8. Surface water

This section addresses the freshwater quality of the project area and downstream receiving environments. This includes an assessment of the current conditions and discusses the potential impacts that the construction and operation of the Project may have on the water environment.

8.1 Existing environment

The project area is located within the Calliope River catchment which encompasses an area of approximately 2,236 km^2, bounded by the Mount Larcom Range to the east and the Calliope Range to the west. The Calliope River is approximately 100 km in length and includes the four major tributaries of Oakey Creek, Paddock Creek, Double Creek and Larcom Creek.

The project area is located within the freshwater reaches of the Calliope River (ie above the tidal limit of 32.8 km Adopted Middle Thread Distance (AMTD), the proposed Castle Hope Dam site) (C & R Consulting 2005) and Larcom Creek.

Water use within this area is mainly associated with dry land grazing, however some irrigated cropping and industrial pressures occur.

8.1.1 Calliope River

General characteristics

The Calliope River flows in an easterly direction from its headwaters in the Calliope Range. It discharges into Port Curtis north of Gladstone near the proposed WICT at Golding Point (refer Figure 8.1).

Within this area, the Calliope River is characterised by a series of large, deep waterholes. This is supported by the EPA wetland mapping which characterises the reach as a riverine system (ie wetlands and deepwater habitats contained within the river channel). Similar habitats were identified on Farmer Creek and Larcom Creek. These in-stream freshwater pools provide important habitat for native fish of the area.

The Minister for DNRW released the Water Resource (Calliope River Basin) Plan 2006 in December 2006. In May 2007, a Draft Resource Operations Plan (ROP) for the Calliope River Basin was released for public comment. At the time of writing, the ROP has not been gazetted, therefore the Calliope River is currently an unregulated system. Further to this unregulated status, with the absence of any major impoundments in the catchment, the Calliope River is unique in this regard.

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

While the catchment has undergone extensive clearing, with up to 66% of native vegetation removal estimated (Accad *et al* 2003), one factor influencing the in-stream water quality is the presence of a relatively thin, riparian corridor (predominantly native vegetation) along the entire freshwater length of the Calliope River.

The system's uniqueness, coupled with the intrinsic ecological value of the system, makes the Calliope River "*a high value system worthy of conservation and preservation.*" (C & R Consulting 2005).

The Calliope River has a mean annual discharge 153,000 ML and is characterised by high flood variability. An analysis of the flow record undertaken using the River Analysis Package (RAP) showed that river height varies by approximately 12 m (C & R Consulting 2005). This accords with the elevated debris observed during the field inspection. During dry periods, flow reduces to a continuous base flow.

Flood history

Stream flow records in the Calliope River commenced in October 1938 when the gauging station at Castlehope was opened. Table 8.1 summarises the 10 largest flood events recorded at Castle Hope stream gauge (Source DNRW), with corresponding Average Recurrence Interval (ARI) derived from flood frequency analysis.

Table 8.1 Ten largest recorded flood events for Calliope River

Year	Flow (m^3/s)	ARI (years)
2003	2,768	13
1996	1,905	6
1990	1,912	6
1978	2,908	15
1973	3,864	35
1971	2,154	8
1956	2,099	7
1949	2,589	11
1947	4,038	40
1942	2,828	14

The flood record is 4038 m^3/s on the 12 February 1947. The most recent significant flood occurred on 6 February 2003 when a peak flow of 2,770 m^3/s was recorded (5th highest on record). There is no flood history data available for creeks within this catchment.

8.1.2 Larcom Creek

The northern section of the Project is located within the Larcom Creek subcatchment, which encompasses an area of approximately 340 km^2. The proposed Aldoga Rail Yard will intersect Larcom Creek on the northern side of the existing NCL.

Larcom Creek is a major tributary of the Calliope River, which is sourced to the west of Mount Larcom and flows south west prior to discharging into the Calliope River north of Castlehope. The creek is generally characterised in the lower reaches by a series of large, deep waterholes and by a series of smaller ephemeral creeks and waterholes in the upper reaches.

A limestone and clay mine at East End, operated by Cement Australia, discharges collected groundwater from the mine into an ephemeral creek which flows into a naturally occurring lagoon (Wilmott Lagoon) formed by a sediment levee on Larcom Creek. Water from the lagoon flows into Larcom Creek just upstream from the confluence with Scrub Creek. Salinity of the lagoon has historically been known to be variable due to evaporative effects between flood episodes (Connell Wagner 1996), however with constant discharge from mine dewatering, the ephemeral creek now flows permanently and Wilmott Lagoon does not experience periods of extensive evaporative drawdown. Discharge to Larcom Creek occurs on an almost permanent basis.

8.1.3 Farmer Creek

Farmer Creek is a minor tributary of the Calliope River with a catchment area of approximately 50 km^2. Farmer Creek is characterised by ephemeral flows between small unconnected freshwater pools, particularly in the upper reaches. A palustrine wetland (ie wetlands with persistent emergent vegetation) was identified within the lower reaches of Farmer Creek. This has formed as a result of deliberate construction of a waterway barrier (ie weir) on Farmer Creek. The effect on Farmer Creek is seen as an accumulation of water along an anabranch of Farmer Creek, creating a large, permanent pool.

The Gladstone Nickel Project (GNP) Residue Storage Facility (RSF) is proposed to be located at the headwaters of Farmer Creek adjacent to the existing Rio Tinto Alumina Refinery residue management area. The GNP RSF will be constructed to ensure that discharge will only occur under extreme climatic conditions. The proposed seepage collection system ensures that any seepage is collected and returned to the impoundment for reclamation.

8.1.4 Scrubby Creek, Vallis Creek and other un-named creeks

There are a number of ephemeral creeks within the project area that may be traversed by the Project, however, by their nature, these ephemeral creeks do not support significant permanent pools between rainfall events. They are not supported by groundwater base flow during dry periods.

8.1.5 Water storages

Presently there are no major impoundments or water storage reservoirs in the Calliope River basin. Water supply for the Gladstone area is predominantly drawn from Awoonga Dam on the Boyne River.

Investigations into the future security of water supply for the Gladstone area have identified a site on the Calliope River at Castlehope as a potential location for a new dam. Inundation plans provided by DNRW for three potential dam elevation level (EL) scenarios (27, 30 and 35 m Australian Height Datum (AHD)) indicate that, if constructed, the dam's inundation area will encroach into the current project area.

This has been considered during the design with the Moura Link Western Option immune to an inundation area of full supply level (FSL) of 35 m. However, the Moura Link Eastern Option is not immune to the inundation areas proposed. The inundated area associated with the higher dam EL options also extends through the Bruce Highway corridor into the GSDA and also into the Dawson Highway and MSL corridors.

Raising a dam at the Castlehope site was one of nine options identified by the DNRW. With consideration of factors including quality, reliability, price, environmental impacts and social impacts Gladstone Area Water Board (GAWB) rank the Castle Hope Dam options seventh (27 m AHD) and eighth (35 m AHD) (GAWB Strategic Water Plan). Figure 8.2 illustrates the Castle Hope Dam inundation area for an FSL of 23 m and an FSL 35 m (data was not available for 27 m AHD).

The GAWB threshold criteria (which effectively require provisioning of water within two years of planning being finalised and diversification of supply) also reject the Castle Hope Dam as it will take between 7.5 and 12 years to deliver water. The Calliope River Water Resource Plan (2006) and the Central Queensland Regional Water Supply Strategy have recognised that the Calliope River basin is not a suitable water supply option for Gladstone's urban or industrial purposes (Queensland Competition Authority 2007). It is understood GAWB has also sold property it had originally purchased for this development.

For these reasons, the more favoured water supply options identified within the region are likely to be investigated further in the first instance. However, at this stage DNRW is unable to withdraw the Castle Hope Dam from the DNRW register as a potential future dam option.

On a local scale water storages within close proximity to the project area were primarily used for stock watering purposes. No referable dams were identified within the project area.

