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Surat Basin Rail Project
SEIS – Soils Response
Surat Basin Rail Pty Ltd

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Contents

1. Introduction

1.1 Background

The Surat Basin Rail Project, herein referred to as 'the Project', is a proposed open access, multi-user railway connecting the Western Railway System, situated 230 km west of Toowoomba, with the Moura Railway System, located near Banana 130 km west of Gladstone. The Project covers a linear distance of 210 km, with a corridor width of approximately 60 m.

The Project has been optimised for coal freight traffic and can accommodate the following operating scenarios:

- Narrow gauge coal railway
- Narrow gauge coal freight railway
- Dual gauge coal freight

The Project consists of a single track with up to eight passing loops. Provisional allowance in the Project's design has been made to allow for future electrification of the rail line.

The Project will have a minimum design life of 50 years and is expected to reach full operational capacity within five to ten years of construction.

1.2 Purpose of report

This document has been prepared as an appendix to the Surat Basin Rail Project Supplementary Environmental Impact Statement (SEIS) document to address the issues raised during the Project EIS consultation period pertaining to the soil environment and values of the Project area. This document presents a summary of the submissions received relating to the soil environment and cross-references the EIS submissions to the relevant sections within this document which contains additional information relating to each issue.

1.3 Scope

Information provided in this report includes the following:

- A review of proposed cut and fill volumes, latest Reference Design information and spoil storage locations current as at 12 June 2009 and recommendations for management measures for unsuitable material for inclusion in the EMP
- A review of the latest Reference Design and survey information current as at 12 June 2009 and aerial photography for the project area
- An identification of locations of occupation and stock crossings within and adjacent to watercourses
- An identification of on-farm erosion control and soil conservation measures distinguishable from a review of aerial photography
- Recommendations for site specific erosion and sediment control measures and potential opportunities for modification, integration and improvement for project erosion and sediment controls with on-farm mitigation measures and controls
- A review of property soil conservation plans held on-file by DERM
- Review water source/supply and management options developed by the project's water team (surface water and groundwater) and develop specific recommendations for management measures in relation to impacts to soil and impacts resulting from soil disturbance for inclusion in the EMP
- A review of additional soil mapping data provided by DERM (03/08/09), geotechnical data and EIS soils investigation data and a correlation assessment to demonstrate coverage (% area) of dominant land units within the project area achieved during the EIS
- A review of surface water, groundwater and hydraulics information to identify potential impacts to soils from disturbance in relation to surface water, groundwater and hydraulic regimes, including issues of salinity and sodic soil management

1.4 Summary of comments

A summary of the EIS submissions received during the SBR EIS consultation process relevant to soils issues is included in Appendix A (Table 1). The corresponding SEIS soils section that responds and provides additional information for this is also provided.

2. Additional Information and Assessment

2.1 Alignment soil impacts

2.1.1 Identified high risk soil types

Investigations undertaken as part of the SBR EIS and also subsequent investigations have identified several soil types that are considered to be of high risk for erosion, dispersion and salinity. Table 2.1 lists the high risk soil types identified in the project area and the corresponding alignment chainages. Two chainage lengths have been provided, one for the project area and one for the alignment. This is to indicate where:

- The alignment will cross high risk soils, where soil disturbance will occur
- The project area crosses high risk soils, where soil disturbance may occur (eg if haul roads are constructed in that area)

Table 2.1 High risk soil type details

Soil Type[1]	Risk	Chainage (project area)	Chainage (alignment)
CB3	Salinity	3.5-9.5, 13-18.5, 22.5-33.5, 36-40, 43.8-45.5, 46.5-50.5, 67.5-74.5, 77.3-87.2	3.5-9.5, 13-18.5, 22.5-33.5, 36-40, 43.8-45.5, 67.5-70.6, 72-74.5, 77.3-87.2
SI4	Salinity	0-3.5, 9.5-13, 18.5-22.5, 33.5-36, 41-43.8, 62-67.5, 70.6-72	0-3.5, 9.5-13, 18.5-22.5, 33.5-36, 41-43.8, 62-67.5, 70.6-72
MM7	Dispersion, erosion, salinity	107-129, 178.5-184, 185.5-187.6, 203-208	107-129, 178.5-184, 185.5-187.6, 203-208

Table Note: [1] CSIRO DAAS 2004

High risk soils Mitigation Measures

Mitigations for high risk soils as identified in Table 2.1 (CB3, SI4 and MM7) include:

- Areas of existing erosion and/or identified dispersive soils are to be isolated and remediated (eg dispersive soils may be treated with gypsum) to prevent further damage
- Chainages as identified in Table 2.1 for CB3, SI4 and MM7 will require additional monitoring and potentially sample collection and analysis during construction. Daily visual inspections of these high risk soils will be required whilst works are occurring in these areas. Once works have been completed in the high risk areas, and the area stabilised, monitoring can be reduced to weekly inspections.

2.1.2 Earthworks description and management measures

Review of cut and fill details

A review of the proposed cut and fill locations and quantities as at 15 July 2009 was undertaken. Table 2.2 presents areas of cut and fill, the location (alignment chainage) and a description of the earthworks proposed to be undertaken.

Table 2.2 Cut and fill description details

Cut/Fill	Description	Chainage Location
Cut	Material required for road works, excess spoiled	5.9
Fill	Borrow material required for the rail (depending on construction staging)	11
Cut	Excess cut material used on private overpass ramps (30 km)	28.3
Fill	Material required for road works, potential source cut widening 35 km	34.7
Cut/Fill	Fill batter slope/grading optimisation or cut widening at 37 km	35.9
Cut/Fill	Minor optimisation	44.5
Fill	Minor optimisation or material used on potential access road connection to Nathan Road	53.6, 60.6
Fill	Material required for road works, cut at 65 km to be widened	64.8
Fill	Material required for road works	78.4
Fill	Excess fill material can be optimised by fill batter slope and grading optimisation	83.3, 145, 158.3
Cut	Excess cut material can be minimised with cut batter slope optimisation as cut will have very large percentage of sandstone	89.4, 93
Fill	Excess fill material can be optimised by fill batter slope and grading optimisation, required material sourced from cut widening at 101 km	101.8
Fill	Excess fill material can be optimised by fill batter slope and grading optimisation, required material sourced from cut widening at 121 km	121.9
Cut/Fill	Large and long haul can be minimised with cross sections and grading optimisation	139, 154.5
Fill	Excess fill material on southern side of Castle Creek can be optimised by fill batter slope and grading optimisation, additional material source Kitty Marran road works and cut widening	167.9
Fill	Excess fill material on northern side of Castle Creek can be optimised by fill batter slope and grading optimisation, additional material source cut widening 169 km and 171 km	168.4
Fill	Excess fill material on southern side of Lonesome Creek can be optimised by fill batter slope and grading optimisation, additional material source cut widening at 172 km	175.7
Cut	Material required for road works additional widening required	182.3, 189.8, 199.8

There will be approximately 11,929,111 m^3 of cut and 11,687,448 m^3 of fill in total across the alignment; this leaves a balance of approximately 655,775 m^3 of fill that will require disposal.

