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TOOWOOMBA RANGE RAILWAY

SITE INVESTIGATION AND REMEDIAL SLOPE DESIGN – CH 142.630 TO 142.810 KM

Submitted to:
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Report Number. 137632080-011-R-Rev0

REPORT

Golder Associates

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1.0 INTRODUCTION

At the request of Queensland Rail (QR) a geotechnical investigation and remedial slope design has been undertaken by Golder Associates (Golder) for the slope located below the rail line between approximate Chainage (Ch) 142.630 km and Ch 142.810 km on the Toowoomba Range Railway. The field investigation was completed between 18 February and 12 March 2015.

The work was completed as per the scope detailed in Golder Proposal 137632080-007-P-Rev0 (5 February 2014).

This report presents the findings of the geotechnical investigation and analysis, together with a proposed remedial slope design for tender purposes and recommendations for further work.

2.0 BACKGROUND

The slope below the rail line between Ch 142.630 km and Ch 142.810 km has been subject to instability since at least March 2011 and the slope was initially remediated at this time by QR. Further instability including rail line settlement and a landslip affecting the slope crest and mid-slope area between approximate Ch 142.700 km and Ch 142.725 km occurred in February 2013. Since that time this site has been studied including geotechnical and hydrological assessments, and a geophysical survey by Golder and monitoring by QR have been undertaken. Details of the work completed to date are presented in the following documents:

1) Golder Technical Memorandum – *Toowoomba Range Railway, Geotechnical Assessment, Slope between Ch 142.630 km and Ch 142.810 km* (reference 137632080-001-TM-Rev0, 6 September 2013).

2) Golder Technical Memorandum – *Toowoomba Range Railway, Geophysics Survey, Ch 142.630 km to Ch 142.810 km* (reference 137632080-003-TM-Rev0, 12 August 2013).

3) Golder Technical Memorandum – *Toowoomba Range Railway Scoping Study, Geotechnical Risk Assessment, Preliminary Findings and Recommendations* (reference 147632056-001-TM-Rev0, 9 July 2014).

4) Golder Report – *Toowoomba Range Railway Scoping Study, Hydrological Assessment* (reference 147632056-003-R-RevA, 9 July 2014).

5) Golder Technical Memorandum – *Toowoomba Range Railway, Geotechnical Certification of Temporary Access Tracks, Ch 142.7 km and Ch 144.7 km* (reference 137632080-010-TM-Rev0, 10 April 2015).

3.0 SITE DESCRIPTION

3.1 General

The site generally comprises the natural upslope area and downslope fill embankment, either side of the rail line and access road between approximate Ch 142.630 km and Ch 142.810 km. The rail line is inferred to be located on a combination of cut and fill along this section. The main focus in this section of railway is the landslip located along the edge of the access road between Ch 142.700 km and Ch 142.725 km.

The general site layout is shown in Figure 1 and the site is shown in Photographs 1 to 4.

Cross-sections showing topography, relevant surface features and ground conditions based on borehole drilling are presented on Drawings D001 and D002.

Further site details are provided in Document 1 referenced above in Section 2.0.

Access to the slope crest was provided by the existing access road located adjacent and parallel to the rail line. A temporary access track was constructed along an existing unused track to provide drill rig access to the slope toe area (for details refer to Document 5 referenced above in Section 2.0).

3.2 Existing Drainage

Three under-rail culverts are located within this site and the details as reported on the supplied QR database are summarised in Table 1.

Table 1: Summary of Under-Rail Culverts (Ch 142.630 – 142.810 km)

Chainage (km)	Culvert Type	Dimension	Length (m)
142.630	Corrugated metal pipe	600 mm diameter	10
142.680	Pre-cast concrete box culvert	900 mm × 600 mm	11
142.750	Corrugated metal pipe	450 mm diameter	10

Remediation of the slope between Ch 142.630 km and Ch 142.810 km will require replacement and possible upgrading of the under-rail culverts listed above.

4.0 METHOD OF INVESTIGATION

4.1 Subsurface Investigation

The subsurface investigation comprised drilling of four boreholes to depths of between 13.08 m and 14.61 m below ground level (bgl) using a track mounted Comacchio Geo 205 drill rig. Boreholes BH01 and BH03 were located adjacent to the rail line on the access road, and Boreholes BH02 and BH04 were located along the toe of the embankment. The boreholes were advanced using a combination of drilling methods including open hole augering, cased washboring, and limited NMLC diamond drill coring. *In situ* testing comprised Standard Penetration Tests (SPT) completed at typical depth intervals of 1.5 m. Boreholes were backfilled with cement grout (along slope crest) or drill cuttings (slope toe).

Additionally, seven Dynamic Cone Penetrometer (DCP) tests were completed along the upslope table drain to depths of between 0.3 m and 1.9 m bgl, to assess the consistency/density of shallow subsurface materials.

Test locations are shown on Figure 1.

All work within the railway corridor was carried out under the supervision of a QR appointed Protection Officer (PO).

Test locations were cleared for buried services by an independent subcontractor (CRLS) engaged by Golder.

Subsurface materials were logged by a geotechnical engineer from Golder in general accordance with AS1726-1993 *Geotechnical Site Investigations*.

A summary of subsurface conditions encountered is presented in Section 5.0, and Reports of boreholes, together with DCP test results are presented in **Appendix A**. Reference should also be made to the '*Explanation of notes, abbreviations & terms used on borehole and test pit reports*' presented in the same Appendix.

North Surveys Pty Ltd were engaged by Golder to survey borehole and DCP test locations, and key topographic features including slope crests and toes, to supplement the existing LiDAR survey data. Survey coordinates are relative to Australian Height Datum and Map Grid of Australia 1994.

4.2 Laboratory Testing

Laboratory testing was carried out on selected samples recovered from the boreholes and included:

- Natural moisture contents
- Atterberg limits
- Particle Size Distribution (PSD)
- Emerson Class Number (ECN)

Laboratory testing was carried out in accordance with AS1289-2000 *Methods of Testing Soils for Engineering Purposes* at Golder's NATA accredited laboratory in West End, Brisbane and the test reports are presented in **Appendix B**.

5.0 RESULTS OF INVESTIGATION

5.1 Subsurface Conditions

5.1.1 General

The subsurface conditions encountered at borehole locations generally comprised embankment fill overlying colluvium or residual soil, in turn overlying extremely weathered mudstone with some interbedded sandstone layers.

The presence of temporary platform fill was confined to boreholes located along the slope toe, and was associated with access tracks and work platforms constructed to provide temporary drill rig access.

The *in situ* materials encountered during the subsurface investigation correlate with published geological maps of the area, which indicate that the bedrock comprises Jurassic aged Koukandowie Formation consisting of lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale and minor coal.

A summary of the encountered subsurface conditions is presented in Table 2 and detailed borehole logs are presented in **Appendix A.**

Table 2: Summary of Ground Conditions (Ch 142.630 – 142.810 km)

Ground Profile and Material Description	Depth to Top (metres below ground level)			
	BH01	BH02	BH03	BH04
FILL – Sandy GRAVEL (Road-base) Fine to medium, grey and brown, fine to medium sand with some clay, medium dense to dense.	0.0	NE	0.0	NE
Temporary Platform FILL BH02: Sandy CLAY, low to medium plasticity, brown, fine to medium sand, moist, very soft. BH04: Silty SAND, fine to medium, orange and pale brown, moist, medium dense.	NE	0.0	NE	0.0
Embankment FILL – Sandy Clay Low to medium plasticity, brown, grey and orange, fine to medium sand, some gravel, moist, soft to firm typically grading stiff to very stiff with depth. BH01: between 1.4 – 3.8 m depth, a 2.4 m thick, very loose to loose, ash gravel layer was encountered.	0.3	1.6	0.2	NE
COLLUVIUM / SLOPEWASH Gravelly Sandy CLAY/Gravelly Clayey SAND, low to medium plasticity, brown, grey and orange, fine to medium sand, fine to medium gravel, moist, firm to stiff and very stiff to hard/medium dense to dense.	6.7	2.9	3.8	1.0
RESIDUAL SOIL BH01: Sandy Clayey GRAVEL, fine to medium, brown and pale grey, low plasticity clay, fine to medium sand, moist, dense; underlain by Silty SAND, fine to medium, pale grey, moist, dense. BH03: Silty CLAY, medium plasticity, brown and grey, dry, hard. BH04: Silty SAND, fine to medium, orange and pale brown, dry, medium dense.	9.2	NE	6.3	1.8
MUDSTONE – fine grained, brown and grey, extremely low to low strength, extremely weathered. Occasional decomposed zones up to 4.1 m thick comprising very stiff to hard clay. BH02: Sandstone layer 4 m thick between 8.2 – 12.2 m, fine to medium, orange and brown, extremely low to low strength, extremely weathered (completely decomposed to dense sand between 11.0 – 12.2 m).	10.8	8.2	8.2	4.2
Termination Depth	14.61	13.14	13.08	13.12
Groundwater Observations	N/O	N/O	N/O	N/O

Notes: NE – Not Encountered.
N/O – Groundwater not observed.

5.1.2 Embankment Fill

The embankment fill below the existing access road adjacent to the rail line typically comprised sandy clay and varied in thickness between 3.8 m (BH03) and 6.7 m (BH01), with SPT N values ranging between 1 and 15.

In Borehole BH01 at 1.4 m depth within the embankment fill, a 2.4 m thick very loose, ash gravel layer was encountered. Complete drill fluid loss was encountered in this material at a depth of 2.5 m. In the vertical failure scarp at the slope crest adjacent to Borehole BH01, observations indicate the presence of a gravelly clay and ash fill layer between 5.0 m and 6.5 m depth. The difference in depth to the top of the ash fill layer at these two locations (separated by a distance of approximately 15 m) highlights the discontinuous nature and random distribution of the ash fill material throughout the embankment fill.

At the slope toe in Borehole BH02 the embankment fill comprised silty clay and was 1.3 m thick (SPT N of 13), and was overlain by 1.6 m thickness of temporary platform fill. Embankment fill was not encountered at the slope toe in Borehole BH04.

A total of seven DCP tests were completed along the upslope table drain opposite Boreholes BH01 and BH03. The value of blow counts was typically less than or equal to 20 per 300 mm prior to refusal which is inferred to generally correlate with SPT N values observed in the embankment fill. DCP refusal was observed between depths of 0.3 m and 1.9 m bgl, with the refusal depth increasing in a general westerly direction.

The results of the borehole drilling generally indicate that the thickness of embankment fill and depth to *in situ* material decrease in a north-easterly direction along the railway corridor from the landslip zone, which correlates with the DCP test results.

5.1.3 Colluvium and Slope Wash

Colluvium was encountered in three boreholes underlying the embankment fill (BH01, BH02 and BH03) and typically comprised very stiff to hard, gravelly sandy clay and medium dense to dense gravelly clayey sand, between 2.5 m and 5.5 m thick. SPT N values in the colluvium varied between 23 and 37.

A layer of surficial slope wash, 0.8 m thick and comprising firm to stiff, sandy clay was encountered in Borehole BH04 (underlying temporary platform fill). An SPT N value of 8 was recorded in this material.

5.1.4 Residual Soil

Residual soil was encountered in three boreholes underlying colluvium or slope wash (BH01, BH03 and BH04), with a variable composition including medium dense to very dense silty sand, dense sandy clayey gravel and hard silty clay, between 1.6 m and 2.4 m thick. SPT N values in the residual soil varied between 16 and 47.

5.1.5 Bedrock

The depth to *in situ* weathered rock, which is likely to form the foundation for the slope remediation, varied between 8.2 m and 10.8 m bgl adjacent to the railway, and between 4.2 m and 8.2 m bgl along the slope toe.

The weathered rock typically comprised extremely low to low strength, extremely weathered mudstone. In Borehole BH02 an interbedded layer of 4 m thick, extremely low to low strength, extremely weathered sandstone was encountered.

Decomposed zones were observed within the bedrock at the following borehole locations: BH02/11.0 – 12.2 m (completely weathered sandstone comprising medium dense to dense clayey sand), and BH04/5.5 – 9.6 m (completely weathered mudstone comprising very stiff to hard sandy clay).

Construction of a temporary fill platform was required for drill rig access to progress Borehole BH04 and this required excavation of a 3 m high cut batter. The batter exposed *in situ,* extremely to distinctly weathered mudstone, with some interbedded sandstone layers up to 0.3 m thick. The rock bedding was measured as dipping less than or equal to 5° below horizontal in a general westerly direction. Two sets of sub-vertical jointing were observed, both dipping greater than or equal to 80° below horizontal in approximate north-north-westerly and north-easterly directions.

5.1.6 Groundwater Observations and Drill Fluid Loss

Groundwater observations were not possible in the boreholes (whether it was present or not) due to the addition of water into the borehole during the drilling process. However, it is possible that groundwater is present, or may be present in the future, in the materials underlying the railway corridor (particularly after heavy or prolonged rainfall). It should be noted that the ground investigation was completed during the months of February and March after a relatively wet summer.

Drill fluid loss, indicating the likely presence of permeable and relatively lower density/poorer quality materials, was observed at the following borehole locations: BH01/2.5 m in ash gravel fill, BH02/11.2 m in a decomposed sandstone layer, and BH04/4.8 m and 11.5 m in extremely weathered mudstone.

5.2 Previous Geophysics Survey

The results of the geophysics survey completed in June 2013 were reported in Document 2 referenced above in Section 2.0. The geophysics factual data has been reproduced and borehole data has been overlayed onto this to show a general comparison between energy wave velocities, and material types and strengths (refer Figures 2 and 3).

This comparison highlights the good correlation between wave velocity and material strength (as indicated by SPT N values) for the surface fill and underlying natural soils (and this boundary is approximated by the bottom of the blue shading shown in Figures 2 and 3).

The results also show that the contrast in wave velocity between the natural soils and underlying bedrock is typically indistinct, and the reason for this is likely to be related to the typically weathered and weakened nature of the top layers of bedrock.

Although the change in material strength (as indicated by SPT N values) is variable between the natural soils and underlying bedrock, the results generally indicate increasing strength with increasing depth.

The borehole data confirms earlier conclusions made on the basis of the geophysics alone, that the thickness of surface fill decreases in north-easterly and south-westerly directions moving away from the landslip zone along the railway corridor.

5.3 Laboratory Test Results

The laboratory test results are summarised in Table 3 below.

The results indicate that the tested materials include medium plasticity clay and low liquid limit silts. Emerson class numbers of 5 and 6 were recorded, indicating that the tested soils are generally non-dispersive.

Table 3: Summary of Laboratory Test Results (Ch 142.630 – 142.810 km)

BH ID	Sample Depth		Moisture Content (%)	Atterberg Limits			Particle Size Distribution			Emerson Class Number
	From (m)	To (m)		Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Gravel (%)	Sand (%)	Fines (%)	
BH01	10.0	10.45	18.7	-	-	-	0	74	26	-
BH01	7.0	7.45	-	-	-	-	-	-	-	6
BH02	4.0	4.45	25.7	43	8	7.5	-	-	-	6
BH02	5.5	5.95	18.9	-	-	-	13	39	48	-
BH03	2.5	2.95	32.2	-	-	-	0	98	2	6
BH03	7.0	7.45	22.4	-	-	-	-	-	-	6
BH04	2.5	2.95	8.3	-	-	-	1	67	32	5
BH04	5.5	5.95	14.0	47	26	13	-	-	-	6
BH04	11.5	11.95	-	-	-	-	-	-	-	6

6.0 SLOPE STABILITY ASSESSMENT

6.1 General

Observations made on the Toowoomba Range Railway by Golder since 2011 indicate that poor or inadequately maintained surface water drainage, and/or an increase in pore water pressures in the embankment fill are key contributing factors to slope instability. Other factors contributing to slope instability are considered to include the following:

- Inadequately prepared foundation along the slope toe.
- Lack of restraining force or shear key along the slope toe.
- Lack of adequately benched and drained slope core.

