Geotechnical Report for Resource Consent

Lot 3 DP 392270, Kingston Road,
Queenstown

Report prepared for:

Scope Resources Ltd

Report prepared by:

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Distribution:

QLDC

Scope Resources Ltd

GeoSolve Limited (File)

September 2019

GeoSolve Ref: 190413

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1 Introduction

1.1 General

This report presents the results of a geotechnical investigation carried out by GeoSolve Ltd in order to assess the natural hazard risk and provide geotechnical inputs for three proposed reservoir (tank) structures within Lot 3 DP 392270, Kingston Road, Queenstown.

This report is intended to supplement a resource consent application with the local council authority. A plan showing the proposed development is detailed in Appendix A and a photo of the general area for the building platform is shown below in photograph 1 & photograph 2.

The geotechnical investigation was carried out for the Scope Resources Ltd in accordance with GeoSolve Ltd.'s proposal dated 8 July 2019, which outlines the scope of work and conditions of engagement.

Photograph 1. Site photo looking northwest (building platform indicated by red arrow).

Photograph 2. Site photo looking east (building platform indicated by red arrow).

1.2 Proposed Development

Drawings completed by Clark Fortune McDonald & Associates (CFMA) have been provided to Geosolve and indicate it is proposed to construct 3 reservoir (tank) structures on moderately sloping ground with an associated access road.

Due to the sloping nature of the site earthworks will be required to establish a level building platform for the proposed tanks. It is understood that cuts, up to approximately 7.0 m in depth, are proposed to site the tanks on a generally level building platform. An overflow channel will be located at the south western corner of the proposed building platform to take surface water flows in the Southern Gully, a natural drainage path in south of the platform.

It is also understood minor cut earthworks will be undertaken for the construction of the access road.

A protective bund is proposed to be constructed at the top of the excavation, up to approximately 1.25 m in vertical height.

A visual protection mound is also proposed as part of the development, located downslope of the proposed tanks, adjacent to the crest of a moderately sloping terrace slope. Fill earthworks up to approximately 10.5 m are required for the construction of this mound.

The tank foundations are expected to comprise a concrete slab with perimeter thickening. The tank itself is expected to be of steel construction.

The approximate extent of the proposed earthworks is attached, Appendix C.

The position of the proposed tanks outlined in Appendix A, Figures 1a and 1b.

2 Site Description

2.1 General

The subject property which the proposed lots are located on is legally described as Lot 3 DP 392270, Kingston Road, Queenstown.

The site is located south of Frankton, on Kingston Road (SH6), as shown in Figure 1 below.

Figure 1. Site location (indicated by yellow outline) in relation to Frankton (Source: http://maps.qldc.govt.nz/qldcviewer/).

The subject property is bounded by a commercial quarry to the west and north, farmland to the south and a building platform to the east.

The subject site is generally sited on discontinuous terraced slopes formed by alluvial depositions of material adjacent to the glacial margins. These slopes have since been modified (post-glacial) by erosion, deposition and incision of various creeks.

Stoney and Southerly Creeks have deeply incised the slope that the proposed development is sited on, located to the north and south of the site respectively, as shown on Figure 1a, Appendix A.

The building platform for the reservoir structures is currently unused with ground cover comprising grass and scrubs.

2.2 Topography and Surface Drainage

The reservoir site has been surveyed and the site topography is shown on Figure 1b, Appendix A. Figure 1a and Figure 1b provide Lidar data for the general slope area.

The site is located on the moderately sloping western aspect ground, approximately 1100 metres from the toe of The Remarkables mountain range.

In this area the hillside falls for approximately 700 metres (horizontal distance) to Kingston Road. The reservoir site is at RL400 with surrounding slopes being at approximately 10-20°. Surface drainage will generally be from east to west, moving downslope, and will generally follow overland flow paths and existing access roads within, and adjacent to, the site.

Approximately 30 m to the west, or downslope of the building platform, the crest of a steep (approximately 30°) terrace slope is present. An overland flow path was observed to flow through the site on the northern side of the proposed building platform and down the terrace slope (shown on Figure 1b, Appendix A).

The terrace slope topographically separates the site from the lower ground surface of the Stoney Creek Quarry. The crest of the quarry excavation is located approximately 210 metres downslope of the proposed building platform.

A deeply incised ephemeral creek, named Southern Gully, is located to the south of the site and the crest of this steeply sloping (ranging between approximately 30-40°) gully feature is approximately 20-25 metres from the proposed building platform. The gully provides drainage to a localised fan surface located upslope of the subject site. The crest of this localised fan surface is located approximately 320 metres from the eastern site boundary (shown on Figure 1b, Appendix A). It is inferred that this gully will provide a preferential path for any upslope flow on this fan surface, intercepting any large upslope surface flow from entering the proposed building platform.

The crest of the fan surface extends in a southerly direction to the incised channel of Southerly Creek and it is inferred that Southerly Creek will provide a preferential path for any drainage upslope of the local fan surface.

Southerly Creek tracks along the southern boundary of the lot, approximately 100 m south of the building platform before exiting through a culvert to the neighbouring property. It should be noted that the incision of the southern gully and Southerly Creek has formed a ridge feature. This ridge feature continues downslope from the proposed building platform providing an effective barrier between Southerly Creek and the site.

The locations and extent of the significant topographic and drainage feature are shown on Figure 1b, Appendix A.

No surface water was observed within the building platform area during site investigations.

Seepage was recorded in Test Pit 4, 5 and 6.

3 Geotechnical Investigations

An engineering geological site inspection has been undertaken with confirmatory subsurface investigations including geomorphic mapping of the proposed building platforms and surrounding area. The following geotechnical investigations were completed on site between the 23rd and 24th of July 2019 for the purposes of this report:

- 7 test pits (TP1-7) which were advanced to a maximum depth of 6.0 m below ground level (bgl) to produce geological logs of the subsoils;
- Geomorphological mapping of the proposed building platforms and surrounding area was undertaken by an engineering geologist to assess the landforms and natural hazards at the subject site, accompanied by preliminary hazard modelling;
- Inspection of the Stoney Creek Quarry;
- Aerial photography analysis to assess the geomorphology and natural hazards at the subject site;
- A review of a Geotechnical Report prepared for a proposed development in the neighbouring property undertaken by Tonkin & Taylor entitled “The Oasis Development, Stoney Creek, Frankton- Natural Hazard Assessment Report”, dated May 2008.