Currently spoil storage locations have not been specifically identified however excess spoil will be disposed of at locations within the proposed State Development Area (SDA).

Latest project design information

Impacts to soils will be updated during detailed design once information regarding construction methods has been developed.

2.1.3 Soil Salinity

The SBR EIS provided results of soil profile salinity conditions analysis. This analysis indicated that the soils in the project area generally ranged from non-saline to moderately saline. Two samples collected indicated highly saline material and one sample indicated extremely saline material. The soils units that contained these samples were CSIRO (DAAS, 2004) soil type CB3 and SI4 (highly saline in Chromosol) and MM7 (extremely saline in Dermosol).

Potential Impacts

Potential impacts to soil salinity:

- Disturbance of saline soils due to excavation or cut and fill activities, leading to saline contamination of previously non-saline soils
- Spreading of soil salinity through runoff and or infiltration through saline soils exposed due to excavation activities
- Increased risk of soil salinity and degradation through changes in water tables resulting from construction works

Areas where a geological restriction to groundwater flow is present can be susceptible to increased risk of salinity. The geological restriction forces a rise in the water table potentially bringing saline groundwater to the surface and causing salt seepage and concentration of surface salts through evaporation (DNRQ 1997). Certain landform patterns can indicate potential areas of risk, landform patterns have been analysed and areas of risk are listed in Table 2.3.

Table 2.3 Landform areas at risk of groundwater salinity discharge

Landform feature	Alignment Chainage (km)
Basalt form	141-142
	152-153
Catchment restriction - roadway	53-54
Confluence of streams	12-13
	20-21
	42-43
	63-64
	90-91
	106-107
	125-126
	135-136
	158-159
	176-177
	197-198
Alluvial valley	99-109

Design
To minimise potential impacts discussed above the following mitigation measures will be applied during detailed design:

- Design culvert placement in embankment structures to minimise impact to the natural drainage pattern
- Minimise clearing of vegetation especially in the creek floodplains
- Where appropriate incorporate salt tolerant tree species in saline areas to minimise the likelihood of salt level increases from rises in groundwater level as part of the site rehabilitation/revegetation plan
- Detailed design geotechnical studies to include further investigation into the extent of shrink-swell soils, especially in areas where sodic soils have been detected
- Adopt water efficiency strategies, including the recycling and reuse of wastewater to limit groundwater extraction
- Minimise the land clearing within the project area
- To minimise the effect on the drainage and hydrology from compaction of soils due to embankment construction and rail traffic, rail alignments should be located on the ridgeline of slopes where possible
- To minimise water table rises from compaction of soils where acceptable deep rooted salt tolerant tree species should be planted and allowed to establish and/or interception drains should be installed
- A detailed assessment of surface and subsurface drainage patterns shall be conducted to provide adequate information for culvert positioning
- Detailed geotechnical studies shall provide information for the drainage assessment with regard to soil compaction and infiltration rates
- Consult with landowners for a collaborative management approach, which will be captured in the EMPs for construction and operation
- Design lined water storage ponds for saline/contaminated water to reduce the risk of infiltration

Construction
To minimise potential impacts during construction, the following mitigation measures will be applied:

- Storage of salinity prone soils shall be undertaken in a manner that prevents rainfall, runoff and overland flow from infiltrating through these soils causing degraded water quality
- Assess excavation and cut and fill areas for soil salinity prior to undertaking these activities. Where possible avoid disturbing areas suspected to contain soil salinity
- Where saline soil or waters cannot be avoided, saline soils should be contained and adequate drainage, containment and treatment (where required) should be provided to prevent contamination of runoff and overland flow leading to contamination of non-saline soils
- Water storages should be adequately lined to prevent infiltration into the underlying water table
- Use gypsum or other calcium based soil ameliorants to improve soil sodicity conditions where appropriate
- Water quality and groundwater monitoring will be undertaken to monitor any significant fluctuations in water level, EC, cations and anions which may provide indications of any changes on site
- A Soil Handling and Management Sub Plan will be developed prior to construction, which will facilitate the implementation and define mitigation measures for potential construction and operation impacts. The Soil Handling and Management Sub Plan will be an ongoing document that will be reviewed and implemented at several stages of the project to mitigate impacts that may arise through changes in design and site conditions
- Groundwater extraction to be controlled in accordance with the findings of groundwater studies

- Monitor standing water levels within groundwater bores on a monthly basis to identify any increases/decreases associated with construction works
- Quarterly sampling and cation analysis for at risk soils to monitor changes due to construction works during activity within these areas, at a rate to be agreed in consultation with DERM
- Monthly visual inspection of reinstated areas for bare areas, stunted vegetation, visible salt patches/scolds or burns
- During dewatering of any cuts (if required) monitor discharge water for cations, pH and electrical conductivity. Monitoring will be undertaken to identify any changes in groundwater quality
- Where sodic or high risk soils have been identified and groundwater is proposed to be used for dust control/earthworks or other construction activities, Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC) groundwater analysis will need to be undertaken to allow for comparison and classification using Figure 9.2.3 of the ANZECC 2000 water quality guidelines. From this analysis mitigation measures or alternate construction methods will need to be developed during detailed design
- Storage of salinity prone soils shall be undertaken in a manner that prevents rainfall, runoff and overland flow from infiltrating through these soils causing degraded water quality
- Storage of saline water supply and/or waste water shall be within lined containment ponds design3dto minimise the risk of infiltration

Operation
To minimise potential impacts during operation, the following mitigation measures will be applied:

- A level of maintenance on surface and subsurface drains will be required to minimise risk of impact to drainage patterns and hydrology of the landscape
- Visual monitoring for any signs of salinity (eg saline outbreaks, vegetation, waterlogging and salt burns)
- Maintain rehabilitation/revegetation areas established during construction of the project

2.2 Property based impacts

2.2.1 Soil conservation plans and property erosion control measures

The *Soil Conservation Act 1986* is an Act to consolidate and amend the law relating to the conservation of soil resources and to facilitate the implementation of soil conservation measures by landholders for the mitigation of soil erosion. It provides for the approval of soil conservation property plans to ensure the co-ordination of runoff to control erosion.

