	80 m							
Comments:	Site is a bunded pool upstream of a bed level crossing, with very low flow. Surface is covered with a scum and plant/flower matter. Dead trees overhanging on right bank. *Persicaria* spp. in the bed and on the banks. Rocky substrate on the left bank and at bed level crossing, sand/silt elsewhere.							

Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2018

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos GLNG (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos GLNG project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP design document, titled *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program* (frc environmental 2018). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the fourth year the REMP has been implemented.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake the DRRS REMP in 2018.

The purpose of this report is to present and record the methods and results of the 2018 post-wet and pre-wet REMP surveys, and provide an assessment of potential adverse effects of the release on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP) on each survey. Sampling utilised the methods nominated in the REMP and included sediment quality, aquatic habitat, macroinvertebrate, fish and geomorphological (i.e. bed and bank stability) monitoring.

The work presented in this report was carried out by suitably qualified persons (Dr Ben Cook and Dr Andrew Bentley who are professional aquatic ecologists with Ph.D. qualifications in freshwater biology and a combined total of over 28 years of industry experience as aquatic ecologists) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 1 – 4 May 2018.; the pre-wet survey was implemented 24 – 27 September 2018.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are shown in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two water types: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As prescribed by the REMP, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and one (DRMP1) on the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges into the Waterbody and 8 km downstream of the	-25.692	149.216

Site	Description	GDA94	
		Latitude	Longitude
	confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.		
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2018 post-wet season REMP survey:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek. This is consistent with water quality conditions throughout the baseline monitoring program, and
- approximately 134 ML of produced water was released in the month prior to the survey (i.e. 12 – 22 April 2018), although there were no releases the week before or during the survey [1]

The following quality assurance outcomes relate to the 2018 pre-wet season REMP survey:

- approximately 107 ML of produced water was released in the month prior to the survey (i.e. 10 – 18 September 2018), although there were no releases during the survey [1].

[1] The average volume of produced water that is released is 105 ML per month.

149° E

149.2° E

Dawson River

Harris Creek

Boyd Creek

Belington Hut State Forest

Injune-Road

Expedition Resources Reserve

Beilba State Forest

Expedition (Limited Depth) National Park

Hutton Creek

Fitzroy Basin

DRR1

DRMP1

S4

WLMP4

WLMP5

WLMP1

DRR2

Stephenton State Forest

Commissioner Creek

Hallett State Forest

Sids Pocket Road

149° E

149.2° E

frc environmental
AQUATIC ECOLOGISTS
deep thinking.science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme Receiving Environment Program

Map 2.1:
Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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LEGEND

Monitoring Site
- Control sites upstream of receiving environment
- Waterbody sites within receiving environment
- Dawson River sites within receiving environment
- Watercourse
- Lake/Reservoir
- Basin

Road Network
- Local Road

Protected Area
- National Park
- Other Reserve

N

SCALE

0 2.25 4.5
Kilometres

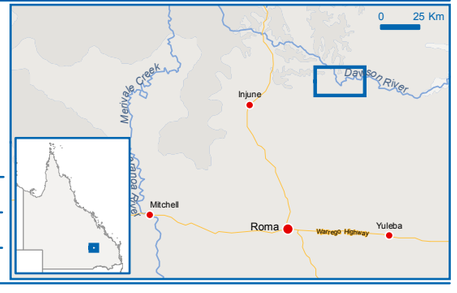
Scale: 1:80,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2017-06-20

DRAWN BY
AB

VERSION
01



3 Water Quality

3.1 Methods

Survey Procedure

Water quality was measured in situ for temperature, pH, electrical conductivity, dissolved oxygen and turbidity using a calibrated meter. Measurements were taken approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites.

Water sample were collected approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites, directly into sampling containers provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed. Two (replicate) samples were collected from one site on each survey for assessing within-site variation. Parameters analysed in the laboratory were: suspended solids, ammonia, nitrogen, and total and dissolved boron and zinc.

Data Analysis

Results were compared to the local water quality guidelines developed for the DRRS REMP (frc environmental 2018). Relative percent difference was calculate for the replicate samples collected at one site on each survey to assess within-site variation.

3.2 Results

Results for the water quality results (Table 3.1, Table 3.2 and Table 3.3) showed that:

- The concentration of dissolved oxygen was lower than the guideline range at sites WLMP4 (4.3 mg/L) and DRR2 (4.4 mg/L) in the post-wet season, but complied with all other sites in the post-wet season and complied with all sites in the pre-wet season. The full range baseline range for the concentration of dissolved oxygen in the Waterbody is 0.13 to 19.9 mg/L, indicating that the recoded value at site WLMP4 in the post-wet survey is within the natural range of variation. The full baseline range recorded at site DRR2 on Hutton Creek is 7.7 to 17.2 mg/L, indicating that the

recorded value at DRR2 in the post-wet survey is lower than baseline range, noting this site is a control site that is not influenced by the release of produced water.

- all other parameters complied with the guideline at all sites during the post-wet and pre-wet surveys, and
- the relative percent difference for suspended solids and ammonia was high, indicting high within-site variation for these parameters.

Table 3.1 Water quality results compared to the local water quality guidelines for the 2018 post- wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	20.2	24.0	22.0	15.8 – 27.1	19.4	18.5	20.4	–	20.5
Dissolved oxygen	mg/L	–	6.4 – 16.1	4.3	10.5	7.5	6.4 – 16.1	6.9	7.4	7.0	6.4 – 16.1	4.4
Electrical conductivity	µS/cm	–	627	229	179	182	500	305	354	291	500	302
pH	unit	–	6.5 – 8.5	7.3	7.0	7.5	6.5 – 8.5	7.4	7.7	7.5	6.5 – 8.5	7.5
Suspended solids	mg/L	5	128	–	–	–	50	12	<5	<5	50	<5
Turbidity	NTU	–	Monitor only	30.5	23	63	Monitor only	12.9	16.5	12.9	Monitor only	23.4
Nutrients												
Ammonia as N	mg/L	0.01	0.9	–	–	–	0.9	0.03	0.03	0.03	0.9	<0.01
Total nitrogen	mg/L	0.1	3.93	–	–	–	0.62	0.2	0.2	<0.1	0.62	0.6
Total metals and metalloids												
Boron	mg/L	0.05	1000	0.20	0.34	0.33	1000	<0.05	<0.05	<0.05	1000	<0.05
Zinc	mg/L	0.005	12	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Dissolved Metals and metalloids												
Boron	mg/L	0.05	1000	0.16	0.27	0.28	1000	<0.05	<0.05	<0.05	1000	<0.05
Zinc	mg/L	0.005	8	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value.

– No guideline or data

Table 3.2 Water quality results compared to the local water quality guidelines for the 2018 pre- wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	23.5	25.5	22.3	15.8 – 27.1	20.0	20.5	19.0	–	22.9
Dissolved oxygen	mg/L	–	6.4 – 16.1	9.0	11.0	7.2	6.4 – 16.1	7.2	8.3	6.7	6.4 – 16.1	9.8
Electrical conductivity	µS/cm	–	627	267	173	175	500	296	307	281	500	263
pH	unit	–	6.5 – 8.5	7.6	8.4	7.9	6.5 – 8.5	7.4	7.7	7.5	6.5 – 8.5	8.2
Suspended solids	mg/L	5	128	<5	10	16	50	6	<5	30	50	6
Turbidity	NTU	–	Monitor only	6.12	10.3	26.0	Monitor only	7.5	3.9	4.9	Monitor only	5.4
Nutrients												
Ammonia as N	mg/L	0.01	0.9	0.06	0.1	0.07	0.9	0.07	0.03	0.03	0.9	0.2
Total nitrogen	mg/L	0.1	3.93	0.6	0.6	0.6	0.62	0.02	0.1	0.1	0.62	0.6
Total metals and metalloids												
Boron	mg/L	0.05	1000	0.34	0.56	0.5	1000	<0.05	<0.05	<0.05	1000	<0.05
Zinc	mg/L	0.005	12	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Dissolved Metals and metalloids												
Boron	mg/L	0.05	1000	0.34	0.41	0.5	1000	0.05	<0.05	<0.05	1000	<0.05
Zinc	mg/L	0.005	8	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value.

– No guideline or data

Table 3.3 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters.

Parameter	Unit	LOR	Post-wet survey Site S4			Pre-wet Survey Site WLMP1		
			Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD
Suspended solids	mg/L	5	<5	10	120	10	26	89
Ammonia as N	mg/L	0.01	0.03	0.06	133	0.1	0.05	67
Total Nitrogen	mg/L	0.1	0.2	0.2	0	0.6	1.0	50
Total boron	mg/L	0.05	<0.05	<0.05	0	0.56	0.48	15
Total zinc	mg/L	0.005	–	–	–	<0.005	<0.005	0
Dissolved boron	mg/L	0.05	<0.05	<0.05	0	0.41	0.48	16
Dissolved zinc	mg/L	0.005	–	–	–	<0.005	<0.005	0

4 Sediment Quality

4.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids).

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2018).

4.2 Results

Results for the laboratory analyses of sediment quality (Table 4.1 and Table 4.2) showed that:

- The concentration of manganese in the post wet survey was higher than the local trigger value at site WLMP1. However, the concentration of manganese at site WLMP1 (665 mg/kg) was less than the 95th percentile of baseline data for manganese in sediment (760 mg/kg), and therefore consistent with ambient baseline conditions.
- The concentration of aluminium was higher than the local trigger value at sites WLMP1 and WLMP5 in the pre-wet survey. The concentration of aluminium at site WLMP1 (15000 mg/kg) was less than the 95th percentile of baseline data for aluminium in sediment (15133 mg/kg), and therefore consistent with ambient baseline conditions. However, the concentration of aluminium at site WLMP5 (17600 mg/kg) was higher than the maximum of baseline data for aluminium in sediment in the Waterbody (15600 mg/kg).
- The concentration of iron was higher than the local trigger value at sites WLMP1 and WLMP5 in the pre-wet survey. However, the concentration of iron at sites WLMP1 (21100 mg/kg) and WLMP5 (21000 mg/kg) was equal to, or lower than the

maximum concentration of iron in sediment recorded in the Waterbody (i.e. 21100 mg/kg), indicating that the concentration of iron was consistent with ambient baseline conditions. .

- The concentration of all other parameters complied with the applicable local sediment quality guideline at all sites on each survey, noting that boron and selenium could not be assessed because the limit of reporting (LOR) was higher than the local trigger value.

Table 4.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2018 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	7510	12600	11700	5191	740	4460	1720	11800	990
Arsenic (As)	mg/kg	5	20	6	9	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	50	18.8	< 50	< 50	< 50	17.9	< 50	< 50	< 50	25	< 50
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	6	9	10	80	< 2	4	2	80	< 2
Copper(Cu)	mg/kg	5	65	9	16	14	65	< 5	< 5	< 5	65	< 5
Iron (Fe)	mg/kg	50	17867	12100	16700	12700	9353	3940	6540	4560	20700	5200
Lead (Pb)	mg/kg	5	50	13	17	15	50	< 5	6	< 5	50	< 5
Manganese (Mn)	mg/kg	5	648	387	665	345	230.5	67	175	100	337	28
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	10	11	10	21	< 2	5	2	21	3
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	41	62	56	200	5	22	12	200	9

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.2 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2018 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	12200	15000	17600	5191	1750	5300	5930	11800	2200
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	50	18.8	< 50	< 50	< 50	17.9	< 50	< 50	< 50	25	< 50
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	8	9	13	80	< 2	4	4	80	2
Copper(Cu)	mg/kg	5	65	12	15	19	65	< 5	< 5	7	65	< 5
Iron (Fe)	mg/kg	50	17867	16800	21100	21000	9353	4780	8440	13500	20700	7140
Lead (Pb)	mg/kg	5	50	12	14	17	50	< 5	6	9	50	< 5
Manganese (Mn)	mg/kg	5	648	506	554	418	230.5	430	185	316	337	51
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	10	11	13	21	2	4	6	21	3
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	55	64	76	200	8	20	33	200	24

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

5 Aquatic Habitat, and Bed and Bank Stability

5.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP design document (frc environmental 2018).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons were made against baseline condition, as presented in the REMP design document (frc environmental 2018).

5.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 5.1 and Table 5.2) showed:

- bed and bank stability at all sites and for all water types had not changed from baseline condition
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with water levels higher than many of the baseline surveys, resulting in increased cover of submerged large woody debris and submerged aquatic plants, and
- all other aquatic habitat features for all water types had not changed from baseline condition.

Table 5.1 Habitat characteristics of each water type in the 2018 post-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	*high*	*low to moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low to moderate*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 5.2 Habitat characteristics of each water type in the 2018 pre-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*low*
Substrate diversity	*low*	*high*	*low to moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low to moderate*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

6 Macroinvertebrate Communities

6.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2018).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual* (DES 2018). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. The REMP design document considers an error rate of <5% acceptable for macroinvertebrate sorting and identification, with the error rate of < 2% for this study.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (i.e. families in most cases in this assessment). 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each site, and the median for each index calculated for each water type, and compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP design document; frc environmental 2018). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range , then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

6.2 Results

Results for macroinvertebrate indices showed that (Table 6.1, Table 6.2, Table 6.3 and Table 6.4):

- the abundance of macroinvertebrates was:
  - higher than the local biological guideline range at all sites except DRR2 in the post-wet survey, and at all sites except WLMP5 and DRR2 in the pre-wet survey
  - within the local biological guideline range at site DRR2 in the post-wet survey and at sites WLMP5 and DRR2 in the pre-wet survey
  - higher than the local biological guideline range for the Waterbody and Dawson River water types in each survey
  - within the local biological guideline range for the Hutton Creek water type in each survey
- taxonomic richness of macroinvertebrates was:
  - higher than the local biological guideline range at all sites except DRMP1 in the post-wet survey, and at all sites except DRMP1, DRR1 and S4 in the pre-wet survey
  - within the local biological guideline range at site DRMP1 in the post-wet survey and at sites DRMP1, DRR1 and S4 in the pre-wet survey
  - higher than the local biological guideline range for the Waterbody, Dawson River and Hutton Creek water types in the post-wet survey, and for the Waterbody and Hutton Creek water types in the pre-wet survey
  - within the local biological guideline range for the Dawson River water type in the pre-wet survey
- PET richness of macroinvertebrates was:
  - higher than the local biological guideline range at all sites in the post-wet survey, and at all sites except DRMP1, DRR1 and S4 in the pre-wet survey
  - within the local biological guideline range at sites DRMP1, DRR1 and S4 in the pre-wet survey
  - higher than the local biological guideline range for the Waterbody and Hutton Creek water types in each survey
  - within the local biological guideline range for the Dawson River water type in each survey

  - higher than the baseline range at WLMP4 and WLMP1 in the pre-wet survey, and at site DRR2 in both surveys

- SIGNAL-2 Scores for macroinvertebrates were:
  - higher than the local biological guideline range at all sites except DRMP1 and DRR1 in the post-wet survey, and at all sites except DRMP1, DRR1 and S4 in the pre-wet survey
  - within the local biological guideline range at sites DRMP1 and DRR1 in the post-wet survey, and at sites DRMP1, DRR1 and S4 in the pre-wet survey
  - higher than the local biological guideline range for the Waterbody and Hutton Creek water types in each survey
  - within the local biological guideline range for the Dawson River water type in each survey
  - higher than the baseline range at sites WLMP1 and WLMP5 in the post-wet survey, and at site WLMP4 in the pre-wet survey.

Table 6.1 Macroinvertebrate results for each site in the 2018 post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	351.0	474.0	325.0	39.9–152.0	158.0	235.0	187.0	23.0–207.4	165.0
Taxonomic Richness	5.67–10.8	13.00	13.00	14.00	9.93–16.9	16.00	19.00	19.00	4.0–10.0	18.00
PET richness	0 – 1.2	2.0	2.0	3.0	1.47–4.0	5.0	5.0	4.0	0–1.0	4.0
SIGNAL-2 Score	2.65 – 3.20	3.52	3.62	3.82	3.46–4.00	3.95	4.02	3.86	2.90–3.30	3.71

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Table 6.2 Macroinvertebrate results for each water type in the 2018 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	375.0	39.9 – 152.0	193.0	23.0 – 207.4	165.0
Taxonomic Richness	5.67–10.8	13.00	9.93 – 16.9	19.00	4.0 – 10.0	18.00
PET richness	0 – 1.2	2.0	1.47 – 4.0	4.0	0 – 1.0	4.0
SIGNAL-2 Score	2.65 – 3.20	3.62	3.46 – 4.00	3.95	2.90 – 3.30	3.71

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Table 6.3 Macroinvertebrate results for each site in the 2018 pre-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	364.0	275.0	252.0	39.9–152.0	224.0	186.0	254.0	23.0–207.4	185.0
Taxonomic Richness	5.67–10.8	13.00	16.00	12.00	9.93–16.9	16.00	16.00	13.00	4.0–10.0	16.00
PET richness	0 – 1.2	3.0	3.0	2.0	1.47–4.0	3.0	2.0	3.0	0–1.0	4.0
SIGNAL-2 Score	2.65 – 3.20	3.56	3.21	3.36	3.46–4.00	3.94	3.90	3.78	2.90–3.30	3.61

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Table 6.4 Macroinvertebrate results for each water type in the 2018 pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	290.0	39.9 – 152.0	219.0	23.0 – 207.4	185.0
Taxonomic Richness	5.67–10.8	14.00	9.93 – 16.9	14.00	4.0 – 10.0	16.00
PET richness	0 – 1.2	3.0	1.47 – 4.0	3.0	0 – 1.0	4.0
SIGNAL-2 Score	2.65 – 3.20	3.36	3.46 – 4.00	3.90	2.90 – 3.30	3.61

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

7 Fish

7.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 7.1 and Table 7.2). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 181742) and Animal Ethics Approval (CA 2015/08/893 and 2018/08/1224) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 7.1 Effort used to catch freshwater fish in the 2018 post-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	11:30	7:30	40 h
WLMP1	fyke net (2)	pool	14:15	10:00	39.5 h
WMLP5	fyke net (2)	pool	16:00	11:30	39 h
Dawson River					
DRMP1	fyke net (2)	pool	15:00	9:00	36 h
S4	fyke net (2)	pool	16:00	11:00	38 h
DRR1	fyke net (2)	pool	13:00	8:00	38 h
Hutton Creek					
DRR2	fyke net (2)	pool	17:30	14:30	42 h

Table 7.2 Effort used to catch freshwater fish in the 2018 pre-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	13:30	7:30	36 h
WLMP1	fyke net (2)	pool	15:30	10:00	37 h
WMLP5	fyke net (2)	pool	16:00	12:30	41 h
Dawson River					
DRMP1	fyke net (2)	pool	15:30	11:00	39 h
S4	fyke net (2)	pool	16:00	12:30	41 h
DRR1	fyke net (2)	pool	15:00	9:00	36 h
Hutton Creek					
DRR2	fyke net (2)	pool	15:30	07:30	32 h

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2018) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

7.2 Results

Ten species of native fish were caught and / or observed during the 2018 REMP surveys (Table 7.3 and Table 7.4). None of these species are conservation significant species under

the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act).

The number of native species caught at each site ranged from four (sites WLMP1 and WLMP5 in the post-wet survey and sites DRMP1 and DRR2 in the pre-wet survey) to nine (site S4 in the post-wet survey). Total abundance of fish at each site ranged from 19 (site DRMP1 in the post-wet survey) to 2240 (site WLMP1 in the pre-wet survey). The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites. The most commonly recorded species were carp gudgeons, Agassiz's glassfish, fly-specked hardyhead and eastern rainbowfish. No exotic species were caught.

All water types achieved the local biological guideline for fish on each survey (i.e. had an observed : expected ratio of species diversity that was ≥ 1) (Table 7.5 and Table 7.6). This indicates that the diversity of fish caught during the 2018 REMP surveys were the same as or higher than that recorded during the baseline monitoring program. Increased water levels compared to baseline condition may have created favourable conditions for fish.

All sites also achieved the biological guideline for exotic fish, indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 7.3 Total abundance of freshwater fish for each species at each site in 2018 post-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	291	178	60	3	4	9	1	**546**
Craterocephalus stercusmuscarum	flyspecked hardyhead	32	97	31	1	–	7	–	**168**
Hypseleotris spp.	carp gudgeon	544	90	145	1	7	20	77	**884**
Leiopotherapon unicolor	spangled perch	1	–	–	–	1	–	1	**3**
Macquaria ambigua	yellow belly	–	–	–	–	2	–	–	**2**
Melanotaenia splendida splendida	eastern rainbowfish	–	92	59	11	3	91	9	**265**
Nematalosa erebi	bony bream	–	–	–	–	2	11	1	**14**
Neosilurus hyrtlii	Hyrtl's catfish	3	–	–	–	1	–	–	**4**
Pseudomugil signifer	Pacific blue eye	–	–	–	–	5	1	–	**6**
Tandanus tandanus	freshwater catfish	–	–	–	3	5	–	–	**8**
Total native individuals		**871**	**457**	**295**	**19**	**30**	**139**	**89**	**1900**
Total native species		**5**	**4**	**4**	**5**	**9**	**6**	**5**	**10**

– not caught

Table 7.4 Total abundance of freshwater fish for each species at each site in 2018 pre-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	509	503	422	–	3	8	1	**1446**
Craterocephalus stercusmuscarum	flyspecked hardyhead	88	504	33	–	–	–	–	**625**
Hypseleotris spp.	carp gudgeon	666	974	1187	9	30	120	433	**3419**
Leiopotherapon unicolor	spangled perch	1	1	1	–	–	–	–	**3**
Macquaria ambigua	yellow belly	–	–	–	–	–	–	3	**3**
Melanotaenia splendida splendida	eastern rainbowfish	25	253	1	14	23	3	25	**344**
Nematalosa erebi	bony bream	–	5	1	–	21	2	–	**29**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	2	–	–	–	–	**2**
Pseudomugil signifer	Pacific blue eye	–	–	–	11	13	4	–	**28**
Tandanus tandanus	freshwater catfish	–	–	–	1	1	2	–	**4**
Total native individuals		**1289**	**2240**	**1647**	**35**	**91**	**139**	**462**	**5903**
Total native species		**5**	**6**	**7**	**4**	**6**	**6**	**4**	**10**

– not caught

Table 7.5 Comparison of fish monitoring results with the local biological objective for fish for the 2018 post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	6	1.5
Dawson River	5	10	2.0
Hutton Creek	2	5	2.5

Table 7.6 Comparison of fish monitoring results with the local biological objective for fish for the 2018 pre-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	7	1.75
Dawson River	5	6	1.2
Hutton Creek	2	4	2.0

8 Macrocrustaceans – Exoskeleton Assessment

8.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 8.1).

8.2 Results

The macrocrustaceans caught during the 2018 REMP surveys were of the same species caught from each water type during the baseline monitoring program (Table 8.2), although yabbies (*Cherax destructor*) were also caught at site WLMP5 in the post-wet survey. All specimens had exoskeletons that were of robust and good condition (Table 8.2 and Table 8.3). No macrocrustaceans were recorded in breeding condition during the post-wet season survey, which is consistent with the results of baseline surveys implemented in Autumn. Macrocrustaceans were breeding (i.e. gravid) in the Waterbody in the pre-wet survey, which is consistent with the results of baseline surveys implemented in Spring, although macrocrustaceans were not recorded to be breeding in the Dawson River in the pre-wet survey.

Table 8.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 8.2 Macrocrustacean species and condition recorded during the 2018 post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
	Cherax sp.	*Caridina* spp.	*Caridina* spp.
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae); *Cherax* sp. – yabby (family Parastacidae).

Table 8.3 Macrocrustacean species and condition recorded during the 2018 pre-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense* *Caridina* spp.
Breeding condition	breeding (i.e gravid)	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae).

9 Assessment of Environmental Changes

The monitoring results for the 2018 post-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- The concentration of dissolved oxygen in water at site DRR2 on Hutton Creek, which is lower than baseline conditions; however, as this site is a control site, this result is not an impact from the release of produced water
- Physical habitat features in the Waterbody, which had improved from baseline condition due to higher water levels. The higher water levels have increased submerged aquatic plant cover and the cover of large woody debris in water in the Waterbody
- The concentration of aluminium in sediment in the Waterbody at site WLMP5 (i.e. 17600 mg/kg) was higher than the baseline range recorded for the Waterbody. The cause of the high concentration of aluminium in sediment at this site is not clear, although it is not likely related to the release of produced water, because site WLMP1 (closest to the release location) was within the baseline range. The maximum baseline concentration of aluminium in sediment recorded during the baseline studies was 18500 mg/kg at Hutton Creek, suggesting that waterway sediment in the local area can have concentrations of aluminium that are higher than that recorded at site WLMP5 in the pre-wet survey. The biological data for macroinvertebrates and fish indicate no adverse ecological effects of the high concentration of aluminium in sediment at site WLMP5 in the pre-wet season.
- Most macroinvertebrate indices were higher than the local biological guideline but within the baseline range, although PET Richness and SIGNAL-2 scores were sometimes higher than the baseline range in the Waterbody and Hutton Creek. These high values indicate a larger proportion of more sensitive macroinvertebrate taxa were in the Waterbody and Hutton Creek than recorded in the baseline studies, likely because of higher water levels since the baseline studies (e.g. sites DRR2 and WLMP4 were often dry during the baseline studies).

Overall, the 2018 post-wet and pre-wet REMP survey results indicated that the release of desalinated produced water from ROP2 has not impacted the aquatic environmental values of the receiving environment.

10 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.

DES, 2018, *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009*, report prepared for Queensland Department of Environment and Science.

EHMP, 2007. *Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report*. South East Queensland Healthy Waterways Partnership, Brisbane.

frc environmental, 2018, *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program*, report prepared for Santos.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994.*

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2018, frc environmental 10 April 2019

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions (B37), (B38)(i), (B38)(k) and (B38)(m) of environmental authority EPPG00928713 dated 9th October 2018, as detailed in the Receiving Environment Monitoring Program, dated 27th June 2018

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Benjamin Douglas Cook

(Insert full name of person making this declaration)

of, Wynnum, Brisbane

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the requirements of conditions (B37), (B38)(i), (B38)(k) and (B38)(m) of environmental authority EPPG00928713 dated 9th October 2018;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2018, frc environmental, 10 April 2019;
4. The content of Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2018, frc environmental, 10 April 2019 is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2018, frc environmental, 10 April 2019 meets the requirements of conditions ((B37), (B38)(i), (B38)(k) and (B38)(m) of environmental authority EPPG00928713 dated 9th October 2018.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at Cleveland, Redland City

(Insert name of town or city and suburb)

this 10 day of April in the year 2019

(Insert day, e.g. 18th) (Insert month) (Insert year)

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No.: 71072 DEPT. OF JUSTICE & ATTORNEY-GENERAL

Signed

(Person making this declaration)

S McDonald

Signed

(Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations~~ / ~~Solicitor / Barrister~~

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature	Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – current)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Lady Annie Operations Receiving Environment Monitoring Program 2017. CST Minerals Lady Annie Pty Ltd.
- Poitrel Mine 2017 Receiving Environment Monitoring Program. BHP BMC.
- South Walker Creek Mine 2017 Receiving Environment Monitoring Program. BHP BMC.
- Oaky Creek Coal Mine 2017 Receiving Environment Monitoring Program. Glencore. 2017.
- Newlands Coal Project 2017 In-stream Monitoring Program. Glencore Coal Queensland.
- Clermont Open Cut Receiving Environment Monitoring Program. Clermont Open Cut. 2014 – 2017.
- Chinchilla Beneficial Use Scheme: Receiving Environment Monitoring Program. SunWater. 2013 – ongoing.
- Glebe Beneficial Use Scheme Receiving Environment Monitoring Program. SunWater. 2015-ongoing.

Andrew Bentley

B.Sci., B.Sc. (Hons.), Ph.D.

Ecologist | Freshwater

andrewbentley@frcenv.com.au

With over ten years of industry and academic experience across a range of disciplines, Andrew brings a strong set of skills and knowledge to each project he works on. He has a Ph.D. in freshwater biology and has a thorough understanding of the biogeography, ecology and management of freshwater ecosystems. Andrew joined frc environmental after working on both academic and government projects, most recently for Griffith University, Monash University, National Parks Queensland and the Queensland Department of Environment and Resource Management.

Andrew's key expertise lies in the design and implementation of research on aquatic environments, specifically the ecological assessment, connectivity and biodiversity of freshwater ecosystems. He has extensive experience in the assessment and delivery of advice in relation to waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs) and the protection of aquatic Matters of National Environmental Significance (MNES) and aquatic Matters of State Environmental Significance (MSES).

Andrew has extensive field experience throughout Australia using a range of sampling techniques, has a wide range of laboratory skills (including microscopy, DNA barcoding), a strong set of computer and analytical skills, and prolific knowledge in the analysis of ecological data using univariate and multivariate approaches. He has extensive field experience across a range of disciplines with experience in the collection and identification of freshwater biota, trapping and banding of birds, tracking of mammals and measuring and monitoring of aquatic and riparian health pre- and post- rehabilitation.

Andrew has communicated the results of his work in peer-reviewed journals, technical reports for the Queensland Government and the Australian Rivers Institute and international and Australian conference presentations. He also utilises his strong communication skills to educate others through tutoring both academically and privately. Andrew is known by his colleagues as a highly approachable diligent worker that goes above and beyond to produce good quality science.

Specialisations

- Aquatic ecological assessment and management
- Molecular ecology and DNA barcoding of freshwater fish, crustaceans and invertebrates
- Water and sediment quality
- Experimental design and statistical analysis

Employment History

- Ecologist (Freshwater), frc environmental, Brisbane (2015 – current)
- Research Assistant, Australian Rivers Institute, Brisbane (2007 – 2016)
- Fieldwork Assistant, Griffith University, Brisbane (2006 – 2016)
- Academic Tutor, Griffith University, Brisbane (2008 – 2012)
- Fieldwork Assistant, Department of Environment and Resource Management (2006 – 2006)

Relevant Project History

During previous university-based employment, Andrew both lead and collaborated on a number of projects relating to freshwater ecology, and contributed to a number of published peer-reviewed journal articles, some of which he was lead author.

In his current role, Andrew has worked at different capacities on approximately 50 commercial water quality and / or freshwater ecology projects, including as Project Manager and Field Trip Leader. Andrew is currently the Project Manager for several ongoing Receiving Environment Monitoring Programs, and has a keen eye for data quality assurance and interrogating data using a range of statistical approaches. As a field ecologist, he is highly skilled in the identification of aquatic fauna and flora, a stickler for correct sample collection and preservation procedures, and comprehensive with respect to health and safety.

Some recent project examples include:

- Dawson River Release Scheme: Receiving Environment Monitoring Program. Santos. 2017.
- Blyth Creek Baseline Biological Monitoring Program. Santos. 2015 – 2017
- Yuleba Creek Baseline Biological Monitoring Program. Santos. 2016 – ongoing.
- Glebe Beneficial Use Scheme: Receiving Environment Monitoring Program. Sunwater. 2015 – ongoing.
- Chinchilla Beneficial Use Scheme: Receiving Environment Monitoring Program. SunWater. 2015 – ongoing.
- Kirar Weir Fishway Monitoring, SunWater. 2016 – ongoing
- Ambient and Event Water Quality Monitoring Programs. Redland City Council. 2015 – ongoing.
- Poitrel Mine 2017 Receiving Environment Monitoring Program, BHP BMC.
- South Walker Creek Mine 2017 Receiving Environment Monitoring Program, BHP BMC.
- Clermont Open Cut Receiving Environment Monitoring Program 2017. Glencore
- Olive Downs North Receiving Environment Monitoring Program 2017. Peabody
- Post-construction Aquatic Values Assessment for Gas Transmission Pipeline Crossings of Watercourses. E2M on behalf of Origin Energy. 2015.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	02/05/18 (post-wet)	**Habitat Bioassessment Score**	50

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	moderate		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	moderate-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	*noogoora burr*
			sand	10 %		macrophytes		*Bidens pilosa*
Hydrology			silt / clay	90 %				*sida*
Flow regime	ephemeral	**Deposits**	none					*thistle*
Water depth	2.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			*grasses*
Wetted width	60 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		cropping
Channel width	65 m							

Comments: Water was slightly turbid with no flow. A red algal slick was observed on the waters' surface near the banks. Both banks were heavily vegetated with *Carex* sp. and *Juncus* sp. dominant. Woody debris and fallen trees were scattered throughout the channel, with some instream vegetation and trailing vegetation along the banks also providing habitat for aquatic fauna.

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	24/09/18 (pre-wet)	**Habitat Bioassessment Score**	53

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5–10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	moderate		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	low–moderate, convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	noogoora burr
			sand	10 %		macrophytes		*Bidens pilosa*
Hydrology			silt / clay	90 %				sida
Flow regime	ephemeral	**Deposits**	none					thistle
Water depth	2.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			grasses
Wetted width	55 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	<0.01 m/s				Waterway barrier	none		cropping
Channel width	65 m							

Comments: Water was slightly turbid due to high concentration of plankton in the water column. Both banks were heavily vegetated with *Carex* sp. and *Juncus* sp. dominant. Woody debris and fallen trees were scattered throughout the channel, with some instream vegetation and trailing vegetation along the banks also providing habitat for aquatic fauna. Periphyton algae was present on in-stream aquatic plants and woody debris.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	01/05/18 (post-wet)	**Habitat Bioassessment Score**	53

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 m – 15 m
Pattern	regular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt spp.
Bank shape	Low-convex, moderate-convex		pebble	5 %		pool		Acacia sp.
			gravel	0 %		large woody debris		Callitris sp.
Hydrology			sand	5 %		macrophytes	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	90 %	**In-stream disturbance**			sida
Water depth	1.5 m	**Deposits**	silt		Flow modification	none		noogoora burr
Wetted width	75 m	**Bed stability**	moderate aggradation		Waterway barrier	none		thistle
Flow	no flow						**Adjacent land use**	grazing
Channel width	70 m							native vegetation

Comments: Water was slightly turbid with no flow. Water level was high and at the bank edge. Riparian vegetation was predominantly grasses with the waters' edge dominated by native sedges, *Juncus* sp. and floating plants. Scattered large woody debris and dead standing timber provide habitat for aquatic fauna.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	24/09/18 (pre-wet)	**Habitat Bioassessment Score**	46

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	3 m – 5 m
Pattern	regular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt spp.
Bank shape	low—moderate, convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris		Callitris sp.
Hydrology			sand	5 %		macrophytes	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	95 %	**In-stream disturbance**			sida
Water depth	2 m	**Deposits**	silt		Flow modification	none		noogoora burr
Wetted width	65 m	**Bed stability**	moderate aggradation		Waterway barrier	none		thistle
Flow	<0.01 m/s						**Adjacent land use**	grazing
Channel width	70 m							native vegetation

Comments: Water was slightly turbid due to high plankton concentration in the water column. Water level was high and at the bank edge where significant pugging from cattle access was present. Riparian vegetation was predominantly grasses with the waters' edge dominated by native sedges, Juncus sp. and floating plants. Scattered large woody debris and dead standing timber provide habitat for aquatic fauna. Periphyton algae was observed on the surface of most submerged vegetation and habitat.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	01/05/18 (post-wet)	**Habitat Bioassessment Score**	54

Downstream view

Upstream view

Channel Morphology	
Stream order	2
Pattern	mildly sinuous
Bank stability	high
Bank shape	moderate-convex, low-convex

Hydrology	
Flow regime	ephemeral
Water depth	1.5 m
Wetted width	70 m
Flow	no flow
Channel width	75 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	0 %
	pebble	0 %
	gravel	0 %
	sand	10 %
	silt / clay	90 %
Deposits	silt	
Bed stability	moderate aggradation	

Aquatic Habitat	
Habitat diversity	moderate
Habitat present	deep
	shallow
	pool
	large woody debris
	macrophytes

In-stream disturbance	
Flow modification	none
Waterway barrier	none

Riparian Zone	
Riparian width	5 m
Disturbance	very high
Dominant species	Eucalypt spp.
	Acacia sp.
Weed species	*Bidens pilosa*
	noogoora burr
	sida
	thistle
Adjacent land use	native vegetation
	cropping

Comments: No flow was observed. Banks were 90% covered with vegetation with a small riparian zone (~5 m) and cropping paddocks on both banks. The water's edge was dominated by sedge such as *Juncus* sp.. Some floating vegetation and scattered woody debris were present. The substrate was blanketed in silt with a covering of terrestrial leaf litter.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	25/09/18 (pre-wet)	**Habitat Bioassessment Score**	42

Downstream view

Upstream view

Channel Morphology

Stream order	2
Pattern	mildly sinuous
Bank stability	high
Bank shape	low-convex

Hydrology

Flow regime	ephemeral
Water depth	2 m
Wetted width	90 m
Flow	<0.01 m/s
Channel width	100 m

Substrate

Composition	bedrock	0 %
	boulder	0 %
	cobble	0 %
	pebble	0 %
	gravel	0 %
	sand	5 %
	silt / clay	95 %
Deposits	silt	
Bed stability	moderate aggradation	

Aquatic Habitat

Habitat diversity	moderate
Habitat present	deep
	shallow
	pool
	large woody debris
	macrophytes

In-stream disturbance

Flow modification	none
Waterway barrier	none

Riparian Zone

Riparian width	2–5 m
Disturbance	very high
Dominant species	Eucalypt spp.
	Acacia sp.
Weed species	*Bidens pilosa*
	noogoora burr
	sida
	thistle
Adjacent land use	native vegetation
	cropping

Comments: No flow was observed. Banks were heavily grazed and mostly bare ground with some aquatic plants, such as *Juncus* sp., *Ludwigia peploides* and *Persicaria decipiens* only on the waters' edge where extensive pugging was observed. A small riparian zone (~5 m) was present on both banks with some cropping paddocks. Some floating vegetation and scattered large and small woody debris were present. The substrate was blanketed in silt but relatively compacted with a covering of terrestrial leaf litter.