8.1.6 Surface water extraction licenses

A DNRW water extraction licence database search identified 103 records for the Calliope River Basin (including tributaries). Of the records identified, 24 were considered to be close enough to the project area to be identified as potentially impacted by the Project. Database records indicate there are multiple licences and multiple authorised purposes listed for some land parcels, therefore the number of potentially affected land owners is less than the number of potentially affected licences. At the time of writing, authorised purposes included domestic supply, stock, irrigation, aquaculture, water harvesting, quarrying and to divert a watercourse.

Licences are described by the type and purpose of authorisation for which the licence is granted. Table 8.2 summarises the types of licences identified within, adjacent to or in close proximity to the project area and the amount of allocated water. At the time of data extraction from the DNRW database, four of the licensed pumps were yet to be installed.

Table 8.2 Summary of DNRW water licence information

Authorisation type	Number of authorisations	Allocation (ha)	Allocation (ML)
Licence to take water (ie pumping)	15	218	201
Riparian water access (ie pumping)	7	N/A	N/A
Licence to interfere by impounding flow (ie damming)	1	N/A	N/A
Licence to interfere with the course of flow (ie diverting)	1	N/A	N/A

Due to the extensive use of bridges and culverts to convey flows under the proposed rail line, catchment hydrology is to be largely unaltered in the project area. It is unlikely that any licence holders downstream would experience a decrease in stream flow attributable to the Project, similarly as the amount of impervious surface area being created is not significant, in terms of catchment hydrology, it is unlikely that an appreciable increase in peak flow runoff would be observed (refer Section 8.3) If adequate erosion and sediment control measures are not implemented, particularly during the construction phase, water quality downstream could be impacted. To mitigate this potential impact, the erosion and sediment control plan will be tailored to ensure downstream water quality is protected.

8.1.7 Quarry material allocation notices

A quarry material allocation notice and approval under the *Water Act 2000* must be obtained to extract stone, gravel, sand, rock, clay, earth and soil from a non-tidal watercourse or lake, where such material is not removed as waste. That is, the material will be sold or used in some other beneficial way (eg building materials).

DNRW advised in May 2008 that there are no holders of Quarry Material Allocation Notices recorded in the Calliope Basin.

8.1.8 Environmental Values and Water Quality Objectives

The *Environment Protection (Water) Policy 1997* (EPP (Water)) under the EP Act identifies Environmental Values (EVs) and Water Quality Objectives (WQO) for waters within Queensland.

The EPP (Water) serves to protect Queensland's environment while allowing for ecologically sustainable development. This is achieved through the policy by providing a framework for:

(a) identifying environmental values for Queensland waters; and
(b) deciding and stating water quality guidelines and objectives to enhance or protect the environmental values; and

> *(c) making consistent and equitable decisions about Queensland waters that promote efficient use of resources and best practice environmental management; and*
> *(d) involving the community through consultation and education, and promoting community responsibility.*

Part 3, Section 7 of the policy states that:

> *(1) The "environmental values" of waters to be enhanced or protected under this policy are:*
> *(a) for a water in schedule, column 1 – the environmental values stated in the document opposite the water in schedule 1, column 2; or*
> *(b) for another water – the qualities in subsection (2).*
>
> *(2) The qualities are:*
> *(a) if the water –*
> *(i) is a pristine water – biological integrity of a pristine aquatic ecosystem; or*
> *(ii) is not a pristine water – biological integrity of a modified aquatic ecosystem; and*
> *(b) suitability for recreational use; and*
> *(c) suitability for minimal treatment before supplying as drinking water; and*
> *(d) suitability for agricultural use; and*
> *(e) suitability for industrial use.*
>
> *(3) However, if a natural property of the water precludes enhancement or protection of a particular environmental value, subsection (1)(b) does not apply to the value.*
>
> *(4) For subsection (1)(a), a document is taken to state environmental values for a water if it states one or more values (however described) that are equivalent to a quality or qualities in subsection (2).*

Watercourses within the project area are defined by the EPP (Water) as a modified aquatic ecosystem. In the absence of scheduled WQOs for the watercourses intersecting the project area, EVs have been determined from the EPP (Water) subsection (2).

The EVs of the creek systems within the freshwater extent of the Calliope River basin are related to adjacent land use. The systems are primarily used for grazing purposes. The catchment also supports industrial uses within the GSDA and extractive uses (mining) at East End Mine south of Mount Larcom township.

The Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines provide guideline values or descriptive statements for different indicators to protect aquatic ecosystems and human users of waters (eg primary recreation, human drinking water, agriculture, stock watering). The ANZECC guidelines are a broad scale assessment and it is recommended that, where applicable, locally relevant guidelines are adopted.

The data set of locally derived information about the creek systems is not sufficient to be used as baseline data for deriving WQOs.

In the absence of this locally specific data, the Queensland EPA's Queensland Water Quality Guidelines 2006 (QWQG) are intended to address the need identified in the ANZECC Guidelines by:

- Providing guideline values (numbers) that are tailored to Queensland regions and water types
- Providing a process/framework for deriving and applying local guidelines for waters in Queensland (ie more specific guidelines than those in the ANZECC)

For the purpose of determining appropriate WQOs for the project area, the East Coast – Central (Basins 117-136) region has been adopted from QWQG (refer Table 8.3). Calliope River is identified as Basin 132.

Table 8.3 Central coast region physio-chemical guidelines for lowland streams

Parameter	Guideline
Ammonia Nitrogen (NH_3)	20 µg/L
Oxidised Nitrogen (oxidised N)	60 µg/L
Organic Nitrogen (organic N) [1]	420 µg/L
Total Nitrogen (total N)	500 µg/L
Filterable Reactive Phosphorus	20 µg/L
Total Phosphorus	50 µg/L
Chlorophyll a	5.0 µg/L
Dissolved Oxygen (DO)[2]	85 % saturation – 110 % saturation
Turbidity	50 NTU
Suspended Solids	10 mg/L
pH[3]	6.5 – 8.0
Conductivity[4]	970 (µS/cm @ 25°C)
Temperature[5]	19 - 28°C

Table notes:

1 During periods of low flow and particularly in smaller creeks, build up of organic matter derived from natural sources (eg leaf litter) can result in increased organic N levels (generally in the range of 400-800 µg/L). This may lead to total N values exceeding the QWQG values. Provided that levels of inorganic N (ie NH3 + oxidised N) remain low, then the elevated levels of organic N should not be seen as a breach of the guidelines, provided this is due to natural causes.

2 DO guidelines (% saturation) only apply to water that is flowing. Stagnant pools in intermittent streams naturally experience values of DO below 50% saturation.

3 During floods or nil flow periods, pH values should not fall below 5.5 (except in wallum areas) or exceed 9.

4 QLD salinity zone Central Coast South – 75th percentile adopted as preliminary guideline as per QWQG recommendations. QWQG notes that salinity in this area is high and variable.

5 Derived local guideline using 20th/80th percentile data from QWQG reference site "Calliope River at Castlehope" (133 data points).

For parameters where QWQG provides no guideline value, ANZECC (2000) has been adopted as the best practice default. It is acknowledged that the application of QWQG to ephemeral and intermittently flowing streams is questionable, however in the absence of appropriate guidelines for such environments, the default WQOs have been adopted. Compliance or otherwise with the guideline values will be discussed in terms of local conditions.

QWQG states that for "slightly to moderately disturbed" waters, compliance against the guideline values should be assessed using the median value of the data set for each site.

8.1.9 Water quality data sources

Historical water quality data on the freshwater reaches of Calliope River and Larcom Creek is limited. Existing data is associated with environmental studies conducted as part of large scale developments (eg Aldoga Aluminium Smelter) or as part of long-term monitoring by the EPA within the estuarine reach. As the Project is located within the freshwater reaches of the system, only those freshwater sites have been examined.