Slope stability analysis was undertaken using the Morgenstern-Price limit equilibrium method and the computer program SLOPE/W (GEO-SLOPE, 2012). Several cases were analysed including a back analysis to assess the likely conditions present at the time of failure, and the proposed remedial design to verify its adequacy.

The material type and strength properties adopted for the stability analyses are summarised in Table 4. These are based on the ground conditions revealed in the investigation boreholes, laboratory test results and previous experience of slope behaviour in this region.

Table 4: Adopted Geotechnical Parameters for Slope Stability Analysis

Material	Unit Weight γ (kN/m^3)	Cohesion c' (kPa)	Friction Angle ϕ' (degrees)
Embankment Fill	18	2	26
Colluvium	18	5	30
Residual Soil	18	5	30
Extremely Weathered Rock	22	25	30
Rock Fill	20	0	40

6.2 Back Analysis

A back analysis was undertaken to model the inferred slope condition at the time of failure between approximate Ch 142.700 km and Ch 142.725 km, and this was based on the following assumptions:

- Material properties summarised in Table 4.
- Slope angle of 27° below horizontal.
- Slope height of approximately 20 m.
- Groundwater conditions:
  - Dry.
  - Wet, with a Pore Water Pressure Ratio (Ru) of 0.15 and 0.2.

The results of the slope stability analysis including the adopted geological model and critical failure surface are presented on Figures C-1 and C-2 in **Appendix C**.

The back analysis results indicate that the slope was likely to be marginally stable in dry conditions with a Factor of Safety (FoS) of 1.1 obtained. In wet conditions, with an Ru of 0.2 in the embankment fill and underlying colluvium and residual soil, a FoS of less than unity was obtained (0.9). This critical failure surface is located within the embankment fill and the results support the hypothesis that slope failure was probably triggered by the infiltration of surface water into the embankment fill combined with poor drainage.

7.0 PROPOSED REMEDIAL SLOPE DESIGN

7.1 General Approach

The following general approach is proposed for slope remediation at the Ch 142.7 km site:

- Excavation and removal of fill, colluvium and residual soil to expose the underlying *in situ* weathered rock at the slope toe and across the slope.
- Excavation of a shear key trench in the *in situ* weathered rock at the slope toe to provide the foundation and lateral restraint for the new construction.
- Preparation of a temporary benched cut in the *in situ* weathered rock across the slope to provide the base for the new construction.
- Reconstruction of the slope to a 1V:1.5H batter using select rock fill and assuming that the existing slope crest position is to be maintained. This proposed solution has the benefit of being relatively easy to construct with conventional earth moving equipment, and results in a free-draining slope which reduces the risk of pore water pressure build up and the potential instability associated with this condition.

Details of the proposed remedial design, suitable to inform the tender process, are presented in Drawings D001 and D002.

7.2 Design Assumptions and Verification

The global stability of slopes is typically defined by a FoS of 1.3 for the temporary condition, and a FoS of 1.5 for the permanent condition and this general approach was adopted for the remedial slope design.

In addition to constraints imposed by material types and geometry, the proposed remedial design also considered the following surcharge loads:

- 12 kPa attributable to railway ballast, sleepers and track.
- 80 kPa for train loading (worst case, e.g. train parking on slope).
- 10 kPa on the access road.

Slope stability analysis was undertaken to verify the proposed remedial design and a summary of the results is presented in Table 5.

Further details of the slope stability analysis including the adopted geological model and critical failure surface are presented on Figures C-3 and C-4 in **Appendix C**.

Table 5: Summary of Slope Stability Analysis (Ch 142.630 - 142.810 km)

Batter Angle[1]	Slope Height (m)	Mid-Slope Bench (4 m width)	Surcharge Loading[2] (kPa)	Rockfill Properties[3]	Groundwater Conditions	Factor of Safety
35°	23.6	No	92	c'=0, ϕ'=40°	Dry	1.21
35°	23.6	No	92	c'=5, ϕ'=40°	Dry	1.44
35°	23.6	Yes	92	c'=0, ϕ'=40°	Dry	1.36
					Wet[4], Ru = 0.15	1.36
35°	23.6	Yes	92	c'=2, ϕ'=40°	Dry	1.48
					Wet[4], Ru = 0.15	1.48

Notes: 1 – Approximately equivalent to 1V:1.5H (34°).
2 – Worst case: 12 kPa for railway ballast, sleepers and track; and 80 kPa for train loading.
3 – c' is cohesion in kPa, ϕ' is friction angle.
4 – Pore water pressure ratio in colluvium and residual soil.

For the proposed batter angle, slope height and surcharge loads summarised in Table 5 the slope stability results indicate that it is unlikely that a FoS of 1.5 could be achieved for a new slope comprising one continuous batter (without inclusion of a mid-slope bench). For this scenario a FoS of 1.21 was obtained for a dry condition, and a sensitivity analysis revealed that a FoS of 1.44 could be achieved only by increasing the cohesion of the rockfill to 5 kPa. A cohesion value of 5 kPa is considered too high and unrealistic for rock fill material.

With the introduction of a 4 m wide mid-slope bench the results indicate that a FoS of 1.36 could be achieved for a dry condition by modelling the rockfill with zero cohesion and a friction angle of 40°. Subsequently by modelling the rockfill with a small cohesion value of 2 kPa to simulate the interlocking and self-supporting nature of coarse rockfill, a FoS of 1.48 was obtained. This is considered to be a realistic simulation of what could be achieved using coarse rockfill to re-construct the slope utilising a mid-slope bench.

The stability of the slope model incorporating the mid-slope bench was also checked for a wet condition in the underlying colluvium and residual soil (Ru of 0.15) however this had no adverse effect on the FoS. This result was anticipated on the basis that the rockfill is free draining, and any lateral load exerted by the colluvium and residual soil is adequately resisted by the coarse interlocked rockfill.

In the circumstances (existing earthworks on steep ground) a safety factor of 1.48 for dry conditions is considered satisfactory.

8.0 ENGINEERING COMMENTS AND RECOMMENDATIONS

8.1 Proposed Slope Remediation

It is anticipated that slope remediation at the Ch 142.7 km site will require reconstruction of the slope across an approximate width of 100 m, with the slope height varying between approximately 15 m and 25 m. The full extent of the proposed remediation can only be accurately defined at the time of re-construction following the removal of fill and other unsuitable material.

Reconstruction of the slope to a 1V:1.5H batter is proposed using select coarse rock fill (< 500 mm size) and assuming that the existing slope crest position is to be maintained. This proposed solution has the benefit of being relatively easy to construct with conventional earth moving equipment, and results in a free-draining slope which reduces the risk of pore water pressure build up and the potential instability associated with this condition.

The remedial slope design incorporates a 4 m wide mid-slope bench to be included 10 m below the slope crest where the total slope height exceeds 20 m. The requirement for inclusion of the mid-slope bench will be a function of existing topography and the adopted foundation level across the slope, and therefore will need to be transitioned accordingly. It is generally anticipated that a mid-slope bench will be required in the central part of the proposed new slope (at and adjacent to the existing landslip). However the requirement for a mid-slope bench will be less likely as the eastern and western edges of the new slope are approached (as weathered rock is anticipated at a relatively shallow depth and the new slope height will be less).

Further details are presented in Section 7.1 and Drawings D001 and D002.

Temporary removal of the existing rail line and replacement of a new capping layer and rail line will be required as part of the proposed slope remediation.

The existing slope is densely vegetated by mature trees and these would need to be removed to facilitate the slope remediation.

It is likely that the reconstructed slope toe will impact on the neighbouring privately owned land located south of the railway corridor. It is recommended that QR accurately establish the position of the site boundary so that this can be considered during the next stages of design and construction.

8.2 QR Specifications

Reference should be made to the QR specifications and drawings listed on Drawings D001 and D002 in this report, which provide direction on foundation excavation, earthworks and construction of railway embankments and slopes.

8.3 General Excavatability

Excavation of the existing fill, colluvium, residual soils and extremely low to very low strength, extremely weathered mudstone and sandstone is anticipated to be achievable utilising medium to large excavators (e.g. ≥ 20 tonne) and medium size dozers (e.g. Caterpillar D6). Excavation of low strength or stronger rock may require larger plant or specialised rock excavation equipment such as a ripper (rock pick) or pneumatic rock breaking attachments.

It should be noted that stratigraphic boundaries are likely to vary in both vertical and lateral directions across the slope, particularly the base of fill and top of weathered rock. Additionally the composition of the fill is likely to be variable and include soil, rock and ash.

8.4 Foundation Preparation and Trafficability

The foundation materials exposed after site stripping and bulk excavation could be subject to strength loss if they become wet. Due to the potential for poor trafficability across parts of the site during wet weather, site stripping should be scheduled to occur during periods of dry weather and shortly before the commencement of fill placement. Placement of a granular working platform may be required to maintain trafficability in heavily trafficked areas particularly during wet weather.

The site should be graded to shed surface water runoff away from the construction area.

It is recommended that foundation areas and temporary cuts be assessed by a qualified geotechnical engineer during the construction phase and prior to placement of rockfill.

8.5 Groundwater in Excavations

Groundwater observations were not possible in the boreholes (whether it was present or not) due to the addition of water into the borehole during the drilling process. However, it is possible that groundwater is present, or may be present in the future, in the materials underlying the railway corridor (particularly after heavy or prolonged rainfall). It should be noted that the ground investigation was completed during the months of February and March after a relatively wet summer.

In excavations where groundwater is encountered softening of exposed soil and weathered rock is likely, and excavation sidewalls may be unstable (especially in gravelly/sandy materials). At locations where groundwater is encountered in excavations, it should be directed away from the construction area or towards excavated sumps from which the collected water can be pumped away.

8.6 Site Drainage

8.6.1 General

The re-instatement and possible upgrading of existing drains is considered crucial to the successful remediation of the slope at the Ch 142.7 km site. Drains include longitudinal table drains running along the upslope side of the rail line, and under-rail culverts which divert surface water from the upslope to downslope sides of the rail line.

It is recommended that regular inspection and maintenance of all drainage infrastructure be undertaken as this is an important part of managing the risk of slope instability.

The proposed remedial design incorporates drainage measures within the slope core to reduce the likelihood of pore water pressure build-up or foundation softening. Control measures include grading all benches and excavations within the slope core, and inclusion of agricultural drains, to divert any surface water that infiltrates through the rockfill away from the slope.

8.6.2 Table Drains

Cleaning out and regrading of existing table drains either side of the proposed slope remediation will be required as part of this work. Additionally it is recommended that the reinstated table drain to be located at the top of the new slope is lined to reduce the likelihood of surface water being inadvertently diverted into the newly constructed slope core through the rockfill. It is considered that this could best be achieved by constructing a concrete lined table drain at this location.

8.6.3 Under-Rail Culverts

Existing under-rail culverts at Ch 142.63 km, 142.68 km and 142.75 km will require replacement and possible upgrading. These culverts are the subject of a separate study to confirm their capacity, suitability and scour potential.

It is recommended that discharge from culvert outlets be directed away from slopes (including the toe area). For example, this could be achieved by the use of plastic hose extensions on culvert outlets or by constructing concrete lined channels down slopes. In the case of rockfill slopes it is particularly important to ensure that water is not directed onto the slope where it can infiltrate into the slope core and cause possible softening of foundation materials.

9.0 LIMITATIONS

Your attention is drawn to the document “Limitations” presented in **Appendix D**. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder

Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

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PHOTOGRAPHS

Photograph 1: View south-west along the railway corridor at Ch 142.7 km showing the landslip failure scarp (dashed yellow line), access road and rail line.

Photograph 2: View north (from location of Borehole BH02) showing landslip between approximate Ch 142.700 km and Ch 142.725 km with 7 m vertical failure scarp visible at slope crest adjacent to the access road.

Photograph 3: View south-west showing the slope toe area, temporary access track and drilling at Borehole BH04.

Photograph 4: View north-east showing the temporary access track at the location of Borehole BH04 and *in situ* extremely to distinctly weathered mudstone with interbedded sandstone layers exposed in the upslope cutting.

FIGURES

TOOWOOMBA RANGE RAILWAY GEOTECHNICAL ASSESSMENT AND SLOPE REMEDIATION

QUEENSLAND RAIL LIMITED

SITE PLAN - CH 142.7 KM

LEGEND

- Borehole (March 2015)
- Dynamic Cone Penetrometer (March 2015)
- Geophysics Survey (August 2013)
- Geophysics Survey Point (August 2013)
- Approximate Chainage
- Under Rail Culvert
- Section Line
- Linear Topographic Survey
- Contour - 2m Interval

GEOLOGY

- Tm / TERTIARY / Olivine basalt
- Jbmk / JURASSIC / Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker

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1. Imagery copyright Nearmap.
2. Inset Map Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
3. Topographic Contours derived from LiDAR provided by QLD Government, Department of Natural Resouces and Mines.
4. Geology sourced from QLD Government, Department of Natural Resouces and Mines.