Site	DRMP1	Region	Upper Dawson
Date surveyed:	02/05/18 (post-wet)	Habitat Bioassessment Score	70

Downstream view

Upstream view

Channel Morphology		Substrate			Aquatic Habitat		Riparian Zone	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	5 m left bank, 10 m right bank
Pattern	irregular meanders		boulder	2 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	5%		deep	**Dominant species**	Eucalypt
Bank shape	steep-convex		pebble	3 %		run		Callistemon
			gravel	0 %		riffle	**Weed species**	noogoora burr
			sand	80 %		large woody debris		grasses
Hydrology			silt / clay	10 %		undercut banks		Bidens pilosa
Flow regime	perennial						**Adjacent land use**	native forest
Water depth	1.5 m	**Deposits**	sand, silt		**In-stream disturbance**			riparian
Wetted width	7 m	**Bed stability**	stable		Flow modification	none		cropping
Flow	0.1 m / s				Waterway barrier	none		
Channel width	6 m							

Comments: Banks 75% covered in vegetation (trees, grasses and herbs). Variety of habitats present (run, riffle, pool, deep and shallow). Bars forming in channel. Substantial amount of large woody debris in channel. Little to no aquatic vegetation. Water slightly turbid. Some acid sulfate present.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	26/09/18 (pre-wet)	**Habitat Bioassessment Score**	66

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	5 %		deep	**Dominant species**	Eucalypt
Bank shape	low–steep, convex		pebble	0 %		run		Callistemon
	moderate–vertical, convex		gravel	25 %		riffle	**Weed species**	noogoora burr
			sand	60 %		large woody debris		grasses
Hydrology			silt / clay	10 %		undercut banks		*Bidens pilosa*
Flow regime	perennial						**Adjacent land use**	native forest
Water depth	0.5 m	**Deposits**	sand, silt		**In-stream disturbance**			cropping
Wetted width	8 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.05 m/s				Waterway barrier	none		
Channel width	15 m							

Comments: Several habitats present (run, riffle, pool, deep and shallow). Water slightly turbid. Banks covered in vegetation (trees, grasses and herbs) except where stock access the river. Mid and side channel bars present at site. Substantial amount of large woody debris in channel. Little to no aquatic vegetation.

Site	S4	**Region**	Upper Dawson
Date surveyed:	03/05/18 (post-wet)	**Habitat Bioassessment Score**	55

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – high	**Riparian width**	20 m left, 15 m right
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate-convex		pebble	2 %		pool		Casuarina
			gravel	4 %		run		Callistemon
			sand	90 %		large woody debris	**Weed species**	none
Hydrology			silt / clay	4 %			**Adjacent land use**	forest
Flow regime	perennial							grazing
Water depth	1.5 m	**Deposits**	sand		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.05 m / s				Waterway barrier	none		
Channel width	20 m							

Comments:	Banks with continuous riparian vegetation and scattered Lomandra sp.. Some bar formation (unvegetated). Substantial amount of large woody debris in channel upstream and downstream. Reach is greater than 70% shaded by riparian vegetation. There are a variety of water depth velocities.

Site	S4	**Region**	Upper Dawson
Date surveyed:	26/09/18 (pre-wet)	**Habitat Bioassessment Score**	56

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	15–20 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	steep, convex		pebble	0 %		pool		Casuarina
			gravel	5 %		run		Callistemon
			sand	85 %		large woody debris	**Weed species**	Mexican poppy
Hydrology			silt / clay	10 %				thistle
Flow regime	perennial						**Adjacent land use**	forest
Water depth	1 m	**Deposits**	sand / silt		**In-stream disturbance**			grazing
Wetted width	7 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.02 m/s				Waterway barrier	none		
Channel width	10 m							

Comments: Stream relatively undisturbed except for culvert crossing ~100 m downstream of site. Banks with continuous riparian vegetation and scattered Lomandra sp. and Persicaria sp.. Some bar formation (unvegetated). Substantial amount of large woody debris in channel upstream and downstream. Variety of habitat types including deep runs and shallow riffles. Cattle access site.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	02/05/18 (post-wet)	**Habitat Bioassessment Score**	49

Downstream view

Upstream view

Channel Morphology		Substrate			Aquatic Habitat		Riparian Zone	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – good	**Riparian width**	10 – 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	Steep-convex		pebble	0 %		riffle		Casuarina
			gravel	5 %		pool		Callistemon
Hydrology			sand	80 %			**Weed species**	noogoora burr
Flow regime	perennial		silt / clay	15 %		large woody debris		*Bidens pilosa*
Water depth	1.5 m	**Deposits**	sand		**In-stream disturbance**			grasses
Wetted width	4 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.05 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments: Low flow. Banks were well vegetated with grasses and *Lomandra* sp.. Some mid-channel bars were formed upstream and downstream of site with channel intermittently deep pools and shallow runs. A high number of trees were present on both banks. Some scattered large woody debris in channel and trailing bank vegetation. Some algal growth on large woody debris. Evidence of high flow on banks with debris in trees.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	26/09/18 (pre-wet)	**Habitat Bioassessment Score**	58

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – good	**Riparian width**	10–15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate, convex		pebble	0 %		riffle		Casuarina
	moderate–steep, convex		gravel	0 %		pool		Callistemon
Hydrology			sand	90 %		large woody debris	**Weed species**	noogoora burr
Flow regime	perennial		silt / clay	10 %		macrophytes		*Bidens pilosa*
Water depth	0.5 m	**Deposits**	sand/silt		**In-stream disturbance**			thistle
Wetted width	6 m	**Bed stability**	moderate aggradation		**Flow modification**	none		Mexican poppy
Flow	0.02 m/s				**Waterway barrier**	none	**Adjacent land use**	native forest
Channel width	15 m							light grazing

Comments: Site was located at a shallow section of the creek (~10 m long and 0.2 m deep). Water was slightly turbid and flow was low. Some scattered large and small woody debris was present in channel. Banks were well vegetated with grasses and *Lomandra* sp.. trailing into water on both banks. Some mid-channel bars were formed upstream and downstream of site with channel intermittently deep pools and shallow runs. Some algal growth on large woody debris. Evidence of high flow on banks with debris in trees.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	03/05/18 (post-wet)	**Habitat Bioassessment Score**	74

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 – 10 m
Pattern	irregular meanders		boulder	5 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	25 %		deep	**Dominant species**	Eucalypt
Bank shape	Steep-concave		pebble	30 %		pool		Callistemon
			gravel	10 %		run		Callitris
Hydrology			sand	25 %		large woody debris	**Weed species**	none
Flow regime	intermittent		silt / clay	5 %			**Adjacent land use**	grazing
Water depth	1.5 m	**Deposits**	sand		**In-stream disturbance**			native vegetation
Wetted width	15 m	**Bed stability**	stable		Flow modification	none		
Flow	<0.05 m / s				Waterway barrier	none		
Channel width	20 m							

Comments: Very low flow with some shallow riffle downstream of site. A green algal slick was present. Substrate was diverse with the left bank predominantly rocky substrate and right bank silt. A layer of leaf litter was present on the bed. Trailing vegetation (*Callistemon* sp.) was present intermittently along the left bank. Banks were steep and comprised predominantly of sand with vegetation covering ~50%.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	26/09/18 (post-wet)	**Habitat Bioassessment Score**	52

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	irregular meanders		boulder	10 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	5 %		deep	**Dominant species**	Eucalypt
Bank shape	vertical, concave/convex		pebble	5 %		pool		Callistemon
			gravel	20 %		large woody debris		Callitris
Hydrology			sand	20 %			**Weed species**	none
Flow regime	intermittent		silt / clay	40 %			**Adjacent land use**	grazing
Water depth	2 m	**Deposits**	silt		**In-stream disturbance**			native vegetation
Wetted width	12 m	**Bed stability**	stable		Flow modification	none		
Flow	no flow				Waterway barrier	none		
Channel width	20 m							

Comments: No flow at time of survey. Some nutrient accumulation may be extensive algal clumps floating on water surface. Substrate was diverse with the left bank predominantly rocky substrate and right bank silt. A layer of leaf litter was present on the bed, particularly on the left bank. Trailing vegetation (*Callistemon* sp.) was present intermittently along the left bank. Sediment build up at downstream end of pool and along left bank.

Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos Ltd (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP design document, titled *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program* (frc environmental 2018). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the fifth year the REMP has been implemented.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake the DRRS REMP in 2019.

The purpose of this report is to present and record the methods and results of the 2019 post-wet and pre-wet REMP surveys, and provide an assessment of potential adverse effects of the release on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP). Sampling utilised the methods nominated in the REMP and included water quality, sediment quality, aquatic habitat, macroinvertebrate, fish and geomorphological (i.e. bed and bank stability) monitoring. Assessment of zooplankton was also included for the pre-wet survey in November 2019.

The work presented in this report was carried out by suitably qualified persons (lead by Dr Ben Cook who is a professional aquatic ecologists with Ph.D. qualifications in freshwater biology and over 19 years of industry experience as an aquatic ecologist) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 15 – 18 April 2019, and the pre-wet survey was implemented 5 – 8 November 2019.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are shown in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two water types: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As prescribed by the REMP, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and one (DRMP1) on the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges into the Waterbody and 8 km downstream of the	-25.692	149.216

Site	Description	GDA94	
		Latitude	Longitude
	confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.		
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2019 REMP surveys:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek in the post-wet survey. This is consistent with water quality conditions throughout the baseline monitoring program.
- produced water releases:
  - post-wet survey: 130.5 ML of produced water was released over a two week period in March prior to the survey, with continuous releases in April resulting in 468.72 ML of produced water released from April to May
  - pre-wet survey: there were no releases of produced water in October or early November 2019, although 327 ML of produced water was released in September 2019. Release of produced water in November 2019 commenced on 15/11/2019, after the pre-wet survey had been completed.

149° E

149.2° E

Dawson River

Harris Creek

Boyd Creek

Belington Hut State Forest

Injune-Road

Expedition Resources Reserve

Beilba State Forest

Expedition (Limited Depth) National Park

Hutton Creek

Fitzroy Basin

DRR1

DRMP1

S4

WLMP4

WLMP5

WLMP1

DRR2

Stephenton State Forest

Commissioner Creek

Hallett State Forest

Sids Pocket Road

149° E

149.2° E

frc environmental
AQUATIC ECOLOGISTS
deep thinking.science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme Receiving Environment Program

Map 2.1:
Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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LEGEND

Monitoring Site
- Control sites upstream of receiving environment
- Waterbody sites within receiving environment
- Dawson River sites within receiving environment
- Watercourse
- Lake/Reservoir
- Basin

Road Network
- Local Road

Protected Area
- National Park
- Other Reserve

N

SCALE

0 2.25 4.5
Kilometres

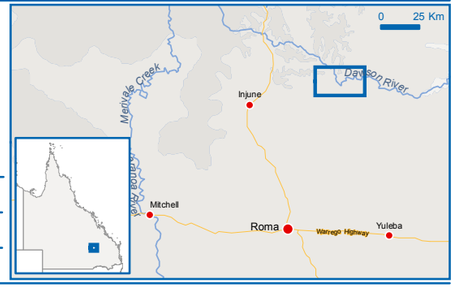
Scale: 1:80,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2017-06-20

DRAWN BY
AB

VERSION
01



3 Water Quality

3.1 Methods

Survey Procedure

Water quality was measured in situ for temperature, pH, electrical conductivity, dissolved oxygen and turbidity using a calibrated meter. Measurements were taken approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites.

Water sample were collected approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites, directly into sampling containers provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed. Two (replicate) samples were collected from one site on each survey for assessing within-site variation. Parameters analysed in the laboratory were: suspended solids, ammonia, nitrogen, and total and dissolved boron and zinc.

Data Analysis

Results were compared to the local water quality guidelines developed for the DRRS REMP (frc environmental 2018). Relative percent difference was calculate for the replicate samples collected at one site on each survey to assess within-site variation.

3.2 Results

Results for the water quality results (Table 3.1, Table 3.2, Table 3.3) showed that:

- The concentration of dissolved oxygen was lower than the guideline range at site:
  - DRMP1 (5.8 mg/L) in the post-wet survey, although this result was within the baseline range for the Dawson River (i.e. baseline minimum of dissolved oxygen was 1.9 mg/L for the Dawson River water type; Appendix D), indicating a result that is consistent with baseline conditions
  - WLMP1 (4.8 mg/L) in the pre-wet survey, although this result was within the baseline range for the Waterbody (i.e. baseline minimum of dissolved

oxygen was 0.13 mg/L for the Waterbody water type; Appendix D), indicating a result that is consistent with baseline conditions

  - DRR2 (5.9 mg/L) in the pre-wet survey, although this result was within the baseline range for Hutton Creek (i.e. baseline minimum of dissolved oxygen was 1.6 mg/L for the Hutton Creek water type; Appendix D), indicating a result that is consistent with baseline conditions

- Electrical conductivity was higher than the guideline at site DRR2 (520 µS/cm) in the post-wet survey, although was within the baseline range for Hutton Creek (i.e. baseline maximum of electrical conductivity was 797 µS/cm for the Hutton Creek water type), indicating a result that is consistent with baseline conditions
- The concentration of suspended solids was higher than the guideline at site WLMP4 (174 mg/L) in the post-set survey and at site WLMP5 (155 mg/L) in the pre-wet survey, although both results were within the baseline range for the Waterbody (i.e. baseline maximum of suspended solids was 665 mg/L for the Waterbody water type; Appendix D), indicating a result that is consistent with baseline conditions
- The concentration of total nitrogen was higher than the guideline at site S4 (1.2 mg/L) in the post-wet survey and at site DRR2 (0.9 mg/L) in the pre-wet survey. However the results were within the baseline range for the Dawson River and Hutton Creek (i.e. baseline maximum of total nitrogen was 1.7 mg/L for the Dawson River water type and 1.6 mg/L for Hutton Creek; Appendix D), indicating a result that is consistent with baseline conditions
- The concentration of total boron was higher than the guideline at site WLMP4 (1.11 mg/L) in the pre-wet survey, with the result higher than the baseline maximum. The result for total boron at site WLMP4 in the pre-wet survey indicates required further investigation.
- all other parameters complied with the guideline at all sites, noting data for total and dissolved zinc was not available for site S4 in the pre-wet survey, and
- the relative percent difference for total nitrogen was relatively high in the post-wet survey, indicting high within-site variation for this parameter. Replicate data was not available for the pre-wet survey.

Table 3.1 Water quality results compared to the local water quality guidelines for the 2019 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	26.9	20.5	24.9	15.8 – 27.1	19.28	22.63	22.33	–	23.19
Dissolved oxygen	mg/L	–	6.4 – 16.1	9.7	8.7	9.5	6.4 – 16.1	5.8	7.3	6.5	6.4 – 16.1	8.2
Electrical conductivity	µS/cm	–	627	270	350	240	500	290	270	260	500	520
pH	unit	–	6.5 – 8.5	8.24	7.0	8.2	6.5 – 8.5	7.4	8.0	7.5	6.5 – 8.5	8.1
Suspended solids	mg/L	5	128	174	13	16	50	16	28	11	50	7
Turbidity	NTU	–	Monitor only	28.9	23.2	23.7	Monitor only	26.4	28.6	39.1	Monitor only	34.5
Nutrients												
Ammonia as N	mg/L	0.01	0.9	0.02	< 0.01	0.01	0.9	0.13	0.01	0.11	0.9	0.03
Total nitrogen	mg/L	0.1	3.93	1.4	0.6	0.6	0.62	0.40	1.2	0.30	0.62	0.40
Total metals and metalloids												
Boron	mg/L	0.05	1.0	0.79	0.94	0.93	1.0	< 0.05	< 0.05	< 0.05	1.0	0.05
Zinc	mg/L	0.005	12	< 0.005	< 0.005	< 0.005	8	< 0.005	< 0.005	< 0.005	8	< 0.005
Dissolved Metals and metalloids												
Boron	mg/L	0.05	1.0	0.80	0.92	0.95	1.0	< 0.05	< 0.05	< 0.05	1.0	0.05
Zinc	mg/L	0.005	8	< 0.005	< 0.005	< 0.005	8	< 0.005	<0.005	< 0.005	8	< 0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value; – No guideline or data.

Table 3.2 Water quality results compared to the local water quality guidelines for the 2019 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	27.6	27.1	24.8	15.8 – 27.1	25.5	26.6	25.6	–	28.6
Dissolved oxygen	mg/L	–	6.4 – 16.1	8.3	4.8	7.4	6.4 – 16.1	6.9	7.2	6.6	6.4 – 16.1	5.9
Electrical conductivity	µS/cm	–	627	306	172	131	500	261	262	300	500	230
pH	unit	–	6.5 – 8.5	6.9	7.2	6.9	6.5 – 8.5	6.9	7.0	6.8	6.5 – 8.5	7.0
Suspended solids	mg/L	5	128	124	81	155	50	10	<5	>5	50	18
Turbidity	NTU	–	Monitor only	17.4	18.3	15.3	Monitor only	16.0	7.6	2.0	Monitor only	7.6
Nutrients												
Ammonia as N	mg/L	0.01	0.9	0.02	0.06	0.02	0.9	0.02	0.01	<0.01	0.9	0.01
Total nitrogen	mg/L	0.1	3.93	1.0	0.8	1.0	0.62	0.1	0.1	<0.1	0.62	0.9
Total metals and metalloids												
Boron	mg/L	0.05	1.0	1.11	0.91	0.94	1.0	0.06	<0.05	<0.05	1.0	<0.05
Zinc	mg/L	0.005	12	<0.005	<0.005	0.012	8	0.008	NA	<0.005	8	
Dissolved Metals and metalloids												
Boron	mg/L	0.05	1.0	1.0	0.85	0.84	1.0	<0.05	<0.05	<0.05	1.0	<0.05
Zinc	mg/L	0.005	8	<0.005	<0.005	<0.005	8	0.005	NA	<0.005	8	<0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value; – No guideline or data.

Table 3.3 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters in the post-wet season survey.

Parameter	Unit	LOR	Post-wet survey		
			Site WLMP5		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	15	16	6.3
Ammonia as N	mg/L	0.01	0.01	0.01	0.0
Total Nitrogen	mg/L	0.1	0.2	0.6	66.7
Total boron	mg/L	0.05	0.95	0.93	2.2
Total zinc	mg/L	0.005	< 0.005	< 0.005	–
Dissolved boron	mg/L	0.05	0.94	0.95	1.1
Dissolved zinc	mg/L	0.005	< 0.005	< 0.005	–

4 Sediment Quality

4.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids).

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2018).

4.2 Results

Results for the laboratory analyses of sediment quality (Table 4.1, Table 4.2, Table 4.3) showed that:

- The concentration of manganese was higher than the local trigger value at sites DRMP1 (260 mg/kg) and DRR1 (721 mg/kg) in the post-wet survey, and at site DRR1 (345 mg/L) in the pre-wet survey. The result for site DRR1 in the post-wet survey was higher than the baseline range recorded in the Dawson River (maximum = 545 mg/kg; Appendix D), noting that site DRR1, which had the highest concentration, is a control site and is not influenced by the release of produced water.
- The concentration of iron was higher than the local trigger value at site DRR1 (15400 mg/kg in the post-wet survey and 10300 mg/L in the pre-wet survey). However, the concentration of iron at this site was lower than the baseline ranged recorded in the Dawson River (19000 mg/kg; Appendix D), indicating that the concentration of iron was consistent with ambient baseline conditions.
- The concentration of all other parameters complied with the applicable local sediment quality guideline at all sites on each survey, noting that boron in the post-

wet survey and selenium on both surveys could not be assessed because the limit of reporting (LOR) was higher than the local trigger value.

- the relative percent difference (RPD) for manganese was relatively high in the post-wet survey, indicting high within-site variation for this parameter. Replicate data was not available for the pre-wet survey.

Table 4.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2019 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	5780	6800	7900	5191	4220	3020	8550	11800	1900
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	5	20	< 5
Boron (B)	mg/kg	50	18.8	< 50	< 50	< 50	17.9	< 50	< 50	< 50	25	< 50
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	5	5	7	80	4	2	6	80	2
Copper(Cu)	mg/kg	5	65	10	11	13	65	7	< 5	12	65	< 5
Iron (Fe)	mg/kg	50	17867	8210	11700	10500	9353	8300	6720	15400	20700	6440
Lead (Pb)	mg/kg	5	50	12	12	15	50	8	6	14	50	< 5
Manganese (Mn)	mg/kg	5	648	304	427	279	230.5	260	106	721	337	81
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	7	8	7	21	5	3	9	21	3
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	35	39	40	200	23	16	36	200	15

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.2 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2019 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	6060	7880	8660	5191	370	360	3230	11800	1210
Arsenic (As)	mg/kg	5	20	<5	<5	<5	20	<5	<5	<5	20	<5
Boron (B)	mg/kg	0.2	18.8	1.0	2.3	1.0	17.9	<0.2	2.6	0.3	25	<0.2
Cadmium (Cd)	mg/kg	1	1.5	<1	<1	<1	1.5	<1	<1	<1	1.5	<1
Chromium (Cr)	mg/kg	2	80	6	6	8	80	<2	<2	3	80	2
Copper(Cu)	mg/kg	5	65	10	12	13	65	<5	<5	6	65	<5
Iron (Fe)	mg/kg	50	17867	9350	14100	14500	9353	1030	1230	10300	20700	5190
Lead (Pb)	mg/kg	5	50	12	13	14	50	<5	<5	8	50	<5
Manganese (Mn)	mg/kg	5	648	291	573	395	230.5	22	18	345	337	39
Mercury (Hg)	mg/kg	0.1	0.15	<0.1	<0.1	<0.1	0.15	<0.1	<0.1	<0.1	0.15	<0.1
Nickel (Ni)	mg/kg	2	21	7	8	9	21	<2	<2	5	21	2
Selenium (Se)	mg/kg	5	1	<5	<5	<5	1.73	<5	<5	<5	1	<5
Zinc (Zn)	mg/kg	5	200	35	45	41	200	<5	<5	22	200	10

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.3 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters in the post-wet season survey.

Parameter	Unit	Site WLMP1 (post-wet survey 2019)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	6800	8090	16.9
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	< 50	< 50	–
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	5	8	37.5
Copper(Cu)	mg/kg	11	15	26.7
Iron (Fe)	mg/kg	11700	11900	1.7
Lead (Pb)	mg/kg	12	16	25.0
Manganese (Mn)	mg/kg	427	305	40.0
Mercury (Hg)	mg/kg	< 0.1	< 0.1	–
Nickel (Ni)	mg/kg	8	8	0.0
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	39	47	17.0

5 Aquatic Habitat, and Bed and Bank Stability

5.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP design document (frc environmental 2018).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons were made against baseline condition, as presented in the REMP design document (frc environmental 2018).

5.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 5.1 and Table 5.2) showed for both surveys that:

- bed and bank stability at all sites and for all water types had not changed from baseline condition
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with water levels higher than many of the baseline surveys providing an increased cover of woody debris and increased diversity of submerged aquatic plants.
- all other aquatic habitat features for all water types remained relatively unchanged since baseline surveys.

Table 5.1 Habitat characteristics of each water type in the 2019 post-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*moderate*
Substrate diversity	*low*	*moderate*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition
blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 5.2 Habitat characteristics of each water type in the 2019 pre-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*high*	*low*	*moderate*
Substrate diversity	*low*	*moderate*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition
blue shading indicated a potential increase in habitat quality compared to baseline conditions

6 Macroinvertebrate Communities

6.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2018).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual* (DES 2018). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. The REMP design document considers an error rate of <5% acceptable for macroinvertebrate sorting and identification, with the error rate of < 2% for this study.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (i.e. families in most cases in this assessment). 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each replicate sample for each site, and then the median per site and median for each water type were calculated. These results were compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP design document; frc environmental 2018). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range, then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

6.2 Results

Results for macroinvertebrate indices showed that (Table 6.1, Table 6.2, Table 6.3 and Table 6.4):

- the abundance of macroinvertebrates was:
  - post-wet survey:
    - within the local biological guideline range at all sites during the post-wet survey
    - within the local biological guideline range for the Waterbody, Dawson River and Hutton Creek water types
  - pre-wet survey:
    - higher than the local biological guideline range at Waterbody sites WLMP1 and WLMP5 and all Dawson River sites in the pre-wet survey, but within the baseline range at all sites (see appendix D)
    - within the local biological guideline range for the Waterbody, Dawson River and Hutton Creek water types
- taxonomic richness of macroinvertebrates was:
  - post-wet survey:
    - higher than the local biological guideline range at sites WLMP4 and WLMP1, and for the Waterbody overall, and higher than the baseline maximum at site WLMP4 (see Appendix D) in the post-wet survey;
    - lower than the local biological guideline range at sites DRMP1 and S4, and for the Dawson River overall, but within the baseline range (see Appendix D)
    - within the biological guideline range for sites DRR1 and DRR2, and for the Hutton Creek water type
  - pre-wet survey:
    - higher than the local biological guideline at all sites and all water types in the pre-wet survey, and slightly higher than the baseline range at site WLMP1 (see Appendix D)
- PET richness of macroinvertebrates was:
  - post-wet survey:
    - higher than the local biological guideline range site WLMP4, but within the baseline range (Appendix D)

  - lower than the local biological guideline at sites DRMP1, S4 and DRR1, and the Dawson River overall, but within baseline range (see Appendix D)
  - within the biological guideline range at sites WLMP1, WLMP5 and DRR2, and for the Waterbody and Hutton Creek water types
  - pre-wet survey:
  - higher than the local biological guideline range at most sites and for all water types, and slightly higher than the baseline range at site WLMP5 and the Waterbody water type

- SIGNAL-2 Scores for macroinvertebrates were:
  - post-wet survey
  - higher than the local biological guideline range at sites WLMP5 and DRR2, and in the Waterbody and Hutton Creek overall, but within the baseline range (Appendix D)
  - within the local biological guideline range at sites WLMP4, WLMP1, DRMP1, S4 and DRR1, and for the Dawson River water type
  - pre-wet survey:
  - higher than the local biological guideline at about half the sites across all water types, and for the Hutton Creek water type overall, and higher than the baseline range at site DRR2 / Hutton Creek water type.

Table 6.1 Macroinvertebrate results for each site in the 2019 post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	100	115.0	96.0	39.9–152.0	57.0	53.0	54.0	23.0–207.4	42.0
Taxonomic Richness	5.67–10.8	20	15.0	6.0	9.93–16.9	9.0	8.0	13.0	4.0–10.0	8.0
PET richness	0.0 – 1.2	2.0	1.0	0.0	1.47–4.0	1.0	1.0	1.0	0–1.0	0.0
SIGNAL-2 Score	2.65 – 3.20	3.14	3.17	3.30	3.46–4.00	3.55	3.73	3.51	2.90–3.30	3.43

Blue shading indicates result is higher than the local biological objective; grey shading is where the result is lower than the local biological objective

Table 6.2 Macroinvertebrate results for each site in the 2019 pre-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	214	260	279	39.9–152.0	225	291	214	23.0–207.4	94
Taxonomic Richness	5.67–10.8	13.4	15.4	12.6	9.93–16.9	17.0	22	20.3	4.0–10.0	14.6
PET richness	0.0 – 1.2	2.0	1.1	3.3	1.47–4.0	3.9	4.7	4.1	0–1.0	2.4
SIGNAL-2 Score	2.65 – 3.20	3.3	2.9	3.5	3.46–4.00	4.1	3.9	3.8	2.90–3.30	3.6

Blue shading indicates result is higher than the local biological objective; grey shading is where the result is lower than the local biological objective

Table 6.3 Macroinvertebrate results for each water type in the 2019 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	100.0	39.9 – 152.0	56.0	23.0 – 207.4	42.0
Taxonomic Richness	5.67–10.8	13.0	9.93 – 16.9	9.0	4.0 – 10.0	8.00
PET richness	0.0 – 1.2	1.0	1.47 – 4.0	1.0	0 – 1.0	0.0
SIGNAL-2 Score	2.65 – 3.20	3.28	3.46 – 4.00	3.55	2.90 – 3.30	3.43

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

Table 6.4 Macroinvertebrate results for each water type in the 2019 pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	251	39.9 – 152.0	244	23.0 – 207.4	94
Taxonomic Richness	5.67–10.8	13.8	9.93 – 16.9	19.8	4.0 – 10.0	14.6
PET richness	0.0 – 1.2	2.1	1.47 – 4.0	4.2	0 – 1.0	2.4
SIGNAL-2 Score	2.65 – 3.20	3.2	3.46 – 4.00	3.9	2.90 – 3.30	3.6

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

7 Fish

7.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 7.1 and Table 7.2). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 181742) and Animal Ethics Approval (CA 2015/08/893 and 2018/08/1224) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 7.1 Effort used to catch freshwater fish in the 2019 post-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	14:20	7:00	33.3 h
WLMP1	fyke net (2)	pool	15:00	10:00	38 h
WMLP5	fyke net (2)	pool	16:00	12:30	41 h
Dawson River					
DRMP1	fyke net (2)	pool	14:00	9:00	38 h
S4	fyke net (2)	pool	15:30	12:30	42 h
DRR1	fyke net (2)	pool	14:30	10:00	39 h
Hutton Creek					
DRR2	fyke net (2)	pool	17:00	15:00	44 h

Table 7.2 Effort used to catch freshwater fish in the 2019 pre-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	14:00	7:30	35 h
WLMP1	fyke net (2)	pool	16:00	8:45	33.5 h
WMLP5	fyke net (2)	pool	16:45	12:15	39 h
Dawson River					
DRMP1	fyke net (2)	pool	16:00	9:50	35.6 h
S4	fyke net (2)	pool	17:00	12:00	38 h
DRR1	fyke net (2)	pool	14:30	7:30	34 h
Hutton Creek					
DRR2	seine net	pool	–	–	2 x 10 m hauls

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2018) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

7.2 Results

Ten species of native fish were caught and / or observed during the 2019 post-wet REMP surveys (Table 7.3), with nine species recorded in the pre-wet survey (Table 7.4). None of these species are conservation significant species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act).

The number of native species caught at each site ranged from two (site DRMP1 in the post-wet season survey), to seven (site WLMP5 in the post-wet survey, and sites WLMP1 and DRR1 in the pre-wet survey). Total abundance of fish at each site ranged from 7 (site S4 in the post-wet season survey) to 3286 (site WLMP1 in the pre-wet survey). The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites. The most commonly recorded species were carp gudgeons, eastern rainbowfish, Agassizi's glassfish and pacific blue eye. No exotic species were caught.

All water types achieved the local biological guideline for fish in both the post-wet and pre-wet surveys (i.e. had an observed : expected ratio of species diversity that was ≥ 1) (Table 7.5 and Table 7.6). This indicates that the diversity of fish caught during the 2019 REMP surveys was the same as or higher than that recorded during the baseline monitoring program. Increased water levels compared to baseline condition may have created favourable conditions for fish.

All sites also achieved the biological guideline for exotic fish (i.e. no exotic fish were caught on either survey), indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 7.3 Total abundance of freshwater fish for each species at each site in 2019 post-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	15	38	62	–	–	22	–	**137**
Craterocephalus stercusmuscarum	flyspecked hardyhead	7	18	30	–	1	2	–	**58**
Hypseleotris compressa	empire gudgeon	–	4	–	–	–	–	–	**4**
Hypseleotris spp.	carp gudgeon	163	946	300	–	–	9	307	**1725**
Macquaria ambigua	yellow belly	–	–	–	–	2	1	1	**4**
Melanotaenia splendida splendida	eastern rainbowfish	18	44	90	5	–	88	253	**498**
Nematalosa erebi	bony bream	–	–	2	–	–	–	8	**10**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	1	–	–	–	–	**1**
Pseudomugil signifer	Pacific blue eye	–	–	–	23	4	44	–	**67**
Tandanus tandanus	freshwater catfish	–	–	1	–	–	–	2	**3**
Total native individuals		**203**	**1050**	**486**	**28**	**7**	**166**	**571**	**2507**
Total native species		**4**	**5**	**7**	**2**	**3**	**6**	**5**	**10**

– not caught

Table 7.4 Total abundance of freshwater fish for each species at each site in 2019 pre-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	103	136	7	–	9	38	–	**293**
Craterocephalus stercusmuscarum	flyspecked hardyhead	1	44	3	–	–	14	–	**62**
Hypseleotris compressa	empire gudgeon	–	–	–	–	–	–	–	**–**
Hypseleotris spp.	carp gudgeon	700	3094	1673	11	17	91	585	**6171**
Macquaria ambigua	yellow belly	–	–	–	3	–	–	–	**3**
Melanotaenia splendida splendida	eastern rainbowfish	–	1	8	2	4	85	27	**127**
Nematalosa erebi	bony bream	4	7	1	–	–	12	1	**25**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	–	–	–	–	–	**–**
Pseudomugil signifer	Pacific blue eye	–	–	–	7	3	66	–	**76**
Tandanus tandanus	freshwater catfish	–	3	–	–	2	2	–	**7**
Leiopotherapon unicolor	Spangled perch	–	1	–	–	1	–	–	**2**
Total native individuals		**808**	**3286**	**1692**	**23**	**36**	**308**	**613**	**6766**
Total native species		**4**	**7**	**5**	**4**	**6**	**7**	**3**	**9**

– not caught

Table 7.5 Comparison of fish monitoring results with the local biological objective for fish for the 2019 post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	8	2.0
Dawson River	5	6	1.5
Hutton Creek	2	5	2.5

Table 7.6 Comparison of fish monitoring results with the local biological objective for fish for the 2019 pre-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	7	1.75
Dawson River	5	9	1.8
Hutton Creek	2	3	1.5

8 Macrocrustaceans – Exoskeleton Assessment

8.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 8.1).

8.2 Results

The macrocrustaceans caught during the 2019 REMP surveys included *Macrobrachium australiense, Caridina* spp., which were caught during the baseline monitoring program (Table 8.1), and crayfish (*Cherax* sp.) at WLMP1 in the post-wet survey but caught at all sites in the pre-wet survey. All specimens had exoskeletons that were of robust and good condition (Table 8.2). No macrocrustaceans were recorded in breeding condition during the post-wet season survey, which is consistent with the results of baseline surveys implemented in Autumn. However, there was evidence that all three taxa were breeding in the pre-wet season, which is consistent with the results of the baseline surveys.

Table 8.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 8.2 Macrocrustacean species and condition recorded during the 2019 post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
	Caridina spp.	*Caridina* spp.	*Caridina* spp.
	Cherax sp.		*Cherax* sp.
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae); *Cherax* sp. – yabby (family Parastacidae).

Table 8.3 Macrocrustacean species and condition recorded during the 2019 pre-wet REMP survey.

Recorded Attribute	**Water Type**		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
	Caridina spp.	*Caridina* spp.	*Caridina* spp.
	Cherax sp.	*Cherax* sp.	*Cherax* sp.
Breeding condition	*Macrobrachium* and *Caridina* breeding with eggs (the *Cherax* caught were all juveniles, indicating breeding)	*Macrobrachium* and *Caridina* breeding with eggs (the *Cherax* caught were all juveniles, indicating breeding)	*Macrobrachium* and *Caridina* breeding with eggs (the *Cherax* caught were all juveniles, indicating breeding)
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae); *Cherax* sp. – yabby (family Parastacidae).