A soil conservation plan contains a map and provides specifications for the necessary soil conservation structures and practices necessary to control erosion at a particular location.

A number of soil conservation plans prepared for sites within and adjacent to the Project area were provided by DERM on 7 August 2009 and reviewed. A summary of the key soil conservation works contained in these plans has been provided in Table 2.4 (adapted from DERM).

The project will intersect a number of property erosion control and soil conservation measures within the corridor. A visual survey of aerial photographs was undertaken to assess on-farm erosion control and soil conservation measures. Erosion control measures identified are included in Table 2.4.

On-farm erosion control measures that are intersected by the project will need to be maintained and potentially adapted through appropriate engineering measures within the project footprint during detailed design.

Impacts to existing on-farm erosion control measures as identified in the soil conservation plans will need to be mitigated during detailed design.

Table 2.4 Soil conservation works that may be impacted by corridor works (6 August 2009)

Lot/Plan	Chainage (km) [i]	Soil Conservation Plan Number	Approved Property Plan [ii] (Y/N)	Existing Erosion Measure [iv]	Chainage (km) [v]	Comments
2/RP170076	13–14	SC345189	N	Contour Bank	13-14	Line adjacent to dam wall; traverses contour banks; requires waterway on eastern side of corridor
22/FT746	15–16+	SC345072	N	Contour Bank	15-17.3	Occupation crossing at erodible watercourse; contour banks discharging East to West — require waterway east of corridor, or resurvey part of these banks to the east
40/FT329	N/A	N/A	N/A	Contour Bank	15-17.3	Aerial photo review only
41/FT603	21.4–22.6	SC345079B	Yes			Minimal impact on soil conservation works
99/FT815	22.6–24.4	SC345103	Yes	Contour Bank	22.5-24.5	Traverses origin end of contour banks; obliterates waterway at chainage 24–24.4 — requires waterway on eastern side of corridor.
48/FT815	24.4–24.8 27.5–28.1	SC345073B	N	Contour Bank	24.5-25, 26.8-28	Contour banks discharge approx. East–West — requires waterway on eastern side of corridor Contour banks discharge approx. North–South — require waterway on north-western side of corridor
6/FT801	28.1–28.7 30–30.5	SC345179	N	Contour Bank	28-29, 29.8-30.8	Traverses origin end of contour banks. Banks discharge East–West — require waterway on eastern side of corridor
2FT880	N/A	N/A	N/A	Contour Bank	43.5-44	Aerial photo review only
4FT942	N/A	N/A	N/A	Contour Bank	64.4-65.8	Aerial photo review only
4846/PH1055	122–123	No Map	N	Contour Bank	122-123.3	Banks approx parallel to corridor drainage line at chainage 123
23DW546	N/A	N/A	N/A	Contour Bank	127.4-129.4	Aerial photo review only
14/DW51	Approx. 153+	MO–A1–3346	N	Contour Bank	150.4-151.5, 152-153.4	Line intersects banks discharging West–East — requires waterway west side of corridor
1/RP620652	168.8–169.3	BM–K1–1133	N	Contour Bank	168.7-170, 170-171.2	Banks discharge West–East — require new waterway on West side of corridor, and then approx. 300 along North side of Castle Creek Road

Lot/Plan	Chainage (km) [i]	Soil Conservation Plan Number	Approved Property Plan [ii] (Y/N)	Existing Erosion Measure [iv]	Chainage (km) [v]	Comments
	169.6–170.0					Banks discharge West–East — require new waterway on West side of corridor to drainage line near chainage 170 Occupation crossing near chainage 170 should not impede discharge from waterways or natural drainage line
	170.0–170.5					Banks discharge West–East — require waterway on West side of corridor to drainage line near chainage 170
45/DW116	N/A	N/A	N/A	Contour Bank	170-171.2	Aerial photo review only
4/DW195	174.0–174.5	BM–K1–1134	N	Contour Bank	173.8-176.4	Line intersects origin end of banks
14CP906943, 18DW56	N/A	N/A	N/A	Contour Bank	179.8-180.7	Aerial photo review only
1RP844269	N/A	N/A	N/A	Contour Bank	183.3-184.2	Aerial photo review only
26/RP844269	186.8–187.5	No map	N	Contour Bank	186.4-187.8	Line intersects origin end of banks
25/DW135	188–192.2	BL-A0-4214	N	Contour Bank	190.2-191.8	Not clear. Line appears to intersect origin end of banks for first 500-600 m At chainage 191.0–191.5 the corridor may intersect discharge end of banks, necessitating an additional waterway. At 191.6–192.2 the corridor may impact on natural flows that discharge to a small stock dam
24/DW134	192.3–193.3 193.8–195.3	BM–A1–2823	N	Contour Bank	192.4-194.7	Line intersects origin end of banks Not clear. Line may intersect discharge end of banks and obliterates small ring tank and associated works near chainage 194.6
19/RP904596	199.3–199.3	No Map	N	Contour Bank	198.6-199.7	Not clear. Line may intersect origin end of banks
10/DW257; 14/DW259; 110/FN261	201.4–202.1 202.5–202.7	BM-AI-2030	Y	Contour Bank	201.2-203.3	Not clear. Line may intersect origin end of banks. Corridor may impact on storage dam
7/DW117	203.4–203.7	No Map	N			Not clear. Possible that banks on eastern side of corridor discharge to north to a waterway along Norths Road. May require a cross-drainage under the rail line; or, a waterway on

