# 9. Groundwater resources

This section describes the existing groundwater conditions in the area and identifies the potential impacts of the Project on the groundwater resources.

Groundwater resources in the project area are an integral part of the overall existing water resource system in the area and is utilised by a number of existing users. It has the potential of being a significant resource for the construction and operation of the Project.

## 9.1 Groundwater legislative requirements

In Queensland a number of areas have been declared as subartesian areas under the *Water Act 2000* and the subordinate legislation, including the *Water Regulation 2002* and Water Resource Plans for individual catchments.

The project area is not located in a declared subartesian area but does lie within the Water Resource (Calliope) Plan area. As such it is subject to general conditions as required under the *Water Act 2000*, the *Water Regulation 2002*, the *Integrated Planning Act 1997* (IPA), the Water Resource (Calliope) Plan and Calliope River Basin Resource Operations Plan.

The *Water Act 2000* requires that a water licence is obtained for taking or interfering with artesian water anywhere in the State. Artesian water is underground water that, when tapped by a bore, flows naturally to the surface. A water licence is also required to take or interfere with subartesian water (underground water that has to be pumped to the surface) in declared subartesian areas or in areas defined in a water resource plan. Generally, subartesian water can be taken for non-intensive stock and domestic purposes without a licence within a declared subartesian area. It is however, necessary to contact the local office of the DNRW, and the Gladstone Regional Council prior to the use of any groundwater resources to ensure that no additional restrictions or requirements have been instigated.

Schedule 8 of the IPA specifies the following relevant operational works as assessable development:

- All work in a watercourse (eg pump, gravity diversion, stream redirection, weir or dam)
- All artesian bores anywhere in the state, no matter what their use
- Subartesian bores in declared groundwater areas used for purposes other than stock and/or domestic purposes
- Subartesian bores in certain declared groundwater areas that are used for stock and/or domestic purposes

It is a requirement of the *Water Act 2000* that all water bores in Queensland are to be constructed by a licensed water bore driller to meet the “Minimum Construction Requirements for Water Bores in Australia”.

Currently there is no provision for artesian or subartesian water within the *Water Resource (Calliope River Basin) Plan 2006*, however there are provisions within the legislation for the administrating Minister to amend or replace these instruments if:

- Authorisations in the plan area are not sufficient to meet emerging requirements for additional water
- There is a risk that taking, or interfering with, subartesian water in the plan area may significantly impact on the plan’s outcomes
- There is a risk that taking, or interfering with, subartesian water in the plan area may significantly affect:
  - The availability of water for existing water entitlements
  - The water requirements of natural ecosystems
  - The quality of water

The EPP (Water) also has measures for the protection of groundwater. These legislative measures attempt to prevent the contamination of groundwater through placing restrictions on the release of waste water. These strict conditions aim to protect groundwater resources and other groundwater users. The EPP (Water) places the responsibility of managing Queensland's groundwater resources back onto the DNRW under the Water Resources Plan process.

The *Water Resource (Calliope River Basin) Plan 2006* does not provide for the regulation of groundwater. The DNRW has previously assessed the groundwater risk in the Calliope River Basin. They concluded that the groundwater resources are not extensive and are primarily used for stock and domestic purposes which are not under threat. Should this situation change the regulation of groundwater may be provided for in a future amendment to the plan.

### 9.1.1 Groundwater quality

The ANZECC Guidelines provide guideline values or descriptive statements for different indicators to protect aquatic ecosystems and human uses of waters (eg primary recreation, human drinking water, agriculture, stock watering). The EPP (Water) also provides environmental value guidelines that are required to be protected or enhanced under the EPP policy. This policy outlines the protection of the following environmental values in Queensland:

- If the water:
  - Is a pristine water—biological integrity of a pristine aquatic ecosystem
  - Is not a pristine water—biological integrity of a modified aquatic ecosystem
- Suitability for recreational use
- Suitability for minimal treatment before supply as drinking water
- Suitability for agricultural use
- Suitability for industrial use

The water quality objectives for the region are not defined under the EPP (Water). However, reference is made regarding the use of water guidelines that protect all environmental values of the water. Therefore, the ANZECC Guidelines have been used for comparison of water quality levels in all cases.