9 Zooplankton

9.1 Methods

Survey Procedure

Zooplankton was assessed only in the pre-wet (November) survey in 2019.

Three samples were collected at each site using a six-meter, depth-integrated tow with a 150 µm mesh plankton net, which samples 'macrozooplankton', but not 'microzooplankton' (i.e. ciliates, rotifers and juvenile microzooplankton – i.e. nauplii), which requires a smaller mesh size of approximately 20 µm (James 1991).

Samples were preserved in methylated spirits and transported to a biological laboratory (Dardanus Scientific) where they were processed by a suitably qualified aquatic invertebrate taxonomy specialist. Microcrustaceans were identified to morphospecies[1], with the exception of *Ceriodaphnia cf dubia*, which was identified to described species level using available taxonomic keys (Shiel 1995). This taxon was of particular interest due to its reported sensitivity to boron (Halcrow 2012).

The abundance of each taxon was determined for a quantitative sub-sample of each sample, and then converted to an abundance for the total sample.

Data Analysis

There is no baseline data for zooplankton and no biological guidelines for zooplankton, although an initial zooplankton survey was completed in September 2018 at the Waterbody sites (i.e. WLMP4, WLMP1 and WLMP5) with this data (i.e. see Appendix D) incorporated in this study. Only data for microcrustaceans (Cladocerans, Ostracods and Copepods) is presented.

Spatial and temporal variability in the zooplankton community was statistically assessed using PERMANOVA and multidimensional scaling, implemented using the Primer software.

[1] Only microcrustacean data is considered, although all taxa were identified during laboratory processing, with insects identified to family or subfamily, and other taxa (e.g. Nematoda) to class or order.

9.2 Results

Ten microcrustacean taxa were found in the post-wet survey, including *Ceriodaphnia cf dubia* (Table 9.1). This taxon was not recorded in September 2018 (see Appendix D), and was only recorded at one Waterbody site and at one site on the Dawson River in the 2019 pre-wet season survey, indicating that this taxon occurs in the receiving environment, but the limited data available suggesting that its occurrence is patchy over time and space.

Microcrustacean diversity was highest in the Dawson River (all ten taxa recorded), intermediate in the Waterbody (five taxa recorded) and lowest in Hutton Creek (only one taxa recorded), noting that the abundances of taxa was high varied. For example, while only one taxon was recorded at the Hutton Creek site, the abundances recorded were much higher than abundances recorded in the Dawson River and the Waterbody. Overall, these results show that the microcrustacean community is highly differentiated between the three water types (locations) (i.e. Dawson River, Waterbody and Hutton Creek (Figure 9.1).

When the microcrustaceans sampled from the Waterbody in September 2018 are included in the analysis, results show a clear separation between the Waterbody over the two years (Figure 9.2). Separation between sites on the Waterbody in September 2018 was notably higher than in November 2019, indicating that in some years different sections of the Waterbody can have distinct microcrustaceans communities. PERMANOVA analysis using the combined 2018 / 2019 data further indicates high and statistically significant spatial and temporal variability in microcrustacean communities:

- between locations (i.e. between the three water types): $F = 6.57$, $P < 0.0001$
- across time (i.e. between 2018 and 2019): $F = 8.12$, $P < 0.0001$
- between sites: $F = 4.54$, $P < 0.001$, and
- across space and time combined (i.e. interaction between location and time): $F = 10.80$, $P < 0.001$.

Table 9.1 Zooplankton (microcrustacean) survey results for the pre-wet season 2019 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP1			WLMP4			WLMP5			DRR1			DRMP1			S4			DRR2		
	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3
Ceridodaphnia cf dubia			14														1				
Chydoridae (Cladocera)											5	10	6	2	50			4			
Bosminidae (Cladocera)													2		30		85	13			
Copepod 1 (Calanoida)	45	31	8	16	28	82	444	648	509	14	3	5	15	4				1	3870	7000	8107
Copepod 2 (Cyclopoida)	41	220	450	65	275	425	115	85		5	4	2	3	1	5	5	10	10			
Ostracod 1					5						2		3	1	11			1			
Ostracod 2			1									2	5		20			1			
Ostracod 3											1			1							
Ostracod 4											4										
Ostracod 5												1	2		5						

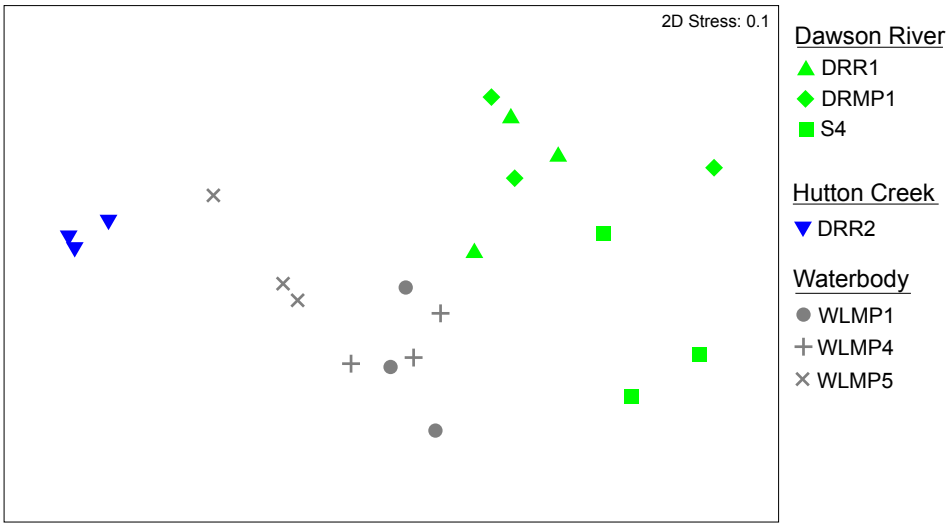


Figure 9.1 MDS plot of microcrustacean communities at each site in the 2019 pre-wet survey, showing separation of the three water types.

Figure 9.2 MDS plot of microcrustacean communities at Waterbody sites in September 2018, and at each site in the 2019 pre-wet season survey, showing separation of the three water types, and separation of the Waterbody samples between 2018 and 2019.

10 Assessment of Environmental Changes

The monitoring results for the 2019 post-wet and pre-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- Physical habitat features in the Waterbody, which had improved from baseline condition due to higher water levels. The higher water levels have increased submerged aquatic plant cover and the cover of large woody debris in water in the Waterbody
- The concentration of total boron in water at site WLMP4 (1.11 mg/L), which was higher than the local guideline and the baseline maximum in the pre-wet survey. Direct toxicity studies of the effect of boron on aquatic biota of the region showed that even the most sensitive aquatic species (a microcrustacean, *Ceriodaphnia cf dubia*) had No Observable Effect Concentrations (NOEC) of 10.3 mg/L, with algae of the region having NOEC of 20.7 mg/L (Halcrow 2013). Thus, the recorded concentration of boron at site WLMP4 in the pre-wet survey likely has low risk of environmental harm.
- The taxonomic richness of macroinvertebrate at site WLMP4 in the post-wet survey and site WLMP1 in the pre-wet survey was higher than the baseline range recorded in the Waterbody. PET richness was higher than the baseline range at site WLMP5 and the Waterbody overall in the pre-wet survey, and SIGNAL-2 Score was slightly higher than the baseline range at site DRR2 / Hutton Creek water type in the pre-wet survey. However, abundance was not increased from baseline at any site, no macroinvertebrate index has decreased from baseline condition. Thus, the results do not reflect an impact, but likely reflects improved habitat conditions from baseline conditions in the Waterbody and the Hutton Creek site, both of which had sites that were often dry or with only shallow water (i.e. sites WLMP4 and DRR2 for many of the baseline surveys.

Assessment of zooplankton was added to the REMP for the first time in the pre-wet survey 2019, with results showing high spatial and temporal variability in microcrustacean communities. The taxon of specific interest, *Ceriodaphnia cf dubia*, which is considered to be the taxon of the region with highest sensitivity to boron, was recorded at two receiving environment sites (WLMP1 in the Waterbody and S4 on the Dawson River).

Overall, the 2019 post-wet and pre-wet survey results indicated that the release of desalinated produced water from ROP2 has not likely impacted the aquatic environmental values of the receiving environment.

11 References

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Halcrow, 2013. Dawson River Release Scheme Direct Toxicity Assessment: Fish Test, Addendum to Direct Toxicity Report (Halcrow November 2012). Prepared for Santos GLNG, February 2013.

James, M. R., 1991, Sampling and preservation methods for the quantitative enumeration of microzooplankton. New Zealand Journal of Marine and Freshwater Research, 25, 305-310.

Shiel, R.J. 1995. A Guide to the Identification of Rotifers, Cladocerans and Copepods from Australian Inland Waters. Cooperative Research Centre for Freshwater Ecology, Albury.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019, frc environmental 14 July 2020

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions. (B38)(g), (B38)(h), (B38)(i), (B38)(k), (B38)(l) and (B38)(m) of environmental authority EPPG00928713 dated 9th October 2018, as detailed in the Receiving Environment Monitoring Program, dated 27th June 2018

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Benjamin Douglas Cook

(Insert full name of person making this declaration)

of, Wynnum, Brisbane

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

Declaration of compliance for written documents

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is appended to the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019, frc environmental, 14 July 2020;
2. The authority holder has fully complied with the requirements of conditions (B38)(g), (B38)(h), (B38)(i), (B38)(k), (B38)(l) and (B38)(m) of environmental authority EPPG00928713 dated 28 November 2019;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019, frc environmental, 14 July 2020;
4. The content of Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019, frc environmental, 14 July 2020 is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2019, frc environmental, 14 July 2020 meets the requirements of conditions (B38)(g), (B38)(h), (B38)(i), (B38)(k), (B38)(l) and (B38)(m) of environmental authority EPPG00928713 dated 28th November 2019.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at Cleveland, Redland City

(Insert name of town or city and suburb)

this 29th day of JULY in the year 2020

(Insert day, e.g. 18th) (Insert month) (Insert year)

Signed

(Person making this declaration)

Signed

(Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations / Solicitor / Barrister~~

E. John Handley **JP (Qual)**

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No. 80636 DEPT. OF JUSTICE & ATTORNEY-GENERAL

Approved By

Signature

Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species. Ben is fully AUSRIVAS accredited.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Senior Principal Ecology (Freshwater), frc environmental, Brisbane (2019 – current)
- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – 2019)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Clermont Coal Operations REMP 2014, 2015, 2016 2017, 2018, 2019. Glencore.
- Chinchilla End of Waste Scheme (formally Chinchilla Beneficial Use Scheme) REMP 2013, 2014, 2015, 2016, 2017, 2018, 2019. Sunwater.
- Poitrel Mine REMP 2017, 2018, 2019. BHP BMC.
- South Walker Creek Mine REMP 2017, 2018, 2019. BHP BMC.
- Olive Downs North Mine REMP 2017, 2018, 2019. Peabody Energy.
- Glebe End of Waste Scheme (formally Glebe Beneficial Use Scheme) REMP 2015, 2016, 2017, 2018, 2019. Sunwater.
- Mount Isa Mines REMP 2019. Glencore
- Lady Lorretta Mine REMP 2018, 2019. Glencore.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	15/04/19 (post-wet)	**Habitat Bioassessment Score**	59

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	high		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	low-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	*noogoora burr*
			sand	10 %		macrophytes		*Bidens pilosa*
Hydrology			silt / clay	90 %				*sida*
Flow regime	ephemeral	**Deposits**	none					creeping lantana
Water depth	2.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			grasses
Wetted width	70 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	75 m							

Comments: Banks heavily vegetated with *Juncus* sp. and *Carex* sp. In shallower sections *Vallisneria* sp. has formed dense meadows with some *Ludwegia peploides* scattered throughout. Some small and large woody debris present throughout reach. Water slightly turbid. No algal slick present.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	16/04/19 (post-wet)	**Habitat Bioassessment Score**	48

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	regular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt spp.
Bank shape	Low-convex, moderate-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris		Callitris sp.
Hydrology			sand	10 %		macrophytes	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	90 %	**In-stream disturbance**			noogoora burr
Water depth	1.5 m	**Deposits**	silt		Flow modification	none		
Wetted width	120 m	**Bed stability**	moderate aggradation		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	115 m							native vegetation

Comments: Dense beds of *Vallisneria* sp. along reach, *Ludwegia peploides* (flowering) also dense on recently exposed moist bed. *Juncus* sp., *Carex* sp. and *Persicaria* spp. covering banks. Water column slightly turbid with no algal or hydrocarbon slick visible. Large and small woody debris present along reach.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	16/04/19 (post-wet)	**Habitat Bioassessment Score**	55

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	very high
Bank stability	high		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	low-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	*Bidens pilosa*
Hydrology			sand	10 %		macrophytes		noogoora burr
Flow regime	ephemeral		silt / clay	90 %				sida
Water depth	1.5 m	**Deposits**	silt					
Wetted width	100 m	**Bed stability**	moderate aggradation		**In-stream disturbance**		**Adjacent land use**	native vegetation
Flow	no flow				Flow modification	none		cropping
Channel width	110 m				Waterway barrier	none		

Comments: Water column slightly turbid with no obvious algal or hydrocarbon slick. Scattered dead standing timber and small woody debris. *Ludwegia peploides* fringing waters edge, with scattered patches of *Potamogeton crispus* in beds and *Cyperus gymnocaulis* on bank.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	17/04/19 (post-wet)	**Habitat Bioassessment Score**	69

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	2%		deep	**Dominant species**	Eucalypt
								Casurina
Bank shape	steep-convex		pebble	2 %		run		Callistemon
			gravel	1 %		riffle	**Weed species**	noogoora burr
			sand	85 %		large woody debris		grasses
Hydrology			silt / clay	10 %		undercut banks		Bidens pilosa
								purple top
Flow regime	perennial						**Adjacent land use**	native forest
Water depth	1 m	**Deposits**	sand, silt		**In-stream disturbance**			riparian
Wetted width	12 m	**Bed stability**	stable		Flow modification	none		cropping
Flow	0.05 m / s				Waterway barrier	none		
Channel width	12 m							

Comments: Water slightly turbid with moderate flow. Scattered patches of *Vallisneria* sp. and *Potamogeton crispus.* Substrate dominated by sand with extensive small and large woody debris. Undercut bank present providing habitat along with trailing roots. Banks heavily vegetated with grasses, herbs and scattered *Lomandra* sp..

Site	S4	**Region**	Upper Dawson
Date surveyed:	17/04/19 (post-wet)	**Habitat Bioassessment Score**	49

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – high	**Riparian width**	10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate-convex		pebble	0 %		pool		Casuarina
			gravel	5 %		run		Callistemon
						macrophytes		
			sand	70 %		large woody debris	**Weed species**	none
Hydrology			silt / clay	25 %			**Adjacent land use**	forest
Flow regime	perennial							grazing
Water depth	1.5 m	**Deposits**	Sand/silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.02 m / s				Waterway barrier	none		
Channel width	20 m							

Comments:	Water slightly turbid at site with slow flow. Some macrophytes present within reach with scattered patches of macrophyte debris. Banks 75% vegetated with scattered *Lomandra* sp., *Persicaria* sp. and dock. Some vegetated sand bar formation. No apparent algal or hydrocarbon slick. Evidence of cattle access to site.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	17/04/19 (post-wet)	**Habitat Bioassessment Score**	59

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – good	**Riparian width**	10 – 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	Steep-convex		pebble	0 %		run		Casuarina
			gravel	0 %		pool		Callistemon
Hydrology			sand	80 %		macrophytes	**Weed species**	noogoora burr
Flow regime	perennial		silt / clay	20 %		undercut bank		*Bidens pilosa*
Water depth	1.0 m	**Deposits**	Sand/silt		**In-stream disturbance**			grasses
Wetted width	5 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.02 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments: Low flow. Water moderately turbid. Substrate dominated by sand with some deposits of silt. Beds of *Vallisneria* sp. present. Banks heavily vegetated with grasses, *Lomandra* sp. and native trees >10 m. Exotic species dominate understory. Undercut banks, trailing bank vegetation and small woody debris provide some instream habitat. Some bar formation downstream of site with channel a series of deeper pools and shallow runs.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	17/04/19 (post-wet)	**Habitat Bioassessment Score**	65

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	10%	**Habitat diversity**	low	**Riparian width**	5 – 10 m
Pattern	irregular meanders		boulder	10 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	50 %		deep	**Dominant species**	Eucalypt
Bank shape	Steep-concave		pebble	3 %		pool		Callistemon
			gravel	2 %		large woody debris		Callitris
Hydrology			sand	15 %			**Weed species**	none
Flow regime	intermittent		silt / clay	10 %			**Adjacent land use**	grazing
Water depth	1 m	**Deposits**	Sand/silt		**In-stream disturbance**			native vegetation
Wetted width	15 m	**Bed stability**	stable		Flow modification	none		
Flow	No observable flow				Waterway barrier	none		
Channel width	20 m							

Comments: No flow apparent at site. Reach has dried to a series of large isolated in channel pools. Water moderately turbid. Abundance and diversity of fringing aquatic vegetation low with no obvious instream aquatic vegetation. Some large and small woody debris present providing habitat along with boulder and rock faces. Some algal slick present, likely due to standing water. No hydrocarbon slick observed.

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	5/11/19 (pre-wet)	**Habitat Bioassessment Score**	45

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	high		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	low-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	*sida*
			sand	5 %		macrophytes		creeping lantana
Hydrology			silt / clay	95 %				
Flow regime	ephemeral	**Deposits**	silt					
Water depth	1.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			
Wetted width	95 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	100 m							

Comments: Banks heavily vegetated with *Juncus* sp. and *Carex appressa*. In shallower sections *Vallisneria* sp. has formed dense meadows with some *Ludwigia peploides* scattered on moist exposed wetland bed. There was also large patches of *Azolla* sp along with small and large woody debris present throughout reach. Water slightly turbid. No algal slick present.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	5/11/19 (pre-wet)	**Habitat Bioassessment Score**	66

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	regular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt spp.
Bank shape	Low/flat-convex		pebble	2 %		pool		Acacia sp.
			gravel	3 %		large woody debris		Callitris sp.
Hydrology			sand	5 %		macrophytes	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	90 %	**In-stream disturbance**			
Water depth	2.0 m	**Deposits**	silt		Flow modification	none		
Wetted width	100 m	**Bed stability**	moderate aggradation		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	120 m							native vegetation

Comments: Evidence of access by livestock at site. Riparian zone heavily cleared on either bank. Dense beds of *Vallisneria* sp. along reach, *Ludwegia peploides* (flowering) also dense on recently exposed moist bed. *Juncus* sp., *Carex* sp. and *Persicaria* spp. covering banks. Water column slightly turbid with no algal or hydrocarbon slick visible. Large and small woody debris present along reach.

Site	WLMP5	Region	Upper Dawson
Date surveyed:	5/11/19 (pre-wet)	Habitat Bioassessment Score	36

Downstream view

Upstream view

Channel Morphology		Substrate			Aquatic Habitat		Riparian Zone	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	very high
Bank stability	moderate		cobble	0 %		shallow	**Dominant species**	Eucalypt spp.
Bank shape	low-convex		pebble	0 %		pool		Acacia sp.
			gravel	0 %		large woody debris	**Weed species**	*Ludwegia peruviana*
Hydrology			sand	10 %		macrophytes		noogoora burr
Flow regime	ephemeral		silt / clay	90 %				sida
Water depth	1.5 m	**Deposits**	silt					
Wetted width	100 m	**Bed stability**	moderate aggradation		**In-stream disturbance**		**Adjacent land use**	native vegetation
Flow	no flow				Flow modification	none		cropping
Channel width	110 m				Waterway barrier	none		

Comments: Water column slightly turbid with no obvious algal or hydrocarbon slick. Scattered dead standing timber and small woody debris. *Ludwegia peploides* fringing waters edge, with scattered patches of *Potamogeton crispus* in beds and *Cyperus gymnocaulis* in large patches on bank. Evidence of stock access at site.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	7/11/19 (pre-wet)	**Habitat Bioassessment Score**	98

Downstream view

Upstream view

Channel Morphology		Substrate			Aquatic Habitat		Riparian Zone	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	2%		deep	**Dominant species**	Eucalypt
								Casuarina
Bank shape	moderate-convex		pebble	5 %		run		Callistemon
			gravel	10 %		riffle	**Weed species**	noogoora burr
			sand	73 %		large woody debris		grasses
Hydrology			silt / clay	10 %		undercut banks		purple top
Flow regime	perennial					macrophytes	**Adjacent land use**	native forest
Water depth	1 m	**Deposits**	sand, silt		**In-stream disturbance**			riparian
Wetted width	10 m	**Bed stability**	Moderate aggradation		Flow modification	none		cropping
Flow	0.1 m / s				Waterway barrier	none		
Channel width	12 m							

Comments: Water slightly turbid with moderate flow. Scattered patches of *Vallisneria* sp. and *Potamogeton crispus.* Substrate dominated by sand with some point bar formation and scouring of stream bed. Extensive small and large woody debris. Undercut bank present providing habitat along with trailing roots. Banks heavily vegetated with grasses, herbs and scattered *Lomandra* sp.

Site	S4	**Region**	Upper Dawson
Date surveyed:	6/11/19 (pre-wet)	**Habitat Bioassessment Score**	70

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate – high	**Riparian width**	10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	2 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate-convex		pebble	3 %		pool		Casuarina
			gravel	15 %		run		Callistemon
						macrophytes		
			sand	35 %		large woody debris	**Weed species**	none
Hydrology			silt / clay	45 %			**Adjacent land use**	forest
Flow regime	perennial							grazing
Water depth	1.0 m	**Deposits**	Sand/silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	0.02 m / s				Waterway barrier	Pipe culvert downstream of site		
Channel width	10 m							

Comments:	Water slightly turbid at site with slow flow. Large mid-channel bar reaching left bank. Some macrophytes present within reach with scattered patches of macrophyte debris. Banks 75% vegetated with scattered *Lomandra* sp., *Persicaria* sp. and dock. Some vegetated sand bar formation. No apparent algal or hydrocarbon slick. Evidence of cattle access to site. Pipe culvert downstream potential barrier to fish passage

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	6/11/19 (pre-wet)	**Habitat Bioassessment Score**	84

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate-convex		pebble	0 %		run		Casuarina
			gravel	2 %		macrophytes		Callistemon
Hydrology			sand	90 %		Undercut bank	**Weed species**	noogoora burr
Flow regime	perennial		silt / clay	8 %				*Bidens pilosa*
Water depth	0.5 m	**Deposits**	Sand/silt		**In-stream disturbance**			grasses
Wetted width	5 m	**Bed stability**	bed stable		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.1 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments: Water slightly turbid. Substrate dominated by sand with some deposits of silt. Beds of *Vallisneria* sp. present. Banks heavily vegetated with grasses, *Lomandra* sp. and native trees >10 m. Undercut banks, trailing bank vegetation and small woody debris provide some instream habitat. Some bar formation downstream of site with channel a series of deeper pools and shallow runs.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	7/11/19 (pre-wet)	**Habitat Bioassessment Score**	46

Downstream view

Upstream view

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	10%	**Habitat diversity**	low	**Riparian width**	5 – 10 m
Pattern	irregular meanders		boulder	10 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	50 %		deep	**Dominant species**	Eucalypt
Bank shape	moderate-concave		pebble	5 %		pool		Callistemon
			gravel	2 %		large woody debris		Callitris
Hydrology			sand	13 %			**Weed species**	none
Flow regime	intermittent		silt / clay	10 %			**Adjacent land use**	grazing
Water depth	1 m	**Deposits**	Sand/silt		**In-stream disturbance**			native vegetation
Wetted width	10 m	**Bed stability**	stable		Flow modification	none		
Flow	No flow				Waterway barrier	none		
Channel width	15 m							

Comments:	No flow apparent at site. Reach has dried to a series of large isolated in channel pools. Water moderately turbid. Abundance and diversity of fringing aquatic vegetation low with no obvious instream aquatic vegetation. Some large and small woody debris present providing habitat along with boulder and rock faces and leaf litter. Some algal slick present, likely due to standing water. No hydrocarbon slick observed.

Appendix D Baseline Range for Water Quality and Sediment Quality Data, and Macroinvertebrate Indices

Table D1 Baseline Maximum for Water Quality Parameters

Parameter	Unit	Waterbody	Dawson River	Hutton Creek
		Maximum	Maximum	Maximum
Temperature	ºC	9.0 – 36.4	10.3 – 32.1	14.8 – 31.6
Dissolved oxygen	mg/L	0.13 – 19.9	1.93 – 13.1	1.6 – 8.2
Electrical conductivity	µS/cm	1724	2568	1144
pH	unit	6.7 – 9.7	6.5-8.4	6.3 – 9.2
Suspended solids	mg/L	665	71	220
Turbidity	NTU	821	1243	531
Ammonia as N	mg/L	1.63	0.1	0.1
Total nitrogen	mg/L	30.3	1.7	1.6
Boron (total)	mg/L	0.30	0.24	0.13
Zinc (total)	mg/L	0.035	0.014	0.029
Boron (dissolved)	mg/L	0.24	2.0	0.11
Zinc (dissolved)	mg/L	0.063	0.052	0.022

Baseline range presented for temperature, dissolved oxygen and pH.

Table D2 Baseline Maximum for Sediment Quality Parameters

Parameter	**Unit**	**Waterbody**	**Dawson River**	**Hutton Creek**
		Maximum	**Maximum**	**Maximum**
Aluminium (Al)	mg/kg	16800	12800	18500
Arsenic (As)	mg/kg	6	5	8
Boron (B)	mg/kg	27.5	13.5	26.9
Cadmium (Cd)	mg/kg	<LOR	<LOR	<LOR
Chromium (Cr)	mg/kg	26.8	70.3	19.4
Copper(Cu)	mg/kg	19	12	18
Iron (Fe)	mg/kg	23900	19000	32000
Lead (Pb)	mg/kg	25.1	15	23.5
Manganese (Mn)	mg/kg	1020	545	705
Mercury (Hg)	mg/kg	0.8	<LOR	<LOR
Nickel (Ni)	mg/kg	30.4	296	15
Selenium (Se)	mg/kg	<LOR	<LOR	<LOR
Zinc (Zn)	mg/kg	74	46	68

Table D3 Full Baseline Range of Macroinvertebrate Indices

Index	Waterbody		Dawson River		Hutton Creek	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Abundance	16	512	15	411	1	590
Taxonomic Richness	3	15	6	25	1	20
PET Richness	0	2	0	6	0	3
SIGNAL-2 Scores	2.36	3.64	2.57	4.41	2	3.38

Table D5 Zooplankton Data (microcrustacean data only) from September 2018 Survey of Waterbody

Taxa	Higher Taxa	WLMP1			WLMP4			WLMP5		
		Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Microcrustaceans										
Daphnia sp 1	Daphniidae (Cladocera)	4000	15625	75000	260	85	170	15000	5000	8500
Daphnia sp 2	Daphniidae (Cladocera)						10			
Chydoridae (Cladoceran 1)	Chydoridae				25	90	5			
Cladoceran 2	Cladocera				15	15	5			
Bosminidae (Cladoceran 3)	Cladocera	20			5	40	5	90	165	60
Copepod 2 (Cyclopoida)	Copepoda				100	240	205			
Copepod 1 (Calanoida)	Copepoda				25	100	5	1500	3250	2575
Ostracod 2	Ostracoda	20			15					
Ostracod 1	Ostracoda	25	10	50	15		10			
Ostracod 3	Ostracoda				5		5			

Note: taxonomic names used in the 2018 study have been updated here to align with the 2019 data

Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos Ltd (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP Design Report, titled *Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program* (frc environmental 2015). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the fifth year the REMP has been implemented.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake DRRS REMP monitoring and reporting in 2020.

The purpose of this report is to present and record the methods and results of the 2020 post-wet (May) and pre-wet (October) season REMP surveys, and provide an assessment of potential adverse effects of the release, if any, on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP Design Report). Sampling utilised the methods nominated in the REMP Design Report and included water quality, sediment quality, aquatic habitat, macroinvertebrates, fish and geomorphological (i.e. bed and bank stability) monitoring.

The work presented in this report was carried out by suitably qualified persons (Dr Ben Cook and Dr Andrew Mather who are professional aquatic ecologists with Ph.D. qualifications in freshwater biology and a combined total of over 25 years of industry experience as aquatic ecologists) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 21 – 26 May 2020, and the pre-wet survey was implemented 12 – 16 October 2020.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are presented in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two water types: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As detailed in the REMP Design Report, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and one (DRMP1) on the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges	-25.692	149.216

Site	Description	GDA94	
		Latitude	Longitude
	into the Waterbody and 8 km downstream of the confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.		
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2020 post-wet season REMP survey:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek during the post-wet survey. This is consistent with water quality conditions throughout the baseline monitoring program.

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Map 2.1 Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program.

3 Water Quality

3.1 Methods

Survey Procedure

Water quality was measured in situ for temperature, pH, electrical conductivity, dissolved oxygen and turbidity using a calibrated multi-probe water quality meter. Measurements were taken approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites.

Water samples for laboratory analysis were collected approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites, directly into sampling containers provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed. Two (replicate) samples were collected from one site on each survey for assessing within-site variation. Parameters analysed in the laboratory were: suspended solids, ammonia, nitrogen, and total and dissolved boron and zinc.

Data Analysis

Results were compared to the local water quality guidelines developed for the DRRS REMP (frc environmental 2015), noting that the current project-specific guideline for the concentration of total boron in water is adopted from AECOM (2019). Relative percent difference was calculated for the replicate samples collected at one site on each survey to assess within-site variation.

3.2 Results

Results for the water quality results (Table 3.1, Table 3.2, Table 3.3 and Table 3.4) showed that:

- the concentration of dissolved oxygen was lower than the guideline range at site DRR2 on Hutton Creek (2.1 mg/L and 3.8 mg/L during the 2020 post-wet survey and pre-wet survey, respectively). The concentration of dissolved oxygen was also lower than the baseline range for Hutton Creek during both surveys (i.e. baseline minimum of dissolved oxygen was 7.7 mg/L for the Hutton Creek water type; Appendix D).

However, site DRR2 on Hutton Creek is a control site; thus, low dissolved oxygen at this site was not influenced by the release of desalinated produced water.

- the concentration of total nitrogen was higher than the guideline at site DRR2 on Hutton Creek (1.2 mg/L and 0.7 mg/L during 2020 post-wet and pre-wet surveys, respectively). However, the concentration of total nitrogen was lower than the baseline range for the Hutton Creek (i.e. baseline maximum of total nitrogen was 1.9 mg/L for the Hutton Creek water type; Appendix D). The concentration of total nitrogen was higher than the guideline at site DRMP1 on the Dawson River during the 2020 pre-wet survey (0.7 mg/L). However, the concentration of total nitrogen was lower than the baseline range for the Dawson River (i.e. baseline maximum of total nitrogen was 1.7 mg/L for the Dawson River water type; Appendix D). Therefore, the concentration of total nitrogen was consistent with baseline water quality conditions at sites DRR2 and DRMP1.
- all other parameters complied with the guideline at all sites, and
- the relative percent difference for all parameters were relatively low, indicting low within-site variation for these parameters.

Table 3.1 Water quality results compared to the local water quality guidelines for the 2020 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	16.06	17.80	15.21	15.8 – 27.1	15.22	–	13.97	–	15.53
Dissolved oxygen	mg/L	–	6.4 – 16.1	6.6	7.0	8.3	6.4 – 16.1	7.8	–	7.1	6.4 – 16.1	2.1
Electrical conductivity	µS/cm	–	627	302	114	108	500	193	–	211	500	196
pH	unit	–	6.5 – 8.5	7.6	7.4	7.5	6.5 – 8.5	7.2	–	7.4	6.5 – 8.5	7.1
Suspended solids	mg/L	5	128	11	12	8	50	15	–	8	50	31
Turbidity	NTU	–	Monitor only	17.3	21.5	16.9	Monitor only	27.6	–	19.9	Monitor only	86.2
Nutrients												
Ammonia as N	mg/L	0.01	0.9	0.01	0.03	0.01	0.9	0.03	–	0.03	0.9	0.33
Total nitrogen	mg/L	0.1	3.93	0.6	0.4	0.4	0.62	0.20	–	0.10	0.62	1.20
Total metals and metalloids												
Boron	mg/L	0.05	2.9	1.07	0.92	0.94	1.0	0.25	–	0.05	1.0	0.05
Zinc	mg/L	0.005	12	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	0.006
Dissolved Metals and metalloids												
Boron	mg/L	0.05	2.9	0.89	0.88	0.89	1.0	0.22	–	< 0.05	1.0	< 0.05
Zinc	mg/L	0.005	8	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	< 0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value; – No guideline or data.

Table 3.2 Water quality results compared to the local water quality guidelines for the 2020 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	26.30	21.93	23.79	15.8 – 27.1	23.17	–	21.55	–	22.41
Dissolved oxygen	mg/L	–	6.4 – 16.1	9.5	4.8	6.6	6.4 – 16.1	6.2	5.7	5.2	6.4 – 16.1	3.8
Electrical conductivity	µS/cm	–	627	239	117	108	500	219	225	263	500	328
pH	unit	–	6.5 – 8.5	8.8	5.0	7.1	6.5 – 8.5	7.2	7.13	7.0	6.5 – 8.5	7.1
Suspended solids	mg/L	5	128	8	9	15	50	19	–	10	50	13
Turbidity	NTU	–	Monitor only	6.2	19.8	3.8	Monitor only	13.6	6.41	11.2	Monitor only	15.2
Nutrients												
Ammonia as N	mg/L	0.01	0.9	< 0.01	0.08	0.03	0.9	0.04	–	< 0.01	0.9	< 0.01
Total nitrogen	mg/L	0.1	3.93	0.50	0.30	0.30	0.62	0.70	–	< 0.10	0.62	0.70
Total metals and metalloids												
Boron	mg/L	0.05	2.9	1.23	0.92	0.95	1.0	0.30	–	< 0.05	1.0	< 0.05
Zinc	mg/L	0.005	12	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	< 0.005
Dissolved Metals and metalloids												
Boron	mg/L	0.05	2.9	1.17	0.89	0.88	1.0	0.28	–	< 0.05	1.0	< 0.05
Zinc	mg/L	0.005	8	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	< 0.005

Table 3.3 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters in May 2020.

Parameter	Unit	LOR	Post-wet survey Site WLMP4		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	11	9	20.0
Ammonia as N	mg/L	0.01	0.01	0.01	0.0
Total Nitrogen	mg/L	0.1	0.6	0.7	15.4
Total boron	mg/L	0.05	1.07	1.08	0.6
Total zinc	mg/L	0.005	< 0.005	< 0.005	–
Dissolved boron	mg/L	0.05	0.89	1.00	11.6
Dissolved zinc	mg/L	0.005	< 0.005	< 0.005	–

Table 3.4 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters in October 2020.

Parameter	Unit	LOR	Post-wet survey Site WLMP5		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	15	13	14.3
Ammonia as N	mg/L	0.01	0.03	< 0.01	–
Total Nitrogen	mg/L	0.1	0.3	0.3	0.0
Total boron	mg/L	0.05	0.95	0.96	1.0
Total zinc	mg/L	0.005	< 0.005	< 0.005	–
Dissolved boron	mg/L	0.05	0.88	0.88	0.0
Dissolved zinc	mg/L	0.005	< 0.005	< 0.005	–

4 Sediment Quality

4.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids).

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2015).

4.2 Results

Results for the laboratory analyses of sediment quality (Table 4.1 and Table 4.3) showed that:

- the concentration of manganese was higher than the local guideline at sites WLMP4 and DRR1 during the 2020 post-wet survey (676 mg/kg and 404 mg/kg, respectively). However, the concentration of manganese was lower than the baseline range recorded in the Waterbody and Dawson River (maximum = 1020 mg/kg and 545 mg/kg respectively; Appendix D), noting that site DRR1 is a control site and is not influenced by the release of desalinated produced water. The concentration of manganese was higher than the local guideline at sites WLMP4 and WLMP1 during the 2020 pre-wet survey (663 mg/kg and 919 mg/kg, respectively). However, the concentration of manganese was lower than the baseline range recorded in the Waterbody (maximum = 1020 mg/kg; Appendix D). Thus, the concentration of manganese in sediment was consistent with baseline sediment quality conditions.
- the concentration of iron was higher than the local guideline at site DRR1 (13700 mg/kg) during the 2020 post-wet survey. However, the concentration of iron at this site was lower than the baseline range recorded in the Dawson River (19000 mg/kg;

Appendix D), indicating that the concentration of iron in sediment was consistent with baseline sediment quality conditions.

