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16. SURFACE WATER QUALITY

16.1. Description of environmental values

This section addresses Section 3.4.3.1 of the ToR and describes the existing environment for water quality that may be affected by the Project in the context of environmental values as defined in local, State and national guidelines.

16.1.1. Regulatory framework

The following documents were reviewed to identify the key environmental values and applicable water quality objectives for the Dawson Catchment:

- Policy for the Maintenance and Enhancement of Water Quality in Central Queensland;
- *Environmental Protection Act 1994*;
- *Environmental Protection (Water) Policy 2009*;
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;
- Queensland Water Quality Guidelines 2009; and
- Fitzroy Basin Association Regional Water Quality Monitoring and Reporting.

16.1.1.1. Policy for the Maintenance and Enhancement of Water Quality in Central Queensland

This policy developed by the Queensland Department of Employment, Economic Development and Innovation (2003) provides a non-regulatory Head of Agreement for collaborative planning and management of water quality by all local government, industry and landholders. The policy is a means for implementation of strategies for river health and water quality and recognises the importance of accurately assessing, valuing, monitoring and reporting on the condition of the region's water resources for planning and management.

16.1.1.2. Environmental Protection Act 1994

The objective of the *Environmental Protection Act 1994* (EP Act) is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecological sustainable development) (Queensland Government, 1994).

16.1.1.3. Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2009* (EPP (Water)) is subordinate legislation under the EP Act. This policy was developed to fulfil the objective of the EP Act, in relation to protection of Queensland waters. This policy is consistent with and should be seen as an extension of the *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 Guidelines for Fresh and Marine Water Quality* (EPA, 2007).

The purpose of the EPP (Water) is achieved by providing a framework for:

- identifying environmental values for Queensland waters;
- stating water quality guidelines and objectives to protect or enhance the environmental values;
- providing framework for making consistent and equitable decisions about Queensland waters; and

- involving the community through consultation and education, and promoting community responsibility (EPA, 2009).

Schedule 1 of the EPP (Water) identifies Environmental Values (EVs) for waters (including beds and banks) in Queensland. EVs describe the natural qualities and/ or beneficial uses of a water body that are to be protected (EPA, 2007).

Under Schedule 1 of the EPP (Water), Water Quality Objectives (WQOs) are established as quantitative targets to protect or enhance the EVs identified for a water body. WQOs can be set for physical, chemical and biophysical components or indicators of aquatic environments (EPA, 2007). The Dawson River and its tributaries are not listed under Schedule 1 of this Policy, and as such a generic set of environmental values for waters to be protected or enhanced have been adopted (Section 16.1.2).

The EPP (Water) describes the process for determining which water quality guidelines to use in water quality planning and decision making (EPA, 2007). In general, where there is more than one set of applicable guidelines, the most locally accredited guideline information shall take precedence over broader guidelines (EPA, 2006c). The Queensland Water Quality Guidelines (QWQG) take precedence over the (broader) ANZECC and ARMCANZ (2000) guidelines, where the QWQG provide values for Queensland waters that are more localised than the ANZECC and ARMCANZ (2000) Guidelines (EPA, 2007).

16.1.1.4. Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000

The primary objective of the ANZECC and ARMCANZ (2000) guidelines is "to provide an authoritative guide for setting WQOs required to sustain current, or likely future, environmental values [uses] for natural and semi-natural water resources in Australia and New Zealand" (*ANZECC and ARMCANZ, 2000*). The purpose of the guideline is to provide both government and the general community with a sound set of tools for assessing and managing ambient water quality in natural and semi-natural water resources (*ANZECC and ARMCANZ, 2000)*.

The ANZECC and ARMCANZ (2000) guidelines aim to protect environmental values through the identification of management goals that focus on issues (concerns or potential problems) (*ANZECC and ARMCANZ, 2000)*. Despite this, the guidelines are not mandatory and due to the vast range of environments, ecosystem types and food production systems in both Australia and New Zealand, it is recognised that a three-tiered approach including national, state or territory, and regional or catchment scales are required (*ANZECC and ARMCANZ, 2000)*.

In accordance with this recognition, the QWQG were developed to provide state-wide guidelines. In addition, the QWQG (2009) also provide the framework for establishing local and regional guidelines.

16.1.1.5. Queensland Water Quality Guidelines 2009

As mentioned previously, the Dawson River and its tributaries are not specifically listed under Schedule 1 of the EPP (Water) and therefore, the Queensland Water Quality Guidelines 2009 (QWQG (2009)), for regional rivers in the Central Coast of Queensland, apply to the Project area. In the absence of more specific regional data, the QWQG (2009) default to ANZECC and ARMCANZ (2000) values. The relevant guidelines can be found in Table 16-1 and Table 16-2. The guidelines listed in the QWQG (2009) are derived from reference data that is generally representative of waterway conditions under normal flow regimes. Due to regional variability in geology and climate it must be noted that these values should only be used in a regional context to identify sites or sub-catchments that differ to the regional average.

Table 16-1 Applicable water quality guidelines for the Project area

Parameter		Units	ANZECC and ARMCANZ (2000) Guideline
Ammonia Nitrogen		µg/L	10
Oxidised Nitrogen		µg/L	15
Organic Nitrogen		µg/L	225
Total Nitrogen		µg/L	250
Filterable Reactive Phosphorus		µg/L	15
Total Phosphorus		µg/L	30
Dissolved oxygen	Lower	% saturation	90
	Upper	% saturation	110
Turbidity		NTU	25
pH	Lower	pH units	6.5
	Upper	pH units	7.5
Conductivity		µS/cm	340

Table 16-2 Applicable water quality guidelines for metals in the Project area

Parameter	Units	ANZECC and ARMCANZ (2000) Guideline
Aluminium	µg/L	55 (pH >6.5)
Arsenic (As III)	µg/L	24
Arsenic (As V)	µg/L	13
Boron	µg/L	370
Cadmium	µg/L	0.2
Chromium (CrVI)	µg/L	1
Copper	µg/L	1.4
Lead	µg/L	3.4
Manganese	µg/L	1900
Mercury (inorganic)	µg/L	0.6
Nickel	µg/L	11
Selenium (total)	µg/L	11
Silver	µg/L	0.05
Zinc	µg/L	8

Although the pipeline is located in the Condamine catchment, no significant releases will be made into the environment. As such the water quality guidelines for this catchment are not discussed.

16.1.1.6. Fitzroy Basin Association

The Fitzroy Basin Association (FBA) is a regional community based organisation that exists to facilitate sustainable development in Central Queensland (FBA, 2010). The FBA, together with the Department of Environment and Resource Management (DERM), is currently in the process of identifying EVs and establishing WQOs for the Fitzroy Basin, including the Dawson sub-catchment. When finalised, the EVs and WQOs identified by the FBA will be suitable for scheduling under the EPP (Water). Although only presented as a draft, the FBA website currently identifies EVs and WQOs relevant to the Dawson sub-catchment (Section 16.1.2).

16.1.2. Defining environmental values

EVs for waterways are the qualities of the water that make it suitable for supporting aquatic ecosystems and human water uses. Environmental values highlighted in the ANZECC and ARMCANZ (2000), the QWQG (2009) and draft values specified by the FBA were used as the basis for adopting a set of environmental values for the study area.

16.1.2.1. Defining the waterbody

In accordance with the ANZECC and ARMCANZ (2000) and for the purposes of defining the waterbody for this Project, the river and creeks within the Dawson River Catchment (both upstream and immediately downstream of the dam) are defined as 'Upland Rivers and Streams', occurring above altitudes of 150 m AHD. Below Nathan Gorge the reach of the Dawson River and associated tributaries are defined as 'Lowland River and Streams'. Upon completion of the Project, a freshwater reservoir will be created which will be defined as a Freshwater Lake/Reservoir by the ANZECC and ARMCANZ (2000).

16.1.2.2. Environmental values

EVs describe key environmental characteristics that are important for the health of the ecosystem, public benefit, welfare, health or safety and which require protection from the effects of pollution, waste discharge and modified sediment processes (ANZECC and ARMCANZ, 2000). The QWQG (2009) recognise the following EVs:

- aquatic ecosystems;
- primary industries (including irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- recreation and aesthetics;
- drinking water;
- industrial water (gas exploration in upper reaches); and
- cultural and spiritual values.

Currently there are no EV's established for the Dawson River, as per Schedule 1 of the EPP (Water) 2009. As the Dawson River has no formally established EVs, a conservative approach has been taken, whereby it has been assumed that all EVs should be applied by default (Table 16-3). Although only in draft format, it should be noted that all of the

EVs listed in Table 16-3 are specified by the FBA as relevant to the Dawson River within the Project area. A detailed description of the EVs, as listed in the QWQG (2009), is provided in Table 16-4.

Table 16-3 Environmental values for the Dawson River

Environmental Value	Dawson River
Aquatic ecosystems	✓
Primary Recreation	✓
Secondary Recreation	✓
Human Consumer	✓
Drinking Water	✓
Visual recreation	✓
Farm Supply	✓
Irrigation	✓
Cultural heritage	✓
Industrial use	✓
Stock water	✓
Aquaculture	✓

Table 16-4 Environmental values as described in QWQG (2009)

Environmental Values	Definitions
Aquatic Ecosystems	The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas. Waterways include perennial and intermittent surface waters, ground waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes, lagoons, natural and artificial channels and the bed and banks of waterways.
Primary industries	Irrigation: Suitability of water supply for irrigation. Farm Water Supply: Suitability of domestic farm water supply, other than drinking water. Stock Watering: Suitability of water supply for production of healthy livestock. Aquaculture: Health of aquaculture species and humans consuming aquatic foods (such as fish, molluscs and crustaceans) from commercial ventures. Human Consumers of Aquatic Foods: Health of humans consuming aquatic foods.
Recreation and aesthetics	Primary Recreation: Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example swimming. Secondary Recreation: Health of humans during recreation which involves indirect contact and a low probability of water being swallowed for example boating and fishing. Visual Amenity: Amenity of waterways for recreation which does not involve any contact with water.
Drinking Water	Suitability of raw drinking water supply. This assumes minimal treatment of water is required.
Industrial uses	Suitability of water supply for industrial use.
Cultural and spiritual values	Indigenous and non-indigenous cultural heritage

16.1.2.3. Water quality objectives

Water Quality Objectives (WQOs) are specific, quantitative, long-term water quality targets that need to be met to protect the chosen EVs. Currently there are no WQOs established for the Dawson River, as per Schedule 1 of the EPP (Water) 2009. WQOs considered relevant to the dam have been determined using the EPP Water (2009), QWQG (2009), the Water Resource (Fitzroy Basin) Plan 1999, ANZECC and ARMCANZ (2000) and those stated on the FBA website.

Three levels of aquatic ecosystem protection exist under the ANZECC and ARMCANZ (2000) Guidelines; high conservation value; slightly to moderately disturbed; and highly disturbed. High conservation value ecosystems are largely unmodified or have undergone little change due to human activities. These areas are commonly found within national parks, conservation reserves or inaccessible locations (QWQG, 2009). Slightly too moderately disturbed ecosystems have experienced some change from human activities however the integrity of the ecosystem is largely intact and the biological communities remain in a healthy condition (QWQG, 2009). Slightly-moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing and/or pastoralism. Highly disturbed ecosystems are measurably degraded ecosystems but may still retain some ecological value (QWQG, 2009). Based on land uses within the Dawson Catchment, existing water extraction and extent of land clearing and grazing, for the purposes of assigning a level of protection, the Dawson Catchment has been classified as a slightly to moderately disturbed ecosystem.

Key WQOs for the protection of 'slightly to moderately' disturbed aquatic ecosystems associated with Nathan Dam storage and surrounding waterbodies, as outlined in QWQGs (2009), are presented in Table 16-5. The two sets of WQOs listed - 'dam and surrounds' and 'water storage' – relate to the fact that upon completion, the Water storage area will be defined as a Freshwater Lake/Reservoir under the QWQG (2009) and thus subject to a different set of guidelines. Key WQOs presented on the FBA website are also included for consideration.

Table 16-5 Key WQOs for the protection of aquatic ecosystem for proposed dam storage and surrounds

Indicator	WQOs for dam and surrounds	WQOs for water storage	FBA WQOs for Upper Dawson
Turbidity (NTU)	< 25	< 20	n/a
Chlorophyll-a (µg/L)	< 5	< 5	n/a
Total Nitrogen (µg/L)	< 250	< 350	< 350
Total Phosphorus (µg/L)	< 30	< 10	< 70
Dissolved Oxygen (% sat.)	90% - 110%	90% - 110%	n/a
pH (pH units)	6.5 - 7.5	6.5 - 8.0	6.5 - 8.0
Conductivity (µS/cm)	< 340	< 340	< 360

'n/a' means not available

Key WQOs for the protection of drinking water supply, as outlined in QWQGs (2009), are presented in Table 16-6. These WQOs have been derived through investigations of Wivenhoe Dam in South East Queensland, but would be appropriate for drinking water supply storages throughout Queensland (QWQG, 2009). Compliance with these key WQOs for the EVs of aquatic ecosystem and drinking water supply will meet WQOs for all other chosen EVs.

Table 16-6 Key WQOs for the protection of drinking water supply

Indicator	Water Quality Objective (WQO)
Suspended solids	Level 1: 25 mg/L Level 2: 100 mg/L
Blue-green algae (cyanobacteria)	< 2,000 cells/mL
Algal biomass	Level 1: < 30,000 cells/mL *Cylindrospermopsin* or *Microcystin* No Level 2
Algal toxin	Level 1: 0.1 µg/L *Microcystin* or 0.2 µg/L *Cylindrospermopsin* Level 2: 4 µg/L *Microcystin* or 1 µg/L *Cylindrospermopsin*
Taste and odour	Level 1: 5 µg/L Geosmin or 10 µg/L MIB or 10 µg/L combined Geosmin and MIB Level 2: > 30 µg/L of both Geosmin and MIB combined
Cryptosporidium	Level 1: 0 cyst Level 2: 10 cysts per 10 L
Giardia	Level 1: 0 cyst Level 2: 10 cysts per 10 L
E coli	Level 1: < 60 cfu/100mL No Level 2
Total coliforms	Level 1: > 800 cfu/100mL No Level 2
Manganese (soluble)	Level 1: 50 µg/L Level 2: 200 µg/L
Iron (soluble)	Level 1: 50 µg/L Level 2: 200 µg/L
Turbidity	Level 1: 25 NTU Level 2: 100 NTU
Colour	Level 1: 50 Hazen Units No Level 2
Conductivity	Level 1: > 50% change from long-term median Level 2 same as Level 1 (no treatment options to remove salt)
Dissolved oxygen	Level 1: < 4 mg/L at surface No Level 2
Pesticides	Level 1: Above detection limits specified by Qld Health Scientific Services Level 2: Notification of spills or illegal dumping
Hydrocarbons	No Level 1 Level 2: Notification of spills or illegal dumping

Level 1 denotes Level 1 Hazard and Critical Control Point (HACCP) response rating, namely: treatment-plant-process-change required to ensure water quality and quantity to customers is not compromised.

Level 2 denotes Level 2 Hazard and Critical Control Point (HACCP) response rating, namely: treatment-plant-process-change required but water quality and quantity to customers may still be compromised.

Although key WQOs for the protection of drinking water supply are provided above, it should be noted that the primary purpose of water sourced from Nathan Dam will be for industrial water supply, with a minor demand for drinking water supply. All drinking water supplies will be treated by the entity purchasing water from SunWater prior to distribution to its customers.

16.1.3. Methodology

The general condition of the Fitzroy Basin and the Dawson Catchment was assessed via a literature review. A summary of data used to assess existing and historical water quality within the Project area and other storages in the Fitzroy Basin is provided in Table 16-7. For the purposes of this EIS, existing water quality data is summarised and compared with the WQOs for aquatic ecosystems noting that the WQOs for aquatic ecosystems capture all of the WQOs for the other EVs applicable to the Dawson Catchment.