Connell Hatch subsequently undertook two additional rounds of water quality sampling in August 2007 and February 2008, which included sampling a total of eight sites within the project area. The programme included two sites on Calliope River, five on Larcom Creek and one on Farmer Creek (refer Figure 8.1).

The DNRW watershed database identified three monitoring stations on Calliope River and one on Larcom Creek. Water quality data exists for all stations, however the station on Calliope River at Castlehope (proposed Castle Hope Dam location) provides the most extensive record for the greatest number of parameters. Data attributes are summarised for each DNRW site in Table 8.4.

Site 132001A is located on the Calliope River approximately 5 km downstream of the project area, while site 1320005 is located on the Calliope River approximately 7 km upstream. Site 130006 is located even further upstream of the project area and is included only for reference. Site 1320017 on Larcom Creek at Wycheproof Road is located at the same site as monitoring site 3, upstream of the project area.

Table 8.4 Summary of data attributes for DNRW sites

	DNRW sites			
	132001A	**1320005**	**1320006**	**1320017**
Station name	Calliope River @ Castlehope	Calliope River @ Calliope Station	Calliope River @ Mount Alma	Larcom Creek @ Wycheproof Road
Location	Easting 306347.6 Northing 7345944.0	Easting 293700.0 Northing 7341940.0	Easting 279091.0 Northing 7336090.0	Easting 295862.0 Northing 7352865.0
Catchment area	1,228 km^2	756 km^2	165 km^2	279 km^2
Flow gauging	✓	✓	✓	✓
Water quality	✓	✓*	✓*	✓*
Data range	1961-2007	1992-1997	1992-1998	1992-1997

Table note:
* Selected water quality parameters recorded at this site

The Calliope River site at Castlehope is currently identified as a "freshwater reference site" as defined by QWQG.

8.1.10 Monitoring site descriptions

The monitoring site descriptions are shown in Section 7.

8.1.11 Monitoring results

The median values for the data set are presented for each site in Table 8.5. The full data set is presented in Appendix F1.

Table 8.5 Median water quality observations

		Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		132001A		1320017		1320006		1320005	
	WQOs	Calliope R	n	Larcom Ck	n	Farmer Ck*	n	Larcom Ck	n	Larcom Ck	n	Calliope R	n	Larcom Ck	n	Larcom Ck	n	Calliope R	n	Larcom Ck	n	Calliope R	n	Calliope R	n
Water Temp (°C)	19 - 28	21.2	3	22.55	2	24.39	2	22.06	2	23.7	7	23.7	2	21.8	9	26.4	4	25.1	133	21.8	13	22.6	17	23.1	17
pH	6.5 - 8.0	7.47	3	7.38	2	7.27	2	7.54	2	6.92	7	7.78	2	7.17	9	6.74	4	8.00	208	7.53	14	8.03	19	8.00	18
Dissolved Oxygen (mg/L)		4.75	3	4.35	2	5.65	2	3.15	2	4.26	6	6.35	2	3.11	6	3.98	4	8.10	42	4.95	2	7.55	4	6.38	2
Dissolved Oxygen (%saturation)	85-110	56.3	3	54.5	2	74.9	2	41.0	2	55.3	6	78.8	2	40.3	6	51.3	4	N/A		N/A		N/A		N/A	
Conductivity (µS/cm@25°C)	970	1116	3	2331	2	125	2	4191	2	350	7	356	2	1866	8	469	4	1120	227	2480	13	922	20	1272	17
Turbidity (NTU)	50	2.9	3	6.35	2	50.1	2	40.1	2	26.0	4	12.1	2	3.9	4	2.8	1	3.0	120	3.4	2	1.0	6	2.0	2
Total Suspended Solids (mg/L)	10	5	2	9	2	15	2	11	2	10	6	8	2	5	9	8	4	10	97	1	1	7	3	5	1
Total Aluminium (mg/L)	0.055	0.26	2	0.14	2	0.35	2	0.11	2	0.05	6	0.41	2	0.01	8	0.07	4	N/A		N/A		N/A		N/A	
Total Arsenic (mg/L)	0.024	0.001	2	0.0015	2	0.001	2	0.0015	2	0.005	6	0.001	2	0.005	9	0.005	4	N/A		N/A		N/A		N/A	
Total Cadmium (mg/L)	0.0002	0.0001	2	0.0002	2	0.0001	2	0.0001	2	0.005	6	0.0001	2	0.005	9	0.005	4	0.0013	1	N/A		N/A		N/A	
Total Chromium (mg/L)	0.001	0.001	2	0.001	2	0.001	2	0.001	2	0.005	6	0.001	2	0.005	6	0.005	4	N/A		N/A		N/A		N/A	
Total Copper (mg/L)	0.0014	0.0015	2	0.0015	2	0.0015	2	0.0015	2	0.005	6	0.002	2	0.005	9	0.005	4	N/A		N/A		N/A		N/A	
Total Iron (mg/L)	N/A	0.45	2	0.55	2	0.73	2	0.39	2	1.49	4	0.68	2	0.75	5	0.72	2	0.1	1	N/A		N/A		N/A	
Total Lead (mg/L)	0.0034	0.001	2	0.001	2	0.001	2	0.001	2	0.005	6	0.002	2	0.005	9	0.005	4	N/A		N/A		N/A		N/A	
Total Zinc (mg/L)	0.008	0.005	2	0.005	2	0.005	2	0.005	2	0.011	6	0.013	2	0.005	9	0.006	4	N/A		N/A		N/A		N/A	
Total Petroleum Hydrocarbons (C6-C9)(mg/L)	N/A	0.02	2	0.02	2	0.02	2	0.02	2	0.05	6	0.02	2	0.05	6	0.05	4	N/A		N/A		N/A		N/A	
Total Petroleum Hydrocarbons (C10-C14)(mg/L)	N/A	0.05	2	0.05	2	0.05	2	0.05	2	0.05	6	0.05	2	0.04	6	0.05	4	N/A		N/A		N/A		N/A	
Total Petroleum Hydrocarbons (C15-C28)(mg/L)	N/A	0.1	2	0.1	2	0.05	2	0.15	2	0.1	6	0.1	2	0.1	6	0.1	4	N/A		N/A		N/A		N/A	
Total Petroleum Hydrocarbons (C29-C36)(mg/L)	N/A	0.05	2	0.05	2	0.10	2	0.07	2	0.1	6	0.05	2	0.1	6	0.1	4	N/A		N/A		N/A		N/A	
Total Mercury (mg/L)	0.0019	0.0001	2	0.0001	2	0.0001	2	0.0001	2	0.001	6	0.0001	2	0.001	9	0.001	4	N/A		N/A		N/A		N/A	
Total Nitrogen (mg/L)	0.5	0.5	2	0.6	2	0.8	2	1.4	2	1.5	6	0.4	2	1.1	9	1.7	4	0.4	29	N/A		0.2	2	N/A	
Total Phosphorus (mg/L)	0.05	0.07	2	0.03	2	0.03	2	0.09	2	0.09	6	0.05	2	0.07	9	0.09	4	0.03	45	N/A		0.09	2	N/A	
Chlorophyll a (µg/L)	5	5	2	3	2	12	2	9	2	8	2	5	2	4	2	1	1	N/A		N/A		N/A		N/A	

Table notes:

1 Shaded cells represent a median value greater than the WQO for the given parameter
2 n = number of records used to derive the median value
3 WQOs adopted for metals are default ANZECC (2000) trigger values for slightly – moderately disturbed ecosystems (ie 95% protection of species)
4 Older data sets incorporated for Sites 5, 6 and 7 trigger an apparent exceedance of the WQO due to differences in the Limit of Reporting (LOR) for laboratory analyses performed at the time (ie Cadmium, Chromium, Copper, Lead) Further, the current LOR for Copper is slightly greater than the WQO also triggering an apparent exceedance. ANZECC protocol is to report "<LOR" as half of the LOR therefore this should not be considered as an exceedance.