Test pit and Scala Penetrometer locations and logs are contained in Appendix A and B respectively.

4 Subsurface Conditions

4.1 Geological Setting

The site is located in the Wakatipu basin, a feature formed predominantly by glacial advances. Published references indicate the last glacial event occurred in the region between 10,000 and 20,000 years ago. Glaciations have left deposits of glacial till, glacial outwash and lake sediments over ice–scoured bedrock. Post glacial times have been dominated by the erosion of the bedrock and glacial sediments, with deposition of alluvial gravels by local watercourses, and beach and lacustrine sediments during periods of high lake levels.

No active fault traces are known by GeoSolve to exist in the immediate vicinity of the site, although an inactive fault trace is inferred to be present approximately 200 m to the north. However, a significant seismic risk exists in the region from potentially strong ground shaking associated with rupture of the Alpine Fault which is located along the west coast of the South Island. There is a high probability that an earthquake with a magnitude greater than 8 will occur on the Alpine fault within the next 50 years.

4.2 Stratigraphy

The subsurface material observed during site investigations comprised:

- 0.0- 0.3m of **Topsoil**, overlying:
- 0.4 - 4.0m of **Fan Alluvium,** overlying:
- 1.6 – 5.3m of **Outwash Gravels**, overlying:
- 0.0 – 1.7m of **Glacial Till**, overlying:
- 0.0 – 0.9m of **Glacial Gravels**, overlying:
- **Schist bedrock** at depth (inferred).

Topsoil was observed at the surface of all test pits to depths of 0.3m, consisting of dark brown organic sandy silt with gravel and rootlets.

Fan alluvium has been identified at the test locations. These sediments generally comprise two distinct units. The two units are:

- **Gravels and Sandy Gravels** (Fan Alluvium) generally comprising medium dense to dense gravels and sandy gravels, with a variable constituent of silt, observed in TP1, TP4 to TP7 inclusive.
- **Sandy Silt** (Fan Alluvium) generally comprising stiff to very stiff non-plastic sandy silt, with a variable constituent of gravel, observed in TP2 and TP3 to a depth of 0.7 m bgl.

Outwash Gravels have been identified at the test locations. These sediments generally comprise dense bedded sandy gravels, with a variable component of silt, cobbles and boulders. The base of the outwash gravels were not encountered in TP1, TP4 to TP7 inclusive.

Glacial Till has been identified at the location of TP5 and TP6. These sediments generally comprise generally comprising very stiff to hard non-plastic sandy silt. The lateral extent of these soils were not defined during the site investigations.

Glacial Gravels have been identified at the location of TP5 and TP6, generally comprising dense sandy gravels. The extent of the glacial gravels was not encountered in TP5 and TP6.

Full details of the observed subsurface stratigraphy can be found within the test pit logs contained in Appendix B.

Schist bedrock is inferred to underlie the subject site at depth.

Figure 2a, 2b, 2c & 2d, Appendix A, provides a ground model through the reservoir area.

It should be noted that two machine boreholes were undertaken within the Stoney Creek Quarry as part of the liquefaction assessment for the Tonkin and Taylor May 2008 Geotechnical Report prepared for The Oasis development. The machine boreholes BH01 and BH02 were advanced to 10.5 m and 12 m respectively. Sandy gravels inferred to be outwash alluvium were encountered to the extent of the machine boreholes.

The machine borehole locations and logs are contained in Appendix A and B respectively.

Sandy gravels were also generally observed in the excavated walls of Stoney Quarry, located downslope of the subject site. The quarry walls were inferred to be up to 20 m in vertical height and comprised lenses of sand, silt and fine gravel within the alluvium.

4.2.1 Groundwater

The regional groundwater table was not intercepted in the test pitting investigation and previous machine borehole investigation. The regional groundwater table is expected to be at significant depth beneath the development.

Perched seepages where identified in test pits 4, 5 and 6. Flow rates of up to 2-4L/min were estimated in the field.

Perched water tables may generally occur at the contact of the fan alluvium and outwash gravels, or outwash gravels and glacial soils.

Perched seepages or the regional groundwater were not encountered within quarry walls, located immediately downslope of the subject site, indicating unsaturated sandy gravels extend beyond 20 m below the proposed building platforms.

5 Hazard Assessment

5.1 Landslide

5.1.1 Remarkables Terrace

An area of inferred landslide activity, which is shown on the QLDC hazard maps, lies to the north east (upslope) of the site boundary, as shown on Figure 1a, Appendix A. This landslide is classed by QLDC as "non-verified" This is sourced from IGNS QMAP 1:50,000 Compilation Sheets.

We understand that the mapping of the landslide feature at the site is based on a broad-brush aerial photography assessment. Detailed geomorphological field mapping and an aerial photography analysis has been conducted as part of the hazard assessment for the subject site.

The ground surface up slope of the site appears to naturally steepen locally at the locations of both aggregational terraces and degradational depressions. No deep seated, recent or active slope instability was observed by GeoSolve Ltd during the site walkover in the vicinity of the proposed building platform.

No evidence has been identified to date which indicates the site of the proposed building platform or accessway has experienced historic or recent geotechnical instability and associated ground movement.

Given the age of the soil deposits encountered during the test pit investigation (fan alluvium overlying outwash gravels), absence of subsurface landslide debris material and the lack of geomorphological evidence for movement, it is expected that the area of the proposed development has not been affected by slope instability. There is a nil to extremely low risk from the mapped landslide feature adversely affecting the stability of the proposed development.

These findings are generally in agreement with the visual appraisal conducted by Tonkin & Taylor for the May 2008 report. The report states:

> *"Engineering geological mapping and interpretation based on aerial photos and site walkover show no visible signs of current or historic slope instability (including landslide movements) occurring on the slopes between Kingston Road (SH6) and the toe of the Remarkables, and for at least 1km to the north and south of the site."*

5.1.2 Western Slopes of The Remarkables

A QLDC mapped non-verified landslide feature is located within the south facing catchment slopes of Stoney Creek, as shown on Figure 1a, Appendix A. This feature is located approximately 1000 m to the east of the proposed building platform. From the results of the aerial photography analysis the mapped extent of the instability is inferred to be historical and typical of a creeping schist landslide, likely to be activated by the ongoing incision of the toe of the slide by Stoney Creek and increases in porewater pressure.