Table 16-7 Summary of data-sets

Data Source	Data Sets		Period of Data Collection	Area Described			
				Other Water Storages in the Fitzroy Basin	*Nathan Dam water area*	*Downstream of Nathan Dam inundation and buffer*	*Nathan Dam Pipeline*
DERM	Mackenzie Rv at Tartrus Weir	(site #: 130109A)	1986 - 2002	x			
	Fitzroy Rv at Eden Bann Weir	(site #: 130007A)	1983 - 1994	x			
	Dawson Rv at Taroom	(site #: 130302A)	1963 - 2006		x		
	Dawson Rv at Nathan Dam site	(site #: 1303013)	1998 - 1999		x		
	Dawson Rv at Glebe	(site #: 130303B)	1963 - 2005		x		
	Dawson Rv at Glebe Weir – Tailwater	(site #: 130345A)	1975 - 2006		x		
	Dawson Rv at Glebe Weir - Headwater	(site #: 130338A)	1982 - 2005		x		
	Dawson Rv at Nathan Gorge	(site #: 130320A)	1963 - 1986			x	
	Dawson Rv at Isla Delusion Crossing	(site #: 130358A)	1990 - 2001			x	
	Dawson Rv at Theodore	(site #: 130305A)	1963 - 2001			x	
	Dawson Rv at Woodleigh	(site #: 130317A)	1963 - 1984			x	
	Dawson Rv at Baralaba	(site #: 130304A)	1963 - 1989			x	
	Dawson Rv at Neville Hewitt Weir - Tailwater	(site #: 130361A)	1998 - 2001			x	
	Dawson Rv at Beckers	(site #: 130322A)	1964 - 2006			x	
SunWater	Dawson Rv at Glebe Weir		2001 - 2008		x		
	Dawson Rv at Gyranda Weir		2001 - 2010			x	
	Dawson Rv at Moura Weir		2001 - 2010			x	
	Dawson Rv at Neville Hewitt Weir		2001 - 2010			x	
	Dawson Rv at Theodore		2001 - 2010			x	
	Orange Creek Weir		2002 - 2004			x	
	Nogoa Rv at Fairbairn Dam		2001 - 2010	x			
	Fitzroy Basin ROP Annual Report 2006/2007		2006 - 2007	x			
	Fitzroy Basin ROP Annual Report 2007/2008		2007 - 2008	x			

Data Source	Data Sets	Period of Data Collection	Area Described			
			Other Water Storages in the Fitzroy Basin	***Nathan Dam water area***	***Downstream of Nathan Dam inundation and buffer***	***Nathan Dam Pipeline***
Nathan Dam and Pipeline EIS Baseline Study	FRC 2008	Dec 2007		x	x	
	Ecowise 2008a	Jun 2008		x	x	
	Ecowise 2008b	Oct 2008		x	x	
	FRC 2009	Jan 2009				x
Dawson Dam IAS and Supplementary Report	Anderson and Howland 1997 and 1998	1996 - 1998		x	x	

16.1.4. Dam and surrounds

16.1.4.1. Fitzroy Basin

The wider Fitzroy Basin is characterised by relatively high inputs of nutrients compared to other Australian catchments (Meecham, 2003; Moss *et al*., 1992); fluctuating and often low dissolved oxygen (DO) concentrations (Berghuis and Long 1999) and high turbidity (Meecham, 2003). However, description of water quality within the Fitzroy Basin is complicated by seasonal climate variation and influence from stream flows. Characterisation of the basin as a whole is therefore difficult and has limited application.

DEWHA (2007), through the Australian Natural Resources Atlas, compiled an assessment of water quality within the Fitzroy Basin. Although seventeen monitoring sites representing 97% of the catchment were monitored, data on relevant parameters is limited. The assessment found that surface water conductivity levels were within the relevant guidelines for health, agriculture and ecosystem values. Turbidity, however, exceeded ANZECC and ARMCANZ (2000) guidelines at most sites and consequently rendered the water unsuitable for human consumption and for the protection of aquatic species. Nutrient trends were limited due to insufficient data and could only be established for total phosphorus and total nitrogen. Total phosphorus concentrations were found to be moderate to high and were positively associated with the high level of suspended particles. Total nitrogen data was limited to the lower catchment and was recorded at extremely high concentrations.

Nutrient sources within the Fitzroy Basin have been strongly linked to diffuse sources (e.g. terrestrial runoff and agricultural practices) rather than point sources (FBA, 2008; Rolfe *et al.,* 2004a). This is, in part, due to both land use within the Fitzroy Basin and flood events.

The key land uses within the Fitzroy Basin include grazing, mining, agriculture (including dry-land and irrigated cropping), forestry and fishing. Grazing and cropping can contribute to poor water quality in different ways. Grazing covers a large area of the Basin, and as such contributes the most in terms of load (kg/ha/yr) impact on water quality. Whereas irrigated cropping, although occupying a relatively small proportion of the Basin, relies heavily on water storage, intensive fertiliser and pesticide use and large scale water use so may impact via higher concentrations of nutrients over short periods.

16.1.4.2. Other water storages in the Fitzroy Basin

SunWater undertakes routine monitoring of water quality at sites within the Fitzroy Basin in accordance with the requirements of the Fitzroy Basin Resource Operations Plan (ROP). Monitoring is undertaken at the following sites:

- Bingegang Weir (Mackenzie River);
- Tartrus Weir (Mackenzie River);
- Eden Baan Weir (Fitzroy River); and
- Fairbairn Dam (Nogoa River).

While each to these storages has individual characteristics, the results from routine monitoring indicate the potential water quality in Nathan Dam. A summary of these monitoring results is provided below, based on the Bingegang Weir, Tartrus Weir, and Eden Bann Weir ROP annual reports for 2006/07 and 2007/08 (SunWater, 2007; SunWater, 2008) and blue-green algae monitoring data provided by SunWater for Fairbairn Dam for the 2001 – 2010 period.

- Bingegang Weir

SunWater 2007-2008 monitoring results

Cyanobacteria were not detected in Bingegang Weir. This is consistent with the weak stratification classification of this storage.

Some nitrogen levels exceeded the guideline values and most of the phosphorous levels exceeded the guidelines. This was also reflected at the Inflow sites.

SunWater 2006-2007 monitoring results

For the majority of the 2006/07 water year, water temperatures were relatively homogeneous through the depth profile, varying by less than 3 °C on any one occasion. There was evidence of stratification in September – January; however, the shallow depth limited the variation. The water temperature recorded in the storage through the water year ranged from a minimum of 15.1 °C, to a maximum of 28.7 °C, with a median figure of 21.6 °C.

During the entire year the Bingegang Weir storage showed chemical stratification. However, strong stratification did not occur, in part due to the shallow depth of the weir. The February through May readings showed depleted oxygen levels throughout the profile. The DO readings recorded in the storage through the water year ranged from 0.22 - 7.17 mg/L, with a median figure of 4.26 mg/L.

Electrical Conductivity (EC) ranged from 150 - 320 µS/cm, with a median figure of 193 µS/cm.

The pH levels ranged from 6.7 - 8.2, with a median figure of 7.4.

Total Nitrogen (TN) levels ranged from 510 - 1110 µg/L, with a median figure of 710 µg/L.

Total Phosphorus (TP) levels ranged from 10 - 360 µg/L, with a median figure 210 µg/L.

- Tartrus Weir

SunWater 2007-2008 monitoring results

Cyanobacteria were only detected in Tartrus Weir during October to December 2007, including a small count of *Anabaena circinalis*. As the stratification pattern of Tartrus is unknown, a correlation cannot be drawn at this stage, however the occurrence of cyanobacteria during these months is within the "bloom season".

A weak to nil thermal stratification pattern was observed for Tartrus Weir, with dissolved oxygen (DO) data slightly erratic for the period.

Some nitrogen levels exceeded the guideline values and most of the phosphorous levels exceeded the guidelines. This was also reflected at the inflow sites.

SunWater 2006-2007 monitoring results

For the majority of the 2006/07 hydrologic year (1st July – 31st June), water temperatures were relatively homogeneous through the depth profile, varying by less than 3 °C. Strong stratification was recorded in November – January. The water temperature recorded in the storage through the water year ranged from 16.2 - 31.8 °C, with a median figure of 22.4 °C.

During the warmer months, October - January, and in May, the Tartrus Weir storage showed chemical stratification. Strong stratification was recorded in November and December, whilst the May readings showed depleted oxygen levels throughout the profile. The DO readings recorded in the storage through the water year ranged from 0.59 - 12.56 mg/L, with a median figure of 6.20 mg/L.

Electrical conductivity ranged from 124 - 218 µS/cm, with a median figure of 158 µS/cm.

The pH levels ranged from 6.6 - 8.5, with a median figure of 7.7.

Total nitrogen levels ranged from 240 - 850 µg/L, with a median figure of 670 µg/L. The storage readings were lowest in June.

Total phosphorus levels ranged from 40 - 250 µg/L, with a median figure of 130 µg/L.

- Eden Bann Weir

SunWater 2007-2008 monitoring results

The stratification pattern for Eden Bann Weir is yet to be determined. Therefore monthly DO and temperature profiles were sampled during October 2007 through to May 2008.

Based on the data, a slight thermal stratification is demonstrated during September and October, with DO results generally homogenous throughout the profile and the period. This is consistent with Eden Bann Weir representing a shallow impoundment, with a stratification pattern likely to be affected by meteorological conditions.

Electrical conductivity in the storage and sampled releases was within the guideline values, as was the inflow water quality. pH was below guideline values in some samples during the summer months within the storage, but not in releases. Upstream pH levels were generally within the guidelines, though slightly elevated in some samples.

Nitrogen levels generally exceeded the guideline values within the storage, during releases and in the background data collected at the inflow site. Phosphorous levels exceeded the guidelines in all samples, including the inflow samples.

No cyanobacteria were detected in Eden Bann Weir during the monitoring period.

- Fairbairn Dam

The species of cyanobacteria *Anabaena circinalis* and *Cylindrospermopsis raciborskii* were detected in Fairbairn Dam at various times in the 2001 to 2010 period. From 221 data points, *Anabaena circinalis* was recorded to be present on eight occasions, three (1%) of which, were above the QWQG (2009) drinking water quality guideline value of

2,000 cells/ml. All three times cell counts were above 2,000 cells/ml are related to a single 'bloom' event occurring throughout the April - May period of 2010.

Cylindrospermopsis raciborskii was slightly more abundant, being noted to be present in 93 of 264 data points, 37 (14 %) of which, were above the QWQG (2009) drinking water quality guideline value of 2,000 cells/ml. The occasions on which cell counts were above 2,000 cells/ml are relatively short lived and related to seven 'bloom' events:

- November 2001 – February 2002 (peak cell count of 12,000 cells/ml);
- October 2002 - February 2003 (peak cell count of 46,200 cells/ml);
- November - December 2003 (peak cell count of 3,500 cells/ml);
- November 2005 (peak cell count 2,800 cells/ml);
- February 2009 (peak cell count 20,300 cells/ml);
- November 2009 (peak cell count of 2,800 cells/ml); and
- November 2009 – January 2010 (peak cell count of 24,500 cells/ml).

Comparison of storages

Comparison of water quality results collected at Tartrus and Eden Bann Weir DERM monitoring sites with SunWater's monitoring site at Glebe Weir-Headwater reveals relatively similar medians for conductivity, dissolved oxygen (DO), pH and water temperature (Table 16-7). Turbidity, total nitrogen (TN) and total phosphorus (TP) at Glebe Weir is observed to be greatly elevated compared to Tartrus and Eden Bann Weir.

Table 16-8 Comparison of water quality between Tartrus Weir, Eden Bann Weir and Glebe Weir

Parameter	**Units**	**Glebe Weir - Headwater**		**Tartrus Weir**		**Eden Bann Weir**	
		No. of Samples	***Median***	***No. of Samples***	***Median***	***No. of Samples***	***Median***
pH	pH units	57	7.8	55	7.8	88	7.7
Conductivity	µS/cm	57	210	55	340	88	224
DO	mg/L	54	7.8	55	5.2	88	7.7
Temperature	°C	57	24	55	25.7	88	24.3
Turbidity	NTU	51	168	38	23	62	62
Total Nitrogen as N	µg/L	54	1200	9	580	10	480
Total Phosphorus as P	µg/L	54	320	10	80	10	185

Overview of existing storage monitoring results

Results of water quality monitoring programs conducted at these other water storages in the Fitzroy Basin indicate that:

- storages tend to be unstratified most of the year, or slightly stratified during the warmer months (September – January). Strong stratification only occurred in Tartrus Weir in one period from November 2006 to January 2007;
- total nitrogen and phosphorus levels tend to exceed guidelines, in both inflow waters and the storages;
- electrical conductivity is generally below guidelines; and

- cyanobacterial species occur, but in low numbers.

16.1.4.3. *Dawson Catchment*

The Dawson Catchment covers an area of approximately 50,800 km^2. The Dawson River eventually flows into the Fitzroy River, approximately 85 km south-west of Rockhampton. The Dawson Catchment covers 35% of the Fitzroy Basin.

Land-use within the Dawson sub-catchment is dominated by grazing with small areas of irrigated cropping and some areas of state forest located higher in the catchment.

The Dawson River has highly variable stream-flow and is characterised by a series of long and deep relatively permanent pools separated by runs (Burrows & Butler, 1998). The middle and lower reaches are long and winding and are characterised by very low gradient. The lower section of the Dawson River is highly regulated with 34% of the river, downstream of the proposed dam, currently impounded. This reach is also where irrigation occurs. The Dawson River always contains water, although some of its tributaries dry out seasonally (Burrows & Butler, 1998).

16.1.4.4. *Proposed water storage area*

The dam will inundate 75.2 km of the Dawson River, including approximately 30 km of the existing Glebe Weir water storage, beginning 2 km upstream of the Gyranda Weir back waters (at FSL) and ending a further 20 km upstream of the Glebe Weir pool. The water storage will back up to the town of Taroom, the only town in the immediate catchment, and will extend into several small tributaries. There are 18 permanent or intermittent tributaries that enter the water storage area. The catchment area upstream of the proposed dam is approximately 23,185 km^2. The new river regime will consist of the unregulated Dawson River flowing into the dam which then releases downstream to the existing Gyranda Weir pool and then to the other weirs further downstream. Water will also be extracted from water storage to enter the pipeline.

Historical DERM data

Water quality results were obtained from DERM historical records as listed in Table 16-7. A summary of water quality results collected at each of the monitoring sites is presented in Table 16-9 and presented in full in Appendix 16-A. Note that some of the values, particularly the metal levels in Glebe Weir, are derived from only one sample and may not represent long term levels.

Table 16-9 Summary of median water quality data collected at DERM monitoring stations (DERM, 2010)

Parameter	Units	Relevant Guideline	Site				
			Taroom	Nathan Dam	Glebe Recorder	Glebe Weir - Tailwater	Glebe Weir - Headwater
In-situ							
pH	pH units	6.5 - 7.5	**7.7**	7.1 - **7.7****	**7.6**	**7.6**	7.5
Conductivity	µS/cm	340	258	160 - 181**	180	189	164
DO	mg/L	x	5	4.0 - 9.3**	9.4*	7.7	5.9
Temperature	°C	x	23	17.3 - 19.4**	28.4*	24	25
Turbidity	NTU	25	**59**	**33 - 190****	**330***	**100**	**168**
Metals							
Aluminium	µg/L	55	50^	0 - 30**^	**60***	**90^**	50^
Boron	µg/L	370	30	0 - 0**	50 - 60**	20	20
Cadmium	µg/L	0.2					**200***
Chromium	µg/L	1					2000*
Copper	µg/L	1.4	**30^**	0 - 0**^	**30***	**20^**	4000*^
Lead	µg/L	3.4					2000*
Manganese	µg/L	1900	20^	0 - 0**^	30*	0 - 10**^	90000*
Nickel	µg/L	11					5000*
Zinc	µg/L	8	**10^**	**10 - 40**^**	**70***	0 - **20**^**	**20000*^**
Nutrients							
Nitrate as N	µg/L	10	**100**	**210 - 1300 ****	0 - **2400****	**20 - 50****	**1310**
Nitrite + Nitrate as N	µg/L	15	**30***			**110 - 1110****	**105**
Total Kjeldahl Nitrogen as N	µg/L	225	670*	920 - 920**		750*	1900*
Total Nitrogen as N	µg/L	250	**670**	230 - **920****	**1420***	**2550***	**960**
Total Phosphorus as P	µg/L	30	**140**	**80 - 280****	**480***	**110 - 520****	**320**
Reactive Phosphorus - Filtered	µg/L	15	**45**			18 - 84**	**89**
Other							
Colour	Hazen Units	50		17 - 29**	6*	33	26
Chl-a	µg/L	5					**8 - 28****

X = absence of guideline value
* = value generated from a single data point
** = min and maximum range displayed as dataset is insufficient to generate median value
^ = value for dissolved concentration (not total)
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

SunWater data

SunWater water quality sampling results are derived from three sites associated with Glebe Weir: an inflow site for which data only exists as monthly surface data between October 2007 and May 2008; a tailwater site (GS 130345A) immediately downstream of the weir, with surface spot data collected quarterly from December 2001 to September 2004, no data for 2005 - 2006, then monthly from September 2007, and; a headwater site (GS 130338A) immediately upstream of the weir, with grab or profile data quarterly from September 2001 to September 2004 and monthly data since. Water quality results from these three sites is summarised in Table 16-10 and presented in full in Appendix 16-B.