8.1.12 Water quality discussion

The combined data set provides sufficient information for a range of parameters to allow characterisation of the existing surface water quality of the Calliope River, Larcom Creek and Farmer Creek as it relates to the project area. The observed water quality is typical of ephemeral systems in Central Queensland, which are typically characterised by periods of flow during rain/flood events followed by periods of reduced connectivity of pools during dry periods. As such, the water quality can be highly variable, being dominated by higher sediment loads during flood events and higher electrical conductivity during dry periods.

Key indicators of water quality as they relate to the systems of interest are discussed in detail in the below sections. The comments below should be read in conjunction with Table 8.5, paying particular attention to the number of records used to derive the median values. For some sites, the ephemeral nature of the system has prevented the collection of sufficient records to be statistically significant. The DNRW site data is considered to be more representative of median conditions as it provides a longer period of observation for some of the parameters.

Physical water quality indicators

- In the natural environment surface water temperature is highly variable, changing diurnally (ie on a daily cycle) and seasonally reflecting the ambient air temperatures. Factors such as intact riparian vegetation greatly assist in keeping the diurnal fluctuation to a minimum due to the protective cover of tree branches offering shading to the watercourse. Median temperatures for all three systems complied with the WQO derived from the DNRW reference site. During periods where pools are disconnected from flow, the surface water temperature may be significantly warmer and thermal stratification is likely to occur in deeper pools.
- The median pH for all systems generally complied with the WQO, with the minor exception of the DNRW site on Calliope River at Mount Alma. While waterway pH is primarily a function of the surrounding soil types and geology, pH is another parameter that can vary considerably depending on flow conditions and land uses impacting on waterway nutrient concentrations. High algal productivity in a system can manifest as elevated pH (usually accompanied by supersaturation of dissolved oxygen) due to the process of algal respiration.
- Dissolved oxygen is a critical factor influencing the health of an aquatic ecosystem. Sensitive biota will not tolerate dissolved oxygen concentrations that are too low for extended periods of time and as such hardy species will become dominant under these conditions and overall diversity will be diminished. Disconnected pools characteristically have low dissolved oxygen as water stagnates and decomposing organic matter (ie aquatic weeds, leaves etc) break down. The median dissolved oxygen saturation at sites 1-8 were below the WQO, with the lowest readings typically being observed in Larcom Creek. This is consistent with the smaller size of pools observed in this system. The DNRW site on Calliope River at Castlehope has recorded data for a significantly longer period and includes observations under a range of flow conditions. DNRW only records observations for dissolved oxygen in mg/L. When converted to percent saturation corrected for temperature the long term median is approximately 100% saturation (refer Figure 8.3).

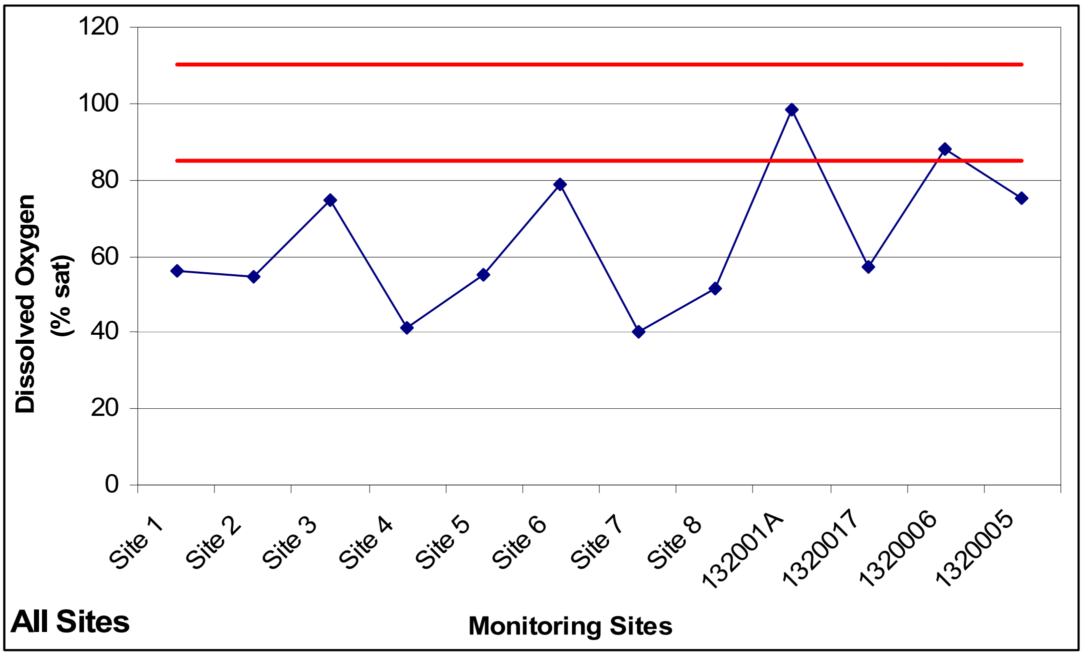

Figure 8.3 Median dissolved oxygen as % saturation

- Electrical conductivity (EC)/salinity is highly variable and most sites have median values above the WQO. With the exception of the most upstream DNRW site, which is a considerable distance upstream of the project area, there is no apparent trend of increasing or decreasing salinity with progression upstream or downstream in Calliope River or Larcom Creek (refer Figure 8.4 and Figure 8.5). EC increases significantly as pools evaporate and the dissolved minerals concentrate in the remaining water.