It should be noted that recent fresh scarps are located in close proximity at the toe of the south facing slope, adjacent to Stoney Creek. Given the proximity of this feature from the subject site (approximately 1100 m) and relatively low angle topography along this distance, there is a nil to extremely low risk from the mapped landslide feature adversely affecting the stability of the proposed development.

It should be noted that this landslide feature is a possible source area for material to discharge into Stoney Creek, contributing to a potential debris flow hazard from this source of instability within the catchment, further details of this hazard are discussed in Section 5.2 of this report.

5.2 Alluvial Fan

5.2.1 General

According to QLDC hazard mapping, the proposed development is mapped as a "less recently active fan" in the ORC alluvial fan mapping, as shown on Figure 1a, Appendix A.

An alluvial fan hazard assessment has been undertaken for the proposed development.

Stoney and Southerly Creeks have deeply incised the slope that the proposed development is sited on, located to the north and south of the proposed development respectively.

5.2.2 Stoney Creek

Stoney Creek is located to the north of the proposed development and is generally moderately to deeply incised. To the north east of the proposed building platform the channel transitions from being moderately incised to having a relatively flat bed, creating an area where avulsion could occur. It is inferred that flood flows could cause avulsion, similarly mobilisation of the identified landslide material into the channel could block the channel and enable a debris flood/flow situation.

Avulsion of the Stoney Creek channel could result in flow into the overland flow paths surrounding the main channel of the creek. These overland flow paths appear to have been subject to human modification as part of the quarry development in the northern part of the quarry and now converge into one main channel above the quarry, to the north of the subject site.

Access roads within the site are also likely to provide preferential flow paths during avulsion of the river channel.

The proposed building platform is separated from the "recently active" mapped alluvial fan hazard associated with Stoney Creek by elevated aggregational mound features. The proposed building platform appears to be sufficiently setback, approximately 250-300 m, to mitigate any potential alluvial fan hazard from the main channel of Stoney Creek.

A mapped "fan recently active" QLDC mapped hazard, inferred to be associated with the historical avulsion of Stoney Creek, is located upslope to the north east of the site, approximately 350-400 m of the proposed building platform. It is inferred that this channel is now abandoned and is not anticipated to affect the proposed development.

In summary, the avulsion of Stoney Creek is considered feasible, however, the reservoir site is assessed to be adequately protected by the existing natural landforms and slope contours directly upslope.

5.2.3 Southerly Creek

A deeply incised gully, Southern Gully, is located on the south of the site and the crest of this steeply sloping gully feature is approximately 20-25 metres from the proposed building platform. It is inferred that the southern gully will provide a preferential path for any upslope drainage and will mitigate any potential alluvial fan hazard from the south.

As discussed, it should be noted that the incision of the southern gully feature and Southerly Creek has formed a ridge feature between Southerly Creek and the proposed building platform. This ridge feature is observed to continue below the proposed building platform and the likelihood of an alluvial fan hazard from Southerly Creek affecting the site is considered very low.

In summary the natural landforms and slope contours provide sufficient protection to the reservoir site from activity associated with Southern Gully and Southerly Creek.

5.2.4 Building Platform

The building platform is generally lacking any features that would suggest recent alluvial fan activity.

It should be noted that the fan alluvium material is a relatively shallow, up to approximately 0.9 m below the existing ground surface at the location of the proposed building platform. The fan alluvium is underlain by outwash gravels or glacial soils generally encountered to the extent of the subsurface investigations, confirming that deposition at the site has been governed primarily by a glacial processes and alluvial fan deposition is limited to post-glacial fan deposition of incising drainage channels.

In general, significant topsoil development indicated a substantial passage of time since alluvial activity. This suggests the fan deposits are historic and their accumulation is not an active or recent process.

Based on the above, the risk of alluvial fan activity affecting the proposed development is considered to be very low and unlikely to affect the proposed development and no mitigation measures or further assessment is required for the proposed development with respect to this hazard.

Nevertheless, it is understood that the proposed protective bund located at the crest of the building platform batter slope excavation will provide mitigation to any sheet flow runoff that may be possible during periods of high rainfall.

5.3 Liquefaction

On the QLDC hazard mapping the site is classed as LIC 1 (P). This indicates the site has a probably low risk of liquefaction but requires specific investigations for a definitive assessment.

A site wide liquefaction risk review has been conducted for the purposes of this report.

The following comments are provided with respect to liquefaction.

- Discrete perched seepages were encountered in TP 4, 5 & 6 however all other test pits were dry. The regional groundwater table was not intercepted.

- Medium dense to dense/stiff to very stiff soils were intercepted in the test pit locations.
- Sandy gravels were generally observed in the excavated walls of Stoney Quarry located downslope of the subject site.
- Previous machine borehole undertaken in the floor of the Stoney Creek Quarry encountered sandy gravels to a maximum depth of 12 m.
- The previous machine boreholes did not encounter any sand or silt lenses, or the regional ground water level.
- The groundwater table is expected to be greater than 20m below ground surface at the site.
- A non-liquefiable crust is present below the proposed building platform.

Based on the above observations the risk of liquefaction is considered low at the site. No further engineering consideration is required with respect to this hazard.

5.4 Rockfall

The site is located proximity 1000 m from the toe of the steeply sloping Remarkables mountains, upslope of the eastern site boundary. No angular schist boulders indicative of rock fall debris were identified within or immediately upslope of the subject site.

A preliminary rock fall analysis has been undertaken to determine the spatial extent of a modelled rock fall event. A 3D statistical rock fall analysis has been undertaken using RAMMS (Rockfall) software.

The potential trajectories of the modelled rock falls for the Remarkables bluff systems, assuming no forest are shown on Figures 2 -3 below.