Table 16-10 Summary of median water quality data associated with SunWater monitoring program of Glebe Weir 2001-2008 (SunWater, 2010)

Parameter	Units	Relevant Guideline	Site		
			Glebe Weir - Inflow	Glebe Weir - Headwater	Glebe Weir - Tailwater
pH	pH units	6.5-7.5	**7.8**	**7.8**	**7.7**
Conductivity	µS/cm	340	**345**	210	205
DO	mg/L	x	6.15	7.85	7.8
Temp	°C	x	24	24	25
TN	µg/L	250	**710**	**1200**	**1000**
TP	µg/L	30	**280**	**320**	**310**
Turbidity	NTU	25	**209**	**425**	**500**
Chl-a	µg/L	5		2 - **24****	1

X = absence of guideline value
** = min and maximum range displayed as dataset is insufficient to generate median value
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

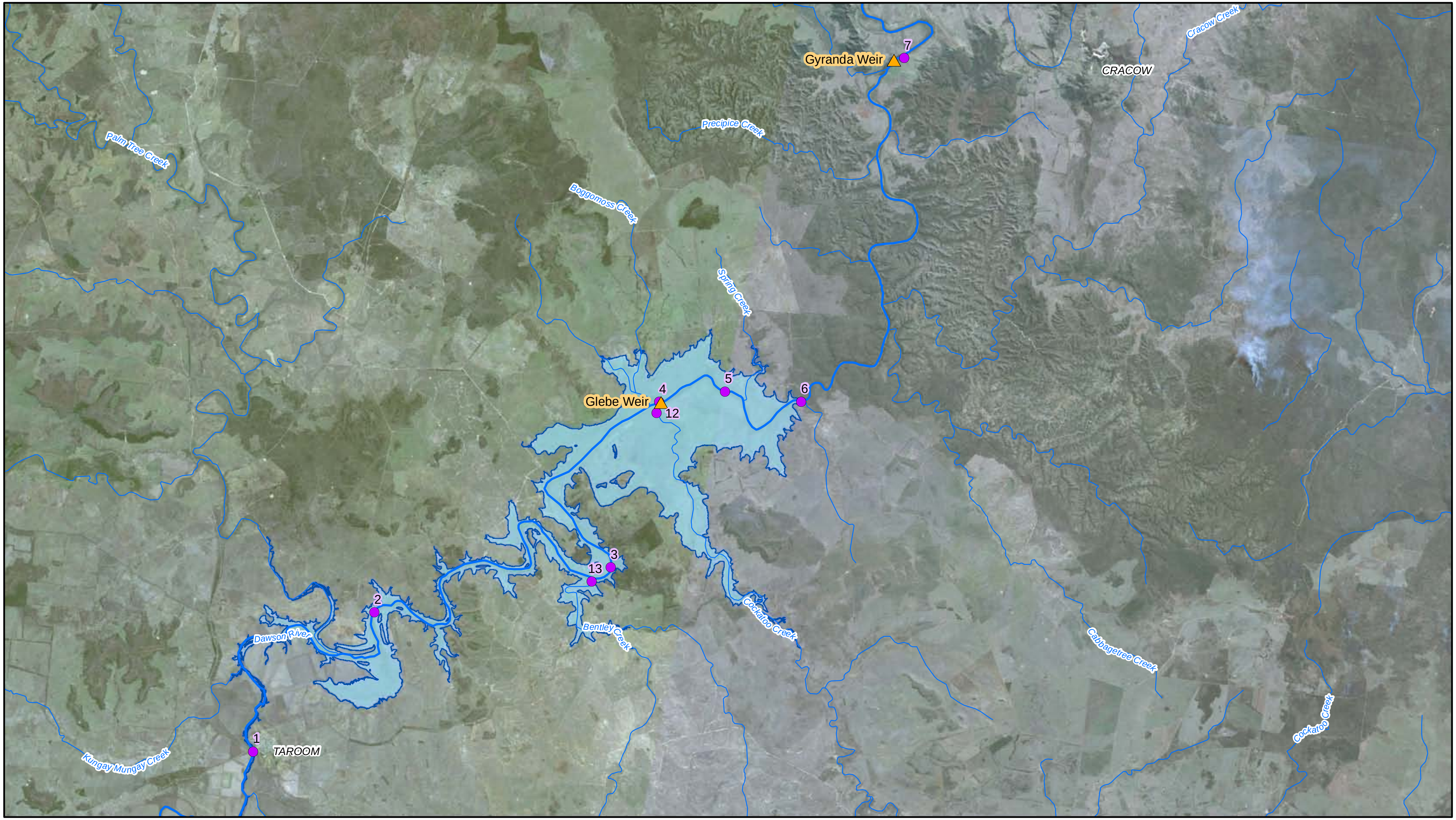
Nathan Dam baseline study data

Data for key parameters from the Nathan Dam EIS baseline study is summarised in Table 16-11, Table 16-12 and Table 16-13 and presented in full in Appendix 12-A, Appendix 12-B and Appendix 12-C. All values represent results from a single monitoring event.

The site network included sites on the main channel of the Dawson River upstream (N1), within (N2, N3, N4 and N5) and downstream (N6 and N7) of the water storage area. Two sites were located within the proposed water storage area on tributaries of the Dawson River; Bentley Ck (N13) and Cockatoo Creek (N12). Sites N1 and N3 are natural pools 59.2 and 15.1 km upstream of the existing Glebe Weir, respectively; site N2 is a glide (a flowing but not turbulent habitat) 39.2 km upstream of Glebe Weir; site N4 is situated within Glebe Weir (in close proximity to the wall); sites N5 and N6 are shallow riverine pools 4.7 and 11.2 km downstream from Glebe Weir; and site N7 is in Gyranda Weir pool, situated 41.7 km downstream from Glebe Weir (Figure 16-1).

It should be noted that the sites ranged from large deep pools to small shallow pools, flowing water (when available) and off-stream water bodies (billabongs). Sites were selected to represent the range of waterbodies in the study area so consistency between sites should not necessarily be expected.

The laboratories limit of resolution (LOR) was often above the guideline level for metals.



LEGEND

- Water Quality Site Locations
- Weir
- Dawson River
- Watercourse
- Full Supply Level (183.5 m AHD)

Projection: GDA94 Zone 56

Figure 16-1

0 1.5 3 6
Kilometres

N

Scale 1:300,000 (at A4)

SKM SunWater Making Water Work

NATHAN DAM AND PIPELINES EIS

Map displaying relative site locations associated with Nathan Dam EIS baseline surveys

I:\QENV2\Projects\QE40192\400 - Nathan - Spatial\ArcMXD\Figures\160_SurfaceWaterQuality\Figure_16-1_WQ_Sites_Associated_With_Baseline_Study.mxd Produced: 29/06/2011

Table 16-11 Summary of in-situ water quality results associated with Nathan Dam EIS pre wet-season baseline survey 2007 (adapted from FRC, 2008)

Parameter	Units	Relevant Guideline	Site N1 during flood	Site N2 pre-flood	Site N2 during flood	Site N4 pre - flood	Site N12 pre-flood
Temperature	°C	X	23	23.9	23.9	23.5	24.6
pH	pH units	6.5 – 7.5	6.5	6.8	6.8	**6.3**	**6.3**
Conductivity	(µS/cm)	340	110	**442**	440	198	198
DO	mg/L	X		2.7	2.5	1.9	1.9
DO	% sat	90 - 110		**31.4**	30.5	**22.8**	**22.8**
Turbidity	NTU	25	1180	**600**	600	**600**	**600**

x = absence of guideline value
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3
note: = water quality measurements collected during 'flood' conditions cannot be compared to guideline.

Table 16-12 Summary of in-situ water quality results associated with Nathan Dam EIS post-wet season baseline survey 2008 (adapted from Ecowise, 2008a)

Parameter	Units	Relevant Guideline	Site N1	N2	N3	N4	N5	N6	N7	N13
In-situ										
Temperature	°C	X	14.8	15.3	17.2	16.7	11.5	14.4	17.9	19.6
pH	pH units	6.5 – 7.5	7.5	7.5	7.4	7.4	7.1	7.1	7.1	**7.8**
Conductivity	(µS/cm)	340	312	**340**	320	214	222	152	181	**370**
DO	mg/L	X	6.2	8.2	6.5	7.7	4.4	5.8	6.4	8.5
DO	% sat	90 - 110	**61.8**	**83.6**	**68**	**80**	**41.3**	**57**	**68**	95
Turbidity	NTU	25	22	**28**	20	**131**	13	**38**	**137**	16
Metals										
Aluminium (pH <6.5)	µg/L	55	**170**	**510**	**230**	**3870**	**320**	**760**		**170**
Copper	µg/L	1.4	1	**2**	**2**	**4**	**2**	<1		1
Zinc	µg/L	8	<5	6	**71**	**15**	<5	**32**		<5
Nutrients										
Nitrite + Nitrate as N	µg/L	15	**86**	<10	<10	**170**	<10	<10		<10
Total Kjeldahl Nitrogen as N	µg/L	225	**400**	**300**	**1000**	**1000**	**800**	<100		200
Total Nitrogen as N	µg/L	250	**500**	**300**	**1000**	**1100**	**800**	<100		200
Total Phosphorus as P	µg/L	30	30	**50**	20	**120**	**50**	**90**		30
Reactive Phosphorus - Filtered	µg/L	15	11	<10	<10	**18**	<10	**36**		<10

X = absence of guideline value
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

Table 16-13 Summary of in-situ water quality results associated with Nathan Dam EIS pre wet-season baseline survey 2008 (adapted from Ecowise, 2008b)

Parameter	Units	Relevant Guideline	Site N1	N2	N3	N4	N5	N6	N7	N13
In-situ										
Temperature	°C	x	24.5	24.3	26.1	23.5	22.2	21.6	22.9	29.1
pH	pH units	6.5 – 7.5	7.1	7.2	7.3	7.2	7	6.9	7.2	7.3
Conductivity	(µS/cm)	340	**387**	**400**	258	228	286	230	291	267
DO	mg/L	x	3.7	4.9	5.3	7.1	5	6.1	6.6	4.8
DO	% sat	90 - 110	**46.1**	**60.6**	**67.7**	**85.6**	**59.7**	**71.2**	**78.5**	**64**
Turbidity	NTU	25	**58**	**91**	**96**	**147**	**51**	**124**	**39**	**101**
Metals										
Aluminium (pH <6.5)	µg/L	55	**2520**	**3410**	**460**	**5750**	**570**	**1640**		**3000**
Copper	µg/L	1.4	**3**	**4**	**3**	**5**	**2**	**3**		**4**
Zinc	µg/L	8	6	**9**	<5	**14**	<5	<5		**9**
Nutrients										
Nitrite + Nitrate as N	µg/L	15	**70**	**90**	<10	10	<10	**110**		<10
Total Kjeldahl Nitrogen as N	µg/L	225	**800**	**2000**	**2600**	**1400**	**1400**	**1000**		**1100**
Total Nitrogen as N	µg/L	250	**900**	**2100**	**2600**	**1400**	**1400**	**1100**		**1100**
Total Phosphorus as P	µg/L	30	**200**	**200**	**370**	**1840**	**2160**	**200**		**710**
Reactive Phosphorus - Filtered	µg/L	15	**40**	**70**	**30**	**100**	**110**	**40**		**50**

X = absence of guideline value
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

Discussion of data for key water quality parameters

Temperature

Historical data obtained from DERM and SunWater report water temperatures throughout the proposed wwater storage area to range from 9 - 31 °C. Median values are noted to vary depending upon site but were between 23 - 25 °C. Data collected during the Nathan Dam EIS pre wet-season baseline survey support this finding with water temperature generally noted to be between 23 - 25 °C. As would be expected under normal conditions, results from the Nathan Dam EIS baseline study indicate that water temperatures are subject to seasonal variation, with notably lower temperatures, below 20 °C, observed at all sites throughout the study area during the cooler, post-wet season (June 2008) sampling event. The study also indicated that at all sites water temperature steadily decreases with increasing depth (Figure 16-2 and Figure 16-3); and slightly decreases overnight (Figure 16-4).

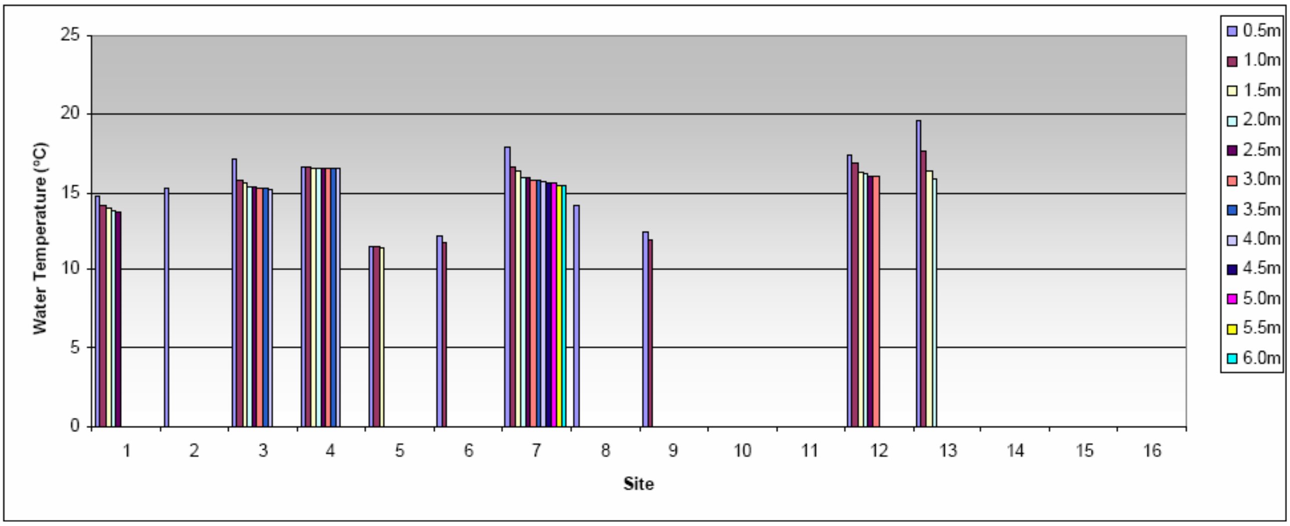


Figure 16-2 Temperature profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Note: sampling was not conducted at sites N10, N11, N14, N15 and N16.

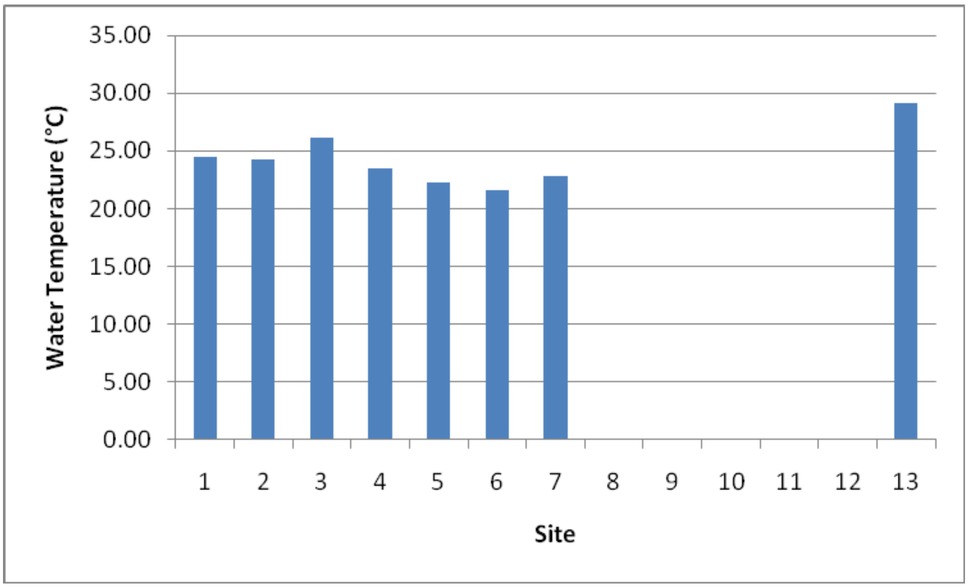


Figure 16-3 Temperature at sites sampled during the 2008 pre wet-season baseline survey (as presented in Ecowise, 2008b)

Note: sampling was not conducted at sites N8, N9, N10, N11 and N12.