0 5 10 20 30 40 50 metres

SCALE (at A3) 1:1,000

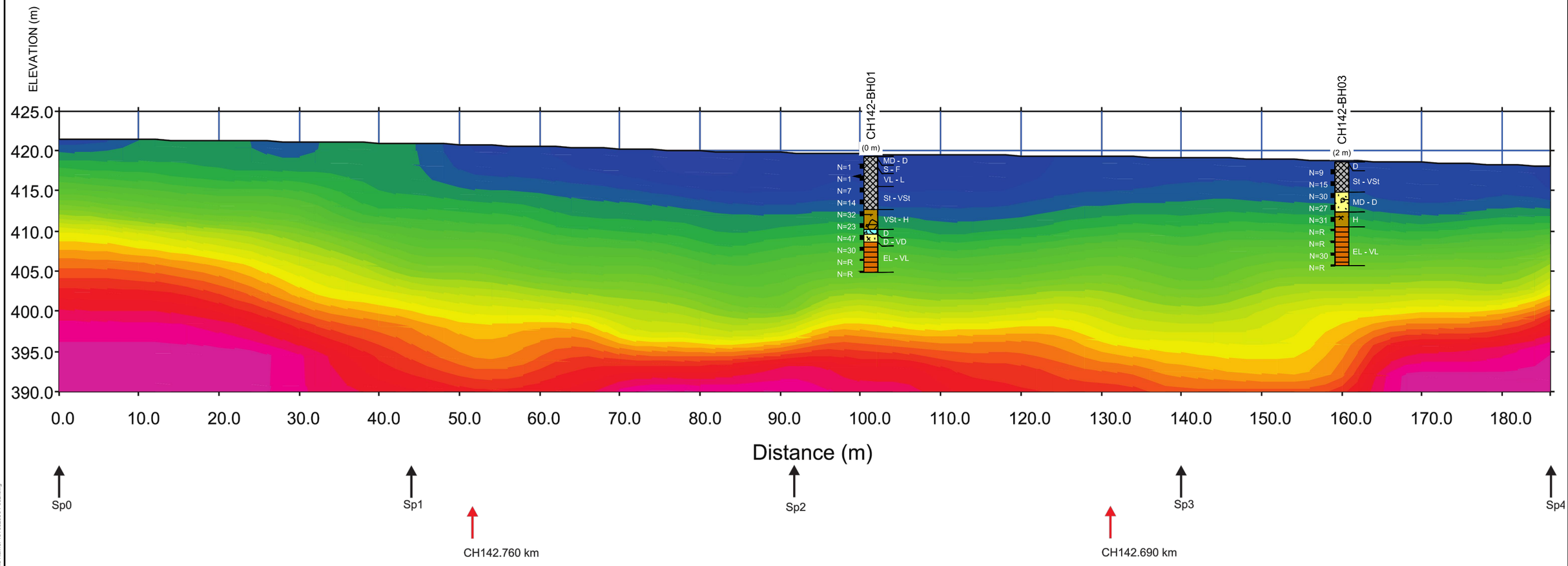
DATUM GDA 94, PROJECTION MGA Zone 56

PROJECT: 137632080-011
DATE: 22 APR 2015
DRAWN: SL
CHECKED: GR

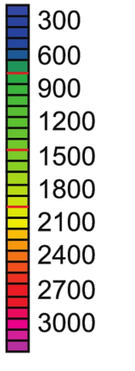
FIGURE 1

Golder Associates

File Location: R:\01 Client\Queensland Rail\137632080\Programs\ArcGIS\137632080-011-D-Rev0-F001-142-7.mxd



P-wave velocity



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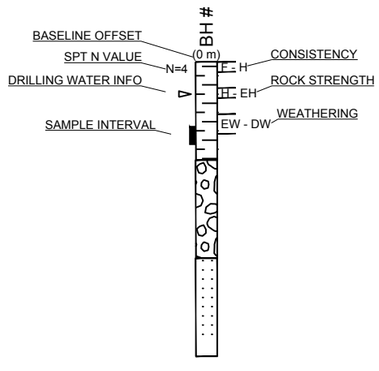

MATERIAL GRAPHIC

- FILL
- GRAVELLY SANDY CLAY (COLLUVIUM)
- GRAVELLY CLAYEY SAND (COLLUVIUM)
- SANDY CLAYEY GRAVEL (RESIDUAL SOIL)
- SILTY SAND (RESIDUAL SOIL)
- SILTY CLAY (RESIDUAL SOIL)
- MUDSTONE

H & V 1:500

0 5 10 15 20 25m

Coord.System: MGA94 Zone 56 Height Datum: AHD

CLIENT
QUEENSLAND RAIL LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-04-30
DESIGNED	SCF
PREPARED	MPB
REVIEWED	GR
APPROVED	DCS

PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
GEOPHYSICS SURVEY CH 142.630 - 142.810 km
SEISMIC REFRACTION FACTUAL DATA, WITH OVERLAYED BOREHOLE DATA

PROJECT NO.	CONTROL	REV.	FIGURE
137632080	011	0	F002

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

0 25 mm

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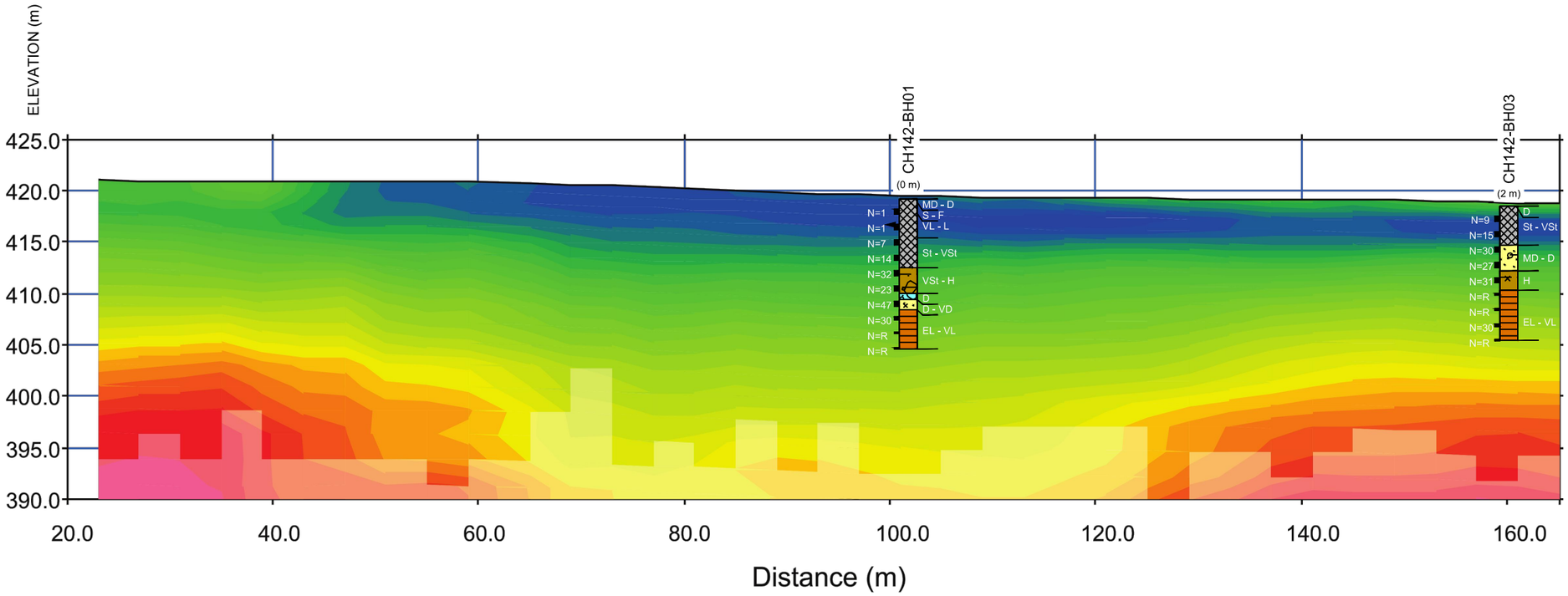
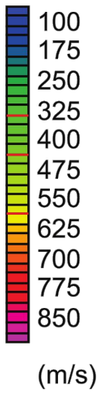


S-wave velocity



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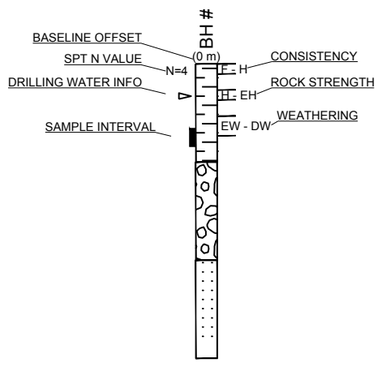
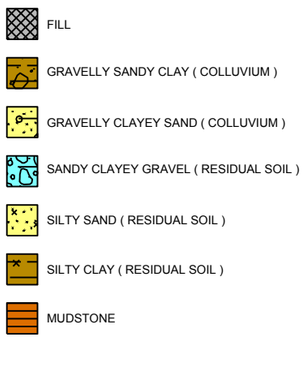


MATERIAL GRAPHIC



H & V 1:500

0 5 10 15 20 25m

Coord.System: MGA94 Zone 56 Height Datum: AHD

CLIENT
QUEENSLAND RAIL LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-04-30
DESIGNED	SCF
PREPARED	MPB
REVIEWED	GR
APPROVED	DCS

PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
GEOPHYSICS SURVEY CH 142.630 - 142.810 km
MASW FACTUAL DATA, WITH OVERLAYED BOREHOLE DATA

PROJECT NO.	CONTROL	REV.	FIGURE
137632080	011	0	F003

25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

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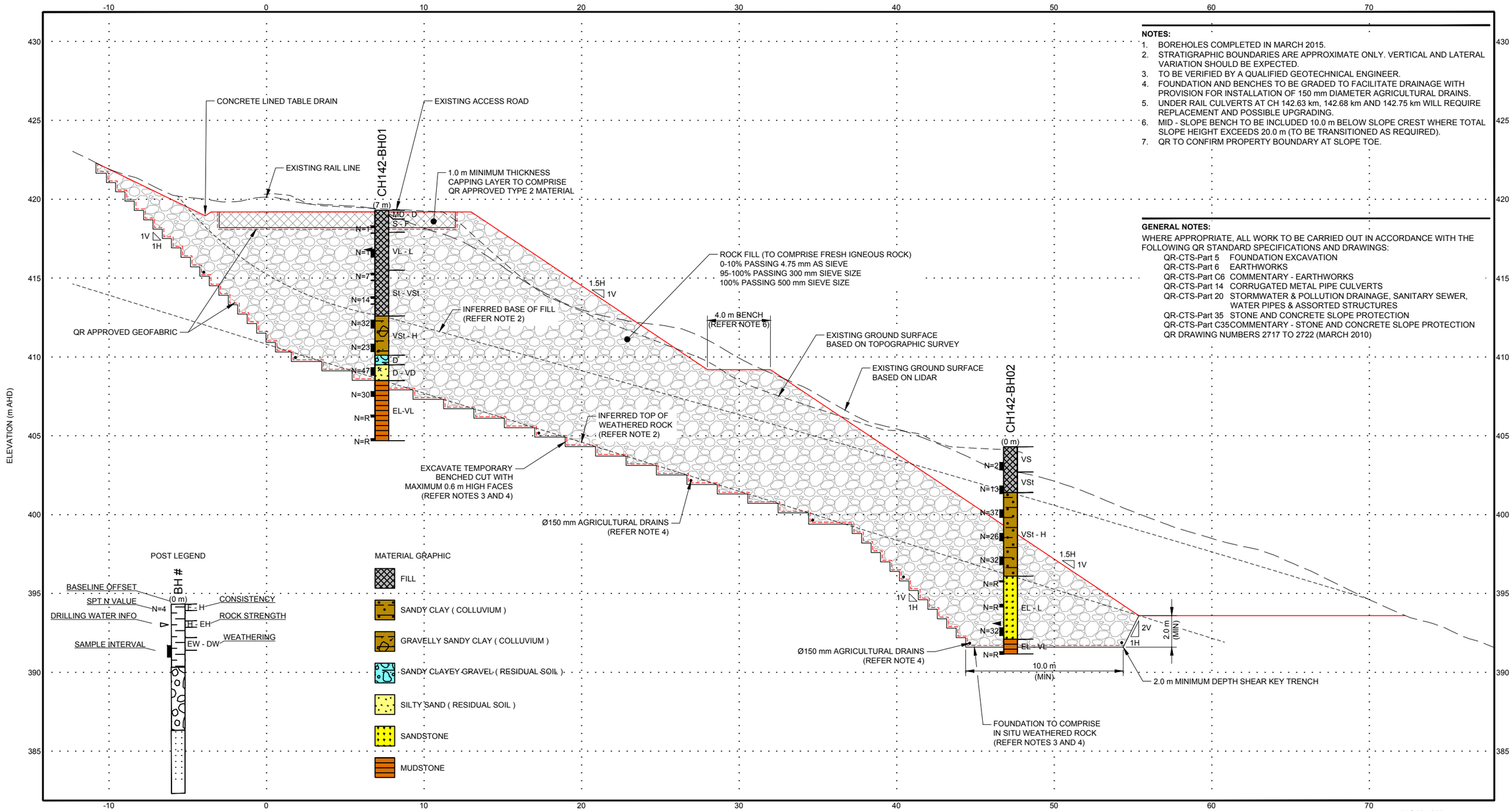
DRAWINGS



NOTES:

1. BOREHOLES COMPLETED IN MARCH 2015.
2. STRATIGRAPHIC BOUNDARIES ARE APPROXIMATE ONLY. VERTICAL AND LATERAL VARIATION SHOULD BE EXPECTED.
3. TO BE VERIFIED BY A QUALIFIED GEOTECHNICAL ENGINEER.
4. FOUNDATION AND BENCHES TO BE GRADED TO FACILITATE DRAINAGE WITH PROVISION FOR INSTALLATION OF 150 mm DIAMETER AGRICULTURAL DRAINS.
5. UNDER RAIL CULVERTS AT CH 142.63 km, 142.68 km AND 142.75 km WILL REQUIRE REPLACEMENT AND POSSIBLE UPGRADING.
6. MID - SLOPE BENCH TO BE INCLUDED 10.0 m BELOW SLOPE CREST WHERE TOTAL SLOPE HEIGHT EXCEEDS 20.0 m (TO BE TRANSITIONED AS REQUIRED).
7. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.

GENERAL NOTES:

WHERE APPROPRIATE, ALL WORK TO BE CARRIED OUT IN ACCORDANCE WITH THE FOLLOWING QR STANDARD SPECIFICATIONS AND DRAWINGS:

QR-CTS-Part 5	FOUNDATION EXCAVATION
QR-CTS-Part 6	EARTHWORKS
QR-CTS-Part C6	COMMENTARY - EARTHWORKS
QR-CTS-Part 14	CORRUGATED METAL PIPE CULVERTS
QR-CTS-Part 20	STORMWATER & POLLUTION DRAINAGE, SANITARY SEWER, WATER PIPES & ASSORTED STRUCTURES
QR-CTS-Part 35	STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35	COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION
QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)	

H & V 1:250

0 2 4 6 8 10m

Coord.System: MGA94 Zone 56 Height Datum: AHD

NOT FOR CONSTRUCTION - ISSUED FOR

TENDER

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2015-04-30	ISSUED FOR TENDER	SCF	MPB	GR	DCS

CLIENT
QUEENSLAND RAIL LIMITED

CONSULTANT
Golder Associates

BRISBANE OFFICE
147 CORONATION DRIVE
MILTON, QLD 4064
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[+61] (7) 3721 5400
www.golder.com

PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH 142.630 TO CH 142.810 km
SECTION AA