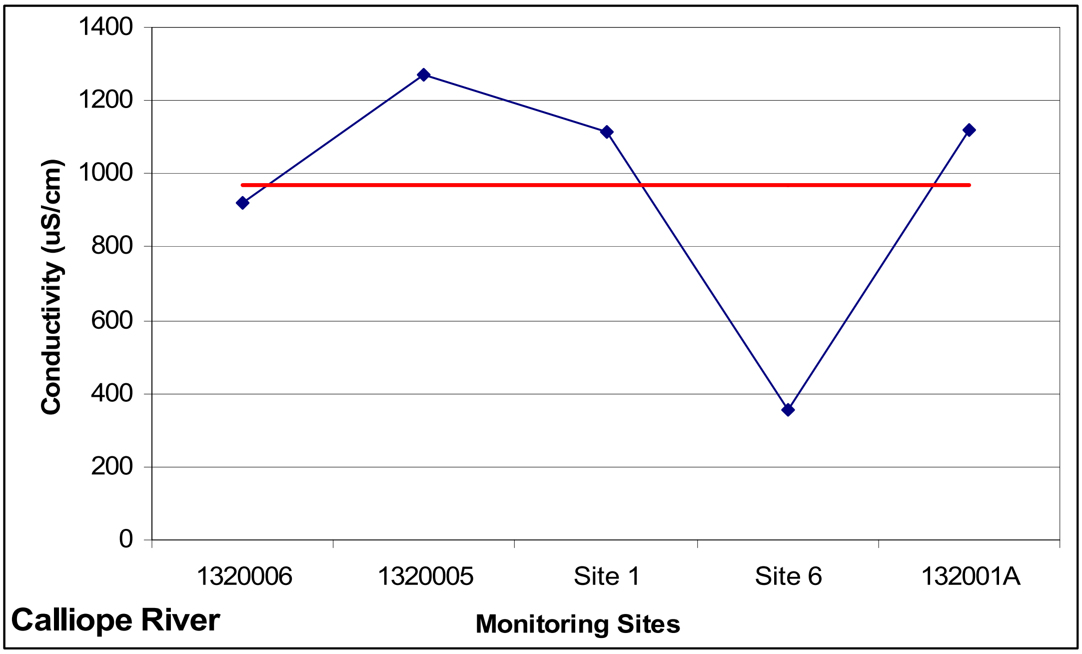

Figure 8.4 Median electrical conductivity variation (µS/cm) – Calliope River

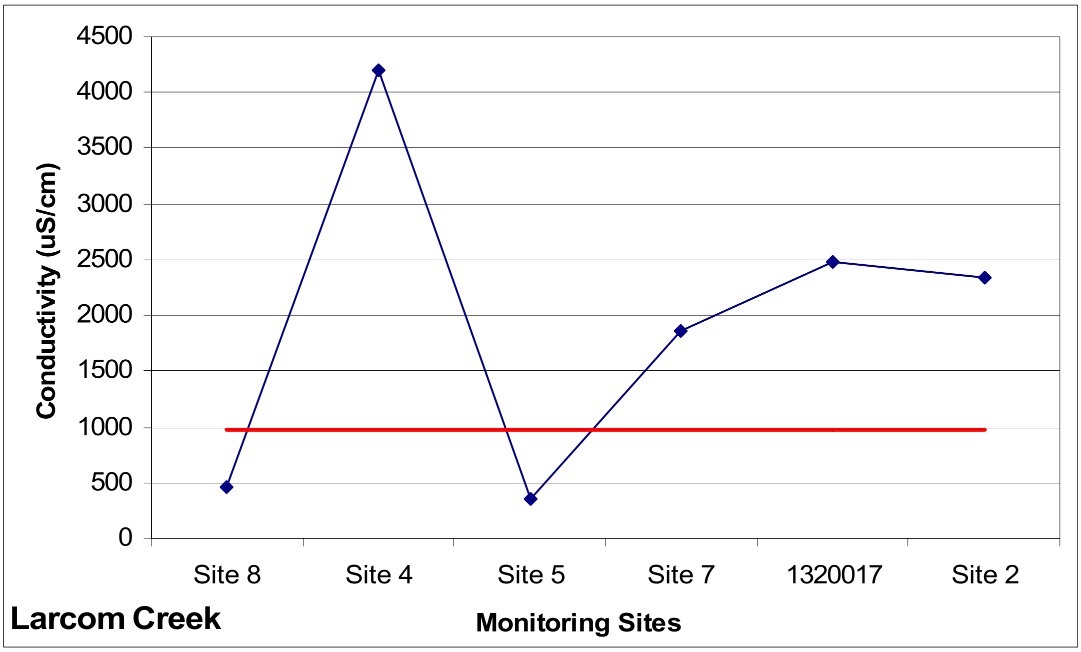

Figure 8.5 Median electrical conductivity variation (µS/cm) – Larcom Creek

- Median turbidity only slightly exceeded the WQO at the wetland on Farmer Creek. Turbidity in the wetland may be due to waterfowl stirring up the substrate. At most other locations, the median turbidity was quite low with the majority under 10 NTU (refer Figures 8.6 and 8.7). Larcom Creek at sites 4 and 5 recorded median values of 40.1 NTU and 26.0 NTU, respectively, indicating that these sites are typically more turbid than other sites within the catchment. This is likely to be due to cattle accessing the waterholes in this area, but also due to the substrate composition having a larger proportion of silt and mud at these locations relative to other sites which had higher substrate compositions of sand, cobbles and boulders.

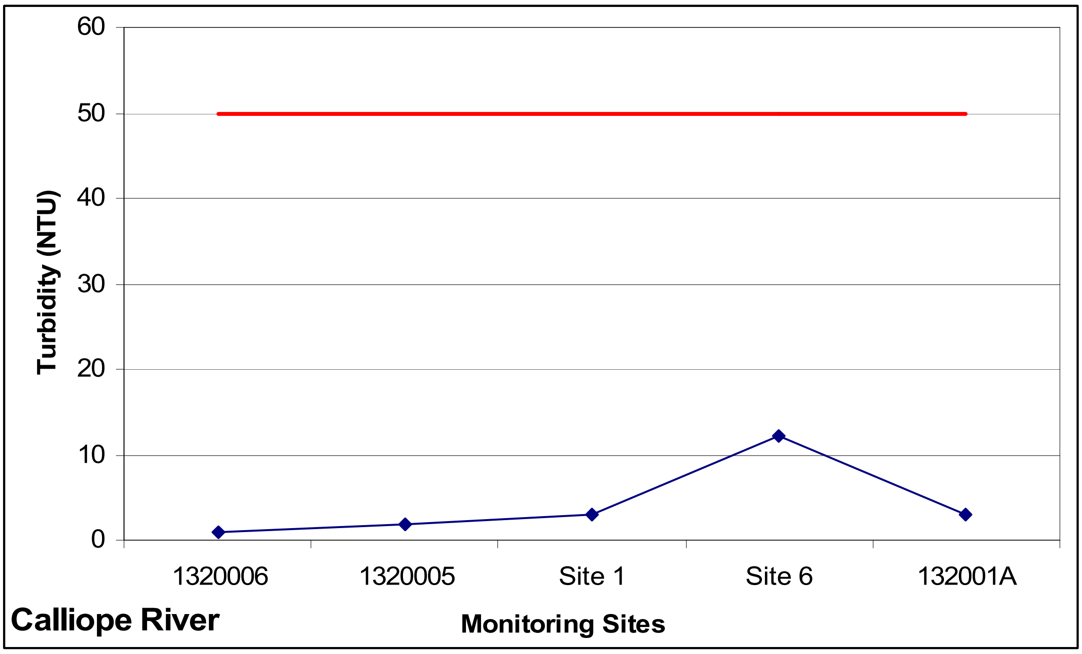

Figure 8.6 Median turbidity variation (NTU) – Calliope River

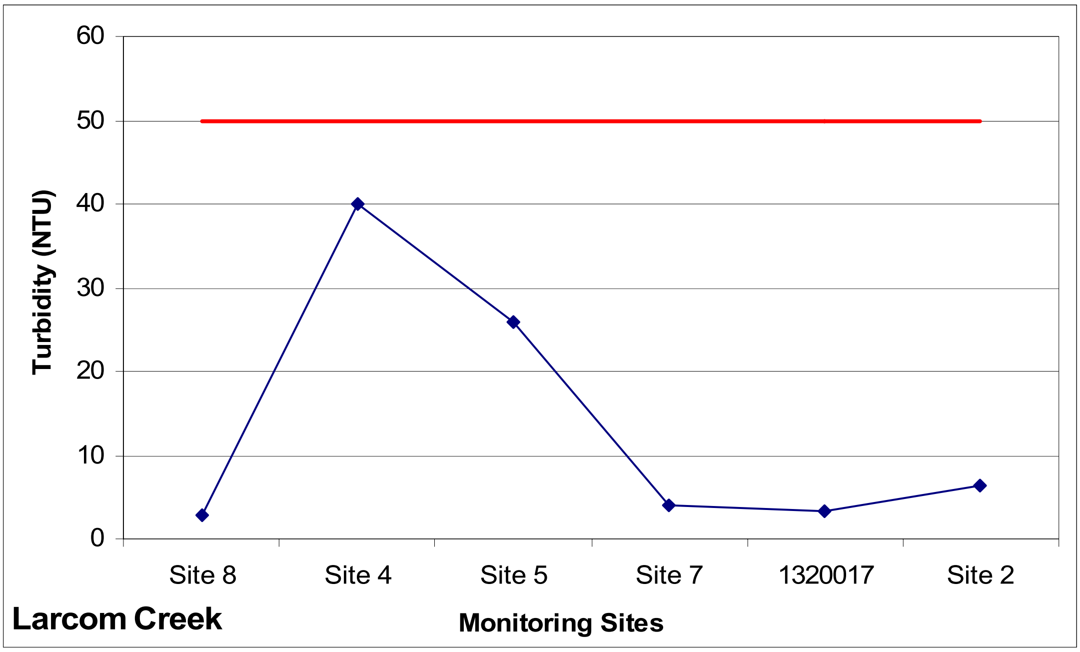

Figure 8.7 Median turbidity variation (NTU) – Larcom Creek

Chemical water quality indicators

Analysis of samples can be performed for hundreds of analytes, however generally there is a standard suite of analysis that is undertaken. Over the years, the "standard suite" has been supplemented with additional analytes and as such, monitoring records from different sources may have data for some parameters but not others. Similarly, as laboratory techniques improve, the analytical detection limit (also known as the "limit of reporting" and commonly reported as LOR) has improved such that most appropriately equipped NATA accredited laboratories can now provide analysis to minute concentrations with an acceptable level of accuracy and precision[1].