- the concentration of aluminium was higher than the guideline at site DRR1 (6530 mg/kg) during the 2020 post-wet survey. However, the concentration of iron at this site was lower than the baseline range recorded in the Dawson River (12800 mg/kg; Appendix D), indicating that the concentration of iron in sediment was consistent with baseline sediment quality conditions.
- the concentration of all other parameters complied with the applicable local sediment quality guidelines at all sites, noting that selenium could not be assessed because the limit of reporting (LOR) was higher than the local guideline.
- the relative percent difference (RPD) for boron was relatively high during the 2020 post-wet survey, and for boron and manganese during the 2020 pre-wet survey, indicating relatively high within-site variation for these parameters.

Table 4.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2020 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	6170	5030	7800	5191	630	450	6530	11800	1810
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	0.2	18.8	3.3	4.0	4.1	17.9	0.2	0.2	0.3	25	0.2
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	6	4	8	80	< 2	< 2	6	80	3
Copper(Cu)	mg/kg	5	65	11	10	14	65	< 5	< 5	10	65	< 5
Iron (Fe)	mg/kg	50	17867	12700	8320	15300	9353	1780	950	13700	20700	5960
Lead (Pb)	mg/kg	5	50	13	8	14	50	< 5	< 5	12	50	< 5
Manganese (Mn)	mg/kg	5	648	676	418	553	230.5	66	27	404	337	94
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	8	6	10	21	< 2	< 2	8	21	< 2
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	38	38	46	200	< 5	< 5	34	200	11

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.2 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2020 pre-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13933	6700	8180	8410	5191	1450	690	2030	11800	2660
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	0.2	18.8	2.5	2.8	9.0	17.9	< 0.2	< 0.2	< 0.2	25	< 0.2
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	7	6	8	80	< 2	< 2	2	80	4
Copper(Cu)	mg/kg	5	65	11	13	13	65	< 5	< 5	< 5	65	< 5
Iron (Fe)	mg/kg	50	17867	13000	13400	12500	9353	3700	2070	5120	20700	7650
Lead (Pb)	mg/kg	5	50	14	12	12	50	< 5	< 5	< 5	50	7
Manganese (Mn)	mg/kg	5	648	663	919	199	230.5	220	53	54	337	115
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	9	9	8	21	< 2	< 2	3	21	3
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	34	50	39	200	8	< 5	13	200	14

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.3 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters for the 2020 post-wet season survey.

Parameter	Unit	Site WLMP4 (post-wet survey 2020)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	6170	5840	5.5
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	4	2	66.7
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	6	6	0.0
Copper(Cu)	mg/kg	11	11	0.0
Iron (Fe)	mg/kg	12700	13600	6.8
Lead (Pb)	mg/kg	13	12	8.0
Manganese (Mn)	mg/kg	676	906	29.1
Mercury (Hg)	mg/kg	< 0.1	< 0.1	–
Nickel (Ni)	mg/kg	8	9	11.8
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	38	38	0.0

Table 4.4 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters for the 2020 pre-wet season survey.

Parameter	Unit	Site WLMP5 (pre-wet survey 2020)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	8410	8460	0.6
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	9	5.8	43.2
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	8	8	0.0
Copper(Cu)	mg/kg	13	14	7.4
Iron (Fe)	mg/kg	12500	16400	27.0
Lead (Pb)	mg/kg	12	13	8.0
Manganese (Mn)	mg/kg	199	521	89.4
Mercury (Hg)	mg/kg	< 0.1	< 0.1	–
Nickel (Ni)	mg/kg	8	10	22.2
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	39	48	20.7

5 Aquatic Habitat, and Bed and Bank Stability

5.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP Design Report (frc environmental 2015).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons were made against baseline condition, as presented in the REMP Design Report (frc environmental 2015).

5.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 5.1 and Table 5.2) showed:

- bed and bank stability at all sites and for all water types had not changed from baseline condition
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with water levels higher than many of the baseline surveys providing an increased cover of woody debris and increased diversity of submerged aquatic plants, and
- all other aquatic habitat features for all water types remained relatively unchanged since baseline surveys.

Table 5.1 Habitat characteristics of each water type in the 2020 post-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*moderate*	*moderate*
Bed stability	*low to moderate*	*low*	*moderate*
Substrate diversity	*low*	*moderate*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 5.2 Habitat characteristics of each water type in the 2020 pre-wet REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate*	*low to moderate*	*low*
Bed stability	*low to moderate*	*low to moderate*	*low to moderate*
Substrate diversity	*low*	*moderate*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*low to moderate*
Flow habitats	*low*	*moderate*	*low*
Physical habitat features	*moderate*	*high*	*low*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

6 Macroinvertebrate Communities

6.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2015).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual* (DES 2018). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. The REMP design document considers an error rate of <5% acceptable for macroinvertebrate sorting and identification, with the error rate of < 1% for this study.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (i.e. families in most cases in this assessment). 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each replicate sample for each site, and then the median per site and median for each water type were calculated. These results were compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP Design Report; frc environmental 2015). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range , then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

6.2 Results

Results for macroinvertebrate indices showed that (Table 6.1,

Table 6.3):

- the abundance of macroinvertebrates was:
  - higher than the local guideline range at Dawson River sites S4 and DRR1 and Hutton Creek site DRR2, and the Hutton Creek water type, during the pre-wet survey; and higher than the guideline range at site DRR2 and the Hutton Creek water type during the post-wet survey
  - lower than the local guideline range at all waterbody sites in the post-wet survey (i.e. sites WLMP4, WLMP1 and WLMP5), lower than the guideline range at site WLMP1 during the pre-wet survey, and lower than guideline range for the Waterbody water type during the post-wet survey. However, the abundance of macroinvertebrates was within the range recorded during baseline surveys in each case (see Appendix D)
  - within the local guideline range for the Dawson River water type during the post-wet survey and the pre-wet survey
- taxonomic richness of macroinvertebrates was:
  - higher than the local guideline range at Waterbody sites WLMP4 and WLMP5 and Hutton Creek site DRR2 during the post-wet survey, higher than the guideline range at Waterbody site WLMP4, Dawson River site DRR1 and Hutton Creek site DRR2 during the pre-wet survey, and higher than the guideline range for Waterbody and Hutton Creek water types in both post-wet and pre-wet surveys. However, the taxonomic richness of macroinvertebrates was within the baseline range in each case (see Appendix D)
  - within the guideline range for site WLMP1 and all Dawson River sites (i.e. sites DRMP1, S4 and DRR1) during the post-wet survey, and within guideline range for Waterbody sites WLMP1 and WLMP5 and Dawson River sites DRMP1 and S4 during the pre-wet survey.
- PET richness of macroinvertebrates was:
  - higher than the local guideline range at Waterbody sites WLMP4 and WLMP5 during the post-wet survey, and higher than the guideline range at sites WLMP4, DRR1 and DRR2, and for the Hutton Creek water type, during the pre-wet survey. However, PET richness of macroinvertebrates was within the baseline range in each case (Appendix D)

  - lower than the local guideline range at site DRMP1 and for the Dawson River water type during the post-wet survey, but within baseline range (see Appendix D)
  - within the guideline range at sites WLMP1, S4, DRR1 and DRR2, and for all water types during the post-wet survey, and at sites WLMP1, WLMP5, DRMP1, S4 and for the Waterbody and Dawson River water types during the pre-wet survey

- SIGNAL-2 Scores for macroinvertebrates were:
  - higher than the local guideline range at sites WLMP4 and WLMP5, and for the Waterbody during the post-wet survey and the pre-wet survey. However, SIGNAL-2 Scores for macroinvertebrates were within the baseline range in each case (Appendix D)
  - within the local guideline range at sites WLMP1, all Dawson River sites (i.e. DRMP1, S4 and DRR1), Hutton Creek site DRR2, and for the Dawson River and Hutton Creek water types during the post-wet survey.

Table 6.1 Macroinvertebrate results for each site in the 2020 post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	67.0	30.0	67.0	39.9–152.0	103.0	119.0	196.0	23.0–207.4	464.0
Taxonomic Richness	5.67–10.8	13.0	8.0	13.0	9.93–16.9	12.0	14.0	14.0	4.0–10.0	14.0
PET richness	0.0 – 1.2	2.0	0.0	2.0	1.47–4.0	1.0	3.0	2.0	0–1.0	1.0
SIGNAL-2 Score	2.65 – 3.20	3.45	2.86	3.23	3.46–4.00	3.54	3.83	3.53	2.90–3.30	3.00

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 6.2 Macroinvertebrate results for each site in the 2020 pre-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	132.0	83.0	100.0	39.9–152.0	148.0	211.0	222.0	23.0–207.4	301.0
Taxonomic Richness	5.67–10.8	16.0	8.0	10.0	9.93–16.9	13.0	15.0	19.0	4.0–10.0	14.0
PET richness	0.0 – 1.2	3.0	0.0	1.0	1.47–4.0	3.0	4.0	5.0	0–1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.52	2.91	3.24	3.46–4.00	3.73	3.94	3.92	2.90–3.30	3.14

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 6.3 Macroinvertebrate results for each water type in the 2020 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	51.0	39.9 – 152.0	119.0	23.0 – 207.4	464.0
Taxonomic Richness	5.67–10.8	12.0	9.93 – 16.9	13.0	4.0 – 10.0	14.0
PET richness	0.0 – 1.2	1.0	1.47 – 4.0	3.0	0 – 1.0	1.0
SIGNAL-2 Score	2.65 – 3.20	3.26	3.46 – 4.00	3.56	2.90 – 3.30	3.00

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

Table 6.4 Macroinvertebrate results for each water type in the 2020 pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	103.0	39.9 – 152.0	211.0	23.0 – 207.4	301.0
Taxonomic Richness	5.67–10.8	11.0	9.93 – 16.9	17.0	4.0 – 10.0	14.0
PET richness	0.0 – 1.2	1.0	1.47 – 4.0	4.0	0 – 1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.24	3.46 – 4.00	3.84	2.90 – 3.30	3.14

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading indicates where the macroinvertebrate index is lower than the local biological objective

7 Fish

7.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 7.1 and Table 7.2). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 199434) and Animal Ethics Approval (CA 2015/08/893 and 2018/08/1224) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 7.1 Effort used to catch freshwater fish in the 2020 post-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	15:45	7:45	32 h
WLMP1	fyke net (2)	pool	14:30	8:40	36.33 h
WMLP5	fyke net (2)	pool	14:15	9:00	37.5 h
Dawson River					
DRMP1	fyke net (2)	pool	11:30	13:10	51.33 h
S4	fyke net (2)	pool	15:15	11:10	39.83 h
DRR1	fyke net (2)	pool	10:45	10:15	47 h
Hutton Creek					
DRR2	fyke net (2)	pool	13:00	7:15	36.5 h

Table 7.2 Effort used to catch freshwater fish in the 2020 pre-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	15:30	14:30	46 h
WLMP1	fyke net (2)	pool	17:00	8:30	31 h
WMLP5	fyke net (2)	pool	16:40	10:50	36.33 h
Dawson River					
DRMP1	fyke net (2)	pool	12:30	11:10	45.33 h
S4	fyke net (2)	pool	8:00	8:30	49 h
DRR1	fyke net (2)	pool	12:00	9:15	42.5 h
Hutton Creek					
DRR2	fyke net (2)	pool	12:30	11:45	46.5 h

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2015) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

7.2 Results

Ten species of native fish were caught and / or observed during the 2020 post-wet REMP survey (Table 7.3), with twelve species recorded in the pre-wet survey (Table 7.4). None of these species are conservation significant species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act).

The number of native species caught at each site ranged from two (sites DRR2 in the pre-wet survey) to eleven (site DRMP1 in the pre-wet survey). Total abundance of fish at each site ranged from ten (site DRR2 in the pre-wet survey) to 1287 (site WLMP5 in the pre-wet survey). The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites, such as the high density of macrophytes in waterbody sites. The most commonly recorded species were common gudgeons, eastern rainbowfish, Agassiz's glassfish and flyspecked hardyheads. No exotic species were caught.

All water types achieved the local guideline for fish in both the post-wet and pre-wet surveys (i.e. had an observed: expected ratio of species diversity that was ≥ 1) (Table 7.5). This indicates that the diversity of fish caught during the 2020 REMP period was consistent with the diversity of fish recorded during the baseline monitoring program. Increased water levels compared to baseline condition may have created favourable conditions for fish in the Waterbody.

All sites achieved the biological guideline for exotic fish with none captured at any site during the 2020 post-wet or pre-wet REMP surveys, indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 7.3 Total abundance of freshwater fish for each species at each site in 2020 post-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	72	48	37	–	2	–	–	**159**
Craterocephalus stercusmuscarum	flyspecked hardyhead	21	59	88	–	–	–	–	**168**
Hypseleotris compressa	empire gudgeon	–	20	–	–	–	–	–	**20**
Hypseleotris spp.	carp gudgeon	134	757	419	14	–	4	29	**1357**
Leiopotherapon unicolor	spangled perch	1	–	–	–	–	–	4	**5**
Macquaria ambigua	yellow belly	–	–	–	2	–	–	–	**2**
Melanotaenia splendida splendida	eastern rainbowfish	–	84	1	–	–	1	–	**86**
Nematalosa erebi	bony bream	1	2	4	–	–	–	–	**7**
Pseudomugil signifer	Pacific blue eye	–	–	–	–	6	7	–	**13**
Tandanus tandanus	freshwater catfish	–	1	–	3	4	–	2	**10**
Total native individuals		**229**	**971**	**549**	**19**	**12**	**12**	**35**	**1827**
Total native species		**5**	**7**	**5**	**3**	**3**	**3**	**3**	**10**

– not caught

Table 7.4 Total abundance of freshwater fish for each species at each site in 2020 pre-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	217	17	8	28		4		**274**
Anguilla reinhardtii	longfin eel				1				**1**
Craterocephalus stercusmuscarum	flyspecked hardyhead	54	62	33	2				**151**
Hypseleotris spp.	carp gudgeon	97	546	1193	5	10	72	8	**1931**
Leiopotherapon unicolor	spangled perch	1							**1**
Macquaria ambigua	yellow belly				1				**1**
Melanotaenia splendida splendida	eastern rainbowfish	33	22	48	9		28		**140**
Nematalosa erebi	bony bream		1	1	2				**4**
Porochilus rendahli	Rendahl's catfish				1				**1**
Pseudomugil signifer	Pacific blue eye				1	3			**4**
Scleropages leichardti	southern saratoga				1		1		**2**
Tandanus tandanus	freshwater catfish		1	4	4	2	1	2	**14**
Total native individuals		**402**	**649**	**1287**	**55**	**15**	**106**	**10**	**2524**
Total native species		**5**	**6**	**6**	**11**	**3**	**5**	**2**	**12**

Table 7.5 Comparison of fish monitoring results with the local biological objective for fish for the 2020 post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	8	2.0
Dawson River	5	6	1.2
Hutton Creek	2	3	1.5

Table 7.6 Comparison of fish monitoring results with the local biological objective for fish for the 2020 pre-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	7	1.75
Dawson River	5	11	2.2
Hutton Creek	2	2	1

8 Macrocrustaceans – Exoskeleton Assessment

8.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 8.1).

8.2 Results

The macrocrustaceans caught during the 2020 REMP surveys included *Macrobrachium australiense* and *Caridina* spp., which were caught during the baseline monitoring program (Table 8.1). All specimens had exoskeletons that were of robust and good condition (Table 8.2). No macrocrustaceans were recorded in breeding condition during the post-wet season survey, which is consistent with the results of baseline surveys implemented in Autumn. A single gravid *Caridina* spp. was collected from site DRR2 during the pre-wet survey, however no gravid specimens were collected from the Dawson River or Waterbody sites during the pre-wet survey, and gravid *Macrobrachium australiense* were not recorded at any site. These, results suggest that the pre-wet survey was implemented shortly prior to population-level breeding by macrocrustaceans had commenced.

Table 8.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 8.2 Macrocrustacean species and condition recorded during the 2020 post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
	Caridina spp.	*Caridina* spp.	
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae).

Table 8.3 Macrocrustacean species and condition recorded during the 2020 pre-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense* *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp.
Breeding condition	not breeding	not breeding	breeding (a single *Caridina* only)
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

9 Zooplankton

9.1 Methods

Survey Procedure

Zooplankton was assessed in the post-wet (May) and pre-wet (October) surveys in 2020.

Three samples were collected at each site using a six-meter, depth-integrated tow with a 150 µm mesh plankton net, which samples 'macrozooplankton', but not 'microzooplankton' (i.e. ciliates, rotifers and juvenile microzooplankton – i.e. nauplii), which requires a smaller mesh size of approximately 20 µm (James 1991).

Samples were preserved in methylated spirits and transported to a biological laboratory (Dardanus Scientific) where they were processed by a suitably qualified aquatic invertebrate taxonomy specialist. Microcrustaceans were identified to morphospecies[1], with the exception of *Ceriodaphnia cf dubia*, which was identified to described species level using available taxonomic keys (Shiel 1995). This taxon was of particular interest due to its reported sensitivity to boron (AECOM 2019).

The abundance of each taxon was determined for a quantitative sub-sample of each sample, and then converted to an abundance for the total sample.

Data Analysis

There is no baseline data for zooplankton and no biological guidelines for zooplankton, although an initial zooplankton survey was completed in September 2018 at the Waterbody sites (i.e. WLMP4, WLMP1 and WLMP5) with this data (i.e. see Appendix D) incorporated in this study. Only data for microcrustaceans (Cladocerans, Ostracods and Copepods) is presented.

Spatial and temporal variability in the zooplankton community was statistically assessed using PERMANOVA and multidimensional scaling, implemented using the Primer software.

[1] Only microcrustacean data is considered, although all taxa were identified during laboratory processing, with insects identified to family or subfamily, and other taxa (e.g. Nematoda) to class or order.

9.2 Results

Eight microcrustacean taxa were found in the 2020 post-wet survey and ten microcrustacean taxa were found in the 2020 pre-wet survey. This included *Ceriodaphnia cf dubia* (Table 9.1), which was identified at site DRR2 on Hutton Creek during the 2020 post-wet survey. This taxon was not recorded in September 2018 (see Appendix D), and was only recorded at one Waterbody site and at one site on the Dawson River in the 2019 pre-wet season survey. *Ceriodaphnia cf dubia* was not present at any site during the 2020 pre-wet survey, indicating that this taxon occurs in the receiving environment, but the limited data available suggests that its occurrence is patchy over time and space.

Microcrustacean diversity was highest in the Dawson River (seven taxa recorded in the post-wet survey and eight taxa recorded during the pre-wet survey), intermediate in Hutton Creek during the post-wet survey (five taxa recorded) but low during the pre-wet survey (three taxa recorded) and low in the Waterbody sites (three taxa and four taxa recorded in the post-wet and pre-wet surveys, respectively), noting that the abundances of taxa was highly varied. For example, while less taxa were recorded at the Hutton Creek site, the abundances recorded were much higher than abundances recorded in the Dawson River and the Waterbody. Overall, these results show that the microcrustacean community is highly differentiated between the three water types (locations) (i.e. Dawson River, Waterbody and Hutton Creek (Figure 9.1), but also highly variable across time (i.e. between surveys).

When the microcrustaceans sampled from the Waterbody in September 2018, all sites in November 2019 and both May and October 2020 surveys are included in the analysis, results show a clear separation between the Waterbody in September 2018 and more recent surveys (Figure 9.3). Separation between sites on the Waterbody in September 2018 was notably higher than in November 2019, May 2020 and October 2020. Microcrustacean communities in Dawson River sites were also differentiated between November 2019, May 2020 and October 2020, indicating that in some years different sections of the Waterbody and Dawson River can have distinct microcrustaceans communities. PERMANOVA analysis using the combined 2018 / 2019 / 2020 data further indicates high and statistically significant spatial and temporal variability in microcrustacean communities:

- between locations (i.e. between the three water types): $F = 9.9812$, $P = <0.001$
- across time (i.e. between surveys): $F = 4.235$, $P = <0.001$
- between sites: $F = 6.5879$, $P = <0.001$, and
- across space and time combined (i.e. interaction between location and time): $F = 6.5879$, $P = 0.002$.

Table 9.1 Zooplankton (microcrustacean) survey results for the post-wet season 2020 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP4			WLMP1			WLMP5			DRMP1			S4			DRR1			DRR2		
	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Ceridodaphnia cf dubia																			365	575	110
Ceridodaphnia Sp 1											2							14	875	3000	480
Ceidodaphnia Sp 2										3		5									
Chydoridae (Cladocera)										3		6									
Bosminidae (Cladocera)	3		9		16					6		8	4		19				15	35	
Copepod 1 (Calanoida)	8	1	1	417	565	1170	840	92	1040	126	19	87	22	22	57	13	16	28	6500	15300	10000
Copepod 2 (Cyclopoida)	54	118	78	19	70		1	3		32	9	45	55	15	174	21		31	1825	5050	3350
Ostracod 3										2											

Table 9.2 Zooplankton (microcrustacean) survey results for the pre-wet season 2020 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP4			WLMP1			WLMP5			DRMP1			S4			DRR1			DRR2		
	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Daphnia sp. 1 *(Daphnia carinata)*												1				2			31	1875	3750
Ceridodaphnia Sp 1																				80	235
Ceidodaphnia Sp 2		2							1												
Chydoridae (Cladocera)					2		5	2	1	8		13	4		3			5			
Bosminidae (Cladocera)													1								
Copepod 1 (Calanoida)					5	2	76	25	85	111	92	179	1			1	2	2	3000	3800	2000
Copepod 2 (Cyclopoida)	26	29	20	1500	84		9	93	55	10	11	36	38	193	136			2			
Ostracod 1										1	2			39	22			2			
Ostracod 2											7		2	12	5						
Ostracod 5														2							

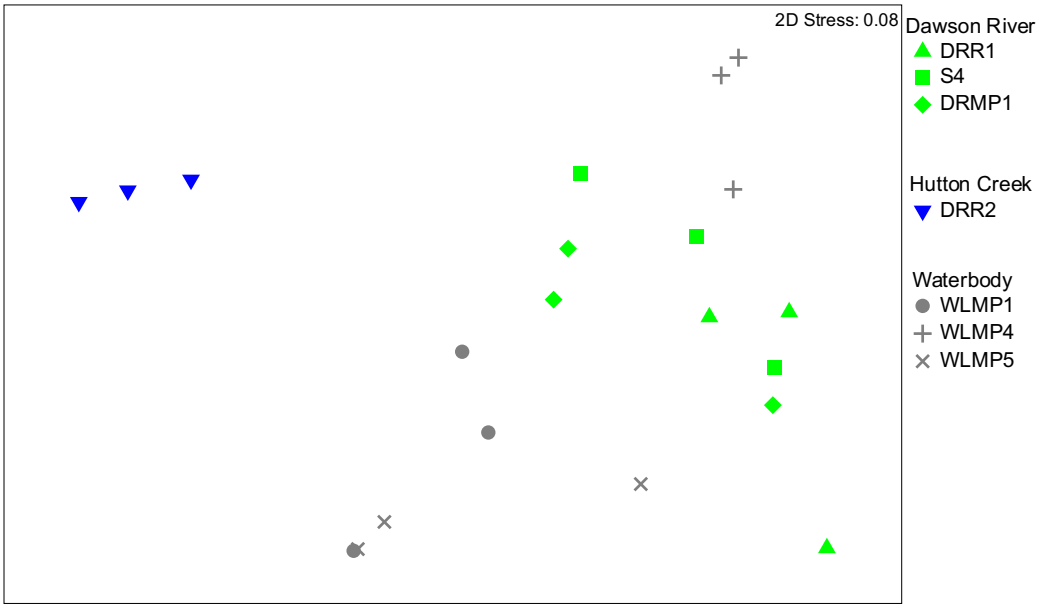

Figure 9.1 MDS plot of microcrustacean communities at each site in the 2020 post-wet survey, showing separation of the three water types.

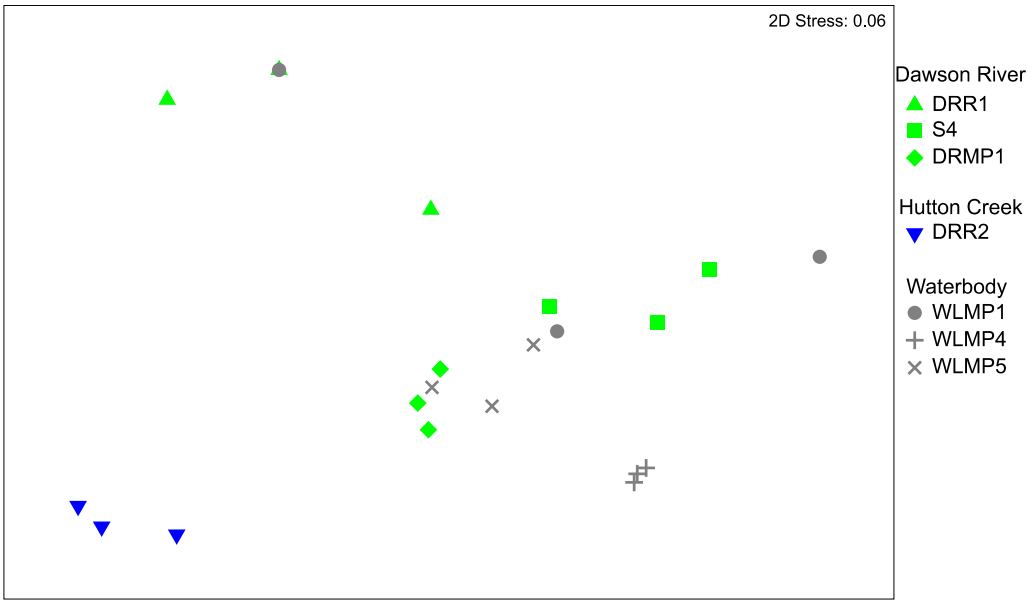

Figure 9.2 MDS plot of microcrustacean communities at each site in the 2020 pre-wet survey, showing separation of the three water types.

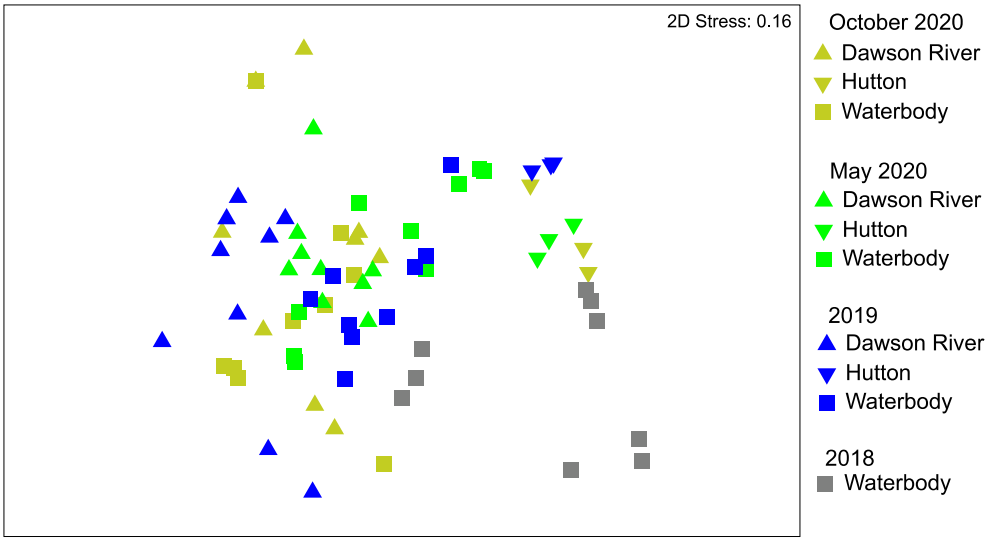

Figure 9.3 MDS plot of microcrustacean communities at Waterbody sites in September 2018, at each site in the 2019 pre-wet season survey, at each site in the May 2020 post-wet survey and at each site in the October 2020 pre-wet survey showing separation of the three water types, and separation of the Waterbody samples between 2018, 2019 and 2020.

10 Assessment of Environmental Changes

The monitoring results for the 2020 post-wet and pre-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- Physical habitat features in the Waterbody, which had improved from baseline condition due to higher water levels. The higher water levels have increased submerged aquatic plant cover and the cover of large woody debris in water in the Waterbody
- The taxonomic richness of macroinvertebrate at site WLMP4 and WLMP5 was higher than the baseline range recorded in the Waterbody in the post-wet survey and at WLMP4 in the pre-wet survey. However, abundance was not increased from baseline, and PET richness and SIGNAL-2 Scores had not decreased from baseline condition, indicating that the normal expected number of sensitive taxa are still present. Thus, the result does not reflect an impact, but likely reflects improved habitat conditions from baseline conditions, as sites WLMP4 and WLMP5 were dry or with very shallow water for many of the baseline surveys.

Overall, the 2020 post-wet and pre-wet REMP survey results indicated that the release of desalinated produced water from ROP2 has not impacted the aquatic environmental values of the receiving environment.

11 References

AECOM, 2019, Revised Boron Site-Specific Water Quality Criterion - Dawson River Release Scheme. Prepared for Santos.

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DES, 2018, Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009, report prepared for Queensland Department of Environment and Science.

EHMP, 2007. Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane.

frc environmental, 2015, Santos GLNG Dawson River Release Scheme: Receiving Environment Monitoring Program, report prepared for Santos.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867*. This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994*.

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020, frc environmental 12th January 2021

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with conditions in Appendix A of Environmental Authority EPPG00928713 dated 2nd September 2020, as detailed in the Receiving Environment Monitoring Program, dated 12th January 2021

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos Ltd

I, Benjamin Douglas Cook

(Insert full name of person making this declaration)

of, Wynnum, Brisbane

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is appended to the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020, frc environmental 12 January 2021;
2. The authority holder has fully complied with the requirements of conditions in Appendix A of Environmental Authority EPPG00928713 dated 2nd September 2020, ;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020, frc environmental 12 January 2021;
4. The content of the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020, frc environmental 12 January 2021 is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2020, frc environmental 12 January 2021 meets the requirements of conditions in Appendix A of Environmental Authority EPPG00928713 dated 2nd September 2020,

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

Taken and declared before me, at Wynnum Courthouse
(Insert name of town or city and suburb)

this 15th (Insert day, e.g. 18th) day of Jan (Insert month) in the year 2021 (Insert year)

Signed
(Person making this declaration)

Signed
(Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations~~ / ~~Solicitor / Barrister~~

(Print name and registration number, if applicable)

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No.: 79355 DEPT. OF JUSTICE & ATTORNEY-GENERAL

Approved By

Signature

Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species. Ben is fully AUSRIVAS accredited.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Senior Principal Ecologist (Freshwater), frc environmental, Brisbane (2019 – current)
- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – 2019)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Clermont Coal Operations REMP 2014, 2015, 2016 2017, 2018, 2019, 2020. Glencore.
- Chinchilla End of Waste Scheme (formally Chinchilla Beneficial Use Scheme) REMP 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020. Sunwater.
- Poitrel Mine REMP 2017, 2018, 2019, 2020. BHP BMC.
- South Walker Creek Mine REMP 2017, 2018, 2019, 2020. BHP BMC.
- Olive Downs North Mine REMP 2017, 2018, 2019. Peabody Energy.
- Glebe End of Waste Scheme (formally Glebe Beneficial Use Scheme) REMP 2015, 2016, 2017, 2018, 2019, 2020. Sunwater.
- Mount Isa Mines REMP 2019, 2020. Glencore
- Lady Lorretta Mine REMP 2018, 2019. Glencore.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	22/05/20 (post-wet)	**Habitat Bioassessment Score**	57 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	20 to >30m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		shallow	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	0 %		pool		
	Right bank: low/convex		gravel	0 %		large woody debris	**Weed species**	Noogoora burr
			sand	20 %		macrophytes		*Bidens pilosa*
Hydrology			silt / clay	80 %				*Parthenium*
Flow regime	ephemeral	**Deposits**	silt					grasses
Water depth	>1.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			
Wetted width	50 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	80 m							

Comments:	Site is a large wetland, that ends 50m ‘downstream’ of site. There is no flow. Dead shrubs in water along edge suggest previous lower water levels. Aquatic birds present (black swans, and pelicans). Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp. and *Azolla* sp.). *Juncus usitatus* and *Persicaria* sp. line banks. No bare ground in riparian zone. Left bank riparian vegetation is dominated by grasses with some scattered Eucalypts. Right bank riparian vegetation is dominated by large Eucalypts, with grass understory. Evidence of cattle and pig access to water.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	22/05/20 (post-wet)	**Habitat Bioassessment Score**	52 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 to 30m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate to high
Bank stability	moderate to high		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: low/concave		pebble	0 %		pool		
	Right bank: low/convex		gravel	0 %		large woody debris		
Hydrology			sand	5 %		macrophytes	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	95 %	**In-stream disturbance**			
Water depth	>1.5 m	**Deposits**	silt		Flow modification	none		
Wetted width	60 m	**Bed stability**	moderate aggradation		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	90 m							cropping

Comments: Site is a long, wide wetland with no flow. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp. and *Azolla* sp.), and choking width of channel downstream of site. Aquatic birds present during survey (pelicans and cormorants). Evidence of cattle access to water and some erosion on banks. Right bank riparian vegetation in better condition than left bank (more aquatic plants lining edge, dense native riparian vegetation). Dead trees provide some aquatic habitat. Film on surface near bank.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	25/05/20 (post-wet)	**Habitat Bioassessment Score**	56 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 to 15m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	moderate		cobble	0 %		shallow	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		pool		
	Right bank: moderate/convex		gravel	0 %		large woody debris	**Weed species**	*Bidens pilosa*
Hydrology			sand	0 %		macrophytes		Noogoora burr
Flow regime	ephemeral		silt / clay	100 %				
Water depth	>1.5 m	**Deposits**	silt					
Wetted width	80 m	**Bed stability**	moderate aggradation		**In-stream disturbance**		**Adjacent land use**	native vegetation
Flow	no flow				Flow modification	none		grazing
Channel width	85 m				Waterway barrier	none		

Comments:

Site is a wetland. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp. and *Azolla* sp.). Substrate is soft silt with large amount of small woody detritus forming bed. Dead Eucalypt trees lining edges of water on both banks. Evidence of cattle access to water. Left bank riparian vegetation very narrow and dense with weeds (Noogoora burr, *Bidens pilos*). Several meters of bank covered with native aquatic plants (*Lomandra* sp., *Juncus* sp., *Persicaria* sp.). Aquatic birds present at time of survey (pelicans, grebes, cormorants, herons). Right bank riparian vegetation large, with native forest upstream of survey site.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	24/05/20 (post-wet)	**Habitat Bioassessment Score**	71 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology	
Stream order	6
Pattern	mildly sinuous/irregular
Bank stability	moderate
Bank shape	Left bank: moderate-concave, wide lower bench Right bank: moderate/steep-convex

Hydrology	
Flow regime	perennial
Water depth	1 m
Wetted width	4 m
Flow	0.2 m / s
Channel width	20 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	0%
	pebble	0%
	gravel	0%
	sand	70 %
	silt / clay	30 %
Deposits	sand, silt	
Bed stability	moderate aggredation	

Aquatic Habitat	
Habitat diversity	high
Habitat present	shallow
	deep
	run
	riffle
	log jams
	macrophytes
	undercut banks
	large woody debris
	undercut banks

In-stream disturbance	
Flow modification	none
Waterway barrier	none

Riparian Zone	
Riparian width	8 to 10 m
Disturbance	low
Dominant species	Eucalypt
	Casurina
	Callistemon
Weed species	Noogoora burr
	Bidens pilosa
	grasses
Adjacent land use	native forest
	riparian
	grazing

Comments: Site is a narrow stream with moderate flow, and shallow and deep pool sections. *Lomandra longifolia* lining steep banks. Many fallen trees across stream. Cattle access to water evident. Some leeching on bank, and some erosion on banks. Evidence of recent high flow on banks, with silt and detritus deposits on banks, and large log jams on banks. Riparian vegetation is mostly trees and is continuous throughout site.