Lot/Plan	Chainage (km) [i]	Soil Conservation Plan Number	Approved Property Plan [ii] (Y/N)	Existing Erosion Measure [iv]	Chainage (km) [v]	Comments
						the eastern side of the corridor to discharge to the south
78/FN48; 120/FN69	205.2–206.3	MO–AO–4011	N	Contour Bank	205.2-206.9	Line intersects origin end of banks
118/RP860088	206.7–207.0	MO–AO–4011	N	Contour Bank	205.2-206.9	Line obliterates small stock dam and associated diversion bank
119/RP860088	208.0–208.6	MO–AO–4011	N	Contour Bank	207.9-209.6	Not clear. Possible that banks discharge to South East requiring a waterway on the western side of corridor, and a cross-drain West–East at 1/RL7914 boundary
114/FN69	208.7–209.1	MO–AO–4011	N			Not clear. Possible that banks discharge to South East requiring a waterway on the western side of corridor. Corridor may impact on storage dam near chainage 209.3. Occupation crossing at broad watercourse below dam wall
1/RL7914; 51/FN216	N/A	N/A	N/A	Contour Bank	207.9-209.6	Aerial photo review only

Notes:

i) Refers to Aerial Photographs 1 – 14 in *Environmental Impact Statement*, *Volume 1—Main Text Feb 2009,* Surat Basin Rail Project.
ii) Runoff control plans may be approved under provisions of the *Soil Conservation Act, 1986,* as Property Plans. Other suitable works that may be impacted by works along the corridor have been identified by examination of aerial photographs, however may not be approved under the Act.
iii) N/A = Not available
iv) Existing erosion control measures identified within the project alignment from the aerial photography survey 2009
v) Chainage for existing erosion control measures identified from aerial photograph survey 2009

Soil erosion hazard zones are areas of soil that are at risk from erosion and are defined on soil conservation plans. Some areas along the project alignment and corridor have been classified using this system. Table 2.5 lists the areas which have been classified and their hazard level. Descriptions of the hazard ratings are provided in Table 2.6.

Table 2.5 Soil Erosion Hazard Zones drawn from soil conservation plans

Chainage	Soil Erosion Hazard - Alignment	Soil Erosion Hazard - Corridor	Map Reference
168.3-169.2	2	2	BM–K1–1133
169.2-169.6	4a	4a	BM–K1–1133
169.6-170.5	2	2	BM–K1–1133
170.5-171.4	Alignment does not cross a Soil Erosion Hazard Zone	4a	BM–K1–1133
171.4-172.7	Alignment does not cross a Soil Erosion Hazard Zone	2	BM–K1–1133
173.0-173.8	Alignment does not cross a Soil Erosion Hazard Zone	3	BM–K1–1134
173.8-175.1	2	2	BM–K1–1134
175.1-176.3	3	3	BM–K1–1134

Table 2.6 Soil Erosion Hazard Zones for Central Queensland extensive cropping areas (taken from DERM soil conservation plans)

Soil Erosion Hazard		Recommendations	
Zone	*Degree*	*Land Use*	*Land Management*
1	Low	Permanent Cropping	• Contour cultivation (with strategic banks if required) • Strip cropping • Conservation cropping (eg stubble retention, reduced tillage)
2	Moderate	Permanent Cropping	• Contour banks at standard spacing • Moderate levels of conservation cropping (eg stubble retention, reduced tillage)
3	High	Occasional cropping (pasture rotation) or cropping with erosion resisting cropping systems	• Contour banks at standard spacing • High levels of conservation cropping (eg predominance of winter cereal crops with minimum or zero tillage practices) • Inclusion pasture rotation 50% of the time
4a	Severe	Not recommended for cropping	• Unsuitable for cultivation under current technology
4b	N/A	Grazing, non-crop area	• Severe limitations other than erosion (eg stoniness)
f	Flood/variable	Cropping under erosive flooding	• Specific practices dependent on situation (eg zero tillage)

2.2.2 Good Quality Agricultural Land

The EIS identified areas of GQAL which will be impacted by the Project. As stated in the EIS, areas of GQAL were considered during the detailed design phase of the Project to minimise impact to these areas wherever possible.

Due to changes in the Project alignment since publication of the EIS, the areas of GQAL impacted by the Project have now changed. GQAL is further discussed in the Landuse and Planning chapter.

2.2.3 Occupational and stock crossings

The Project will intersect a number of occupational and stock crossings which are situated within or adjacent to waterways. The locations of these crossings have been detailed in Table 2.8.

Table 2.8 Occupational and Stock Crossings within or adjacent to a watercourse intersected by the alignment

Chainage	Within/Adjacent to Watercourse
11	Within watercourse
19	Adjacent to watercourse
27	Within watercourse
29	Within watercourse
31	Within watercourse
34	Within watercourse
51	Within watercourse
53	Adjacent to watercourse
85	Adjacent to watercourse
94	Adjacent to watercourse
104	Adjacent to watercourse
111	Adjacent to watercourse
114	Adjacent to watercourse
123	Within watercourse
126	Adjacent to watercourse
129	Adjacent to watercourse
132	Within watercourse
138	Adjacent to watercourse
142	Adjacent to watercourse
148	Within watercourse

Chainage	Within/Adjacent to Watercourse
149	Adjacent to watercourse
155	Within watercourse
202	Adjacent to watercourse
203	Adjacent to watercourse
209	Adjacent to watercourse

2.3 Other potential Impacts

The following provides information further to that provided in the EIS pertaining to potential impacts the Project may have on a number of factors relating to the soil values of the Project area.

2.3.1 Surface water, groundwater and hydraulics impacts

A review of additional surface water, water supply requirements, groundwater and hydraulics information was undertaken to identify potential impacts to soils and from the disturbance of soils in relation to surface water, groundwater and hydraulics resulting from the impact of design, including issues of salinity and sodic soil management.

Hydraulic Impacts

Construction of the proposed rail alignment results in afflux on Roche, Mayne and Cockatoo, Cracow, Orange, Castle and Juandah Creeks upstream of the design structures. Afflux impacts upon some roads, access tracks and undeveloped properties by increased flood depth and extents. The highest impacts are found in Mayne and Cockatoo Creeks where flood extents increase by approximately 950 m as a result of afflux. Further refinement of the bridge structures could reduce anticipated impacts and it is recommended that further investigation be undertaken during the detailed design phase.

Peak velocities immediately downstream of the proposed Roche Creek, Mayne and Cockatoo Creeks, Ross Creek, Cracow Creek and Juandah Creek crossings increase, with Cockatoo and Juandah Creeks' peak velocities increasing by 0.9 and 1.6 m/s respectively. As a result, scour protection may be required and is to be investigated during the detailed design phase. This should include an assessment of channel stability and sediment transport. Two methods of scour protection were investigated: dumped rock and gabions and rock mattress. The preliminary analysis indicated that use of gabions and rock mattresses would require a significantly less volume of rock. Gabions and rock mattresses are therefore recommended for scour protection in the vicinity of bridges. Two other alternative scour protection measures are the provision of additional cross-sectional area and the use of energy dissipaters.