PROJECT NO.	CONTROL	REV.	of	DRAWING
137632080	011	0		D001

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

0

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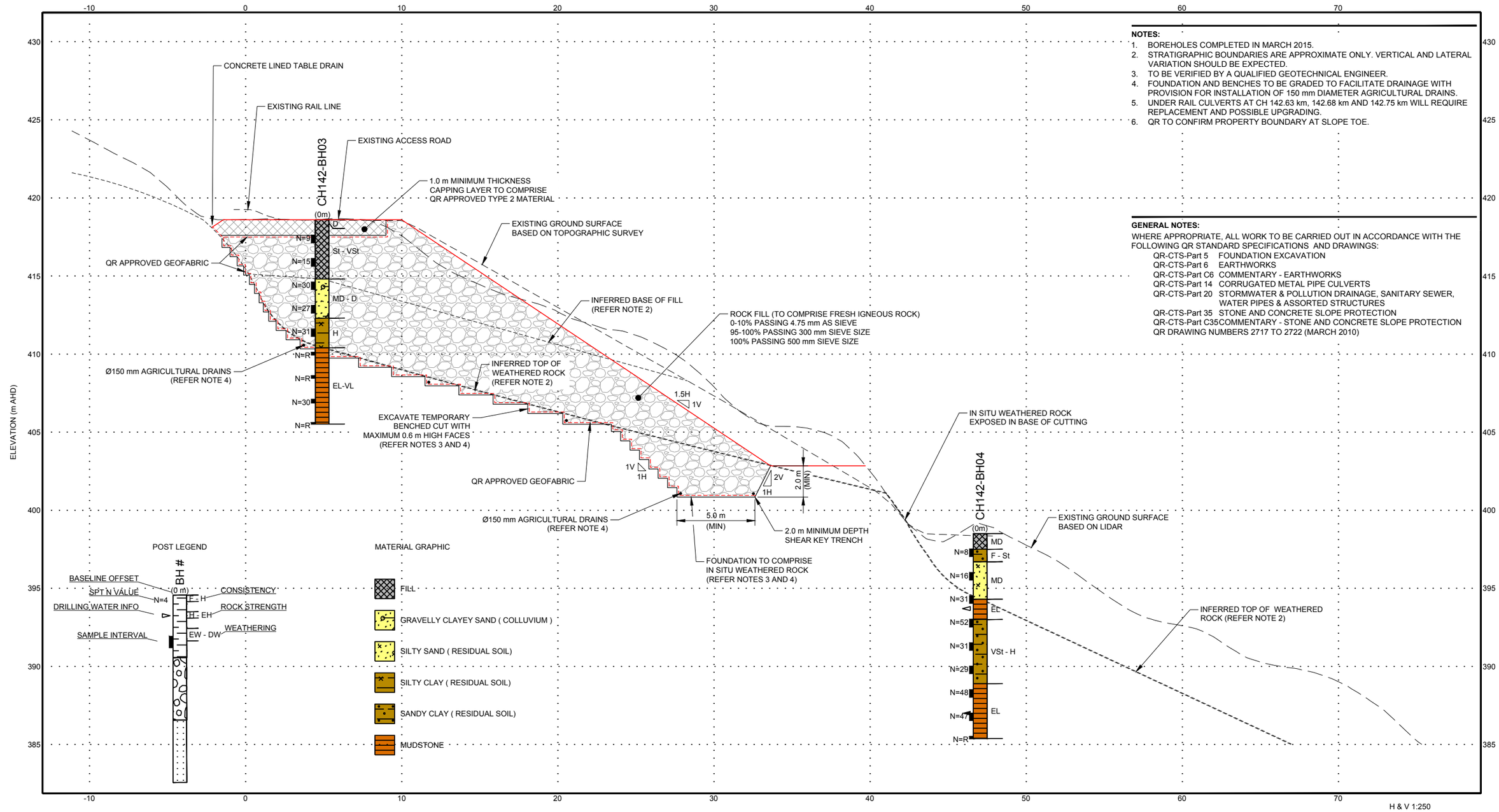

NOTES:

1. BOREHOLES COMPLETED IN MARCH 2015.
2. STRATIGRAPHIC BOUNDARIES ARE APPROXIMATE ONLY. VERTICAL AND LATERAL VARIATION SHOULD BE EXPECTED.
3. TO BE VERIFIED BY A QUALIFIED GEOTECHNICAL ENGINEER.
4. FOUNDATION AND BENCHES TO BE GRADED TO FACILITATE DRAINAGE WITH PROVISION FOR INSTALLATION OF 150 mm DIAMETER AGRICULTURAL DRAINS.
5. UNDER RAIL CULVERTS AT CH 142.63 km, 142.68 km AND 142.75 km WILL REQUIRE REPLACEMENT AND POSSIBLE UPGRADING.
6. QR TO CONFIRM PROPERTY BOUNDARY AT SLOPE TOE.

GENERAL NOTES:

WHERE APPROPRIATE, ALL WORK TO BE CARRIED OUT IN ACCORDANCE WITH THE FOLLOWING QR STANDARD SPECIFICATIONS AND DRAWINGS:

QR-CTS-Part 5	FOUNDATION EXCAVATION
QR-CTS-Part 6	EARTHWORKS
QR-CTS-Part C6	COMMENTARY - EARTHWORKS
QR-CTS-Part 14	CORRUGATED METAL PIPE CULVERTS
QR-CTS-Part 20	STORMWATER & POLLUTION DRAINAGE, SANITARY SEWER, WATER PIPES & ASSORTED STRUCTURES
QR-CTS-Part 35	STONE AND CONCRETE SLOPE PROTECTION
QR-CTS-Part C35	COMMENTARY - STONE AND CONCRETE SLOPE PROTECTION
QR DRAWING NUMBERS 2717 TO 2722 (MARCH 2010)	

NOT FOR CONSTRUCTION - ISSUED FOR

TENDER

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2015-04-30	ISSUED FOR TENDER	SCF	MPB	GR	DCS

CLIENT
QUEENSLAND RAIL LIMITED

CONSULTANT
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147 CORONATION DRIVE
MILTON, QLD 4064
AUSTRALIA
[+61] (7) 3721 5400
www.golder.com

PROJECT
TOOWOOMBA RANGE RAILWAY
REMEDIAL SLOPE DESIGN

TITLE
CH 142.630 TO CH 142.810 km
SECTION BB

PROJECT NO.	CONTROL	REV.	of	DRAWING
137632080	011	0		D002

APPENDIX A

Report of Boreholes and DCPT Results

REPORT OF BOREHOLE: CH142-BH01

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401049.0 m E 6961992.0 m N MGA94 56
SURFACE RL: 419.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.61 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 11/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	419.30				GW	FILL: Sandy GRAVEL fine to medium grained, grey, fine to medium sand	D - M	MD - D	Road-base
				0.30								
				419.00				CI	FILL: Sandy CLAY medium plasticity, brown and orange, fine to medium sand	M	S - F	Embankment fill
			1		CH142-BH01-001 SPT 1.00-1.45 m 1, 1 N=1							
				1.40								
				417.90				GP	FILL: Ash dark grey, granular, fine gravel sized, less than 10 mm			
			2									
RD		◀			CH142-BH01-002 SPT 2.50-2.95 m 0, 1 N=1					D	VL - L	Complete drill fluid loss at 2.5 m depth
			3									
				3.80								
				415.50				CL	FILL: Sandy CLAY low plasticity, brown and orange, fine to medium sand, with some fine to medium gravel			
			4		CH142-BH01-003 SPT 4.00-4.45 m 1, 1, 6 N=7							
			5							M	St - VSt	
					CH142-BH01-004 SPT 5.50-5.95 m 5, 7, 7 N=14							
			6									
				6.70								
				412.60				CL-CI	Gravelly Sandy CLAY low to medium plasticity, brown, fine to medium sand, fine to medium gravel			Colluvium
			7		CH142-BH01-005 SPT 7.00-7.45 m 5, 14, 18 N=32							
			8							M	VSt - H	
					CH142-BH01-006 SPT 8.50-8.95 m 4, 8, 15 N=23							
			9									
				9.20								
				410.10				GC	Sandy Clayey GRAVEL fine to medium grained, rounded to sub-rounded, quartz and lithic, brown and pale grey, low plasticity clay, fine to medium sand	M	D	Residual Soil (Decomposed Conglomerate)
				9.80								
				409.50				SW			D -	
			10									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a
RL3

REPORT OF BOREHOLE: CH142-BH01

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401049.0 m E 6961992.0 m N MGA94 56
SURFACE RL: 419.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 14.61 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 11/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10		CH142-BH01-007 SPT 10.00-10.45 m 12, 17, 30 N=47			SW	Silty SAND fine to medium grained, pale grey	M	VD D - VD	Residual Soil (Decomposed Sandstone)
				10.80 408.50					MUDSTONE fine grained, brown and grey, extremely low to very low strength, extremely weathered			Koukandowie Formation
			11		CH142-BH01-008 SPT 11.50-11.79 m 18, 30/140 mm							
			12									
			13		CH142-BH01-009 SPT 13.00-13.09 m 30/90 mm							
			14									
				404.69	CH142-BH01-010 SPT 14.50-14.61 m 30/110 mm				END OF BOREHOLE @ 14.61 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED			
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH142-BH02

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401059.0 m E 6961953.0 m N MGA94 56
SURFACE RL: 404.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.14 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 10/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	404.30				CL-CI	FILL: Sandy CLAY low to medium plasticity, brown, fine to medium sand		VS	Temporary Platform Fill
			1		CH142-BH02-001 SPT 1.00-1.45 m 1, 1, 1 N=2							
				1.60								
				402.70				CI	FILL: Silty CLAY medium plasticity, brown, with some fine gravel		VSt	Embankment Fill
			2		CH142-BH02-002 SPT 2.50-2.95 m 3, 4, 9 N=13							
				2.90								
RD				401.40				CL-CI	Sandy CLAY / Sandy SILT low to medium plasticity, brown, grey and orange, fine to medium sand, with some fine to medium gravel, some clayey sand layers throughout			Colluvium
			3									
			4		CH142-BH02-003 SPT 4.00-4.45 m 9, 16, 21 N=37					M		
			5								VSt - H	
			6		CH142-BH02-004 SPT 5.50-5.95 m 9, 12, 14 N=26							
			7		CH142-BH02-005 SPT 7.00-7.45 m 10, 14, 18 N=32							
			8									
				8.20								
				396.10					SANDSTONE fine to medium grained, orange and brown, extremely low to low strength, extremely weathered			Koukandowie Formation
			9		CH142-BH02-006 SPT 8.50-8.56 m 30/60 mm							
			10									

REPORT OF BOREHOLE: CH142-BH02

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401059.0 m E 6961953.0 m N MGA94 56
SURFACE RL: 404.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.14 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 10/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD		◄	10		CH142-BH02-007 SPT 10.00-10.14 m 30/140 mm				SANDSTONE fine to medium grained, orange and brown, extremely low to low strength, extremely weathered			
			11	*11.00* 393.30					11 to 12.2 m grades to residual soil clayey sand, fine to medium, orange and brown, moist, medium dense exhibits residual rock structure			Decomposed Zone 11.0-12.2m Complete drill fluid loss at 11.2 m
			12		CH142-BH02-008 SPT 11.50-11.95 m 10, 11, 21 N=32							
				12.20 392.10					MUDSTONE fine grained, brown and grey, extremely low to very low strength, extremely weathered			
			13		CH142-BH02-009 SPT 13.00-13.14 m 30/140 mm							
				391.16					END OF BOREHOLE @ 13.14 m TARGET DEPTH GROUNDWATER NOT OBSERVED BACKFILLED			
			14									
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH142-BH03

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401101.0 m E 6962018.0 m N MGA94 56
SURFACE RL: 418.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.08 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	418.60				GC	FILL: Clayey Sandy GRAVEL fine to medium grained, sub-angular, grey and brown, fine to medium sand, low plasticity clay	D	D	Road - base
				0.20								
				418.40				CI	FILL: Gravelly Sandy CLAY / Clayey SAND medium plasticity, brown and grey, fine to medium sand, fine to medium gravel			Embankment Fill
			1		CH142-BH03-001 SPT 1.00-1.45 m 2, 3, 6 N=9							
			2							M	St - VSt	
					CH142-BH03-002 SPT 2.50-2.95 m 5, 6, 9 N=15							
			3									
				3.80								
RD				414.80				SC	Gravelly Clayey SAND fine to medium grained, dark brown, low plasticity clay, fine to medium gravel			Colluvium
			4		CH142-BH03-003 SPT 4.00-4.45 m 10, 15, 15 N=30							
			5							M	MD - D	
					CH142-BH03-004 SPT 5.50-5.95 m 11, 13, 14 N=27							
			6									
				6.30								
				412.30				CI	Silty CLAY medium plasticity, brown and grey			Residual Soil
			7		CH142-BH03-005 SPT 7.00-7.45 m 10, 15, 16 N=31					D	H	
			8									
				8.20								
				410.40					MUDSTONE fine grained, brown and grey, extremely low to very low strength, extremely weathered			Koukandowie Formation
					CH142-BH03-006 SPT 8.50-8.64 m 30/140 mm							
			9									
			10									

REPORT OF BOREHOLE: CH142-BH03

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401101.0 m E 6962018.0 m N MGA94 56
SURFACE RL: 418.60 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.08 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 16/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD			10		CH142-BH03-007 SPT 10.00-10.13 m 30/130 mm				MUDSTONE fine grained, brown and grey, extremely low to very low strength, extremely weathered			Koukandowie Formation
			11									
					CH142-BH03-008 SPT 11.50-11.72 m 20, 30/70 mm							
			12									
			13		CH142-BH03-009 SPT 13.00-13.08 m 30/80 mm							
				405.52					END OF BOREHOLE @ 13.08 m TARGET DEPTH GROUNDWATER NOT OBSERVED GROUTED			
			14									
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF BOREHOLE: CH142-BH04

SHEET: 1 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401117.0 m E 6961979.0 m N MGA94 56
SURFACE RL: 398.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.12 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 9/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT			0	398.50				SM	FILL: Silty SAND fine to medium grained, orange and pale brown	M	MD	Temporary Platform Fill
				1.00								
			1	397.50	CH142-BH04-001 SPT 1.00-1.45 m 3, 3, 5 N=8			CL	Sandy CLAY low plasticity, brown, fine to medium sand	M	F - St	Slope Wash
				1.80								
			2	396.70				SM	Silty SAND / Sandy SILT fine to medium grained, orange and pale brown			Residual Soil (Decomposed Sandstone)
					CH142-BH04-002 SPT 2.50-2.95 m 2, 6, 10 N=16					D	MD	
			3									
			4	*4.20*	CH142-BH04-003 SPT 4.00-4.45 m 9, 10, 21 N=31							
				394.30					MUDSTONE fine grained, brown and grey, extremely low strength, extremely weathered			Koukandowie Formation
				4.80								
		◁	5	393.70					4.8 to 5.0 m carbonaceous mudstone layer			Partial drill fluid loss at 4.8 m depth
				5.50								
RD				393.00	CH142-BH04-004 SPT 5.50-5.95 m 20, 24, 28 N=52			CI	Sandy CLAY medium plasticity, brown and grey, fine sand			Residual Soil (Decomposed Mudstone)
			6									
			7		CH142-BH04-005 SPT 7.00-7.45 m 9, 14, 17 N=31					M	VSt - H	
			8									
					CH142-BH04-006 SPT 8.50-8.95 m 8, 13, 16 N=29							
			9	*9.60*								
				388.90					MUDSTONE fine grained, grey, extremely low strength, extremely weathered			
			10									

REPORT OF BOREHOLE: CH142-BH04

SHEET: 2 OF 2

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

COORDS: 401117.0 m E 6961979.0 m N MGA94 56
SURFACE RL: 398.50 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 13.12 m

DRILL RIG: Comacchio Geo 205
CONTRACTOR: GeoDrill Pty Ltd
LOGGED: SCF DATE: 9/3/15
CHECKED: GR DATE: 1/4/15

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
RD		◀	10		CH142-BH04-007 SPT 10.00-10.45 m 20, 18, 30 N=48				MUDSTONE fine grained, grey, extremely low strength, extremely weathered			
			11									
					CH142-BH04-008 SPT 11.50-11.95 m 8, 20, 27 N=47							Complete drill fluid loss at 11.5 m
			12	*12.20* 386.30					becoming very low strength			
			13		CH142-BH04-009 SPT 13.00-13.12 m 30/120 mm							
				385.38					END OF BOREHOLE @ 13.12 m TARGET DEPTH GROUNDWATER NOT OBSERVED BACKFILLED			
			14									
			15									
			16									
			17									
			18									
			19									
			20									