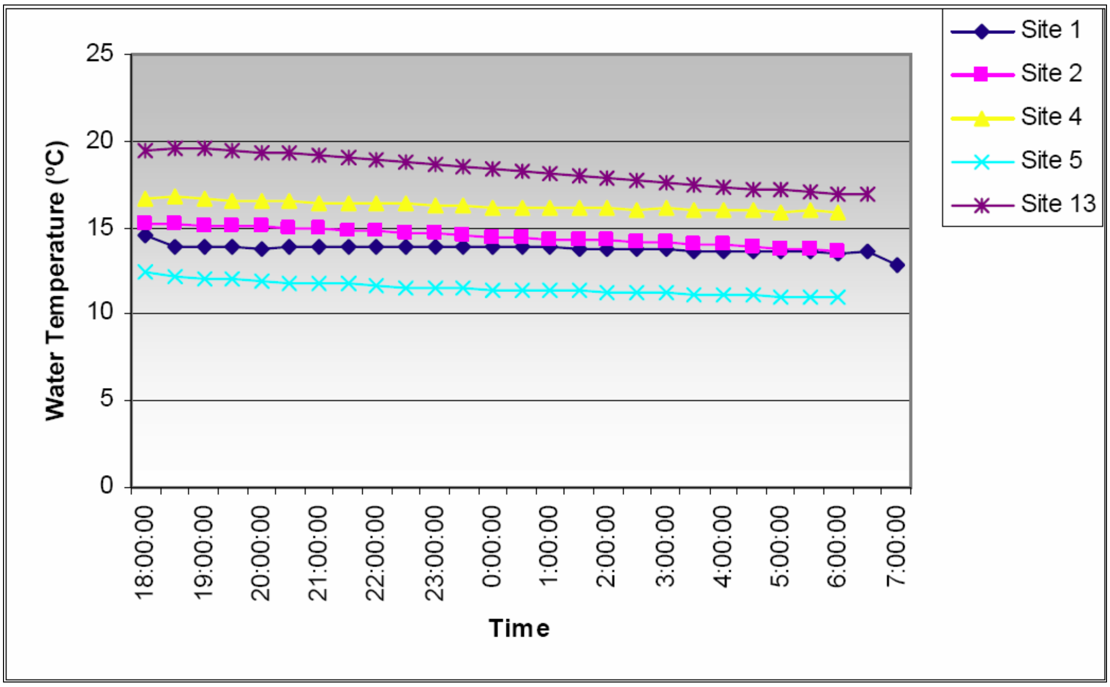


Figure 16-4 Diurnal temperature profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Conductivity

Historic data obtained from DERM and SunWater report conductivities ranging from 89 - 522 µS/cm throughout the study area. Although maximum values generally exceed the relevant QWQG (2009) guideline trigger value of 340 µS/cm, median values were generally between 180 and 250 µS/cm. Data collected during the Nathan Dam EIS baseline surveys supports this pattern of results with conductivity observed to be below 340 µS/cm at the majority of sites in both post- and pre wet-season surveys, and a maximum value of 400 µS/cm. As would be expected under normal conditions, results from the study indicate that electrical conductivities are subject to seasonal variation, with slightly higher concentrations observed at all sites during the pre-wet season sampling event. Results from the study indicate that at all sites conductivities remain stable throughout the water column (Figure 16-5 and Figure 16-6) and stable overnight (Figure 16-7).

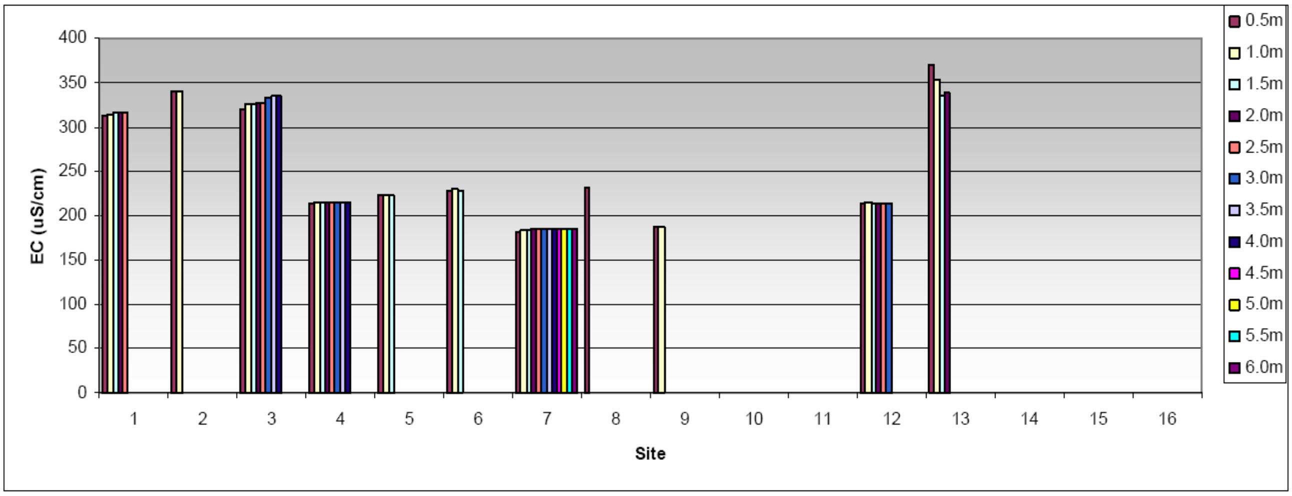


Figure 16-5 Conductivity profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Note: sampling was not conducted at sites N10, N11, N14, N15 and N16.

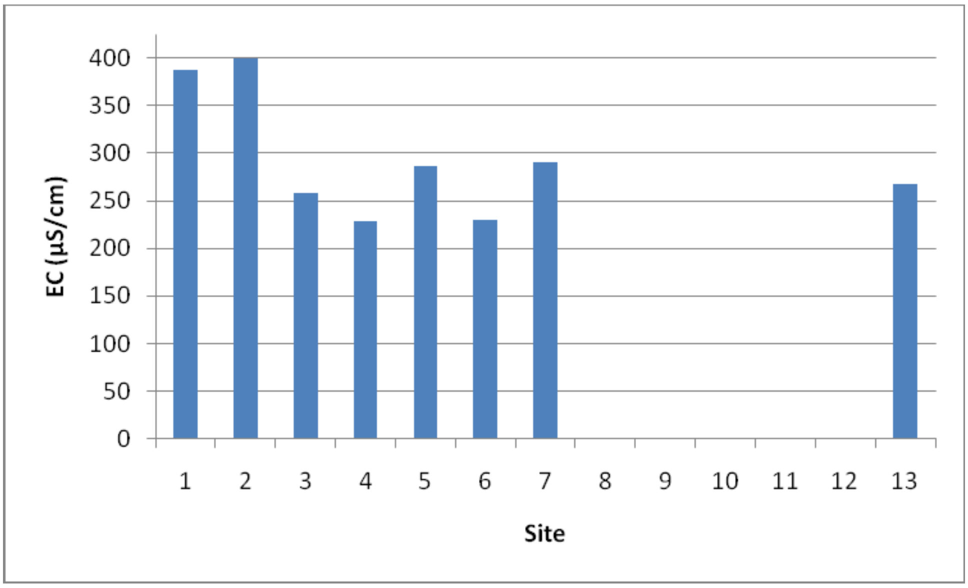


Figure 16-6 Conductivity at sites sampled during the 2008 pre wet-season baseline survey (as presented in Ecowise, 2008b)

Note: sampling was not conducted at sites N8, N9, N10, N11 and N12.

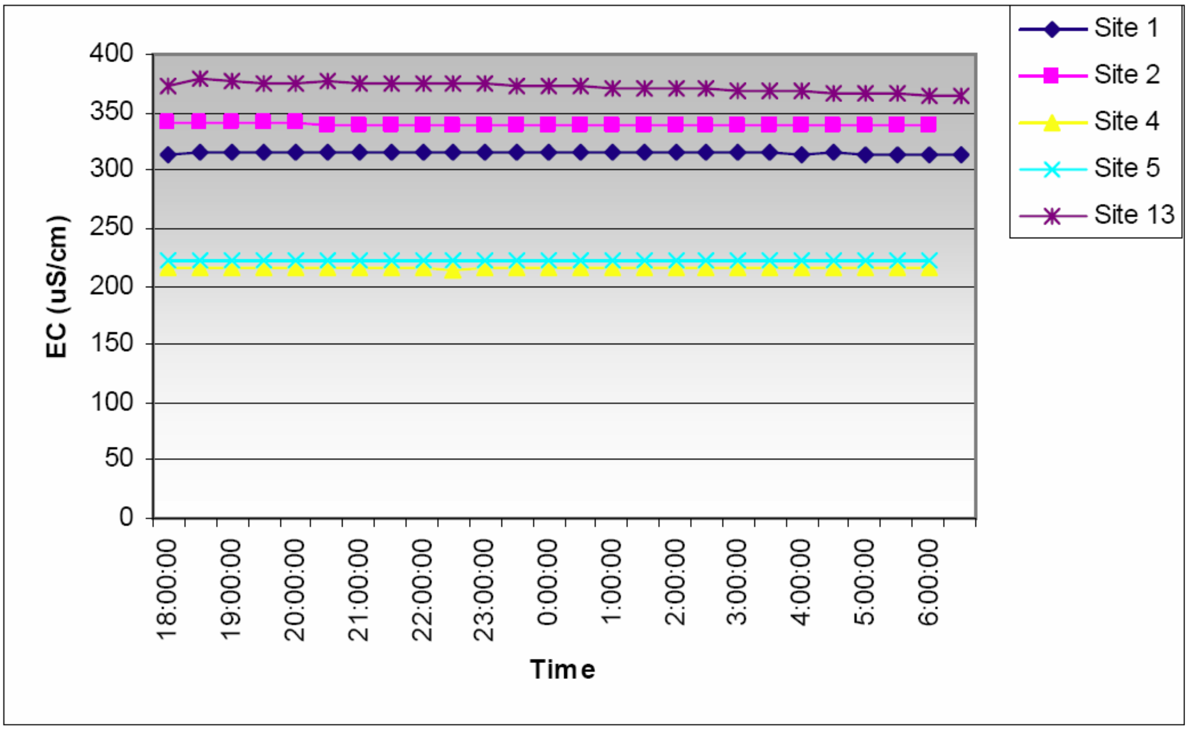


Figure 16-7 Diurnal conductivity profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008b)

pH

Historic data obtained from DERM and SunWater report pH values ranging from 6.5 - 8.5 throughout the study area. Median values were noted to vary slightly depending upon site but were observed to fall between 7.5 - 7.8, and thus generally above the QWQG (2009) upper guideline value 7.5. A similar pattern of results is displayed by data collected during the Nathan Dam EIS baseline surveys, with pH values ranging from 6.3 - 7.7, and generally within the QWQG (2009) guideline range of 6.5 - 7.5. Had a more flexible pH range of 6.5 - 8.5 been adopted, as proposed by the FBA draft WQOs, historic medians for all sites and all measurements collected during the baseline surveys, would have fallen within the 'relevant guideline' range. Seasonal variation in pH levels is apparent in the results from the baseline surveys, with slightly lower values observed at all sites during the pre-wet season sampling event. Results from the baseline study post-wet season sampling event, indicate slight fluctuations in pH throughout the water column (Figure 16-8 and Figure 16-9), with some sites recording a slight decreasing trend. At all sites pH was observed to remain relatively stable overnight (Figure 16-10).

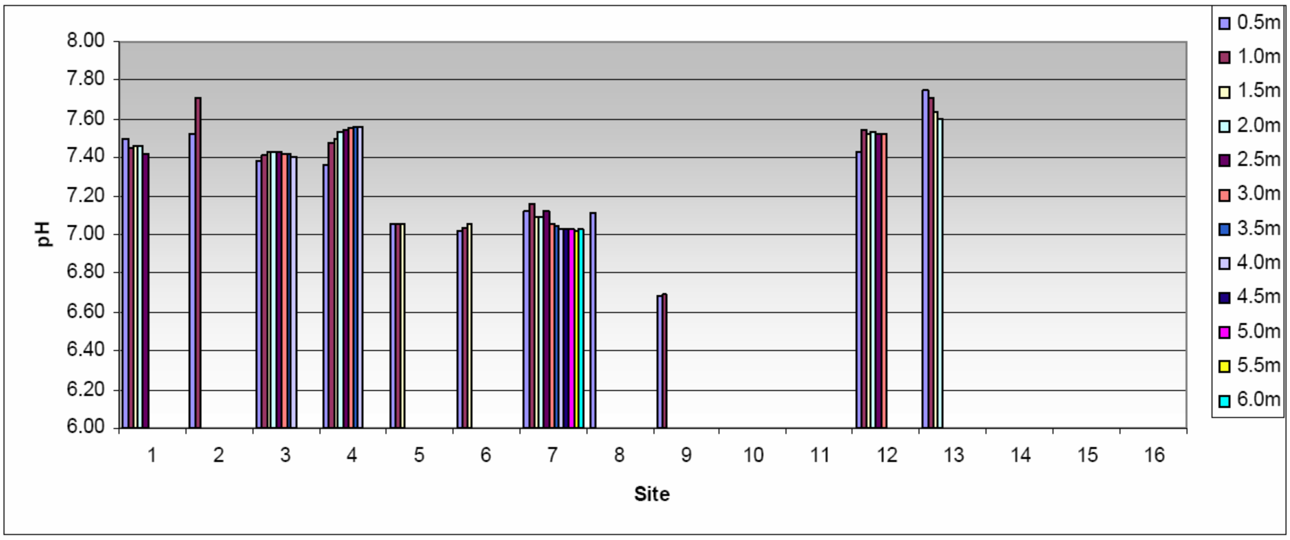


Figure 16-8 pH profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Note: sampling was not conducted at sites N10, N11, N14, N15 and N16.

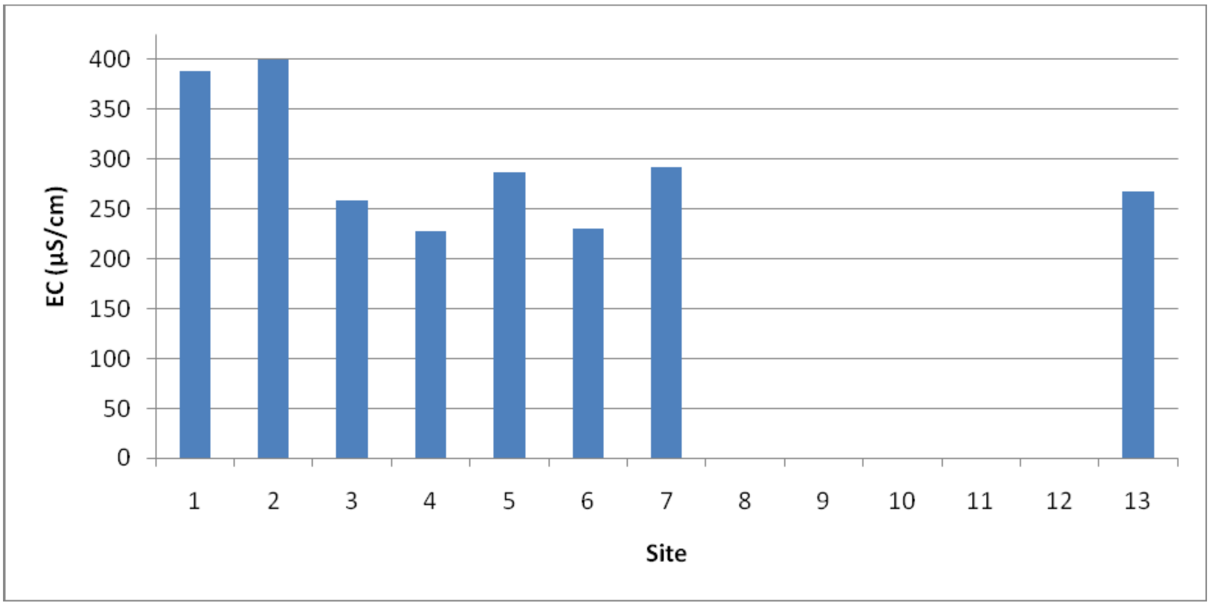


Figure 16-9 Conductivity at sites sampled during the 2008 pre wet-season baseline survey (as presented in Ecowise, 2008b)

Note: sampling was not conducted at sites N8, N9, N10, N11 and N12.

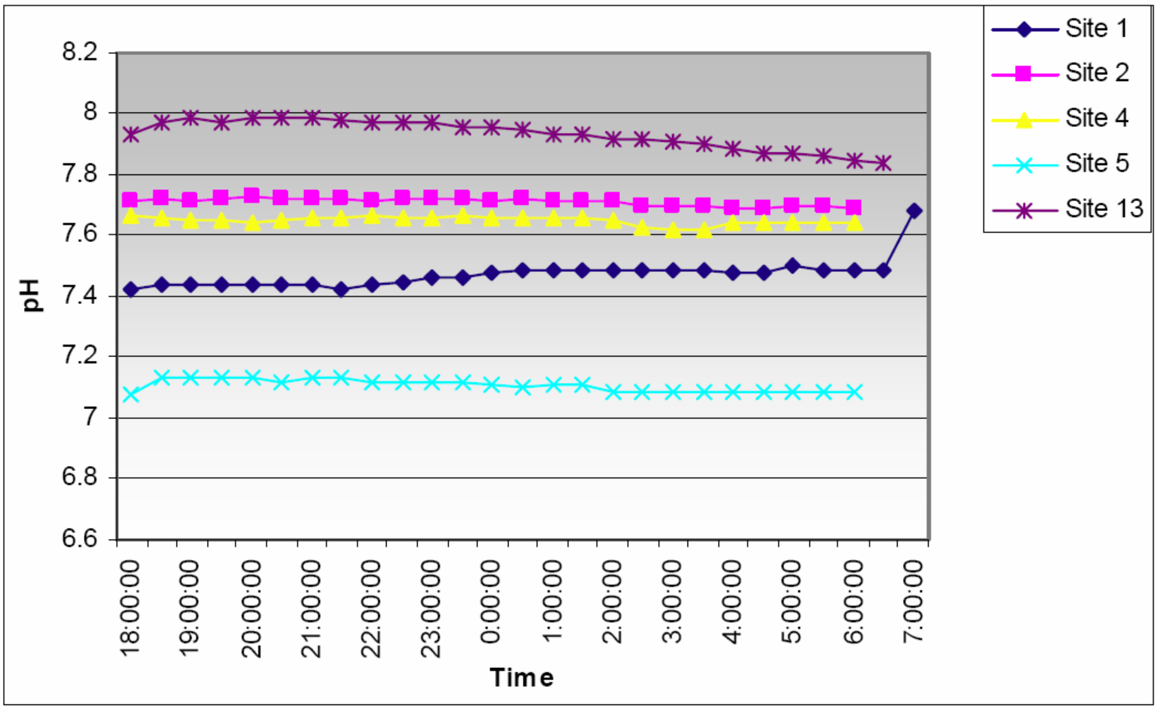


Figure 16-10 Diurnal pH profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Dissolved oxygen

There is limited data on DO concentrations throughout the proposed water storage area. Coupled with this, results can depend on a number of factors including, but not limited to, time of sampling, presence of macrophytes, biological oxygen demand, presence/absence of algae and thermal stratification. Medians generated from historic DERM and more recent SunWater data-sets should be interpreted with caution as they are based on a relatively small number of data points.

