CHAPTER 5

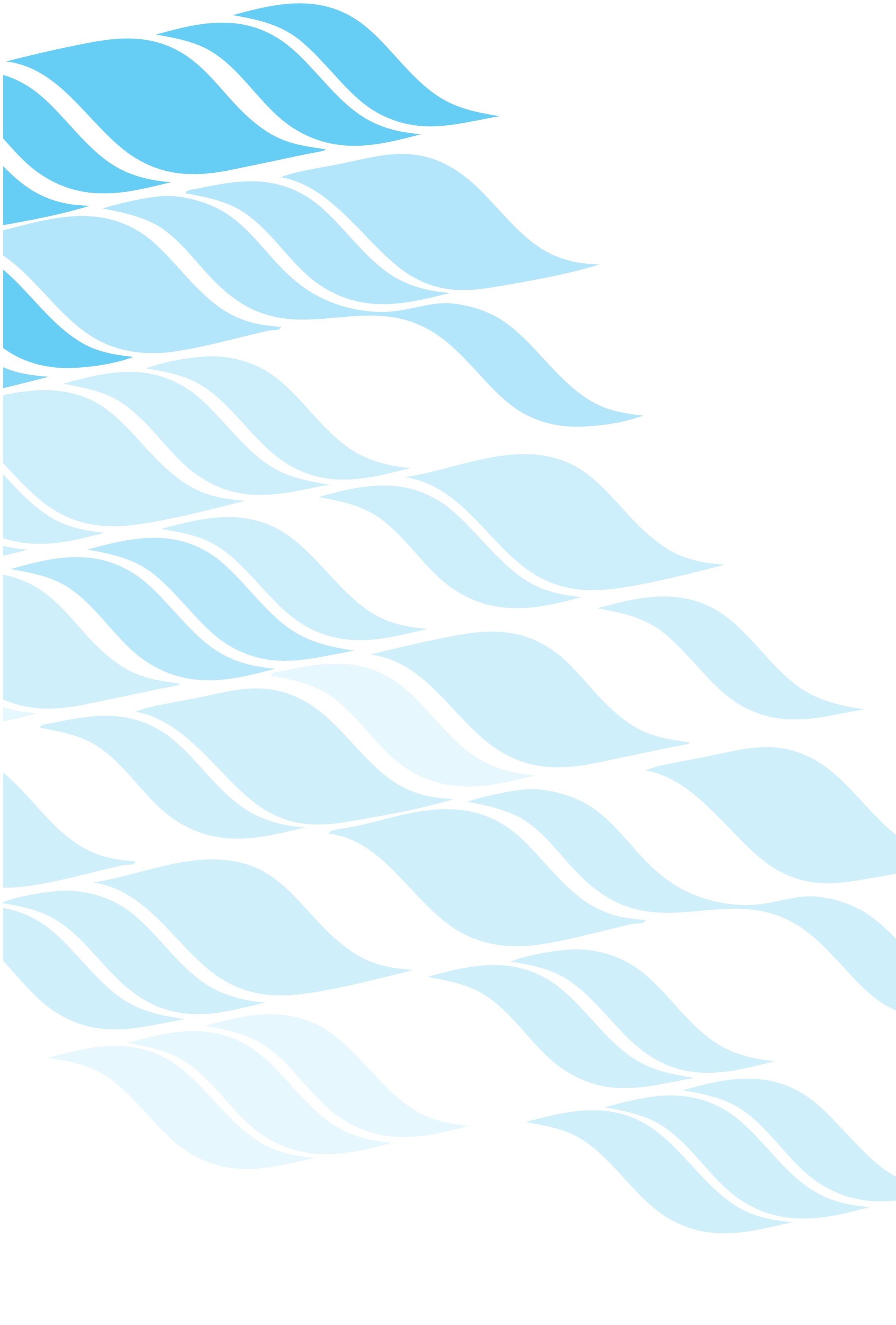
GLADSTONE – FITZROY

PIPELINE PROJECT

Environmental Impact Statement

Soils and Contaminated Land

Gladstone Area Water Board



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5. Soils and Contaminated Land

5.1 Introduction

This chapter outlines the baseline environment and impact assessment for the Gladstone-Fitzroy Pipeline project (the project) with respect to soils and contamination. This includes consideration of Acid Sulfate Soils (ASS) and Good Quality Agricultural Land (GQAL). (See Section 5.2.2 for a definition of GQAL)

The study area has been defined for this chapter as the land within the generally 30 m right-of-way (ROW) that is to be cleared for construction and includes the sites for project infrastructure. Where relevant, the areas directly adjacent to the ROW have been included.

This chapter aims to address the requirement (ToR) of Sections 3.2.3 and 3.2.4 in the EIS Terms of Reference (Appendix A). It should be noted that Chapter 17, Landscape and Visual Assessment, addresses the requirements of the ToR with respect to Topography and Geomorphology.

Due to the nature of the soils assessment and the Preliminary ASS Assessment (Golder Associates, 2007), the respective baseline and impacts sections have not been split up into the two sections of the project area (Fitzroy to Bajool and Bajool to Gladstone) as has been done for GQAL and contaminated land.

5.2 Baseline Methodology

5.2.1 Soils

Soils and geology in the project area have been described based on desktop analysis and on field work that was completed by the Queensland Government's Central Queensland Geotechnical Unit (CQGU) as part of the preliminary geotechnical investigation. Desktop studies have included a review of existing mapping including:

- Median ambient levels of total phosphorus are above the Queensland Water Quality Guidelines Water Quality Objectives (EPA, 2006, with 2007 minor updates)
- Queensland Dominant Soils (Department of Natural Resources, Mines and Water 2006)
- Geology of Queensland 2005 (Department of Natural Resources and Mines 2005)
- Fitzroy, Rockhampton and Calliope Planning Scheme overlay maps.

Fieldwork included soil sampling from the test pits during the preliminary geotechnical investigations and was undertaken by CQGU between August and October 2007. Test pits were planned to be completed at approximately 500 m intervals for the length of the project alignment between the Fitzroy River and the Gladstone State Development Area (GSDA). Test pits were numbered from 1 to 220 from the location of the Aldoga Reservoir north to the Fitzroy River intake (see Figure 5.1 and Figure 5.2).

Test pits 1 to 28 are located within the GSDA and were not completed during preliminary investigations as the alignment in the GSDA was not known at that time. Some planned test pits were also not completed due to land access limitations. Further geotechnical investigations will occur prior to construction, for areas within the GSDA but also including the rest of the corridor. Test pits were excavated using a backhoe or similar plant, typically to a depth of 3 m or refusal on rock. This allowed sampling of soils to the proposed trench excavation depth of 2.5 to 3 m.

During the preliminary test pit program, soils were logged for each test pit in accordance with *AS 1726-1993 Geotechnical Site Investigations*. These soil logs were then transcribed into terminology consistent with The Australian Soil and Land Survey 2nd Edition (1990) based on the original classification supported in some instances by inspection of relevant soil samples. Transcribed Test Pit Logs are included in Appendix E1.

The preliminary assessment of soils within this chapter has been based on a terrain assessment of the subject route, soil types and erosion and dispersion potential, with reference to CQGU's laboratory test results on 34 soil samples and soil logs. Results of soil tests conducted by the CQGU on 34 soil samples recovered from test pits evenly distributed along that part of the project route investigated are provided in Appendix E1. Emerson Class Number (34 tests) and Dispersion Index (four tests) were used as the basis for allocation of Dispersion Potential (with reference to Salinity test results).

The Emerson Class is a measure of the dispersion characteristics of the soil. Soils are classified into one of eight classes: Class 1 soils are those that have a strong dispersion reaction whilst Class 8 are soils which remain coherent in water. The Dispersion Index is a second dispersion-based test that determines percentage dispersion of a soil at a 0.005 mm particle suspension. The higher the dispersion percentage, the more dispersive the soil. By interpreting results from these two tests, a relative Dispersion Potential was derived based on classifications of high, medium and low. Results are shown in Table 5.3 (there were no low results).

Erosion potential has been subjectively deemed high, medium and low based on soil type as described in test pit logs (where available), and in some cases, supported by soil particle size distribution and consistency limits tests. The presence of shallow rock is also an adverse influence on erosion potential and where present in a test pit, the erosion potential category has been modified accordingly.

Gradient is also an important factor in assessing erosion potential (i.e. the steeper the grade, the higher the erosion potential). Therefore as a guide, in areas with significant soil disturbance proposed on gradients steeper than 15 percent, the erosion potential category may be higher than indicated. Terrain modelling has identified those areas that have gradients above 15 percent. Small and sparse areas of gradients more than 15 percent occur throughout the ROW however there are particular areas where steeper slopes are vast. These have been mapped in Figure 5.3.

Laboratory screening was undertaken on a number of samples of the predominant subsurface soil types encountered along the project route. Screening comprised Emerson Class tests carried out on 34 samples, and included determination of pH and Electrical Conductivity (Salinity).

Dispersion potentials have also been subjectively deemed high medium and low based on the Emerson Class test results, where Emerson Classes 1 and 2 are generally considered to have a high dispersion potential.

Dispersion and erosion potential for soil types encountered in the test pits excavated are summarised in Table 5.3. The Table includes geological and soil landscape units and any relevant laboratory results.

It should be noted that the assessment included herein is based on preliminary estimates of earthworks, soil logs and laboratory test results conducted by CQGU.

5.2.2 Good Quality Agricultural Land (GQAL)

As per the *Planning Guidelines: Identification of Good Quality Agricultural Land* (DPI & DHGP 1993), GQAL is land which is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources. It includes cropping and animal production but does not include intensive animal uses such as factory farming. Land can be classified as GQAL regardless of whether it is currently cultivated.

The extent and quality of GQAL surrounding the project area was ascertained from the Calliope and Fitzroy Council's GQAL overlay maps. From these, the area of and type of GQAL affected by the project was mapped and determined.

5.2.3 Contaminated Land

Contaminated land in the project area was identified using two processes:

- A desktop review of the available land uses and guidance documents, primarily the EPA'S *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (1998)*
- A search of the Contaminated Land Register (CLR) and Environmental Management Register (EMR) for Queensland.

These two processes identified a number of contaminated sites that are discussed in the following sections.

Along with this, a preliminary risk assessment was carried out to quantify the risk the potential contaminated land poses to the project. The risk of each potential contaminated land site has been graded subjectively based on high, medium, low or negligible risk.

It is also important to note at this point that unknown contaminated land not captured by the CLR or EMR may be encountered along the corridor. Examples of unknown contamination that could be encountered include contamination arising from the use of pesticides, presence of cattle dips and unidentified dump sites.

5.2.4 Acid Sulfate Soils (ASS)

The preliminary ASS assessment included a desktop study and field investigations and forms the precursor to the detailed ASS investigation and ASS Management Plan that will be completed prior to the commencement of construction.

5.2.4.1 Desktop study

The methods adopted in the desktop study are generally based on the methodology recommended in the current Queensland State Government, State Planning Policy (SPP 2/02) Guideline "*Planning and Managing Development involving Acid Sulfate Soils*" and Department of Natural Resources and Water (DNRW) "*Queensland Acid Sulfate Soil Technical Manual*" - 2004. These included a review of published maps and data on the occurrence of ASS in eastern Australia (in particular in Central Queensland).

Assessment of the following criteria was undertaken:

- Site topography and height above sea level (Australian Height Datum (AHD))
- Proposed construction methods and detailed optioneering design of the project
- Published maps of ASS distribution in Central Queensland
- Regional geology and indicative soil types and their origins.

The information collected was used as the basis of assessment of the likely extent of ASS/PASS materials present in specific areas along the project corridor and the associated risk of disturbance in these areas. The scope of the study was limited to interpretation of available published maps, aerial photographs and existing soils data with respect to detailed optioneering design drawings of the project alignment. With subsequent ground proofing conducted during field investigations at locations where access was possible.

5.2.4.2 Field Investigations

Sampling for ASS was undertaken by CQGU from August through to October 2007 during the preliminary geotechnical investigation program. Of the 65 sampling locations initially targeted by the desktop study, 54 were selected, mostly located in low lying areas at or below 5 m AHD. Some locations originally targeted did not prove to be accessible or were found to contain no alluvial soils. Some samples were also recovered from another four locations, not initially marked for testing.

It was not possible given site access limitations and time constraints to undertake sampling at all of the locations where ASS might be present, but all areas assessed as having a high risk of containing ASS (during in the desktop study) were investigated. The exception to this was the very eastern end of the project alignment beyond Yarwun, which may include soils that contain ASS. This area will be sampled as part of the detailed ASS investigation to be completed prior to the commencement of construction and will determine site specific management measures required.

The test pits were excavated using a backhoe or similar plant and typically extended to 3 m depth or refusal on rock. This allowed sampling of soils to below the proposed trench excavation depth of 2 to 2.5 m. Small disturbed soil samples were recovered at approximately 0.25 m intervals down the side of the test pits. Generally 12 samples were recovered from each test pit, however, less samples were recovered at some locations. Samples were labelled, sealed in plastic bags and kept refrigerated until laboratory testing was undertaken.

In addition to the above sampling, a soil scientist from Golder Associates undertook an inspection tour of the project alignment to observe local topographical features and vegetation, for any signs of existing ASS impacts. Several locations identified by the desktop component of the investigation were targeted, and walk over inspections were conducted.

A photographic record of these inspections is included on Figure 5.4.

Sampling and Laboratory Screening

The test pits sampled and ASS screening samples collected and tested are summarised in Table 5.1 and shown in Figure 5.4.

Table 5.1 Test pit (TP) Sampling Locations

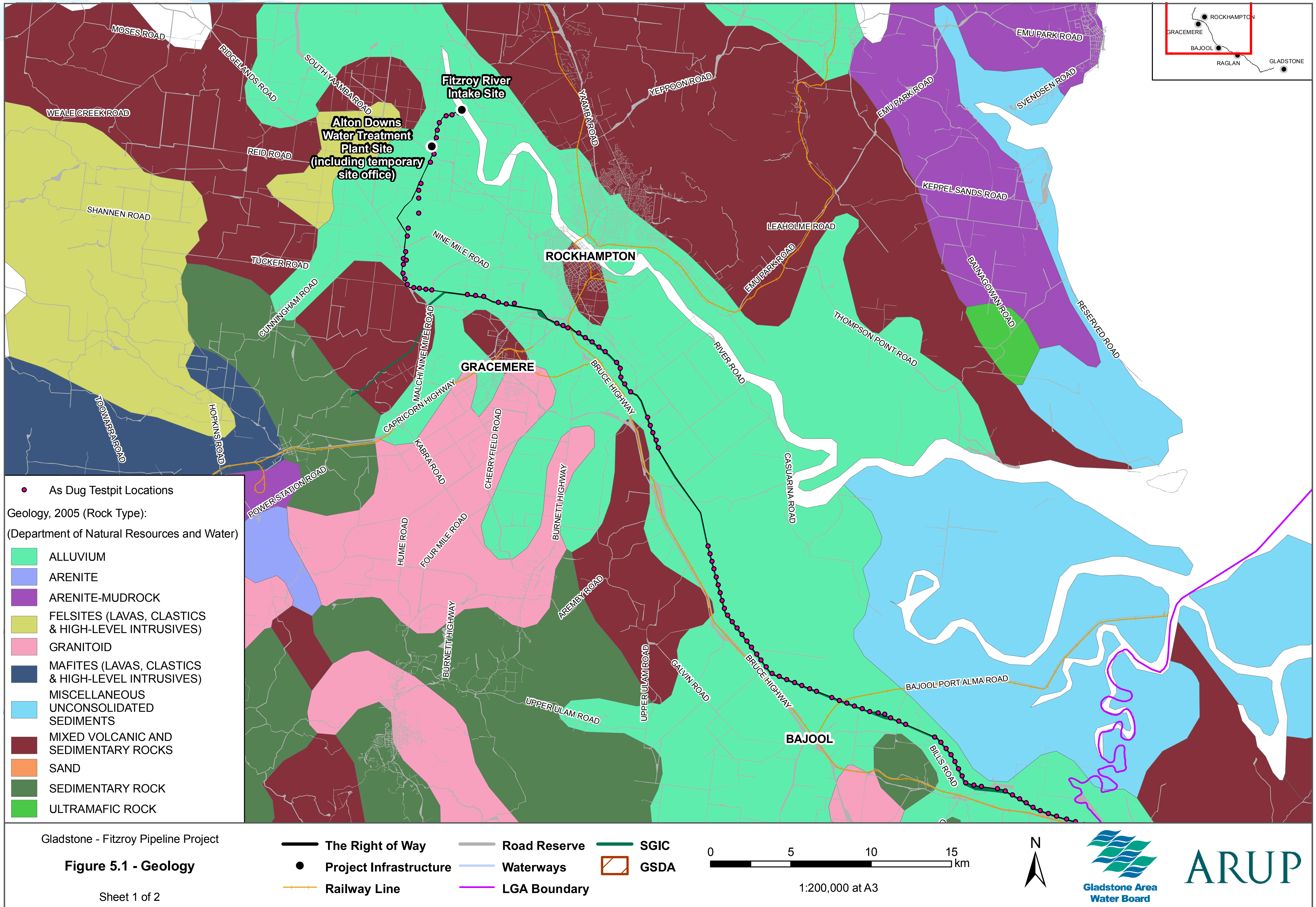
Location	Test Pits Sampled	Samples Screened
Epala to Raglan (TP56 - TP71)	TP69 – TP71	12
Raglan to Bajool (TP72 - TP111)	TP72 - TP74, TP78 - TP83, TP87, TP88, TP91 - TP99, TP102 - TP110	304
Bajool to Archer (TP112 - TP128)	TP112, TP114, TP115, TP119, TP120, TP123	72
Archer to Midgee (TP129 - TP139)	TP130 - TP133, TP138	60
Midgee to Gavial (TP140 - TP154)	TP151	12
Gavial to Rocklands (TP155-TP164)	TP155, TP159, TP160, TP162, TP163	23
Rocklands to Archer Park (TP165 - TP220)	TP165 - TP169, TP172, TP220	76

Preliminary Screening

The pH/pH_{FOX} screening method is a test to determine pH (a measure of acidity and alkalinity) of a soil sample and thus determine its acidity. It consists of two steps; initially determining the field pH of a 1:5 soil : water suspension, followed by the addition of 30 percent Hydrogen Peroxide, allowing the sample time to oxidise, before determining the pH_{FOX} (after oxidation) of the reacted sample. A total of 559 soil samples were screened in this manner.