Further details of hydraulic impacts and mitigation measures are available in the SEIS – Surface Water Response.

Surface water

Changes to on-farm erosion control measures may lead to nutrients and on-farm contaminants (such as hydrocarbons and pesticides) being carried by overland flow into surrounding areas, causing contamination of soils in downstream areas. Proposed mitigation measures for these impacts includes the construction of new contour banks where the alignment intercepts existing contour banks. There is a range of potential surface water impacts that relating to salinity that may also impact on soils. The disposal of drained saline groundwater may impact on downstream soil salinity, also the disturbance of saline soils may result in salt contaminated overland flow which may transport salinity to downstream soils.

Further details of surface water impacts and mitigation measures are available in the SEIS – Surface Water Response.

Groundwater

Contamination of groundwater due to surface spills and leaks of chemicals and pollutants during both construction and operation phases may subsequently contaminate soils. Saline groundwater that is extracted or disrupted may flow to soils and increase salinity.

Further details of groundwater impacts and mitigation measures are available in the SEIS – Groundwater Response.

2.3.2 Water supply requirements

A review of the water source/supply requirements and management options information developed was undertaken. Peak water demand information is provided in Table 2.9.

Table 2.9 Peak daily water demand during construction across the rail alignment

Chainage		Peak Daily Water Demand (ML)		
		Camp	Ground Conditioning	Dust Suppression
0	9000	0	0.74	0.108
9000	19280	0	1.73	0.123
19280	63000	0.0675	0.85	0.46
63000	96000	0.0675	0.76	0.33
96000	125000	0	0.75	0.468
125000	168000	0.0675	0.79	0.276
168000	213000	0	1.23	0.54

Water abstraction has the potential to have a number of adverse impacts on the soil values of the Project site. Management measures will need to be developed to:

- Manage ground disturbance activities
- Minimise soil erosion
- Improve soil and geotechnical stability

Water source supply and management mitigation measures

Management and mitigation measures include:

- Detailed investigation of areas of proposed disturbance within the rail corridor and properties affected by the Project to adequately assess the environmental status of soils or subsurface materials (including groundwater resources) to be disturbed during construction
- Implement measures to slow and/or prevent overland runoff. Such mechanisms include the installation of grass filter strips (or retention of existing grass filter strips) and/or the installation of artificial structures (eg diversion bunds, agricultural pipe chutes with rock protection at the base to convey water down batters without causing erosion, rock check dams along drainage lines)
- Stabilise disturbed areas as soon as possible following construction with a treatment appropriate to the location disturbed (eg hydromulch and seed batters, jute mat in drainage channels)
- Refuelling of plant will be undertaken away from any waterways, such that any accidental spills can be quickly and easily contained and will not enter a waterway
- An extraction permit will be required for groundwater used for construction water supply. Hydraulic testing of the aquifer to establish a sustainable yield will also need to be undertaken

- The choice of location for groundwater supply bores will need to consider the volume and quality needs for the end use of water
- Site structure should account for the presence of groundwater on the site with respect to potential embankment stability, floor heave and corrosive water issues
- All permanent erosion and sediment control structures will be regularly inspected and they will have a schedule for inspection and maintenance
- Periodic maintenance on surface and subsurface drains will be required
- Soil handling and management measures will be developed in the EMP and implemented prior to the commencement of construction. Measures to be incorporated include:
  - Erosion and sediment control
  - Topsoil management
  - Soil contamination protection and management
- Drainage and overland flow will need to be carefully managed and controlled so as not to impact on the stability of the rail embankments
- Design retaining wall structures to accommodate some water pressure distribution in accordance with recommendations and findings of the geotechnical investigations that have been undertaken for the Project

Water quality analysis from project boreholes has identified boreholes not suitable for water extraction for project purposes. Boreholes producing groundwater with >2,000 mg/L of Total Dissolved Solids (TDS) are deemed unsuitable for project purposes and must not be used, Table 2.10 lists boreholes unsuitable for water extraction. Refer to Figure F5 for suitability of groundwater bores.

Table 2.10 Boreholes classified as not suitable for water extraction based on Total Dissolved Solids.

Category	**Range of Total Dissolved Solids (TDS) – mg/L**	**Boreholes**
Extreme	>10,000	14943, 15892, 15782, 17306, 12838, 16789, 15774, 15053, 10719, 58234, 13030812, 58377, 13030813, 13030380
Not Suitable	2,000-10,000	13030817, 13831, 17944, 15783, 84032, 58298, 44097, 58393, 14362, 17796, 58297, 16040, 15789, 14943, 16119, 12763, 31331, 15828, 48841, 13030809, 15854, 13030814, 16125, 15838, 15855, 17799, 15856, 15765, 15761, 89641, 58101, 17800, 14745, 10474, 15386, 16191, 17800, 34929, 32880, 17800, 58537, 15499, 58101, 16107, 14986, 58005, 48887, 16405, 16836, 14861, 16000, 16189, 17197, 58491, 12221, 43870, 58304, 16217, 48861, 16135, 31995, 32975, 30972, 16102, 14943, 58304, 15960, 17196, 58379, 15777, 15862, 58393, 30972, 15580, 30972, 16224, 30972, 34708, 30972, 58435, 30972, 17448, 89640, 62043, 15598, 30655, 15753, 15598, 15673, 30655, 15500, 58536, 15672, 15053, 30655, 13041, 58608, 26372, 14180, 15538, 68097, 15895, 15967, 14590, 17984, 14222, 15508, 10464, 26119, 13791, 17796, 58409, 15848

2.3.3 Additional soil mapping

Additional soil mapping was provided by DERM on 3 August 2009. A review of the additional soil mapping data, geotechnical data and EIS soils investigation data was undertaken. A correlation assessment of all soil investigation locations was completed to demonstrate coverage (% area) of dominant land units within the project area achieved during the EIS. Inputs required for more detailed soil mapping prior to construction were also determined.

Soil investigations were undertaken as part of the EIS and also as part of further investigations. Map S8a - Soil Investigation Locations and CSIRO (2004) Mapping Units and Map S8b - Soil Investigation Locations and CSIRO (ZDD) Mapping Units illustrate the soil investigation locations undertaken as part of the SBR investigations overlayed on soil types from the CSIRO Mapping Units.