## 9.2 Methodology

### 9.2.1 Hydrogeology

Hydrogeological properties were identified from a review of the Geology of Rockhampton 1:250,000 Map Sheet (Kirkgaard and Hunt 1974) and the Geology of Monto 1:250,000 Map Sheet (Queensland Department of Mines 1981)

### 9.2.2 DNRW groundwater database

Records from the DNRW groundwater database were accessed to determine the nature of the groundwater system throughout the project area. These records are limited as the area is not a Declared Subartesian Area. And as such there were no legislative requirements for the registration or reporting of groundwater bore locations or construction details until the implementation of the *Water Act 2000*.

Records were examined for bores located within a 3 km radius of the project area.

### 9.2.3 Groundwater monitoring

To account for the shortfall in available groundwater information five groundwater monitoring boreholes were established within and adjoining the project area. The monitoring boreholes were established to verify and delineate the condition of the groundwater resources within the area.

Two monitoring bores are located within and in the vicinity of the proposed Aldoga Rail Yard and three along the proposed Moura Link (refer Figure 9.1). The bores have been constructed by a licensed driller and are between 12 m and 20 m depth. The bores have been constructed using PVC casing and gravel or sand packed screens. Drilling and construction logs are presented in Appendix G1.

A field quality sampling round of the project monitoring bores was conducted in mid May 2008.

### 9.2.4 Groundwater flow direction

There are insufficient records throughout the area surrounding the Project to construct groundwater contour plots of the region. The water levels available for the bores existing in the project area are limited to the May 2008 monitoring results. Further, the water levels available are from differing aquifers and would not be reflective of a single hydrostatic level.

Localised groundwater flow paths can generally be assumed to be a reflection of topographical variations such as surface drainage patterns.

### 9.2.5 Seasonal variations

Due to the lack of an existing groundwater monitoring network or water level records for the area it is not possible to determine the seasonal variations of groundwater in the immediate project area. However, monitoring bore (97147) is screened within a limestone aquifer in the Larcom Creek aquifer and is indicative only. The differing aquifer materials may reflect different recharge and discharge patterns.

### 9.2.6 Hydraulic parameters

The transmissive and storage properties determine the rate and amount of water that can be extracted from an aquifer. The two properties, hydraulic conductivity and storativity are important in characterising the groundwater flow system. These aquifer properties are most reliable when interpreted from pump test data. Other sources such as the interpretation from lithological logs provide data more representative of the site or bore than the aquifer.

The Transmissivity (T) of the aquifer was found to be $1.25 \times 10^{-1}$ $m^2/d$. The Hydraulic Conductivity (K) is then $2.67 \times 10^{-5}$ cm/s with an assumed effective aquifer thickness of 5.5 m.

Transmissivity is the measure of the amount of water that can be transmitted horizontally through a unit width by the full saturated thickness of the aquifer under a hydraulic gradient of 1. Transmissivity values can change as the water table is reduced in an unconfined aquifer.

The design yield of a bore is the volume of water as determined by the pumping test results which can be safely extracted from the bore.

Storativity is a dimensionless quantity of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in head. No values have been calculated for the bores in the area due to the short duration of the pumping tests and the lack of observation bore data for these tests.

## 9.3 Existing environment

Knowledge of groundwater in the catchment traversed by the Project is limited. A preliminary assessment, based on geological information, indicates that the catchment is dominated by low-yielding fractured rock aquifers. In general, the water quality is suitable for medium to high salt tolerant crops, for stock watering and some domestic purposes, but not for human consumption. Groundwater in the Calliope catchment is not regulated or controlled. Subsequently licences are not required for installing or using bores.

### 9.3.1 Hydrogeology

A review of the Geology of Rockhampton 1:250,000 Map Sheet (Kirkgaard and Hunt 1974) and the Geology of Monto 1:250,000 Map Sheet (Queensland Department of Mines 1981) indicate that the northern portion of the project area, including the proposed Aldoga Rail Yard area is underlain by Quaternary alluvial deposits consisting of gravels, silts, sands and clays (refer Figure 9.1). These sediments overlie, in part, the lower permian Berserker Beds in the east and the lower carboniferous Crana Beds in the west.