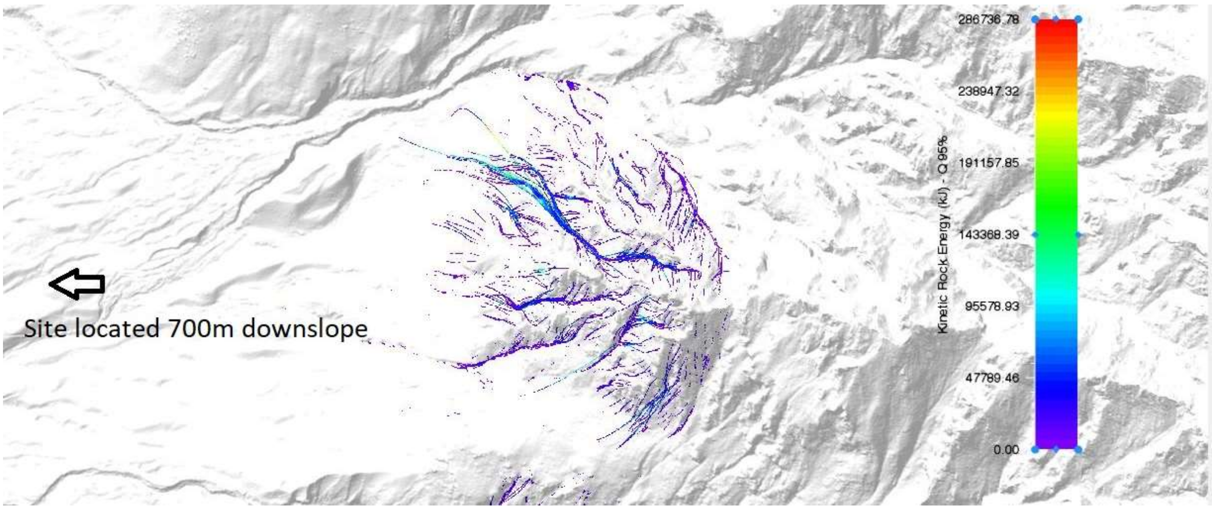

Figure 2: Screen shot showing theoretical trajectories of all modelled rock falls from an area release type (Remarkable Bluffs) with trees not present on the slopes beneath. The site is located downslope and is not shown.

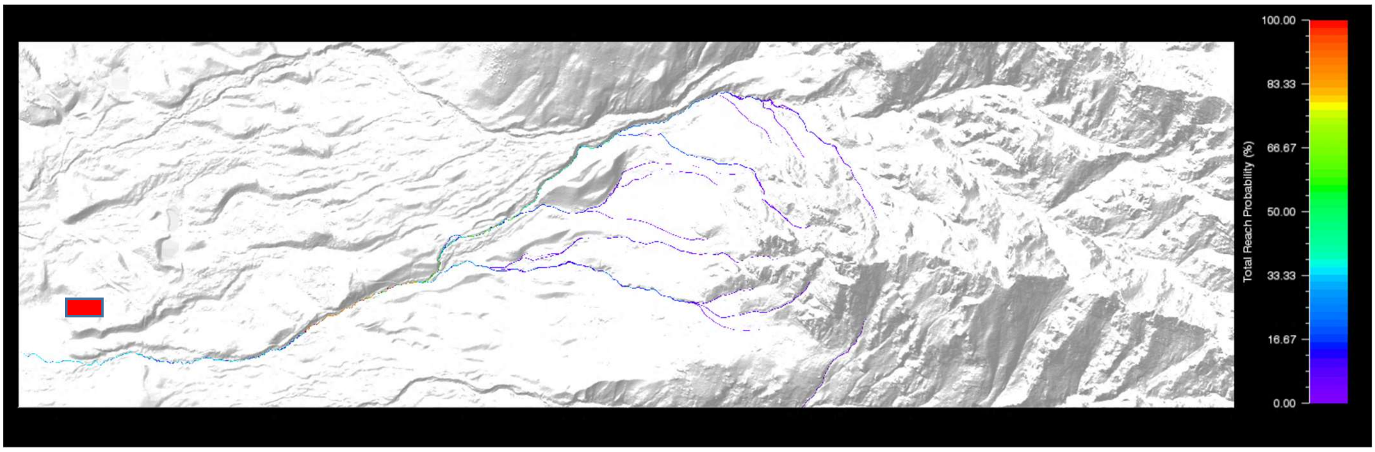

Figure 3: Screen shot showing the probability that a modelled rockfall will reach a given cell within the model (total reach probability) of all modelled rock falls from an area release type (Remarkable Bluffs) with trees not present on the slopes beneath. The site boundary of the site boundary is shown in red.

The results of the assessment suggest the slope topography significantly influences the run-out area and energy of the rock fall and that large rockfall boulders will funnel into existing incised drainage paths and will not runout into the subject site.

In general, we consider the risk of rock fall at the proposed site to be low based on our site walkover, mapping, and 3-D rock fall modelling.

We conclude that construction of the proposed development is feasible from a rock fall risk perspective and no mitigation works are required with respect to this hazard.

6 Engineering Considerations

6.1 General

The recommendations and opinions contained in this report are based upon ground investigation data and mapping obtained at discrete locations on site and historical information held on the GeoSolve database. The nature and continuity of subsoil conditions away from the investigation locations is inferred and cannot be guaranteed.

6.2 Geotechnical Parameters

Table 1 provides a summary of the recommended geotechnical design parameters for the soils expected to be encountered during construction of the proposed new building platforms.

Table 1 - Recommended Geotechnical Design Parameters

Unit	**Thickness (m)**	**Bulk Density** γ **(kN/m^3)**	**Effective Cohesion** c´ **(kPa)**	**Effective Friction** ϕ´ **(deg)**	**Elastic Modulus E (kPa)**	**Poissons Ratio** ν
Topsoil (organic SILT)	0.3	To be removed beneath building platforms				
Engineered Fill	-	18	0	35 (TBC)	20,000-30,000	0.3
Fan Alluvium (medium dense to dense GRAVEL and sandy GRAVEL and stiff to very stiff sandy SILT)	0.4- 4.0	18	0	Sandy GRAVEL 32-34 SILT 30-32	5,000 - 20,000	0.3
Outwash Gravels & Glacial Gravels (dense, sandy GRAVEL with minor/trace cobbles and silt and trace boulders)	0.00-5.3+	19	0	35-36	30,000	0.3
Glacial Till (very stiff to hard sandy SILT)	0.0-1.7	18	2	34	20,000	0.3

6.3 Site Preparation

During earthworks operations all topsoil, organic matter, and other unsuitable soils should be removed from the construction areas in accordance with the recommendations of NZS 4431:1989.