The number of soil investigation locations for each mapping code and the type of investigation (test pit, borehole, seismic and landform survey location) are listed in Tables 2.11 (CSIRO ZDD mapping) and 2.12 (CSIRO 2004). The tables also include the total area and investigation locations per unit area for each soil code. This allows for the density of investigation locations to be analysed, to provide assurance that densities are acceptable.

Table 2.11 Soil investigation locations within CSIRO ZDD soil map units

Map Unit	Test Pits	Boreholes	Seismic	Landform	TOTAL	Total Area (km^2)	Samples per km^2
B	16	5	0	1	22	0.67	33.00
Bf	29	11	2	6	48	1.39	34.57
Bl	30	11	6	4	51	1.39	36.69
Ca	2	4	2	2	10	0.74	13.51
Do	4	0	0	1	5	0.21	24.03
E	36	9	6	2	53	1.67	31.80
H	8	3	0	2	13	0.56	23.39
Hl	4	0	0	0	4	0.33	12.11
I	6	4	3	0	13	0.38	33.93
J	16	7	2	3	28	0.98	28.70
K	19	5	0	2	26	1.03	25.24
Km	2	0	0	0	2	0.11	19.04
Mf	14	4	3	3	24	0.66	36.24
Mo	27	8	4	4	43	1.20	35.87
N	0	5	5	1	11	0.62	17.63
Na	6	4	2	1	13	0.49	26.36
Or	5	2	0	0	7	0.28	25.40
Te	13	9	6	7	35	0.90	39.03
W	61	22	2	7	92	2.81	32.72

Table 2.12 Soil investigation locations within CSIRO soil map units

Map Unit	Test Pits	Boreholes	Seismic	Landform	TOTAL	Total Area (km^2)	Samples per km^2
Bz1	5	9	7	3	24	1.59	15.08
CB3	66	22	4	7	99	3.46	28.60
Kb17	23	10	6	3	42	1.04	40.29
Kb18	9	4	0	0	13	0.44	29.31
Kb20	54	15	2	8	79	2.40	32.93
LK13	21	5	4	3	33	1.03	31.94
MM10	8	4	2	2	16	0.35	45.29
MM7	43	9	4	6	62	2.26	27.42
Mm13	3	1	0	0	4	0.23	17.50
Qa6	11	8	6	6	31	0.65	47.53
Sl4	29	20	2	3	54	1.63	33.21
Va30	26	6	6	5	43	1.32	32.69

A summary of soils observation and investigation location density statistics is provided in Table 2.13. The recommended investigation/observation density was adapted from CSIRO *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al* 2008 Second Edition, Table 14.4). This guideline provides recommended observation location densities for the preparation of land resource surveys. A cartographic scale of 1:50,000 was determined as the benchmark for acceptable observation/investigation location density. The recommended range of observation densities for 1:50,000 provided by the guideline is 2 to 4 observations/km^2, with a minimum acceptable of 1 observation/km^2.

Soil investigation/observation densities for SBR exceed the densities provided by the guideline; in some cases by up to 1100 percent (see Table 2.13). The soil investigation/observation densities are sufficient to exceed the recommended range provided by the guideline for a scale 1:25,000.

Table 2.13 Density statistics for soil sampling

Mapping	Parameter/Calculation	Density of soil investigations undertaken			Guideline[1] (high recommended) for 1:50,000 samples/km^2
		High	Low	Average	
CSIRO (ZDD)	Investigation and observation locations per km^2 (Table 2.9)	39.03	12.11	27.86	4
	Observation and investigation locations undertaken as a percentage of the highest nominated density[1] (4 samples/km^2)	976%	303%	696%	100%
CSIRO (2004)	Investigation and observation locations per km^2 (Table 2.10)	47.53	15.08	21.21	4
	Observation and investigation locations undertaken as a percentage of the highest nominated density[1] (4 samples/km^2)	1,188%	377%	530%	100%

Table Note:
[1] CSIRO *Guidelines for Surveying Soil and Land Resources* (Second Edition, Table 14.4)

2.3.4 Requirement for further investigation

Mapping data for the CSIRO (ZDD) featured a soil type (Rr) within the project footprint, located at approximately chainage 64 to 65 that was not investigated during the field works. Inspection of soil classification mapping reveals that this soil type is in close proximity to the alignment centreline but does not cross it. This does not however mean that this soil type will not be disturbed or encountered during project works as construction or operational project activities may cross this area. Examples of these activities include haul roads and easements.

Additional investigations including survey, trial pitting and potentially geotechnical investigations will need to be undertaken prior to works commencing in this area.

3. General management measures

3.1.1 Design mitigation measures for erosion control

The *Soil conservation measures—Design manual for Queensland 2004* produced by DERM provides design requirements for the effective use of soil conservation strategies. Summaries of these requirements are outlined below, for further detail and technical requirements please refer to the abovementioned design manual.

Designing for risk

The design of an erosion control measure must take into account how often it is acceptable for the measure to be exceeded, resulting in an overflow or failure of the erosion control measure. The probability or risk of the failure of an erosion control strategy is calculated using a set of statistical measures. Acceptable levels of failure can be set and then the required design can be calculated. The Average Recurrence Interval (ARI) defines the average number of years between a rainfall or runoff event and an event of the same or greater volume.

It is generally accepted that erosion control measures should be designed to handle a rainfall or runoff event with an ARI of 10 years. Where a more conservative design is required a design should allow for an event of a greater ARI. Where public safety or safety of particular property is in question a more conservative design should be adopted.

Suitable measures will be undertaken during the detailed design stage to ensure the location of occupation and stock crossings do not lead to increased erosion risks resulting from concentrated runoff flows in association with access tracks. The relocation of crossings away from watercourses in areas of erosive soils will be undertaken where practicable.

Contour banks

Contour banks are designed to reduce the slope length that runoff flows along. Reducing the slope length reduces the likelihood of runoff reaching erosive velocities as it drains through the catchment.

There are four main types of contour banks:

- Narrow-based
- Broad-based
- Broad-based top side
- Broad-based bottom side

Different construction types are used depending on the equipment available for construction and the requirements of the contour bank and underlying soil.

Contour bank design should aim to keep flow velocities within the contour banks to below 0.6 m/s for erosion resistant soils and 0.4 m/s for more vulnerable soils.