The Berserker Beds consist of lapilli, vitric, and crystal tuffs, andesitic and acid flows, agglomerate, tuffaceous conglomerates, mudstone and lithic arenite. The Crana Beds, an older component of the Yarrol Basin sequence, abut the Berserker beds in the western portion of the proposed Aldoga Rail Yard. The Crana Beds consist of feldspathic and lithic arenite, conglomerate, mudstone, siltstone, andesitic flows and tuff, and rare acid flows.

The remainder of the project area is underlain by the lower to middle Devonian Mount Holly Beds consisting of acid to intermediate ash flow tuff, ash fall tuff, acid or basic flows, volcanic arenite, siltstone, mudstone, conglomerate, crinoidal and coralline limestone.

The project area is characterised by low undulating hills. The general area is dissected by Larcom Creek and Calliope River with associated alluvial deposits of limited lateral and vertical extent. Generally the area is overlain by thin alluvial, colluvial and residual soils over a fractured and weathered basement.

### 9.3.2 Groundwater use

The majority of groundwater extracted from within the area is for pastoral, horticulture and domestic purposes. There is no data available for the quantification of groundwater use throughout the area.

The requirements of the Water Resource (Calliope) Plan and Resource Operating Plan do not currently address the use of artesian or subartesian water use within the area and as such there is no metered groundwater use data available.

### 9.3.3 DNRW groundwater database

The DNRW groundwater database search indicated that there are 29 private groundwater bores in the general vicinity of the project area (refer Figure 9.1). There are no DNRW groundwater monitoring bores within the project area and as such consistent collection of water level and quality data has not been undertaken in the area.

Of the 29 recorded private bores, two are hand dug wells within the alluvial deposits associated with the Calliope River each to a depth of 7.9 m. The remaining 27 bores are accessing water from the fractured rock of the Berserker Beds (2) and the Mount Holly Beds (24). These bores are reported to have been screened within the fractured bedrock at depths ranging from 5 m to 50 m below ground level (bgl).

The project area is also located within the vicinity of the Mount Larcom groundwater management unit (GMU). The Mount Larcom GMU centres around the East End limestone mine, which is approximately 10 km south west of the township of Mount Larcom, and extends over 82 $km^2$. A limestone aquifer is the major water supply source in the GMU and is predominantly jointed in nature, with some solution enlarged joints.

The groundwater supplies are principally obtained from solution cavities, with minor groundwater supplies available from fractured zones and joints in the limestone and from factures only within the volcanoclastic rocks interbedded with the limestone. Yields from production bores in the limestone deposits range from 0.1 L/s, from fractured zones, up to 20 L/s from limestone associated with associated solution cavities. The average yield is less than 1 L/s. Supplies available from the volcanoclastic members range from 0.1 L/s to 4 L/s, with an average of about 0.5 L/s. Water quality is the limiting factor in the development and use of groundwater resources, as the groundwater obtained from the limestone deposits is usually hard (ie high mineral content) (ANRA 2007).

### 9.3.4 Groundwater condition

**Water levels**

Currently groundwater level data from the 29 private bores in the project area is unavailable due to a lack of monitoring and because of restrictions in access to the boreholes.

Previous studies indicate that the majority of water comes from the shallow groundwater system at depths less than 20 m (C and R Consulting 2005). This aquifer system is underlain by a deeper, 30-35 m system that is probably present in the Tertiary weathering zone and derived sediments from the base Palaeozoic geology.