Historic data obtained from DERM report indicate surface DO concentrations range from 3.4 - 10.0 mg/L throughout the water storage area. Medians were variable depending upon site location but were between 5.0 - 7.85 mg/L. Data collected during the Nathan Dam EIS baseline surveys indicate surface DO concentrations to be highly variable between site and season with values generally above the QWQG (2009) Drinking Water Guideline minimum value of 4 mg/L, but generally below the QWQG (2009) guideline value of 90% saturation for protection of ecosystems.

The SunWater data set includes vertical profiling of the water column (measured at 1.0 m intervals) at the Glebe Weir headwater site. Inspection of this data-set reveals:

- stratification was observed to occur on six occasions (April '08, January '06, November '05, February '05, March '04 and December '01). The occurrence, degree and depth of stratification were observed to vary on each occasion;

- very low DO concentrations were observed to occur throughout the entire water column on ten occasions (April 2007, March 2007, April 2006, March 2006, February 2006, December 2005, October 2005, April 2005, November 2004 and March 2002); and
- potential supersaturation was observed to occur on seven occasions (August '07, July '07, June '07, July '06, March '03, December '03 and June '02).

Vertical profiling of DO concentrations throughout the water column (measured in 0.5 m intervals) conducted during the 2008 post-wet season sampling event, revealed that DO concentrations declined with increasing depth (Figure 16-11 and Figure 16-12). Diurnal logging of DO concentrations conducted during the same sampling event suggest that at this time DO concentrations remain stable (Figure 16-13).

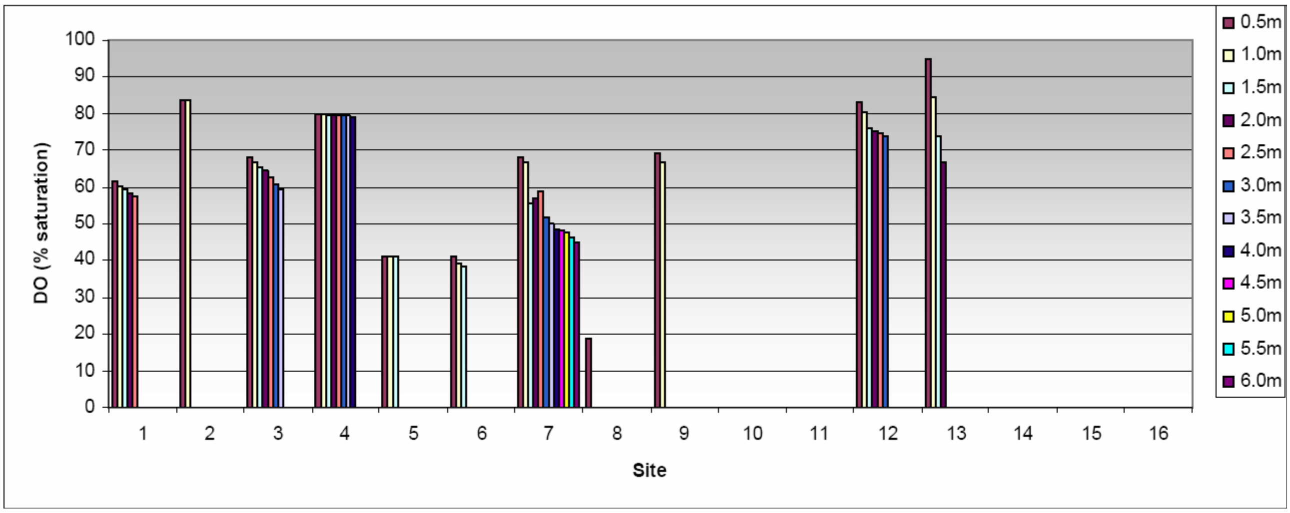


Figure 16-11 DO profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Note: sampling was not conducted at sites N10, N11, N14, N15 and N16.

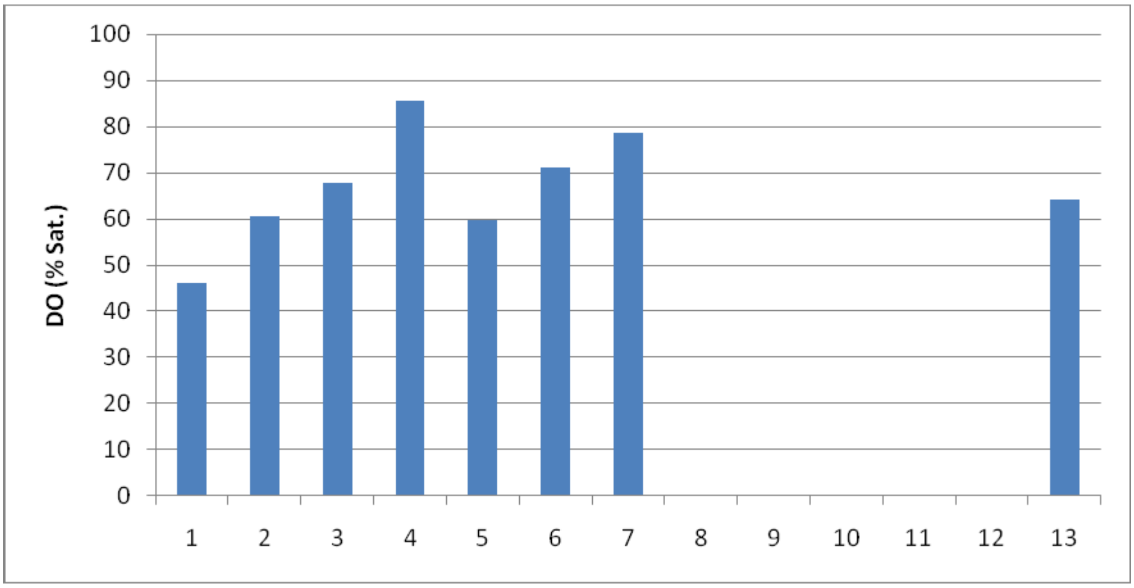


Figure 16-12 DO at sites sampled during the 2008 pre wet-season baseline survey (as presented in Ecowise, 2008b)

Note: sampling was not conducted at sites N8, N9, N10, N11 and N12.

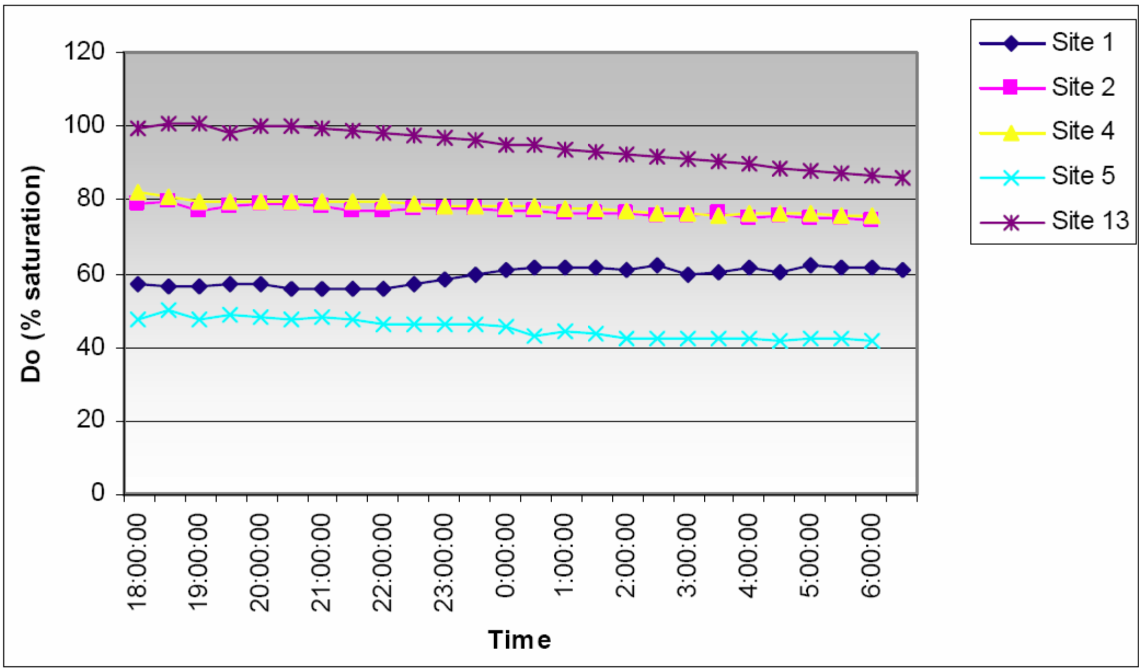


Figure 16-13 Diurnal DO profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

Turbidity

Water quality within the water storage area is characterised by temporally and spatially variable turbidity levels, with maximum turbidity levels greatly in excess of the QWQG (2009) guideline value of 25 NTU. Historical data obtained from DERM report turbidity to range between 1 - 2790 NTU throughout the water storage area, whilst data obtained from SunWater report turbidity to range between 2 - 1400 NTU. Data collected during the Nathan Dam EIS baseline surveys recorded turbidity to range between 13 - 147 NTU during 2008 post- and pre wet-season surveys; values which contrast sharply with turbidity levels of 600 NTU observed throughout the water storage area during the 2007 pre-wet season baseline survey (prior to flooding). As expected, results from the baseline study indicate that turbidity levels are subject to seasonal variation, with markedly higher levels observed at all sites during the pre-wet season sampling event. Results from the baseline surveys indicate that at all sites turbidity levels remain stable throughout the water column (Figure 16-14 and Figure 16-15) and stable overnight (Figure 16-16).

Results from the baseline surveys also indicate that turbidity is higher at Glebe Weir (site 4) than other monitoring locations within the water storage area. Gyranda Weir (site 7) displayed similar levels during the 2008 post-wet season survey but not during the 2008 pre-wet season survey.

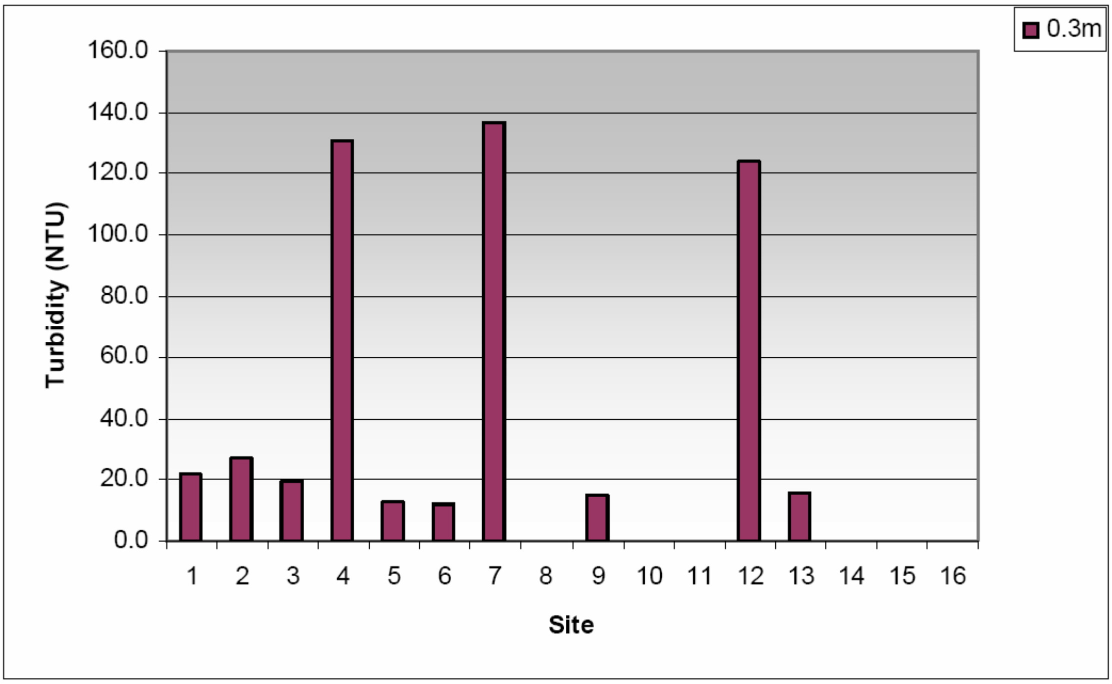


Figure 16-14 Turbidity at sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

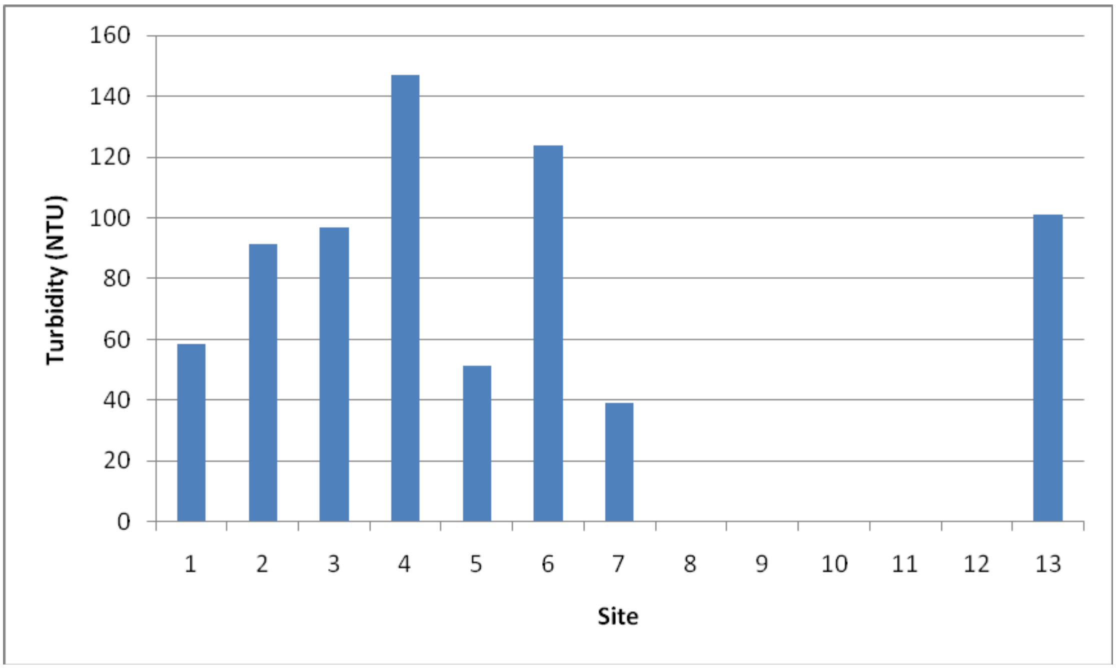


Figure 16-15 Turbidity at sites sampled during the 2008 pre wet-season baseline survey (as presented in Ecowise, 2008b)

Note: sampling was not conducted at sites N8, N9, N10, N11 and N12.