Actual ASS are soils where oxidation of pyritic material has already occurred releasing acid and resulting soils with low pH (pH less than 4.5). Potential ASS contain unoxidised pyritic material that if allowed to oxidise will form acid. Such soils may also be partly oxidised and therefore also actual ASS.

Samples that either display a reduction in pH (one unit or more) and have a pH_{FOX} of 4.5 or less may contain ASS. Samples that either display a significant reduction in pH (three units or more) or have a pH_{FOX} of less than 3.0 are considered 'probable' ASS. If the initial field pH is also low, then the sample may contain actual acidity.

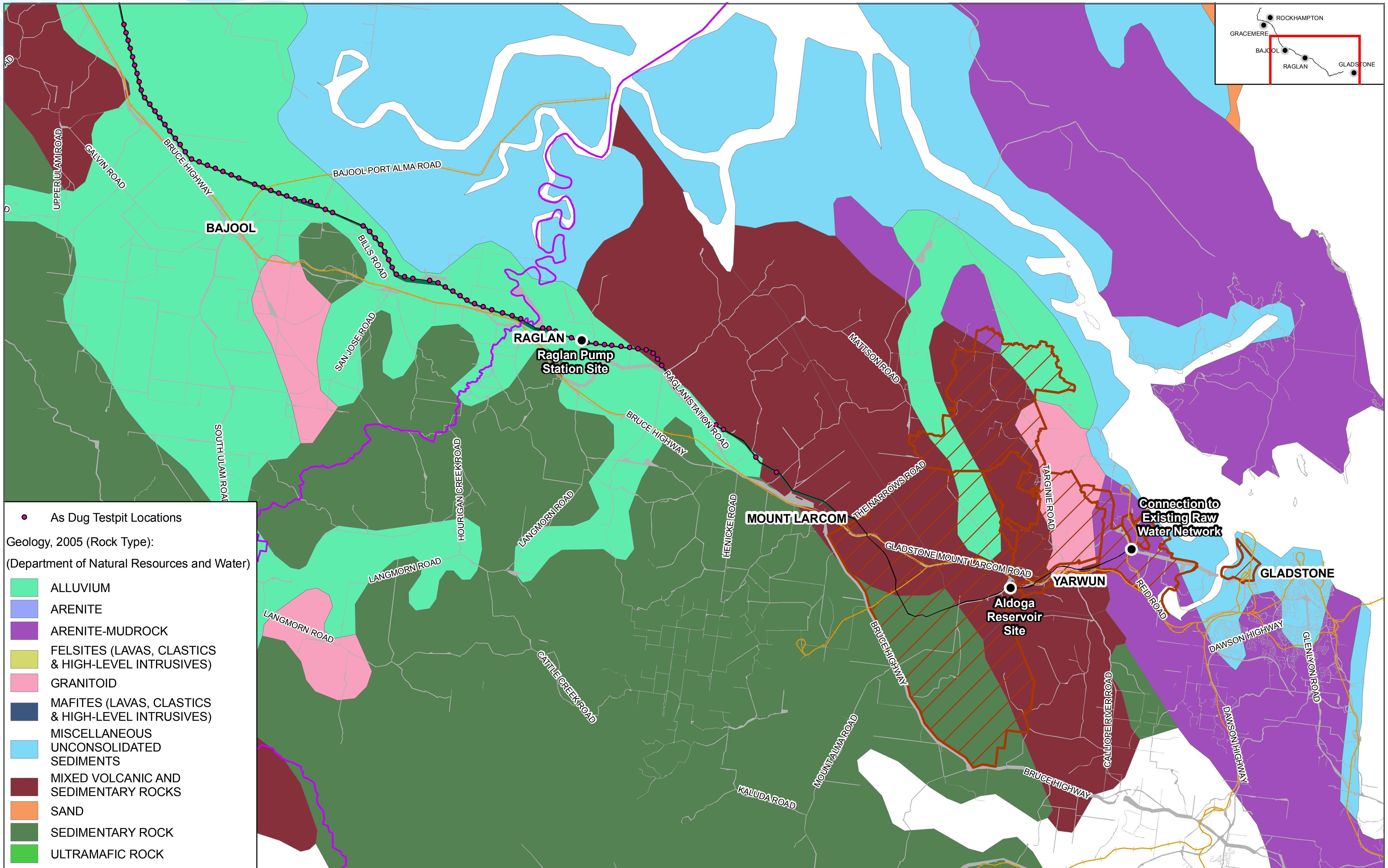


Gladstone - Fitzroy Pipeline Project

Figure 5.1 - Geology

Sheet 1 of 2

While every care is taken to ensure the accuracy of this data, the Gladstone Area Water Board (GAWB) makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which might be incurred as a result of the plan being inaccurate or incomplete in any way and for any reason. It should also be noted that final survey of the pipeline alignment and SGIC boundary are yet to occur and may result in changes to the alignments depicted here.



Gladstone - Fitzroy Pipeline Project

Figure 5.1 - Geology

Sheet 2 of 2

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

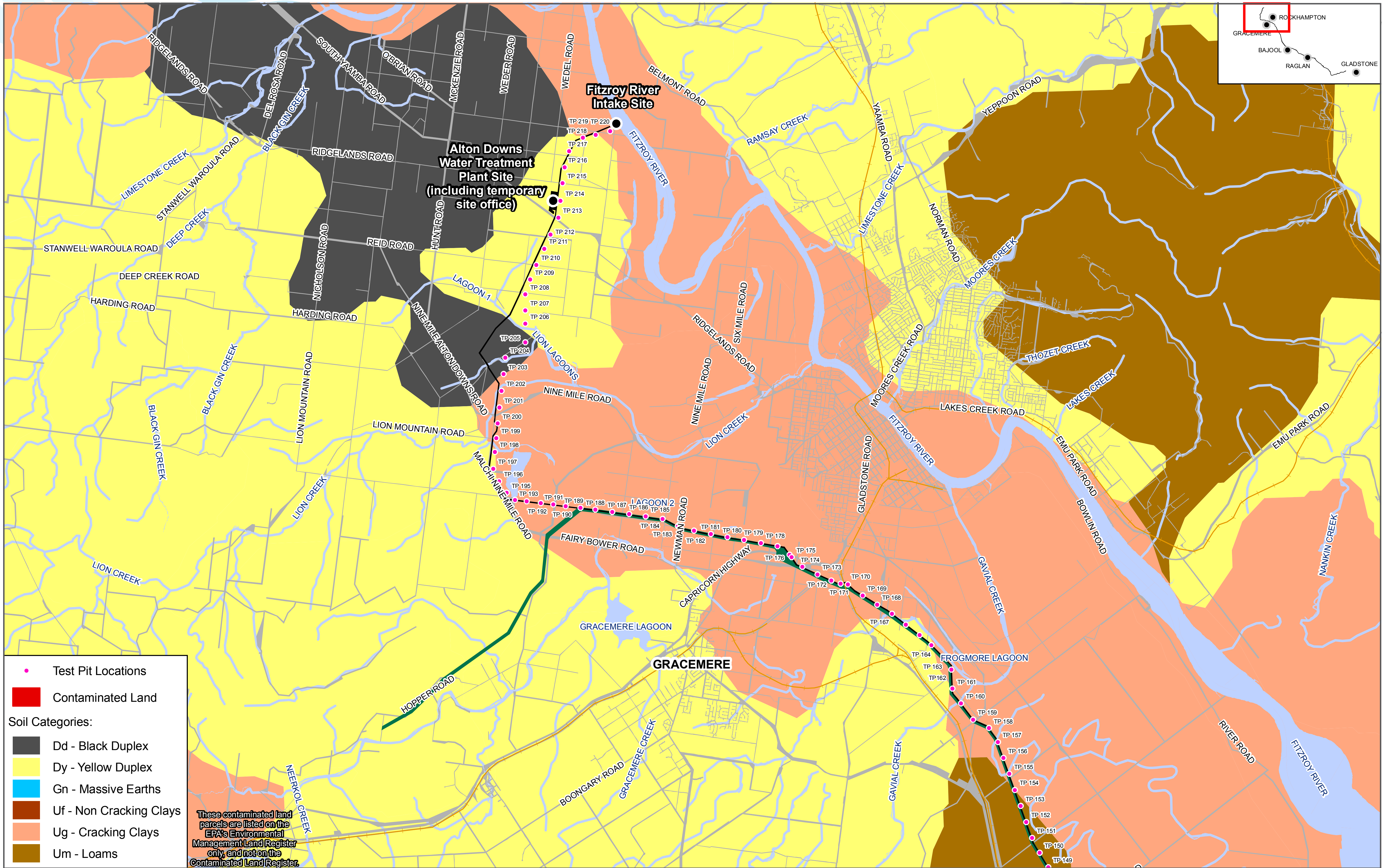
0 5 10 15 km

1:200,000 at A3

N

Gladstone Area Water Board

ARUP



Gladstone - Fitzroy Pipeline Project

Figure 5.2 - Soil Types and Contaminated Land

Sheet 1 of 4

The Right of Way | Project Infrastructure | Railway Line | Road Reserve | Waterways | LGA Boundary | SGIC | GSDA

0 2 4 6 8 km

1:100,000 at A3

N

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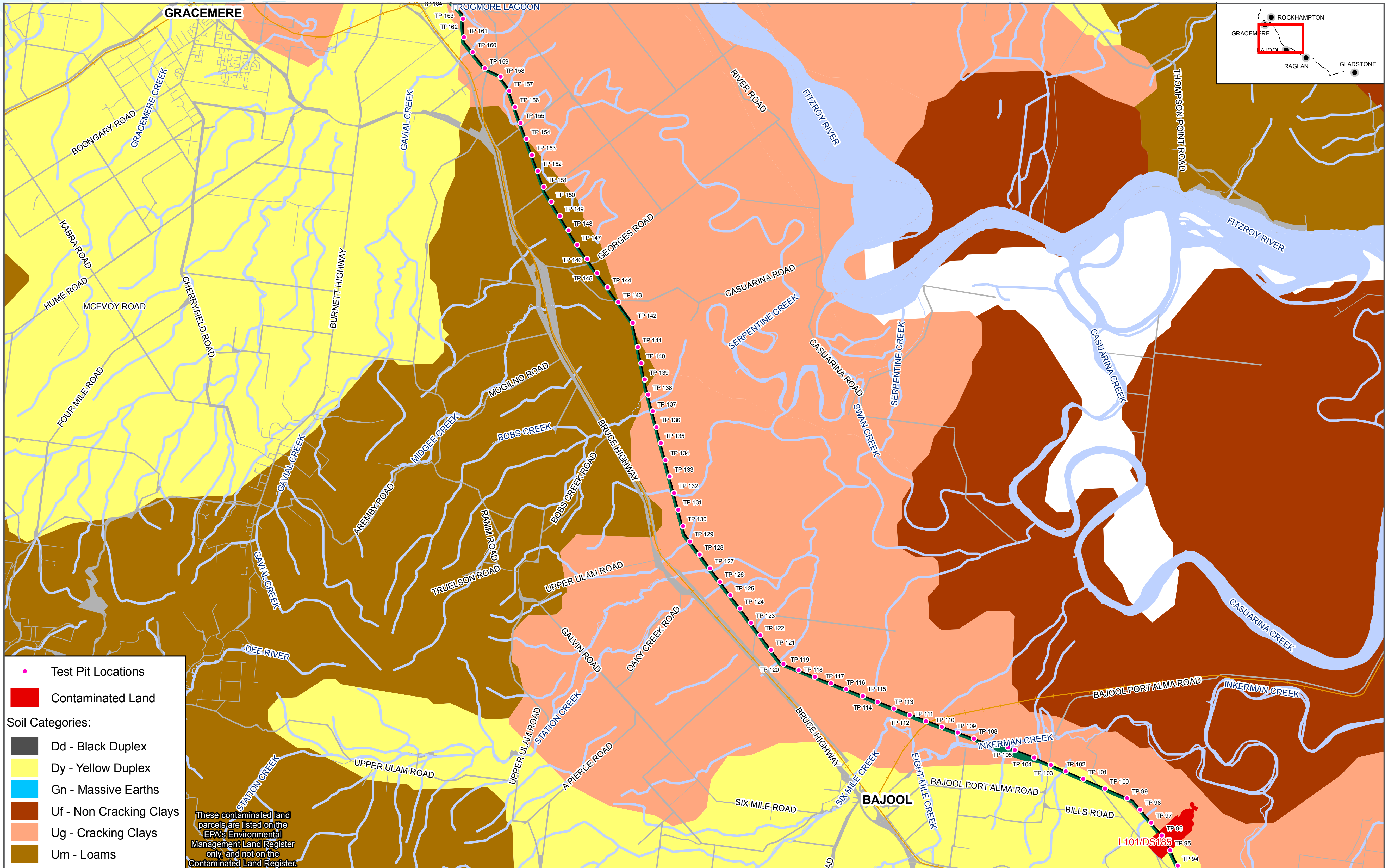

Gladstone - Fitzroy Pipeline Project

Figure 5.2 - Soil Types and Contaminated Land

Sheet 2 of 4

The Right of Way	Road Reserve	SGIC
Project Infrastructure	Waterways	GSDA
Railway Line	LGA Boundary	

0 2 4 6 8 km

1:100,000 at A3

N

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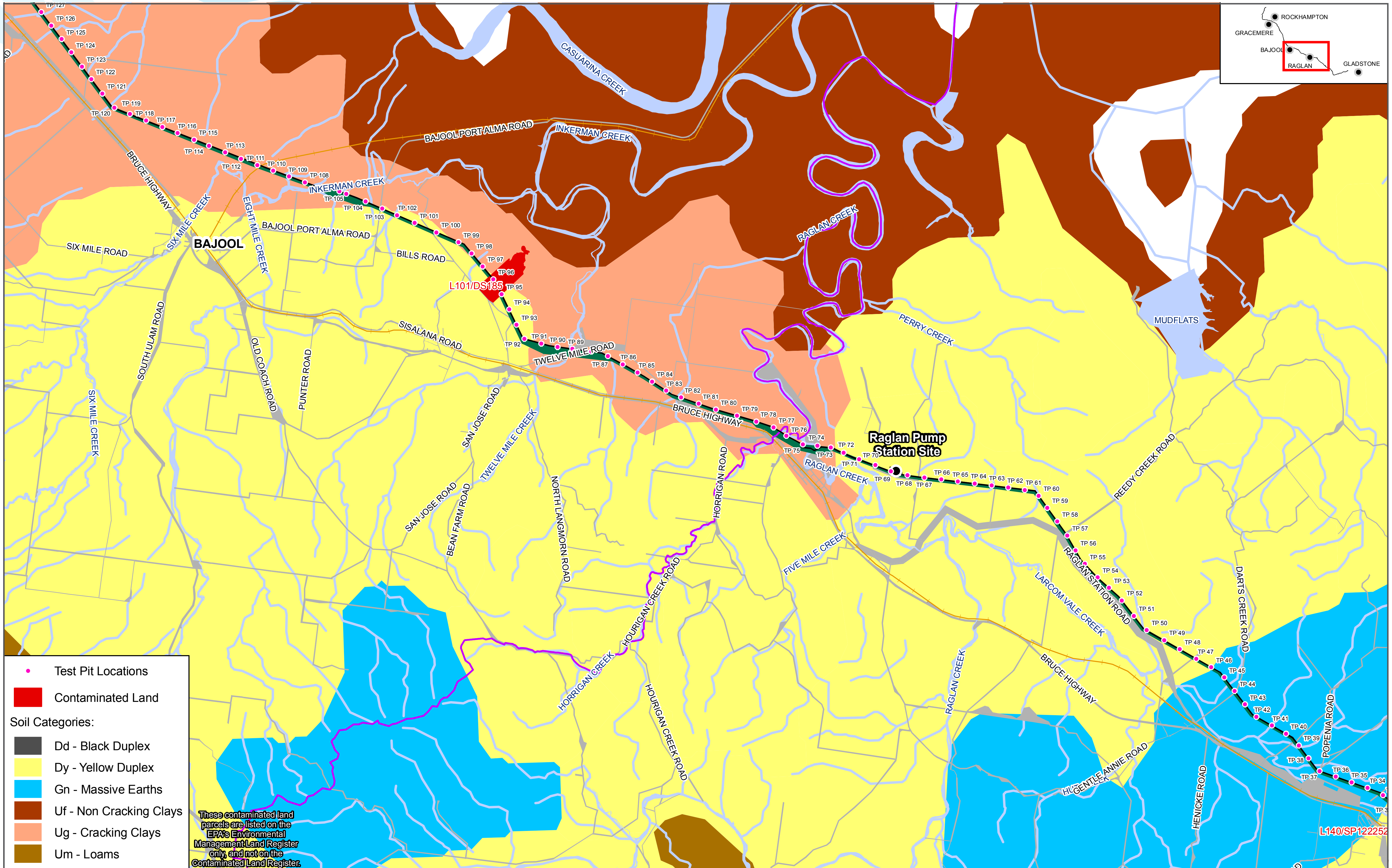