Water levels within the five monitoring boreholes installed as part of this EIS supported this with the water levels between 6 m and 15 m (refer Table 9.1)

**Table 9.1 Monitoring bore locations**

| Bore No | Depth (m bgl) | SWL (m) |
|---|---|---|
| BH101 | 20 | 15 |
| BH102 | 20 | 10.16 |
| BH103 | 11 | 6.08 |
| BH104 | 12 | 9.47 |
| BH105 | 12 | 8.82 |

**Table notes:**
m bgl = metres below ground level
SWL = standing water level

Monitoring bore BH101 has been installed within the fractured zone of the siltstone and arenite of the Mount Holly beds. Water levels indicate that there is little connectivity with the overlying alluvials and reflect the expected water table of the surrounding area. Groundwater would be expected to be shallower in the alluvial deposits of the area. Groundwater was reported at 10.16 m bgl in monitoring bore BH102. Installed within the tuff of the Mount Holly Beds this reflects the groundwater levels of the fractured rock areas of the central portion of the Moura Link.

The remaining three monitoring bores have been installed within alluvial deposits. Monitoring bores BH103 (Moura Link) and BH105 (Aldoga) are alluvials associated with Larcom Creek, and monitoring bore BH104 within the alluvials of the proposed Aldoga Rail Yard associated with the unnamed creek to the west of Larcom Creek. Monitoring bore BH103 has a standing water level of 6.08 m bgl, while boreholes BH104 and BH105 levels are at 9.47 and 8.82 m bgl, respectively.

Records for bore 97147 extend from 20 November 1996 to 5 September 2006. A graph of groundwater elevations for bore 97147 is presented as Figure 9.2.

Water level measurements were recorded quarterly for this period of time. It should be noted that this sampling pattern is most likely to miss short lasting extreme highs and lows. The records should however provide sufficient information to determine a steady state aquifer sample. This bore was observed to have a seasonal variation on average of 1.62 m/y, a maximum of 4.52 m in a calendar year and a minium seasonal fluctuation of 0.41 m/y.

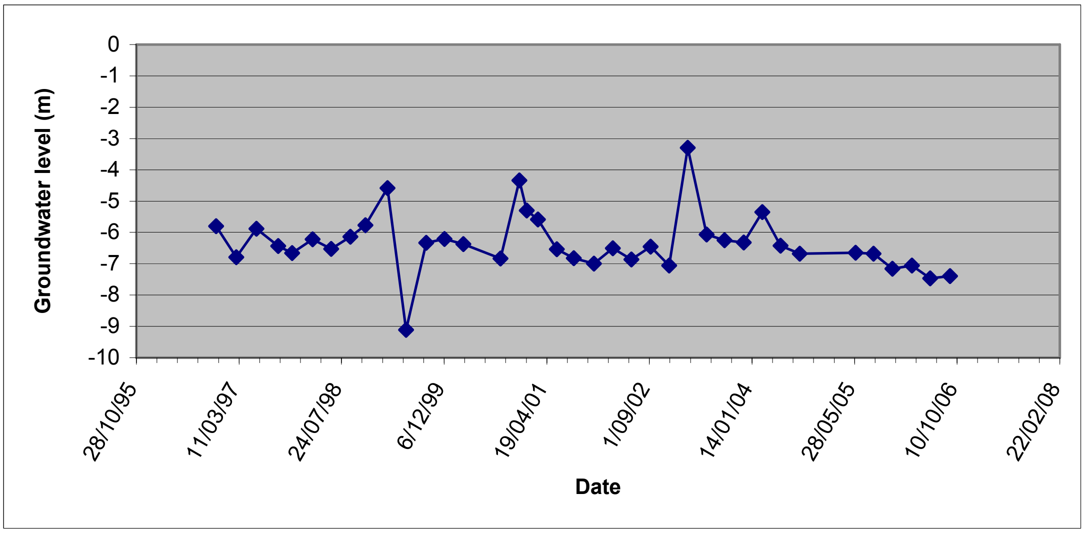


**Figure 9.2 Water levels – Bore 97147**

## Groundwater quality

Field quality tests for pH, electrical conductivity, dissolved oxygen, and temperature were conducted for bores at the time of sampling. The results of these tests are presented in Table 9.2.