Site	S4	**Region**	Upper Dawson
Date surveyed:	25/05/20 (post-wet)	**Habitat Bioassessment Score**	94 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	3 to 8 m
Pattern	mildly sinuous/irregular		boulder	5 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	moderate		cobble	10 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	10 %		pool		Casuarina
	Right bank: steep/convex		gravel	10 %		run		Callistemon
						riffles		
			sand	60 %		large woody debris	**Weed species**	Noogoora burr
Hydrology			silt / clay	5 %		trailing bank vegetation	**Adjacent land use**	forest
Flow regime	perennial					macrophytes		grazing
Water depth	0.5 m	**Deposits**	Sand		**In-stream disturbance**			
Wetted width	6 m	**Bed stability**	moderate aggradation		Flow modification	road culvert at site		
Flow	0.3 m / s				Waterway barrier	none		
Channel width	20 m							

Comments: Site is a flowing creek with a variety of sediment sizes and habitat types. Fallen trees, riffles, pools and undercut banks provide habitat. Evidence of cattle access to creek. Box culvert under road crossing in middle of site. Callistemon lining creek, although all trees have been cleared around road crossing. Sand deposits forming some bars, with one vegetated midstream bar. Pump hoses on bank next to road crossing. Erosion on right bank downstream of causeway

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	24/05/20 (post-wet)	**Habitat Bioassessment Score**	55 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	15 – 15 m
Pattern	mildly sinuous/irregular		boulder	0 %	**Habitat present**	shallow	**Disturbance**	low
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate-steep/concave		pebble	0 %		run		Casuarina
						pool		
	Right bank: steep-vertical/convex		gravel	0 %		large woody debris		Callistemon
						trailing roots		
Hydrology			sand	95 %		macrophytes	**Weed species**	Noogoora burr
Flow regime	perennial		silt / clay	5 %				*Bidens pilosa*
Water depth	1.0 m	**Deposits**	Sand/silt		**In-stream disturbance**			grasses
								Scot's thistle
Wetted width	6 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.1 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments:	Site is a slow flowing stream with soft, sandy substrate. Several fallen trees in water, and sediment deposits high up on bank from high flows. Dense growth of *Callistemon* and *Casuarina* in riparian zone on both banks. *Lomandra longifolia* and *Casuarina* growing on sand bars. Evidence of cattle access to water. Noogoora burr extensive on banks. Large patches of erosion behind riparian vegetation on right bank.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	23/05/20 (post-wet)	**Habitat Bioassessment Score**	44 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	10 – >30 m
Pattern	irregular meanders		boulder	60 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	low to moderate		cobble	5 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	2 %		pool		Callistemon
	Right bank: moderate-steep/convex		gravel	3 %		large woody debris		
Hydrology			sand	20 %			**Weed species**	Noogoora burr
								grasses
Flow regime	intermittent		silt / clay	10 %			**Adjacent land use**	grazing
Water depth	>1.5 m	**Deposits**	Sand/silt		**In-stream disturbance**			native vegetation
Wetted width	8 m	**Bed stability**	moderate aggradation		Flow modification	none		
Flow	No observable flow				Waterway barrier	none		
Channel width	20 m							

Comments: Site is a turbid pool that extends upstream of site. Downstream pool ends at log jam with large sediment deposits and *Callistemon* growing in bed. Cattle access to creek bed evident, with extensive tracks and churned up sediment in bed. Creek bed is made up of large boulders, but covered in thick layer of sand and silt. Evidence of recent high flow – sediment/silt high several meters up on banks and large log jams. Freshwater mussel shells in bed, and dead crayfish exoskeleton in side channel on left bank. Erosion on bank of side channel on left bank.

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	13/10/20 (pre-wet)	**Habitat Bioassessment Score**	45 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	2.5 to 15m
Pattern	isolated lake (oxbow lake)		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	moderate to high		cobble	0 %		shallow	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		pool		
	Right bank: low-moderate/convex		gravel	0 %		large woody debris	**Weed species**	Noogoora burr
			sand	0 %		macrophytes		*Bidens pilosa*
Hydrology			silt / clay	100 %				Scott's thistle
Flow regime	intermittent	**Deposits**	silt					terrestrial grasses
Water depth	>1.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			
Wetted width	50 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	80 m							

Comments: Site is an oxbow lake. Lake ends (historical) ~100m upstream of sampling location. Banks dense with *Juncus* sp. and grasses for ~2m on right banks ad ~20m on left bank. Macrophytes dense in water (*Vallisneria* sp., *Ludwigia peploides*, *Azolla* sp., *Myriophyllum* sp.). Algae on surface around edge. Some unhealthy *Persicaria* sp. on right bank. Evidence of cattle access to water, and cattle tracks on bank. Bank cleared beyond riparian zone, but some regrowth has been allowed. Eucalypts line waters' edge, particularly left bank.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	13/10/20 (pre-wet)	**Habitat Bioassessment Score**	50 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 to 10m
Pattern	isolated lake (oxbow lake)		boulder	0 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	moderate		cobble	0 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		pool		
	Right bank: low/convex		gravel	0 %		large woody debris		
Hydrology			sand	5 %		macrophytes	**Weed species**	terrestrial grasses
Flow regime	intermittent		silt / clay	95 %	**In-stream disturbance**			Noogoora burr
Water depth	>1.5 m	**Deposits**	silt		Flow modification	none		Scott's thistle
Wetted width	50 m	**Bed stability**	moderate aggradation		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	90 m							

Comments: Site is an oxbow lake. Macrophytes line edges (*Vallisneria* sp., *Ludwigia peploides*, *Azolla* sp.) and banks (*Juncus* sp., *Cyperus* sp., *Sida* sp.). Riparian vegetation dominated by eucalypt in canopy and terrestrial grasses in understory. Left bank is more densely vegetated than right bank, with eucalypts, grasses and a wider riparian zone. Beyond riparian zone cleared for grazing. Evidence of cattle access to water. Water birds present (black swans, pelicans, cormorants). Dead eucalypts in water – evidence of previous lower water levels.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	13/10/20 (pre-wet)	**Habitat Bioassessment Score**	51 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	3 to 10m
Pattern	isolated lake (oxbow lake)		boulder	0 %	**Habitat present**	deep	**Disturbance**	high
Bank stability	moderate		cobble	0 %		macrophytes	**Dominant species**	Eucalypt
Bank shape	Left bank: low-moderate/convex		pebble	0 %		pool		
	Right bank: flat/convex		gravel	0 %		large woody debris	**Weed species**	Mexican poppy
Hydrology			sand	5 %				Scott's thistle
Flow regime	intermittent		silt / clay	95 %				
Water depth	>1.5 m	**Deposits**	silt					
Wetted width	60 m	**Bed stability**	moderate aggradation		**In-stream disturbance**		**Adjacent land use**	cropping
Flow	no flow				Flow modification	none		grazing
Channel width	90 m				Waterway barrier	none		

Comments: Site is an oxbow lake. Bank/edge dense with macrophytes (*Vallisneria* sp., *Ludwigia peploides*, *Azolla* sp.) covering 5m of edge, and *Cyperus* sp. and *Juncus* sp. covering the bank. Eucalypts at water's edge, but cleared directly behind it. Dead eucalypts in water from previous lower water level. Evidence of cattle access to water on right bank. Dense patches of *Sida* sp. in riparian zone.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	14/10/20 (pre-wet)	**Habitat Bioassessment Score**	76 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology	
Stream order	6
Pattern	mildly sinuous
Bank stability	low to moderate
Bank shape	Left bank: low to steep-convex Right bank: steep-convex

Hydrology	
Flow regime	perennial
Water depth	0.7 m
Wetted width	6 m
Flow	0.2 m / s
Channel width	12 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	2%
	pebble	3%
	gravel	5%
	sand	80 %
	silt / clay	10 %
Deposits	sand, silt	
Bed stability	moderate aggredation	

Aquatic Habitat	
Habitat diversity	high
Habitat present	shallow deep run log jams trailing roots macrophytes undercut banks large woody debris

In-stream disturbance	
Flow modification	none
Waterway barrier	none

Riparian Zone	
Riparian width	8 to 10 m
Disturbance	low to moderate
Dominant species	Callistemon
Weed species	Noogoora burr Scot's thistle grasses
Adjacent land use	native forest grazing cropping

Comments:	Site is a slow to moderate flowing stream with densely vegetated banks (mostly Callistemon and *Lomandra* sp.). Large fallen trees in water from previous high flow provide habitat. Undercut banks where banks are steep. Majority of river shaded by Callistemon. Vegetated bars on left bank, dominated by *Lomandra* sp. Evidence of cattle access to water.

Site	S4	**Region**	Upper Dawson
Date surveyed:	15/10/20 (pre-wet)	**Habitat Bioassessment Score**	80 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	5 to 8 m
Pattern	straight/mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate to high
Bank stability	low to moderate		cobble	10 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate to steep/convex		pebble	5 %		pool		Callistemon
	Right bank: steep/convex		gravel	15 %		run		
						riffles		
			sand	60 %		large woody debris	**Weed species**	Noogoora burr
Hydrology			silt / clay	10 %		trailing bank vegetation		Scot's thistle
Flow regime	perennial					macrophytes		Mexican poppy
Water depth	0.5 m	**Deposits**	Sand / silt		**In-stream disturbance**			terrestrial grasses
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	box culvert at site		
Flow	0.2 m / s				Waterway barrier	none	**Adjacent land use**	native forest
Channel width	20 m							grazing

Comments: Site is on a shallow creek with moderate flow at a road crossing. Water flows through a box culvert at road crossing with a pool backed up behind it. Weeds prevalent at road crossing (Mexican poppy, Scot's thistle, Noogoora burr), where native Callistemon has been cleared. Some deposition of sand/gravel downstream where vegetated bars have formed. Remnant Callistemon on right bank, but little other riparian vegetation. Some erosion evident on banks, with large erosion scar on right bank downstream of road crossing. Callistemon shading river upstream and downstream of road crossing. Evidence of cattle access to water.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	14/10/20 (pre-wet)	**Habitat Bioassessment Score**	62 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	5 – 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow	**Disturbance**	moderate
Bank stability	low		cobble	0 %		deep	**Dominant species**	Callistemon
Bank shape	Left bank: steep/convex		pebble	0 %		run		Casuarina
						pool		
	Right bank: steep-vertical/concave		gravel	0 %		large woody debris		
						undercut banks		
Hydrology			sand	90 %		macrophytes	**Weed species**	Noogoora burr
Flow regime	perennial		silt / clay	10 %		trailing roots		*Bidens pilosa*
Water depth	0.5 m	**Deposits**	Sand/silt		**In-stream disturbance**			grasses
								Mexican poppy
Wetted width	6 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.1 m / s				**Waterway barrier**	none		grazing
Channel width	20 m							cropping

Comments:	Site is a creek with variable flow/depth/width. Water is slightly turbid from recent rain. Macrophytes line banks in sections and on large vegetated bar on left bank (*Persicaria* sp. and *Lomandra* sp.). Left bank is native forest. Right bank is cleared for grazing, but riparian vegetation largely intact. Large amount of weeds on right bank (Scot's thistle, Noogoora burr, Mexican poppy). Large remnant *Casuarina* and *Callistemon* in riparian vegetation.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	15/10/20 (pre-wet)	**Habitat Bioassessment Score**	42 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0%	**Habitat diversity**	low	**Riparian width**	5 – 15 m
Pattern	irregular meanders/ isolated pool		boulder	10 %	**Habitat present**	shallow	**Disturbance**	high
Bank stability	low		cobble	30 %		deep	**Dominant species**	Eucalypt
Bank shape	Left bank: steep/concave		pebble	5 %		pool		Callistemon
	Right bank: moderate/concave		gravel	5 %		large woody debris		
Hydrology			sand	30 %			**Weed species**	Noogoora burr
								terrestrial grasses
Flow regime	intermittent		silt / clay	20 %				Mexican poppy
Water depth	>1.2 m	**Deposits**	Sand/silt		**In-stream disturbance**			wild tobacco
Wetted width	8 m	**Bed stability**	moderate aggradation		Flow modification	none	**Adjacent land use**	grazing
Flow	No flow				Waterway barrier	none		native vegetation
Channel width	20 m							

Comments:	Site is an isolated pool in a rocky and sandy channel. Extensive evidence of cattle access to creek bed. Water is turbid, with algae on bottom in shallow sections. Cattle faeces in water. Substrate large to moderate sized boulders surrounded by finer sediment (mostly sand/silt). Some macrophytes and weeds in dry sections of bed and on bank. Large woody debris in water. Upstream of pool large Callistemon in bed suggests flow is not common. Log jams upstream of pool.

Appendix D Baseline Range for Water Quality and Sediment Quality Data, and Macroinvertebrate Indices

Table D1 Baseline Maximum for Water Quality Parameters

Parameter	Unit	Waterbody	Dawson River	Hutton Creek
		Maximum	Maximum	Maximum
Temperature	ºC	9.0 – 36.4	10.3 – 32.1	15.5 – 35.6
Dissolved oxygen	mg/L	0.13 – 19.9	1.93 – 13.1	7.7 – 17.2
Electrical conductivity	µS/cm	1724	2568	797
pH	unit	6.7 – 9.7	6.5-8.4	6.9 – 8.8
Suspended solids	mg/L	665	71	175
Turbidity	NTU	821	1243	612
Ammonia as N	mg/L	1.63	0.1	0.1
Total nitrogen	mg/L	30.3	1.7	1.9
Boron (total)	mg/L	0.30	0.24	0.11
Zinc (total)	mg/L	0.035	0.014	0.019
Boron (dissolved)	mg/L	0.24	2.0	0.13
Zinc (dissolved)	mg/L	0.063	0.052	0.008

Baseline range presented for temperature, dissolved oxygen and pH.

Table D2 Baseline Maximum for Sediment Quality Parameters

Parameter	**Unit**	**Waterbody**	**Dawson River**	**Hutton Creek**
		Maximum	**Maximum**	**Maximum**
Aluminium (Al)	mg/kg	16800	12800	18500
Arsenic (As)	mg/kg	6	5	8
Boron (B)	mg/kg	27.5	13.5	26.9
Cadmium (Cd)	mg/kg	<LOR	<LOR	<LOR
Chromium (Cr)	mg/kg	26.8	70.3	19.4
Copper(Cu)	mg/kg	19	12	18
Iron (Fe)	mg/kg	23900	19000	32000
Lead (Pb)	mg/kg	25.1	15	23.5
Manganese (Mn)	mg/kg	1020	545	705
Mercury (Hg)	mg/kg	0.8	<LOR	<LOR
Nickel (Ni)	mg/kg	30.4	296	15
Selenium (Se)	mg/kg	<LOR	<LOR	<LOR
Zinc (Zn)	mg/kg	74	46	68

Table D3 Full Baseline Range of Macroinvertebrate Indices

Index	Waterbody		Dawson River		Hutton Creek	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Abundance	16	512	15	411	1	590
Taxonomic Richness	3	15	6	25	1	20
PET Richness	0	2	0	6	0	3
SIGNAL-2 Scores	2.36	3.64	2.57	4.41	2	3.38

Table D4 Zooplankton Data (microcrustacean data only) from September 2018 Survey of Waterbody

Taxa	Higher Taxa	WLMP1			WLMP4			WLMP5		
		Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Microcrustaceans										
Daphnia sp 1 (*Daphnia carinata*)	Daphniidae (Cladocera)	4000	15625	75000	260	85	170	15000	5000	8500
Daphnia sp 2 (*Daphnia lumholtzi*)	Daphniidae (Cladocera)						10			
Chydoridae (Cladoceran 1)	Chydoridae				25	90	5			
Cladoceran 2	Cladocera				15	15	5			
Bosminidae (Cladoceran 3)	Cladocera	20			5	40	5	90	165	60
Copepod 2 (Cyclopoida)	Copepoda				100	240	205			
Copepod 1 (Calanoida)	Copepoda				25	100	5	1500	3250	2575
Ostracod 2	Ostracoda	20			15					
Ostracod 1	Ostracoda	25	10	50	15		10			
Ostracod 3	Ostracoda				5		5			

Note: taxonomic names used in the 2018 study have been updated here to align with the 2019/2020 data

Dawson River Release Scheme Receiving Environment Monitoring Program

Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos Ltd (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP design document, titled *Santos Ltd Dawson River Watercourse Releases: Receiving Environment Monitoring Program* (frc environmental 2021). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the sixth year the REMP has been implemented for the purpose of monitoring the desalinated release.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake the DRRS REMP monitoring and reporting in 2021.

The purpose of this report is to present and record the methods and results of the 2021 post-wet (May) and pre-wet (October) season REMP surveys, and provide an assessment of potential adverse effects of the desalinated release on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP Design Report). Sampling utilised the methods nominated in the REMP and included water quality, sediment quality, aquatic habitat, macroinvertebrate, fish and geomorphological (i.e. bed and bank stability) monitoring.

The work presented in this report was carried out by suitably qualified persons (professional aquatic ecologists with qualifications and academic and industry experience in freshwater biology, and a combined total of over 25 years of industry experience as aquatic ecologists) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 17 – 21 May 2021, and the pre-wet survey was implemented 11 – 15 October 2021.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are shown in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two water types: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As prescribed by the REMP, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and two on the Dawson River (DRMP1 and S4). Site DRMP1 is downstream of the confluence where the tributary from the Waterbody enters the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153

Site	Description	GDA94	
		Latitude	Longitude
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges into the Waterbody and 8 km downstream of the confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.	-25.692	149.216
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2021 post-wet season and pre-wet season REMP surveys:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek. This is consistent with water quality conditions throughout the baseline monitoring program.

149° E

149.2° E

Dawson River

Harris Creek

Boyd Creek

Belington Hut State Forest

Injune Road

Expedition Resources Reserve

Beilba State Forest

Expedition (Limited Depth) National Park

Hutton Creek

Fitzroy Basin

DRR1

DRMP1

S4

WLMP4

WLMP5

WLMP1

DRR2

Stephenton State Forest

Commissioner Creek

Hallett State Forest

Sids Pocket Road

149° E

149.2° E

frc environmental
AQUATIC ECOLOGISTS
deep thinking.science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme Receiving Environment Program

Map 2.1: Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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LEGEND

Monitoring Site

- Control sites upstream of receiving environment
- Waterbody sites within receiving environment
- Dawson River sites within receiving environment
- Watercourse
- Lake/Reservoir
- Basin

Road Network

- Local Road

Protected Area

- National Park
- Other Reserve

N

SCALE

0 2.25 4.5

Kilometres

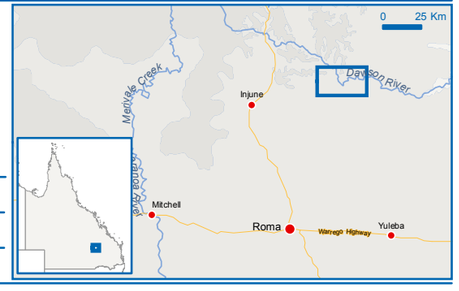
Scale: 1:80,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2017-06-20

DRAWN BY
AB

VERSION
01



3 Water Quality

3.1 Methods

Survey Procedure

Water quality was measured in situ for temperature, pH, electrical conductivity, dissolved oxygen and turbidity using a calibrated meter. Measurements were taken approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites.

Water samples were collected approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites, directly into sampling containers provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed. Two (replicate) samples were collected from one site on each survey for assessing within-site variation. Parameters analysed in the laboratory were: suspended solids, ammonia, nitrogen, and total and dissolved boron and zinc.

Data Analysis

Results were compared to the local water quality guidelines developed for the Dawson River Watercourse Releases REMP (frc environmental 2021). To assess within-site variation, relative percent difference was calculated for the replicate samples collected at one site on each survey where results were at least ten times greater than the LOR.

3.2 Results

Results for the water quality (Table 3.1, Table 3.2, Table 3.3 and Table 3.4) showed that:

- During the post-wet survey, the water temperature was lower than the guideline at all Waterbody sites (i.e. WLMP4: 11.43 ºC, WLMP1: 18.04 ºC, WLMP5: 16.38 ºC) and all Dawson River sites (i.e. DRMP1: 13.81 ºC, S4: 9.95 ºC, DRR1: 12.85 ºC), but was within the baseline range at all Waterbody sites (i.e. 9.0 – 36.4 ºC) and all Dawson River sites (i.e. 10.3 – 32.1 ºC) with the exception of site S4 for the post-wet survey. Low water temperature at site S4 during the post-wet survey is

discussed further in Section 10. Water temperature achieved the guideline at all sites during the pre-wet survey.

- During the post-wet survey, the concentration of dissolved oxygen was lower than the guideline range at site DRR2 (5.5 mg/L), and was also lower than the baseline range for Hutton Creek (i.e. baseline minimum of dissolved oxygen was 7.7 mg/L for the Hutton Creek water type; Appendix D). However, site DRR2 is a control site; thus, low dissolved oxygen at this site was not influenced by the release of treated coal seam water. During the pre-wet survey, the concentration of dissolved oxygen was lower than the guideline range at sites WLMP4 (3.6 mg/L) and WLMP1 (2.3 mg/L) and at Dawson River sites DRMP1 (5.4 mg/L) and DRR1 (5.4 mg/L). However, the concentration of dissolved oxygen was within the baseline range for sites on both the Waterbody and the Dawson River (Appendix D).
- The pH of water was lower than the guideline at site WLMP4 (i.e. 6.0) during the post-wet season survey and at WLMP1 (i.e. 6.28) during the pre-wet season survey. These results were also lower than the baseline range for the Waterbody (i.e. baseline minimum pH was 6.7 for the Waterbody water type; Appendix D). The low pH of water at sites WLMP4 in the post-wet season survey and WLMP1 in the pre-wet season survey is discussed further in Section 10.
- all other parameters complied with the guideline at all sites.
- the relative percent difference for most parameters were relatively low, indicating low within-site variation for these parameters. However, the relative percent difference for suspended solids and total nitrogen was moderate in the post-wet survey, and moderate for total nitrogen in the pre-wet season survey. These findings suggest that results for these parameters should be treated as estimates rather than precise values in the respective surveys.

Table 3.1 Water quality results compared to the local water quality guidelines for the 2021 post- wet season REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	11.43	18.04	16.38	15.8 – 27.1	13.81	9.95	12.85	–	11.42
Dissolved oxygen	mg/L	–	6.4 – 16.1	10.5	8.3	8.3	6.4 – 16.1	8.4	9.7	7.8	6.4 – 16.1	5.5
Electrical conductivity	µS/cm	–	627	289	119	121	500	247	255	251	500	168
pH	unit	–	6.5 – 8.5	6.0	7.8	7.7	6.5 – 8.5	7.5	7.2	7.3	6.5 – 8.5	7.1
Suspended solids	mg/L	5	128	6	10	7	50	6	–	6	50	13
Turbidity	NTU	–	Monitor only	7.3	10.4	11.1	Monitor only	15.1	15.0	13.4	Monitor only	96.5
Nutrients												
Ammonia as N	mg/L	0.01	0.9	< 0.01	< 0.01	< 0.01	0.9	0.02	–	0.01	0.9	0.07
Total nitrogen	mg/L	0.1	3.93	0.60	0.20	0.30	0.62	< 0.10	–	0.10	0.62	0.70
Total metals and metalloids												
Boron	mg/L	0.05	2.9	1.38	1.15	1.20	2.9	0.10	–	< 0.05	2.9	< 0.05
Zinc	mg/L	0.005	12	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	< 0.005
Dissolved Metals and metalloids												
Boron	mg/L	0.05	2.9	1.40	1.22	1.25	2.9	0.06	–	< 0.05	2.9	< 0.05
Zinc	mg/L	0.005	8	< 0.005	< 0.005	< 0.005	8	< 0.005	–	< 0.005	8	0.007

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value; – No guideline or data.

Table 3.2 Water quality results compared to the local water quality guidelines for the 2021 pre-wet season REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	22.3	24.6	25	15.8 – 27.1	23.3	23.2	23.7	–	22.7
Dissolved oxygen	mg/L	–	6.4 – 16.1	3.6	2.3	7.8	6.4 – 16.1	5.4	7.7	5.4	6.4 – 16.1	6.4
Electrical conductivity	µS/cm	–	627	228	162	148	500	281	280	275	500	215
pH	unit	–	6.5 – 8.5	7.83	6.28	7.65	6.5 – 8.5	7.22	7.7	7.22	6.5 – 8.5	7.36
Suspended solids	mg/L	5	128	<5	<5	6	50	10	–	14	50	12
Turbidity	NTU	–	Monitor only	11.9	3.2	11.1	Monitor only	39.3	19.3	20.2	Monitor only	66
Nutrients												
Ammonia as N	mg/L	0.01	0.9	<0.01	<0.01	0.02	0.9	0.08	–	0.08	0.9	<0.01
Total nitrogen	mg/L	0.1	3.93	0.4	0.2	0.4	0.62	0.2	–	0.2	0.62	0.8
Total metals and metalloids												
Boron	mg/L	0.05	2.9	1.64	1.27	1.32	2.9	<0.05	–	<0.05	2.9	<0.05
Zinc	mg/L	0.005	12	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005
Dissolved Metals and metalloids												
Boron	mg/L	0.05	2.9	1.77	1.47	1.49	2.9	<0.05	–	<0.05	2.9	<0.05
Zinc	mg/L	0.005	8	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

Table 3.3 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters.

Parameter	Unit	LOR	Post-wet season survey		
			Site WLMP1		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	10	7	35.3
Ammonia as N	mg/L	0.01	< 0.01	< 0.01	–
Total Nitrogen	mg/L	0.1	0.2	0.3	40
Total boron	mg/L	0.05	1.15	1.17	1.7
Total zinc	mg/L	0.005	< 0.005	< 0.005	–
Dissolved boron	mg/L	0.05	1.22	1.20	1.7
Dissolved zinc	mg/L	0.005	< 0.005	< 0.005	–

Table 3.4 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters

Parameter	Unit	LOR	Pre-wet season survey		
			Site WLMP4		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	<5	<5	–
Ammonia as N	mg/L	0.01	<0.01	<0.01	–
Total Nitrogen	mg/L	0.1	0.4	0.6	40
Total boron	mg/L	0.05	1.64	1.62	1
Total zinc	mg/L	0.005	<0.005	<0.005	–
Dissolved boron	mg/L	0.05	1.77	1.79	1
Dissolved zinc	mg/L	0.005	<0.005	<0.005	–

4 Sediment Quality

4.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids).

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2021).

4.2 Results

Results for the laboratory analyses of sediment quality (Table 4.1 and Table 4.) showed that:

- The concentration of manganese at site WLMP4 (1,050 mg/kg) was higher than the local trigger value (676 mg/kg), and was slightly higher than the baseline range recorded in the Waterbody (maximum = 1,020 mg/kg; Appendix D) in the post-wet season survey. The high concentration of manganese in sediment at site WLMP4 in the post-wet season survey is discussed further in Section 10. Manganese complied with the local trigger value at all sites in the pre-wet survey.
- The concentration of all other parameters complied with the applicable local sediment quality guidelines at all sites, noting that selenium could not be assessed because the limit of reporting (LOR) was higher than the local trigger value.
- the relative percent difference (RPD) for aluminium, copper, iron, lead and zinc was moderate in the post-wet season survey, and moderate for manganese in the pre-wet season survey. These findings suggest moderately high within-site variation for these parameters and that results for these parameters should be treated as estimates rather than precise values.

Table 4.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2021 post-wet season REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13,933	6,440	6,300	6,200	5,191	460	980	650	11,800	2,850
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	0.2	18.8	2.2	3.3	2.8	17.9	< 0.2	< 0.2	< 0.2	25	< 0.2
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	6	5	6	80	< 2	< 2	< 2	80	4
Copper(Cu)	mg/kg	5	65	11	12	12	65	< 5	< 5	< 5	65	< 5
Iron (Fe)	mg/kg	50	17,867	16,800	11,200	9,900	9,353	2,770	1,540	2,200	20,700	10,100
Lead (Pb)	mg/kg	5	50	14	12	11	50	< 5	< 5	< 5	50	10
Manganese (Mn)	mg/kg	5	648	1,050	475	288	230.5	27	41	100	337	163
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	9	8	8	21	< 2	< 2	< 2	21	4
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	34	42	33	200	< 5	< 5	< 5	200	17

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

Green shading indicated where the LOR was higher than the trigger value.

Table 4.2 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2021 pre-wet season REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13,933	6,470	5,740	12,500	5,191	530	1660	810	11,800	2770
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	0.2	18.8	2.5	4.2	9.0	17.9	< 0.2	< 0.2	< 0.2	25	< 0.2
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	6	5	10	80	< 2	< 2	< 2	80	3
Copper(Cu)	mg/kg	5	65	11	9	17	65	< 5	< 5	< 5	65	< 5
Iron (Fe)	mg/kg	50	17,867	10,000	9,510	14,800	9,353	1,600	2,850	1,720	20,700	6,690
Lead (Pb)	mg/kg	5	50	13	10	16	50	< 5	< 5	< 5	50	6
Manganese (Mn)	mg/kg	5	648	289	270	535	230.5	140	86	49	337	127
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	7	7	12	21	< 2	< 2	< 2	21	3
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	35	29	60	200	< 5	6	< 5	200	14

Table 4.3 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters.

Parameter	Unit	Site WLMP1 (post-wet season survey 2021)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	6,300	8,970	35.5
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	3.3	2.8	15.9
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	5	6	18.2
Copper(Cu)	mg/kg	12	6	66.7
Iron (Fe)	mg/kg	11,200	6,470	53.5
Lead (Pb)	mg/kg	12	16	28.6
Manganese (Mn)	mg/kg	475	572	18.5
Mercury (Hg)	mg/kg	< 0.1	< 0.1	–
Nickel (Ni)	mg/kg	8	9	11.87
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	42	27	43.5

Table 4.4 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters.

Parameter	Unit	Site WLMP4 (pre-wet season survey 2021)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	6,470	7,170	10.2
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	2.5	2.9	14.81
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	6	7	13.8
Copper(Cu)	mg/kg	11	11	–
Iron (Fe)	mg/kg	10,000	11,200	11.32
Lead (Pb)	mg/kg	13	14	7.4
Manganese (Mn)	mg/kg	289	379	26.9
Mercury (Hg)	mg/kg	<0.1	< 0.1	–
Nickel (Ni)	mg/kg	7	8	13.3
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	35	38	8.21

5 Aquatic Habitat, and Bed and Bank Stability

5.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP design document (frc environmental 2021).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons were made against baseline condition, as presented in the REMP design document (frc environmental 2021).

5.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 5.1) showed that:

- bed and bank stability at all sites and for all water types had not changed from baseline condition, with the exception of bed stability in the Dawson River water type which had slightly improved
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with water levels higher than many of the baseline surveys providing an increased cover of woody debris and increased diversity of submerged aquatic plants, and
- all other aquatic habitat features for all water types remained relatively unchanged since baseline surveys.

Table 5.1 Habitat characteristics of each water type in the 2021 post-wet season REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate to high*	*low to moderate*	*low to moderate*
Bed stability	*moderate*	*moderate*	*moderate*
Substrate diversity	*low to moderate*	*moderate to high*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate to high*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition
blue shading indicated a potential increase in habitat quality compared to baseline conditions

Table 5.2 Habitat characteristics of each water type in the 2021 pre-wet season REMP survey.

Habitat Attribute	Habitat Characteristics		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate to high*	*low to moderate*	*low to moderate*
Bed stability	*moderate*	*moderate*	*moderate*
Substrate diversity	*low to moderate*	*moderate to high*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate to high*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition
blue shading indicated a potential increase in habitat quality compared to baseline conditions

6 Macroinvertebrate Communities

6.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2021).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual* (DES 2018). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. The REMP design document considers an error rate of <5% acceptable for macroinvertebrate sorting and identification, with the error rate of < 1% for this study.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (i.e. families in most cases in this assessment). 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each replicate sample for each site, and then the median per site and median for each water type were calculated. These results were compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP design document; frc environmental 2021). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range , then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

6.2 Results

Results for macroinvertebrate indices showed that (Table 6.1, Table 6.2, Table 6.3, Table 6.4):

- the abundance of macroinvertebrates was:
  - Higher than the local biological guideline range at Dawson River site DRR1 during the post-wet season survey; and higher than the guideline range at Dawson River sites S4 and DRR1, and the Dawson River water type, during the pre-wet season survey. However, these results were within the baseline range (see Appendix D).
  - Lower than the local water quality guidelines at waterbody sites WLMP1 and WLMP5, and the Waterbody water type, in the post-wet and pre-wet season surveys; however, the abundance of macroinvertebrates was within the baseline range in each case (see Appendix D).
  - Within the local biological guideline range in all other cases.
- taxonomic richness of macroinvertebrates was:
  - Higher than the local biological guideline range at Waterbody site WLMP4 and Hutton Creek site DRR2 in the post-wet and pre-wet season surveys, but within the baseline range (see Appendix D) at site DRR2 during the post-wet and pre-wet survey. Taxonomic richness was also higher than the local biological guideline range for the Hutton Creek water type in the post-wet and pre-wet season surveys, but within the baseline range (see Appendix D). High taxonomic richness at site WLMP4 is discussed further in Section 10, noting this is a positive ecological change from baseline condition.
  - Lower than the local biological guideline range at Waterbody site WLMP5, but within the baseline range for the post-wet survey (see Appendix D).
  - Within the local biological guideline range in all other cases.
- PET richness of macroinvertebrates was:
  - Higher than the local biological guideline range at Waterbody site WLMP4 and Hutton Creek site DRR2 in the post-wet and pre-wet season surveys, but within the baseline range at both sites during the post-wet and pre-wet surveys (Appendix D). PET richness was also higher than the local biological guideline range for the Hutton Creek water type, but within the baseline range, during the post-wet and pre-wet surveys.
  - Within the local biological guideline range in all other cases
- SIGNAL-2 Scores for macroinvertebrates were:

- Higher than the local biological guideline range at all Waterbody sites (WLMP4, WLMP1 and WLMP5), Dawson River site DRMP1 and Hutton Creek site DRR2 in the post-wet season survey. Higher than the local biological range at Waterbody sites WLMP1 and WLMP5, Dawson River site DRR1 and Hutton Creek site DRR2 for the pre-wet season survey. These results were within the baseline range, with the exception of site DRR2 in the post-wet season survey – this result is discussed further in Section 10, noting it represents a positive ecological change from baseline condition. SIGNAL-2 scores were also higher than the local biological guideline range for the Waterbody and Hutton Creek water types, but within the baseline range (Appendix D), for the post-wet and pre-wet season surveys.
- Within the local biological guideline range in all other cases.

Table 6.1 Median macroinvertebrate results for each site in the 2021 post-wet season REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	150.0	71.0	54.0	39.9–152.0	142.0	77.0	274.0	23.0–207.4	205.0
Taxonomic Richness	5.67–10.8	16.0	6.0	5.0	9.93–16.9	13.0	16.0	16.0	4.0–10.0	11.0
PET richness	0.0 – 1.2	2.0	0.0	0.0	1.47–4.0	4.0	4.0	4.0	0–1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.74	3.25	3.42	3.46–4.00	4.25	3.97	4.00	2.90–3.30	3.64

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

Table 6.2 Median macroinvertebrate results for each site in the 2021 pre-wet season REMP survey

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	217	62	61	39.9–152.0	93	168	214	23.0–207.4	148
Taxonomic Richness	5.67–10.8	18	7.0	9.0	9.93–16.9	15	14	15	4.0–10.0	12
PET richness	0.0 – 1.2	2.0	0	0	1.47–4.0	3.0	3.0	4.0	0–1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.10	3.40	3.33	3.46–4.00	3.90	4.0	4.21	2.90–3.30	3.42

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

Table 6.3 Median macroinvertebrate results for each water type in the 2021 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	89.0	39.9 – 152.0	131.0	23.0 – 207.4	205.0
Taxonomic Richness	5.67–10.8	6.0	9.93 – 16.9	15.0	4.0 – 10.0	11.0
PET richness	0.0 – 1.2	0.0	1.47 – 4.0	4.0	0 – 1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.50	3.46 – 4.00	3.87	2.90 – 3.30	3.64

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

Table 6.4 Median macroinvertebrate results for each water type in the 2021 pre-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	91	39.9 – 152.0	153.5	23.0 – 207.4	148
Taxonomic Richness	5.67–10.8	10	9.93 – 16.9	13	4.0 – 10.0	12
PET richness	0.0 – 1.2	1.0	1.47 – 4.0	3.0	0 – 1.0	2.0
SIGNAL-2 Score	2.65 – 3.20	3.33	3.46 – 4.00	3.94	2.90 – 3.30	3.42

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

7 Fish

7.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 7.1). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 255214) and Animal Ethics Approval (CA 2021/02/1478) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 7.1 Effort used to catch freshwater fish in the 2021 post-wet season REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	15:00	8:15	34.5 h
WLMP1	fyke net (2)	pool	14:30	12:30	44 h
WMLP5	fyke net (2)	pool	14:00	10:30	41 h
Dawson River					
DRMP1	fyke net (2)	pool	15:15	12:30	42.5 h
S4	fyke net (2)	pool	14:00	8:30	37 h
DRR1	fyke net (2)	pool	14:30	10:15	39.5 h
Hutton Creek					
DRR2	fyke net (2)	pool	14:00	8:30	37 h

Table 7.2 Effort used to catch freshwater fish in the 2021 pre-wet season REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	14:20	8:10	36 h
WLMP1	fyke net (2)	pool	16:50	9:20	33 h
WMLP5	fyke net (2)	pool	11:30	7:20	39.67 h
Dawson River					
DRMP1	fyke net (2)	pool	13:45	8:40	37.83 h
S4	fyke net (2)	pool	12:30	7:15	37.5 h
DRR1	fyke net (2)	pool	15:30	10:00	37 h
Hutton Creek					
DRR2	fyke net (2)	pool	17:00	11:45	37.5 h

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2021) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

7.2 Results

Thirteen species of native fish were caught and / or observed during the 2021 post-wet season REMP survey (Table 7.2), with nine species recorded in the pre-wet season survey (Table 7.3). None of these species are conservation significant species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature*

Conservation Act 1992 (NC Act), and none are no-take species under the Queensland *Fisheries Act* 1994.