Gladstone - Fitzroy Pipeline Project

Figure 5.2 - Soil Types and Contaminated Land

Sheet 3 of 4

The Right of Way	Road Reserve	SGIC
Project Infrastructure	Waterways	GSDA
Railway Line	LGA Boundary	

0 2 4 6 8 km

1:100,000 at A3

N

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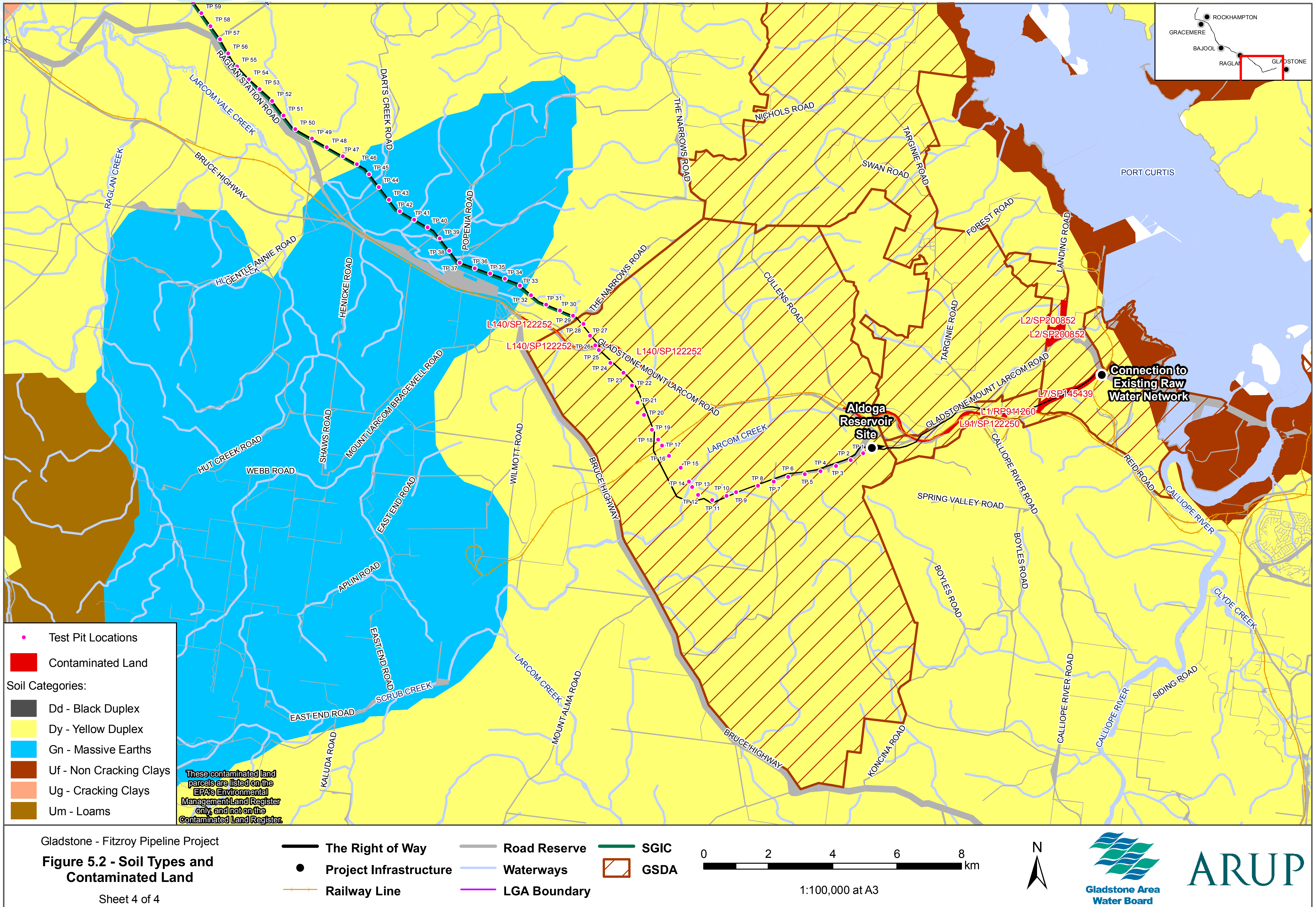

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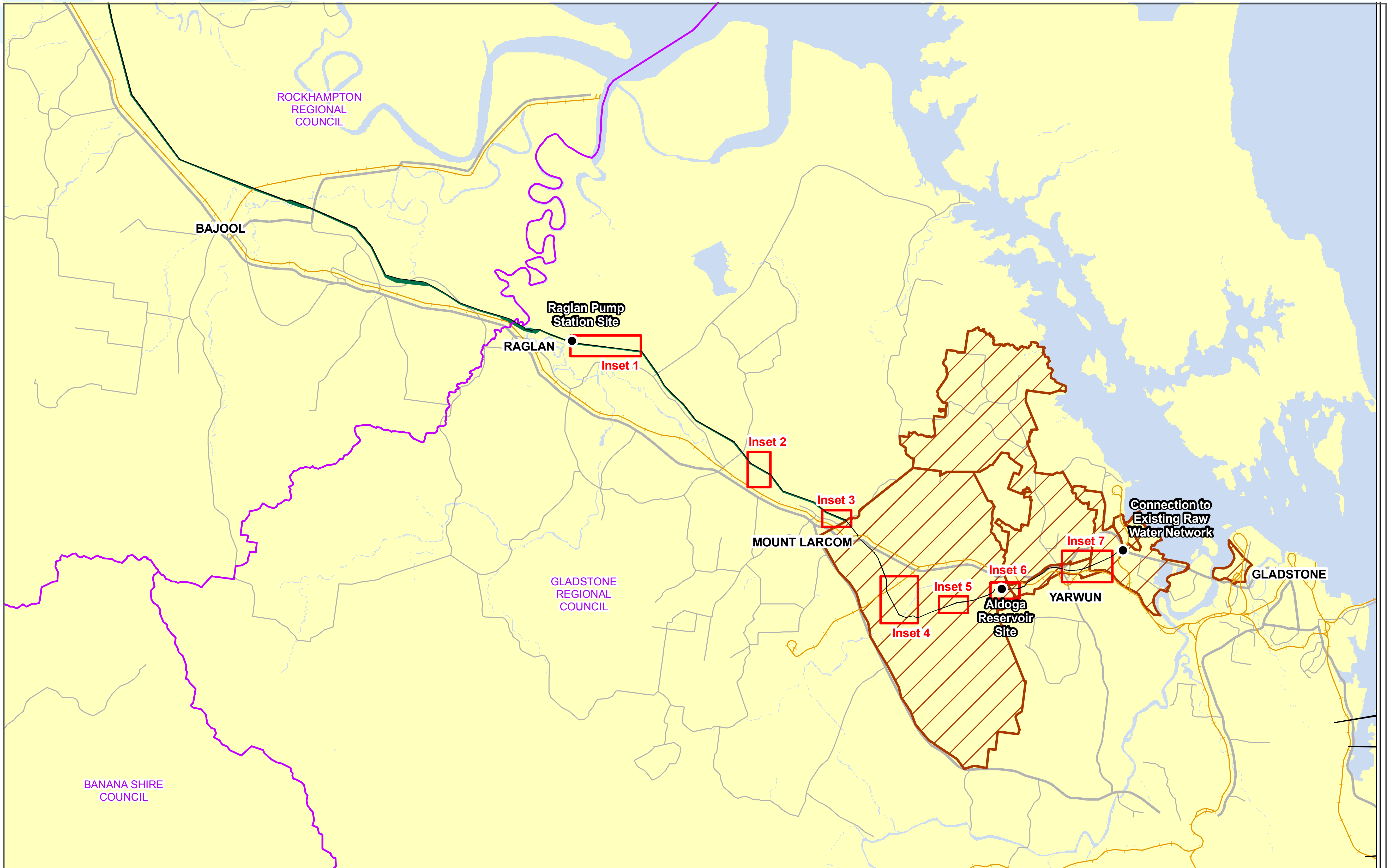

Gladstone - Fitzroy Pipeline Project

Figure 5.3 - Gradients Above 15% Overview Map - Bajool to Gladstone

Sheet 1 of 3

The Right of Way
Project Infrastructure
Railway Line
LGA Boundary
SGIC
GSDA
Terrain Mapset Extents

0 5 10 15 Km

1:200,000 at A3

N

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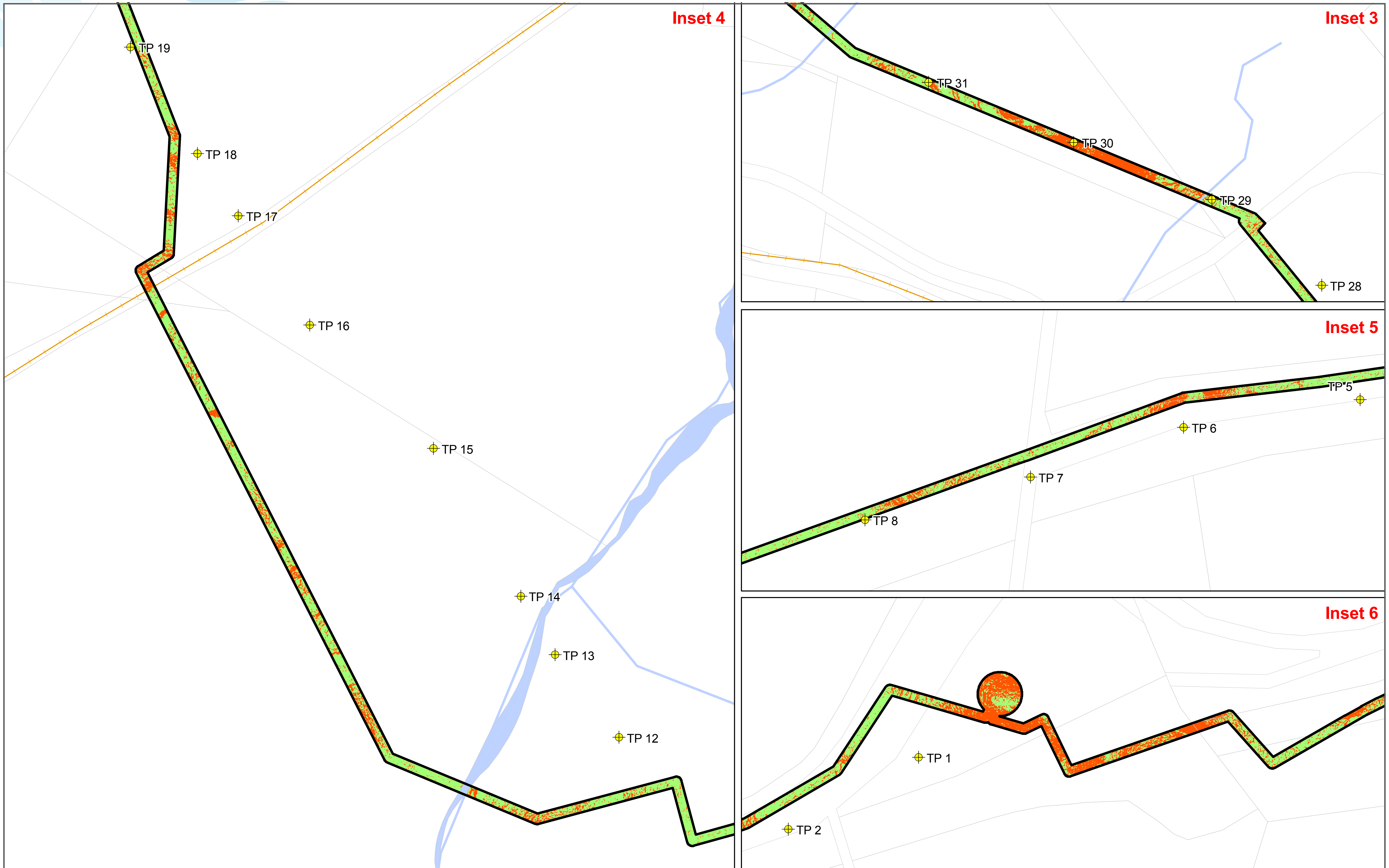

Gladstone - Fitzroy Pipeline Project

Figure 5.3 - Gradients Above 15%

Sheet 2 of 3

Gladstone - Fitzroy Pipeline Project

Figure 5.3 - Gradients Above 15%

Sheet 3 of 3

The Right of Way
Railway Line
Waterways
Cadastre
Planned Test Pit Locations

Slope:
Above 15%
Below 15%

0 190 380 570 760 m

Insets are 1:10,000 at A3

N

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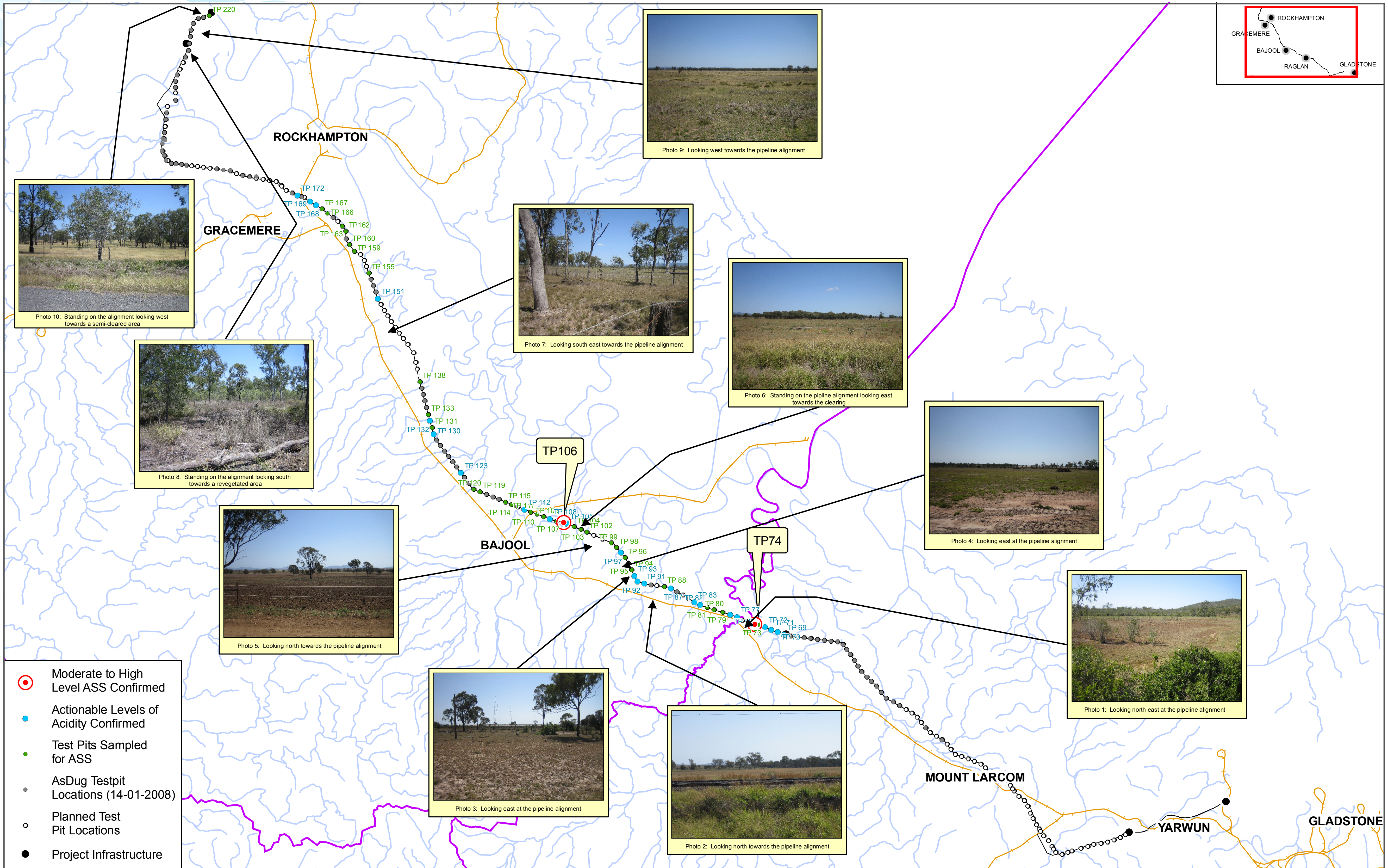

Gladstone - Fitzroy Pipeline Project

Figure 5.4 - Acid Sulfate Soils

Sheet 1 of 1

The Right of Way | Waterways
Project Infrastructure | LGA Boundary
Railway Line

1:250,000 at A3

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Quantitative Analytical Methods

Quantitative analysis was carried out by either the 'Suspension Peroxide Oxidation Combined Acidity and Sulfate' (SPOCAS) or Chromium Reducible Sulfur test methods. These test methods have been adopted in Queensland by Queensland Acid Sulfate Soils Investigation Team (QASSIT) and replace the older 'Peroxide Oxidation Combined Acidity and Sulfate' (POCAS) test method in 2004. These test methods incorporate determination of acidity retained in stable oxidation minerals such as 'jarosite', and allows for calculation of 'net acidity' based on acid generating potential, actual and retained acidity and any inherent alkaline buffering capacity (due to fine textured calcareous materials that may be present).