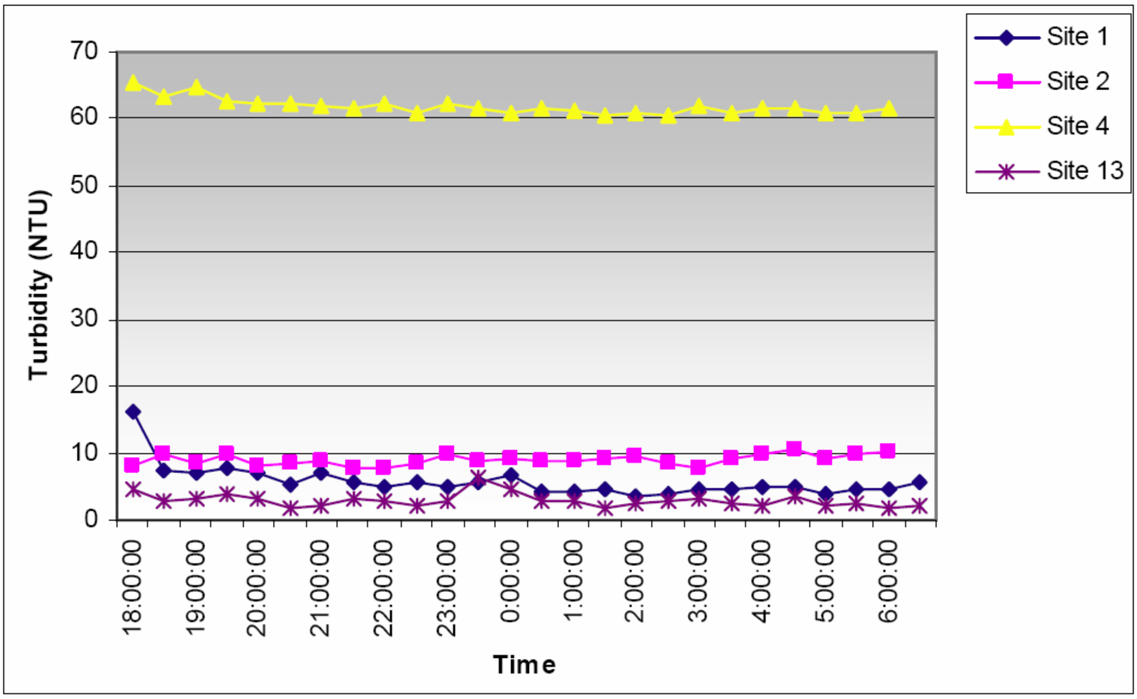


Figure 16-16 Turbidity profiles for sites sampled during the 2008 post wet-season baseline survey (as presented in Ecowise, 2008a)

- Nutrients

Historical DERM nutrient data is very limited. DERM records often do not have data relating to all of the nutrient related water quality parameters listed in Table 16-1 and in the majority of cases when data is present for a particular parameter, the data set is too small to generate median values. Although median values were able to be produced for the Dawson River at Taroom and the Dawson River at Glebe Weir Headwater sites, these data sets are still relatively small and should be interpreted with caution.

Generally, historical DERM and SunWater data report nutrient concentrations to significantly exceed relevant guidelines for all parameters measured (Table 16-1). Samples collected during the Nathan Dam EIS baseline surveys support the observation of high nutrient concentrations throughout the study area. Results from the baseline study indicate that nutrient concentrations are subject to seasonal variation, with generally higher concentrations observed during the pre-wet season sampling event.

- Metals

Historical metals data is very limited. DERM records often do not have data relating to all the metal related water quality parameters listed in Table 16-1 and in the majority of cases when data is present for a particular parameter, the data set is too small to generate median values. Additionally, it should also be noted that for the majority of the metals listed, the data at some sites represents measurements of soluble concentrations, whilst at others, total.

Although limited, the data-set indicates concentrations of aluminium, cadmium, copper and zinc to be in excess of relevant WQOs at one or more sites throughout the proposed water storage area. Data collected during baseline surveys supports this finding, with total concentrations of aluminium, copper and zinc to be in excess of relevant WQOs at several sites in both pre-wet and post-wet surveys. In particular, concentrations of these three metals at Glebe Weir (site 4) were observed to be several times higher than measurements collected at all other sites within the proposed water storage area. Results from the baseline study indicate that metal concentrations are subject to seasonal variation, with generally higher concentrations observed during the pre-wet season sampling event.

- Bacteria

No bacterial data has been located for this study. There is a sewage treatment plant located in Taroom that discharges into the Dawson River. Considering the relatively low human population (633) of Taroom and the legislative requirements placed on discharge limits, human derived enteric bacterial levels are expected to be low. Agriculturally derived bacterial concentrations may be expected to be elevated at times, particularly during overland flow events.

- Chlorophyll and algae

Historical DERM data is very limited with respect to Chlorophyll and Algae. Chlorophyll-a (Chl-a) concentrations were observed to range from 2 - 7 µg/L and 8 - 28 µg/L at Taroom and Glebe Weir Headwater, respectively. SunWater data reports chlorophyll-a concentrations to range from 0 - 24 µg/L across Glebe Weir with a median value of between 1- 2 µg/L. Collectively, these results indicate that chlorophyll-a measurements do exceed the relevant guideline of 5 µg/L throughout the water storage area and can be particularly elevated in Glebe Weir.

Results from SunWater monitoring programs indicate that blue-green algal records show highest counts in October 2001 and December 2003 (peak cell counts per species of 8570 cells/ml, with *Aphanocasps holsatica* the most common species and occasional, significant representation by *Anabaena spiroides*, *Planktolyngbya minor* and *Cylindrospermopsis raciborskii*). No significant numbers have been recorded since this time.

- Colour

Colour data is restricted to a small amount of historical data recorded by DERM. There is no guideline for colour in relation to aquatic ecosystems, although there is for drinking water supply. This guideline was supplied by the south-east Queensland Water Corporation and is based on their guideline for water storages in south-east Queensland. The guideline of 50 Hazen Units is used in this report. Values ranged from 7 - 208 Hazen Units throughout the proposed water storagewater storage with a median of 26 Hazen Units recorded at Glebe Weir Headwater. Although, as mentioned above, it is important to remember that drinking water sourced from Nathan Dam will be treated prior to use.

- Pesticides and herbicides

Pesticides and herbicides were monitored as part of the baseline surveys (Ecowise 2008a and 2008b; Appendix 12-B and Appendix 12-C). Individual results from one pre- and one post-wet season sampling event were compared to relevant guidelines as there was insufficient data to create medians. In regards to certain parameters (Heptachlor, Aldrin, alpha-Endosulfan, cis-Chlordane, Dieldrin, 4.4'-DDE, Endrin, beta-Endosulfan, 4.4'-DDT, Methoxychlor, Dimethoate, Diazinon, Chlorpyrifos, Malathion, Parathion, Azinphos Methyl and MCPA), the LOR was above the guideline value. As such, it remains unknown whether or not the parameters were exceeded or met the guideline value. There was no demonstrated exceedance of the guidelines in either of the sample periods.

- Macrophytes

The extent and location of freshwater macrophytes has been presented in Chapter 11.

16.1.4.5. Water quality downstream of proposed Nathan Dam

The baseline study included two sites (N6 and N7) downstream of the water storage area. Results and discussion for these sites are included in Section 16.1.3.

Historic DERM data for the Dawson Catchment is limited. A summary of DERM data obtained for sites downstream of the proposed Nathan Dam wall is detailed in Table 16-14. Generally, the water quality appears to be similar at all monitoring sites, with no pattern discernable with increasing distance downstream. As the median values presented in Table 16-14 have been generated from relatively small data-sets, caution must be exercised when interpreting this data.

Table 16-14 Summary of median water quality data downstream of the proposed Nathan Dam wall (DERM, 2010)

Parameter	Units	Relevant Guideline	Site: Nathan Gorge (130320A) AMTD 307.2 km	Isla Delusion Crossing (130358A) AMTD 264.0 km	Theodore (130305A) AMTD 230.1 km	Woodleigh (130317A) AMTD 193.6 km	Baralaba (130304A) AMTD 84.7km	Neville Hewitt Weir (130361A) AMTD 82.6 km	Beckers (130322A) AMTD 71.0 km
Conductivity	µS/cm	340	267	167	216	269	228	138	192
pH	pH Units	6.5-7.5	**7.8**	7.5	7.5	**7.7**	**7.6**	7.4	**7.6**
DO	mg/L	X		6.1	5.8	6.4		6.0	6.6
Temperature	°C	X	22.5	24.5	26.1	25.6		22.2	26.7
Turbidity	NTU	25	**100**		**100**	**100**	**92**	**780**	**100**
Total Suspended Solids	mg/L	X	40	50	40	40	31	775	50
Metals									
Aluminium	µg/L	55			50	**50^**		**50^**	**50^**
Boron	µg/L	371	30			50	30	100	30
Copper	µg/L	1.4		**40^**		**30^**		**50^**	**30^**
Manganese	µg/L	1900	50^		0	20^	**5000^**	200^	0^
Zinc	µg/L	8		**20^**	**51**	**10^**		**20^**	**10^**
Nutrients									
Nitrate as N	µg/L	700	**1000**	**2100**	**1405**	**1100**	**1200**		**1500**
Nitrite + Nitrate as N	µg/L	15			**156^**	**249^**			
Total Kjeldahl Nitrogen as N	µg/L	225			**908**	**740**			**911**
TN	µg/L	250			**890**	**990**			**920**
TP	µg/L	15			**233**	**300**			**245**
Reactive Phosphorus - Filtered	µg/L	30			**70^**	**90**			**60**
Other									
Colour	Hazen Units	50		23	30	30	20	16	

X = absence of guideline value
'blank cell = data not collected for parameter
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3
^ = dissolved metal (not total)

A summary of data supplied by SunWater for storages situated along the Dawson River is presented in Table 16-15. Although generally similar across all storages, median and maximum values for TN and TP are noted to be highest at Glebe Weir, which is upstream of most of the irrigation areas. Maximum Chl-a concentrations are also noted to be higher in Glebe Weir than other storages.

Table 16-15 Summary of water quality in small storages situated on the Dawson River (SunWater, 2010)

Site	Parameter	TN	TP	Chl-a
	Relevant Guideline	250 µg/L	30 µg/L	x
Glebe Weir (headwater)	*Median*	**1200**	**320**	n/a
	Minimum	300	90	2
	Maximum	4200	930	24
Gyranda Weir (tailwater)	*Median*	**800**	**200**	1
	Minimum	400	0	0
	Maximum	3200	400	14
Orange Creek Weir (tailwater)	*Median*	**860**	**210**	1
	Minimum	450	20	0
	Maximum	1100	320	4
Theodore Weir (headwater)	*Median*	**970**	**210**	1
	Minimum	410	60	0
	Maximum	210	650	3
Moura Weir (headwater)	*Median*	**940**	**190**	1
	Minimum	400	40	0
	Maximum	3500	610	14
Neville Hewitt Weir (tailwater)	*Median*	**820**	**170**	2
	Minimum	0	0	0
	Maximum	2900	340	16

X = absence of guideline value
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

16.1.4.6. *Relationship of water quality to flow*

There is limited information available relating water quality and flow in the Dawson River. Generally, medium to high flows are associated with increased turbidity, suspended solids, nutrients, metals, pesticides and herbicides (depending on land use), organic carbon and decreased conductivity.

Data from the Dawson Dam IAS and Supplementary Report (Anderson and Howland, 1997; 1998) consisted of grab samples and profiles at a number of sites from upstream of Glebe Weir down to Theodore Weir over a two year period. Key findings from the reports are:

- sampling after short-term cease-to-flow conditions during spring and early summer in 1996 showed minor stratification and moderate de-oxygenation upstream of Glebe Weir. Dissolved oxygen concentration were generally much lower 5 km downstream of Glebe Weir than in the weir proper;
- sampling at low flow conditions in 1997 showed de-oxygenation persisted upstream of the weirs. At Glebe Weir stratification occurred at 2.5 m depth and oxygen concentrations declined to 1.5 mg/L below 3.5 m depth. No stratification was observed downstream of the weir; and
- sampling after a prolonged period of cease-to-flow during spring and early summer in 1997 showed major stratification and severe de-oxygenation at all riverine sites between Glebe Weir and Theodore Weir. Sampling in the Glebe Weir showed only minor temperature stratification and de-oxygenation.

Sampling along the Dawson River during the 1994 - 1996 period (Anderson and Howland, 1997) indicated that:

- during and after flow events, the Dawson River was found to have moderate to high turbidity;
- median level of suspended solids was 157 mg/L. When only the data after a flow event were considered, the median value increased to 244 mg/L;
- median value of TN for 102 samples was 1,065 µg/L. Under baseflow conditions the median was less than 750 µg/L. The WQO is a median of 350 µg/L; and
- median value of TP for 102 samples was 215 µg/L. Under baseflow conditions the median was generally less than 100 µg/L. The WQO is a median of 10 µg/L.

Results from SunWater monitoring programs and the Nathan Dam EIS baseline study indicate that:

- the quality of water in Glebe Weir pool is linked to the time elapsed since the last inflow event. For example, very low DO concentrations were observed in March and April 2008 following a relatively dry wet-season and low level flow in March. The sample collected in March occurred on the second day after the weir spilled. Data from the November 2005 to January 2006 period is also informative as a small flush occurred in early November, bringing highly turbid, low DO water. The weir was fully flushed in December 2005 such that by January 2006 it had higher DO levels except in very deep water;
- following periods of no flow, the first inflows often occur as relatively small events and are of poor quality water;
- Glebe Weir stratifies at times of extended zero inflow but the depth of stratification varies. The occurrence and degree of stratification varies from year to year;
- riverine pools on the Dawson River can also stratify under cease-to-flow conditions;

- DO concentrations steadily decline with increasing depth within Glebe Weir and other riverine pools on the Dawson River, and can be very low in deep water during periods of low to no flow;
- during extended no flow periods Glebe Weir and other riverine pools on the Dawson River display decreased surface turbidity, increased conductivity and potentially, supersaturated DO concentrations in surface waters;
- the main changes in water quality observed during the Nathan Dam EIS baseline study pre-wet season sampling event were significantly increased turbidity and lowered conductivity;
- the SunWater monitoring programs indicate that blue-green algae had their highest counts in Glebe Weir in October 2001 and December 2003. No significant numbers have been recorded since;
- releases from Glebe Weir during winter, spring and potentially during summer months, sometimes account for the only flow occurring in the Dawson River;
- the nearest site downstream from Glebe Weir often shows low DO, irrespective of releases from Glebe Weir; and
- the Nathan Dam EIS baseline study post-wet season survey did not detect elevated pesticide concentrations.

16.1.4.7. Suitability of water for existing uses

The existing uses of water within the Project area along the Dawson River are:

- primary, secondary and visual recreation;
- irrigation, stock water and farm water supply (domestic – other than drinking); and
- drinking water supply (e.g. Theodore Weir is situated approximately 65 km downstream).

No information was available with respect to pathogens (such as faecal coliforms or *E. coli*); a key parameter used to assess whether a waterbody is suitable for human use.

Generally, water quality within the study area is suitable for all EVs outlined in Table 16-3. Turbidity levels observed within the proposed water storage area indicate that concentrations of Suspended Solids (SS) are most likely in excess of the QWQG (2009) drinking water guideline value. Additionally, concentrations of chlorophyll-a (chl-a) and blue-green algae are also noted to occasionally be in excess of QWQG (2009) drinking water quality guideline values. Observed levels of SS, chl-a and blue-green algae would not pose a significant threat to the supply of drinking water.

Existing water quality within the study area is considered to be suitable for irrigation and stock water without treatment. For water to become suitable for drinking, standard urban water treatment plant processes would be required.

16.1.4.8. Water quality issues and their causes

Water quality issues for existing storages on the Dawson River within the study area are:

- high sediment (turbidity) levels;
- high nutrient levels;
- fluctuating DO from low to supersaturated levels; and
- DO stratification of Glebe Weir.

Water quality issues downstream from existing storages on the Dawson River within the Project area are:

- high sediment (turbidity) levels;
- high nutrient levels; and
- DO stratification in the natural riverine pools.

16.1.4.9. Confirmed and likely causes of present water quality

The current water quality within the study area is likely due to the moderate to high level of land clearing and associated degradation observed within the Dawson Catchment.

Land-use within the Dawson Catchment predominately consists of grazing (FBA, 2008). The State of the Rivers report for the Upper Dawson Sub-Catchment identified grazing as occurring adjacent to 75 % of sites (Telfer, 1995). Grazing was identified as the major factor contributing to the disturbance of the reach environs (noted to occur at 63 % of sites). Grazing was also identified as the major factor affecting the stability of stream beds (noted to occur at 88 % of sites). Cattle crazing can potentially influence water quality through the clearing of vegetation for pastoral land, loss of riparian zone, soil disturbance, stream bank erosion, access of cattle to waterways and riparian vegetation, application of fertilisers and pesticides, overgrazing leading to erosion, and faecal and nutrient contamination. As a result of the high levels of vegetation clearing which has occurred throughout the catchment for the creation of pastoral land, increased amounts of surface runoff, containing elevated concentrations of sediment (turbidity) and nutrients, would enter the Dawson River and its tributaries.

The Dawson River has highly variable, often low stream-flow and is characterised by a series of long and deep relatively permanent pools separated by runs (Burrows & Butler, 1998). These deep riverine pools and constructed weirs provide still water and receive low amounts of inflow (responsible for mixing of the waterbody) throughout most of the year. The DO stratification of natural riverine pools and constructed weirs observed throughout the study area is most likely explained by the relatively low amounts of inflow into deep pools.

16.1.5. Pipeline

The pipeline runs south from Nathan Dam through the Dawson River catchment before crossing the Great Dividing Range and heading east through the Condamine River catchment to Dalby. The Condamine River is part of the upper northern section of the Murray-Darling Basin. A number of streams of various sizes in both catchments are crossed by the pipeline and these streams vary considerably along the ephemeral – permanent continuum. However these systems are basically low order headwater streams and tend to have intermittent flows with some permanent water holes.

frc environmental conducted a pre-wet season survey of the pipeline route in January 2009 (Chapters 12 and 13 and Appendix 12-D), which, to-date, represents the only water quality data available for the majority of streams to be crossed by the pipeline. *In-situ* water quality data collected during this survey is presented in Table 16-16 and discussed in the following text. Water quality sampling was undertaken at different times of the day. EVs and WQOs for waterways in the Dawson Catchment and the upper Condamine catchment crossed by the pipeline are the same as those for The dam and surrounds presented in Table 16-5.