The gradient used within a contour bank is important as the overland flow within the area should have a velocity that is not too high, creating erosion but also not too low, causing pooling and ineffective drainage. High gradients within a contour bank can lead to erosion within the contour bank area and high runoff velocities and volumes. Low gradients within a contour bank can lead to ineffective drainage and low areas that cause ponding until they fill with sediment. Low gradients can also lead to infiltration into groundwater which can result in a range of issues such as salinity.

The length of contour banks is largely dependent on the steepness of the underlying land. Natural drainage lines are closer together on steeper terrain restricting the length of contour banks.

Generally wider contour banks are preferred due to the smaller cost of construction per unit area and the ease of farm machinery operation. There are a number of factors that constrict the width of contour banks, such as greater level of erosion due to the larger area and the tendency for runoff to combine and form channels within the banks.

The effectiveness of a contour bank is greatly dependent on the type and roughness of the ground cover. Contour banks featuring dense vegetation are significantly more effective at retaining soil and preventing sediment runoff than bare or recently harvested crops.

The project corridor and alignment intersect a number of contour banks (listed in Table 2.8). These structures will need to be maintained/modified to ensure that current erosion control measures employed by property owners are maintained and continue to perform their function.

Diversion banks

Diversion banks are used to divert runoff and overland flow from cropping areas or structures and to channel it to a specific waterway or water body. Diversion banks are typically required to handle larger volumes of runoff than contour banks and should be designed for an ARI of 20 years. It is common for diversion banks to be used to collect runoff from contour banks and feed it to larger waterways or to prevent runoff from entering areas with unstable soils.

Waterways

It is important to note that the definition of waterways from *Soil conservation measures — Design manual for Queensland 2004* is not consistent with DERM's (formerly NRW) definition of a waterway. In this context it refers to a constructed drainage channel with higher capacity than a diversion bank.

The purpose of waterways is to collect runoff from contour banks and to move at non-erosive velocities to larger water systems such as creeks or rivers. Due to the increased size of the banks and the volume of runoff that waterways are required to provide for, waterways are typically designed for an ARI of 20 to 50 years. Waterway design must take into account the size of the catchment area feeding the waterway as well as other factors such as soil type, gradient, and ground cover. Waterways require good ground vegetation cover for safe and stable operation.

At the detailed design stage the location and function of the on-farm runoff control measures should be taken into account when designing associated stormwater drainage for the corridor and the adjacent lands.

Ensure that the corridor location and construction activities include consideration of adjacent on-farm infrastructure.

3.2 Construction erosion control and soil conservation

Objectives:

- Minimise land/water contamination
- Reduce incidence of erosion, sedimentation and pollution and contain eroded sediment and pollution material within the site
- Install erosion and sediment control devices, sediment basins and stormwater ponds during early works so these measures are available and effective prior to major disturbance events early
- No gross pollutants leaving the site during construction and operational phases
- Water quality discharging from site during construction should be within limits set by environmental authorities

Mitigation measures:

General

- Develop and implement measures in accordance with the *Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites 1996* to ensure that soil erosion does not accelerate as a result of the project

- Erosion and sediment controls shall be installed progressively during site preparation works and prior to any site disturbance for construction, vegetation clearance or services installation. Areas of identified high erosion potential shall be cordoned off and tracks and access roads shall be marked using star pickets, wire and marked with tape. Locations of haul routes and access tracks shall be marked on site plan and delineated on the ground with tape and flagging
- Development of an Erosion and Sediment Control Plan (ESCP) no later than 14 days prior to the commencement of construction related activities in a section of the site (eg earthworks, removal of stockpiled materials onsite. The ESCP shall be developed in accordance with the level of detail stipulated in the Erosion and Sediment Control Manual (Institute of Engineers 1996)
- Sediment fences shall be located along contours where possible with appropriate spacing's and returns where required. Sediment fence posts should have maximum spacing's of 2 m
- Sediment fences shall be inspected daily for UV degradation, effectiveness and capacity (maintained at greater than 60% capacity). Sediment fences shall not be removed until disturbed areas have been stabilised
- Uncontaminated sediment removed from erosion and sediment control devices shall be stockpiled and used in landscaping
- Ensure accurate reinstatement of soil profiles after disturbance where the disturbance is temporary in nature, particularly in areas of class A and B agricultural land (eg topsoil stripping or stockpiling)

Cut/fill areas

- Where batters are constructed or where surfaces are seeded for vegetation purposes, surfaces will be contoured and contour ripped utilising appropriate earthmoving/agricultural equipment and practices
- Strip and stockpile topsoil for progressive re-use during landscaping and stabilisation of the site and conservation area
- The site layout is to be designed with minimised slope, gradient and length to reduce erosion potential
- Sediment laden runoff discharging to watercourses shall be minimised, with all surface runoff directed through an erosion and sediment control device prior to discharge
- Significant earthworks shall occur in the dry season to prevent sediment runoff in rainy periods

Drainage works

- Erosive potential of surface runoff on disturbed areas shall be reduced through use of check dams, bunds and/or cut-off drains across the contour. This shall reduce the distance of overland flow and convey water to stable drainage lines at a non-erosive velocity as per relevant guidelines
- Where possible, undertake progressive stripping of topsoil immediately prior to drainage works
- Diversion drains shall be installed prior to significant land disturbance and around stockpile sites to divert surface runoff from undisturbed areas into stable drainage lines at non-erosive velocities
- If a greater than 2 year ARI storm event occurs before construction of new flow paths are complete, existing or alternative drainage paths shall be provided
- Retain vegetation in drainage lines until the latest possible time in order to reduce erosion risks and retain filtering capacity and where possible retain vegetation root mass permanently

Vehicle movement

- Access roads shall be clearly indicated through onsite signage and onsite drawings
- Restrict movement of vehicles to access tracks and designated haulage roads
- All vehicle exit points utilised by construction vehicles shall incorporate a stabilised entry/exit point with minimum length of 15 m, width of 3 m, and 50-70 mm crushed rock laid over geotextile with a minimum thickness of 150 mm
- No construction traffic allowed beyond the bounds of the construction site, except to utilise designated haulage routes and designated site entry and exit points. These

access points will be equipped with shakedown facilities to remove mud from wheels and bodies of haulage trucks and other equipment before they enter public roads (wheel wash facilities shall also be installed at major entry/exit point for the site)
- Establishment of restricted egress points from the site after rain events, as well as installation of rumble grids and/or set up of wheel wash down areas at egress points