The latter test method was used on soils that contained obvious organic matter, which might contain sulfur of organic origin that could artificially 'inflate' the Percent Oxidisable Sulfur (S_{POS}) levels reported using the SPOCAS method.

When determining the presence of ASS, sulfidic derived acidity had been historically determined in Queensland using the following equation:

- Total Potential Acidity (TPA) = Total Actual Acidity (TAA) + Total Sulfidic Acidity (TSA).

However, experience has proved this method to not always be adequate. Thus an overall acid-base accounting (ABA) method has been derived to calculate a 'net acidity' value which is used to qualify analytical test results and calculate liming rates. This takes into account possible inherent alkalinity as acid neutralising capacity (ANC) and retained acidity in semi-stable forms as Net Acid Soluble Sulfur (as S_{NAS}). The resulting ABA equation is:

- 'Net acidity' = actual acidity (as TAA) + retained acidity (as $S_{NAS,}$ if present) + remaining potential acidity (as TSA) – any acid neutralising capacity (ANC).

Quantitative Testing

Samples were chosen from screening tests that exhibited probable or possible indications of ASS/PASS, and from those immediately above or below possible PASS layers to allow some definition of the vertical extent of any ASS layers detected.

As the work was of a preliminary nature only, aimed at assessing the risk of ASS occurrence rather than quantifying the extent of occurrence, quantitative analysis was generally limited to one sample per test pit for locations with only negative screening results. However, for the scope of this preliminary assessment, it is considered that the overall number of samples selected for analysis is sufficient to predict where further ASS investigations will be required at the detailed design for construction phase of the project. A total of 81 samples were submitted for analysis to the ALS Brisbane NATA accredited analytical laboratory for testing.

5.3 Impact Assessment Methodology

The impact of the project upon soils, ASS and contaminated land was evaluated using significance criteria made specific to this chapter of the EIS as shown in Table 5.2. These criteria allow for a standard assessment process and provide a context for describing the significance of the impact.

Table 5.2 Impact Significance Criteria for Soils and Contaminated Land

Significance	Criteria
Major adverse	**Soil** Actions (such as excavating, placing soils or leaving vast expanses of unstable soils open to erosion) resulting in the mobilisation of large volumes of soil and sufficient to cause severe erosion and large-scale impact to local waterways in the short and long-term. Adverse impacts of national or international significance arise. **Good Quality Agricultural Land** Losses of A, B or C GQAL that results in detectable reductions in current and future agricultural production on a State to national scale. **Contaminated Land** The disturbance of large volumes of soil containing high levels of contamination (i.e. exceeding the Ecological Investigation Level (EIL) by more than an order of magnitude), or significant volumes of soil containing very high levels of one or more contaminants (exceeding EIL by several orders of magnitude and/or health based limits), which results in mobilisation of the contaminant within the receiving environment. Sufficient to cause immediate, irreversible impact to the local environment and longer-term adverse impacts on the receiving environment. Adverse effects of national or international significance would result. **Acid Sulfate Soils** Uncontrolled direct disturbance of large volumes of ASS having an adverse short and long-term effect on sites of national or international significance.
High adverse	**Soil** Actions (such as excavating, placing soils or leaving vast expanses of unstable soils open to erosion) that result in detectable erosion and obvious impact on local waterways and that contribute to longer-term siltation impacts on the receiving environment. If the actions are not managed, adverse effects of State or national significance arise. **Good Quality Agricultural Land** Losses of A, B or C GQAL that results in detectable reductions in current and future agricultural production on a regional to state scale. **Contaminated Land** The disturbance of large volumes of soil containing high levels of contamination (i.e. exceeding the EIL by more than an order of magnitude), or significant volumes of soil containing very high levels of one or more contaminants (exceeding EIL by several orders of magnitude and/or health based limits), which results in mobilisation of the contaminant within the receiving environment. Sufficient to cause adverse impact to the local environment and long-term impacts on the receiving environment. Careful management can avoid or mitigate adverse effects. Effects of state or national significance will ensue if left unmanaged. **Acid Sulfate Soils** The disturbance of a substantial volume of ASS or smaller volumes of ASS containing high levels of oxidisable sulfur, having an adverse short and long-term effect on sites of state or national significance if unmanaged. Careful management can mitigate this problem.
Moderate adverse	**Soil** Actions (such as excavating, placing soils or leaving areas of unstable soils open to erosion) that result in localised erosion, limited impact to local waterways and also contribute to the accumulative long-term siltation of the receiving environment. Adverse effects of local and State significance may result if the works are unmanaged. **Good Quality Agricultural Land** Losses of A, B or C classed GQAL beyond that of natural variation in current levels of productivity. A loss of A, B or C classed GQAL that results in a noticeable reduction in actual or potential agricultural production on a regional scale. **Contaminated Land** The disturbance of either large volumes of soil containing isolated environmentally significant levels of contamination or smaller volumes containing consistent levels of contamination (i.e. exceeding EIL, but less than an order of magnitude, but not exceeding health based limits), which may result in limited mobilisation of contamination within the immediate receiving environment. Implementation of careful management can mitigate the problem. Local ecological and recreational values will be affected if contamination spreads. **Acid Sulfate Soils** The disturbance of a significant volume of ASS (greater than 1,000 m^3) containing high levels of oxidisable sulfur or large scale filling over actual ASS, resulting in short-term degradation of the local receiving environment. Careful management of works can mitigate the impacts, and adverse effects of local or state significance may occur if the disturbance is continued.

Significance	Criteria
Minor adverse	**Soil** Actions (such as minor excavation works, placing soils, or leaving areas of unstable soils open to erosion) that result in small scale localised erosion and unlikely to cause significant impact upon waters within the receiving environment. However, adverse effects of local significance will ensue if management measures are not correctly implemented. **Good Quality Agricultural Land** A loss of A, B or C classed GQAL that results in localised reductions to potential or actual agricultural production. Unlikely to cause a perceivable reduction to levels of agricultural production on a regional scale, however will have some consequences for individual producers. **Contaminated Land** The disturbance of minor volumes of soil containing isolated occurrences of environmentally significant levels of one or more contaminants (i.e. exceeding EIL, but not exceeding health-based limits), which may result in mobilisation of small amounts of contaminant within the immediate receiving environment. Appropriate management measures can mitigate any adverse effects of local significance **Acid Sulfate Soils** The disturbance of a minor volume of ASS (less than 1,000 m^3) or filling greater than 0.5 m depth over actual ASS, resulting in generation of periodic or continue low yield acid runoff. Appropriate management can mitigate these impacts.
Negligible	**Soil** The managed excavation of placement of small quantities of soil on-site or the exposure of small areas of soil in areas not prone to runoff. Not likely to cause measurable impact to local receiving water quality. **Good Quality Agricultural Land** No impact upon GQAL or an impact that is insignificant on local scales and to individual agricultural producers. **Contaminated Land** The disturbance of small volumes of soil containing isolated occurrences of environmentally significant levels of a contaminate (i.e. exceeding EIL, but not exceeding phyto-toxicity thresholds or health based limits), which may result in mobilisation of small amounts of contaminants within the immediate receiving environment. Degradation of the local receiving environment is unlikely and degradation to the greater receiving environments will be imperceptible. **Acid Sulfate Soils** The disturbance of small volumes of ASS (less than 100 m^3) or filling involving less than 500 m^3 of fill, over actual ASS, resulting in generation of periodic or continual low yield acid runoff. Degradation of the local receiving environment is not likely and degradation of the greater receiving environment will be imperceptible.
Beneficial	**Soil and Good Quality Agricultural Land** Carefully managed works that result in the enhancement of GQAL or the stabilisation of soils (i.e. by geofabric, rip-rap and landscaping), that were otherwise at risk of erosion. Such stabilisation measures result in improved runoff water quality and reduce risk of adverse environmental impact to the receiving environment. **Contaminated Land** Where the management of the disturbance of small volumes of contaminated soil resulting in an improvement of the quality of ecological resources of the receiving environment and/or a reduction of risk to human health, (i.e. the placement of contaminated soil that is currently exposed, beneath sealed pavements of capping layers). **Acid Sulfate Soils** Where disturbance of ASS is minor, and the management measure employed result in an improvement of the quality of ecological resources of the local receiving environment. For example, the creation relocation of habitats, or introduction of passive, in-situ ASS management measures that would achieve improvements in the quality of groundwater and/or runoff leaving the site.

5.4 Assumptions and Limitations

5.4.1 Soils

34 out of 220 possible test pits were tested to derive soil characteristics. These are shown in Appendix E1. In addition to this, planned test pits along the GSDA were neither excavated or sampled as this part of the pipeline alignment was not determined at the time of the preliminary geotechnical investigations. Where test pits weren't sampled, neighbouring test pits with similar geologic and soil characteristics were used to extrapolate dispersion potentials. However, in some instances, a lack of information has meant that dispersion potentials for some test pits could not be determined (as per Table 5.3.)

5.4.2 Good Quality Agricultural Land

The extent and quality of GQAL within the former Rockhampton City Council area was unable to be determined as no current GQAL mapping exists for that area. Rural land use within the Council's zoning maps were used as a proxy and the surrounding GQAL from the former Fitzroy Shire was used to extrapolate the GQAL class within Rockhampton City Council's jurisdiction.

5.4.3 Contaminated Land

It should be noted that a comprehensive list of the potential impacts arising from disturbance of contaminated land can only be established after preliminary and detailed site investigations have been carried out for each identified site. These will be carried out prior to construction.

5.4.4 Acid Sulfate Soils

At this stage in the study, only a preliminary ASS investigation had been undertaken, with a full investigation and ASS Management Plan required to be prepared prior to construction (for some areas of the pipeline route). Also the GSDA was not sampled as the exact location of the alignment in this area had not been determined at the time of the preliminary field investigation.

The field sampling does not fully comply with the requirements of the SPP 2/02; however it does provide an indication of the likelihood of ASS occurrence at the locations investigated. The purpose of this assessment is to highlight specific areas along the project route that will require detailed ASS investigations and to some extent, indicate where ASS do occur, so that these areas may be avoided where possible or that design and construction methods can be modified to allow management of ASS. Low lying areas unable to be accessed were assessed as having a moderate risk of ASS occurring, based on the absence of test data alone.

5.5 Relevant Legislation and Policy

5.5.1 Environmental Protection Act 1994 (Qld)

5.5.1.1 General duty of care

Section 319 of the *Environmental Protection Act 1994* imposes a general 'duty of care', which specifies that a person must not undertake any activity that may harm the environment without taking reasonable and practical measures to prevent or minimise the harm.

5.5.1.2 The Environmental Management and Contaminated Land Registers

The Environmental Management Register (EMR) is a land use and planning register that records land that has been, or is being used, for a notifiable activity. It is maintained by the Environmental Protection Agency (EPA).

The EMR provides information on current and historical land use, including whether the land has been or is currently used for a notifiable activity, or has been contaminated by a hazardous contaminate. A notifiable activity is an activity that is considered likely to cause land contamination.

In most circumstances, sites on the EMR pose 'low risk' to human health or the environment under their current land use, however presence on the EMR does not necessarily mean they are contaminated.

On the other hand, the Contaminated Land Register is a register of confirmed contaminated land that is causing or may cause serious environmental harm. This land is entered when it is shown that the land needs remediation or management to prevent serious environmental harm or adverse public health effects.

5.5.2 State Planning Policy 1/92 Good Quality Agricultural Land (GQAL)

This planning policy outlines the development and conservation of GQAL in Queensland. The State Government recognises the need to conserve good quality land as it is considered to be a finite resource and as such is to be protected from development that can potentially lead to diminished productivity.

Non-agricultural development, such as the Gladstone-Fitzroy Pipeline project, needs to demonstrate an overarching need in terms of public benefit to justify the loss of GQAL. As a water supply project with minimal impacts to GQAL, economic benefits to the region and state, and with particular locational requirements, this project is considered to meet the requirements of the policy.

Table 5.3 Soil baseline data

Location	Locality	Mapped Geology	Landscape - based on 2005 Terrain Units *	Dominant Subsoil Texture	Shallow Rock	Erosion Potential	Dispersion Testing	Dispersion Potential
Yarwun → Ambrose	before TP1	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics GRANITOID. Granite, granodiorite, diorite and gabro	Dy - Yellow Duplex	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
Yarwun → Ambrose	TP1 - TP7	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics Not Determined	Dy - Yellow Duplex	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
Yarwun → Ambrose	TP8 - TP15	SEDIMENTARY ROCK, Basalt, andesitic tuff, conglomerate, arenite, mudstone, limestone	Dy - Yellow Duplex	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
Yarwun → Ambrose	TP16 - TP39	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex (TP16-32) Gn- Massive Earths (TP33-39)	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
Yarwun → Ambrose	TP40 - TP42	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Gn- Massive Earths	Clay, Low - Med Plasticity	Yes	Mod-High	Not Determined	Not Determined
Ambrose → Epala	TP43 - TP46	ALLUVIUM, sand, silt, mud, gravel	Gn- Massive Earths	Clay Loam, Low - Med Plasticity	Yes	Moderate -High	Not Determined	Not Determined
Ambrose → Epala	TP47 - TP48	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay Loam, Low - Med Plasticity	Yes	Moderate -High	Not Determined	High *
Ambrose → Epala	TP49 - TP51	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Ambrose → Epala	TP52 - TP55	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Epala → Raglan	TP56	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Med - High Plasticity	No	Low	Not Determined	High *
Epala → Raglan	TP57 - TP58	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	Clay, Low - Med Plasticity	No	Moderate	Not Determined	High *
Epala → Raglan	TP59 - TP62	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	Clay, Medium Plasticity	Yes	Moderate	Emerson No. 1	High
Epala → Raglan	TP63 - TP65	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Low Plasticity	Yes	Moderate -High	Emerson No. 1 (DI only 2%)	Moderate
Epala → Raglan	TP66 - TP68	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Low Plasticity	Yes	Moderate -High	Not Determined	Moderate *
Epala → Raglan	TP69 - TP71	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Raglan → Bajool	TP72 - TP73	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Low - Med Plasticity	Yes	Mod-High	Not Determined	High *
Raglan → Bajool	TP74 - TP86	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Medium Plasticity	No	Low - Moderate	Emerson No. 1	High
Raglan → Bajool	TP87 - TP88	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clayey Sand	No	Moderate	Not Determined	High *

Location	Locality	Mapped Geology	Landscape - based on 2005 Terrain Units *	Dominant Subsoil Texture	Shallow Rock	Erosion Potential	Dispersion Testing	Dispersion Potential
Raglan → Bajool	TP89 - TP93	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Emerson No. 1	High
Raglan → Bajool	TP94 - TP97	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Low - Med Plasticity	No	Moderate	Emerson No. 1	High
Raglan → Bajool	TP98	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, High Plasticity	No	Low	Emerson No. 2	Moderate
Raglan → Bajool	TP99 - TP103	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Medium Plasticity	No	Low - Moderate	Emerson No. 2 (DI only 5%)	Moderate
Raglan → Bajool	TP104 - TP105	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Not Determined	High *
Bajool → Archer	TP106 - TP112	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Low - Med Plasticity	No	Moderate	Emerson No. 1	High
Bajool → Archer	TP113 - TP114	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Not Determined	High *
Bajool → Archer	TP115 - TP119	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Medium Plasticity	No	Low - Moderate	Emerson No. 1	High
Bajool → Archer	TP120	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Not Determined	High *
Bajool → Archer	TP121 - TP126	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Bajool → Archer	TP127 - TP129	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Emerson No. 2	Moderate
Archer → Midgee	TP130	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Low Plasticity	No	Moderate	Not Determined	High *
Archer → Midgee	TP131 - TP136	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Archer → Midgee	TP137	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay Loam, Low - Plasticity	No	Moderate	Not Determined	High *
Archer → Midgee	TP138 - TP147	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Not Determined	Undetermined
Archer → Midgee	TP148 - TP150	ALLUVIUM, sand, silt, mud, gravel	Um - Loams	Clay, Med - High Plasticity	No	Low	Not Determined	Undetermined
Midgee → Gavial	TP151 - TP154	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Emerson No. 2	Moderate
Midgee → Gavial	TP154 - TP158	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, High Plasticity	No	Low	Emerson No. 1	High
Gavial → Rocklands	TP159 - TP160	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Low - Med Plasticity	No	Moderate	Not Determined	High *

Location	Locality	Mapped Geology	Landscape - based on 2005 Terrain Units *	Dominant Subsoil Texture	Shallow Rock	Erosion Potential	Dispersion Testing	Dispersion Potential
Gavial → Rocklands	TP161 - TP165	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay, Low - Med Plasticity	No	Moderate	Emerson No. 1	High
Gavial → Rocklands	TP166 - TP167	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Rocklands → Archer Park	TP168 - TP174	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay/Loam, Low - Med Plasticity	No	Moderate	Emerson No. 1	High
Rocklands → Archer Park	TP175 - TP186	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 2	Moderate
Rocklands → Archer Park	TP187 - TP190	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Not Determined	Not Determined	Not Determined	Not Determined	Not Determined
Rocklands → Archer Park	TP191 - TP194	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Rocklands → Archer Park	TP195 - TP199	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay. Medium Plasticity	No	Low	Emerson No. 1	High
Rocklands → Archer Park	TP200 - TP202	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Clay, Med - High Plasticity	No	Low	Emerson No. 1	High
Rocklands → Archer Park	TP203 - TP205	ALLUVIUM, sand, silt, mud, gravel	Dd - Black Duplex	Clay, Med - High Plasticity	No	Low	Not Determined	High *
Rocklands → Archer Park	TP206 - TP217	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay. Medium Plasticity	No	Low	Emerson No. 1	High
Rocklands → Archer Park	TP218-TP220	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Clay/Loam, Low - Med Plasticity	No	Moderate	Emerson No. 1	High

NOTES:
1. * Based on the Emerson Number of same soil type where present in adjoining area(s).
2. Dispersion Potential is based on Emerson Number, unless other soil test data available.
3. Erosion Potential is based on dominant subsoil soil texture and the assumption of at least moderate surface gradients.
4. Each entry is shaded according to the type of mapped geology (Mixed Volcanic and sedimentary rocks; Sedimentary Rock; or Alluvium).