**Table 9.2 Groundwater field quality results**

| Bore No. | pH | Electrical Conductivity (µS/cm) | Dissolved Oxygen (% saturation) | Temperature (˚C) |
|---|---|---|---|---|
| BH101 | 7.69 | 1,089 | NA | 24.3 |
| BH102 | 7.38 | 514 | NA | 26.1 |
| BH103 | 6.82 | 4,892 | 7.07 | 24.5 |
| BH104 | 7.24 | 1,188 | NA | 25.1 |
| BH105 | 6.84 | 4,348 | NA | 25.6 |

Electrical conductivity (EC) ranged between 500 and 4,900 µS/cm. These levels were to be expected as groundwater sourced from DNRW was variable across with ECs ranging from 200 µS/cm to 23,100 µS/cm.

Groundwater with ECs below 1,000 µS/cm were observed within the weathered and fractured granites to the east of the proposed Aldoga Rail Yard and within the tuffaceous volcanics to the south of the Calliope River. All groundwater samples (6) associated with the Mount Holly Beds limestones were observed to have ECs in excess of 5,000 µS/cm except for one sample collected at the southern extent of the project area and adjacent to the Calliope River which had a conductivity of 1,750 µS/cm. A sample was collected from fractured andesite within the Berserker Beds at the northern boundary of the proposed Aldoga Rail Yard and was reported to have an EC of 1,510 µS/cm.

The recorded pH for waters sampled was between 6.4 and 8.6 which marginally exceed the recommended drinking water guideline range of between 6.5 and 8.5. These guidelines are based on the need to reduce corrosion and encrustation in pipes and fittings.

In addition to *in-situ* monitoring, groundwater samples were collected and analysed by a National Association of Testing Authorities (NATA) accredited laboratory. Table 9.3 presents the results of the water analysis.

**Table 9.3 Summary of groundwater analytical results: Dissolved major cations and metals**

| Bore No. | pH | Total Dissolved Solids (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Sodium (mg/L) | Copper (mg/L) | Nickel (mg/L) | Fluoride (mg/L) |
|---|---|---|---|---|---|---|---|---|
| BH101 | 7.92 | 762 | 40 | 30 | 821 | 0.0162 | 2.54 | 0.7 |
| BH102 | 7.72 | 3,220 | 125 | 176 | 821 | 0.002 | 0.007 | 4.9 |
| BH103 | 7.16 | 2,870 | 116 | 227 | 629 | 0.001 | 0.007 | 0.7 |
| BH104 | 7.47 | 675 | 52 | 50 | 141 | 0.001 | 0.001 | 3.0 |
| BH104 | 7.33 | 2,440 | 150 | 181 | 530 | 0.004 | 0.003 | 0.3 |

The results indicate that the groundwater in the study area is unsuitable for drinking water without treatment but suitable for stock and irrigation, although elevated fluoride levels in BH102 and BH103 are above the recommended 2 mg/L. The full results of the water sample analysis are included in Appendix G2.

Six of the samples exceeded the recommended upper level for hardness in drinking water of 200 mg/L and may lead to build-up of scale in bores, pipes, and hot water systems. It is recommended that any groundwater is tested prior to the determination of use for drinking or reticulation.

Four of the nine samples analysed for iron were found to exceed the drinking water guideline of 0.3 mg/L. Iron values ranged from 0 mg/L to 4.0 mg/L. Sodium levels were recorded between 24 mg/L and 4,950 mg/L with six samples exceeding the drinking water guidelines of 180 mg/L. Two bores exceeded the guidelines for sulphate of 250 mg/L. Sample levels were reported to range between 2 mg/L and 950 mg/L.

The palatability of drinking water has been rated according to Total Dissolved Solids concentrations by a scale developed by Bruvold and Daniels (1990) and as such three samples were rated as good (>80 mg/L and <500 mg/L), one as poor (>800 mg/L and <1,000 mg/L) and the remainder as unacceptable for drinking water purposes (>1,000 mg/L).

Generally, the poorer quality water encountered within the project area appears to be associated with the limestone within the Crana Beds and fresher waters associated with the volcanics of the Berserker Beds in the area.

### Groundwater flow directions

In the eastern portion of the proposed Aldoga Rail Yard it is assumed that groundwater flow is in a general south westerly direction adjacent to and with localised variations towards Larcom Creek. The western portion of the proposed Aldoga Rail Yard is assumed to be in a south easterly direction towards Larcom Creek.