The number of native species caught at each site ranged from three (site DRR1) to nine (site WLMP5) in the pre-wet season survey, and from four (sites S4 and DRR2) to six (sites WLMP1, WLMP5 and DRR1). Total abundance of fish at each site ranged from ten (site S4) to 1088 (site WLMP5) in the post-wet season survey, and from 28 (site DRMP1) to 948 (site WLMP5) in the pre-wet season survey. The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites. The most commonly recorded species were carp gudgeons, eastern rainbowfish, Agassizi's glassfish and flyspecked hardyheads. No exotic species were caught.

All waterbody types achieved the local biological guideline for fish (i.e. had an observed: expected ratio of species diversity that was ≥ 1) (Table 7.). This indicates that the diversity of fish caught during the 2021 REMP survey was consistent with, or higher than, the diversity of fish recorded during the baseline monitoring program. Increased water levels compared to baseline condition may have created favourable conditions for fish, particularly at Waterbody sites.

All sites achieved the biological guideline for exotic fish with none captured at any site during the 2021 post-wet or pre-wet REMP season surveys, indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 7.2 Total abundance of freshwater fish for each species at each site in 2021 post-wet season REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	77	110	136	1	2	22	–	**348**
Craterocephalus stercusmuscarum	flyspecked hardyhead	5	3	106	1	–	–	–	**115**
Hypseleotris compressa	empire gudgeon	–	12	–	1	1	–	–	**14**
Hypseleotris spp.	carp gudgeon	20	254	660	–	–	6	51	**991**
Leiopotherapon unicolor	spangled perch	–	1	2	–	–	–	–	**3**
Macquaria ambigua	yellow belly	–	–	–	–	–	–	2	**2**
Melanotaenia splendida splendida	eastern rainbowfish	18	37	175	5	–	–	3	**238**
Nematalosa erebi	bony bream	–	1	1	–	–	–	–	**2**
Neosilurus hyrtlii	Hyrtl's catfish	–	–	1	–	–	–	–	**1**
Philypnodon grandiceps	flathead gudgeon	–	–	–	–	–	–	1	**1**
Porochilus rendahli	Rendahl's catfish	–	–	2	–	–	–	–	**2**
Pseudomugil signifer	Pacific blue eye	–	–	–	3	1	–	–	**4**
Tandanus tandanus	freshwater catfish	4	1	5	1	6	2	–	**19**
Total native individuals		**124**	**419**	**1088**	**12**	**10**	**30**	**57**	**1740**
Total native species		**5**	**8**	**9**	**6**	**4**	**3**	**4**	**13**

– not caught

Table 7.3 Total abundance of freshwater fish for each species at each site in 2021 pre-wet season REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Species									
Ambassis agassizii	Agassiz's glassfish	14	10	156	4	–	11	–	**195**
Craterocephalus stercusmuscarum	flyspecked hardyhead	4	21	243	–	2	8	–	**278**
Hypseleotris spp.	carp gudgeon	43	580	511	3	–	24	199	**1360**
Leiopotherapon unicolor	spangled perch	–	1	–	–	–	–	–	**1**
Melanotaenia splendida splendida	eastern rainbowfish	8	–	30	18	12	56	62	**175**
Nematalosa erebi	bony bream	–	2	2	–	–	–	–	**4**
Philypnodon grandiceps	flathead gudgeon	–	–	–	–	–	–	1	**1**
Pseudomugil signifer	Pacific blue eye	–	–	–	1	6	81	–	**88**
Tandanus tandanus	freshwater catfish	1	4	6	2	34	2	3	**52**
Total native individuals		**618**	**70**	**948**	**28**	**54**	**182**	**265**	**2165**
Total native species		**5**	**6**	**6**	**5**	**4**	**6**	**4**	**9**

– not caught

Table 7.4 Comparison of fish monitoring results with the local biological objective for fish for the 2021 post-wet season REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	10	2.5
Dawson River	5	7	1.4
Hutton Creek	2	4	2.0

Table 7.5 Comparison of fish monitoring results with the local biological objective for fish for the 2021 pre-wet season REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	7	1.75
Dawson River	5	6	1.2
Hutton Creek	2	4	2.0

8 Macrocrustaceans – Exoskeleton Assessment

8.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 8.1).

8.2 Results

The macrocrustaceans caught during the 2021 REMP surveys included *Macrobrachium australiense* and *Caridina* spp., which were caught during the baseline monitoring program (Table 8.1), and *Cherax* spp. which were not caught at any habitat type during the baseline surveys. All specimens had exoskeletons that were of robust and good condition (Table 8.2). No macrocrustaceans were recorded in breeding condition during the post-wet season season survey, which is consistent with the results of baseline surveys implemented in Autumn. A single gravid *Caridina* spp. was collected from each of sites WLMP4 and DRMP1, and eight gravid *Macrobrachium australiense* were recorded at site DRR1 during the pre-wet season survey. These results suggest that the pre-wet season survey was implemented early in the population-level breeding season for macrocrustaceans.

Table 8.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense* *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 8.2 Macrocrustacean species and condition recorded during the 2021 post-wet season REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense* *Caridina* spp. *Cherax* spp.	*Macrobrachium australiense*	*Macrobrachium australiense* *Caridina* spp.
Breeding condition	not breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae); *Cherax* spp. – crayfish (family Parastacidae).

Table 8.3 Macrocrustacean species and condition recorded during the 2021 pre-wet season REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense* *Caridina* spp.	*Macrobrachium australiense* *Caridina* spp	*Macrobrachium australiense* *Caridina* spp. *Cherax* spp.
Breeding condition	Breeding (a single *Macrobrachium* only)	Breeding (a single *Caridina* and 8 *Macrobrachium*)	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)); *Cherax* spp. – crayfish (family Parastacidae).

9 Zooplankton

9.1 Methods

Survey Procedure

Zooplankton was assessed in the post-wet (May) and pre-wet (October) surveys in 2021.

Three samples were collected at each site using a six-meter, depth-integrated tow with a 150 µm mesh plankton net, which samples 'macrozooplankton', but not 'microzooplankton' (i.e. ciliates, rotifers and juvenile microzooplankton – i.e. nauplii), which requires a smaller mesh size of approximately 20 µm (James 1991).

Samples were preserved in methylated spirits and transported to a biological laboratory (Dardanus Scientific) where they were processed by a suitably qualified aquatic invertebrate taxonomy specialist. Microcrustaceans were identified to morphospecies[1], with the exception of *Ceriodaphnia cf dubia*, which was identified to described species level using available taxonomic keys (Shiel 1995). This taxon was of particular interest due to its reported sensitivity to boron (AECOM 2019; Halcrow 2013).

The abundance of each taxon was determined for a quantitative sub-sample of each sample, and then converted to an abundance for the total sample.

Data Analysis

There is no baseline data for zooplankton and no biological guidelines for zooplankton, although an initial zooplankton survey was completed in September 2018 at the Waterbody sites (i.e. WLMP4, WLMP1 and WLMP5) with this data (i.e. see Appendix D) incorporated in this study. Only data for microcrustaceans (Cladocerans, Ostracods and Copepods) is presented.

Spatial and temporal variability in the zooplankton community was statistically assessed using PERMANOVA and multidimensional scaling, implemented using the Primer software.

[1] Only microcrustacean data is considered, although all taxa were identified during laboratory processing, with insects identified to family or subfamily, and other taxa (e.g. Nematoda) to class or order.

9.2 Results

Eight microcrustacean taxa were found in the 2021 post-wet season survey, and seven taxa during the 2021 pre-wet survey (Table 9.1 and Table 9.2). *Ceriodaphnia cf dubia*, which is considered a sensitive environmental receptor, was recorded at site WLMP5 in the Waterbody in the 2021 post-wet season survey, but was not recorded at any site in the 2021 pre-wet survey. The occurrence of this taxon over time has been patchy but spread across all water types, with records only for one Waterbody site and at one site on the Dawson River in the 2019 pre-wet season survey, and at Hutton Creek site DRR2 in the 2020 post-wet survey.. The taxon *Bosminidae* was only recorded from a single site in each of the 2020 and 2021 pre-wet season surveys, but was recorded across multiple sites in the 2020 and 2021 post-wet season surveys, suggesting a seasonal trend to the abundance of this taxon.

Microcrustacean diversity was highest in the Waterbody (seven taxa recorded in the post-wet survey and four taxa recorded during the pre-wet survey), although Hutton Creek had equal diversity in the pre-wet season survey. The abundance of microcrustaceans was much higher in Hutton Creek than the other water types, and lowest in the Dawson River, in the post-wet season survey. However, abundances were broadly similar between Hutton Creek and Waterbody water types in the pre-wet season survey, and lowest in the Dawson River. The abundance of copepod 1, recorded at Hutton Creek during October 2021 pre-wet season is the lowest it has been recorded for this site. The consistently low abundance of microcrustaceans in the Dawson River maybe related to near-perennial flows in this water type compared to Hutton Creek (periodic flow) and the Waterbody (non-flowing).

The high abundance of microcrustaceans in Hutton Creek drive strong differentiation of this site from the other sites for the post-wet survey, and high variability within and between sites for the Waterbody and Dawson River water types (Figure 9.1). The results for the pre-wet season survey indicate that the microcrustacean fauna of Hutton Creek is similar to site WLMP1 in the Waterbody, and that there is high variability within and between sites for the Waterbody and Dawson River water types (Figure 9.2).

When all microcrustacean data collected between September 2018 and October 2021 is considered, results indicate a reasonably common pool of microcrustacean taxa across the three water types. However, not all species from this pool occur evenly across sites or water types, or across time, with PERMANOVA analysis using the combined data indicating high and statistically significant spatial and temporal variability in the composition of microcrustacean communities:

- between locations (i.e. between the three water types): F = 12.978, P = 0.0001
- across time (i.e. between 2018, 2019, 2020 and 2021): F = 3.7083, P 0.0001

- between sites: F = 6.429, P 0.0001, and
- across space and time combined (i.e. interaction between location and time): F = 3.2369, P 0.0001.

Table 9.1 Zooplankton (microcrustacean) survey results for the post-wet season 2021 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP4			WLMP1			WLMP5			DRMP1			S4			DRR1			DRR2		
	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Ceridodaphnia cf dubia								1													
Ceidodaphnia Sp 2		2																			
Chydoridae (Cladocera)					2	1									3			2			
Bosminidae (Cladocera)		2						1				1								7	165
Copepod 1 (Calanoida)	11	2					2	3	1										5000	7000	8200
Copepod 2 (Cyclopoida)			9	451	56	33	10	31	51	3	1	1	5	29	26	1		23			
Ostracod 1										1		1						2			
Ostracod 5						1															

Table 9.2 Zooplankton (microcrustacean) survey results for the pre-wet season 2021 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP4			WLMP1			WLMP5			DRMP1			S4			DRR1			DRR2		
	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Daphnia sp. 2 *(Daphnia lumholtzi)*																			1	3	2
Ceridodaphnia Sp 1																				76	16
Ceidodaphnia Sp 2	1		3			1		1													
Bosminidae (Cladocera)											1[a]										
Copepod 1 (Calanoida)	1			332	526	28		1											470	420	680
Copepod 2 (Cyclopoida)	640	326	115	7	11	64	9	8	16	1		3								17	9
Ostracod 2									1				1	1							

[a] = removed from PERMANOVA and MDS analyses due to being an extreme outlier

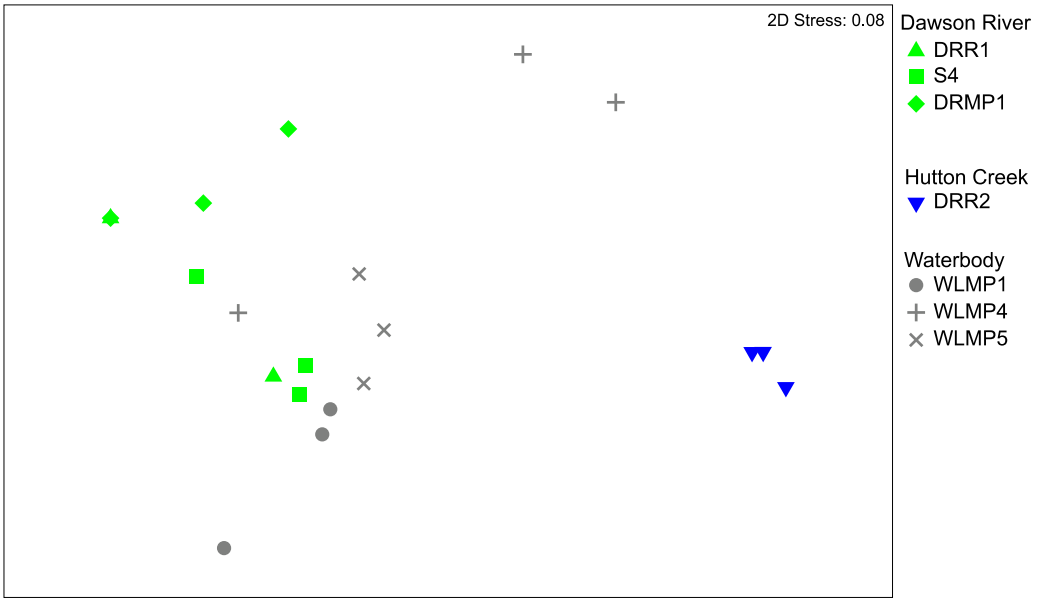


Figure 9.1 MDS plot of microcrustacean communities at each site in the 2021 post-wet season survey.

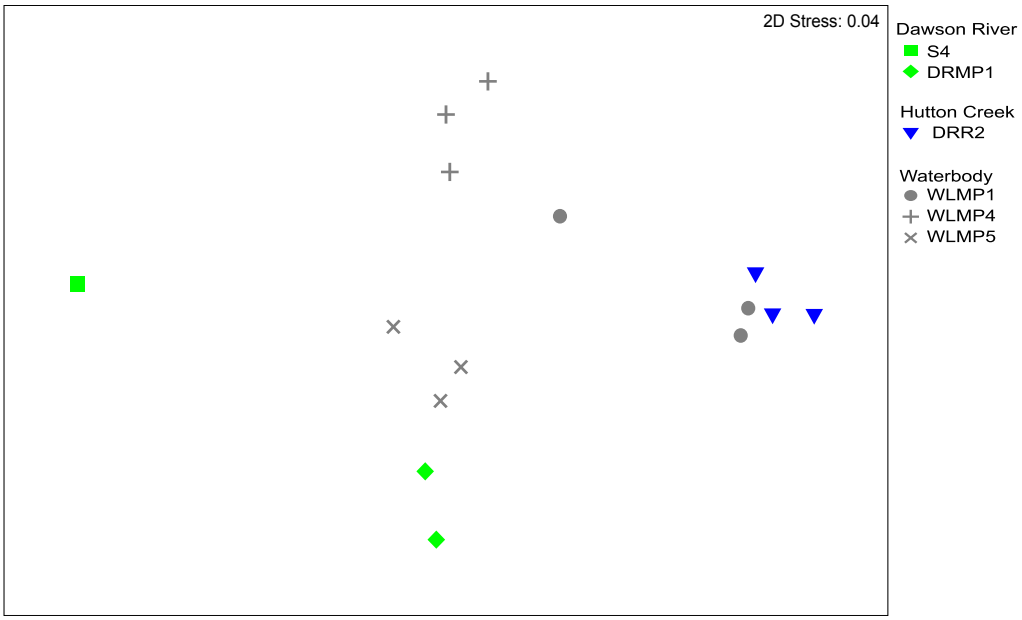


Figure 9.2 MDS plot of microcrustacean communities at each site in the 2021 pre-wet season survey.

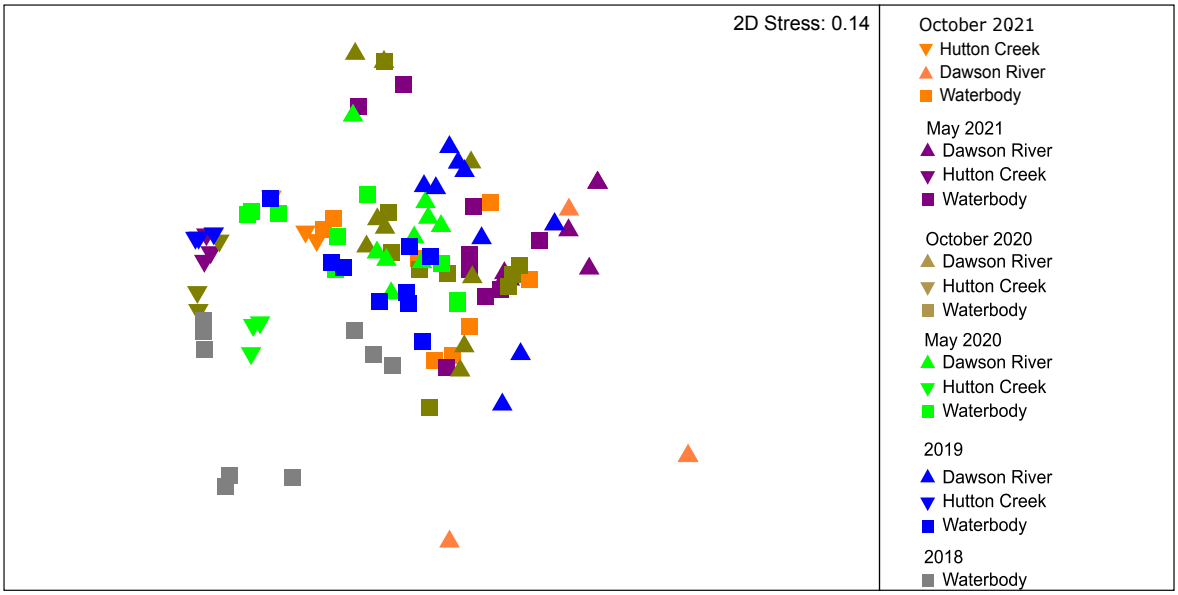


Figure 9.3 MDS plot of microcrustacean communities on all surveys September 2018 and October 2021.

10 Assessment of Environmental Changes

The monitoring results for the 2021 post-wet and pre-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- Physical habitat features in the Waterbody, which had improved from baseline condition due to higher water levels from the release of desalinated water. The higher water levels have increased submerged aquatic plant cover and the cover of large woody debris in water in the Waterbody, thereby improving aquatic habitat. Although the water level had dropped between the post-wet and pre-wet season surveys, this did not have an impact on the physical habitat features.
- Bed stability of the Dawson River, which has improved from the baseline condition. This is a positive change for the aquatic ecology of the Dawson River, but would be independent of the release of desalinated water.
- The temperature of water at site S4 (i.e. 9.95 ºC) was lower than the local WQG and lower than the baseline minimum for the Dawson River water type in the post-wet survey. However, the temperature of water at site S4 was higher than the baseline minimum for the Waterbody (i.e. 9.0 ºC), indicating consistency with the natural range of variability in water temperature in local waters. The temperature of water at site S4 was not influenced by the release of desalinated water because sites in the Waterbody (closest to the release location) did not have low water temperature.
- The pH of water at Waterbody site WLMP4 (i.e. 6.0 in the post-wet season survey; 6.28 in the pre-wet season survey) was lower than the baseline range, and lower than the baseline minimum for the Waterbody water type (i.e. 6.7) in the post-wet survey. However, this result is unlikely to be related to the release of desalinated water, because the pH of water was within the baseline range at the site closest to the release point (WLMP1) in both surveys. Furthermore, reviews of the effects of pH on freshwater biota indicate no acutely lethal effects to fish in the pH range 5.0 to 9.0 (ANZG 2018), although sub-lethal effects may occur in sensitive fauna at the lower end of this spectrum (i.e. pH <6.0) (ANZG 2018). Thus, the recorded pH of 6.0 and 6.28 at WLMP4 is unlikely to be of concern for aquatic ecology.
- The concentration manganese in sediment at site WLMP4 (i.e. 1050 mg/kg) was slightly higher than the baseline maximum for the Waterbody (i.e. 1020 mg/kg) in the post-wet survey. There are no default guidelines for manganese in sediment, or published toxicity ranges in ANZG (2018). However, ANZG (2018) states that natural background concentrations can be multiplied by a factor of 2 to provide an interim guideline; such as in this case providing a 'high guideline value' for investigation of an exceedance of the local trigger value. More conservatively multiplying the 80th percentile (rather than the maximum) of baseline data for

manganese in sediment in the Waterbody by 2 gives: 648 mg/kg x 2 = 1296 mg/kg. Using 1296 mg/kg as an interim high guideline value for the concentration of manganese in sediment to assess the exceedance of the local trigger value at WLMP4 indicates that the concentration of manganese at this site is not likely to be of concern for the Environmental Values of the Waterbody, as the recorded concentration of manganese in sediment at site WLMP4 was well below 1296 mg/kg. Furthermore, the high concentration of manganese in sediment recorded at site WLMP4 was unlikely to be related to the release of desalinated water because the concentration of manganese in sediment at the site closest to the release location (i.e. site WLMP1) was within the baseline range.

- The taxonomic richness at site WLMP4 in the post-wet season survey (i.e. 16) and pre-wet season survey (i.e. 18) was higher than the baseline maximum (i.e. 15). However, these results reflect a positive, albeit minimal, change from baseline condition. Site WLMP4 was often dry during the baseline monitoring program, and the higher richness of macroinvertebrate taxa likely reflects improved habitat quality compared to baseline condition (see point one above).
- The SIGNAL-2 score of macroinvertebrates at site DRR2 in the pre-wet survey (i.e. 3.64) was higher than the baseline maximum for this water type (i.e. 3.38). However, these results reflect a positive, albeit minimal, change from baseline condition. Site DRR2 was often dry, or a small isolated pool with poor habitat quality, during the baseline monitoring program. The higher richness of macroinvertebrate taxa likely reflects improved habitat quality compared to baseline condition.

Overall, the 2021 post-wet and pre-wet survey results indicated that the release of desalinated produced water from ROP2 has not impacted the aquatic environmental values of the receiving environment.

11 References

AECOM 2019, *Revised Boron Site-Specific Water Quality Criterion - Dawson River Release Scheme*.

ANZG 2018. Australian and New Zealand guidelines for fresh and marine water quality. Australian Government, Canberra.

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.

DES 2018, *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009*, report prepared for Queensland Department of Environment and Science, Brisbane.

EHMP 2007, *Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report*. South East Queensland Healthy Waterways Partnership, Brisbane.

frc environmental 2021, *Santos Ltd Dawson River Watercourse Releases: Receiving Environment Monitoring Program*, report prepared for Santos Ltd.

Halcrow 2013, *Dawson River Release Scheme Direct Toxicity Assessment: Fish Test. Addendum to Direct Toxicity Report (Halcrow, November 2012)*, report prepared for Santos GLNG.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994.*

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with monitoring obligations as stated in the Receiving Environment Monitoring Program (REMP) as required by condition (B41) of environmental authority EPPG00928713 dated 3 November 2021

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Benjamin Douglas Cook

(Insert full name of person making this declaration)

of, Wynnum, Queensland

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

Declaration of compliance for written documents

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the monitoring requirements as stated in the REMP as required by condition (B41) of environmental authority EPPG00928713 dated 3 November 2021;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021;
4. The content of Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021 is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Annual Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021 meets the monitoring requirements as stated in the REMP as required by condition (B41) of environmental authority EPPG00928713 dated 3 November 2021.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867.*

(Print name and registration number, if applicable)

Taken and declared before me, at Cleveland

(Insert name of town or city and suburb)

this 15th (Insert day, e.g. 18th) day of December (Insert month) in the year 2021 (Insert year)

Signed

(Person making this declaration)

S Roennefelt JP (Qual)

Signed

(Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations~~ / ~~Solicitor / Barrister~~

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No.: 108818 DEPT. OF JUSTICE & ATTORNEY-GENERAL

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature	Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species. Ben is fully AUSRIVAS accredited.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Senior Principal Ecology (Freshwater), frc environmental, Brisbane (2019 – current)
- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – 2019)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Clermont Coal Operations REMP 2014, 2015, 2016 2017, 2018, 2019, 2020, 2021. Glencore.
- Chinchilla End of Waste Scheme (formally Chinchilla Beneficial Use Scheme) REMP 2013, 2014, 2015, 2016, 2017, 2018, 2019. 2020, 2021. Sunwater.
- Fraser Coast Regional Council STPs Surface Water and Groundwater REMPs 2019, 2020, 2021.
- South Walker Creek Mine REMP 2017, 2018, 2019, 2020, 2021. BHP BMC.
- of Waste Scheme (formally Glebe Beneficial Use Scheme) REMP 2015, 2016, 2017, 2018, 2019, 2020, 2021. Sunwater.
- Dugald River Mine REMP 2021. MMG.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	18/05/21 (post-wet)	**Habitat Bioassessment Score**	65 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	5 to 50m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low to moderate/convex		pebble	0 %		large woody debris		Acacia
	Right bank: low/convex		gravel	0 %		macrophytes	**Weed species**	Noogoora burr
			sand	10 %		tree roots		grasses
Hydrology			silt / clay	90 %				
Flow regime	ephemeral	**Deposits**	silt					
Water depth	>1.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			
Wetted width	60 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	60 m							

Comments:	Site is the 'upstream' end of an oxbow lake. There is no flow. Dead shrubs and trees in water along edge suggest previous lower water levels. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides, Myriophyllum* sp. and *Azolla* sp.). *Juncus usitatus* and *Persicaria* sp. on banks. little bare ground in riparian zone. Right bank riparian vegetation is dominated by grasses with some scattered Eucalypts. Left bank riparian vegetation is dominated by large Eucalypts, with grass understory. Evidence of cattle access to water.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	18/05/21 (post-wet)	**Habitat Bioassessment Score**	64 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	5 to 25m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	moderate to high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	0 %		large woody debris		
	Right bank: flat/convex		gravel	0 %		macrophytes		
Hydrology			sand	10 %		tree roots	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	90 %	**In-stream disturbance**			Scot's thistle
Water depth	>1.5 m	**Deposits**	silt		Flow modification	none		*Bidens Pilosa*
Wetted width	60 m	**Bed stability**	moderate aggradation		Waterway barrier	none		noogoora burr
Flow	no flow						**Adjacent land use**	grazing
Channel width	60 m							

Comments: Site is a long, wide wetland (oxbow lake) with no flow. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.), and choking width of channel 'upstream' of site. Aquatic birds present during survey (pelicans and cormorants). Evidence of cattle access to water and some erosion on banks. Left bank riparian vegetation in better condition than right bank (more aquatic plants lining edge, dense native riparian vegetation). Dead trees provide some aquatic habitat. Film on surface near bank. Sediment soft and made up of detritus and silt. Large woody debris and macrophyte beds provide some aquatic habitat.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	18/05/21 (post-wet)	**Habitat Bioassessment Score**	65 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	10 to 25m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	0 %		large woody debris		
	Right bank: flat/convex		gravel	0 %		macrophytes	**Weed species**	*Bidens pilosa*
Hydrology			sand	10 %		tree roots		noogoora burr
Flow regime	ephemeral		silt / clay	90 %				Scot's thistle
Water depth	>1.5 m	**Deposits**	silt					
Wetted width	80 m	**Bed stability**	moderate aggradation		**In-stream disturbance**		**Adjacent land use**	native vegetation
Flow	no flow				Flow modification	none		grazing
Channel width	85 m				Waterway barrier	none		cropping

Comments: Site is a long, wide wetland at the 'downstream' end of an oxbow lake. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.). Substrate is soft silt with large amount of small woody detritus and silt forming bed. Dead Eucalypt trees lining edges of water on both banks. Evidence of cattle access to water. Right bank riparian vegetation very narrow and dense with weeds (*Bidens Pilosa* and *Sida* sp.). Several meters of bank covered with native aquatic plants (*Carex* sp., *Juncus* sp., *Persicaria* sp. and *Cyperus* sp.). Left bank riparian vegetation large, with native forest downstream of survey site.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	19/05/21 (post-wet)	**Habitat Bioassessment Score**	84 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

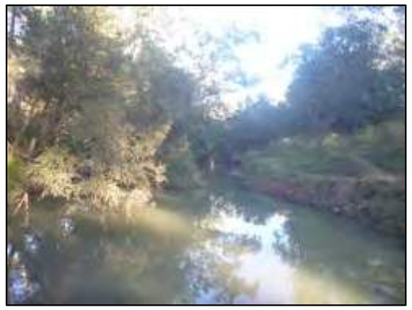
Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	20 %	**Habitat diversity**	high	**Riparian width**	15 to 20 m
Pattern	irregular		boulder	2 %	**Habitat present**	shallow and deep	**Disturbance**	low to moderate
Bank stability	low to moderate		cobble	0%		run, riffle and pool	**Dominant species**	Casuarina
						log jams		Callistemon
Bank shape	Left bank: moderate to steep – convex, wide lower bench		pebble	0%		macrophytes	**Weed species**	Noogoora burr
						undercut banks		*Bidens pilosa*
	Right bank: steep – convex		gravel	3%		large woody debris		grasses
			sand	70 %		tree roots		*Ruellia* sp.
Hydrology			silt / clay	5 %		leaves and twigs		
Flow regime	perennial						**Adjacent land use**	native forest
Water depth	0.7 m	**Deposits**	sand / silt		**In-stream disturbance**			grazing
Wetted width	10 m	**Bed stability**	moderate aggredation		Flow modification	none		cropping
Flow	0.2 m / s				Waterway barrier	none		
Channel width	20 m							

Comments: Site is a narrow stream with an irregular pattern, moderate flow, and shallow and deep pool, riffle and run sections. *Lomandra longifolia* lining steep banks. Many fallen trees across stream. Cattle access to water evident. Some erosion on banks, and behind riparian zone. Evidence of recent high flow on banks, with silt and detritus deposits on banks, and large log jams on banks. Riparian vegetation is mostly Callisetmon, with grass and weed (noogoora burr, *Bidens pilosa, Ruellia* sp.) understory and is continuous throughout site.

Site	S4	**Region**	Upper Dawson
Date surveyed:	20/05/21 (post-wet)	**Habitat Bioassessment Score**	82 (Good)

Downstream view

Right Bank



Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 to 15 m
Pattern	mildly sinuous		boulder	5 %	**Habitat present**	shallow and deep	**Disturbance**	low to moderate
Bank stability	low to moderate		cobble	10 %		runs, riffles and pools	**Dominant species**	Eucalypt
Bank shape	Left bank: steep/concave		pebble	2 %		large woody debris		Callistemon
	Right bank: moderate to steep/concave		gravel	3 %		trailing bank vegetation		
						undercut banks		
			sand	70 %		macrophytes	**Weed species**	Noogoora burr
Hydrology			silt / clay	10 %		tree roots		grasses
Flow regime	perennial					leaves and twigs		Scot's thistle
Water depth	0.5 m	**Deposits**	Sand/silt		**In-stream disturbance**			*Bidens pilosa*
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	culvert at site	**Adjacent land use**	native forest
Flow	0.3 m / s				Waterway barrier	box culverts		grazing
Channel width	12 m							

Comments: Site is a flowing creek with a variety of sediment sizes and habitat types. Fallen trees, riffles, pools and undercut banks provide habitat. Evidence of cattle access to creek. Box culvert under road crossing in middle of site. Callistemon lining creek, although all trees have been cleared around road crossing. Sand deposits forming some bars, with one vegetated (*Persicaria* sp. and *Juncus usitatus*) midstream bar. *Lomandra longifolia* on banks. Pump hoses on bank next to road crossing. Erosion on right bank downstream of causeway

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	19/05/21 (post-wet)	**Habitat Bioassessment Score**	81 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 – 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow and deep	**Disturbance**	low
Bank stability	low to moderate		cobble	0 %		run, riffle and pool	**Dominant species**	Callistemon
Bank shape	Left bank: moderate/concave		pebble	0 %		large woody debris		Casuarina
						trailing roots		
	Right bank: steep/convex		gravel	0 %		macrophytes		
Hydrology			sand	95 %		undercut banks	**Weed species**	Noogoora burr
Flow regime	perennial		silt / clay	5 %		tree roots		*Bidens pilosa*
Water depth	0.6 m	**Deposits**	silt		**In-stream disturbance**			grasses
Wetted width	10 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.1 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments:	Site is a slow flowing stream with soft, sandy substrate and shallow and deep pools, runs and riffles. Water slightly turbid. Several fallen trees in water, and sediment deposits high up on bank from high flows. Dense growth of *Callistemon* and *Casuarina* in riparian zone on both banks. *Lomandra longifolia* and *Casuarina* growing on sand bars. Evidence of cattle access to water. Some patches of *Vallisneria* sp. in bed. Noogoora burr extensive on banks. Large patches of erosion behind riparian vegetation on right bank.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	20/05/21 (post-wet)	**Habitat Bioassessment Score**	56 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	5 %	**Habitat diversity**	low to moderate	**Riparian width**	5 – 10 m
Pattern	mildly sinuous		boulder	10 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	low to moderate		cobble	10 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate to steep/convex		pebble	30 %		tree roots		Callistemon
	Right bank: moderate /convex		gravel	5 %		large woody debris		
Hydrology			sand	10 %		leaves and twigs	**Weed species**	Noogoora burr
								grasses
Flow regime	intermittent		silt / clay	30 %				*Bidens pilosa*
Water depth	1 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	15 m	**Bed stability**	moderate erosion		Flow modification	none	**Adjacent land use**	grazing
Flow	nil				Waterway barrier	none		native forest
Channel width	20 m							

Comments: Site is a turbid pool that extends downstream of site. Upstream pool ends at log jam with large sediment deposits and *Callistemon* growing in bed. Cattle access to creek bed evident, with extensive tracks and churned up sediment in bed. Creek bed is made up of large boulders and a variety of other sediment sizes, but covered in a layer of sand and silt. Evidence of recent high flow – sediment/silt high several meters up on banks and large log jams. Freshwater mussel shells in bed. Erosion on bank of side channel on left bank.