REPORT OF DCP TESTS

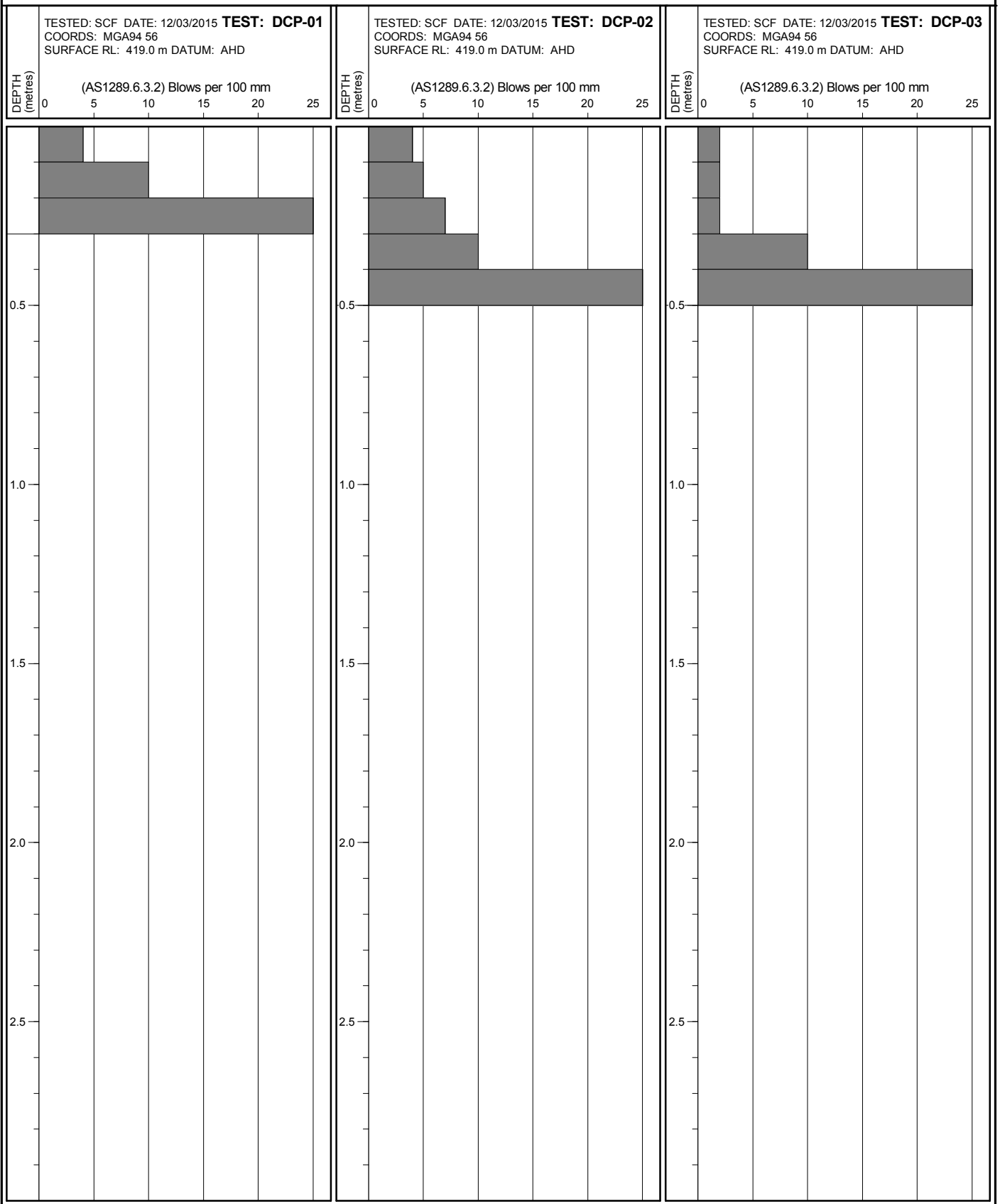
CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

SHEET: 1 OF 3
CHECKED: GR DATE: 1/4/15

TESTED: SCF DATE: 12/03/2015 **TEST: DCP-01**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD

TESTED: SCF DATE: 12/03/2015 **TEST: DCP-02**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD

TESTED: SCF DATE: 12/03/2015 **TEST: DCP-03**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD



This report of penetrometer must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

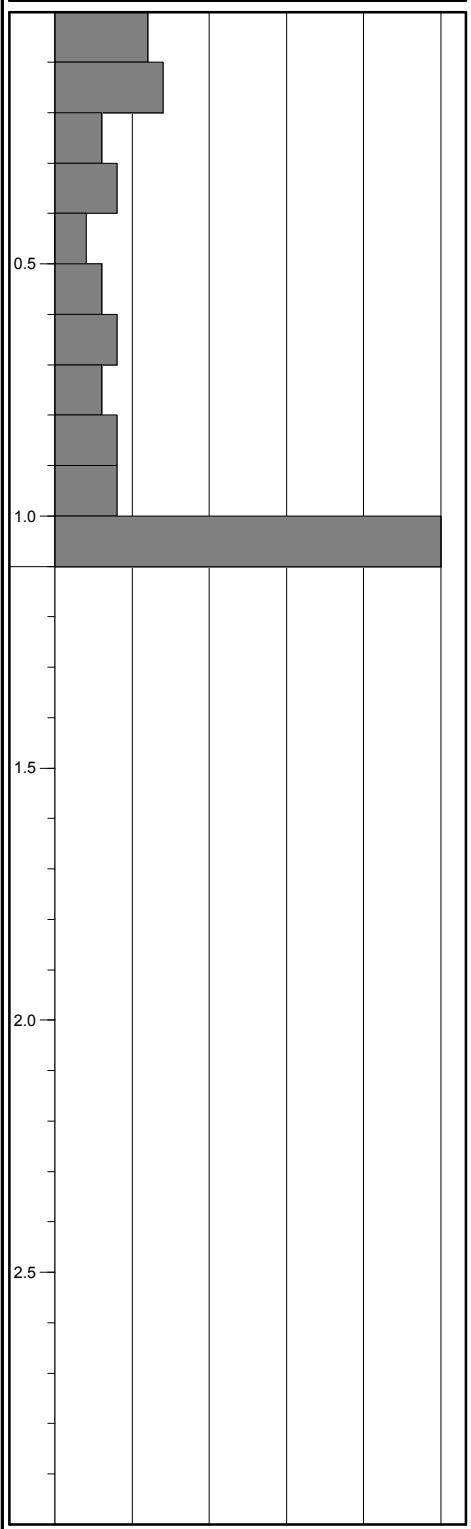
GAP gINT FN. F04a
RL3

REPORT OF DCP TESTS

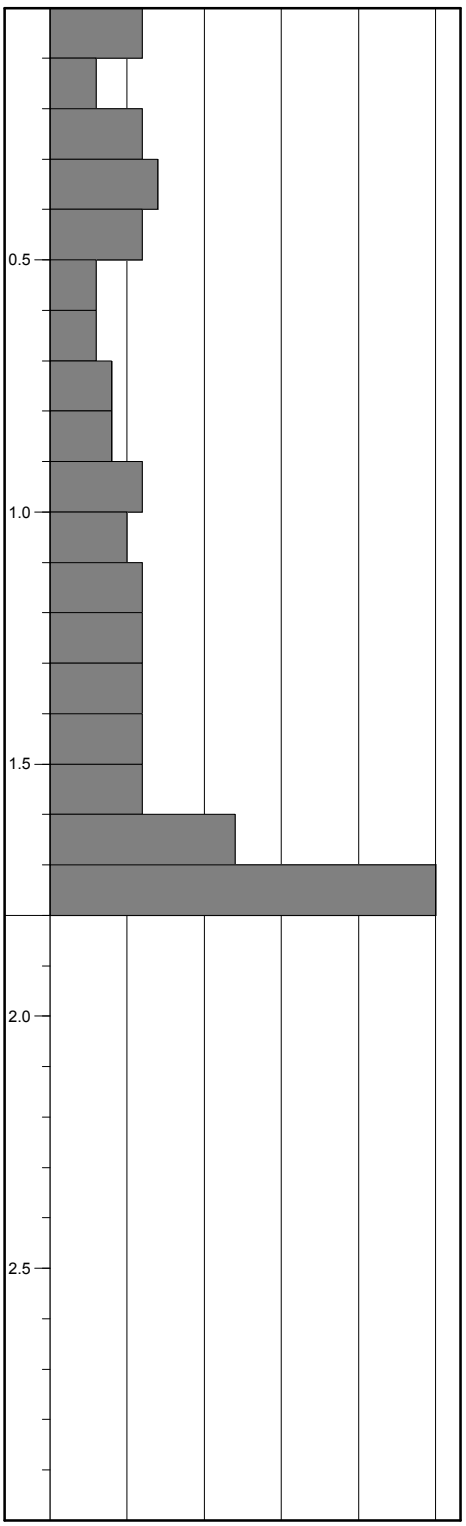
CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

CHECKED: GR DATE: 1/4/15

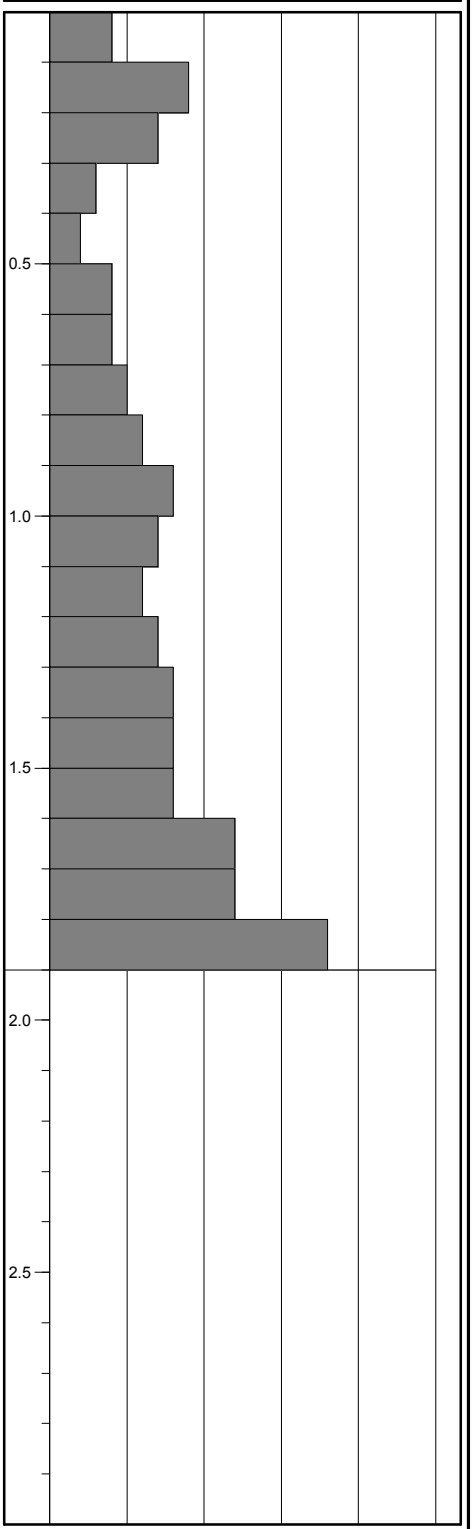
TESTED: SCF DATE: 12/03/2015 **TEST: DCP-04**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD



TESTED: SCF DATE: 12/03/2015 **TEST: DCP-05**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD



TESTED: SCF DATE: 12/03/2015 **TEST: DCP-06**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD



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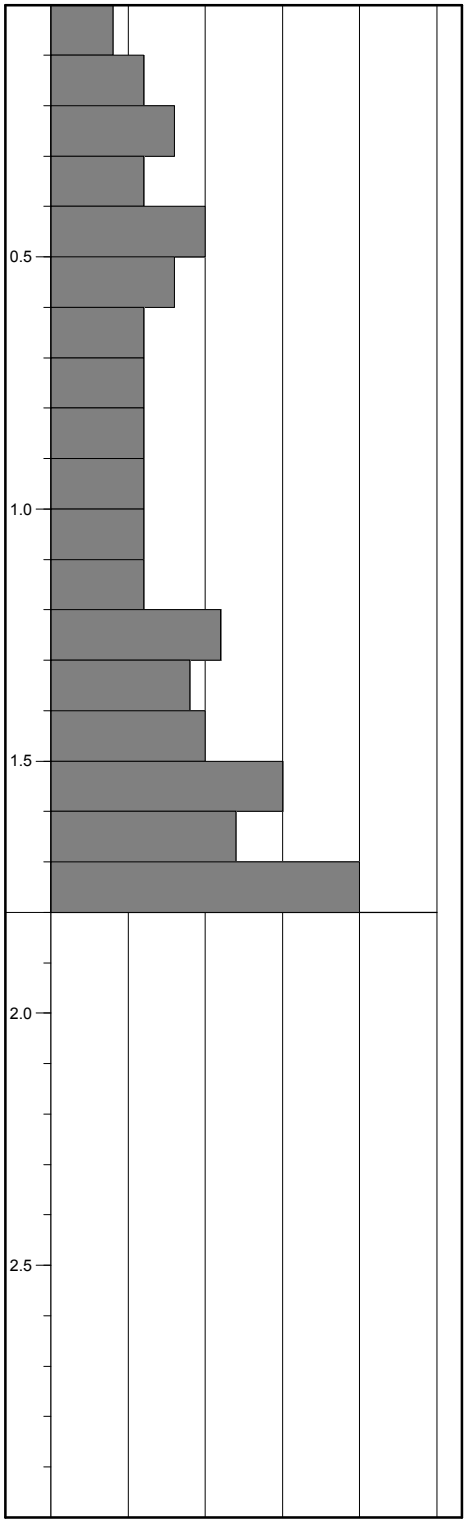
REPORT OF DCP TESTS

CLIENT: Queensland Rail Limited
PROJECT: Remedial Slope Design
LOCATION: Toowoomba Range Railway
JOB NO: 137632080

SHEET: 3 OF 3
CHECKED: GR DATE: 1/4/15

TESTED: SCF DATE: 12/03/2015 **TEST: DCP-07**
COORDS: MGA94 56
SURFACE RL: 419.0 m DATUM: AHD



This report of penetrometer must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F04a
RL3

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	NQ	Diamond Core - 47 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	HQ	Diamond Core - 63 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	HMLC	Diamond Core – 63mm
HA	Hand Auger	PT	Push Tube	BH	Tractor Mounted Backhoe
ADH	Hollow Auger	CT	Cable Tool Rig	EX	Tracked Hydraulic Excavator
DTC	Diatube Coring	JET	Jetting	EE	Existing Excavation
WB	Washbore or Bailer	NDD	Non-destructive digging	HAND	Excavated by Hand Methods

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests
DCP	Dynamic cone penetration test
CPT	Static cone penetration test
CPTu	Static cone penetration test with pore pressure (u) measurement

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \text{Axial lengths of core} > 100 \text{ mm}}{\text{Length of core run}} \times 100$$

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT REPORTS

 FILL

 GRAVEL (GP or GW)

 SAND (SP or SW)

 SILT (ML or MH)

 CLAY (CL, CI or CH)

 ORGANIC SOILS (OL or OH or Pt)

 COBBLES or BOULDERS

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

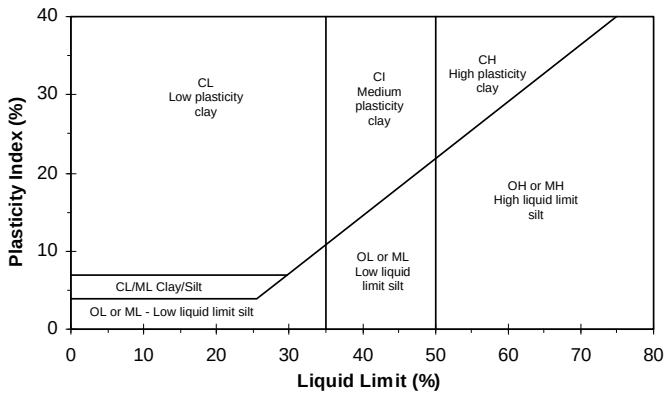
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

TERMS FOR ROCK MATERIAL STRENGTH & WEATHERING AND ABBREVIATIONS FOR DEFECT DESCRIPTIONS

STRENGTH

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa)	Field Guide
EL	Extremely Low	< 0.03	Easily remoulded by hand to a material with soil properties.
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK STRENGTH TEST RESULTS

▼ Point Load Strength Index, $I_s(50)$, Axial test (MPa)

◀ Point Load Strength Index, $I_s(50)$, Diametral test (MPa)

Relationship between $I_s(50)$ and UCS (unconfined compressive strength) will vary with rock type and strength, and should be determined on a site-specific basis. UCS is typically 10 to 30 x $I_s(50)$, but can be as low as 5.