The remainder of the project area will have various flow directions as groundwater follows down valley directions of the various localised systems. Generally flow will be towards the local minor and major watercourses which will act as groundwater sinks. Regionally, groundwater flow will be directed towards the Calliope River in the southern extent of the project area.

### Hydraulic parameters

A review of the DNRW groundwater database indicates that there is a single recorded pump test within a 3 km radius of the project area. The results of the pump test indicate a transmissivity of 9 $m^2$/day and no storativity value was recorded. The design yield for the bore was 0.9 L/s.

During the field activities a constant discharge pump test and recovery test was conducted at monitoring bore BH103. In addition, water level observations were recorded during the test. The test was conducted for seven (7) minutes with a pump flow rate of 4.3 L/min. Pumping was ceased at this time when pump suction was broken with a water level in the bore of 11.10 m bgl. Due to the short duration of pumping, emphasis was placed on ensuring that recovery data was collected.

The recovery test data has been analysed using the Theis Recovery method.

Groundwater supplies from the fractured rock aquifer in the vicinity of the project area are variable in nature which is dependent upon the level of fracturing occurring within the rock at any given location. The supplies obtained from the alluvial material associated with the Calliope River, Larcom Creek and other watercourses nearby is associated with narrow bands of relatively thin alluvials and is also dependent on specific bore locations.

Pearce (1982) reports transmissivity values for Devonian limestone from the Mount Larcom district ranging from 10 $m^2$/day in poorly fractured areas to 3,000 $m^2$/day for bores that tap solution channels.

## 9.4 Recharge sources

Groundwater recharge can be by either through direct infiltration via rainfall, overland flow and/or through surface water – groundwater interconnectivity. Comparing water levels in groundwater bores with rainfall residual mass curves or with the nearby streamflow heights can provide an indication of the source of major changes in groundwater levels.

Whilst it is hard to determine the contribution each source makes to groundwater recharge in the project area due to the limited data available, aquifer characteristics can aid in determining general assumptions.

Both alluvial and fractured rock aquifers are able to derive most of their recharge from rainfall infiltration and/or overland flow. Alluvial aquifers also have a greater ability to gain or lose water through streamflow from nearby watercourses.

## 9.5 Groundwater – surface water interaction

Groundwater – surface water interaction occurs in all types of landscape. The interaction takes place in the following three ways:

- Streams, lakes and wetlands gain water from inflow of groundwater through the streambed
- Streams, lakes and wetlands lose water by outflow through the same streambed
- Or they do both, losing in some and gaining in others

For groundwater to discharge into the stream channel, the height of the water table in the vicinity of the watercourse must be higher than the height of the stream-water surface. Conversely, for surface water to seep to groundwater, the height of the stream level must be higher than the height of the groundwater level.

Losing streams can be connected to the groundwater system by a continuous saturated zone or can be disconnected from the groundwater system by an unsaturated flow. Often where the stream is disconnected by an unsaturated zone, the water table may have an apparent mound below the stream if the rate of recharge through the stream bed and unsaturated zone is greater than the rate of lateral groundwater flow away from the water table mound.

The flow of water between the watercourse and the underlying aquifer can be also controlled by the hydraulic properties and features of the aquifer, as well as the geological material separating the aquifer from the surface water. River beds with a coarse gravel bed have a higher degree of interaction between the river and the underlying aquifer than if the watercourse consisted of a thick sequence of clay which is likely to restrict movement of water.

After a storm or large rainfall event the rapid rise in the water level of a watercourse allows water to move from the watercourse into the banks of the watercourse. This is called bank storage and as long as the rise in the water level does not overtop the banks of the watercourse, most of the volume of water that enters the banks returns to the stream within a few days or weeks.

The current level of understanding of the groundwater system of the area does not allow the determination of groundwater fluxes between the aquifers and the associated streams. A correlation of groundwater and surface water level monitoring is required to clearly determine the interaction between water bodies. Perennial watercourses such as Larcom Creek and the Calliope River are likely to act as both groundwater sinks and sources dependent on the geology encountered. The ephemeral streams throughout the area are more likely to act as groundwater sources during periods of flow.