5.5.3 State Planning Policy 2/02 Acid Sulfate Soils

This policy was adopted in 2002 under Schedule 4 of the *Integrated Planning Act 1997* and applies to all land, soil and sediment at or below 5 m AHD where the natural ground level is less than 20 m AHD. The policy applies to developments that involve excavating and or removing of 100 m³ of soil or sediment and the filling of land with 500 m³ or more of material with an average depth of 0.5 m or greater.

5.5.4 National Environmental Protection (Site Contamination) Measure 1999

National Environmental Protection Measures (NEPM) are a set of statutory instruments defined in the *National Environmental Protection Council Act 1994 (Cth)*. The purpose of the Site contamination NEPM is to establish a nationally-consistent approach to the assessment of site contamination. This is to ensure sound environmental management practices are employed by regulators, site assessors, contaminated land auditors, land owners, developers and industry (NEPC, 2007).

An Investigation Level is the concentration of a contaminate above which further appropriate investigation and evaluation will be required (NEPC, 1999). These levels are used to deem the significance of the project's impact due to disturbance of contaminated land (see significance criteria in Section 5.3) and are based on the EPA's EILs and Health-based levels within the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (EPA, 1998, pp. 55)*.

5.6 Baseline Information

5.6.1 Soils

The following sections on soils should be read in conjunction with Table 5.3. Within the table, test pits are described in relation to their geology, subsoil texture, erosion potential, Emerson Class and dispersion potential. Each entry is shaded according to the type of mapped geology (Mixed Volcanic and sedimentary rocks; Sedimentary Rock; or Alluvium).

5.6.1.1 Terrain Assessment

The project area traverses a distance of some 115 km on the southern edge of the floodplain of the Fitzroy River through a number of different geological units and land forms (see Figure 5.1.)

Areas of low lying alluvial floodplain soils (mainly clays, with some sands and loams) predominate in the central and western portion of the corridor, but are absent in the approximately 30 km of the corridor extending west from Yarwun. This part of the alignment is through elevated 'hilly' country, comprising residual land forms underlain by geology comprising 'Mixed Volcanic and Sedimentary Rocks'. In this area of steeper grades, the influence on erosion potential is significant.

Areas above 15 percent gradient are expected to increase the erosion potential category by one level (e.g. medium is increased to high erosion potential). Based on high resolution terrain modelling, approximately 14 percent of the project's area is above 15 percent gradient with the majority of the project route (86 percent of the project area) below the 15 percent gradient. The southern end of the pipeline between Test Pits 78 and the pipeline connection point at Yarwun have a higher density of areas with gradients above 15 percent and this corresponds with the undulating topography.

Areas of terrain with a gradient greater than 15 percent are displayed in Figure 5.3. Most creek crossings also generally have a gradient greater than 15 percent.

5.6.1.2 Soil Dispersion Potential

Dispersive soils are structurally unstable and disperse in water into basic particles (i.e. sand, silt and clay). Dispersive soils tend to be highly erodible when in contact with water and present problems for successfully managing earth works. Dispersion is an indicator of sodic soils as it occurs when excessive sodium is present. When water is present the sodium attaches to the soil and forces fine clay particles apart. This results in a cloud of soil fines forming in runoff that can remain in suspension for an extended period of time.

Results of testing indicated 28 soils of Emerson Class 1 (highly dispersive) and six soils of Emerson Class 2 (dispersive) (see Appendix E1). None of the samples screened were non-dispersive. Four of the samples screened were also tested by CQGU to determine the Dispersion Index (DI). Results of the DI tests confirmed two samples (i.e. TP52 at 1.5 to 2 m and TP155 at 2 to 2.5 m) were dispersive, with DI values of 85 percent and 43 percent respectively. However, the other two DI values were low and do not necessarily indicate dispersive soils.

Results of Emerson Class tests were used to determine dispersion potential of the subsoil sampled along the project route (see Table 5.3). Generally Emerson Class 1 soils were rated as having a high potential. Emerson Class 2 soils (and Class 1 soils where DI results conflicted with the Emerson Number) were rated as having a moderate potential. As mentioned in the assumptions and limitations section, where no specific test data was available for a test pit location, the rating of the neighbour test pit location was used, providing similar soil types were involved. Test results indicate little variation in dispersion potential between the "Yellow Duplex" soils, which were expected to be sodic, and the "Cracking Clays" present along much of the route (see Figure 5.2).

Results of salinity tests conducted on an approximate 1:5 (soil : water) suspension, ranged from 0.4 to 2.2 mS/cm. Only two samples, from TP90 at 1/25 to 1/5 m and TP167 at 1.5 to 1.75 m were higher than 2 mS/cm and may be considered saline. The salinity levels in the remaining samples are fairly typical of coastal soils that are not subject to the influence of salt water. The levels of salinity indicated are not expected to influence soil dispersion (i.e. where soils are sufficiently saline, dispersion is not likely). Dispersive soils generally have lower electrical conductivity (EC) value, which indicates less salt (sodium chloride) present in the soil/water matrix to suppress sodicity.

5.6.1.3 Erosion Potential

Erosion potential is highest in non-cohesive, fine and medium textured soils such as fine to medium sands, silts and low plasticity silty clays. Cohesive (massive) medium to high plasticity clays and gravels with few fines, have lower erosion potential. However, fissured (cracked) high plasticity clays can erode as large 'blocks' if left exposed on moderate to steep slopes.

Topsoils

Soil descriptions and test pit logs (see Appendix E1) indicate that topsoils along the project alignment are generally shallow. Mostly, topsoils comprise low plasticity silty/sandy loams, clay loams and light sandy clays, all of which have a moderate to high potential for erosion if left uncovered on significant gradients (i.e. steeper than 15 percent). The topsoils are generally fine-grained (i.e. more than 33 percent passing 0.02 mm). Therefore fine-grained topsoil particles transported by surface run off would be both dispersive and of significant quantity.

Subsoil

The dominant natural subsoils along the project alignment range from low plasticity clay loams and clayey sands to medium and heavy clays (which predominate in many areas). Erosion potential, based on soil texture and proximity to the surface of rock substrate ranges from 'Low' to 'Moderate - High' ratings. Cohesionless subsoils were generally not encountered. Where local gradient is steeper than approximately 15 percent, the erosion potential rating may be higher (i.e. Moderate becomes 'High').

5.6.2 Good Quality Agricultural Land

5.6.2.1 Fitzroy to Bajool

Between Fitzroy and Bajool, the ROW traverses three classes of GQAL over the former Fitzroy and Calliope Shires (see Figure 5.5):

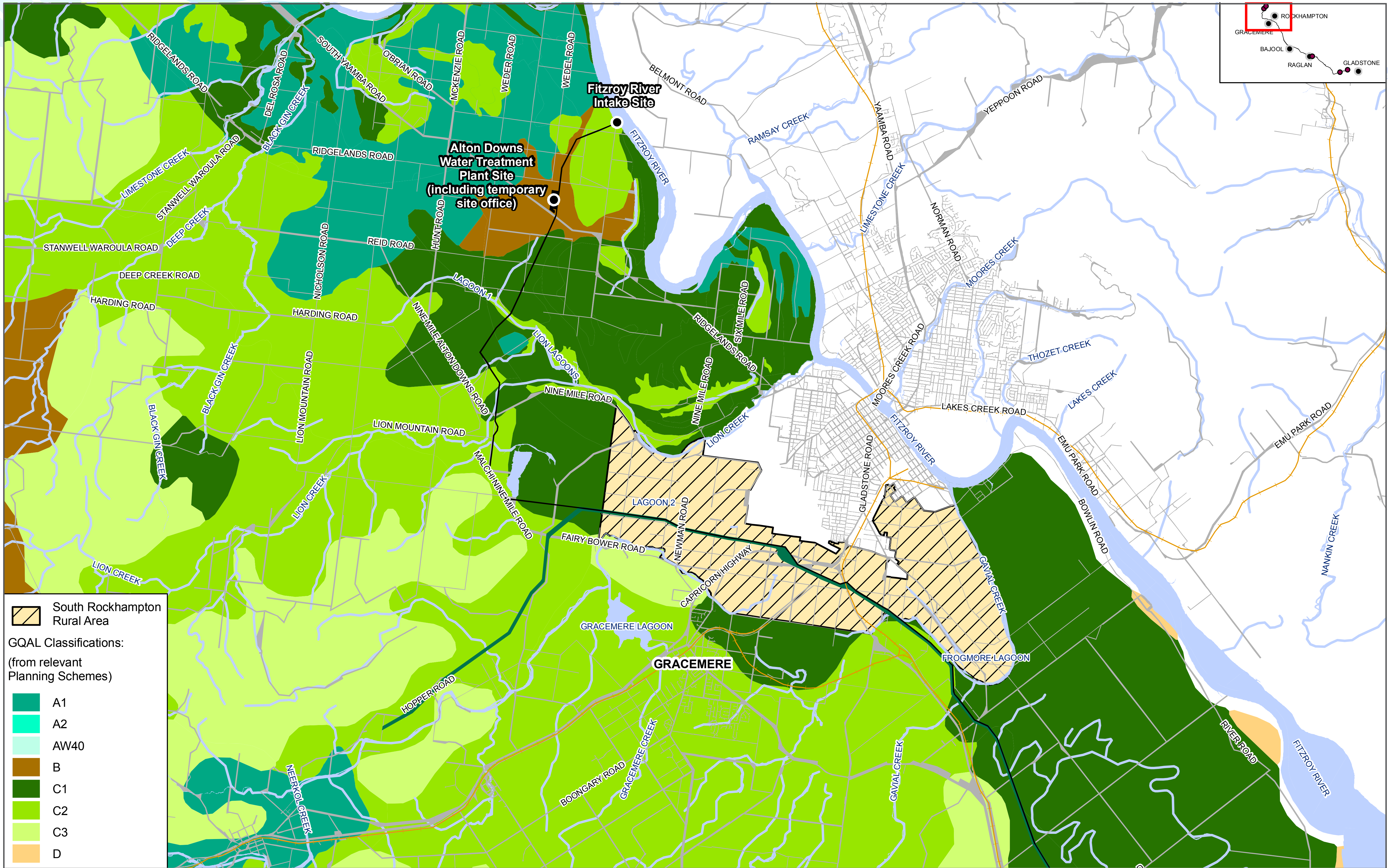
- Class B - Limited crop land (approximately 9 ha)
- Class C1 – Pasture suitable for sown pastures (approximately 102 ha)
- Class C2 – Pasture land suitable for native pastures (approximately 22 ha).

In addition, the WTP is sited on approximately 11.5 ha of Class B GQAL and the intake site is located on 2 ha of Class C2 GQAL.

The classes are defined in the DPI planning guidelines (DPI 1993) as:

- **Class A** – Crop Land is land that is suitable for current and potential crops with limitations to production, which range from none to moderate levels
- **Class B** – Limited Crop Land is land that is marginal for current and potential crops due to severe limitations and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping
- **Class C** – Pasture Land is land that is suitable only for improved native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment.

Between Fitzroy and Bajool, the ROW also traverses the jurisdiction of the former Rockhampton City Council. Although no GQAL information is available for this area, the Rural land use in Council's zoning maps shows that the alignment passes through the South Rockhampton Rural Area. The majority of the land is used for agricultural purposes, primarily grazing for livestock (Rockhampton City Council, 2005). The area is almost entirely surrounded by C1, C2 and C3 classified GQAL in the former Fitzroy Shire and it is therefore likely that it would be classified similarly. Approximately 29 ha of land within the Rockhampton Rural Area is traversed by the ROW.



Gladstone - Fitzroy Pipeline Project

Figure 5.5 - Good Quality Agricultural Land

Sheet 1 of 4

The Right of Way | Road Reserve | SGIC
Project Infrastructure | Waterways | GSDA
Railway Line | LGA Boundary

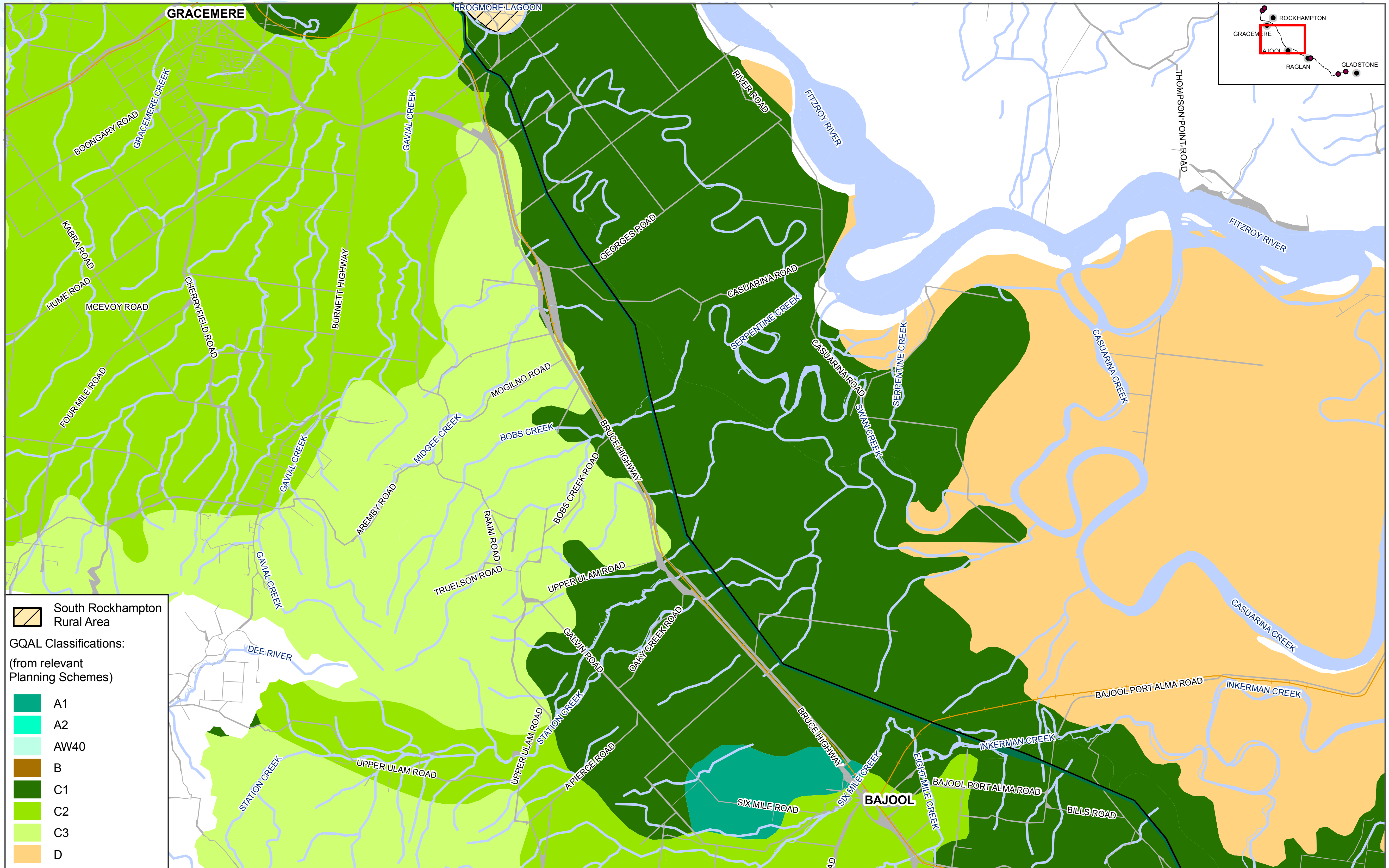
0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