ROCK MATERIAL WEATHERING

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
EW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS FOR DEFECT TYPES AND DESCRIPTIONS

Defect Type

B	Bedding parting
X	Foliation
C	Contact
L	Cleavage
J	Joint
SS/SZ	Sheared seam/zone (Fault)
CS/CZ	Crushed seam/zone (Fault)
DS/DZ	Decomposed seam/zone
IS/IZ	Infilled seam/zone
S	Schistocity
V	Vein

Coating or Infilling

Cn	Clean
Sn	Stain
Vr	Veneer
Ct	Coating or Infill

Planarity

Pl	Planar
Un	Undulating
St	Stepped

Roughness

Sl	Slickensided
Sm	Smooth
Ro	Rough

Vertical Boreholes – The dip (inclination from horizontal) of the defect is given.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

APPENDIX B

Laboratory Test Reports

Golder Associates Pty Ltd
A.B.N. 64 006 107 857
Brisbane Laboratory
28 Bank Street
West End QLD 4101
(PO Box 3247 South Brisbane BC QLD 4101)
T: (61-7) 3840 9500
F: (61-7) 3840 9501
E: BNELab@golder.com.au

Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-10300**	Report Date:	**10/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 142.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300779	15300780	15300781	15300782
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	2/4/2015	2/4/2015	2/4/2015	2/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH142-BH01 (10.0-10.45 m) Sample CH142-BH01-007 SPT	CH142-BH02 (4.0-4.45 m) Sample CH142-BH02-003 SPT	CH142-BH02 (5.5-5.95 m) Sample CH142-BH02-004 SPT	CH142-BH03 (2.5-2.95 m) Sample CH142-BH03-002 SPT
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	**105 to 110**
Moisture Content(%):	**18.7**	**25.7**	**18.9**	**32.2**
Remarks :				

Lab Number:	Soil Description
15300779	
15300780	
15300781	
15300782	

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.
THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL.

APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager

NATA Accred No:1961

Golder Associates Pty Ltd
A.B.N. 64 006 107 857
Brisbane Laboratory
28 Bank Street
West End QLD 4101
(PO Box 3247 South Brisbane BC QLD 4101)
T: (61-7) 3840 9500
F: (61-7) 3840 9501
E: BNELab@golder.com.au

Moisture Content Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 1**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number :	**137632080-10300**	Report Date:	**10/04/2015**
Project :	**Remedial Slope Design**	Order Number:	
Location :	**Ch 142.7 km Toowoomba Range Railway ,**	Test Method:	**AS1289.2.1.1**

Lab No :	15300783	15300784	15300785	
ID No :	-	-	-	
Lot No :	-	-	-	
Item No :	-	-	-	
Date Sampled / Received :	1/4/2015	1/4/2015	1/4/2015	
Date Tested :	2/4/2015	2/4/2015	2/4/2015	
Material Source :	-	-	-	
For Use As :	-	-	-	
Sample Location :	CH142-BH03 (7.0-7.45 m) Sample CH142-BH03-005 SPT	CH142-BH04 (2.5-2.95 m) Sample CH142-BH04-002 SPT	CH142-BH04 (5.5-5.95 m) Sample CH142-BH04-004 SPT	
Drying Temperature(°C):	**105 to 110**	**105 to 110**	**105 to 110**	
Moisture Content(%):	**22.4**	**8.3**	**14.0**	
Remarks :				

Lab Number:	Soil Description
15300783	
15300784	
15300785	

APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager

NATA Accred No:1961

FORM NUMBER: R69-RL-17

Golder Associates Pty Ltd
A.B.N. 64 006 107 857
Brisbane Laboratory
28 Bank Street
West End QLD 4101
(PO Box 3247 South Brisbane BC QLD 4101)
T: (61-7) 3840 9500
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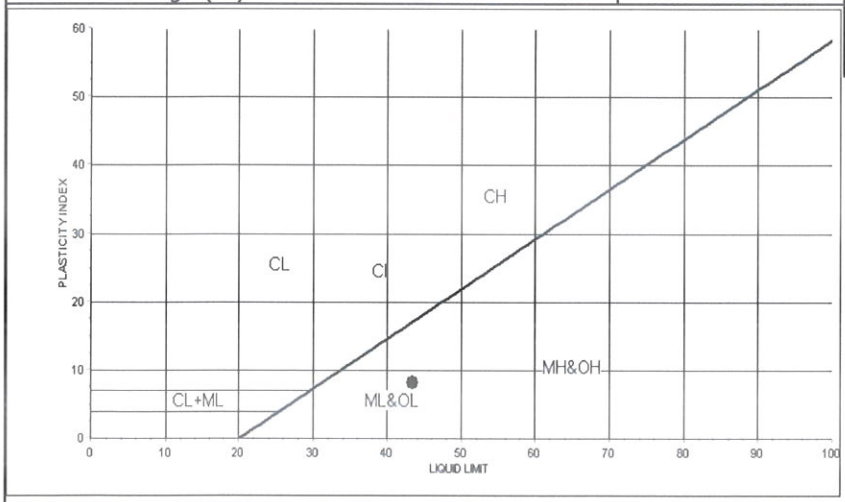
Atterberg Limits Report

Client:	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 2**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number:	**137632080-10300**	Report Date:	**10/04/2015**
Project:	**Remedial Slope Design**	Order Number:	-
Location	**Ch 142.7 km Toowoomba Range Railway ,**		Page 1 of 2
Lab No:	**15300780**		Sample Location
Date Sampled / Received:	**1/04/2015**		CH142-BH02 (4.0-4.45 m)
Date Tested:	**8/04/2015**		Sample CH142-BH02-003
Sampled By:	**Client's Rep.**		SPT
Sample Method:	-		
Material Source:	-	Spec Description:	-
For Use As:	-	Lot Number:	-
Remarks:	-	Spec Number:	-

Plasticity Tests		Test Method	Specification Minimum	Result	Specification Maximum
Sample History:	Oven Dried low temp.				
Moisture Content (%):°C	105 to 110	**AS1289.2.1.1**	-	**25.7**	-
Liquid Limit (%)		**AS1289.3.1.2**		**43**	
Plastic Limit (%)		**AS1289.3.2.1**		**35**	
Plasticity Index (%)		**AS1289.3.3.1**		**8**	
Linear Shrinkage (%)		**AS1289.3.4.1**		**7.5**	
			Linear Shrinkage State after drying	No crumbling or curling	



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Mike Sandilands - Laboratory Manager
NATA Accred No:1961

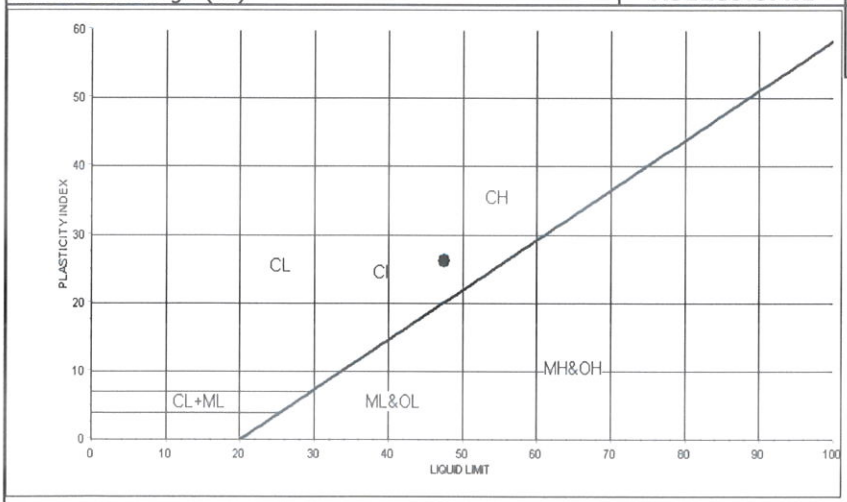
FORM NUMBER: R37-RL-25

Golder Associates Pty Ltd
A.B.N. 64 006 107 857
Brisbane Laboratory
28 Bank Street
West End QLD 4101
(PO Box 3247 South Brisbane BC QLD 4101)
T: (61-7) 3840 9500
F: (61-7) 3840 9501
E: BNELab@golder.com.au

Atterberg Limits Report

Client:	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 2**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**		
Job Number:	**137632080-10300**	Report Date:	**10/04/2015**
Project:	**Remedial Slope Design**	Order Number:	-
Location	**Ch 142.7 km Toowoomba Range Railway ,**	Page 2 of 2	
Lab No:	**15300785**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH142-BH04 (5.5-5.95 m)	
Date Tested:	**8/04/2015**	Sample CH142-BH04-004	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-	Spec Description:	-
For Use As:	-	Lot Number:	-
Remarks:	-	Spec Number:	-

Plasticity Tests		Test Method	Specification Minimum	Result	Specification Maximum
Sample History:	Oven Dried low temp.				
Moisture Content (%):°C	105 to 110	**AS1289.2.1.1**	-	**14.0**	-
Liquid Limit (%)		**AS1289.3.1.2**		**47**	
Plastic Limit (%)		**AS1289.3.2.1**		**21**	
Plasticity Index (%)		**AS1289.3.3.1**		**26**	
Linear Shrinkage (%)		**AS1289.3.4.1**		**13.0**	



Linear Shrinkage State after drying	No crumbling or curling

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APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager
NATA Accred No:1961

FORM NUMBER: R37-RL-25

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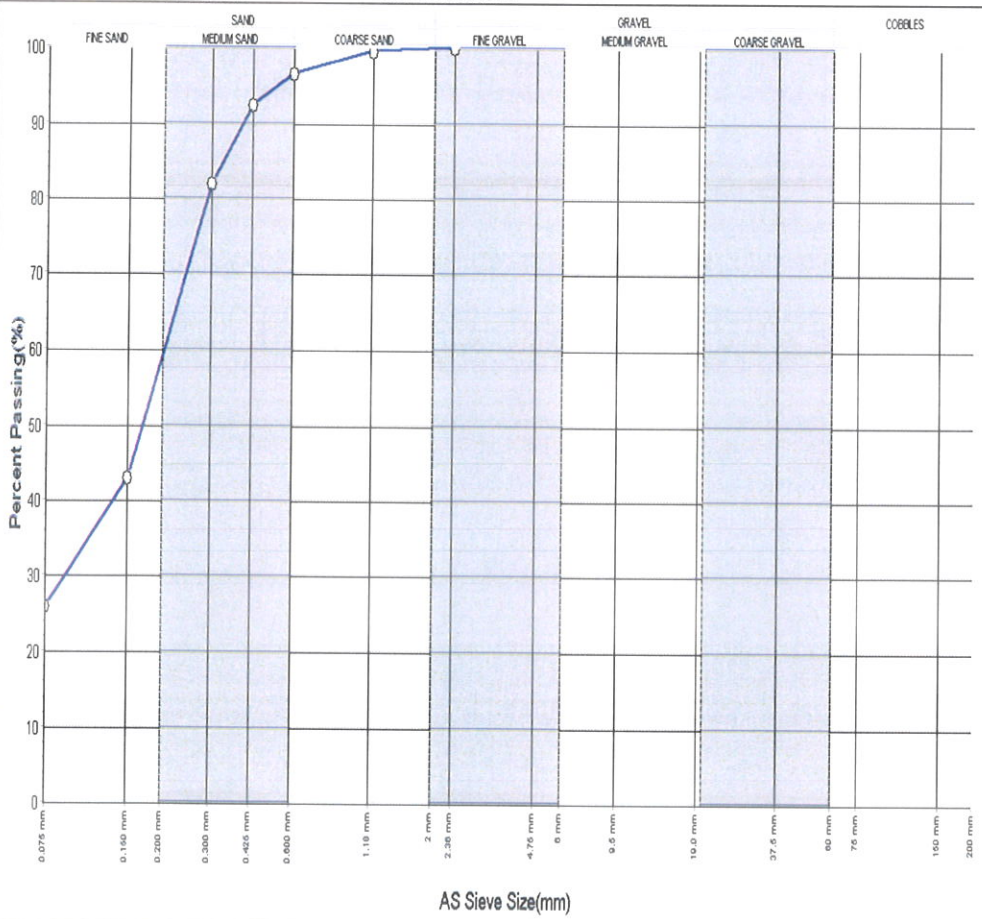
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**
Project:	**Remedial Slope Design**
Location	**Ch 142.7 km Toowoomba Range Railway ,**
Lab No:	**15300779**
Date Sampled / Received:	**1/04/2015**
Date Tested:	**9/04/2015**
Sampled By:	**Client's Rep.**
Sample Method:	-
Material Source:	-
For Use As:	-
Remarks:	-

Job Number:	**137632080-10300**
Report Number:	**137632080-10300 - 3**
Report Date:	**10/04/2015**
	Page 1 of 4

Sample Location
CH142-BH01 (10.0-10.45 m)
Sample CH142-BH01-007
SPT

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	
4.75 mm	
2.36 mm	**100**
1.18 mm	**99**
0.600 mm	**97**
0.425 mm	**92**
0.300 mm	**82**
0.150 mm	**43**
0.075 mm	**26**
Moisture Content (%)	**18.7**

Visual Classification:

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Mike Sandilands - Laboratory Manager