Robust, shallow graded sediment control measures should be instigated during construction where rainwater and drainage run-off across exposed soils is anticipated. If slope gradients in excess of 4% are proposed in erosive soils then the construction and lining of drainage channels is recommended, e.g. with geotextile and suitably graded rock, or similarly effective armouring.

Exposure to the elements should be limited for all soils and covering the soils with polythene sheeting will reduce degradation due to wind, rain and surface run-off. Excavations in soils should be left proud of the finished subgrade level by 200 to 300 mm if a delay prior to construction is expected. The final cut to grade should be performed immediately prior to foundation construction.

Water should not be allowed to pond or collect near or under a foundation slab. Positive grading of the subgrade should be undertaken to prevent water ingress or ponding.

All fill that is utilised as bearing for foundations should be placed and compacted in accordance with the recommendations of NZS 4431:1989 and certification provided to that effect.

We recommend topsoil stripping and subsequent earthworks be undertaken only when a suitable interval of fair weather is expected, or during the earthworks construction season.

6.4 Excavations

Cut excavation excavations will be required for the construction of the proposed development. The cuts will be formed within fan alluvium and outwash gravels.

Recommendations for temporary slope batters are described in the following sections. Slopes that are required to be steeper or higher than those described below should be structurally retained or subject to specific geotechnical design.

A slope stability assessment has been undertaken for the proposed permanent cut slope batters associated with the proposed development, further details and recommendations are provided in Section 6.8 of this report.

All slopes should be periodically monitored during construction for signs of instability and excessive erosion, and, where necessary, corrective measures should be implemented to the satisfaction of a Geotechnical Engineer or Engineering Geologist.

Seepages were observed in the test pits and are likely to be encountered in areas of the excavation. Drainage measures, such as horizontal drains, will be required if excessive groundwater seepages are encountered during excavation (see Section 6.7). The final design and location of all sub-soil drainage works should be confirmed during construction by a suitably qualified and experienced Geotechnical Engineer or Engineering Geologist.

Table 2 summarises the recommended batter angles for temporary batter slopes up to 6 m high, which are formed in the soil materials identified at the site, not associated with the proposed building platform.

Table 2 Recommended maximum batter angles for cut slopes up to 6 m high in site soils.

Material Type	Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Soil (horizontal to vertical)	
	Dry Ground	Wet Ground
Topsoil Fan Alluvium	2H: 1V	3H: 1V
Fan Alluvium	1.5H: 1V	3H: 1V
Outwash Gravels & Glacial Gravels	1.0H: 1V	2H: 1V
Glacial till	0.5H: 1V	2H: 1V

The temporary batter slopes in wet soils are provisional only and should be inspected on a case by case basis.

6.5 Engineered Fill and Engineered Fill Slopes

All fill should be placed and compacted in accordance with the recommendations of NZS4431: 1989 and Queenstown Lakes District Council Standards. All cut and fill earthworks should be inspected and tested as appropriate during construction and certified by a Chartered Professional Engineer.

The fan alluvium (sandy gravel) and outwash gravels could be used as engineered fill on site. The topsoil is not suitable for reuse as a fill source, however can be used for re-topsoiling and in landscaping areas. Due to the changeable grain size of the natural soil materials on site, a range of compaction reference tests will be required. Maximum density and optimum moisture content will vary. Additionally, due to the high proportion of fine-grained soil material observed within the site there should be a contingency in the earthworks programme and budget to strip wet and weaving layers and allow drying time following rainfall. Compaction of the fill sources at lab tested optimum moisture content is critical for these soil types. Cobbles and boulders over 100 mm in size will need to be screened from fill sources. Boulders up to 0.5 m in diameter were observed during the site investigations. Due to the fine-grained soil materials it is recommended that earthfills are completed during warmer months.

All fill slopes less than 3 m in height should be constructed with a maximum batter slope angle of 2.0H: 1.0V (horizontal to vertical) or flatter, if well drained and not structurally influencing the proposed reservoir or other associated structures. If fill slopes are required that do support a structure specific engineering design should be required.

A slope stability assessment has been undertaken for the proposed engineered fill slopes associated with the proposed development, further details are provided in Section 6.8 of this report.

Geogrid reinforced slopes can be considered if engineered fill batters need to be steeper than the above guidelines.

6.6 Ground Retention

All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 1 of this report. Due allowance should be made during the detailed design of all retaining walls for forces such as surcharge due to the sloping ground surface behind the retaining walls, groundwater, seismic and traffic loads.

All temporary slopes for retaining wall construction should be battered in accordance with the recommendations outlined in Table 2 of this report. Where these batter slopes cannot be achieved temporary retaining will be required.

Groundwater seepage was regularly observed during investigations, infiltration of surface water behind retention structures, in particular as a result of heavy or prolonged rainfall, can occur. To ensure potential water seepage or flows are properly controlled behind retaining walls, the following recommendations are provided:

- A minimum 0.3 m width of durable free draining granular material should be placed behind all retaining structures;
- A heavy duty non-woven geotextile cloth, such as Bidim A14, should be installed between the natural ground surface and the free draining granular material to prevent siltation and blockage of the drainage media;
- A heavy-duty (TNZ F/2 Class 500) perforated pipe should be installed within the drainage material at the base of all retaining structures to minimise the risk of excessive groundwater pressures developing. This drainage pipe should be connected to the permanent piped storm water system, and;
- Comprehensive waterproofing measures should be provided to the back face of all retaining walls forming changes in floor level within the dwelling to remove groundwater seepage into the finished buildings.

It is recommended that the retaining wall excavation batters are inspected by a suitably qualified and experienced Geotechnical Engineer or Engineering Geologist.

6.7 Groundwater Issues

The regional water table is expected to lie well below the finished excavation and foundation levels. Dewatering or other groundwater-related construction issues are therefore unlikely to be required.