Analytes can be separated into categories based on the chemical properties being determined. For the purpose of this assessment, the categories are heavy metals, nutrients and hydrocarbons. Within the grouping of "nutrients", total suspended sediment and chlorophyll a have been included for ease of reference as they are intrinsically interlinked through in-stream chemical and biological processes.

Heavy metals

Heavy metals analysed included aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury and zinc. The median values presented in Table 8.5 represent the total metal concentrations. Samples were also analysed for dissolved metal concentrations and the full laboratory results appear in Appendix F2. The ANZECC (2000) guideline trigger values are applied such that if the total metal concentration exceeds the guideline value, the dissolved proportion may be analysed to determine the likelihood of metal availability in the environment. If the dissolved metal concentration also exceeds the guideline value, bioavailability testing may be conducted to determine the likelihood of toxicity to aquatic organisms. Typically however, the latter is cost prohibitive and is usually only undertaken if a significant risk is likely to exist.

[1] The exception to this is where the water being sampled contains elevated concentrations of dissolved salts which can interfere with the matrix used in analyses, requiring large sample dilutions and a higher LOR.

In particular, of the eight sites for which data is available the following has been determined:

- The median total aluminium concentration exceeded the WQO (0.055 mg/L) at six sites. The dissolved aluminium concentration however was well below the WQO indicating that the elevated total aluminium concentrations are not cause for concern.
- The median total cadmium concentration exceeded the WQO (0.0002 mg/L) at one DNRW site (132001A – Calliope River downstream), however it is important to note that this was a once off analysis performed at this site and the dissolved concentration was not analysed. Sites 5, 7 and 8 are not shaded in Table 8.5 because the apparent exceedance is due to the LOR for analysis, which is higher than the WQO for some of the older samples (0.005 mg/L). In all cases, concentrations were reported as less than the LOR. This also applies to the older samples analysed at sites 5, 7 and 8 for the parameters of arsenic, chromium, copper and lead.
- The median total zinc concentration exceeded the WQO (0.008 mg/L) at two sites (sites 5 and 6). The dissolved zinc concentrations were however below the WQO, and in the majority of cases below the LOR indicating that the elevated total zinc concentrations are not cause for concern.

Nutrients

Median concentrations for total nitrogen and total phosphorus have been reported in Table 8.5. Appendix F1 contains the full set of results and DNRW site records which include the species of nitrogen and phosphorus (ie ammonia, nitrite, nitrate, total Kjeldahl nitrogen and reactive phosphorus). The importance of nutrient speciation on waterway health is now well understood and guidelines have been derived for these parameters (refer Table 8.3).

As ephemeral creek flows recede to intermittent pools or permanent waterholes the water temperature increases. Thermal stratification usually develops, particularly where the influence of wind movement on the surface of the water is minimal. Stratification results in a layer of warmer, oxygenated water at the surface, with a cooler, anoxic layer at the bottom. Anoxic conditions allow sulfate reducing bacteria to break down organic nutrients and release hydrogen sulphide gas (rotten egg gas). The distinctive odour is particularly noticeable when the bed sediment is disturbed.

Under these conditions, complex chemical reactions occur, and nutrients that are bound in organic complexes or adsorbed onto sediment particles are released into the water column as inorganic species of nutrients. When the ambient air temperature falls below the temperature of the cooler water in the bottom of the waterhole, the water spontaneously destratifies, bringing the dissolved nutrients to the surface and in some instances triggering algal blooms. A similar situation can result from a sudden inflow of water which causes a displacement of the stratified layers (ie large flood event).

In particular:

- Median total nitrogen concentrations exceeded the WQO at six out of ten sites, with the highest concentrations typically recorded in Larcom Creek.
- Of the limited data available, it is noted that ammonia concentrations exceeded the WQO at the majority of sites, with the highest concentration (0.853 mg/L) recorded at site 4 during the August 2007 survey. Generally however, concentrations are an order or magnitude lower than this maximum recorded. Ammonia sources include decaying detritus in stagnant waterbodies and waste products from cattle. It is highly likely that this is the causative factor of elevated concentrations of ammonia, particularly at sites where cattle have unrestricted access to waterholes.
- Median oxides of nitrogen (nitrite and nitrate) concentrations were below the WQO at all sites, except the DNRW Calliope River site at Castlehope, where a median concentration of 0.089 mg/L (n=4) was recorded.

- Median organic nitrogen concentrations exceeded the WQO at all the EIS monitoring sites, except sites 1, 6 and 7. Of the DNRW sites, data was only available for the Calliope River site at Castlehope, which had a median concentration below the WQO. High organic nitrogen concentrations are indicative of abundant leaf and twig debris, particularly where vegetation is growing in or adjacent to a waterway. This is generally supported by field observations at the monitoring sites noting the presence of abundant riparian vegetation.
- Median total phosphorus concentrations exceeded the WQO at six out of ten sites. Also, not all sites with elevated total phosphorus had elevated total nitrogen. This is due to different nutrient processes and different sources within creek catchments.
- Concentrations of reactive phosphorus, an inorganic bioavailable fraction of total phosphorus were higher than the WQO at sites 1 and 6 only. Both of these sites are located on the Calliope River, potentially indicating a source of inorganic phosphorus exists upstream of the project area. However, the downstream DNRW Calliope River site at Castlehope recorded a median compliance with the WQO so the effects appear to be transient. As concentrations are not excessively high, it is possible that the elevated bioavailable phosphorus may be being attenuated by in-stream nutrient processing, however typical indicators of system productivity (ie chlorophyll *a* concentrations as a surrogate for algal activity) do not necessarily support this.
- Median chlorophyll *a* concentrations higher than the WQO were recorded at sites 3, 4 and 5 (the wetland on Farmer Creek and two consecutive sites on Larcom Creek, respectively). Sites with more surface shading due to vegetation tend to have lower chlorophyll *a* concentrations. Sites where elevated total nutrient concentrations have been recorded correlate with observations of higher chlorophyll *a* concentrations.
- Median suspended solids concentrations higher than the WQO were also recorded at sites 3 and 4, potentially indicating that a greater degree of disturbance is occurring to the bed and banks at these sites. This is likely to be due to cattle directly accessing the waterhole. At the wetland location (site 3) disturbance of the substrate by birds is also a likely contributing factor.

Hydrocarbons

Whilst there is no specific guideline trigger value for total petroleum hydrocarbons (TPH), the general rule of thumb is “no visible sheen/slicks” on the water surface. As surface slicks can be due to factors other than the presence of hydrocarbons, field observations are usually backed up by laboratory analysis of TPH carbon-chain fractions. Results indicate that TPH concentrations were below the LOR at all sites except site 4 during the August 2007 survey, concentrations of 200 µg/L C15-C28 and 80 µg/L C29-C36 were recorded. All results from the February 2008 survey were below the LOR. Site 4 is located downstream of the existing NCL, so it is plausible that this represents an existing source of some TPH fractions.

Often BTEX (Benzene, Toluene, Ethylbenzene, Xylene) analysis is included in water quality investigations. ANZECC (2000) provides default trigger values of 950 µg/L (Benzene), 350 mg/L (ortho-Xylene) and 200 mg/L (para-Xylene). In all instances where laboratory data are available for these parameters, recorded concentrations are well below these default trigger values and in all instances, below the LOR of 1 µg/L, 2 µg/L and 2 µg/L for these parameters, respectively (refer Appendix F2).