Table 16-16 Nathan Dam EIS pipeline route baseline monitoring – in-situ parameters (frc, 2009)

Parameter	Units	Relevant Guideline	Site								
			P1	***P3***	***P4***	***P6***	***P7***	***P8***	***P9***	***P10***	***P11***
Temperature	°C	x	23.5	23.0	30.9	28.3	33.5	32.6	33.5	25.9	29.9
pH	pH units	6.5 - 8.0	7.35	**5.89**	6.75	**5.62**	**6.27**	7.89	6.73	7.27	6.8
Conductivity	(µS/cm)	340	**438**	305	64	53	122	257	258	305	210
DO	mg/L	X	2.46	4.03	1.36	2.80	4.15	6.32	3.71	3.67	4.8
DO	% sat	85 - 110	**23.3**	**49.2**	**25.1**	**32.3**	**61.5**	91.4	**57.4**	**39.7**	**4.8**
Turbidity	NTU	25	**76**	**2600**	**195**	**124**	18	**40**	**211**	**124**	**54**

X = absence of guideline value
'red value' = median value exceeds relevant guideline specified in Section 16.1.2.3

Water temperature

Water temperature ranged from 23.5 °C at Juandah Creek (site P1) to 33.5 °C at Rocky Creek. Water temperature was generally similar across each of the sites surveyed that held water (approximately 27 ºC) and was observed to steadily decrease with increasing depth. Overnight logging in the Condamine River revealed a drop in temperature of approximately 5 ºC.

Electrical conductivity

Conductivity concentrations were observed to be variable across the sites; ranging from 54 µS/cm at Coolumboola Creek (site P6) to 438 µS/cm at Juandah Creek. Conductivity was observed to be almost twice as high at Juandah Creek than the majority of other sites. Conductivity was observed to steadily increase with depth at Rocky Creek (site P7) but was stable throughout the water column at all other sites. Overnight logging in the Condamine River revealed conductivity to be stable at approximately 252 µS/cm. Conductivities recorded at all sites except P1 (Juandah Ck) were observed to fall within the WQO of 340 µS/cm.

pH

pH levels were observed to be variable across the sites; ranging from 5.6 at Coolumboola Creek to 7.9 at the Condamine River. At sites with deep water (P7 and P8), pH was observed to steadily decline with increasing depth. Overnight logging in the Condamine River revealed a drop in pH of approximately 0.4. pH levels at the majority of sites were observed to fall within the WQO of 6.5 - 8.0.

Dissolved oxygen

Dissolved Oxygen (DO) levels were observed to be low (< 40% saturation), except in the surface waters of the larger watercourses. DO concentrations were observed to decrease with increasing depth, to 0% saturation beyond a depth of 1.5 m at sites with deep water (site P7 and P8). Overnight logging in the Condamine River revealed a drop in DO concentrations of approximately 50%, but remained above 30% saturation. All surface water measurements except the Condamine River did not meet the WQO of 85% to 110% saturation.

 Turbidity

Turbidity levels were found to range between 18 NTU at Rocky Creek to 2600 NTU at Little Tree Creek (site P2). It should be noted that observations collected at Little Tree Creek are massively elevated relative to all other sites. Generally, turbidity levels were found to slightly increase with increasing depth. Overnight logging in the Condamine River revealed turbidity to be relatively constant. All sites except Rocky Creek exceeded the WQO of 25 NTU.

16.1.6. Associated infrastructure

The water quality description for the dam and surrounds or pipeline is equally applicable to the associated infrastructure for those Project components particularly the roadworks.

16.2. Potential impacts and mitigation measures

This section addresses Section 3.4.3.2 of the ToR.

16.2.1. Dam and surrounds

16.2.1.1. Downstream water quality during construction

Runoff from construction sites can potentially cause an increase in turbidity (through erosion and sediment runoff) and hydrocarbons (fuel and oil). Activities that may lead to increased turbidity include clay extraction, site clearing, excavation and earthworks, dewatering of foundations, temporary or permanent road construction and related drainage, wastewater from concrete batch plants, vehicle and equipment wash-down activities, spillway foundation cleaning and grouting. Activities that may lead to hydrocarbon pollution include storage of chemicals, vehicle and equipment wash-down activities, equipment leaks, runoff from paved areas and accidents or spillage.

As described in Chapter 2, most construction works in and near waterways will occur in the dry season. This will minimise risks to water quality through reduced runoff, although the site will be vulnerable to high rainfall events that occur in spring and summer. During periods of high rainfall increased amounts of runoff may result in increased turbidity, however, the impact of this is expected to be minimal due to naturally elevated turbidity levels during such events. The construction sequence and timing has been designed to accommodate the above described events and minimise impacts to both constructed works and the environment.

The following proposed mitigation measures, as outlined in Chapter 2 and in the Environmental Management Plans (Chapter 29), during construction will minimise potential impacts to downstream water quality:

- a diversion channel will be constructed around the dam so that normal river flows will pass through the construction site. While sediment and erosion control measures will minimise the transport of sediments to the diversion channel, measures to reduce the turbidity plume downstream may be required in the form of booms ;
- water from the dam construction site, including foundation dewatering wastewater will be directed to sedimentation ponds (Figure 2-8) prior to re-use or discharge as appropriate;
- impacts associated with runoff and related erosion will be addressed by sediment and erosion control plans and waste management plans (Chapters 6, 20 and 29);

- management of wastewater from concrete batch plants, vehicle and equipment wash-down activities, fuels and chemicals, and on-site facilities are discussed in Chapter 29;
- clearing of the water storage area will occur as late as possible in the construction process and will not include clearing of pasture or stumps of trees unless they are in an unsafe area; and
- scheduling of construction works in and near waterbodies to occur during the dry season.

Overall, the Project is expected to have little impact on downstream water quality during the construction phase. Increased turbidity caused by surface runoff throughout the construction site represents the biggest threat to water quality. The impact of increased turbidity levels on water quality predominantly relates to the need to filter extracted water prior to use (which is common knowledge for water extractors). Other impacts relating to aquatic flora (Chapter 12) and fauna (Chapter 13) are addressed in respective chapters.

16.2.1.2. Quality of water within the water storage area during the initial filling phase

Poor water quality is expected within the water storage area during the initial filling phase. This will depend largely on the extent and methods used to clear existing vegetation, the amount of remaining vegetation within the water storage area, inundation of terrestrial soils and the filling period.

Increased nutrient levels are expected as the soils are first inundated and the terrestrial vegetation decomposes within the water storage. While the clearing strategy described in Chapter 2 will substantially reduce the vegetation remaining in the water storage area, decomposition of vegetation as it is inundated will increase biological oxygen demand within the water column and in turn decrease dissolved oxygen (DO) concentrations. Low levels of DO can impact on aquatic fauna and flora and cause fish deaths if levels fall too low.

If high inflow events occur during the initial filling phase, elevated turbidity may be experienced within the water storage area, although the clearing strategy described in Chapter 2 will minimise soil exposure. Depending on the volume in storage the effects of high turbidity may be short or long lived. A low dam level is likely to result in higher turbidity for a longer duration as there is limited dilution effect from existing water in storage. Large inflows will also cause a large proportion of the cleared land to be inundated in a short period of time. While this may deliver high loads of sediments, nutrients and organic matter into the water storage, the concentrations in the water column should be offset by the diluting effect of large inflows. There will also be some degree of settling through the water column, where large particles flocculate and settle to the bottom of the dam.

Based on the storages traces and time to fill analysis shown in Chapter 14, there is a 50% probability of exceeding the minimum operating volume (34,502 ML) within 0.12 years, environmental release trigger (150,000 ML) within 0.95 years and full storage volume (888,405 ML) within 2.89 years. Once full, the dam is predicted to spill approximately once every year (for a mean duration of 23 days), thereby adding to the maintenance of water quality within the storage via “flushing” of the dam.

SunWater will develop a first release strategy to minimise the risk of poor quality water impacting on environmental values downstream of the dam. This is likely to include monitoring water quality in the water storage and in the receiving environment downstream. In periods of high flow, it is likely that background water quality in receiving waters will exceed relevant guidelines (as it does now). It is often accepted that releasing poor quality water from the storage at this time will have minor incremental impact downstream but will greatly assist the attainment of suitable water quality in the storage in the shortest timeframe possible. Impact mitigation measures included in the Project (e.g. management of land use in the flood margin, remediation of potential contamination sources and incorporation of vegetation offset and rehabilitation areas within the surrounding catchment) will contribute to maintaining or improving water quality.

16.2.1.3. Quality of water within the water storage area under normal operating conditions

The historic sediment and nutrient runoff rate from the catchment is not likely to change in the short term so inflow water quality will be similar to that described earlier. Although SunWater intends to obtain ownership of the water storage area and an easement over the flood margin, it is intended that the current land-use activities being undertaken within the surrounds (predominantly grazing and some cropping) will continue (Chapter 2) so local runoff quality will also be similar. As noted, there will be some positive change related to revegetation of the northern margin of the storage and incorporation of vegetation and habitat offset areas.

Due to the depth of the water storage, thermal stratification and seasonal mixing, chemical cycling and sedimentation are all potential impacts once the dam is operational. However, hydrological analysis (Chapter 14) and evidence from other storages in the Fitzroy Basin (Section 16.1.3) suggest that strong and prolonged thermal stratification is not likely, except in periods of prolonged drought, when inflows which are responsible for mixing within the water storage are reduced and still, warm conditions persist for long periods. Although the prevalence of such conditions is temporally variable and does not occur at regularly defined intervals, such conditions have historically occurred on average approximately once in 15-25 years (Chapter 14).

DO levels are closely linked to stratification, overturning and mixing within impoundments. As such it is expected that DO levels will vary seasonally, during wet and dry periods and according to water depth. Other factors such as wind, solar irradiance and runoff will also affect the amount of mixing that will occur within the water storage.

The potential for stratification and turnover events within the water storage is considered moderate. Water quality impacts can occur if the water column becomes stratified for long periods (i.e. weeks to months). This causes the DO levels in the bottom waters to decline to anoxia, which encourages the release of nutrients, toxicants and heavy metals (such as iron and manganese) from the bottom sediments. The bottom waters can also be significantly cooler than the ambient environment, and can lead to cold-water releases from the dam into the downstream river environment, impacting on aquatic flora and fauna. In stratified waterbodies, the top layer can become very still, calm and warm, which provides ideal conditions for the development of algal blooms. The types of algal blooms that develop depend on the availability of nutrients. Cyanobacteria (or blue-green algae) have a competitive advantage over green algae and diatoms if nitrogen is limiting in the water column. This is because blue-green algae can fix nitrogen from the atmosphere. Some species of cyanobacteria produce toxins. Consumptive uses of the dam will be affected if potentially toxic algae blooms occur.

Blue green algae have been reported within the wider Fitzroy Basin at the barrage (Fitzroy sub-catchment; Fabbro and Duivenvoorden, 1996) and within the Dawson River (Dawson sub-catchment; Croke, 2002). However, more recent monitoring of other storages in the Fitzroy Basin (including Fairbairn Dam – the closest large dam to the Nathan Dam site) suggests that stratification and blue green algae blooms are not a predominant feature of these storages (Section 16.1.4).

The potential for wind-driven resuspension of sediments and nutrients from the bottom of the water storage is considered low, and limited to the shallow margins of the storage. The proposed vegetation clearing strategy (Chapter 2) is to clear to within 1.5 m (vertical) below full supply level (FSL). Trees on the margin of the storage will remain in place and provide a wind barrier to reduce wind-driven resuspension. Most of the water storage is more than 5 m deep at FSL (Chapter 2), especially close to the wall and outlet structure, where the storage exists within a relatively steep part of the valley. This will reduce the potential for resuspension affecting released water.

Soils at the FSL level contour have been identified to generally have a low erosion potential (Chapter 6). The potential impact on water quality from soil erosion during operation is considered to be minimal.

16.2.1.4. Macrophytes and algae and their potential effect on water quality

The potential for macrophyte growth in the water storage is discussed in Chapter 12, which indicated that shallow edges of the dam would provide habitat for attached macrophytes, while floating species would colonise the deeper areas. Submerged, attached macrophytes are expected to be largely not present due to fluctuating water levels and high turbidity. Because most of the dam is relatively deep (more than 5 m) with less shallow edge habitat, the potential for nuisance attached macrophyte growth is low.

Generally, the key factors responsible for limiting algae and macrophyte growth are nutrient availability (phosphorus and nitrogen), solar irradiance (amount of shading) and depth. Within the water storage neither nutrients nor solar irradiance are expected to be limiting. Water quality data collected throughout the dam and surrounds study area, however, indicates that the Dawson River is characterised by high turbidity levels. High turbidity levels also act to limit algae and macrophyte growth via reduction in the amount of light penetration into the water column.

Analysis of historic data from other storages within the region indicates that:

- storages tend to be un-stratified most of the year, or slightly stratified during the warmer months (September - January);
- strong stratification rarely occurs; and
- cyanobacterial species occur, but in low numbers.

The potential for cyanobacterial blooms in the water storage is considered to be low.

SunWater already implements a blue green algae warning system for existing storages, and this system will be implemented for the dam. The system includes monitoring and signage similar to a fire hazard warning system (i.e. High, Moderate, Low hazard levels).

Potential impacts on Environmental Values are outlined below, but the risk of these impacts occurring will be mitigated by the hydrological characteristics expected in the water storage (annual rapid filling and steady drawdown, with extended drought periods infrequent), the preliminary operating strategy and the monitoring and warning system to be implemented.

Consequences of increased algae and macrophyte growth can include decreased DO concentrations and increased organic carbon. Reduction in flow into the water storage may also contribute to increased algae and macrophyte growth as it results in a stable growing environment. The combination of high nutrients, no-to-low flow, abundant sunlight and reduced habitat complexity is likely to favour a small number of fast growing species. Increased algae and macrophyte biomass has the potential to reduce the environmental values of the Dawson River. Environmental values that may be affected include recreation and aesthetics, primary industries, aquatic ecosystems, and cultural and spiritual values.

16.2.1.5. Effect of depth and detention time on water quality

In general, longer retention times will result in greater settlement of sediments and nutrients within the water storage resulting in lower turbidity.

Water at depth is expected to have low DO, increased levels of nutrients and higher concentrations of some dissolved metals potentially including iron, manganese, zinc and nitrogen. Release of this poor quality water could impact on aquatic communities downstream, but use of the multi-level offtake will avoid accessing and releasing this water.

- Recreation and aesthetics

Contact with blue green algae can cause problems such as skin rashes, ear ache and itchiness, swollen lips, eye irritation, asthma, sore throats and liver damage (Fabbro and McGregor, 2006). The level of risk increases for primary contact recreation. Activities such as swimming and water-skiing pose a high risk while activities such as fishing, pleasure boating and activities on the water's edge (picnicking and walking) pose a lower risk. Blue green algae blooms can discolour the water and form smelly scums on the surface, reducing the aesthetics of the waterbody. Guidelines for blue green algae for primary contact recreation are detailed in Table 16-17.

Table 16-17 Guidelines for blue green algae for primary contact recreation (QWQG, 2009)

Hazard Status	Guidance level or situation	Health risks	Recommended action
High	Cyanobacterial scum formation in contact recreation areas or >100,000 cells total cyanobacteria mL^{-1} or >50 µg L^{-1} chlorophyll-a with dominance of cyanobacteria.	▪ Short-term adverse health outcomes such as skin irritations or gastrointestinal illness following contact or accidental ingestion. ▪ Severe acute poisoning is possible in worst ingestion cases.	▪ Immediate action to prevent contact with scums. ▪ Signs to indicate high alert level – warning of danger for swimming and other water-contact activities.
Moderate	20,000–100,000 cells total cyanobacteria mL^{-1} or 10–50 µg L^{-1} chlorophyll-a with dominance of cyanobacteria.	▪ Short-term adverse health outcomes e.g. skin irritations, gastrointestinal illness, probably at low frequency.	▪ Signs to indicate moderate alert level – increased health risk for swimming and other water-contact activities.
Low	<20,000 cells total cyanobacteria mL^{-1} or <10 µg L^{-1} chlorophyll-a with dominance of cyanobacteria.	▪ Short-term adverse health outcomes unlikely.	▪ Signs to indicate cyanobacteria either absent or present at low levels.

Analysis of data from other storages within the region indicates that cyanobacteria levels are not expected to be characteristic of the dam, with levels expected to remain below the low hazard status for primary contact recreation the majority of the time. Throughout 10 years of monthly monitoring, Fairbairn Dam (the nearest large dam) only exceeded the low hazard category of 20,000 cells/ml on three occasions.