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	11/10/21 (pre-wet)	**Habitat Bioassessment Score**	51 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 to 20m
Pattern	isolated lake		boulder	0 %	**Habitat present**	shallow to deep	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		large woody debris		
	Right bank: moderate/convex		gravel	5 %		macrophytes	**Weed species**	grasses
			sand	20 %		tree roots		*Noogoora burr*
Hydrology			silt / clay	75 %				
Flow regime	ephemeral	**Deposits**	silt / sand					
Water depth	2.5 m	**Bed stability**	moderate aggradation		**In-stream disturbance**			
Wetted width	60 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	60 m							

Comments:	Site is the 'upstream' end of an oxbow lake. There is no flow. Waterline lower than previous surveys, which has allowed the aquatic plants to dominiate newly exposed bank. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides, Myriophyllum* sp. and *Azolla* sp.). *Juncus usitatus* and *Persicaria* sp. on banks. Evidence of algae on water surface away from bank edge. Some bare ground in riparian zone. Right bank riparian vegetation is dominated by grasses with some scattered Eucalypts. Left bank riparian vegetation is dominated by large Eucalypts, with grass understory. Evidence of cattle access to water.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	11/10/21 (pre-wet)	**Habitat Bioassessment Score**	59 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 to 20m
Pattern	isolated lake		boulder	0 %	**Habitat present**	shallow to deep	**Disturbance**	high
Bank stability	moderate		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		large woody debris		
	Right bank: moderate/convex		gravel	5 %		macrophytes		
Hydrology			sand	25 %		tree roots	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	70 %	**In-stream disturbance**			
Water depth	>2.5 m	**Deposits**	silt		Flow modification	none		
Wetted width	60 m	**Bed stability**	moderate aggradation		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	60 m							

Comments: Site is a long, wide wetland (oxbow lake) with no flow. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.). Aquatic birds present during survey (pelicans and cormorants). Evidence water level has dropped recently with aquatic plants have become dominant on exposed banks. Evidence of cattle access to water and some erosion on banks. Road runs parallel to water body. Dead trees provide some aquatic habitat. Sediment soft and made up of detritus and silt. Large woody debris and macrophyte beds provide some aquatic habitat.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	12/10/21 (pre-wet)	**Habitat Bioassessment Score**	57 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology	
Stream order	2
Pattern	isolated lake
Bank stability	moderate
Bank shape	Left bank: steep/convex
	Right bank: low/convex

Hydrology	
Flow regime	ephemeral
Water depth	>2.5 m
Wetted width	80 m
Flow	no flow
Channel width	85 m

Substrate		
Composition	bedrock	0 %
	boulder	0 %
	cobble	0 %
	pebble	0 %
	gravel	5 %
	sand	20 %
	silt / clay	75 %
Deposits	silt	
Bed stability	moderate aggradation	

Aquatic Habitat	
Habitat diversity	low to moderate
Habitat present	shallow to deep
	pool
	large woody debris
	macrophytes
	tree roots

In-stream disturbance	
Flow modification	none
Waterway barrier	none

Riparian Zone	
Riparian width	10 to 15m
Disturbance	high
Dominant species	Eucalypt
Weed species	grasses
Adjacent land use	grazing

Comments:

Site is located at the 'downstream' end of an oxbow lake. Evidence that water level has dropped from previous surveys, water level is lower than vegetated line. Macrophytes dense on banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.). Substrate is soft silt with large amount of leaves and silt forming bed. Dead Eucalypt trees lining edges of water on both banks. Evidence of cattle access to water. Right bank riparian vegetation very narrow and dense, several meters of bank covered with native aquatic plants (*Juncus* sp., *Persicaria* sp. and *Cyperus* sp.). Left bank riparian vegetation large, with native forest downstream of survey site.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	12/10/21 (pre-wet)	**Habitat Bioassessment Score**	91 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	20 to 25 m
Pattern	regular		boulder	0 %	**Habitat present**	shallow and deep	**Disturbance**	low
Bank stability	moderate		cobble	5 %		run, pool	**Dominant species**	Callistemon
						log jams		
Bank shape	Left bank: steep/convex		pebble	6 %		macrophytes	**Weed species**	grasses
						undercut banks		
	Right bank: steep/convex		gravel	14 %		large woody debris		Noogoora burr
			sand	65 %		tree roots		
Hydrology			silt / clay	10 %		leaves and twigs		
Flow regime	perennial						**Adjacent land use**	grazing
Water depth	1.5 m	**Deposits**	sand / silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	bed stable		Flow modification	none		
Flow	0.05 m / s				Waterway barrier	none		
Channel width	10 m							

Comments: Site is a narrow stream with an regular pattern, moderate flow, and shallow and deep pool, run sections. *Lomandra longifolia* lining steep banks. Many fallen trees across stream. Cattle access to water evident. Some erosion on banks, and behind riparian zone. Evidence of heavy flows with vegetation wrapped around base and branches of trees, and large log jams on banks. Stream has fallen trees extending from bank to bank. Sand bar present in the middle of site. Riparian vegetation is mostly Callisetmon, with grass in the understory and is continuous throughout site.

Site	S4	**Region**	Upper Dawson
Date surveyed:	13/10/21 (pre-wet)	**Habitat Bioassessment Score**	97 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 to 20 m
Pattern	mildly sinuous		boulder	4 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	moderate		cobble	8 %		runs, riffles and pools	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	10 %		large woody debris		Callistemon
								Casuarina
	Right bank: steep/convex		gravel	13 %		trailing bank vegetation		
			sand	50 %		macrophytes	**Weed species**	grasses
Hydrology			silt / clay	15 %		tree roots		Noogoora burr
Flow regime	perennial					leaves and twigs		Mexican poppy
Water depth	0.6 m	**Deposits**	sand		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	culvert at site	**Adjacent land use**	track/road
Flow	0.05 m / s				Waterway barrier	box culverts		grazing
Channel width	10 m							

Comments:	Site is a flowing creek with a variety of sediment sizes and habitat types. Fallen trees, riffles, pools and undercut banks provide habitat. Newly fallen trees located upstream of crossing is blocking surface water flow. Water level is higher than previous surveys with strong flow. Box culvert under road crossing in middle of site, permitting flow under road. Callistemon lining creek trails into stream, however all trees have been cleared around road crossing. Sand deposits forming some midstream bars, downstream of crossing. *Lomandra longifolia* on banks.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	12/10/21 (pre-wet)	**Habitat Bioassessment Score**	89 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	10 – 15 m
Pattern	mildly sinuous		boulder	0 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	moderate		cobble	0 %		run, and pool	**Dominant species**	Callistemon
Bank shape	Left bank: steep/convex		pebble	7 %		large woody debris		Casuarina
						trailing roots		Eucalypt
	Right bank: steep to vertical/convex to concave		gravel	18 %		macrophytes		
Hydrology			sand	40 %		tree roots	**Weed species**	grasses
Flow regime	perennial		silt / clay	35 %				mexican poppy
Water depth	0.3 m	**Deposits**	silt/sand		**In-stream disturbance**			scotch thistle
								Noogoora burr
Wetted width	5 m	**Bed stability**	moderate aggradation		**Flow modification**	none	**Adjacent land use**	grazing
Flow	0.5 m / s				**Waterway barrier**	none		
Channel width	10 m							

Comments: Site consist of two in-channel pool linked by a run in the middle of the site. Slow flowing stream with soft, sandy substrate and shallow and deep pools and runs. Water slightly turbid. Dense growth of *Callistemon* and *Casuarina* in riparian zone on both banks. *Lomandra longifolia* growing banks. Evidence of cattle access to water and heavy flows. Large patches of Mexican poppy and Scotch thistle weeds. Large Saratoga swimming at site.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	13/10/21 (pre-wet)	**Habitat Bioassessment Score**	69 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	20 %	**Habitat diversity**	low to moderate	**Riparian width**	10 – 20 m
Pattern	irregular		boulder	5 %	**Habitat present**	shallow and deep	**Disturbance**	high
Bank stability	low		cobble	10 %		pool, and riffle	**Dominant species**	Eucalypt
Bank shape	Left bank: steep / convex		pebble	4 %		tree roots		Callistemon
	Right bank: vertical /concave		gravel	5 %		large woody debris		
Hydrology			sand	30 %		leaves and twigs	**Weed species**	grasses
						macrophytes		
Flow regime	intermittent		silt / clay	16 %				
Water depth	2 m	**Deposits**	silt/sand		**In-stream disturbance**			
Wetted width	18 m	**Bed stability**	moderate aggradation		Flow modification	none	**Adjacent land use**	grazing
Flow	0.1 m / s				Waterway barrier	none		track
Channel width	20 m							

Comments:	Site is a turbid connected pool that extends upstream of site. The stream extends downstream via a small riffle on the left bank. Cattle access to creek bed evident, with extensive tracks and churned up sediment in bed. Creek bed is made up of a variety of sediment sizes, cobble boulders gravel. Evidence of heavy flow and water mark is high compared to other surveys. Layer of scum and algae was evident on the water surface. Water appears to be bubbling.

Appendix D Baseline Range for Water Quality and Sediment Quality Data, and Macroinvertebrate Indices

Table D1 Baseline Maximum for Water Quality Parameters

Parameter	Unit	Waterbody	Dawson River	Hutton Creek
		Maximum	Maximum	Maximum
Temperature	ºC	9.0 – 36.4	10.3 – 32.1	15.5 – 35.6
Dissolved oxygen	mg/L	0.13 – 19.9	1.93 – 13.1	7.7 – 17.2
Electrical conductivity	µS/cm	1724	2568	797
pH	unit	6.7 – 9.7	6.5-8.4	6.9 – 8.8
Suspended solids	mg/L	665	71	175
Turbidity	NTU	821	1243	612
Ammonia as N	mg/L	1.63	0.1	0.1
Total nitrogen	mg/L	30.3	1.7	1.9
Boron (total)	mg/L	0.30	0.24	0.11
Zinc (total)	mg/L	0.035	0.014	0.019
Boron (dissolved)	mg/L	0.24	2.0	0.13
Zinc (dissolved)	mg/L	0.063	0.052	0.008

Baseline range presented for temperature, dissolved oxygen and pH.

Table D2 Baseline Maximum for Sediment Quality Parameters

Parameter	**Unit**	**Waterbody**	**Dawson River**	**Hutton Creek**
		Maximum	**Maximum**	**Maximum**
Aluminium (Al)	mg/kg	16800	12800	18500
Arsenic (As)	mg/kg	6	5	8
Boron (B)	mg/kg	27.5	13.5	26.9
Cadmium (Cd)	mg/kg	<LOR	<LOR	<LOR
Chromium (Cr)	mg/kg	26.8	70.3	19.4
Copper(Cu)	mg/kg	19	12	18
Iron (Fe)	mg/kg	23900	19000	32000
Lead (Pb)	mg/kg	25.1	15	23.5
Manganese (Mn)	mg/kg	1020	545	705
Mercury (Hg)	mg/kg	0.8	<LOR	<LOR
Nickel (Ni)	mg/kg	30.4	296	15
Selenium (Se)	mg/kg	<LOR	<LOR	<LOR
Zinc (Zn)	mg/kg	74	46	68

Table D3 Full Baseline Range of Macroinvertebrate Indices

Index	Waterbody		Dawson River		Hutton Creek	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Abundance	16	512	15	411	1	590
Taxonomic Richness	3	15	6	25	1	20
PET Richness	0	2	0	6	0	3
SIGNAL-2 Scores	2.36	3.64	2.57	4.41	2	3.38

Table D4 Zooplankton Data (microcrustacean data only) from September 2018 Survey of Waterbody

Taxa	Higher Taxa	WLMP1			WLMP4			WLMP5		
		Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Microcrustaceans										
Daphnia sp 1	Daphniidae (Cladocera)	4000	15625	75000	260	85	170	15000	5000	8500
Daphnia sp 2	Daphniidae (Cladocera)						10			
Chydoridae (Cladoceran 1)	Chydoridae				25	90	5			
Cladoceran 2	Cladocera				15	15	5			
Bosminidae (Cladoceran 3)	Cladocera	20			5	40	5	90	165	60
Copepod 2 (Cyclopoida)	Copepoda				100	240	205			
Copepod 1 (Calanoida)	Copepoda				25	100	5	1500	3250	2575
Ostracod 2	Ostracoda	20			15					
Ostracod 1	Ostracoda	25	10	50	15		10			
Ostracod 3	Ostracoda				5		5			

Note: taxonomic names used in the 2018 study have been updated here to align with the 2019/2020/2021 data

Dawson River Release Scheme Receiving Environment Monitoring Program

Interim Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2022

Prepared for:

Santos

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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1 Introduction

Santos Ltd (Santos) operates a number of gas fields in the Bowen and Surat Basins as part of the Gladstone Liquefied Natural Gas (GLNG) project. The Fairview Arcadia Project Area (FAPA), in the upper Dawson River sub-catchment in central Queensland, is one of a number of Santos project areas in which gas exploration, appraisal, development and production activities are being conducted.

The release of desalinated water from the Fairview Reverse Osmosis Plant 2 (ROP2) to the Dawson River is authorised under the FAPA Environmental Authority (EA) EPPG00928713. The release is known as the Dawson River Release Scheme (DRRS), which became operational in July 2015.

The EA required the development and implementation of a Receiving Environment Monitoring Program (REMP) for the DRRS. REMP monitoring and reporting is guided by the REMP design document, titled *Santos Ltd Dawson River Watercourse Releases: Receiving Environment Monitoring Program* (frc environmental 2021). Under the REMP, pre- and post- wet season sediment quality, biological and geomorphological monitoring is required. This is the seventh year the REMP has been implemented for the purpose of monitoring the desalinated release.

1.1 Purpose and Scope

Santos commissioned frc environmental to undertake the DRRS REMP in 2022.

The purpose of this report is to present and record the methods and results of the 2022 post-wet season REMP survey, and provide an assessment of potential adverse effects of the desalinated release on the receiving waters.

The scope of work included aquatic ecological monitoring at seven sites (defined in the REMP). Sampling utilised the methods nominated in the REMP and included water quality, sediment quality, aquatic habitat, macroinvertebrate, fish and geomorphological (i.e. bed and bank stability) monitoring.

The work presented in this report was carried out by suitably qualified persons (Dr Ben Cook, Will Kempton, Dr Derek Sun and Dr Andrew Mather who are professional aquatic ecologists with Ph.D. qualifications in freshwater biology and a combined total of over 45 years of industry experience as aquatic ecologists) (Appendix A and Appendix B).

2 Monitoring Program

2.1 Timing

The post-wet survey was implemented 4 – 8 April 2022.

2.2 Monitored Sites

The sites that are monitored for the DRRS REMP are shown in Table 2.1 and Map 2.1. The design includes upstream control sites on the Dawson River and Hutton Creek, and sites within the receiving environment. The receiving environment contains two water types: the Dawson River and the Waterbody, which is a floodplain billabong (oxbow lake) adjacent to the Dawson River. As prescribed by the REMP, five receiving environment sites are monitored; three in the Waterbody (WLMP1, WLMP4 and WLMP5) and two on the Dawson River (DRMP1 and S4). Site DRMP1 is downstream of the confluence where the tributary from the Waterbody enters the Dawson River. Site S4 on the Dawson River is specified as the monitoring location for assessment of water quality for protecting the environmental value of drinking water.

Table 2.1 Description of REMP monitoring sites.

Site	Description	GDA94	
		Latitude	Longitude
Waterbody sites within the Receiving Environment			
WLMP1	Waterbody; 200 m downstream of where the tributary gully discharges into the Waterbody.	-25.708	149.146
WLMP4	Waterbody; 1.5 km upstream of where the tributary gully discharges into the Waterbody.	-25.698	149.139
WLMP5	Waterbody; 1.0 km downstream of where the tributary gully discharges into the Waterbody.	-25.701	149.153
Dawson River sites within the Receiving Environment			
DRMP1	Dawson River; 3.5 km downstream of where the tributary gully discharges into the Waterbody and 200 m downstream of the confluence of the tributary gully and the Dawson River.	-25.6905	149.1675
S4	Dawson River at Yebna Crossing; 9.8 km downstream of where the tributary gully discharges	-25.692	149.216

Site	Description	GDA94	
		Latitude	Longitude
	into the Waterbody and 8 km downstream of the confluence of the tributary gully and the Dawson River. Represents the downstream extent of the receiving environment.		
Control Sites Upstream of the Receiving Environment			
DRR1	Dawson River; 550 m upstream of the confluence of the tributary gully and the Dawson River.	-25.688	149.156
DRR2	Hutton Creek; 34 km upstream of the confluence of the tributary gully and the Dawson River	-25.718	148.971

2.3 Quality Assurance

All monitoring was performed by suitably qualified persons.

The following quality assurance outcomes relate to the 2022 post-wet season REMP survey:

- high turbidity did not allow an accurate assessment of submerged habitat at site DRR2 on Hutton Creek. This is consistent with water quality conditions throughout the baseline monitoring program.

149° E

149.2° E

Dawson River

Harris Creek

Boyd Creek

Belington Hut State Forest

Injune Road

Expedition Resources Reserve

Beilba State Forest

Expedition (Limited Depth) National Park

Hutton Creek

Fitzroy Basin

DRR1

DRMP1

S4

WLMP4

WLMP5

WLMP1

DRR2

Stephenton State Forest

Commissioner Creek

Hallett State Forest

Sids Pocket Road

149° E

149.2° E

frc environmental
AQUATIC ECOLOGISTS
deep thinking.science.

PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

Dawson River Release Scheme Receiving Environment Program

Map 2.1: Monitoring sites for the Dawson River Release Scheme Receiving Environment Monitoring Program

SOURCES

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LEGEND

Monitoring Site

- Control sites upstream of receiving environment
- Waterbody sites within receiving environment
- Dawson River sites within receiving environment
- Watercourse
- Lake/Reservoir
- Basin

Road Network

- Local Road

Protected Area

- National Park
- Other Reserve

N

SCALE

0 2.25 4.5

Kilometres

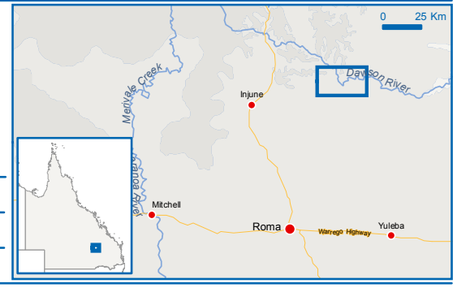
Scale: 1:80,000 @ A3

PROJECTION
Coordinate System: GCS GDA 1994
Datum: GDA 1994
Units: Degree

DATE
2017-06-20

DRAWN BY
AB

VERSION
01



3 Water Quality

3.1 Methods

Survey Procedure

Water quality was measured in situ for temperature, pH, electrical conductivity, dissolved oxygen and turbidity using a calibrated meter. Measurements were taken approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites.

Water samples were collected approximately 0.30 m below the surface of the water in the mid-channel at riverine sites, and >10 m from the edge at Waterbody sites, directly into sampling containers provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed. Two (replicate) samples were collected from one site on each survey for assessing within-site variation. Parameters analysed in the laboratory were: suspended solids, ammonia, nitrogen, and total and dissolved boron and zinc.

Data Analysis

Results were compared to the local water quality guidelines developed for the Dawson River Watercourse Releases REMP (frc environmental 2021). To assess within-site variation, relative percent difference was calculated for the replicate samples collected at one site on each survey where results were at least ten times greater than the LOR.

3.2 Results

Results for the water quality (Table 3.1, Table 3.2 and Table 3.3) showed that:

- The water temperature was higher than the Water Quality Guideline (WQG) at site WLMP5 (30.6 ºC) but was within the Waterbody baseline range (Appendix D).
- The concentration of dissolved oxygen was lower than the WQG range at Dawson River sites DRMP1 (5.2 mg/L) and DRR1 (4.7 mg/L), but was within the baseline range for Dawson River (Appendix D).

- The concentration of total nitrogen was higher than the WQG at Hutton Creek site DRR2 (0.7 mg/L), but was within the baseline range for Hutton Creek (Appendix D).
- all other parameters complied with the guideline at all sites, and
- the relative percent difference for all parameters was low, indicating low within-site variation for these parameters.

Table 3.1 Water quality results compared to the local water quality guidelines for the 2022 post- wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Physical chemical												
Temperature	ºC	–	19.0 – 29.3	23.7	27.95	30.6	15.8 – 27.1	22.2	22.1	22.9	–	24.65
Dissolved oxygen	mg/L	–	6.4 – 16.1	8.15	10.59	12.05	6.4 – 16.1	5.2	6.54	4.7	6.4 – 16.1	7.73
Electrical conductivity	µS/cm	–	627	332	326	311	500	334	358	321	500	250
pH	unit	–	6.5 – 8.5	7.0	7.6	7.9	6.5 – 8.5	7.0	7.3	7.1	6.5 – 8.5	7.7
Suspended solids	mg/L	5	128	12	11	10	50	22	–	30	50	25
Turbidity	NTU	–	Monitor only	21.7	10.4	14.9	Monitor only	15.1	28.7	33.1	Monitor only	54.1
Nutrients												
Ammonia as N	mg/L	0.01	0.9	<0.01	0.03	<0.01	0.9	0.04	–	0.05	0.9	<0.01
Total nitrogen	mg/L	0.1	3.93	1	1	0.9	0.62	0.4	–	0.3	0.62	0.70
Total metals and metalloids												
Boron	mg/L	0.05	2.9	0.47	0.47	0.47	2.9	<0.05	–	<0.05	2.9	< 0.05
Zinc	mg/L	0.005	12	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	< 0.005
Dissolved Metals and metalloids												
Boron	mg/L	0.05	2.9	0.45	0.44	0.46	2.9	<0.05	–	<0.05	2.9	< 0.05
Zinc	mg/L	0.005	8	<0.005	<0.005	<0.005	8	<0.005	–	<0.005	8	<0.005

LOR = analytical limit of reporting

grey shading indicates an exceedance of the guideline value; – No guideline or data.

Table 3.2 Relative percent difference (RPD) calculations for laboratory analysed water quality parameters.

Parameter	Unit	LOR	Post-wet survey		
			Site DRR1		
			Sample 1	Sample 2	RPD (%)
Suspended solids	mg/L	5	30	32	6.5
Ammonia as N	mg/L	0.01	0.3	0.3	0
Total Nitrogen	mg/L	0.1	0.3	0.3	0
Total boron	mg/L	0.05	<0.05	<0.05	–
Total zinc	mg/L	0.005	< 0.005	< 0.005	–
Dissolved boron	mg/L	0.05	<0.05	<0.05	–
Dissolved zinc	mg/L	0.005	< 0.005	< 0.005	–

4 Sediment Quality

4.1 Methods

Survey Procedure

A sediment sample was collected from the top 0.30 m of the bed using a stainless steel trowel at each site, with the sediments transferred directly to the sampling jar provided by a NATA accredited analytical laboratory. Samples were chilled for storage and were delivered to the laboratory within the holding times specified for the parameters that were analysed (i.e. metals and metalloids).

Data Analysis

Results were compared to the local sediment quality guidelines developed for the DRRS REMP (frc environmental 2021).

4.2 Results

Results for the laboratory analyses of sediment quality (Table 4.1 and Table 4.2) showed that:

- The concentration of iron at site S4 (10,900 mg/kg) was higher than the local trigger value (9,353 mg/kg), but was lower than the baseline maximum recorded in the Dawson River (maximum = 19,000 mg/kg; Appendix D).
- The concentration of manganese at site S4 (459 mg/kg) was higher than the local trigger value (230.5 mg/kg), but was lower than the baseline maximum recorded in the Dawson River (maximum = 545 mg/kg; Appendix D).
- The concentration of all other parameters complied with the applicable local sediment quality guidelines at all sites, noting that selenium could not be assessed because the limit of reporting (LOR) was higher than the local trigger value.
- the relative percent difference (RPD) for iron was moderate and high for manganese, indicating moderate within-site variation for these parameters and that results for these parameters should be treated as estimates rather than precise values. The RPD for aluminium was low.

Table 4.1 Sediment quality results for metals and metalloids compared to the local sediment quality guidelines (trigger values) for the 2022 post-wet REMP survey.

Parameter	Unit	LOR	Local trigger – Waterbody	Waterbody			Local trigger – Dawson River	Dawson River			Local trigger – Hutton Creek	Hutton Creek
				WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Aluminium (Al)	mg/kg	50	13,933	5,230	5,660	9,760	5,191	1,050	4,390	550	11,800	2,730
Arsenic (As)	mg/kg	5	20	< 5	< 5	< 5	20	< 5	< 5	< 5	20	< 5
Boron (B)	mg/kg	0.2	18.8	0.3	0.5	1.7	17.9	< 0.2	< 0.2	< 0.2	25	< 0.2
Cadmium (Cd)	mg/kg	1	1.5	< 1	< 1	< 1	1.5	< 1	< 1	< 1	1.5	< 1
Chromium (Cr)	mg/kg	2	80	5	4	8	80	< 2	4	< 2	80	4
Copper(Cu)	mg/kg	5	65	10	9	15	65	< 5	7	< 5	65	< 5
Iron (Fe)	mg/kg	50	17,867	8,490	11,100	13,200	9,353	3,290	10,900	1,680	20,700	7,540
Lead (Pb)	mg/kg	5	50	10	10	16	50	< 5	10	< 5	50	7
Manganese (Mn)	mg/kg	5	648	234	335	547	230.5	211	459	80	337	106
Mercury (Hg)	mg/kg	0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1	< 0.1	< 0.1	0.15	< 0.1
Nickel (Ni)	mg/kg	2	21	7	7	10	21	< 2	5	< 2	21	4
Selenium (Se)	mg/kg	5	1	< 5	< 5	< 5	1.73	< 5	< 5	< 5	1	< 5
Zinc (Zn)	mg/kg	5	200	31	34	47	200	7	26	< 5	200	17

LOR = analytical limit of reporting

grey shading indicates where the trigger value is exceeded.

gold shading indicated where the LOR was higher than the trigger value.

Table 4.2 Relative percent difference (RPD) calculations for laboratory analysed sediment quality parameters.

Parameter	Unit	Site DRR1 (post-wet survey 2022)		
		Sample 1	Sample 2	RPD (%)
Aluminium (Al)	mg/kg	550	580	5.3
Arsenic (As)	mg/kg	< 5	< 5	–
Boron (B)	mg/kg	< 0.2	< 0.2	–
Cadmium (Cd)	mg/kg	< 1	< 1	–
Chromium (Cr)	mg/kg	< 2	< 2	–
Copper(Cu)	mg/kg	< 5	< 5	–
Iron (Fe)	mg/kg	1,680	1,950	14.9
Lead (Pb)	mg/kg	< 5	< 5	–
Manganese (Mn)	mg/kg	80	47	52.0
Mercury (Hg)	mg/kg	< 0.1	< 0.1	–
Nickel (Ni)	mg/kg	< 2	< 2	–
Selenium (Se)	mg/kg	< 5	< 5	–
Zinc (Zn)	mg/kg	< 5	< 5	–

5 Aquatic Habitat, and Bed and Bank Stability

5.1 Methods

Survey Procedure

The in-stream habitat diversity and condition, and stability of bed and banks, at each site was assessed using a method based on the Smart Rivers and Sustainable Rivers Audit Methods, as described in the REMP design document (frc environmental 2021).

Data Analysis

There are no quantitative guidelines or thresholds for aquatic habitat, or bed and bank stability. Instead, qualitative comparisons were made against baseline condition, as presented in the REMP design document (frc environmental 2021).

5.2 Results

Aquatic habitat summary sheets are provided for each site in Appendix C. Comparison of habitat features, and bed and bank stability, with baseline conditions (Table 5.1) showed:

- bed and bank stability at all sites and for all water types had not changed from baseline condition, with the exception of bed stability in the Dawson River water type which had slightly improved.
- physical habitat features at the sites within the Waterbody was higher than the baseline condition, with water levels higher than many of the baseline surveys providing an increased cover of woody debris and increased diversity of submerged aquatic plants.
- all other aquatic habitat features for all water types remained relatively unchanged since baseline surveys.

Table 5.1 Habitat characteristics of each water type in the 2022 post-wet REMP survey.

Habitat Attribute	**Habitat Characteristics**		
	Waterbody	**Dawson River**	**Hutton Creek**
Bank stability	*moderate to high*	*low to moderate*	*low to moderate*
Bed stability	*moderate*	*moderate*	*moderate*
Substrate diversity	*low to moderate*	*moderate to high*	*moderate*
Riparian vegetation condition	*moderate*	*moderate*	*moderate*
Flow habitats	*low*	*moderate to high*	*low*
Physical habitat features	*moderate*	*high*	*low to moderate*

cells that are not shaded have current habitat quality that is the same as baseline condition

blue shading indicated a potential increase in habitat quality compared to baseline conditions

6 Macroinvertebrate Communities

6.1 Methods

Survey Procedure

Seven macroinvertebrate samples were collected from 'clean' edge habitat at each site using a Surber sampler that has a square 0.3 m x 0.3 m frame and 250 µm mesh size. The location of samples was random within each site, and each sample was collected with one edge of the Surber sampler parallel to and within a few centimetres of the water's edge. The substrate within the Surber sampler frame was disturbed (large rocks were cleaned and organisms inside the Surber net amongst finer substrates were gently disturbed by hand or a tool) and the sample was collected by sweeping the net up through the disturbed area. The samples were transferred into a screw-top jar and preserved using ethanol and transported back to the laboratory for identification of specimens to the lowest practical taxonomic level (family in most cases).

Macroinvertebrate sampling was undertaken by a suitably qualified person and in accordance with the methods described in frc environmental (2021).

Macroinvertebrate samples were processed in accordance with the National River Health Program protocols outlined in *Monitoring and Sampling Manual* (DES 2018). Enumeration and identification of samples was done by suitably qualified persons. Sorting, enumeration and data entry was cross checked by a second ecologist for 10% of the samples. The REMP design document considers an error rate of <5% acceptable for macroinvertebrate sorting and identification, with the error rate of < 1% for this study.

Data Analysis

The following indices were calculated for the macroinvertebrate communities at each site:

- *abundance*; abundance is the total number of individuals in a sample.
- *taxonomic richness*; taxonomic richness is the number of taxa (i.e. families in most cases in this assessment). 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 (i.e. number of families within the Plecoptera, Trichoptera and Ephemeroptera orders), the greater the inferred degradation.
- *SIGNAL-2 scores*; SIGNAL-2 (Stream Invertebrate Grade Number — Average Level) (Chessman 2003) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants, and SIGNAL-2 scores are weighted for abundance. 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).

These indices were calculated for each replicate sample for each site, and then the median per site and median for each water type were calculated. These results were compared to the local biological objectives for macroinvertebrates developed for the DRRS REMP (Table 4.6 in the REMP design document; frc environmental 2021). Where the median for an index complied with or was higher than the local biological guideline for that water type, then it was considered that there is no impact to macroinvertebrate communities, and no further assessment was required. Where the median for a macroinvertebrate index was below the local biological guidelines, additional data analysis was used to further assess the monitoring results, in the flowing order:

- compare the monitoring results with the full range of variation observed during baseline monitoring, and if lower than the baseline range, then;
- implement multivariate analyses of macroinvertebrate data, using a before-after-control-impact design.

6.2 Results

Results for macroinvertebrate indices showed that (Table 6.1, Table 6.2):

- the abundance of macroinvertebrates was:
  - Lower than the local biological guideline range at waterbody site WLMP5 but within the range recorded during baseline surveys (see Appendix D).
  - Within the local biological guideline range at Waterbody sites WLMP4 and WLMP1, Dawson River sites DRMP1, S4 and DRR1 and at Hutton Creek site DRR2 and all water types during the post wet survey.
- taxonomic richness of macroinvertebrates was:
  - Higher than the local biological guideline range at all Waterbody sites (WLMP4, WLMP1 and WLMP5) and the Waterbody water type, but within the baseline range (see Appendix D).
  - Within the local biological guideline range for all Dawson River sites (DRMP1, S4 and DRR1) and Hutton Creek site DRR2, and within the local biological guideline range for the Dawson River and Hutton Creek water type.
- PET richness of macroinvertebrates was:
  - Higher than the local biological guideline range at Waterbody site WLMP1 and Hutton Creek site DRR2, but within the baseline range at both sites (Appendix D). PET richness was also higher than the WQG for the Hutton Creek water type, but within the baseline range.
  - Lower than the local biological guideline range at Dawson River site DRMP1 but was within the baseline range (Appendix D).
  - Within the local biological guideline range for site WLMP4 and WLMP5 and Dawson River sites S4 and DRR1, and within the local biological guideline for the Dawson River water type.
- SIGNAL-2 Scores for macroinvertebrates were:
  - Higher than the local biological guideline range at all Waterbody sites (WLMP4, WLMP1 and WLMP5) and Hutton Creek site DRR2. SIGNAL-2 scores were within the baseline range at sites WLMP4, WLMP1 and WLMP5 but higher than the baseline range at site DRR2. SIGNAL-2 scores were also higher than the WQG for the Waterbody water type, but within the baseline range (Appendix D). The SIGNAL-2 score of the Hutton Creek water type was higher than the baseline range (Appendix D) and discussed further in Section 10, noting this is a positive ecological change from baseline condition.

- Lower than the local biological guideline range at Dawson River site DRR1 but within the baseline range (Appendix D).
- Within the local biological guideline range at Dawson River sites DRMP1 and S4 and for the Dawson River water type.

Table 6.1 Median macroinvertebrate results for each site in the 2022 post-wet REMP survey.

Macroinvertebrate Index	Waterbody Local Biological Guideline	Waterbody Sites			Dawson River Local Biological Guideline	Dawson River Sites			Hutton Creek Local Biological Guideline	Hutton Creek Site
		WLMP4	WLMP1	WLMP5		DRMP1	S4	DRR1		DRR2
Abundance	92.3–252.8	133.0	147.0	86.0	39.9–152.0	71.0	102.0	76.0	23.0–207.4	43.0
Taxonomic Richness	5.67–10.8	11.0	14.0	11.0	9.93–16.9	12.0	15.0	11.0	4.0–10.0	10.0
PET richness	0.0 – 1.2	0	2.0	1.0	1.47–4.0	1.0	4.0	2.0	0–1.0	3.0
SIGNAL-2 Score	2.65 – 3.20	3.33	3.21	3.39	3.46–4.00	3.56	3.85	3.41	2.90–3.30	3.44

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

Table 6.2 Median macroinvertebrate results for each water type in the 2022 post-wet REMP survey.

Macroinvertebrate index	Waterbody Local Biological Guideline	Waterbody	Dawson River Local Biological Guideline	Dawson River	Hutton Creek Local Biological Guideline	Hutton Creek
Abundance	92.3–252.8	116.0	39.9 – 152.0	100.0	23.0 – 207.4	43.0
Taxonomic Richness	5.67–10.8	11.0	9.93 – 16.9	11.0	4.0 – 10.0	10.0
PET richness	0.0 – 1.2	1.0	1.47 – 4.0	2.0	0 – 1.0	3.0
SIGNAL-2 Score	2.65 – 3.20	3.25	3.46 – 4.00	3.56	2.90 – 3.30	3.44

Blue shading indicates where the macroinvertebrate index is higher than the local biological objective

Grey shading is where the macroinvertebrate index is lower than the local biological objective

7 Fish

7.1 Methods

Survey Procedure

Fishing involved setting two fyke nets overnight at each site, with one net being of fine mesh size (approximately 4 mm) and the other being of a larger mesh size (approximately 10 mm) (Table 7.1). Nets were set facing upstream and downstream directions at all sites, and floats were used to ensure that air-breathing species (e.g. turtles) had access to the surface at all times.

The sampling of fishes was conducted under current General Fisheries Permit (permit number 255214) and Animal Ethics Approval (CA 2021/02/1478) held by frc environmental.

At each site, the species present and the abundance of each species by life history stage (juvenile, intermediate, adult) was recorded and the apparent health of individuals noted. Identifications of fish were made in the field by experienced aquatic ecologists. Any exotic species caught were recorded and euthanized using methods approved under the ethics approval.

Table 7.1 Effort used to catch freshwater fish in the 2022 post-wet REMP survey.

Site	Method	Habitat	Time In	Time Out	Effort
Waterbody					
WLMP4	fyke net (2)	pool	15:00	8:30	35 h
WLMP1	fyke net (2)	pool	16:00	10:30	37 h
WMLP5	fyke net (2)	pool	13:30	7:30	36 h
Dawson River					
DRMP1	fyke net (2)	pool	14:00	9:30	39 h
S4	fyke net (2)	pool	13:00	9:10	40.33 h
DRR1	fyke net (2)	pool	16:00	11:30	39 h
Hutton Creek					
DRR2	fyke net (2)	pool	16:30	15:15	45.5 h

Data Analysis

The richness of native and exotic fish species was determined for each water type (observed number of species), and this was compared to the expected number of species for that water type (i.e. the local biological guideline for fish) as a ratio. Where the ratio ≥ 1, then it was considered that there has been no impact to fish. Where the ratio is < 1, then the diversity of fish is lower than expected, and an investigation of the factors affecting fish communities was implemented.

The local guidelines for fish, as presented in the REMP (frc environmental 2021) are:

- Waterbody: four species (i.e. ≥ 4)
- Dawson River: five species (i.e. ≥ 5), and
- Hutton Creek: two species (i.e. ≥ 2).

7.2 Results

Eight species of native fish were caught and / or observed during the 2022 post-wet REMP surveys (Table 7.2). None of these species are conservation significant species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Nature Conservation Act 1992* (NC Act).

The number of native species caught at each site ranged from two (site S4) to eight (site WLMP4). Total abundance of fish at each site ranged from 18 (site DRMP1) to 928 (site WLMP4). The range of fish abundances was likely due to different habitat size (i.e. pool dimensions and depth) and / or habitat features among sites. The most commonly recorded species were carp gudgeons, eastern rainbowfish, Agassizi's glassfish and flyspecked hardyheads. No exotic species were caught.