ARUP



Gladstone - Fitzroy Pipeline Project

Figure 5.5 - Good Quality Agricultural Land

Sheet 2 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

ARUP

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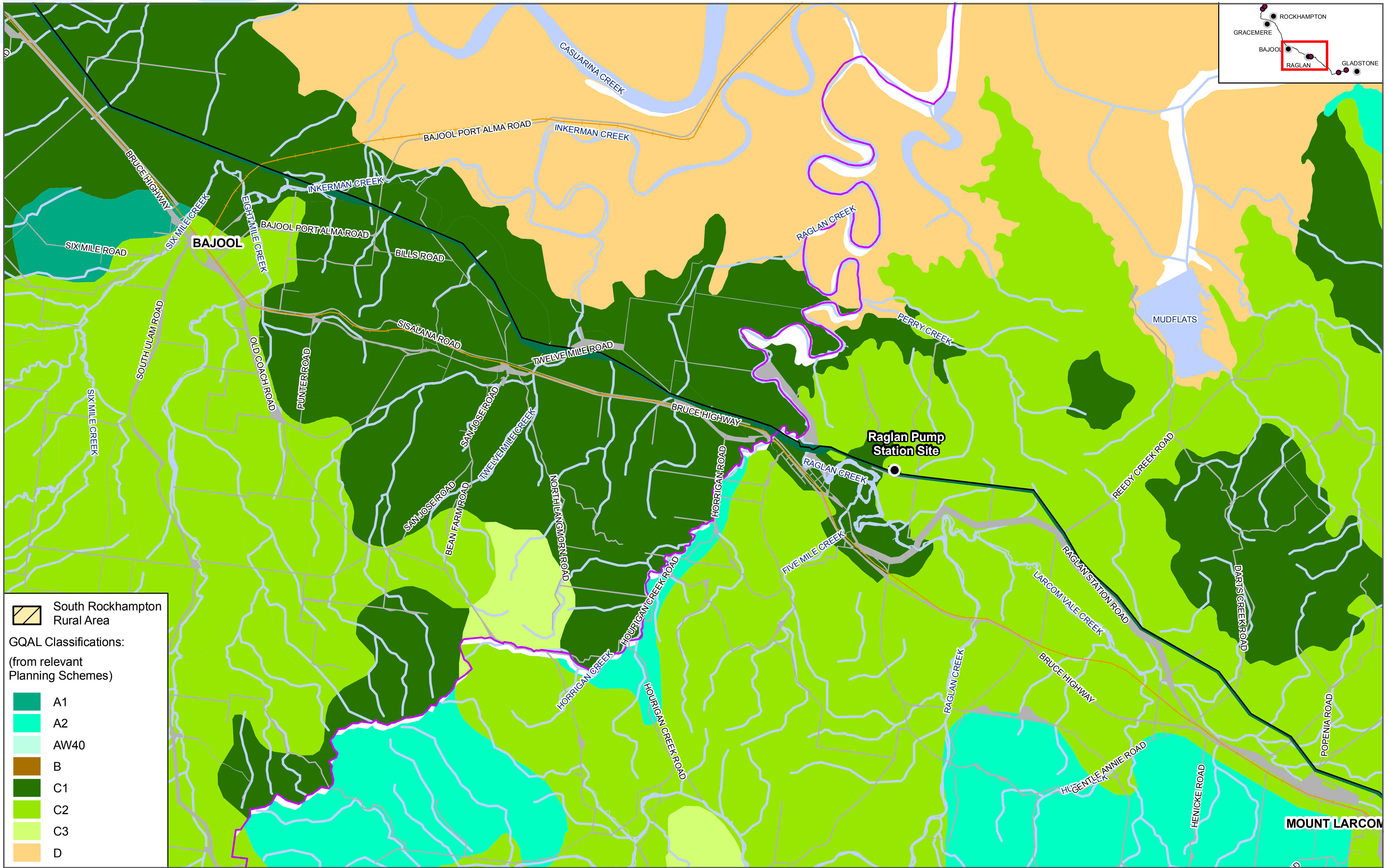


Gladstone - Fitzroy Pipeline Project

Figure 5.5 - Good Quality Agricultural Land

Sheet 3 of 4

The Right of Way
Project Infrastructure
Railway Line
Road Reserve
Waterways
LGA Boundary
SGIC
GSDA

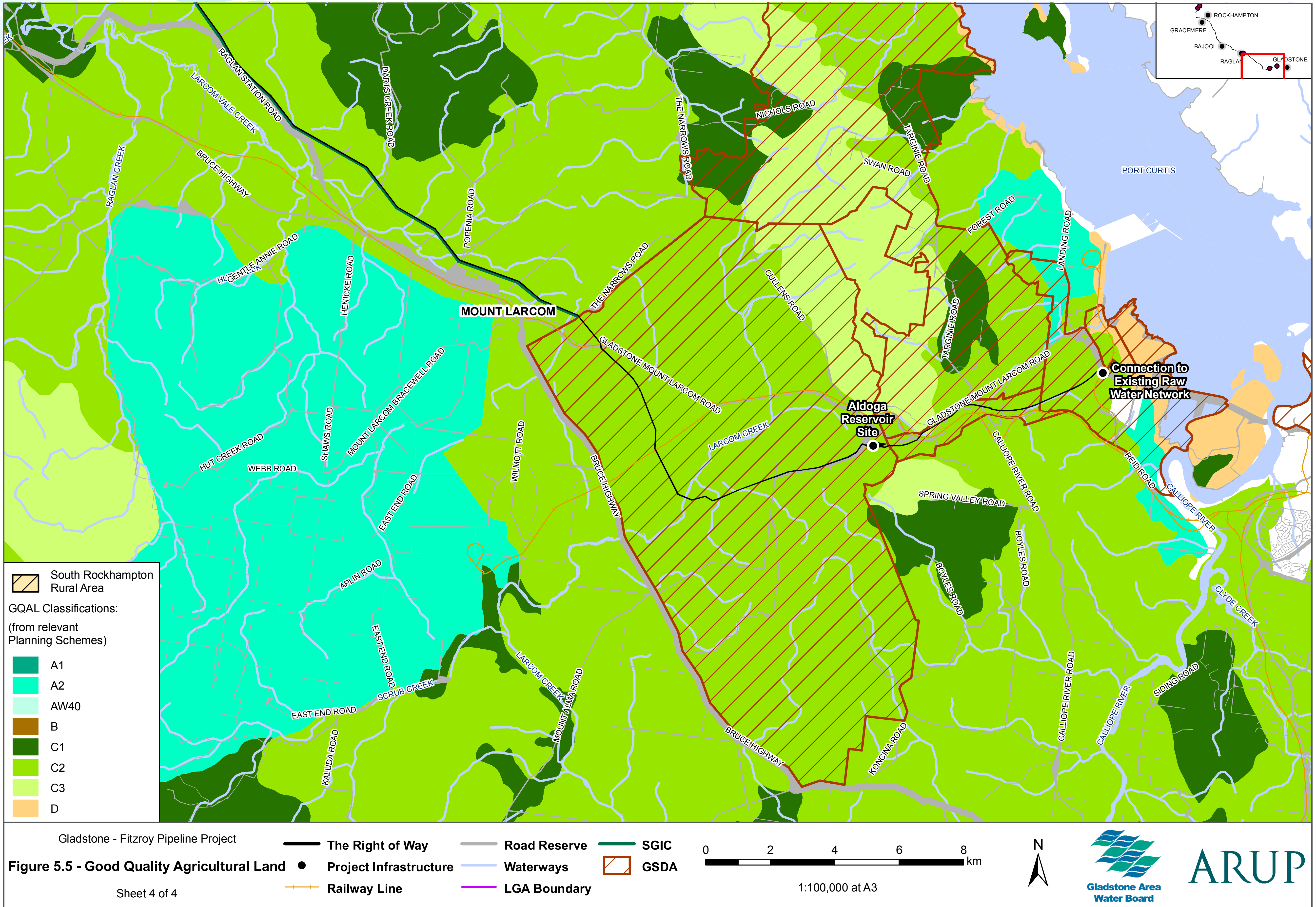
0 2 4 6 8 km

1:100,000 at A3

N

Gladstone Area Water Board

ARUP



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5.6.2.2 Bajool to Gladstone

Between Bajool and Gladstone, the ROW traverses three classes of GQAL over the former Fitzroy and Calliope shires (see Figure 5.5):

- **Class C1** – Pasture Land suitable for sown pastures (approximately 59 ha)
- **Class C2** – Pasture Land suitable for native pastures (approximately 125 ha)
- **Class C3** – Pasture Land suitable for light grazing of native pastures (approximately 1 ha).

Class C GQAL is suitable only for improved native pastures due to limitations which preclude continuous cultivation for crop production, but some areas may tolerate a short period of ground disturbance for pasture establishment (DPI 1993).

The Raglan Pump Station and Reservoir is sited on 6 ha of Class C2 GQAL.

The Aldoga Reservoir is sited on 10.5 ha of Class C2 GQAL.

5.6.3 Contaminated Land

The land use of the region has generally been that of grazing and some cropping. Some activities likely to be associated with these land uses include the use of pesticides, presence of cattle dips, rail corridors and unidentified dump sites. These have the potential to give rise to contaminated land. The following sections outline the sites that are listed on the CLR and the EMR.

5.6.3.1 Fitzroy to Bajool

For the section of pipeline running between the Fitzroy River and Bajool, there are no properties listed on the CLR or EMR that are traversed by the alignment.

5.6.3.2 Bajool to Gladstone

Table 5.4 highlights the lots of land between Gladstone and Bajool that returned results from the searches of both the CLR and EMR. For this section of the pipeline, five lots that traverse the ROW have been identified as being on the EMR. They have been listed on the EMR for a number of reasons. Three of these lots are located around the small town of Yarwun at the southern end of the pipeline in the GSDA, with another located in nearby Mt Larcom. The final lot is located approximately halfway between Raglan and Bajool near the small town of Marmor. These are mapped in Figure 5.2.

In most circumstances, sites on the EMR pose 'low risk' to human health or the environment under their current land use, however presence on the EMR does not necessarily mean they are contaminated.

Table 5.4 Contaminated Land Register (CLR) & Environmental Management Register (EMR) Search Results

Lot plan and Location	Register	Reasons for being on the Register
101DS185 (Marmor)	EMR	The site has been subject to the following Notifiable Activity pursuant to section 374 of the *Environmental Protection Act 1994.* WASTE STORAGE, TREATMENT OR DISPOSAL - storing, treating, reprocessing or disposing of regulated waste (other than at the place it is generated), including operating a nightsoil disposal site or sewage treatment plant where the site or plant has a design capacity that is more than the equivalent of 50,000 persons having sludge drying beds or on-site disposal facilities.
1RP911260 (Yarwun)	EMR	The site has been subdivided from the following site, which is included on the EMR. Subdivided new parcels will remain on the EMR unless it can be shown that they are not located near the contaminating activity. Lot: 1 Plan: RP618672 Address: BOAT CREEK ROAD, YARWUN, QLD, 4694 The site has been subject to the following Notifiable Activity pursuant to section 374 of the *Environmental Protection Act 1994.* LANDFILL - disposing of waste (excluding inert construction and demolition waste).
91SP122250 (Yarwun)	EMR	The site has been subdivided from the following site, which is included on the EMR. Subdivided new parcels will remain on the EMR unless it can be shown that they are not located near the contaminating activity. Lot: 1 Plan: RP601330 Address: BUTLER STREET, YARWUN, QLD, 4680 The site has been subject to the following Notifiable Activity pursuant to section 374 of the *Environmental Protection Act 1994.* RAILWAY YARDS - operating a railway yard including goods-handling yards, workshops and maintenance areas.
7SP145439 (Yarwun)	EMR	The site has been subdivided from the following site, which is included on the EMR. Subdivided new parcels will remain on the EMR unless it can be shown that they are not located near the contaminating activity. Lot: 3 Plan: CP860100 Address: MT. MILLER ROAD, NOT ADVISED, 4680 The site has been subject to the following Notifiable Activity pursuant to section 374 of the *Environmental Protection Act 1994.* GUN, PISTOL OR RIFLE RANGE - operating a gun, pistol or rifle range.
140SP122252 (Mt Larcom)	EMR	The site has been subject to contamination from a hazardous contaminant as follows: HAZARDOUS CONTAMINANT - This site has been subject to a hazardous contaminant. Refer to the summary given below. Possible high arsenic levels along rail corridor.

5.6.4 Acid Sulfate Soils

Pyritic soils or ASS, were deposited in coastal zones throughout the world during the last 6,500 to 10,000 years. When drained for development or otherwise disturbed, the iron pyrite in these sediments oxidises producing sulfuric acid which subsequently lowers the pH in runoff and groundwater, leading to the release of toxic aluminium and iron from the sediments into the groundwater.

ASS are only found in soils of alluvial origin and although most common on low lying coastal floodplains in riverine and delta sediments, may also be found at moderate elevations, along the banks of inland creeks and streams. ASS generally occur below about 5 m AHD, but may be found as high as 20 m AHD if Holocene deposits are present. Sulfidic materials may also occur in parent rock material and their residual weathering products, however, the acidity is bound into the rock matrix and does not readily generate acid runoff. These soils are residual in origin and do not commonly contain ASS, but may contain low level acidity of other mineralogical origin. Although, some profiles in areas along creeks and waterways will have a shallow alluvial layer at the surface.

Generally, the terrain and vegetation observed in the project area was not consistent with that of areas where ASS are found (i.e. no areas of mangroves, tea tree swamp or water logged intra-tidal estuaries were observed). The exception was a low lying area of mangroves (Photo 1 of Figure 5.4) near where Raglan Creek crosses the project alignment (the location of TP74). Subsequently ASS were detected below approximately 2.5 m depth at this location.

Cracking clays occur along the project alignment from approximately TP72 to TP202 (see Figure 5.2) and are mostly *Vertosols,* which are alluvial in origin. *Vertosols* in low lying areas are more likely to contain ASS. These soils are concentrated where the project alignment crosses a number of creeks and passes through alluvial floodplain of the Fitzroy River (most of the middle third of the route from Raglan to Bajool and to a lesser extent from Archer to Midgee).

Areas on the edges of the floodplain at elevations of between 5 m and 10 m AHD, may also contain ASS in either shallow Holocene deposits or to a lesser extent in Pleistocene soils which overlie the residual soils (that are not likely to contain ASS). Investigations indicate that some of these areas are underlain by mainly residual soils with little or no surficial alluvium (often shallower than 0.5 m) and like the residual soils above 10 m AHD, they have a low likelihood of containing actionable levels of ASS.

Table 5.6 indicates the various geological units, predominant soil types and topographic bands along the corridor. Each entry in the table has been colour-coded based on the AHD level (less than 5 m; 5 to 10 m; and more than 10 m). Table 5.6 also indicates the likelihood of ASS occurrence along the project corridor, with degree of risk ranked from negligible to high. Sections of the project alignment that are rated a 'moderate' risk or higher, of containing ASS will require further assessment at time of or prior to construction, as will areas not investigated to date. These areas are indicated on Figure 5.4. ASS were positively identified at two locations between Raglan and Bajool (at TP74 and TP106).

The Queensland Acid Sulfate Layer (NRM 2002) indicates that there is potential for ASS to occur in the section of the route near Yarwun at the 'Gladstone end' of the project. However, much of this part of the route is elevated (e.g. above 10 m AHD and mostly above 20 m AHD).

Initial advice from DNRW indicated that the 'Gladstone area' is particularly prone to ASS, with some samples analysed returning results of the order of 4 to 5 percent oxidisable sulfur around Gladstone, and as high as 8 percent in some areas. Reference to mapping for "Tannum Sands – Gladstone QNRM04285" only includes a small part of the eastern end of the project alignment. Approximately 2 km is shown as mapped, but areas of high ASS risk are limited to the eastern most 200 m or less of the project area.

Previous investigations undertaken for the Gladstone–Pacific Nickel Refinery near Yarwun (approximately 4 km from the eastern end of the project alignment), indicated the presence of potential ASS with up to 4 percent oxidisable sulfur (URS, 2007). It is mainly in these coastal areas within a few kilometres of the east coast that 'high level' ASS has previously been identified.

DNRW also indicated that other areas within the project route containing possible ASS were likely to be around Raglan Creek, Inkerman Creek and Eight Mile Creek. Test pitting and soils analysis was carried out in these areas confirming some ASS near Raglan Creek.

Areas that may contain ASS are generally situated near or adjoining a water body and it is these water bodies that are of environmental significance and where mitigation would be required.

5.6.4.1 Test Results

The majority of the samples screened returned negative screening results. Only 21 samples (from 16 test pits) returned 'possible' results. There was also one 'probable' and one 'positive' result, both from TP106. The pH_{FOX} values in the soils screened ranged from 1.9 and 2.7 in TP106 to 9.3 in TP95, with the majority of samples in the range 5 to 8.

Field pH values (pH_F) were generally in the range 5 to 8 at all locations, which indicates little or no 'actual' acidity present. The exceptions were a few samples of 'topsoil' from isolated locations and samples from below 1 to 1.5 m depth in TP69, TP70 and TP74 (at Raglan), which indicated low levels of actual acidity. TP106 and TP74 were the only locations where the follow up quantitative laboratory analysis clearly identified ASS. The other examples are more likely to be attributed to weak organic acid generated by decay of organic matter rather than ASS derived from pyritic fines.

A summary of ASS screening results with a pH_{FOX} of less than 4.5 is given in Table 5.5.