Dust control
- Use water tanker trucks to suppress dust onsite during construction periods and at other times as necessary on public roads
- All truck loads will be lightly sprayed with water as required for potentially dusty materials. Vehicles transporting loads offsite will be covered in accordance with the appropriate requirements

Storage of material
- All construction fill and stored materials shall be situated in approved storage areas. These areas shall have cutoff and diversion drains to divert runoff, be located on flat land and away from drainage lines
- Slopes, including those within the area of the proposed development and those associated with the drainage line area shall be stabilised or grassed as soon as possible after reaching sub-grade level
- Storage of salinity prone soils shall be undertaken in a manner that prevents rainfall, runoff and overland flow from infiltrating through these soils causing degraded water quality

Revegetation
- Slopes, including those within the area of the proposed development and those associated with the drainage line area shall be stabilised or grassed as soon as possible after reaching sub-grade level
- Revegetation measures or stabilised surface on the exposed areas shall be established as soon as practicable

Spoil Management Measures
There are a number of adverse environmental impacts which may be associated with bulk spoil, contaminated spoil and spoil disposal. These impacts include:

Bulk Spoil
- May generate dust affecting localised waterways, air quality and dust sensitive crops
- Sediment runoff to waterways
- Excess spoil (too much for reuse)

Contaminated Spoil
- Reuse may cause harm to endemic plant species
- Movement of contamination to unaffected areas
- Impact to human health and ecosystem function

Spoil Disposal
- Potential for soil/spoil disposal to impact on/degrade the surrounding environment
- Algal blooms and a decrease in water quality associated with incorrect treatment of contaminated soil/spoil and waste material

To minimise any adverse impact associated with spoil management on the Project site a number of mitigation measures have been developed. These are summarised below.

Stockpiling and spoil
- Stockpiles will be developed in agreed locations in the proposed SDA identified as likely to pose minimal impacts on the environment away from bushland, floodplains and natural drainage areas
- Stockpiles will be placed in locations for relative ease of transportation when required
- Consistent watering will occur to prevent soil loss

- Removal of contaminated soils off-site will comply with the approval requirements for soil disposal permits and the spill response procedure in the event of a spillage
- Separate and mark/identify topsoil stockpiles from spoil stockpiles
- Imported materials shall be stockpiled away from topsoil and spoil materials to prevent stockpile mixing
- Bulk spoil stockpiles shall be covered at all times (ie establish grass coverage or hydromulching) to minimise stockpile loss and prevent sedimentation
- Topsoil stockpiles shall be covered at all times (ie establish grass coverage or hydromulching) to minimise stockpile loss and prevent sedimentation
- Ensure spoil consisting of sodic subsoils are disposed of carefully and not used where it will remain exposed
- Mixing of subsoil with topsoil for sodic soils should be avoided
- Sodic soils should not be used as topsoil
- Avoid locating spoil across slopes where overland flows may be diverted or concentrated

Permanent Stockpiling and spoil

As per stockpiling and spoil, in addition to:

- Permanent stockpiles shall be appropriately vegetated with hydro-mulch or another suitable type of vegetation cover

Contaminated land

- All fuels and chemicals used during the construction phase of the project would be stored in bunded facilities that prevent spills, leakage, or over topping of the facility. The facility should prevent any migration of fuels or chemicals to surface water bodies or the underlying groundwater.
- Construction vehicles would be maintained in accordance with the manufacturer's specifications and would be checked daily for leaks prior to the start of work.
- Construction areas would be regularly checked to confirm that construction equipment is not leaking fluids onto the ground surface. If there is evidence of a spill in the construction zone, the impacts would be contained and the impacted soil would be removed.

Contaminated spoil and management (if encountered)

- Storage of waste material will be in designated waste management areas. For the purpose of activities in a watercourse, stockpiles must be protected and located at least 50 m from the high banks of watercourses, lakes and wetlands
- Appropriate disposal permits for the disposal of contaminated soil from site will be obtained in accordance with Section 424 of the EP Act and retained on file
- Highly contaminated or leachable soils will be separated from less contaminated soils for the ease of treatment and transportation
- All contaminated material to be transported off site and disposed is documented with a disposal permit
- Monitor contaminated material handling periodically to ensure that heavily contaminated material is separated from less contaminated materials for disposal purposes

Monitoring

Site inspections are required in order to ensure that control structures and mitigation measures are effectively preventing environmental harm. The following inspections will occur throughout the construction period.

Daily or after heavy rainfall events

- Visual inspections of soils determined to be a high risk whilst works are occurring in these areas. Once works have been completed in the high risk area, and the area stabilised, monitoring can be reduced to weekly inspections
- An inspection of boundary erosion and sediment control measures
- An inspection of stormwater drainage facilities (after a heavy rainfall event)

- Rainfall depths/levels
- Visual inspection of construction activities in or close to soil areas identified as high risk
- Stormwater release points

Weekly

- Visual inspections of stockpiles for covers and structural development
- Monitoring of known locations of high risk soils
- Inspection of open excavations cutting into water table

Monthly

- Inspection of the maintenance of stockpiles for storing topsoil and excavation spoil. This would involve assessing height and structure and for the potential of sediment loss and sedimentation into waterways and an inspection of maintenance techniques and materials
- Inspections of stockpile locations for potential material mixing and maintenance

Event based

- An Inspection of soil 'hotspots' with a high potential for topsoil erosion or soil structure deterioration should occur before construction commences. This may involve soil sampling and testing. Continual monitoring of unstable locations will occur after the initial inspection

3.3 Operational erosion control and soil conservation

To minimise potential impacts during operation, the following mitigation measures will be implemented:

- Implementation of the EMP for operations
- Periodic maintenance on surface and subsurface drains will be required
- Periodic monitoring and maintenance of erosion prone, dispersive soils will be required in order to maintain stable surface soils, prevent accelerated erosion, remediate disturbed soils and protect vulnerable soils and sensitive areas in the receiving environment
- Vegetation on rail embankment slopes and permanent spoil storage locations/stockpiles shall be maintained to prevent slope face degradation. Revegetation of batters and surfaces through spraying of grass seed will assist in stability

Additional mitigation measures may need to be developed depending on the results of further soil investigations listed above.

4. References

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