All water types achieved the local biological guideline for fish (i.e. had an observed: expected ratio of species diversity that was ≥ 1) (Table 7.3). This indicates that the diversity of fish caught during the 2022 post-wet REMP survey were the same as or higher than that recorded during the baseline monitoring program. Increased water levels compared to baseline condition may have created favourable conditions for fish.

All sites achieved the biological guideline for exotic fish with none captured at any site during the 2022 post-wet REMP survey, indicating that the diversity of exotic fish has not increased compared to baseline conditions.

Table 7.2 Total abundance of freshwater fish for each species at each site in 2022 post-wet REMP survey.

Species	Common Name	Waterbody			Dawson River			Hutton Creek	Total
		WLMP4	WLMP1	WLMP5	DRMP1	S4	DRR1	DRR2	
Native Fish Species									
Ambassis agassizii	Agassiz's glassfish	44	41	117	–	–	1	–	**203**
Craterocephalus stercusmuscarum	flyspecked hardyhead	26	272	25	–	–	7	–	**330**
Hypseleotris spp.	carp gudgeon	826	466	208	–	–	2	–	**1502**
Leiopotherapon unicolor	spangled perch	3	–	–	1	5	–	42	**51**
Melanotaenia splendida splendida	eastern rainbowfish	24	67	–	10	–	18	4	**123**
Nematalosa erebi	bony bream	3	–	–	1	–	1	1	**6**
Neosilurus hyrtlii	Hyrtl's catfish	1	–	–	–	–	–	–	**1**
Tandanus tandanus	freshwater catfish	1	3	3	6	22	1	–	**36**
Total native fish individuals		**928**	**849**	**353**	**18**	**27**	**30**	**47**	**2252**
Total native fish species		**8**	**5**	**4**	**4**	**2**	**6**	**3**	**8**

– not caught

Table 7.3 Comparison of fish monitoring results with the local biological objective for fish for the 2022 post-wet REMP survey.

Water type	Expected number of species (i.e. the local biological objective for fish)	Observed number of species (i.e. number of species caught during survey)	Comparison (i.e. Observed : Expected as a ratio)
Waterbody	4	8	2.0
Dawson River	5	7	1.4
Hutton Creek	2	3	1.5

8 Macrocrustaceans – Exoskeleton Assessment

8.1 Methods

Survey Procedure

Individuals from two of the commonly occurring invertebrate species (*Macrobrachium australiense* and *Caridina* spp.) were examined for signs of potential calcium and magnesium deficiencies: the strength and apparent thickness (i.e. robust or not robust) and condition of the exoskeletons were recorded. The reproductive status of the specimens was also recorded.

Data Analysis

There are no quantitative criteria relating to this parameter; thus qualitative comparisons were made to the baseline records (Table 8.1).

8.2 Results

The macrocrustaceans caught during the 2022 REMP surveys included *Macrobrachium australiense* which were caught during the baseline monitoring program (Table 8.1). All specimens had exoskeletons that were of robust and good condition (Table 8.2). One individual *M. australiense* was recorded in breeding condition at Waterbody site WLMP5 during the 2022 post-wet season survey, which was not consistent with the results of baseline surveys implemented in Autumn where *M. australiense* were not recorded in breeding condition.

Table 8.1 Baseline records of macrocrustacean species and condition.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
		Caridina spp.	*Caridina* spp. [a]
Breeding condition	recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer	Both taxa recorded to breed during spring and summer
	not recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter	Neither taxa recorded as breeding during autumn or winter
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

[a] *Caridina* spp. were caught during 5 of the 7 baseline surveys at site DRR2 on Hutton Creek, suggesting that this taxon is not always present at this site.

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae)

Table 8.2 Macrocrustacean species and condition recorded during the 2022 post-wet REMP survey.

Recorded Attribute	Water Type		
	Waterbody	**Dawson River**	**Hutton Creek**
Species present	*Macrobrachium australiense*	*Macrobrachium australiense*	*Macrobrachium australiense*
Breeding condition	breeding	not breeding	not breeding
Exoskeleton condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition	exoskeletons robust and in good condition

Macrobrachium australiense – long-armed river prawn (family Palaemonidae); *Caridina* spp. – glass shrimp (family Atyidae).

9 Zooplankton

9.1 Methods

Survey Procedure

Zooplankton was assessed in the post-wet (April) survey in 2022.

Three samples were collected at each site using a six-meter, depth-integrated tow with a 150 µm mesh plankton net, which samples 'macrozooplankton', but not 'microzooplankton' (i.e. ciliates, rotifers and juvenile microzooplankton – i.e. nauplii), which requires a smaller mesh size of approximately 20 µm (James 1991).

Samples were preserved in methylated spirits and transported to a biological laboratory (Dardanus Scientific) where they were processed by a suitably qualified aquatic invertebrate taxonomy specialist. Microcrustaceans were identified to morphospecies[1], with the exception of *Ceriodaphnia cf dubia*, which was identified to described species level using available taxonomic keys (Shiel 1995). This taxon was of particular interest due to its reported sensitivity to boron (AECOM 2019; Halcrow 2013).

The abundance of each taxon was determined for a quantitative sub-sample of each sample, and then converted to an abundance for the total sample.

Data Analysis

There is no baseline data for zooplankton and no biological guidelines for zooplankton, although an initial zooplankton survey was completed in September 2018 at the Waterbody sites (i.e. WLMP4, WLMP1 and WLMP5) (i.e. see Appendix D). This data, and all zooplankton data collected since September 2018, is incorporated in this study to assess spatial and temporal patterns. Only data for microcrustaceans (Cladocerans, Ostracods and Copepods) is presented.

Spatial and temporal variability in the zooplankton community was statistically assessed using PERMANOVA and multidimensional scaling, implemented using the Primer software.

[1] Only microcrustacean data is considered, although all taxa were identified during laboratory processing, with insects identified to family or subfamily, and other taxa (e.g. Nematoda) to class or order.

9.2 Results

Eight microcrustacean taxa were found in the 2022 post-wet survey. Microcrustacean diversity was highest in the Dawson River (seven taxa recorded) and intermediate in the Waterbody (three taxa recorded) and Hutton Creek (three taxa recorded), noting that the abundances of taxa was highly varied. For example, while fewer taxa were recorded at the Hutton Creek site, the abundances recorded were generally higher than abundances recorded in the Dawson River and the Waterbody. Overall, these results show that the microcrustacean community is highly differentiated between the three water types (locations) (i.e. Dawson River, Waterbody and Hutton Creek (Figure 9.1).

When the microcrustaceans sampled from the Waterbody in September 2018, all sites in November 2019 and all sites in the 2020, 2021 and 2022 surveys are included in the analysis, results show a clear separation between the Waterbody in September 2018 and more recent surveys (Figure 9.2). Separation between sites on the Waterbody in September 2018 was notably higher than in 2019, 2020, 2021 and 2022 surveys; however, variation in microcrustacean communities between sites and surveys was high. Microcrustacean communities in Dawson River sites were also differentiated between November 2019, May 2020, October 2020, May 2021, October 2021 and April 2022 indicating that in some years different sections of the Waterbody and Dawson River can have distinct microcrustaceans communities. PERMANOVA analysis using the combined 2018 / 2019 / 2020 / 2021 / 2022 data further indicates high and statistically significant spatial and temporal variability in microcrustacean communities:

- between locations (i.e. between the three water types): $F = 3.069$, $P = 0.018$
- across time (i.e. between 2018, 2019, 2020, 2021, 2022): $F = 4.1353$, $P = 0.0001$
- between all sites: $F = 4.1467$, $P = 0.0012$, and
- across space and time combined (i.e. interaction between location and time): $F = 6.0176$, $P = 0.0001$.

Table 9.1 Zooplankton (microcrustacean) survey results for the post-wet season 2022 survey.

Taxa	Waterbody									Dawson River									Hutton Creek		
	WLMP4			WLMP1			WLMP5			DRMP1			S4			DRR1			DRR2		
	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3	Rep -1	Rep -2	Rep -3
Bosminidae (Cladocera)	–	–	–	–	–	1	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–
Copepod 1 (Calanoida)	–	2	2	–	–	1	–	–	–	–	1	–	–	–	–	–	1	–	49	260	39
Copepod 2 (Cyclopoida)	–	–	2	–	36	14	2	3	2	6	–	–	–	4	21	1	1	2	41	83	64
Daphnia 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	3	3	3
Ostracod 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–
Ostracod 2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Ostracod 3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Ostracod 5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–

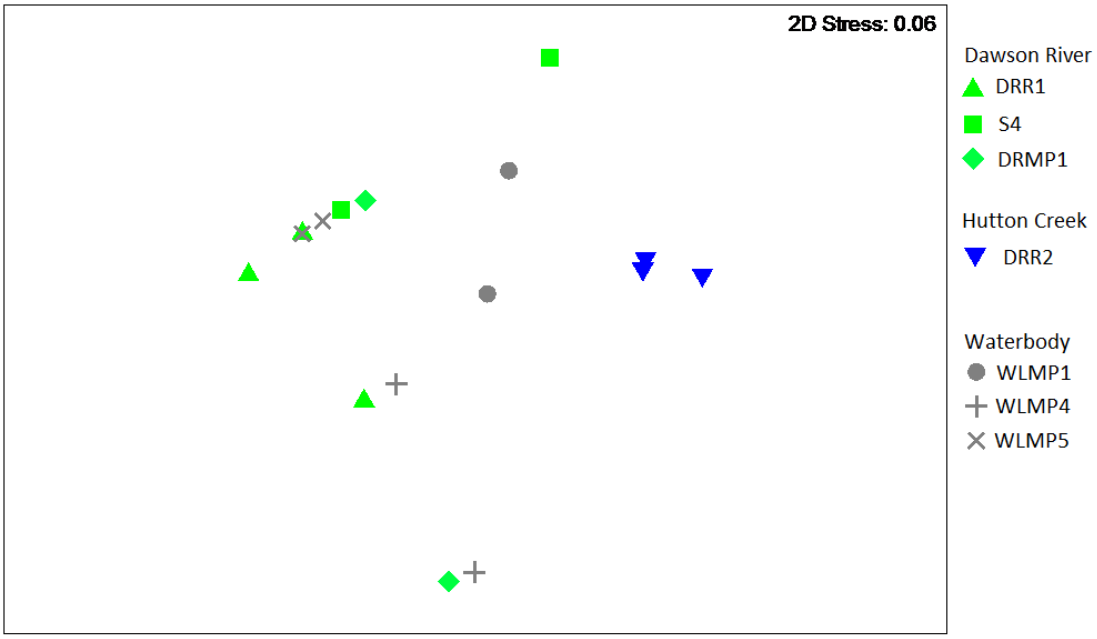


Figure 9.1 MDS plot of microcrustacean communities at each site in the 2022 post-wet survey, showing separation of the three water types.

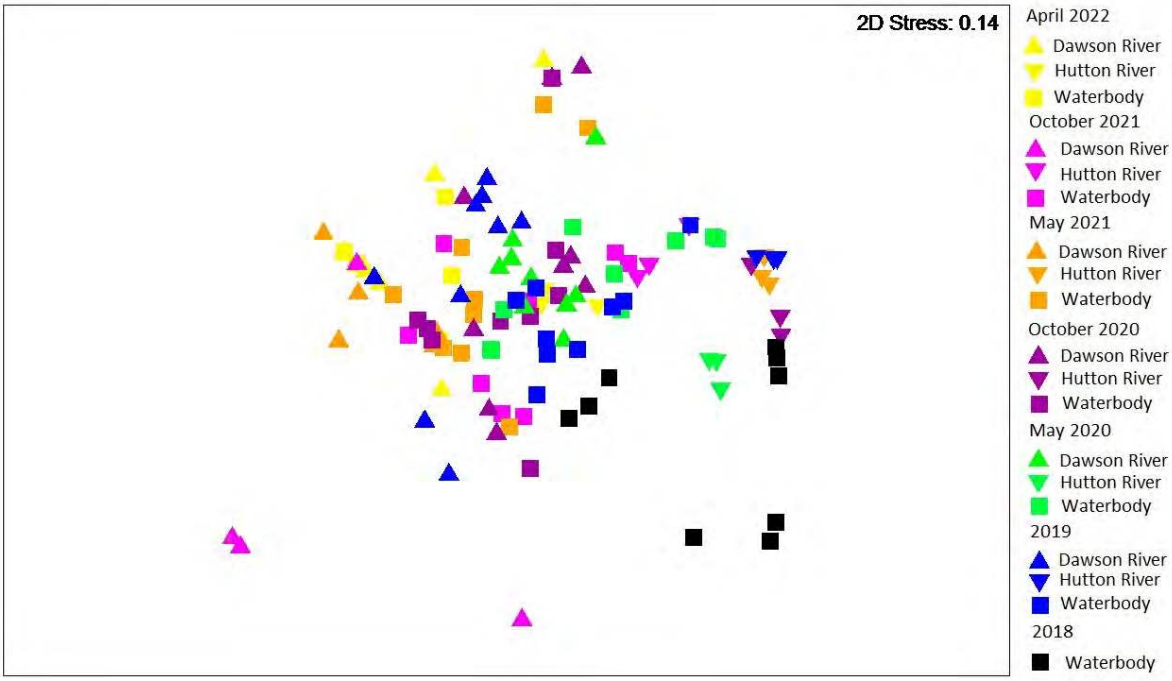


Figure 9.2 MDS plot of microcrustacean communities at Waterbody sites in September 2018, at each site from the 2019 pre-wet season survey to the 2022 post wet survey, showing separation of the three water types, and separation of the Waterbody samples between 2018, 2019, 2020, 2021 and 2022.

10 Assessment of Environmental Changes

The monitoring results for the 2022 post-wet REMP surveys indicated that most monitoring components have not changed from baseline condition, with the exception of:

- Physical habitat features in the Waterbody, which had improved from baseline condition due to higher water levels. The higher water levels have increased submerged aquatic plant cover and the cover of large woody debris in water in the Waterbody, thereby improving aquatic habitat.
- The taxonomic richness and SIGNAL-2 score of macroinvertebrates at site DRR2 were higher than the baseline range recorded in Hutton Creek water type. However, these results likely reflect improved habitat conditions from baseline conditions at site DRR2, which were dry or with very shallow water for many of the baseline surveys.
- Breeding *Macrobrachium australiense* in the Waterbody in autumn, which was only recorded in a single individual, and is an ecological favourable condition and does not indicate adverse conditions related to the release of desalinated water.

Overall, the 2022 post-wet survey results indicated that the release of desalinated produced water from ROP2 has not impacted the aquatic environmental values of the receiving environment.

11 References

AECOM 2019, Revised Boron Site-Specific Water Quality Criterion - Dawson River Release Scheme.

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.

DES 2018, Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009, report prepared for Queensland Department of Environment and Science, Brisbane.

EHMP 2007, Ecosystem Health Monitoring Program 2005-2006, Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane.

frc environmental 2021, Santos Ltd Dawson River Watercourse Releases: Receiving Environment Monitoring Program, report prepared for Santos Ltd.

Halcrow 2013, Dawson River Release Scheme Direct Toxicity Assessment: Fish Test. Addendum to Direct Toxicity Report (Halcrow, November 2012), report prepared for Santos GLNG.

Appendix A Statutory Declaration by Suitably Qualified Person

Statutory Declaration

Resource activities other than mining

Declaration of compliance for written documents

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *This statutory declaration has been prepared to declare the authority holders compliance with the provisions of the* Environmental Protection Act 1994 *(EP Act) or an environmental authority condition that stipulates the requirement to submit a certified written document to the administering authority.*

Oaths Act 1867

QUEENSLAND
TO WIT

Re: Written documents relating to an environmental authority for a resource activity other than mining under the *Environmental Protection Act 1994.*

Written document: Dawson River Release Scheme, Receiving Environment Monitoring Program: Interim Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2022

(Insert type of document, e.g. contingency plan for emergency environmental incidents)

Subject matter: Compliance with monitoring requirements as stated in the Receiving Environment Monitoring Program (REMP) as required by condition (B41) of environmental authority EPPG00928713 dated 24 January 2022

(Insert subject matter, e.g. compliance with environmental authority number PEN1001222222)

Authority holder: Santos TOGA Pty Ltd

(Insert principal holder name)

I, Benjamin Douglas Cook

(Insert full name of person making this declaration)

of, Wynnum, Queensland

(Insert suburb and city of the person making this declaration)

ABN 46 640 294 485

Great state. Great opportunity.

Queensland Government

in the State of Queensland do solemnly and sincerely declare that:

1. I am a suitably qualified person as defined in the environmental authority; having professional qualifications, training, skills and experience relevant to the subject matter and can give authoritative assessment, advice and analysis relative to the subject matter using the relevant protocols, standards, methods or literature. A copy of my curriculum vitae is Annexure A to this declaration[1];
2. The authority holder has fully complied with the monitoring requirements as stated in the REMP as required by condition (B41) of environmental authority EPPG00928713 dated 24 January 2022;
3. All relevant material has been considered in preparing the Dawson River Release Scheme, Receiving Environment Monitoring Program: Interim Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report 2022;
4. The content of Dawson River Release Scheme, Receiving Environment Monitoring Program: Interim Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2022 is accurate and true; and
5. The Dawson River Release Scheme, Receiving Environment Monitoring Program: Interim Supplementary Water Quality, Sediment Quality, Geomorphological and Biological Monitoring Report, 2021 meets the monitoring requirements as stated in the REMP as required by condition (B41) of environmental authority EPPG00928713 dated 24 January 2022.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the *Oaths Act 1867*.

(Print name and registration number, if applicable)

Taken and declared before me, at Wynnum Sth

(Insert name of town or city and suburb)

this 15th day of July in the year 2022

(Insert day, e.g. 18th) (Insert month) (Insert year)

JUSTICE OF THE PEACE (QUALIFIED) QUEENSLAND GOVERNMENT Reg.No.: 10270 DEPT. OF JUSTICE & ATTORNEY-GENERAL

Signed

(Person making this declaration)

Signed

(Cross out whichever is not applicable)

Justice of the Peace / ~~Commissioner for Declarations~~ / ~~Solicitor / Barrister~~

[1] The signatory does need to initial each page of the annexure, but it does need to be marked with the following: "This is the [*insert name of document]* or a copy of the [insert name of document] marked with the letter "A" referred to in the Statutory Declaration [insert sworn/taken/affirmed/solemnly declared] before me at [insert day] of [insert month], [insert year].

Approved By

Signature	Date

Director
Energy Regulation and Implementation Unit
Environmental Protection Act 1994
Department of Environment and Heritage Protection

Enquiries:
Energy Regulation and Implementation Unit
(Level 7, 400 George Street)
Department of Environment and Heritage Protection
Regular or registered post:
GPO Box 2454, Brisbane QLD 4001
Courier or hand delivery:
Level 3, 400 George Street, Brisbane QLD 4000
Telephone: (07) 3330 5619
Facsimile: (07) 3330 5634

Appendix B CVs for Suitably Qualified Persons

Benjamin Cook

B.App.Sc., B.Sc. (Hons.), Ph.D.

Principal Ecologist | Freshwater

bencook@frcenv.com.au

Ben has an established reputation in Australia and internationally for innovative research on the biogeography, ecology and management of freshwater ecosystems and their biota. He has a Ph.D. in freshwater biology and 17 years of professional experience across a range of academic and environmental management roles.

Ben has specialist expertise in the assessment of aquatic ecosystems for environmental and regulatory approval and compliance processes, including environmental investigations. He has extensive experience in the assessment and provision of advice in relation waterway barrier works and fish passage assessment, the development and implementation of water quality and aquatic ecology monitoring programs (e.g. REMPs), aquatic ecosystem constraints analysis, risk-based aquatic ecosystem impact assessment, environmental flows assessment, stygofauna survey and assessment, aquatic Matters of National Environmental Significance (MNES), aquatic Matters of State Environmental Significance (MSES), and management of aquatic pest species. Ben is fully AUSRIVAS accredited.

Ben has long-term experience in technical leadership and management of multidisciplinary aquatic ecology research projects, and his expertise has been sought for Commonwealth, State and Local government funded projects and expert panels, on a large number of commercial projects, and to support a number of legal cases in Queensland. He has communicated the results of his work to a broad range of stakeholders via scientific papers, technical reports, chapters within published books, conference presentations, presentations to community and industry reference groups, interviews with journalists, and participation on expert panels.

Specialisations

- Ecological monitoring and assessment of surface water and groundwater ecosystems for environmental and regulatory approval and compliance purposes
- Development of water quality, aquatic ecology and fish passage monitoring programs to cost-effectively and robustly satisfy development and compliance approval conditions
- Management of environmental flows, threatened aquatic species and aquatic pest species
- Assessment and mitigation of impacts from waterway barriers, including fishway design
- Risk-based aquatic ecological constraints analysis and impact assessment, including development of mitigation and offset options

Employment History

- Senior Principal Ecology (Freshwater), frc environmental, Brisbane (2019 – current)
- Principal Ecologist (Freshwater), frc environmental, Brisbane (2014 – 2019)
- Senior Ecologist, frc environmental, Brisbane (2011 – 2014)
- Scientist, Water Planning Ecology Group, Queensland Department of Environment and Resource Management, Brisbane (2010 – 2011)
- Post-doctoral Research Fellow, Australian Rivers Institute, Griffith University, Brisbane (2006 – 2011)
- Academic Researcher, Australian Rivers Institute, Griffith University, Brisbane (2002 – 2006)
- Project Officer, Waterways Scientific Services, Queensland Environmental Protection Agency (2001 – 2002)
- Environmental Officer, Environmental Management Group, Redland Shire Council (1999 – 2001).

Relevant Project History

While employed in an academic capacity, Ben senior-authored over 20 peer-reviewed journal articles relating to freshwater ecology, and contributed significantly to several studies funded by the National Water Commission.

Since working with frc environmental, Ben has been Project Manager and Technical Lead of over 80 commercial water quality and / or freshwater ecology projects, including numerous projects relating to Receiving Environment Monitoring Programs (REMPs):

- baseline water quality and ecological monitoring programs
- development of local water quality, sediment quality and biological guidelines in accordance with regulator-prescribed approached to guideline development
- design of REMP monitoring plans, in accordance with regulator guidelines for REMP development
- implementation of REMPs, including field survey, data analysis and reporting, and
- environmental investigations, where REMP monitoring results exceed applicable guidelines.

Some recent examples of REMP projects include:

- Clermont Coal Operations REMP 2014, 2015, 2016 2017, 2018, 2019, 2020, 2021. Glencore.
- Chinchilla End of Waste Scheme (formally Chinchilla Beneficial Use Scheme) REMP 2013, 2014, 2015, 2016, 2017, 2018, 2019. 2020, 2021. Sunwater.
- Fraser Coast Regional Council STPs Surface Water and Groundwater REMPs 2019, 2020, 2021.
- South Walker Creek Mine REMP 2017, 2018, 2019, 2020, 2021. BHP BMC.
- of Waste Scheme (formally Glebe Beneficial Use Scheme) REMP 2015, 2016, 2017, 2018, 2019, 2020, 2021. Sunwater.
- Dugald River Mine REMP 2021. MMG.

Appendix C Site Habitat Sheets

Site	WLMP4	**Region**	Upper Dawson
Date surveyed:	5/04/22 (post-wet)	**Habitat Bioassessment Score**	84 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	5 to 50m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	moderate to high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		large woody debris		Melaleuca
	Right bank: low/convex		gravel	0 %		macrophytes	**Weed species**	grasses
			sand	90 %		tree roots		
Hydrology			silt / clay	10 %		detritus		
Flow regime	ephemeral	**Deposits**	silt					
Water depth	1.2 m	**Bed stability**	bed stable		**In-stream disturbance**			
Wetted width	70 m				Flow modification	none	**Adjacent land use**	native vegetation
Flow	no flow				Waterway barrier	none		grazing
Channel width	70 m							mining

Comments:	Site is the ‘upstream’ end of an oxbow lake. There is no flow but water level remains stable from previous surveys. Dead shrubs and trees in water along edge suggest previous lower water levels. Macrophytes dense on both left and right banks (moderate beds of *Vallisneria* sp., *Ludwigia peploides, Myriophyllum* sp. and *Azolla* sp.). *Juncus usitatus* and *Persicaria* sp. on banks. Little bare ground in riparian zone. Right bank riparian vegetation is dominated by grasses with some scattered Eucalypts. Left bank riparian vegetation is dominated by large Eucalypts, with grass understory. Evidence of cattle access to water.

Site	WLMP1	**Region**	Upper Dawson
Date surveyed:	5/04/22 (post-wet)	**Habitat Bioassessment Score**	64 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	5 to 25m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate
Bank stability	moderate to high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: flat/convex		pebble	0 %		large woody debris		Melaleuca
	Right bank: low/convex		gravel	0 %		macrophytes		
Hydrology			sand	0 %		tree roots	**Weed species**	grasses
Flow regime	ephemeral		silt / clay	100 %	**In-stream disturbance**			
Water depth	>1.5 m	**Deposits**	silt		Flow modification	none		
Wetted width	70 m	**Bed stability**	bed stable		Waterway barrier	none		
Flow	no flow						**Adjacent land use**	grazing
Channel width	90 m							

Comments: Site is a long, wide wetland (oxbow lake) with no flow and higher water level than October 2021 survey. Macrophytes present on both banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.). Aquatic birds present during survey (swans and cormorants). Evidence of cattle access to water and some erosion on banks. Some filamentous algae present. Dead trees in stream provide some aquatic habitat. Sediment soft and made up of detritus and silt.

Site	WLMP5	**Region**	Upper Dawson
Date surveyed:	6/04/22 (post-wet)	**Habitat Bioassessment Score**	78 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	2	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	10 to 25m
Pattern	isolated lake		boulder	0 %	**Habitat present**	deep	**Disturbance**	moderate to high
Bank stability	high		cobble	0 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		large woody debris		Melaleuca
	Right bank: low/convex		gravel	0 %		macrophytes	**Weed species**	grasses
Hydrology			sand	0 %		tree roots		noogoora burr
Flow regime	ephemeral		silt / clay	100 %		detritus		
Water depth	>1.5 m	**Deposits**	silt					
Wetted width	75 m	**Bed stability**	bed stable		**In-stream disturbance**		**Adjacent land use**	grazing
Flow	no flow				Flow modification	none		
Channel width	120 m				Waterway barrier	none		

Comments: Site is a long, wide wetland at the ‘downstream’ end of an oxbow lake. Macrophytes dense on both left and right banks (dense beds of *Vallisneria* sp., *Ludwigia peploides* and *Azolla* sp.). Substrate is soft silt with large amount of small woody detritus and silt forming bed. Dead Eucalypt trees lining edges of water on both banks. Evidence of cattle access to water. Vegetation on banks has become thicker after wet season. Water level has slightly elevated since pre-wet survey in October 2021. Several meters of bank covered with native aquatic plants (*Carex* sp., *Juncus* sp., *Persicaria* sp. and *Cyperus* sp.). Left bank riparian vegetation large, with native forest downstream of survey site.

Site	DRMP1	**Region**	Upper Dawson
Date surveyed:	6/04/22 (post-wet)	**Habitat Bioassessment Score**	93 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	15 to 30 m
Pattern	irregular meanders		boulder	5 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	moderate		cobble	0%		run and pool	**Dominant species**	Eucalypt
						log jams		Callistemon
Bank shape	Left bank: moderate – convex		pebble	0%		detritus	**Weed species**	Noogoora burr
						undercut banks		grasses
	Right bank: moderate – stepped		gravel	5%		large woody debris		
			sand	85 %		tree roots		
Hydrology			silt / clay	5 %		l		
Flow regime	perennial						**Adjacent land use**	native forest
Water depth	0.5 m	**Deposits**	sand / silt		**In-stream disturbance**			grazing
Wetted width	15 m	**Bed stability**	bed stable		Flow modification	none		
Flow	0.3 m / s				Waterway barrier	none		
Channel width	20 m							

Comments: Site is a narrow stream with an irregular pattern, moderate flow, and shallow and deep pool, riffle and run sections. Site has been impacted by recent flooding, but water level at time of survey is stable. *Lomandra longifolia* lining steep banks. Many fallen trees across stream. Cattle access to water evident. Some erosion on banks, and behind riparian zone. Evidence of recent high flow on banks, with silt and detritus deposits on banks, and large log jams on banks. Riparian vegetation is mostly Callisetmon, with grass and weed (noogoora burr, grasses) understory and is continuous throughout site.

Site	S4	**Region**	Upper Dawson
Date surveyed:	7/04/22 (post-wet)	**Habitat Bioassessment Score**	78 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	high	**Riparian width**	10 to 15 m
Pattern	irregular meanders		boulder	1 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	low to moderate		cobble	2 %		riffles and pools	**Dominant species**	Eucalypt
Bank shape	Left bank: moderate/convex		pebble	2 %		large woody debris		Callistemon
								Melaleuca
	Right bank: moderate to steep/convex		gravel	3 %		trailing bank vegetation		
						undercut banks		
			sand	5 %		macrophytes	**Weed species**	Noogoora burr
Hydrology			silt / clay	87 %		tree roots		grasses
Flow regime	perennial					detritus		
Water depth	0.4 m	**Deposits**	silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	culvert at site	**Adjacent land use**	grazing
Flow	0.1 m / s				Waterway barrier	box culverts		
Channel width	15 m							

Comments: Site is a slow flowing creek with a variety of sediment sizes and habitat types. Fallen trees, riffles, pools and undercut banks provide habitat. Evidence of cattle access to creek. Box culvert under road crossing in middle of site. Callistemon lining creek, although all trees have been cleared around road crossing. Sand deposits forming some bars, with one vegetated midstream bar. *Lomandra longifolia* on banks. Pump hoses on bank next to road crossing. Erosion on right bank downstream of causeway. Noogoora burr present at moderate density.

Site	DRR1	**Region**	Upper Dawson
Date surveyed:	6/04/22 (post-wet)	**Habitat Bioassessment Score**	98 (Good)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	moderate	**Riparian width**	20 m
Pattern	irregular meanders		boulder	0 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	low to moderate		cobble	0 %		run, pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/concave		pebble	0 %		large woody debris		Melaleuca
						trailing roots		Casuarina
	Right bank: low/concave		gravel	5 %		undercut banks		
Hydrology			sand	90 %			**Weed species**	Noogoora burr
Flow regime	perennial		silt / clay	5 %				grasses
Water depth	0.2 m	**Deposits**	sand/silt		**In-stream disturbance**			
Wetted width	15 m	**Bed stability**	bed stable		**Flow modification**	none	**Adjacent land use**	native forest
Flow	0.2 m / s				**Waterway barrier**	none		light grazing
Channel width	20 m							

Comments:	Site is a moderately fast flowing stream with soft, sandy substrate and shallow and deep pools and runs. Water slightly turbid. Several fallen trees in water, and sediment deposits high up on bank from high flows. Large and small woody debris in stream. Dense growth of *Callistemon* and *Casuarina* in riparian zone on both banks. *Lomandra longifolia* and *Casuarina* growing on sand bars. Evidence of cattle and pig access to water. Freshwater mussel shells in bed. Noogoora burr extensive on banks. Large patches of erosion behind riparian vegetation on right bank.

Site	DRR2	**Region**	Upper Dawson
Date surveyed:	7/04/22 (post-wet)	**Habitat Bioassessment Score**	63 (Moderate)

Downstream view

Right Bank

Upstream view

Left Bank

Channel Morphology		**Substrate**			**Aquatic Habitat**		**Riparian Zone**	
Stream order	6	**Composition**	bedrock	0 %	**Habitat diversity**	low to moderate	**Riparian width**	5 – 10 m
Pattern	irregular meanders		boulder	75 %	**Habitat present**	shallow and deep	**Disturbance**	moderate
Bank stability	moderate		cobble	3 %		pool	**Dominant species**	Eucalypt
Bank shape	Left bank: low/convex		pebble	0 %		tree roots		Callistemon
	Right bank: moderate /convex		gravel	5 %		large woody debris		Melaleuca
Hydrology			sand	12 %		leaves and twigs	**Weed species**	Noogoora burr
								grasses
Flow regime	intermittent		silt / clay	5 %				
Water depth	0.5 m	**Deposits**	sand/silt		**In-stream disturbance**			
Wetted width	10 m	**Bed stability**	moderate aggradation		Flow modification	none	**Adjacent land use**	grazing
Flow	nil				Waterway barrier	none		native forest
Channel width	20 m							

Comments:	Site is a turbid pool that extends downstream of site and is connected by a small riffle restricted by woody debris upstream. Cattle access to creek bed evident, with extensive tracks and churned up sediment in bed. Creek bed is made up of large boulders and a variety of other sediment sizes, covered in a layer of sand and silt. Evidence of recent high flow – sediment/silt high several meters up on banks and large log jams. Freshwater mussel shells in bed. Left bank has experienced some accretion since October 2021 comprising of fine sediment and large woody debris.

Appendix D Baseline Range for Water Quality and Sediment Quality Data, and Macroinvertebrate Indices

Table D1 Baseline Maximum for Water Quality Parameters

Parameter	Unit	Waterbody	Dawson River	Hutton Creek
		Maximum	Maximum	Maximum
Temperature	ºC	11.46 – 35.02	12.0 – 31.5	15.5 – 35.6
Dissolved oxygen	mg/L	4.36 – 14.23	3.40 – 11.60	7.7 – 17.2
Electrical conductivity	µS/cm	968	1215	797
pH	unit	6.8 – 9.0	7.5 – 8.3	6.9 – 8.8
Suspended solids	mg/L	318	67	175
Turbidity	NTU	611	864	612
Ammonia as N	mg/L	0.74	0.09	0.1
Total nitrogen	mg/L	13.4	1.5	1.9
Boron (total)	mg/L	0.20	0.17	0.11
Zinc (total)	mg/L	0.029	0.013	0.019
Boron (dissolved)	mg/L	0.18	0.70	0.13
Zinc (dissolved)	mg/L	0.043	0.024	0.008

Baseline range presented for temperature, dissolved oxygen and pH.

Table D2 Baseline Maximum for Sediment Quality Parameters

Parameter	**Unit**	**Waterbody**	**Dawson River**	**Hutton Creek**
		Maximum	**Maximum**	**Maximum**
Aluminium (Al)	mg/kg	16800	12800	18500
Arsenic (As)	mg/kg	6	5	8
Boron (B)	mg/kg	27.5	13.5	26.9
Cadmium (Cd)	mg/kg	<LOR	<LOR	<LOR
Chromium (Cr)	mg/kg	26.8	70.3	19.4
Copper(Cu)	mg/kg	19	12	18
Iron (Fe)	mg/kg	23900	19000	32000
Lead (Pb)	mg/kg	25.1	15	23.5
Manganese (Mn)	mg/kg	1020	545	705
Mercury (Hg)	mg/kg	0.8	<LOR	<LOR
Nickel (Ni)	mg/kg	30.4	296	15
Selenium (Se)	mg/kg	<LOR	<LOR	<LOR
Zinc (Zn)	mg/kg	74	46	68

Table D3 Full Baseline Range of Macroinvertebrate Indices

Index	Waterbody		Dawson River		Hutton Creek	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Abundance	16	512	15	411	1	590
Taxonomic Richness	3	15	6	25	1	20
PET Richness	0	2	0	6	0	3
SIGNAL-2 Scores	2.36	3.64	2.57	4.41	2	3.38

Table D4 Zooplankton Data (microcrustacean data only) from September 2018 Survey of Waterbody

Taxa	Higher Taxa	WLMP1			WLMP4			WLMP5		
		Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3	Rep-1	Rep-2	Rep-3
Microcrustaceans										
Daphnia sp 1	Daphniidae (Cladocera)	4000	15625	75000	260	85	170	15000	5000	8500
Daphnia sp 2	Daphniidae (Cladocera)						10			
Chydoridae (Cladoceran 1)	Chydoridae				25	90	5			
Cladoceran 2	Cladocera				15	15	5			
Bosminidae (Cladoceran 3)	Cladocera	20			5	40	5	90	165	60
Copepod 2 (Cyclopoida)	Copepoda				100	240	205			
Copepod 1 (Calanoida)	Copepoda				25	100	5	1500	3250	2575
Ostracod 2	Ostracoda	20			15					
Ostracod 1	Ostracoda	25	10	50	15		10			
Ostracod 3	Ostracoda				5		5			

Note: taxonomic names used in the 2018 study have been updated here to align with the 2019/2020/2021/2022 data