- Primary industries

Water affected by blue green algae can cause stock death and as such should not be supplied to stock and should have restricted stock access. Guidelines indicate an increasing risk to livestock health when levels of *Microcystis* exceed 11,500 cells/mL (ANZECC 2000; no guidelines are available for other cyanobacteria). Pets can also be affected if they drink or swim within affected water bodies. Affected water should not be used for irrigation purposes if there is an alternate supply as certain toxins produced by algae can be damaging to plants. Affected water can cause clogging and blockages of meters, valves, filters and sprinklers. Shellfish and crustaceans, such as mussels and yabbies, are known to accumulate cyanotoxins within edible flesh and should not be consumed where waters are infested by potentially toxic algae. Limited information is available on toxin concentrations within fish however it is not advised to consume fish from algae infested waters.

- Industrial water

Affected water can cause clogging and blockages of meters, valves, filters and sprinklers. Contact with affected water supplied as industrial water should be avoided and spraying of water should be restricted. However, with appropriate precautions to protect personnel, spraying of coal and use for coal washing would not be affected.

16.2.1.6. Downstream water quality during operation

Flow plays an important part in influencing water quality with respect to pool, riffle and run habitats. The pattern of results described in Section 16.1.4.6 indicates that base flows and flushing flows are particularly responsible for the maintenance of water quality. The preliminary operational strategy is described in Chapter 14. The strategy includes a baseflow release which is close to natural at low flows and a first post winter release relating to flushing flows at the cessation of the dry season.

As discussed in Chapter 14, mandatory Environmental Flow Objectives of the WRP will be met at downstream locations. Although the non-mandatory seasonal base flow objective was not met at three locations under the 'with dam' scenario, the values observed at each of these locations suggest that water quality impacts are not likely. This is because base flow statistics relative to the present full entitlement scenario are improved in six cases, the same in seven cases and worse in just two. The latter are both due to the oversupply of water below the dam as far as Theodore, caused by regulated releases from the dam and other water storages.

Further, the dam will be able to make releases when the river system would not be flowing in the current situation. This will assist to maintain water quality in the weirs and natural pools downstream. The use of a multi-level offtake structure to select appropriate water quality from within the reservoir f, coupled with the expected flow regime, is expected to ensure no significant change to the quality of water downstream.

As discussed in Chapter 14, medium to high flows, in the 1,500 to 30,000 ML/d range, will be moderately impacted in the 'With Dam' scenario. This is particularly evident at Nathan Gorge as these flows are generally captured by the dam;

however, these impacts decrease at downstream locations. As flows in the range of 1,500 to 30,000 ML/d range are considered flushing flows, in this 2 km reach, minor, localised decline in water quality may occur following construction of the dam. The maintenance of base flows and larger flushing flows is expected to ensure the maintenance of water quality. A more detailed assessment of potential changes to flushing flows as they relate to MNES is provided in Chapter 28.

The potential impacts of flow release on estuarine and near-shore environments are discussed in Chapters 13 and 28. There is a very low probability that the operation of the dam will impact upon the water quality within the Fitzroy Estuary due to the distance, number of other storages and inputs in between, and the compliant flow strategy.

The impact of the Project in relation to sediment and nutrient processes associated with land-use changes are discussed in Section 14.5.1.2.

Agricultural practices in the Fitzroy Basin are improving as a result of Government and industry programs to protect the Great Barrier Reef from further impact. The *Great Barrier Reef Protection Act 2010*, Reef Plan, Grains Best Management Practice incentive, Land and Water Management Plans and wide-ranging activities of the Fitzroy Basin Association are all contributing to improving receiving water quality in the Fitzroy Basin. The Project will not affect achievement of the outcomes specified in the Reef Plan and is highly likely to assist in attaining those outcomes, most obviously through its capture of sediment and the associated nutrients within the water storage.

16.2.2. Pipeline

16.2.2.1. Construction impacts

Potential water quality impacts associated with pipeline construction are similar to those described for the dam (Section 16.2.1.1), although on a smaller scale. Activities with the potential to cause increased sedimentation and turbidity include site clearing, excavation and earthworks, temporary or permanent track construction and related drainage, and vehicle and equipment wash-down. Activities that may lead to hydrocarbon pollution include storage of chemicals, vehicle and equipment wash-down, equipment leaks, and accidents or spillage.

The management of impacts relating to general construction along the pipeline corridor is as described in Section 16.2.1.1. This section will focus on issues specific to the pipeline crossings streams.

The proposed stream crossing technique is trenching and this is described in Chapter 2. The primary potential construction phase impact of the pipeline on surface water quality will centre on runoff, erosion and sedimentation. Most of the streams that need to be crossed flow intermittently and as such, works are programmed for the dry season when it is expected that most crossings will be dry. The larger watercourses (Dogwood, Collumboola, Rocky, Myall and Cooranga creeks) contain perennial waterbodies.

The area affected by construction at each site is very small (< 30 m wide) relative to the stream length and to the catchment area of each stream. The potential for significant impacts on the environmental values of the streams is therefore small, provided that good practice in construction management, especially sediment and erosion control, is implemented.

A draft Construction EMP has been prepared to mitigate the impacts of the construction on surface water resources (Chapter 29). The following outlines the major mitigation measures that will be implemented where practicable as part of the Construction EMP. In particular current good practice erosion and sediment control measures will be provided as outlined in *Best practice Erosion and Sediment Control – International Erosion Control Association Australasia 2008* (or other similar accepted guideline) and with consideration to the relevant sections of the *Code of Environmental Practice – Onshore Pipelines APIA 2009* and the *Environmental Protection (Water) Policy 1997*. These measures include:

- construction work in creeks will be undertaken in dry weather and conditions of minimal or no flow;
- the pipeline trench will be open for a minimal period of time during construction;
- materials excavated will be segregated (e.g. topsoil, sub-soil, creek bed) and reinstated in its natural order;
- materials reinstated will be compacted and reinstated as far as practical to the original profile including vegetation;
- where possible watercourse crossings will be undertaken at approximately 90° to the normal direction of flow within a straight section of the watercourse to minimise erosion;
- the movement of vehicles, plant and personnel will be restricted within the watercourse and its banks. Construction materials will not be stored within the banks of the creeks;
- loss of vegetation will be minimised by avoiding unnecessary clearing;
- sedimentation fences and bunds will be used to contain excavated material during construction; excavated material will be stockpiled away from gully heads, active creek banks, bank erosion or other unstable areas;
- local runoff from disturbed areas will be routed clear of disturbed areas;
- streambed material and stream bank soil will not be mixed at any time;
- if streams are flowing, the construction of temporary waterway barriers during pipeline installation will include the provision to transfer flows from upstream of the works to the downstream channel without passing though the disturbed construction site; and
- monitoring of weather conditions; work in creek crossings and erosion prone areas will not take place if rain and/or storms are forecast.

While these measures will minimise impacts, some temporary disturbance is unavoidable. The impact of the disturbance will be further mitigated by rehabilitation of disturbed areas, as outlined in Chapter 2.

16.2.2.2. Operational impacts

The impacts of the pipeline on surface water quality during normal operation will be negligible. The pipeline is to be constructed below the ground surface for most of its length and includes restoration works as required. Therefore, the operational pipeline will generally not affect the existing land or stream profile.

There is a risk of leakage or rupture as the result of accidental damage from an external source. Considering the high quality of water expected in the storage, the consequence of any leak or rupture to existing water quality is negligible, other than the erosion it may cause in reaching a watercourse. Alternatively, if a pipe bursts into one of the small ephemeral creeks bed scouring may occur. Damage caused from such an event would, however, likely be short lived as a result of the automated shut-down procedures.

Monitoring of the success of rehabilitation along the pipeline will be a component of regular maintenance inspections. Following periods of heavy rainfall, creek crossings will be inspected to check for erosion. Additional rehabilitation will be undertaken as necessary to halt any developing erosion.

If monitoring of pipeline performance indicated a decline in pipeline flow efficiency, sections of the pipeline may require scouring by release of water from dedicated “scour valves” located at low points along the pipeline to remove sediment accumulations, or “pigging” of the pipeline to remove pipe wall slimes or similar accumulations (Chapter 2).

Both scouring and pigging result in the release of small volumes of dirty water, being the volume between one scour point and the next or the volume between pig insertion and retrieval points. The release of these relatively small volumes of water is not expected to have significant impact on adjacent water quality.

16.2.3. Associated infrastructure

Most of the associated infrastructure (construction of roads, power lines and telecommunications) will only have a small potential impact on water quality.

16.2.4. Impact assessment and residual risks

The methodology used for risk assessment and management is discussed in Section 1.8.

This section assesses the risks relevant to surface water quality and summarises the mitigation measures proposed to minimise those risks.

Risks associated with construction and operation phases of the Project are presented in Table 16-18 and Table 16-19 respectively. The definition of consequence and likelihood is presented in Chapter 26. The risk assessment is of the Project as described in Chapter 2, in which SunWater has already incorporated a range of risk reduction and mitigation measures.

Based on this assessment, the following conclusions can be made:

- during construction, the main risk is the mobilisation of sediment and nutrients from disturbed areas of the construction areas (dam, pipeline and associated infrastructure), and the potential impacts that may occur to waterways. These risks are minimised by the construction approach proposed and the implementation of sediment and erosion control plans;
- during construction, the potential for contaminants (e.g. hydrocarbons, wastewater) to enter waterways exists, but the proposed mitigation measures, as outlined in Chapter 2, during construction will minimise these risks;
- during operation of the dam, there will be localised impacts on flow (in the mid range of flows). Baseflows, fishway releases and mandatory Environmental Flow Objectives (EFOs) will be maintained. Sediment and nutrient runoff rate from the catchment into the dam is likely to be similar to pre-dam levels but the dam will trap much of the larger sediment. As a result, no significant adverse impacts on downstream water quality are expected;
- during operation the quality of water within the storage will be suitable for recreational use for the majority of time once the dam has stabilised;

- during operation the quality of water extracted from the storage will be suitable for its intended uses for the majority of the time with minimal treatment;
- water quality in the storage will be monitored during operation so that appropriate measures can be put into place if required, such as sourcing water from a different depth before discharge or offtake;
- during operation of the pipeline negligible impacts are expected from small volumes of water released by scouring and pigging; and
- based on this risk assessment, the impacts relevant to surface water quality can be effectively managed and the residual risks are acceptable.

Table 16-18 Risk assessment results – construction

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with Controls			Additional Mitigation Measures	Mitigation Effectiveness	Residual Risk		
				C	L	Current Risk			C	L	Mitigated Risk
Degraded downstream water quality during dam construction	Impacts would occur around local rainfall events or substantial river flows. Major earthworks, construction of diversion channel and coffer dams, removal of alluvial material from dam site.	Decrease in water quality (particularly, turbidity) downstream of dam construction area	Sediment and erosion controls. Coffer dams and diversion channel. Booms. SunWater to implement water quality monitoring program.	Moderate	Unlikely	Medium			Moderate	Unlikely	Medium
Degraded downstream water quality during pipeline construction.	Site clearing, temporary diversions, excavation, access track construction works. Impacts would occur around coincident rainfall events or stream flow.	Decrease in water quality (particularly, turbidity) downstream .	Sediment and erosion controls.	Minor	Unlikely	Low			Minor	Unlikely	Low

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with Controls			Additional Mitigation Measures	Mitigation Effectiveness	Residual Risk		
				C	L	Current Risk			C	L	Mitigated Risk
Waterway contamination from fuel or chemical spills.	Refuelling and maintenance activities.	Hydrocarbon impact aquatic flora and fauna.	Relatively small quantities will be held. Storage will be in bunded enclosures and runoff will be directed to sedimentation ponds.	Minor	Unlikely	Low			Minor	Unlikely	Low
Waterway contamination from wastewater discharge (e.g. from construction camps and workshops).	Accidental discharge.	Nutrient and bacterial impact aquatic flora and fauna.	No discharge is planned. All wastewater treatment will be by town plant or via porta-loos with residues transported off site.	Minor	Unlikely	Low			Minor	Unlikely	Low

Table 16-19 Risk assessment results - operation

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with Controls			Additional Mitigation Measures	Mitigation Effectiveness	Residual Risk		
				C	L	Current Risk			C	L	Mitigated Risk
Nutrient and sediment input into dam.	More likely to be a problem during the summer months.	Increased growth of aquatic plants and algae.	SunWater to implement land management program around the storage margin. SunWater to implement a water quality monitoring program.	Minor	Possible	Medium			Minor	Possible	Medium
Poor water quality during filling phase.	Suboptimal filling time	A slow fill could contribute to increased nutrients and metals in the water leading to poor water quality.	First Filling Strategy.	Moderate	Possible	Medium			Moderate	Possible	Medium
Poor water quality during normal operating conditions.	Stratification and turnover events are possible but are not a frequent feature of other storages.	Temporary reduction in EVs.	Water quality monitoring program to be implemented.	Minor	Possible	Medium			Minor	Possible	Medium

Hazards	Factors	Impacts	Project Description Controls & Standard Industry Practice	Risk with Controls			Additional Mitigation Measures	Mitigation Effectiveness	Residual Risk		
				C	L	Current Risk			C	L	Mitigated Risk
Poor downstream water quality during operation.	The highest potential risk is during periods of drought.	Chapter 14 suggests there will be a minor impact on flow and the post dam scenario will be compliant with the ROP.	Off take structure to select water levels for release. Operational flow strategy.	Minor	Unlikely	Low			Minor	Unlikely	Low
	Effects reduced with distance downstream the dam.	Changes in water quality in the water storage may have localised effects downstream.									

16.3. Cumulative risks

Construction

Potential impacts to water quality associated with dam construction are unlikely to extend beyond the immediate footprint of the dam and surrounds. With no known projects located in close proximity to the dam, cumulative impacts to water quality during construction are unlikely.

There are two known projects located in the upper Dawson catchment, Elimatta and Wandoan Coal Mine, as well as several petroleum leases/application (Chapter 28). These projects are located over 20 km from the upper reaches of the water storage area area and, with sound management practices, are considered unlikely to significantly impact water quality within or downstream of the dam footprint. Water quality sampling will monitor the quality of inflows during constructions, with any non-conformances recorded and reported to the relevant agencies.

While no other projects are located in close proximity to the dam area, a range of CSG, resource and infrastructure development projects are currently planned along the pipeline route.

SunWater is very cognisant of the fact that the Surat Basin is currently the subject of a large amount of mining and coal seam gas development, and through the consultation process with landholders has become aware that many of the property owners impacted by the pipeline are also impacted by other developments. The primary opportunity for avoiding cumulative impacts, including water quality impacts, is through the placement of the pipeline in road reserves, and by co-locating the pipeline with other infrastructure (notably other pipelines) or along property boundaries to avoid infrastructure being spread across properties.

Further, watercourses along the route flow intermittently or are ephemeral and as works in these areas are programmed for the dry season it is expected that most will be dry when crossed. The preferred crossing method is by trench with the width of clearing of the riparian zone minimised as much as possible. For larger watercourses which contain permanent water that cannot be avoided, the trench area will be isolated by coffer dams constructed from excavated material from either the pipeline trench or imported material. Coffer dams will be stabilised by sandbags and/or geotextile fabric and the watercourse profile will be reinstated and monitored after construction.

Operations

A Cumulative Impacts scenario was modelled in order to represent the infrastructure currently proposed for the basin: Connors River Dam, Nathan Dam and Lower Fitzroy Weirs. Each of these developments is in the early approvals phase and requires a full business case to be developed and approved before they can proceed. It is not assured that they will all progress. Section 14.2.4 provides further detail of model assumptions and outcomes. Figure 28-5 highlights the extent of cumulative impacts associated with flows and water quality.

The WRP environmental flow objectives are met under the Cumulative Impacts scenario in most cases, and where they are not met initially, operational strategies will be revised to ensure that they are met (at least in the case of mandatory flow objectives). Adverse impacts on water quality in the Fitzroy River and Estuary are not expected. Therefore, no ecologically or conservationally significant impacts to the Fitzroy River and Estuary, or Keppel Bay, are expected due to the cumulative impacts of proposed water infrastructure.

Details on key water quality parameters as they relate to matters of national environmental significance are outlined in Chapter 28.

Overall however the impacts of the Cumulative Impacts scenario are moderate and will be able to be managed through a combination of environmental flow releases and management rules. These will need to be developed as the proposed infrastructure is approved and finalised.

16.4. Summary

The existing environment is indicative of a disturbed system, impacted by surrounding land-uses (predominantly grazing and cropping). Potential impacts are separated into construction and operational phases. During construction, the potential impacts relate mainly to reduced surface water quality from sediment disturbance and tranpsort. These are mitigated by sediment and erosion control measures such as a diversion channel, temporary water storage ponds, sediment booms, sediment fences and re-vegetation. During operation, the potential impacts are reduced water quality within the dam during the initial filling phase, reduced water quality within the reservoir caused by turn-over events, and reduced water quality downstream. These are mitigated by the Preliminary Operational Strategy (water releases), a first fill strategy, a multi-level off-take, weed management strategies and revegetation and vegetation offset strategies. Based on this risk assessment, the impacts relevant to surface water quality can be effectively managed and the residual risks are acceptable.