Perched groundwater was observed within Test Pits 4, 5 and 6, and is expected to be encountered during the bulk excavation. The presence of discrete seepages is likely to negatively impact on the stability of the soil slopes over time, and shallow slips, scour and erosion may develop. To control this risk the following options are recommended:

- All areas of seepage to be reviewed during the bulk earthworks by a geotechnical engineer/engineering geologist and, if appropriate, recommendations provided;
- A cut–off drain and swale upslope of the reservoir is recommended in the first instance. The drain (TNZ F/2 Class 500) will need to be located to the base of the proposed excavation and outfall away from the cut. The swale should intercept surface run-off. The final location and depth of the drain should be confirmed on-site. A detail for the cut-off drain can be provided if required;

- Locally re-grading the slopes to shallower angles and other drainage as considered necessary.

6.8 Slope Stability

6.8.1 Design Earthquakes

For the slope stability analysis the design earthquakes have been divided into 2 categories, as follows

- Slopes that can directly affect the building platform, assessed as importance level 4 (IL4), and;
- Slopes considered unable to significantly affect the platform, assessed as importance level 2 (IL2).

The importance level 4 slopes are listed as follows:

- The natural slope to the west of the platform, both with and without the visual mitigation mound;
- The natural slope to the south of the platform, down into Southern Gully, and;
- The proposed cut slope on the eastern (upslope) side of the platform.

In accordance with NZS1170 – Structural Design Actions[1], the following three earthquake scenarios have been considered for the IL4 slopes based on a 50-year design life.

- **Serviceability Limit State - IL 4 (SLS1)** – to avoid damage that would prevent the structure from being used as originally intended without repair (including structural and non-structural components);
- **Serviceability Limit State - IL4 (SLS2)** – the structure maintains operational continuity;
- **Ultimate Limit State - IL 4 (ULS)** – to avoid collapse of the structural system.

The earthquake scenarios used in our analyses of the IL4 slopes are presented in Table 3.

Table 3: Earthquake scenarios used in the slope stability assessment for the IL 4 slopes

	Serviceability Limit State (SLS1) design earthquake IL4	**Serviceability Limit State (SLS2) design earthquake IL4 (Only)**	**Ultimate Limit State (ULS) design earthquake IL4**
Return period (years)	25	500	2500
Moment Magnitude, Mw	6.3	6.3	6.5
Peak horizontal ground acceleration, PGA	0.10g	0.41g	0.74g

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[1] *NZS1170-5 (2004) Structural Design Actions, Part 5: Earthquake Actions – New Zealand.*

Slopes considered unable to significantly impact the building platform should failure occur have been assessed as IL2 structures. In this case the visual mitigation mound proposed on the western side of the reservoir platform is the only slope in this category. Using a 50-year design life the earthquake scenarios are presented in Table 4.

Table 4: Earthquake scenarios used in the slope stability assessment for IL 2 Slopes.

	Serviceability Limit State (SLS1) design earthquake IL2	**Ultimate Limit State (ULS) design earthquake IL2**
Return period (years)	25	500
Moment Magnitude, Mw	6.3	6.3
Peak horizontal ground acceleration, PGA	0.10g	0.41g

In terms of NZS 1170, for both importance cases, Class C sub-soil conditions (shallow soils) are considered to underlie the site. Class D, deep soils, may be present however Class C provides a more conservative assessment.

All slopes have been analysed using the software programme Slope/W and the impact on the proposed development assessed.

6.8.2 Design and Analysis Considerations

We have assumed dry conditions for analysis, and that the proposed cut-off drain will intercept the encountered seepage and that a design flood event will not saturate the excavated building platform.

Saturation of the proposed building platform and southern gully from the overflow discharge channel or flooding event has not been assessed for the purpose of the slope stability analysis described herein.

Saturation of the building platform and surrounding slopes will negatively influence the stability of the site. It is recommended that consideration be given to a flood event, for the building platform and southern gully, at detailed design.

We have assumed the current location of Stoney Creek Quarry for our slope stability analysis. It is understood there is an approved consent enabling quarrying to advance upslope from the crest of the existing quarry, i.e. closer to the proposed reservoir site. It is recommended that additional slope stability analysis is conducted if quarrying earthworks are undertaken closer than 50 m from the toe of the terrace slope.

6.8.3 Stability Analysis Results IL4 Slopes

6.8.3.1 Permanent batter slope – Upslope Cut

Permanent soil cuts, up to approximately 7.0 m in depth and formed at 2H:1.0V, are proposed on the eastern, upslope side of the building platform. A protective mound, up to 1.25 m in vertical height, is proposed adjacent to the crest of this slope. The Slope/W results are provided in Table 5 below.

Table 5: Slope/W analysis results for the Building Platform Batter slope

Stability Case	Target Factors of Safety	Result
Static	> 1.5	1.21-1.46
SLS 1	> 1.2	0.98-1.16
SLS 2	> 1.2	0.56-0.66
ULS	No Target. Magnitude of ground displacements to be estimated.	130-500 mm

The results indicate the stability of the slope does not meet the requirements of the building code with respect to the static, SLS1 and SLS2 cases.

In order to meet the requirement of the building code the slope would need to be regraded to a shallower angle, preliminary assessment of this regrade shows that slope angles will need to be shallower than 3.0H: 1.0V. Due to the sloping nature of the site a 3.0H:1.0V is unlikely to be practical and alternative options are:

- Structural retention, or;
- constructing the slope at the proposed 2H:1.0V and ensure an adequate setback from the slope toe to the reservoir structure is provided.

Should instability of the 2H:1V slope occur the shear plane is expected to exit the slope close to the toe potentially resulting in uplift. A minimum set back of 4 m is recommended in the first instance, sufficient to enable vehicle access between the slope toe and the reservoir structure. In the event of a ULS earthquake some remedial works on the slope may be required however the reservoir should not be adversely affected if sufficiently set-back from the toe.

6.8.3.2 Downslope Terrace Slope

Approximately 30 m to the west, or downslope of the building platform, the crest of a steep terrace slope is present. The terrace slope topographically separates the site from Stoney Creek Quarry. A visual protection mound is proposed adjacent to the crest of the sloping terrace slope. Fill earthworks up to approximately 10.5 m in depth are required for the construction of this mound.

The stability of the terrace slope, with and without the visual mitigation mound, and the impact on the building platform assessed and the Slope/W results are provided in Tables 6 and 7 below.