8.2 Potential water quality impacts

Waterway crossings will be required for the Calliope River, Larcom Creek, Vallis Creek, Sandy Creek and several other unnamed tributaries. The Moura Link Western Alternative Option requires approximately eight waterway crossings including one on Nine Mile Creek, while the Moura Link Eastern Preferred Option requires approximately 12 waterway crossings including four on Scrubby Creek and one on Farmer Creek. It is important to note that the majority of these waterways are ephemeral, hence the approximation of the number of “crossings” of a defined waterway.

Potential impacts on surface water quality exist during both the construction and operational phases of the Project. Construction and operational activities may have the potential to generate a range of pollutants which, if not managed appropriately, will have the potential to affect water quality within Calliope River, Larcom Creek, Farmer Creek and their tributaries, and potentially the receiving waters of Port Curtis. The possible future construction of Castle Hope Dam on the Calliope River may also be potentially impacted.

Potential impacts along the proposed Moura Link are considerably different to those of the proposed Aldoga Rail Yard. For this reason, potential impacts have been segregated into those related to the rail line itself and those relating to the Aldoga Rail Yard.

8.2.1 Potential construction impacts

The primary pollutant of concern during construction is sediment. Activities essential during the construction phase include clearing of vegetation, cut and fill/various earthworks and the construction of waterway crossings (ie installation of culverts and/or bridges). These activities, by their nature, will disturb the soil surface and remove protection from erosion. Uncontrolled erosion has implications for both stream health and engineering aspects. Inadequate erosion and sediment control provisions on site can be costly in terms of project delays due to unworkable site conditions following rain events.

Rail line impacts

Bridge spans will be used to cross major waterways (ie Calliope River, Larcom Creek, and Farmer Creek). However, culverts are likely to be installed in minor ephemeral waterways to allow flow to pass under the rail line. The installation of culverts within the waterways has the potential to destabilise the bed and banks causing scouring and erosion around the structures. This has the potential to cause impacts on the engineered infrastructure (ie undermining, failure) as well as the downstream receiving environment (eg elevated turbidity levels resulting in clogging of fish gills, infilling of stream bed substrate and loss of in-stream biota, smothering aquatic plants and filling in of permanent pools/waterholes which act as refuges for aquatic fauna during dry periods).

Culverts can create a grade change in the stream bed and can cause varying velocities of stream flow, resulting in erosion on the downstream side of the culvert. If the lip of the culvert is set higher than the stream bed then erosion can occur. If maintenance activities to clear weeds (such as Typha and Paragrass) from upstream of the culvert cause over excavation of the bed then shallow ponding can occur resulting in ideal habitat for mosquito breeding.

Due to the existence of class listed weeds in the project area, it will be necessary to wash down mobile plant prior to moving it offsite. Runoff from wash down areas has the potential to impact on waterways through direct transportation of turbid water and weed seeds to adjacent waterways. Also the source of water used for wash down has the potential to impact on surface water quality (ie salinity if bore water is being used or nutrients if recycled water is being used).

Aldoga Rail Yard impacts

The proposed Aldoga Rail Yard straddles Larcom Creek and several small tributaries and will require bridging and culvert work to construct the yard. These activities have the potential to impact on the water quality and the downstream EVs of Larcom Creek and associated tributaries.

Works within the bed and banks of a watercourse have the potential to cause a range of impacts including:

- Liberation of sediment from disturbed/cleared riparian areas
- Disturbance of instream (bed) sediment
- Loss of riparian vegetation and associated impacts on stream habitat including loss of shading

- Destabilisation of creek banks leading to future slumping, collapse of riparian vegetation into creeks and associated bank erosion

Other potential impacts associated with the construction of the Aldoga Rail Yard include:

- Hydrocarbon or chemical leaks and/or spills from mobile plant (ie work vehicles) or storage areas
- Storage and disposal of waste materials
- Runoff of recycled water used on site throughout construction (sourced from the construction sewage treatment facility)
- Runoff of saline bore water (if used) from washdown facilities
- Sediment-laden runoff from exposed areas of fill on site

8.2.2 Potential operational impacts

Rail line impacts

Once operational, the potential impacts of the rail line itself on surface water quality are minimal. Impacts are likely to fall into two distinct categories:

- Unforseen events/accidents/derailments
- Routine maintenance activities

With regard to accidents/spills resulting from the contents of the train leaving the carriage (ie derailment), potential impacts to waterways are likely to be incidental. The risk of a spillage due to train derailment is no higher than the risk of spillage that may occur due to a truck crash on the Bruce Highway. Given the relative few waterway crossings, the likelihood of derailment occurring at or near a waterway crossing, as opposed to elsewhere on the line, is low risk. The majority of the cargo being transported on the Moura Link will be coal for export. Coal is not considered a serious contaminant as it is practically inert in its natural state and can be readily cleaned up using mechanical techniques. Coal is unlikely to cause serious and/or permanent environmental harm.

Routine maintenance activities such as line inspections, clearing maintenance tracks, unblocking culverts etc) may have the potential to generate sediment depending on the activities being undertaken.

Major maintenance activities that would be required on a very infrequent basis (eg replacing sleepers and ballast) have the potential to generate contaminants and sediments on a local scale. This is due to the disturbance of the substrate and ballast, removal of vegetation and the operation of equipment (potential point source).

The proposed Castle Hope Dam inundation area will encompass the Moura Link Eastern Option and it is likely that QR would need to remove the infrastructure if the construction of the dam ever proceeded. It is therefore unlikely that the Moura Link Eastern Option would impact on the proposed dam (inundation area and water quality). The proposed Moura Link Western Option has been designed to accommodate an inundation level of 35 FSL with the main risk associated with the derailment of traffic. Refer to Appendix B2 for further details concerning the Moura Link options.

QR proposes that appropriate provision be made to accommodate a future rail corridor for the Moura link Western Option in Gladstone Regional Council's planning scheme to cover any eventuality of the Castle Hope Dam actually proceeding.

Aldoga Rail Yard impacts

Whilst there will be considerable disturbance and earthworks during the construction of the Aldoga Rail Yard, the highest risk, in terms of impacts relates to the ongoing operation of the rail yard facility. Inappropriate storage and handling of potentially hazardous materials and inappropriate treatment of site process water prior to release present the most likely impacts to surface water quality in Larcom Creek and the downstream receiving environments.

A pollution control system will be implemented to treat process water from the Aldoga Rail Yard as the runoff may contain high concentrations of sediment, hydrocarbons, nutrients and heavy metals. If water is not adequately treated prior to discharge to Larcom Creek, it has the potential to impact on the in-stream biota. Impacts may include clogging of fish gills, infilling of bed substrate, smothering of aquatic plants, direct toxicity effects resulting in disease or death of aquatic organisms and general reduction in waterway health.

Chemical/fuel spills have the potential to cause significant environmental harm to the downstream receiving environment if not adequately contained on site. Impacts from a spill vary widely depending on the type of spill, the volume, the location and potential for interception prior to entering a waterway and the clean up methods utilised.

The proposed Castle Hope Dam catchment will be located directly downstream (Larcom Creek) of the proposed Aldoga Rail Yard. Hence if the dam is constructed there is a potential for the yard to adversely impact on water quality. The main risk is associated with the failure of existing chemical/hydrocarbon storages facilities as well as the treatment systems. This type of failure has the potential to result in toxicants discharging into Larcom Creek, which could eventually end up in the dam (water storage area).

The ephemeral nature of Larcom Creek will minimise the risk of hazardous material entering the dam (ie within the area Larcom Creek is a series of detached pools which would limit the spread of the spills and/or leaks). However, the risk is likely to increase during periods of significant rainfall when there would be flows within Larcom Creek.