Table 5.5 Summary of ASS Screening Results

Location	Test Pit	Layer Depth (m)	Dominant Soil Texture	Recorded Range of pH_{FOX}
Bajool to Raglan	72	0.0-0.2	Medium	4.2
	74	2.5 - 3.0	Fine – Medium	3.0 - 3.2
	77	0.0-0.6	Coarse	3.3
	78	0.0-0.2	Medium	4.1
	79	0.0 - 0.25	Medium	3.5
	80	0.0 - 0.25	Medium	3.5
	82	0.0 -1 .0	Fine – Medium	3.4 - 4.8
	83	0.0-0.2	Medium	3.2
	91	0.5 - 0.75	Fine	4.1
Raglan to Epala	69	1.0 - 2.0	Medium	3.9
	70	0.0 - 1.0	Fine – Medium	3.6 - 3.8
Archer Pk to Rocklands	168	0.0 - 0.25	Medium	4.5
	169	0.0 - 0.25	Fine	3.5
	172	0.0 - 0.25	Medium	3.1
Midgee to Archer	130	0.0-0.25	Medium	3.3
	132	0.0-0.25	Medium	3.7
Archer to Bajool	114	0.0-0.25	Medium	3.5

Table 5.6 Qualitative ASS Risk Summary

Locality	Levels (AHD)	Mapped Geology	Landscape - based on 2005 Terrain Units *	Confirmed by Test Pits	Assumed Risk of ASS	Further Investigation Recommended
before TP1	> 20 m AHD, but below 10 m AHD at start location.	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics. GRANITOID. Granite, granodiorite, diorite and gabro.	Dy - Yellow Duplex	None Undertaken	Generally Low, Moderate at GFP starting location.	Yes * (Start location only, may be in alluvium)
TP1 - TP7	> 20 m	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	None Undertaken	Negligible	No
TP8 - TP15	> 20 m	SEDIMENTARY ROCK, Basalt, andesitic tuff, conglomerate, arenite, mudstone, limestone	Dy - Yellow Duplex	None Undertaken	Negligible	No
TP16 - TP42	> 20 m	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex (TP16-32) Gn- Massive Earths (TP33-42)	Insufficient Undertaken (1)	Negligible	No
TP43 - TP48	> 20 m	ALLUVIUM, sand, silt, mud, gravel	Gn- Massive Earths (TP43-46) Dy - Yellow Duplex (TP47-48)	Shallow Alluvium only	Very Low	No
TP49 - TP51	10 – 20 m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluviun Confirmed	Very Low	No
TP52 - TP55	> 20 m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluviun Confirmed	Very Low	No
TP56	10 – 20 m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium Confirmed	Very Low	No
TP57	10 – 20 m	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	Residual Soils	Negligible	No
TP58	> 20 m	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	Residual Soils	Negligible	No
TP59 - TP62	10 - 20m	MIXED VOLCANIC AND SEDIMENTARY ROCKS, Andesitic to dacitic and basaltic lavas and volcaniclastic rocks and some lacustrine sedimentary rocks; also felsic lava, ignimbrite and other volcaniclastics	Dy - Yellow Duplex	Residual over Metasediments	Negligible	No
TP63 - TP65	10 - 20m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Predominantly Metasediments	Very Low	No
TP66 - TP67	> 20m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Residual Metasediemnts	Negligible	No
TP68	10 - 20m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Residual Metasediemnts	Very Low	No
TP69 - TP71	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium Confirmed	Low (minor acidity confirmed)	No ***
TP72 - TP77	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Moderate (ASS Confirmed at depth)	Yes
TP78 - TP81	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (minor acidity confirmed)	Yes
TP82	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low - Moderate (minor acidity confirmed)	Yes
TP83 - TP88	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium over Residual	Low (minor acidity confirmed)	Yes
TP89 - TP93	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low - Moderate (minor acidity confirmed)	Yes
TP94 - TP95	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium Confirmed	Low (no actionable acidity)	No
TP96 - TP100	< 5m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex (TP96-98) Ug - Cracking Clay (TP99-100)	Alluvium Confirmed	Low - Moderate (minor acidity confirmed)	**Yes** (TP98-100 only) Lime TP96-98 Insitu ***

Locality	Levels (AHD)	Mapped Geology	Landscape - based on 2005 Terrain Units *	Confirmed by Test Pits	Assumed Risk of ASS	Further Investigation Recommended
TP101 - TP103	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (no actionable acidity)	No
TP104 - TP111	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Moderate - High (ASS Confirmed)	Yes
TP112 - TP128	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium over Residual	Low (minor acidity confirmed)	Yes
TP129- TP138	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium over Residual	Low (minor acidity confirmed)	Yes
TP139 - TP147	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay(TP139-142) Um - Loams (TP143-147)	Not Undertaken	Low - Moderate (No Testing)	Yes *
TP148 - TP150	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Um - Loams	Not Undertaken	Low (no testing)	Yes *
TP151 - TP158	< 5m	ALLUVIUM, sand, silt, mud, gravel	Um - Loams (TP151-154) Ug - Cracking Clay (TP155-158)	Alluvium Confirmed	Low - Moderate (minor acidity confirmed)	Yes
TP159 - TP160	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (no actionable acidity)	No
TP161 - TP162	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium Confirmed	Low (no actionable acidity)	No
TP163 - TP171	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low - Moderate (minor acidity confirmed)	Yes
TP172 - TP174	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (minor acidity confirmed)	Yes
TP175 - TP179	< 5m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Not Undertaken	Low - Moderate (No Testing)	Yes *
TP180 - TP186	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (no testing)	Yes *
TP187 - TP190	10 - 20m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Not Undertaken	Low	No
TP191 - TP194	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium Confirmed	Low (no testing)	Yes *
TP195 - TP198	10 - 20m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay	Alluvium over Residual	Very Low	No
TP199 - TP208	5 - 10m	ALLUVIUM, sand, silt, mud, gravel	Ug - Cracking Clay (TP199-202) Dd - Black Duplex (TP203-205) Dy - Yellow Duplex (TP206-209)	Alluvium Confirmed	Low (no testing)	Yes * (TP199-202 only)
TP209 - TP218	10 - 20m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Shallow Alluvium	Very Low	No
TP219	>20 - 10m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium / Colluvium	Very Low	No
TP220	10 - < 5m	ALLUVIUM, sand, silt, mud, gravel	Dy - Yellow Duplex	Alluvium Confirmed	Low - Moderate	Yes **

- Net Acidity detected at rates requiring lime treatment.
NOTES:
* Based only on lack of testing, only areas actually disturbing soils from below 5m AHD need to be investigated
** Risk is due only to proximity to a major waterway
*** Lime insitu at a rate of 5kg/m^3
Each entry in the table has been colour-coded based on the AHD level (<5m; 5-10m; and >10).

Total Acidity Tests - 'Acid Trail'

Test results indicate that the acidity present in the samples analysed varied. However, in the majority of samples it is negligible. Low levels of actual and to a lesser degree potential acidity exceeding the adopted 'action criteria', were identified in 29 of the samples analysed and moderate to high level PASS was detected in two samples (from TP74 and TP106). 'Action criteria' refers to the amount of existing and potential acidity in the soil that triggers the need for management to prevent environmental damage if the soil is disturbed.

Lower levels of acidity were detected in several other samples. Actual acidity levels were in most cases 80 to 100 percent of potential acidity, indicating that either near complete oxidation of the ASS had already occurred or that more likely in some samples the acidity was inherent in the mineralogy of the soil or due to the presence of weak organic acids (and not due to oxidation of sulfidic fines).

The highest individual Total Actual Acidity (TAA) results was still relatively low, 94 moles of acid/tonne for a sample of dark grey clay from TP74 at 2.75m depth (see Table 5.7).

Oxidisable Sulfur (S_{POS}) - 'Sulfur Trail'

Results of Percent Oxidisable Sulfur (S_{POS}) tests, show the levels of oxidisable Sulfur (Sulfides) present to be generally low. Of the samples tested by either the SPOCAS or S_{Cr} method, only nine samples from eight locations, TP77, TP97, TP103, TP104, TP105, TP106 and TP107 returned S_{POS} (or S_{Cr}) levels at or above the detection level of 0.02 percent. These ranged from 0.02 percent to 0.04 percent at most locations. The exceptions being 0.22 percent at TP97 (where significant ANC was also present), and 0.97 percent at TP106 (which was subsequently classed as a high ASS risk area). No significant levels of retained acidity were detected.

Chromium Reducible Sulfur Tests

Results of S_{Cr} test suites carried out on 27 of the samples indicated similar levels of (titratable) actual acidity and to the SPOCAS test results, but with no oxidisable sulfur detected.

Acid Neutralising Capacity (ANC) and Net Acidity – 'Lime Treatable Acidity'

ANC was determined on 32 samples where the resulting pH was 6.5 or higher. ANC values ranged from 16 to 304 moles/tonne thus identifying almost half the samples analysed as containing significant levels of alkaline materials. Very few small shell fragments were identified in the samples screened and it is considered that any calcareous material is fine-grained and thus readily available for buffering of any acidity present in the soil. In several of the samples analysed the ANC was sufficient to reduce the 'net acidity' to below that level which requires lime treatment. Of the 81 samples analysed, 30 returned net acidity values above the action criteria of 18 moles/tonne (which is used in Queensland for major excavations exceeding 1,000 tonnes). Of these, 27 samples indicate a liming rate of 3 kg to 5 kg of lime/m^3 would be required to neutralise the net acidity present (if disturbed). The remaining three samples from two locations (TP74 and TP106), would require lime neutralisation at rates of 12 kg (at TP74), and 6 kg and 64 kg (at TP106), respectively.

Results of quantitative laboratory testing undertaken are included in Appendix E1. Those tests returning 'net acidity' values exceeding the adopted action criteria and thus requiring lime treatment are summarised in Table 5.7.

Values shown in **bold** also exceed the QASSIT texture based 'Action Criteria' for acidity: 62 moles for clays; 36 for clayey sands; and 18 moles for sands (Dear et al, 2002, pp. 6). It should be noted that as the proposed disturbance involves more than 1,000 tonnes of spoil, an 'action criteria' of 18 moles H^+/tonne must instead be adopted.

Table 5.7 Acid Sulfate Results

Section	Test Pit Location	TAA (mole H^+/t)	a-ANC (mole H^+/t)	Soil Description	S_{POS} (%)	'Net Acidity' (mole H^+/t)	pH_{FOX}
Archer Park to Rocklands (TP165 – TP220	TP165 0.0-0.25m	25	25	SCL, dark grey, gravel	<0.02*	25	*--
	TP168 0.0-0.25m	25		ZCL, dark grey, organics	<0.02*	25	*--
	TP169 0.0-0.25m	27	80	LMC, dark brown-grey, organics	<0.02	27	6.9
	TP172 0.0-0.25m	26	60	CL, grey, organics	<0.02	26	6.9
Gavial to Midgee (TP140 – TP154)	TP151 1.75-2.0m	25	--	LC, sandy, grey & red-brown	<0.02	31	5.0
Midgee to Archer (TP129 – TP139)	TP130 0.0-0.25m	35	--	ZL, dk brown	<0.02	35	*--
	TP132 0.0-0.25m	24	--	ZL, grey-brown	<0.02	24	*--
Archer to Bajool (TP112 – TP128	TP112 2.25-2.5m	9	--	MC, pale grey-brown	0.02	22	6.0
	TP123 0.25-0.5m	23	90	MC, dk brown, trace sand	<0.02	23	6.9
Bajool to Raglan (TP72 - TP111)	TP72 0.0-0.2m	20	--	SL, brown, organics	<0.02	20	--*
	TP74 2.5-2.75m	34	--	MC, grey-black, organics	<0.02	44	5.5
	TP74 2.75-3.0m	92	--	LC, grey, reddish-brown	<0.02	111	4.4
	TP77 0.0-0.2m	13	--	LS, dk brown, organics	0.02	26	3.5
	TP78 0.0-0.2m	44	--	CL, brown	<0.02	44	--*
	TP82 0.5-0.75m	22	--	LC, brown	<0.02	29	4.7
	TP83 0.0-0.2m	23	--	CL, pale brown	<0.02	23	--*
	TP87 0.3-0.45m	29	--	ZL, brown	<0.02	29	4
	TP91 0.50-0.75m	25	33	HC, grey	<0.02	28	7.2
	TP92 0.00-0.25m	46	--	HC, grey, organic matter	<0.02*	46	*--
	TP92 0.75-1.0m	26	--	HC, grey	<0.02	26	5.5
	TP93 1.25-1.50m	21	--	HC, grey	<0.02	21	5.7
	TP97 2.75-3.0m	<2	33	LC, pale brown	0.22	24	8.4
	TP105 0.0-0.25m	13	--	LC, brown, organics	0.03	31	4.3

Section	Test Pit Location	TAA (mole H^+/t)	a-ANC (mole H^+/t)	Soil Description	S_{POS} (%)	'Net Acidity' (mole H^+/t)	pH_{FOX}
Bajool to Raglan (TP72 - TP111) (cont)	TP105 0.5-0.75m	20	32	HC, yellow brown & grey	<0.02	20	6.6
	TP106 1.75-2.0m	13	--	LC, dk grey-brown	0.97	616	2.2
	TP106 2.25-2.5m	29	--	LC, grey-brown	<0.02	49	3.6
	TP108 2.75-3.0m	24	--	HC, grey, some orange-brown	<0.02	25	4.8
Raglan to Epala (TP54-TP71)	TP69 1.5m	26	--	LC, grey-brown	<0.02	26	4.7
	TP70 0.5m	37	--	MC, brown, mottled	<0.02	37	4.4
	TP71 0.0-0.5m	31	--	LC, grey-brown	<0.02	31	4.6

5.7 Impacts

5.7.1 Soils

5.7.1.1 Construction

Potential impacts arising from erosion and dispersive soil disturbance are expected to be transient in nature due to the short time periods associated with construction. Erosion and dispersion will potentially affect soil stockpiles, soil left exposed at construction sites (e.g. the trench itself) and soils left exposed in areas cleared of vegetation during the temporary time period of construction. As the soils are generally considered highly dispersive, rain events or other contact with water is likely to result in the break-down of soils into clays, sand silt and clay, creating sediment and nutrient laden runoff. Erosion due to exposure to water (rain events or water use on site) is also likely to create sediment and nutrient laden runoff. Loss of soils through erosion and dispersion also causes stripping of the soils resulting in local productivity yield losses. In addition, if the sediment and nutrient laden runoff is able to enter waterways it has the potential to affect water quality (see Chapter 9, Water Resources and Water Quality). Eroded soils may not directly enter waterways and can be deposited in low gradient areas, in sediment traps, along contour banks or in grassed areas (DNRW 2007a). The exact fate of the sediment is dependent on topography, rainfall intensity and land cover (such as grassed area). Impacts are likely to be greater at creek crossings and during the wet season (December to March (Bureau of Meteorology, 2008).

Local catchment hydrology controls the nature and direction of any surface flows entering and leaving a construction site (i.e. a section of trench). It governs the likely impact that the proposed development will have on any local waterways (e.g. creeks and drains in proximity to the disturbance), through the potential for sediment transportation off-site during construction and after completion of trenching. In particular, construction activities within 100 m of a waterway are considered to pose a potential environmental risk and will require management of earthworks to limit erosion.

As most topsoil layers within the project area are considered to have a moderate to high potential for erosion when left exposed on gradients more than 15 percent, construction around creek beds and other areas close to creeks with gradients of more than 15 percent will have higher potential to create sediment and nutrient laden runoff that enters creeks. The perennial waterbodies and waterways (the Fitzroy River, Lagoon 1 and Eight Mile, Twelve Mile, Horrigan, Raglan and Larcom Creeks) are most vulnerable to the impacts of sedimentation and eutrophication from sediment-laden runoff as they permanently contain water. As described in Chapter 9, Water Resources and Water Quality, the Fitzroy River, Lagoon 1, Eight Mile and Horrigan Creeks display high levels of Total Suspended Solids (TSS) and therefore are less sensitive to sedimentation effects than the other waterways. Twelve Mile and Larcom Creeks on the other hand have low TSS and are therefore more sensitive to small changes in TSS.

In addition to the above impacts, subsidence may occur after backfilling of the trench if soils have not been compacted to a level commensurate with the surrounding soils. This may impact the land use directly above the trench, lead to gully erosion and affect local catchment hydrology.

5.7.1.2 Operations

Operations will have limited impacts upon soils as areas become revegetated (either naturally or through landscaping). Despite this, increased runoff will be created due to the greater area of impermeable surfaces created by the water treatment plant (WTP) and pump stations. This has potential to cause greater velocities in runoff and therefore causing enhanced erosion. It is also possible that maintenance works that involve earthworks will be susceptible to erosion and sedimentation as described above.

5.7.2 Good Quality Agricultural Land

5.7.2.1 Fitzroy to Bajool

There will be temporary disturbances to Class C and B GQAL during construction, however it is expected that pastoral activities will be able to resume in the ROW following construction, subject to the terms of the license agreement.

The other facilities such as the Fitzroy River intake site and pumping station, and the WTP and its associated pump station will remove areas of GQAL for an indefinite time period and thus remove the current and potential agricultural production. This is not considered a significant regional loss to agricultural production as these properties are currently used for non-intensive grazing, however the landowners may experience reduction in agricultural output potential. The extent of area impacted is listed in Table 5.8. Classes C2 and B GQAL is described in section 5.6.2.1.

Table 5.8 Area of GQAL Affected by the Project's Facilities Between Fitzroy and Bajool

Facility	GQAL Class	Approximate Area (ha)
Fitzroy River Intake Site Pump Station	C2	2
WTP and Alton Downs Pump Station	B	11
Total	C2 + B	13

5.7.2.2 Bajool to Gladstone

All GQAL likely to be impacted between Bajool and Gladstone is Class C and can be restored post-construction. Therefore there is only slight potential for losses to baseline agricultural production. New land uses may be restricted from future development above the pipeline depending on the terms of the licensing agreement.

The Raglan Pump Station and Reservoir and Aldoga Reservoir sites will be built over GQAL and thus remove the current and future potential for agricultural production for an indefinite time period. As the Raglan Pump Station and Reservoir site and Aldoga Reservoir sites are both Class C2 low-intensity grazing, the agricultural production lost due to the project is low. Table 5.9 shows the approximate area of GQAL impacted by these two sites. Class C2 GQAL is described in section 5.6.2.1.

Table 5.9 Area of GQAL Affected by the Project's Facilities Between Bajool and Gladstone

Facility	GQAL Class	Approximate Area (ha)
Raglan Pump Station and Reservoir	C2	6
Aldoga Reservoir	C2	10
Total	C2	16

5.7.3 Contaminated Land

5.7.3.1 Fitzroy to Bajool

As no properties listed on the CLR or EMR are traversed by the project area, there are no known likely impacts due to contaminated land disturbance in this section of the project area. However, due to past agricultural uses of the land there is the potential for unknown contaminated sites to exist in the project area.