Table 6: Slope/W analysis results for the terrace slope without visual mitigation mound

Stability Case	Target Factors of Safety	Result
Static	> 1.5	2.25-2.46
SLS 1	> 1.2	1.58-1.87
SLS 2	> 1.2	0.82-0.93
ULS	No Target. Magnitude of ground displacements to be estimated.	15-25 mm

Table 7: Slope/W analysis results for the terrace slope with visual mitigation mound

Stability Case	Target Factors of Safety	Result
Static	> 1.5	1.98-2.38
SLS 1	> 1.2	1.52-1.74
SLS 2	> 1.2	0.80-0.91
ULS	No Target. Magnitude of ground displacements to be estimated.	15-30mm

The results indicate the stability of the terrace slope, with and without the visual mitigation mound, does not meet the requirements of the building code with respect to the SLS2 case. Under ULS loading ground displacements of up to 30 mm are expected to occur in close proximity (< 2 m) to the tank foundation area.

In order to mitigate this downslope slope instability several remedial options, or combination of options, are available to address the identified slope stability issues and include;

- Construction of a dense granular geogrid reinforced raft beneath the building platform and/or a geogrid reinforced slope crest;
- Structure strengthening to accommodate expected displacements;
- Construct an in-ground wall along the crest of the slope;
- Construct affected areas of the structure on pile foundations, and;
- Increase platform set-backs from sloping areas.

The stability of the visual mitigation mound is discussed in Section 6.8.3 below.

6.8.3.3 Southern Gully

The stability of the southern gully slope has been analysed and the results are provided in Table 8 below.

Table 8: Slope/W analysis results for the southern gully slope

Stability Case	Target Factors of Safety	Result
Static	> 1.5	3.04
SLS 1	> 1.2	1.96
SLS 2	> 1.2	1.029
ULS	No Target. Magnitude of ground displacements to be estimated.	10-15 mm

The results indicate the stability of the gully slope, do not meet the requirements of the building code with respect to the SLS2 case. Low level levels of ground displacement are calculated to occur in close proximity (< 2 m) to the proposed tank location.

It is recommended that the slope stability of the proposed building platform is reassessed at detailed design stage to confirm if modification of the southern gully slope or specific design of the foundations system is required. The recommendation outlined above in Section 6.8.8.2 are considered appropriate.

6.8.4 Stability Analysis Results – IL2 Slopes

The stability of the visual mitigation mound has also been assessed. The results show that the mound does not meet the requirements of the building code with respect to the static and SLS cases. It is likely that a reduction of the batter slope and/or a geogrid reinforcement will be required to achieve long-term stability of the mound with the proposed batters. To achieve long term stability batter slopes of approximately 3H:1V will be required, assuming the fill comprises well graded granular materials. If 2H:1V batters are unachievable, then geogrid reinforcement will provide an appropriate solution to steepen batters. The final design solution should be subject to specific engineering design during the detailed design phase of the project.

If displacement of the mound is considered acceptable, i.e. maintenance will be undertaken should displacement occur during a seismic event, then batter slopes of 2H:1V are provided for unreinforced slopes.

6.8.5 Slope Stability Summary

A summary of the slope stability analysis is provided in Table 9 below.

The parameters used in the analysis are considered to be conservative. If desired, improvements in the slope stability results are expected to be achievable at the detailed design stage and would require detailed analysis of the surrounding quarry slopes, and/or completion of further ground investigation. Overall ULS Displacements are relatively low and considered to be manageable. Measures to provide a stable tank foundation, e.g. structural engineering, ground improvement or set-back from the slopes, are expected to be readily achievable for the development.

Table 9: Summary of the slope stability results.

Scenario	Level of Importance	Proposed Design Detail	Slope Stability Result	Design Options
Building Platform Batter Slope (upslope of structure)	IL4	2(H):1(V)	Static, SLS 1 & SLS 2 failure. ULS displacements 130-500mm	Regrade to < 3(H):1(V) Or Expect displacement & set-back structure from toe of slope (~4m)
Terrace Slope without Visual Mitigation Mound (downslope of structure)	IL4	Natural ~25-30°	SLS 2 failure. ULS displacements 15-20mm Failure surface ~1-2m from platform	Expect displacement & design structure and/or platform to accommodate ground movement Or Increase structure set-backs from the slope crest
Terrace Slope with Visual Mitigation Mond (downslope of structure)	IL4	Natural ~25-30°	SLS 2 failure. ULS displacements ~30mm Failure surface ~1-2m from platform	Expect displacement & design structure and/or platform to accommodate ground movement Or Increase structure set-backs from the slope crest
Southern Gully Slope (south of structure)	IL4	Natural ~30°	No Static, SLS 1 or SLS 2 failure (FOS 1.029) ULS displacements ~10-15mm Failure surface ~1-2m from platform	Expect displacement & design structure and/or platform to accommodate ground movement Or Increase structure set-backs from the slope crest
Visual Mitigation Mond	IL2	Various	Static and SLS failure. ULS displacements 90+ mm	Regrade to 3(H):1(V)- TBC at DD Or Geogrid reinforcement in the mound