8.3 Potential hydraulic impacts

Variations to the existing catchments through which the proposed rail infrastructure will be constructed are minimal and subsequent redirection of runoff is negligible. Larcom Creek is the initial receiving waterway for the proposed Aldoga Rail Yard, while the Calliope River is the ultimate receiving waterway for the Project.

8.3.1 Moura Link

The proposed Moura Link will result in some interruption to natural existing drainage patterns. However, as there is minimal variation to existing catchments, there is likely to be minimal impact on existing hydraulic patterns. It is important to note from the preliminary engineering design that:

- There are some proposed diversions to existing drainage paths along the rail line
- Most natural drainage paths are conveyed under the rail via culverts
- Modelling was undertaken to investigate the potential impact new bridges may have on water surface levels at creek crossings

Alterations to natural flow patterns

There are likely to be alterations to existing natural flow paths upstream and downstream of the Project, where constraints prevent standard culvert crossings. Modelling has illustrated that alterations to natural flow will result in no difference in the discharge at the final point of discharge in the Calliope River.

Culverts

At all other drainage crossings culverts will convey the flow under the proposed rail infrastructure and disturbance to natural drainage paths is kept to a minimum. Where practicable culverts will be designed to reproduce natural channel conditions (eg in terms of direction and slope) keeping with the Road Drainage Design Manual (DMR 2002). Conceptual culvert design has not considered fauna movement, this issue will be investigated in the detailed design phase.

In some cases extreme flood events may cause an increase in head water against the embankment. Embankment design will consider potential impacts during the detailed design phase.

Comparison of pre/post bridge water surface levels

Preliminary engineering hydraulic models indicate the Moura Link will cause no significant change in flood levels. HEC RAS was used in this investigation. Results of the model are shown in Table 8.6 which indicates water levels at all major watercourse crossings before and after development during 100 year ARI. Figure 8.8 illustrates the location of major crossings along the Moura Link and NCL.

Table 8.6 Comparison of pre/post construction water surface levels at proposed bridge structures along the Moura Link

Alignment option	Bridge ID	100 year ARI water surface level (m AHD) - immediately upstream		Change (m)
		Existing	Developed	
Moura Link	Vallis Creek	57.64	57.67	0.03
	Vallis Creek Valley	61.67	61.83	0.16
	Larcom Creek	40.85	40.87	0.02
Moura Link Eastern Option	Farmer Creek	27.77	27.77	0.00
	Calliope River	27.18	27.39	0.21
	Scrubby Creek 4	27.54	27.75	0.21
	Scrubby Creek 3	30.03	30.40	0.37
	Scrubby Creek 2	30.52	30.82	0.30
	Scrubby Creek 1	32.39	32.60	0.21

Table 8.6 illustrates that there is no significant change in flood levels from existing to developed scenarios. The maximum increase is 37 cm at Scrubby Creek crossing 3. Based on the assumption that the Moura Link Western Option will be developed to accommodate the Castle Hope Dam inundation area (FSL 35 m) modelling for a 100 year ARI event was not undertaken.

Further hydraulic assessment using a two dimensional model will be undertaken during the detailed design phase of the Project.

8.3.2 Aldoga Rail Yard

The change in land use for the proposed Aldoga Rail Yard will result in a negligible increase in runoff potential. The ultimate point of discharge is Larcom Creek and an unnamed tributary of Larcom Creek which joins Larcom Creek approximately 1,500 m downstream of the project area. Larcom Creek passes through mainly agricultural land prior to discharging into the Calliope River upstream of the Moura Link Western Option.

Development of the yard will result in a change in land use which will increase the percentage of impermeable surface area for catchments located within the yard footprint. However, it is considered unlikely that the negligible increase in peak discharge at Larcom Creek, the final point of discharge, would result in a negative impact to downstream areas.

Stormwater management systems will be incorporated into the yard design and may include longitudinal swales and drainage systems to capture and divert ‘dirty water’ to the industrial wastewater treatment plant. These systems will assist in reducing the peak discharge resulting from increased impermeable area.

Alteration of natural flow paths

Within the proposed Aldoga Rail Yard area there are approximately six natural drainage paths that convey water across the yard area. The design incorporates measures that reduce the need for culverts diverting water to Larcom Creek or the unnamed tributary of Larcom Creek.

However, there may be the need to divert an existing watercourse which intersects the proposed Aldoga Rail Yard to the west of the DPIF tree plantation. This will involve the diversion of the drainage line to the north of the proposed Aldoga Rail Yard east to Larcom Creek. The feasibility of this option will be assessed in during detailed design.

Modelling has indicated that the alterations will have little effect on downstream water as the ultimate point of discharge for these catchments remains the same.

The duplication of the EEMBL and NCL will involve no alterations to existing drainage paths. The duplication design allows generated low flow to follow existing drainage paths through existing culverts by duplicating existing culverts whenever necessary.

Comparison of pre/post bridge water surface levels

Where the proposed Aldoga Rail Yard crosses Larcom Creek several bridge crossings have been proposed. Table 8.7 details water levels at the bridge crossing and at downstream locations in both the existing and developed cases during a 100 year ARI event. The modelling was undertaken in HEC RAS which is considered an appropriate level of modelling for concept design. Further hydraulic assessment will be required during detailed design.

Table 8.7 Comparison of pre/post water surface levels at proposed bridge structure

	100 year ARI water surface level (m AHD) - immediately upstream		Change (m)
	Existing	Developed	
Existing NCL bridge over Larcom Creek (refer Figure 8.8)	46.30	46.58	0.28
400 m downstream	44.85	44.85	0.00
1,400 m downstream	43.41	43.41	0.00
2,400 m downstream	41.28	41.28	0.00

Table 8.7 illustrates that the proposed Aldoga Rail Yard has a minor impact on flood levels close to the site, and the modelling results show no impact downstream of the proposed yard site. Modelling also shows that the proposed yard will not be inundated by the 100 year flood.

8.4 Mitigation measures

Mitigation measures are an essential component of project design to ensure potential impacts on the surface water environment are minimised (reduced to an acceptable level where total elimination is not possible). Mitigation measures are an important aspect of ensuring the EVs of the waterways are protected and the WQOs achieved. The site of the potential future Castle Hope Dam downstream of the project area and the eventual discharge into the receiving environment of Port Curtis highlights the importance of implementing appropriate mitigation measures for this Project.

The measures proposed to mitigate potential surface water impacts for the Project are discussed in Section 20.

8.5 Conclusion

The Project has the potential to impact on the surface water quality of the immediate and receiving environment. The nature and extent of the works may change the water quality and chemistry through construction activities and also through operational activities such as the Aldoga Rail Yard.

It is also recognised that development within the GSDA and overall Calliope River catchment has the potential to impact the proposed Castle Hope Dam if perceived impacts (changes to water quality) are not planned and managed appropriately.

The most likely contaminant to have an impact on water quality will be in the form of suspended sediments entering the water column and changing physical parameters such as light penetration, dissolved oxygen and temperature. This may impact the organisms and ecology of the area if not properly mitigated to a level of acceptable quality.

Mitigation measures for construction activities include of retention and treatment measures to achieve water quality guidelines before release and ongoing monitoring for compliance with discharge criteria. An Operational EMP will manage the discharges into nearby waterways.

These approaches will form a cohesive water quality strategy to minimise potential water quality impacts.

Preliminary engineering hydraulic models indicate that the Project will cause no significant change in flood levels (100 ARI events). It is important to note that this level of modelling is appropriate for conceptual design. Further investigation will be undertaken during the detailed design phase of the Project.

8.6 Commitments

The relevant water quality commitments for the Project include:

- QR will adopt water efficiency strategies (ie recycle and reuse of wastewater and stormwater from buildings) during construction and operation.
- Stormwater management systems will be implemented and maintained during construction and operation to minimise impact on downstream receiving environments, particularly at Larcom Creek and Calliope River.
- QR will minimise potential mosquito breeding sites onsite by preventing ponding waters.
- No significant worsening of flooding upstream and downstream of the Project