5.7.3.2 Bajool to Gladstone

Table 5.10 provides a description of the potential impacts from contaminated land that may occur as a result of the construction of the pipeline in the Bajool to Gladstone section of the project area. Five properties that are recorded on the EMR are traversed by the pipeline, with each having potential impacts. There is also the potential for unknown contaminated sites to exist in this section of the project area as a result of past land uses.

The potential risks posed by the five properties directly affected by the pipeline are listed in Table 5.10.

Table 5.10 Potentially Contaminated Land Between Bajool and Gladstone

Site No.	Notifiable Activity	Lotplan	Distance From Centre of the Route (m)	Potential Impacts
1	Waste Storage, Treatment or Disposal	101DS185	Pipeline traverses property	Release of toxic leachate, explosions
				Adverse impacts on human and environmental health
				Contamination of nearby surface waters
2	Landfill – disposal of waste	1RP911260	Pipeline traverses property	Release of toxic leachate
				Explosions due to the flammability of landfill gas
				Land destabilization
3	Railway Yard	91SP122250	Pipeline traverses property	Disturbance of soils potentially contaminated from the storage and use of hazardous substances
4	Gun, Pistol or Rifle Range	7SP145439	Pipeline traverses property	Unexploded ordinances
				Lead contamination of soil
				Contamination of nearby surface water
5	Possible high levels of arsenic	140SP122252	Pipeline traverses property	Disturb soil during construction which mobilises arsenic that could contaminate nearby surface water

5.7.4 Acid Sulfate Soils

ASS are frequently present in alluvial soil on low lying floodplains. Work to date indicates the presence of generally low level ASS at several locations along the alignment between Raglan and Bajool and other low level acidity not attributed to ASS in some other areas.

Based on the data available, and given that the soils exposed near any waterway crossings are in environmentally sensitive areas, it is considered that the development as a whole poses risk of adverse impact to the receiving environment (i.e. various water bodies) associated with disturbance of ASS.

Due to the nature of ASS in the project area, there are potentially low-level impacts upon the environment. If ASS is disturbed, leachate containing sulfuric acid and metal contaminants can be released into the environment, causing an adverse impact upon the natural and built environment, as well as human health.

Environmental impacts of ASS may include:

- Reduction in water quality resulting in damage to estuarine environments and reduction of wetland biodiversity
- Habitat degradation
- Reduction in plant productivity
- Acidification
- Deoxygenation
- Heavy metal precipitation (e.g. aluminium, iron and manganese), which causes poor plant productivity and smothers plant vegetation and microhabitat (NRW, 2007).

Further description of the potential impacts to water resources as a result of the disturbance of ASS, is provided in Chapter 9, Water Resources and Water Quality.

5.8 Mitigation Measures

5.8.1 Soils

Emerson Class 1 or 2 is indicative of dispersive soils, which generally represent a high dispersion potential and would normally require use of chemically treated sediment retention basins. However, due to the linear nature of a pipeline, the use of sediment retention basins is not practical. Nonetheless, conventional erosion and sediment control (ESC) measures will be developed and implemented to minimise the risk of dispersive soil fines being transported offsite and into local waterways.

Soils along the route are predominantly fine grained (i.e. clays) and the following ESC measures will be applied where excavation will occur within 100 m of waterways:

- Temporary drains or bunds will be constructed where necessary to direct runoff and any overland flow from upslope of excavations, away from any nearby waterways
- Siltation fences will be installed on down-slope site boundaries (along the edge of the trench). Where a waterway is within 50 m, the fence in this area will be of strong construction and supported on sturdy stakes at relatively close centres (i.e. less than 5 m), with an effective seal at the base where the fence touches the ground
- Perimeter diversion drain or bund will be placed around any long-term stockpiles (i.e. reserved topsoil for revegetation)
- Temporary sediment barriers will be installed around any nearby stormwater inlets and along the base of any sediment fences situated along the banks of waterways
- Prompt revegetation or covering/sealing of the backfilled trench, avoiding leaving excavations opened over weekend/ extended breaks.

Where present, unless stripped and removed offsite, topsoils will be stockpiled within bunds well away from any waterways. A light application of agricultural lime (about 1 kg/m^3) will be applied to the surface of topsoils re-used following embedment of the pipeline to limit dispersion potential until grass cover can be reinstated. However, should potentially dispersive soils be retained for re-use on site, treatment with the addition of lime or gypsum at a rate of 2.5 kg/m^3 is common. Topsoil of local origin used near waterways will be treated promptly if to be left exposed.

Soils that have been lime treated for acid sulfates need not be further treated and would be considered non-dispersive. Treatment of run-off in areas not treated with lime will be further addressed in the project Erosions and Sediment Control Plan (ESCP), to be prepared prior to construction.

Soils rated as having 'Moderate' or worse erosion potential will require specific management during construction of the pipeline and should not be left exposed for any significant period of time without stabilisation.

During the wet season the trench will be constructed in manageable lengths so that temporary stockpiling of spoil is minimised. Backfilled soils will be compacted to a level commensurate with the surrounding soils with the aim of preventing erosion and trench subsidence. During final re-profiling of the soil, mounding may be required to compensate for potential subsidence. During 'dry spells', revegetated areas should be watered to promote reinstatement of grass cover.

An erosion and sediment control program will be prepared and implemented for the construction and operation phases of the project. Measures have also been included in the Planning EMP (see Chapter 20, Planning Environmental Management Plan) inline with the *Soil Erosion and Sediment Control Engineering Guidelines for Queensland* (Witheridge et al, 1996).

5.8.2 Good Quality Agricultural Land

Any agricultural land disturbed due to the laying of the pipeline will be restored to its previous condition where possible, and the previous land use will be allowed to continue onsite depending on the easement arrangements. Where the alignment passes through existing cropped GQAL, provisions will be made in consultation with the landowner to allow cropping to re-establish and continue post construction if possible.

5.8.3 Acid Sulfate Soils

Investigations to date have detected actionable levels of acidity and/or the likelihood of ASS in the following sampled test pits (TPs) (see Figure 5.4):

- TP69 - TP71, east of Raglan
- TP72, TP74 and TP77 - TP78 near Raglan
- TP82 and TP83, near Twelve Mile Road
- TP87 and TP91 - TP93 and TP97, near the Toonda - Port Alma Road
- TP105 - TP108, at Inkerman Creek Crossing
- TP112 and TP123, north to northeast of Bajool
- TP130 and TP132, near Archer
- TP151, at Gavial
- TP165, TP168-TP169 andT9172, north of Rocklands.

It is also possible that ASS may be present at the beginning of the project alignment at Yarwun for approximately the first 200 m of the project alignment route.

Based on the results of the investigations undertaken to date and an assessment of risk attributed to construction of the pipeline in low lying areas adjoining water ways, and in order to meet State Government Legislative requirements (i.e. the SPP 2/02), detailed ASS investigations will be required in areas that will involve the disturbance of greater than 100 m^3 of soils from below 5 m AHD.

The requirement for further investigation is based on either actionable levels of soil acidity having been detected or no investigations having been undertaken to date. Investigations should mainly target areas of 'cracking clays' and areas where actionable levels of acidity have been detected.

Investigations of the following areas will be required, if the final detailed design for construction indicates that more than 100 m^3 of soil will be disturbed from below 5 m AHD (see Figure 5.4):

- TP71 - TP93, (11.5 km) near Raglan
- TP98 - TP100, (1 km) near Bajool
- TP103 - TP147, (17.5 km), from Bajool to Midgee
- TP162 - TP186, (7.5 km) at Rocklands
- TP191 - TP 194, (1.5 km) and TP199 - TP202 (1.5 km) west of Archer park
- TP220 at the location of the connection shaft at the Fitzroy River north of Rockhampton.

Given the relatively minor scope of earthworks required for installation of the pipeline (i.e. less than 500 m^3 of soil will be disturbed per 100 m of pipeline installed), a reduced borehole location frequency is recommended for the investigations. One borehole per 100 m of the route in the areas described above is considered adequate for the purpose however will be confirmed in consultation with DNRW.

The following scope of work is proposed for the detailed ASS investigation:

- Boreholes will be drilled to investigate those parts of the corridor described above that will result in excavations below 5 m AHD. Boreholes are to be taken to approximately 1 m below depth of disturbances at each location or to rock
- Sampling and screening of alluvial soil samples recovered at 0.25 m intervals will be carried out
- Sufficient quantitative analysis will be undertaken to define the magnitude and extent of ASS encountered (e.g. two to six SPOCAS or 'Chromium Suite' tests from each borehole)
- A detailed technical ASS assessment report will be prepared with mapping of linear and vertical delineation of ASS/PASS for each area investigated, including suitable lime treatment rates for each section of the works
- Based on the findings of the ASS assessment, a 'stand alone' ASS EMP(s) will be prepared, in accordance with Appendix 4 of the SPP 2/02 Guideline, to manage ASS related construction issues.

Site Management Measures

As a minimum to meet the obligations of duty of care, the following management strategies would be employed at all locations where actionable levels of soil acidity are identified:

- As a general precaution, in areas where the base of the trench is below 5 m AHD (including where investigations are not undertaken), a 'barrier layer' of agricultural lime will be placed on the base of trench excavation to minimise the risk of infiltration passing through any disturbed acidic soils into the groundwater. The barrier will consist of a surface application of agricultural lime applied at a minimum rate of 2 kg/m^2 on the base of trench excavations and on any surfaces left exposed for longer than 48 hours (i.e. over the weekend)
- Where ASS investigations have identified the need to lime treat spoil this will be carried out promptly at the designated rate and liming verification sampling and analysis will be undertaken to confirm that adequate lime has been used
- Low levels of actual acidity identified in 'topsoil' materials from some locations require to be neutralised by addition of small quantities of lime, however, lime verification testing may not be necessary. A nominal rate of 5 kg lime/m^3 of spoil is considered to be adequate for this purpose and include a factor of safety of two or greater for the levels of acidity identified to date in non-ASS materials. Where lime verification testing is not undertaken treated spoil should be returned to the trench as 'back fill' within 24 hours of disturbance (and liming)
- Surface run-off is to be controlled through appropriate site management as listed in the ESCP (i.e. ensure run-off stays inside excavations and is collected and prevented from entering any waterway by use of low earth bunds or other temporary control measures
- Monitor the pH of any water pooled on-site (groundwater seepage and after rainfall events), that requires to be discharged offsite for any reason, and treat with hydrated lime ($Ca(OH)_2$) if necessary, to attain pH less than 8.5 and more than 6.5. Bags of hydrated lime should be kept onsite in a dry state for this purpose, but used sparingly (i.e. add no more than about 50 to 100 g of lime to ponded water and mix well, then carefully monitor the change in pH before adding more if required).

These measures are meant as a guide only and more detailed, site specific management measures will be developed for those sections of the project alignment where ASS are identified as part of the ASS Management Plan to be developed prior to construction. Measures to control ASS have also been described in the Planning EMP (see Chapter 20, Planning Environmental Management Plan).

5.8.4 Contaminated Land

Several measures will be implemented to mitigate the risks associated with the construction of the pipeline and the disturbance of contaminated land. The first of these will be to undertake measures in accordance with the Department of Environment's *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (1998)*. Preliminary site investigations will be undertaken for each identified site in Section 5.6.3 prior to the initiation of any construction work. If the need for further investigation is identified, a detailed site investigation would be undertaken in accordance with the *Draft Guidelines*.

Should any unknown contaminated land be encountered during the preliminary site investigations or during the construction of the pipeline, the relevant investigations will be carried out in accordance with the *Draft Guidelines* in dealing with the area of land involved.

The construction of the pipeline is not expected to cause any land contamination during the construction, commissioning or operational phases as there are not likely to be large quantities of dangerous goods or chemicals stored at the site and any spills will be managed to minimise the impacts to land. Measures for the handling and storage of dangerous goods are included in Chapter 20, Planning Environmental Management Plan. In the unlikely event that a large spill occurred at the site during construction or operation, procedures detailed in the *Draft Guidelines* would be implemented and the relevant authorities notified.

5.9 Residual Impact Assessment

5.9.1 Soils

The effectiveness of management will be influenced by the weather conditions throughout construction. Due to the nature of the soils, it is likely that more erosion, dispersion and sedimentation will take place during heavy or prolonged instances of rain, resulting in small scale localised erosion despite management efforts.

After the completion of earthworks, and sealing and/or turfing of the reinstated surface, no significant erosion potential should persist.

The residual impact is considered to be **negligible** to **minor adverse** (refer to the significance criteria in Table 5.2) depending on the influence of weather events.

5.9.2 Good Quality Agricultural Land

Despite the rehabilitation of GQAL in most of the construction footprint, some areas of Class C and B GQAL will be removed for an indefinite period as a result of the project. During decommissioning and potentially demolition, there will be an opportunity to restore these areas to the current GQAL class, however, assuming that areas of GQAL land will be removed for an indefinite time period, the residual impact is considered to be **minor adverse** (refer to the significance criteria in Table 5.2).

5.9.3 Acid Sulfate Soils

Provided that further ASS investigations are conducted (in accordance with the SPP2/02), in areas indicated in Table 5.6 Qualitative ASS Risk Summary, and that an ASS Management Plan is prepared outlining necessary management measures and these measures are followed, the residual impact associated with ASS is classified as **negligible**.

Based on management plans to be implemented, the residual impacts of the mitigation measures put in place to reduce the impacts associated with ASS are at this stage classified as **negligible** (refer to the significance criteria in Table 5.2). However, the residual impacts will be unable to be determined until full ASS investigations are completed prior to construction.

5.9.4 Contaminated Land

The residual impact following the implementation of the mitigation measures to reduce the impacts associated with contaminated land, are this stage classified as **negligible** (refer to the significance criteria in Table 5.2). However, it is important to highlight the fact that the residual impacts will not be fully understood until a preliminary, and if required, full site investigation is carried out to determine the risk posed by each individual site or any other sites identified during construction.

5.10 Cumulative and Interactive Impacts

Within the Stanwell-Gladstone Infrastructure Corridor (SGIC), this project is the first of many possible pipeline projects. Also within the GSDA it is likely that future pipeline projects will occur in the area. Each future project is likely to result in similar impacts to soils and contaminated land as those identified in this chapter. Although mitigation measures will be implemented it is likely that residual impacts will accumulate including:

- Erosion and sedimentation during the construction phase of each project
- Further disturbance to areas of GQAL during the construction phase of each project
- Disturbance of ASS over a greater area
- Potential disturbance of contaminated sites present in each project corridor.

Interactive effects are those occurring within this project that may be worsened as a result of other impacts. The potential interactive effects relevant to this chapter may include:

- The deterioration of water quality as a result of the disturbance of ASS, contaminated land or erosive soils
- Impacts to flora and fauna as a result of the disturbance of ASS, contaminated land or erosive soils.

Mitigation measures to manage these potential interactive effects are described in this chapter and in Chapter 9, Water Resources and Water Quality.

5.11 Summary and Conclusions

The impact of the project on soils and contaminated land along with mitigation measures and residual impacts have been considered within this chapter.

Construction of the project, although temporary, presents a greater risk of impact than the operational phase. This is due to the fact that construction will involve a significant amount of earthworks, including soil stockpiling and vegetation removal. Such activities have a number of potential associated impacts, which include:

- Potential exposure of highly dispersive soils that exist throughout the alignment
- Areas where the potential for exposed soils to become eroded are high due to gradients and stockpiling of soils
- Disturbance and/or removal of C Class GQAL
- Disturbance of potential acid sulfate soils
- Disturbance of contaminated land and a removal of GQAL.

A number of mitigation measures have been outlined which aim to reduce the project's impacts on soil and contaminated land. Along with those described throughout this chapter, measures include the preparation of a Construction EMP, erosion and ESCP and the completion of a detailed ASS investigation. Further investigation is also necessary to assess the potential impacts of contaminated land in the project area and will be undertaken prior to construction.

Residual impacts resulting from the project are expected to be **negligible** overall, with the exception of the **minor adverse** residual impact associated with GQAL and the potential minor impact associated with soil disturbance (which will vary depending on weather conditions). Table 5.11 provides a summary of impacts and mitigation measures.

Table 5.11 Summary of Impacts

EIS Area: Geology and Soils Feature/ activity	Current Value + Substitutable Y:N	Description of Impact		
		Description in Words	**Mitigation Inherent in Design/Standard Practice Mitigation**	**Residual Impact Significance**
Soils	Yes	• Erosion and sedimentation • Disturbance of soil profiles • Subsidence after backfilling occurs.	• Reduce exposure of soils to the effects of water/rain • Temporary drains and bunds • Siltation Fences and sediment barriers • Prompt revegetation • Use of lime or gypsum to limit dispersion potential • Preparation and implementation of a detailed ESCP and EMP for construction • Backfilled soils will be compacted to a level commensurate with the surrounding soils with the aim of preventing trench subsidence. During final re-profiling of the soil, mounding may be required to compensate for potential subsidence.	Negligible to minor adverse
GQAL	Value: Class C Potentially substitutable	Loss of agricultural productivity	• Consultation with landowners • Rehabilitation of the majority of impacted GQAL area post-construction.	Minor adverse
Acid Sulfate Soils	N/A	Acidification of waterways/groundwater	• Further investigation of additional boreholes • Preparation and implementation of a stand alone ASS Management Plan • Treatment of soils by lime dosing • Control of surface runoff • Water quality monitoring of water pooled onsite • Preparation and implementation of Construction EMP.	Negligible
Contaminated land	N/A	Contamination of soil/ groundwater	• Measures in accordance with the Department of Environment's *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (1998)* • Preliminary 'walk over' site investigation • In-depth site investigation as required.	Negligible

5.12 References

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