NATA Accred No:1961

Form Number : R77-RL-16

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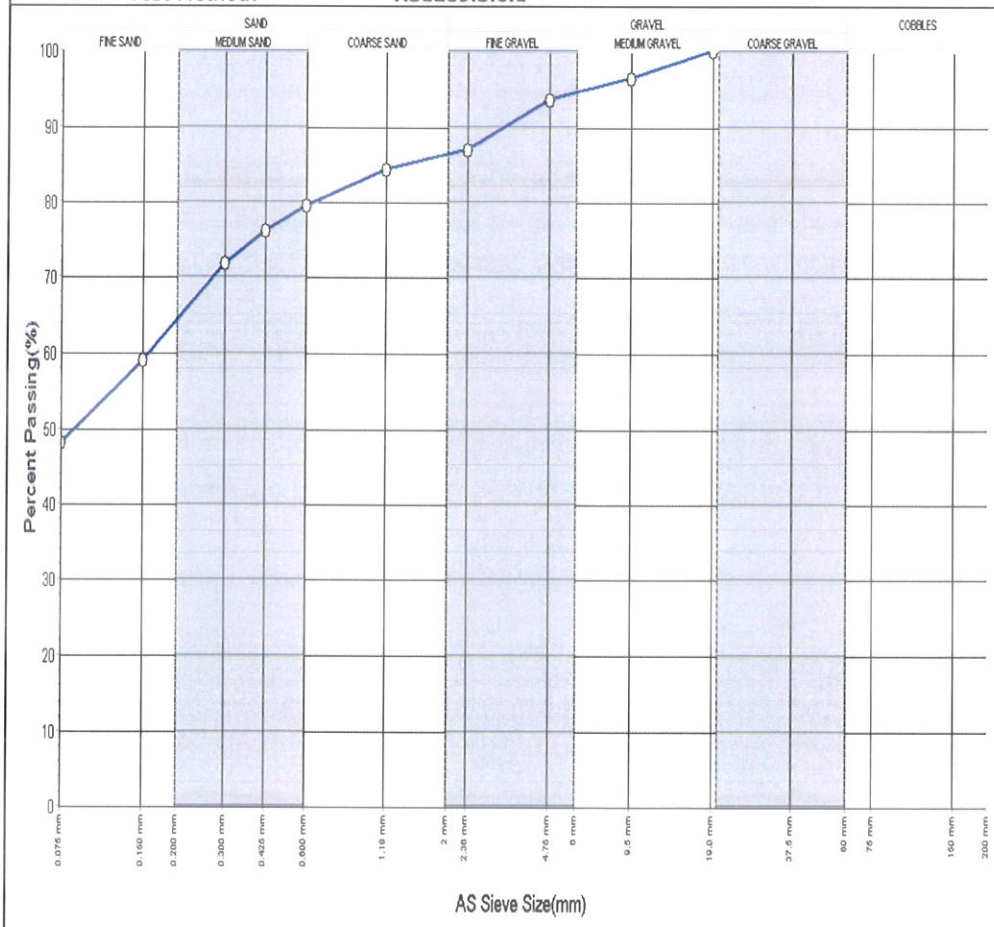
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-10300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-10300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**10/04/2015**
Location	**Ch 142.7 km Toowoomba Range Railway ,**		**Page 2 of 4**
Lab No:	**15300781**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH142-BH02 (5.5-5.95 m)	
Date Tested:	**9/04/2015**	Sample CH142-BH02-004	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	**100**
13.2 mm	-
9.50 mm	**96**
4.75 mm	**94**
2.36 mm	**87**
1.18 mm	**84**
0.600 mm	**80**
0.425 mm	**76**
0.300 mm	**72**
0.150 mm	**59**
0.075 mm	**48**
Moisture Content (%)	**18.9**

Visual Classification:

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Form Number : R77-RL-16

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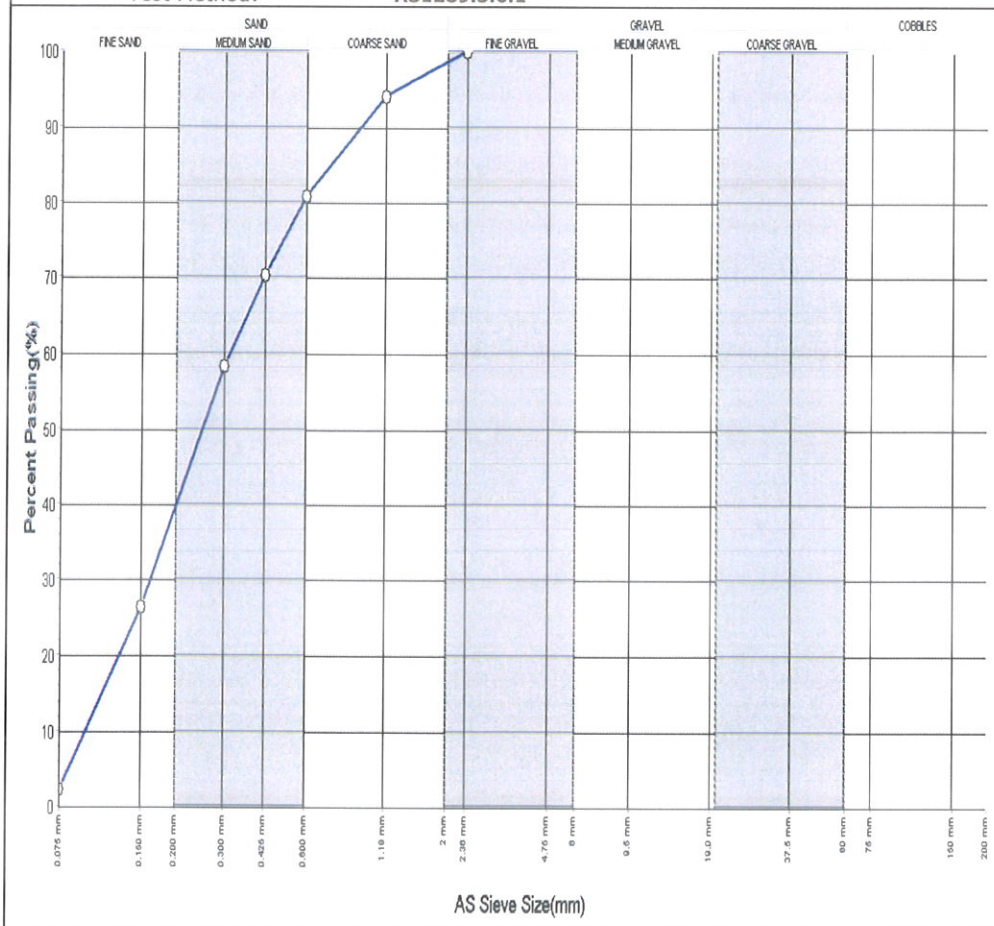
Particle Size Distribution Report

Client:	**Queensland Rail Limited (Toowoomba)**	Job Number:	**137632080-10300**
Client Address:	**PO Box 3357 Toowoomba QLD 4350**	Report Number:	**137632080-10300 - 3**
Project:	**Remedial Slope Design**	Report Date:	**10/04/2015**
Location	**Ch 142.7 km Toowoomba Range Railway ,**		**Page 3 of 4**
Lab No:	**15300782**	Sample Location	
Date Sampled / Received:	**1/04/2015**	CH142-BH03 (2.5-2.95 m)	
Date Tested:	**9/04/2015**	Sample CH142-BH03-002	
Sampled By:	**Client's Rep.**	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: **AS1289.3.6.1**



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	
4.75 mm	
2.36 mm	**100**
1.18 mm	**94**
0.600 mm	**81**
0.425 mm	**70**
0.300 mm	**58**
0.150 mm	**27**
0.075 mm	**2**
Moisture Content (%)	**32.2**

Visual Classification:

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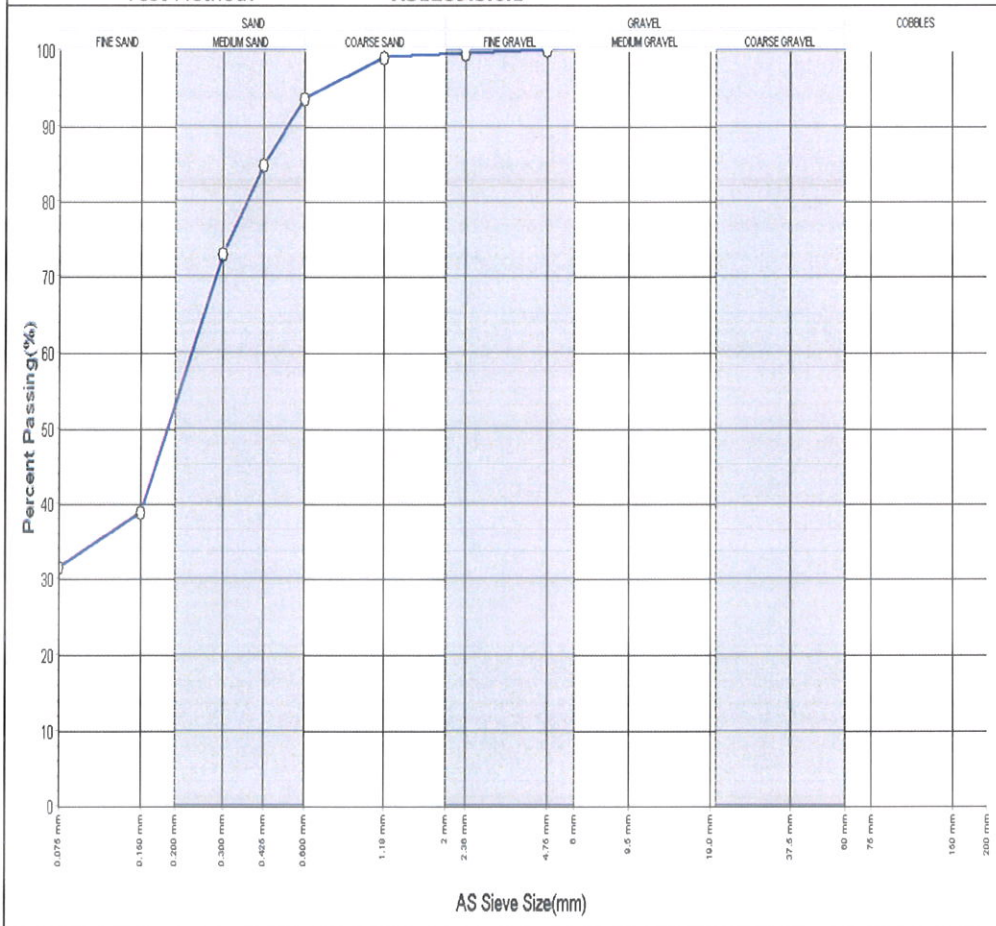
Particle Size Distribution Report

Client:	Queensland Rail Limited (Toowoomba)	Job Number:	137632080-10300
Client Address:	PO Box 3357 Toowoomba QLD 4350	Report Number:	137632080-10300 - 3
Project:	Remedial Slope Design	Report Date:	10/04/2015
Location	Ch 142.7 km Toowoomba Range Railway ,		Page 4 of 4
Lab No:	15300784	Sample Location	
Date Sampled / Received:	1/04/2015	CH142-BH04 (2.5-2.95 m)	
Date Tested:	9/04/2015	Sample CH142-BH04-002	
Sampled By:	Client's Rep.	SPT	
Sample Method:	-		
Material Source:	-		
For Use As:	-		
Remarks:	-		

Test Method: AS1289.3.6.1



A.S. Sieve Sizes	Percent Passing
75.00 mm	
53.00 mm	
37.50 mm	
26.50 mm	
19.00 mm	
13.2 mm	
9.50 mm	
4.75 mm	100
2.36 mm	99
1.18 mm	99
0.600 mm	94
0.425 mm	85
0.300 mm	73
0.150 mm	39
0.075 mm	32
Moisture Content (%)	8.3

Visual Classification:

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Mike Sandilands - Laboratory Manager

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Form Number : R77-RL-16

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Emerson Class Number Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 4**
Address :	**PO Box 3357 Toowoomba QLD 4350**	Report Date:	**10/04/2015**
Job Number :	**137632080-10300**	Order Number:	
Project :	**Remedial Slope Design**	Test Method:	**AS1289.3.8.1**
Location :	**Ch 142.7 km Toowoomba Range Railway ,**		

Lab No :	15300778	15300780	15300782	15300783
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	-	-	-	-
Date Sampled/Received :	1/4/2015	1/4/2015	1/4/2015	1/4/2015
Date Tested :	7/4/2015	7/4/2015	7/4/2015	7/4/2015
Material Source :	-	-	-	-
For Use As :	-	-	-	-
Sample Location :	CH142-BH01 (7.0-7.45 m) Sample CH142-BH01-005 SPT	CH142-BH02 (4.0-4.45 m) Sample CH142-BH02-003 SPT	CH142-BH03 (2.5-2.95 m) Sample CH142-BH03-002 SPT	CH142-BH03 (7.0-7.45 m) Sample CH142-BH03-005 SPT
Soil Description :	-	-	-	-
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	**Distilled Water**
Temperature of Water (°C) :	**24**	**24**	**24**	**24**
Emerson Class Number :	**Class 6**	**Class 6**	**Class 6**	**Class 6**
Remarks :				

APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager
NATA Accred No:1961

FORM NUMBER : R58-RL-12

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Emerson Class Number Report

Client :	**Queensland Rail Limited (Toowoomba)**	Report Number:	**137632080-10300 - 4**
Address :	**PO Box 3357 Toowoomba QLD 4350**	Report Date:	**10/04/2015**
Job Number :	**137632080-10300**	Order Number:	
Project :	**Remedial Slope Design**	Test Method:	**AS1289.3.8.1**
Location :	**Ch 142.7 km Toowoomba Range Railway ,**		

Lab No :	15300784	15300785	15300786	
ID No :	-	-	-	
Lot No :	-	-	-	
Item No :	-	-	-	
Sampling Method :	-	-	-	
Date Sampled/Received :	1/4/2015	1/4/2015	1/4/2015	
Date Tested :	7/4/2015	7/4/2015	7/4/2015	
Material Source :	-	-	-	
For Use As :	-	-	-	
Sample Location :	CH142-BH04 (2.5-2.95 m) Sample CH142-BH04-002 SPT	CH142-BH04 (5.5-5.95 m) Sample CH142-BH04-004 SPT	CH142-BH04 (11.5-11.95 m) Sample CH142-BH04-008 SPT	
Soil Description :	-	-	-	
Type of Water Used :	**Distilled Water**	**Distilled Water**	**Distilled Water**	
Temperature of Water (°C) :	**24**	**24**	**24**	
Emerson Class Number :	**Class 5**	**Class 6**	**Class 6**	
Remarks :				