## 9.6 Potential impacts

This section addresses the potential impacts to the groundwater system during the construction and operational phases of the Project. Potential impacts on the groundwater include:

- Contamination through physical interaction with the underlying groundwater by extraction, excavation and construction.
- Reduced groundwater levels due to over extraction, during construction and operation of the Project, if groundwater is used as the major water supply source.

Potential groundwater impacting contaminants on construction sites and railway facility sites include petroleum hydrocarbons, heavy metals,  pesticides, phenyls, polychlorinated biphenyls, and non metallics, including arsenic, cyanide, sulphur, sulphides and sulphates.

### 9.6.1 Potential construction phase impacts

Potential groundwater impacts during the construction phase include:

- The potential for groundwater contamination from fuel and chemical storage and use
- Contamination of the exposed groundwater through spills, leaks and surface runoff entering the excavations
- Infiltration of impacted leachate from stockpiled soil originating from the excavations
- The intersection or interaction with the groundwater table of building foundations, cut and fill earth works and embankments
- The extraction of groundwater for the provision of water for site works

Groundwater resources are variable in quality and quantity throughout the project area. Generally, useful quantities of groundwater could be expected from the limestones of the Mount Holly beds, or from fault, fracture, and joint zones within the rocks Mount Holly beds, Crana beds or the Berserker beds. Alluvial deposits associated with the larger watercourses such as Larcom Creek and the Calliope River may provide the best opportunity for groundwater supply options.

The over extraction of groundwater during the construction could lead to a reduction in groundwater levels in the vicinity of the project area. This can lead to increased salinity levels within the underlying aquifers and also within overlying soils. This can impact on other users within the vicinity, downflow ecosystems, Phreatophytic (groundwater dependent) vegetation.

The removal of vegetation and soils, and changes to local flows paths and hydrology may also impact on recharge rates and groundwater levels.

### 9.6.2 Potential operation impacts

During the operational phase of the Project potential impacts include:

- The potential for groundwater contamination from fuel and chemical storage and use (especially if underground storage tanks are used)
- The use of pesticides and herbicides for weed and vermin control
- The potential impacts of metals from the train provisioning activities onsite
- The use of chemicals for the cleaning and maintenance of trains onsite
- The extraction of groundwater for the provision of facility water

To mitigate the potential impacts to the groundwater system from the Project mitigation measures will be implemented (refer Section 20).

## 9.7 Mitigation measures

The measures proposed to mitigate the potential groundwater impacts of the Project are discussed in Section 20.

## 9.8 Conclusions

The conclusions below are based on the limited information available from the DNRW groundwater database and the groundwater sampling conducted as a part of this EIS.

Groundwater resources are limited to:

- The limestones of the Mount Holly beds
- Fault, fracture, and joint zones within the rocks Mount Holly beds, Crana beds or the Berserker beds
- Alluvial deposits associated with the larger watercourses

Groundwater flow in the eastern portion of the proposed Aldoga Rail Yard is in a general south westerly direction adjacent to Larcom Creek with localised variations towards the stream. In the western portion of the proposed Aldoga Rail Yard groundwater flow is in a south easterly direction towards Larcom Creek. Within the Moura link section groundwater follows the down valley directions of the various localised systems. Generally groundwater flow is toward the Calliope River in the southern extent of the project area.

Groundwater resources are variable in quality and quantity throughout the project area.

Suitable groundwater supplies may be found through the targeting of larger scale fracture zones and faults within the underlying geology or the alluvial deposits associated with Larcom Creek and the Calliope River. Utilisation of information gained from the geotechnical drilling programme at the commencement of construction planning will assist in targeting suitable locations for water supply bores.

## 9.9 Commitments

The relevant groundwater commitments for the Project include:

- Hydraulic testing of the aquifer, to establish a sustainable yield, should groundwater be used for construction and/or operational water supply.
- Develop and implement management controls for hazardous materials onsite to protect groundwater, including spill response procedures and training.