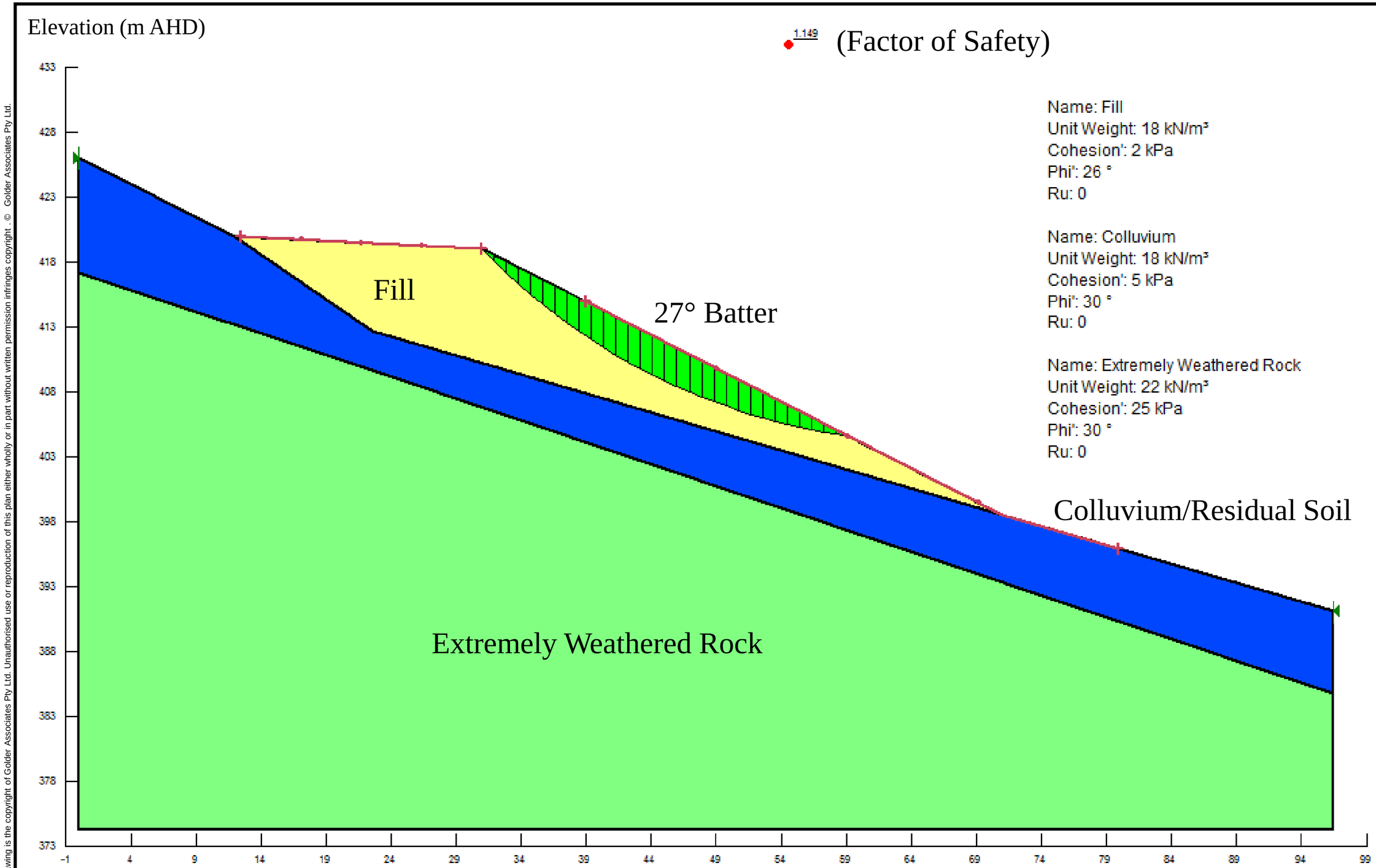
APPROVED SIGNATORY

Mike Sandilands - Laboratory Manager
NATA Accred No:1961

FORM NUMBER : R58-RL-12

APPENDIX C

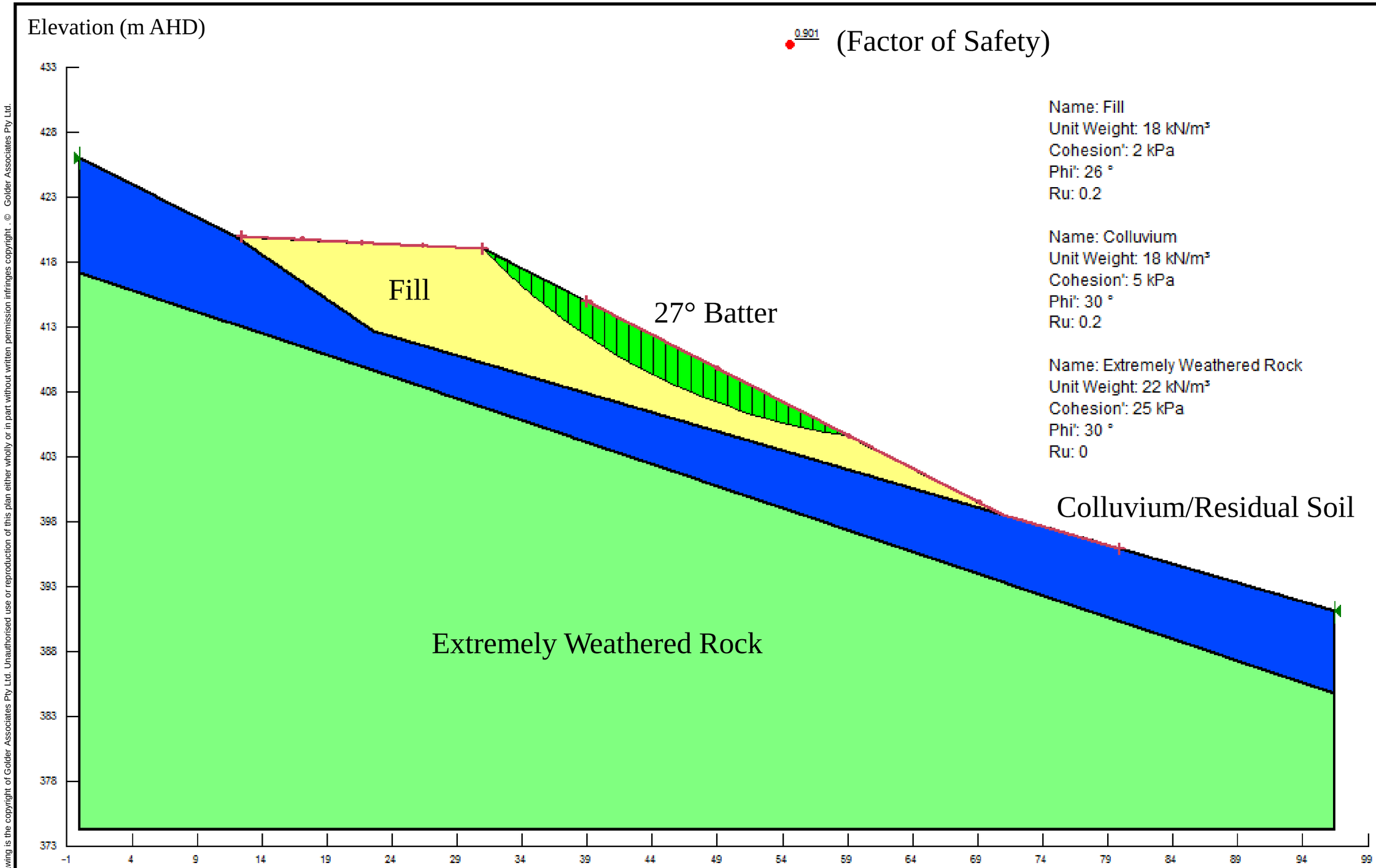
Slope Stability Analysis Results



Golder Associates

CLIENT	Queensland Rail	PROJECT	Toowoomba Range Railway – Ch 142.7 km
DRAWN	SCF	DATE	29/04/2015
CHECKED	GR	DATE	29/04/2015
SCALE	As Shown	TITLE	**Slope Stability Analysis Inferred Initial Conditions, Dry**
PROJECT No	137632080-011	FIGURE No	C-1
REV No	0		A4

T:\Template\Figure_Templates\Powerpoint\GAP A3L.pot



Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 142.7 km
	DRAWN: SCF	DATE: 29/04/2015	TITLE: **Slope Stability Analysis Inferred Initial Conditions, Ru = 0.2**
	CHECKED: GR	DATE: 29/04/2015	
	SCALE: As Shown		PROJECT No: 137632080-011 · FIGURE No: C-2 · REV No: 0 · A4

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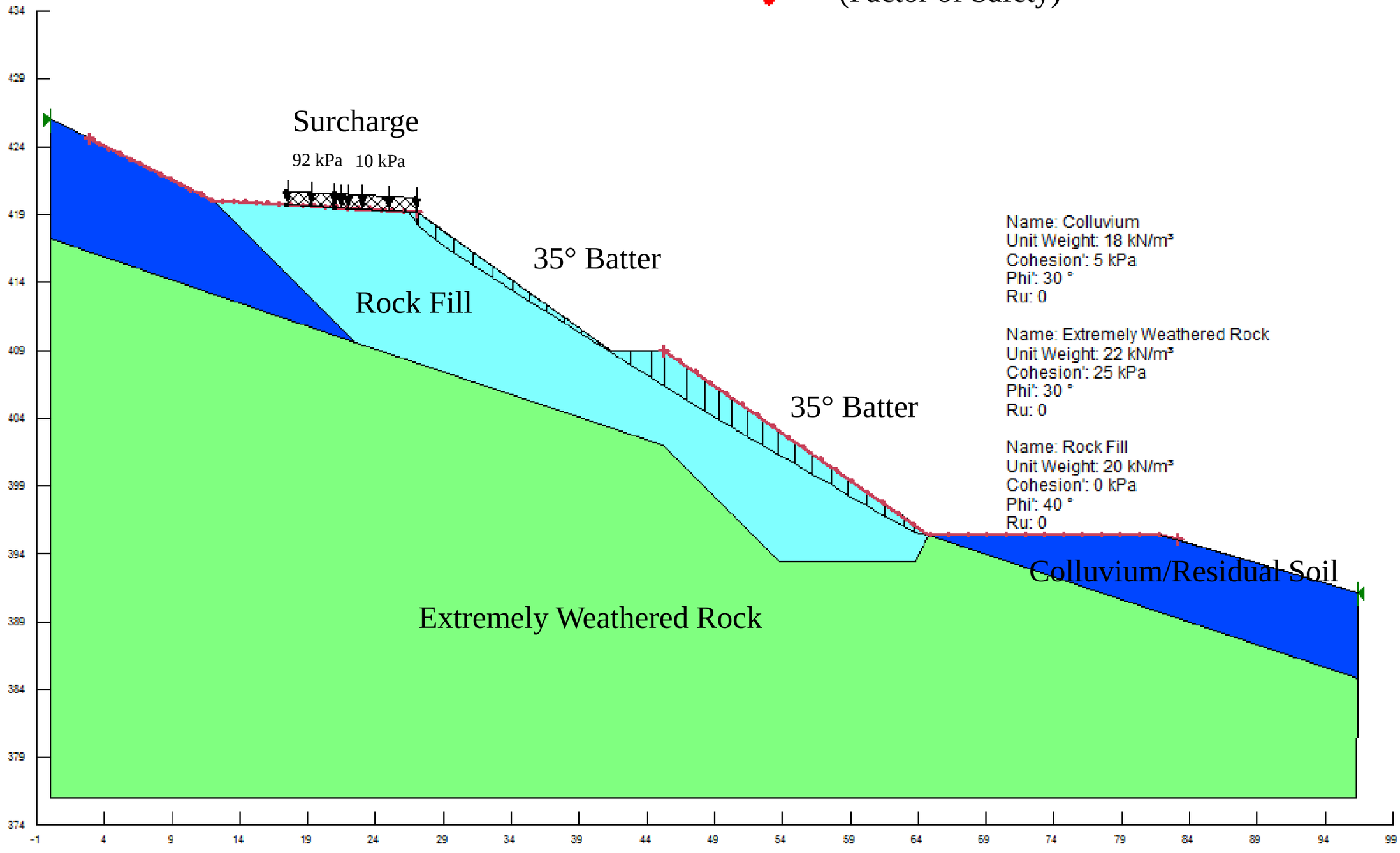
Elevation (m AHD)

1.366 (Factor of Safety)



Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0

Name: Extremely Weathered Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill
Unit Weight: 20 kN/m³
Cohesion': 0 kPa
Phi': 40 °
Ru: 0

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 142.7 km
	DRAWN: SCF	DATE: 29/04/2015	TITLE: **Slope Stability Analysis Rock Fill Remediation, c'=0, ϕ'=40**
	CHECKED: GR	DATE: 29/04/2015	
	SCALE: As Shown	PROJECT No: 137632080-011	FIGURE No: C-3 / REV No: 0 / A4

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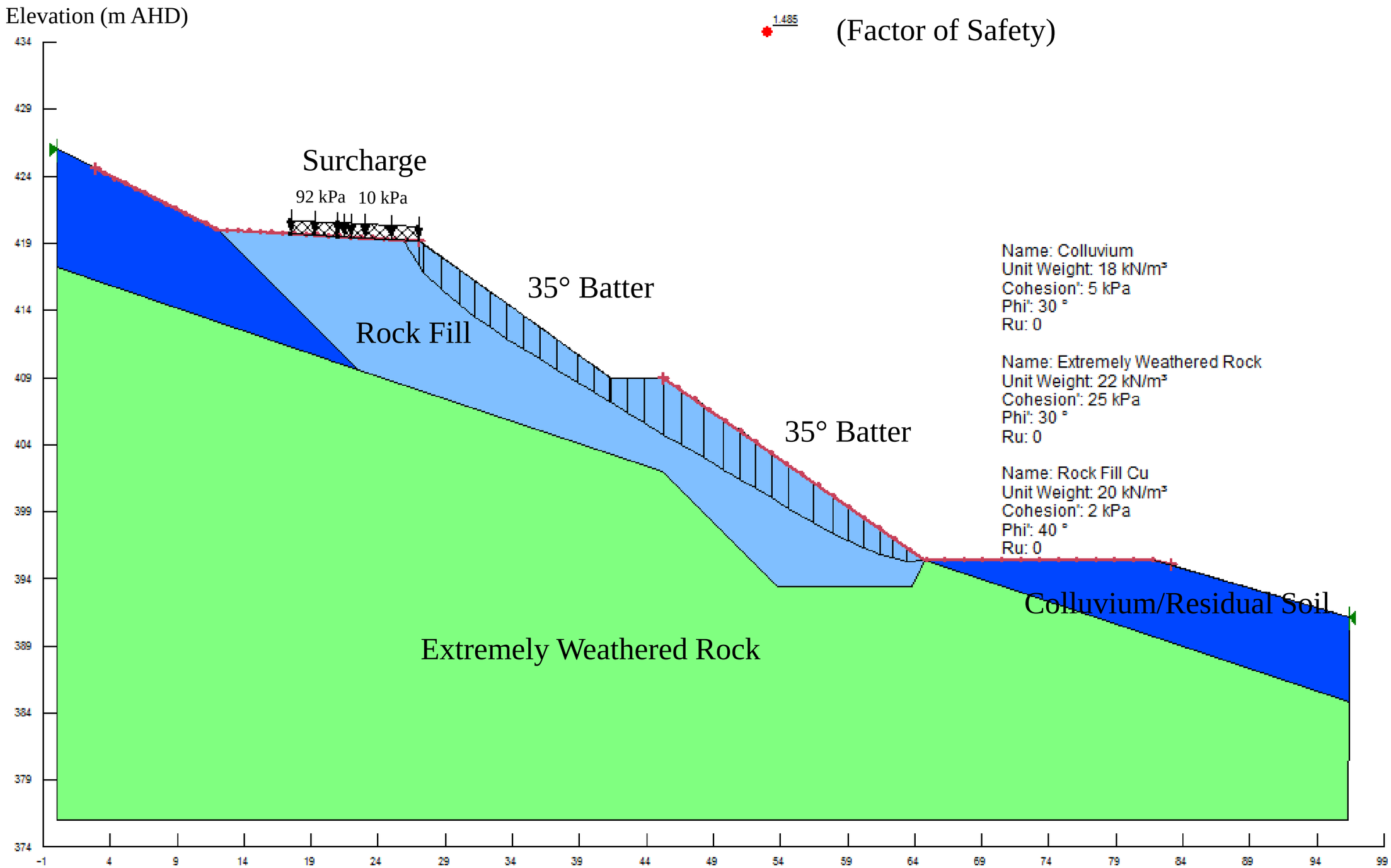

Name: Colluvium
Unit Weight: 18 kN/m³
Cohesion': 5 kPa
Phi': 30 °
Ru: 0

Name: Extremely Weathered Rock
Unit Weight: 22 kN/m³
Cohesion': 25 kPa
Phi': 30 °
Ru: 0

Name: Rock Fill Cu
Unit Weight: 20 kN/m³
Cohesion': 2 kPa
Phi': 40 °
Ru: 0

Golder Associates	CLIENT: Queensland Rail		PROJECT: Toowoomba Range Railway – Ch 142.7 km
	DRAWN: SCF / DATE: 29/04/2015		TITLE: **Slope Stability Analysis Rock Fill Remediation, c'=2, ϕ'=40**
	CHECKED: GR / DATE: 29/04/2015		
	SCALE: As Shown	PROJECT No: 137632080-011 / FIGURE No: C-4 / REV No: 0	A4

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APPENDIX D

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