6.9 Foundations

6.9.1 General

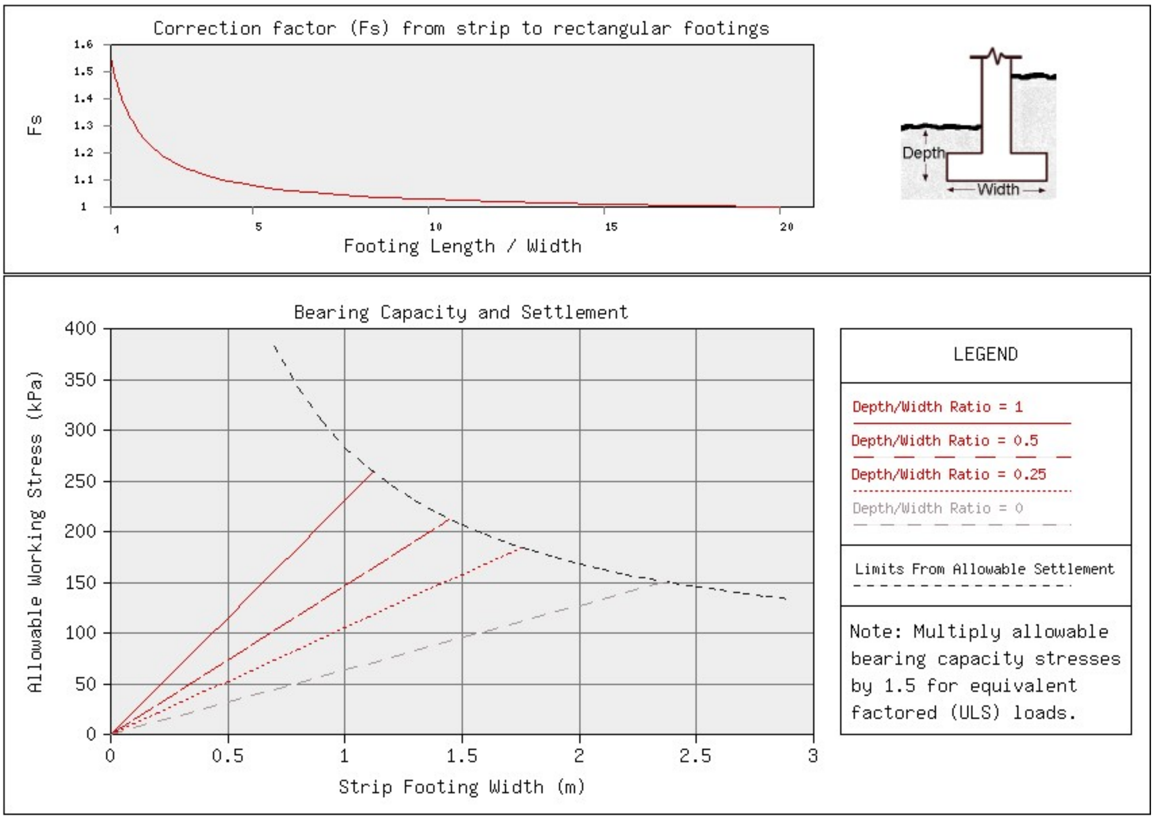
The reservoir foundations are expected to comprise a concrete slab founded at shallow depths. The final foundation solutions should include any requirements determined from the slope stability analysis at detailed design, if appropriate. Where shallow foundations are constructed they should bear on outwash gravels or engineered fill. Topsoil, uncontrolled fill and colluvium will not be suitable for foundation bearing and should be removed from beneath foundation areas.

All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:1989 and certification provided to that effect.

It is recommended the foundation excavations be inspected by a suitably qualified and experienced geotechnical specialist to confirm the conditions are in accordance with the assumptions and recommendations provided in this report.

6.9.2 Shallow Footings

Figure6.1 below summarises the recommended working stresses for shallow footings, which bear upon outwash gravel and engineered fill. It should be noted the foundation working stresses presented on Figure 6.1 are governed by bearing capacity in the case of narrow footings and settlement in the case of wide footings.



Note: Multiply allowable bearing capacity stresses by 1.5 for equivalent factored (ULS) loads.

Figure 6.1. Recommended Bearing for Shallow Footings on outwash gravels or engineered fill.

From Figure 6.1 it can be seen an allowable working stress of approximately 100 kPa is recommended for a 400 mm wide by 400 mm deep strip footing founded within outwash gravels and engineered fill. This corresponds to a factored (ULS) bearing capacity of approximately 150 kPa and an ultimate geotechnical bearing capacity of 300 kPa.

It should be noted that the bearing capacities presented above assume that the loads are vertical with no horizontal loads or moments applied to the foundations. Reduction factors to account for eccentric and/or horizontal loads can be provided during detailed design.

6.9.3 Foundation Options

Under static loadings, shallow strip and pad foundations founded on outwash gravels would be expected to perform adequately at the site.

However, due to the risk of slope displacement, it is considered that discrete shallow foundations alone could not be designed to meet the requirements of the building code, or the performance expectations of the stakeholders.

The following foundation options may also be suitable depending on the requirement of the foundations to accommodate displacement:

- A geogrid reinforced granular or cement stabilised raft underlying a reinforced concrete raft
- Stone Columns

- CFA or Bored Piles

6.9.4 Foundation Selection

Ultimately the foundation decision must be made in conjunction with the client to ensure that the residual site risks meet the building code, are understood and are accepted by all parties.

Selection of the foundation system should be made in collaboration by the structural engineer, the geotechnical engineer, and the client (and their insurers), based on an appraisal of the client’s seismic performance expectations, financial constraints, and constructability issues.

6.10 Stormwater & Overland Flow Paths

Numerous small gully overland flow path features (shown on Figures 1b, Appendix A) are present within, or adjacent to, the proposed lot areas. These small gullies will act as overland flow paths for surface storm water runoff.

Sufficient stormwater drainage of the site is required before construction can begin in any areas in close proximity to the indicative overland flow paths.

A stormwater drainage design is recommended at detailed design stage.

All sources of slope saturation should be eliminated by cut-off drains, swale drains and bunds and redirected around building platforms and access roads.

A geotechnical practitioner should inspect any seepage, spring flow or under-runners that may be encountered during construction of the proposed building platform.

6.11 Accessway

Depending on the final location and extent of the accessway cuts, possibly requiring retaining may be required, and should be reviewed by a geotechnical practitioner to confirm any geotechnical requirements. Underlying fan alluvium and outwash gravels, where not softened by water, are expected to provide CBR values of 10% + with respect to pavement design.

6.12 Site Subsoil Category

For detailed design purposes, it is recommended the magnitude of seismic acceleration be estimated in accordance with the recommendations provided in NZS 1170.5:2004.

The site is likely to be Class C (Shallow soil site) in most locations, however Class D areas are possible. Class D is the conservative assumption and should be considered for detailed design. Specific investigations can be undertaken to confirm the class if critical design elements are present.

6.13 Additional Investigations

If piling is considered, then a sonic borehole will be required to confirm the presence of an adequate bearing stratum and pile design parameters.

It is recommended the foundation subgrade be inspected during construction/platform earthworks by a suitably qualified and experienced geotechnical practitioner to confirm the conditions are in accordance with the assumptions and recommendations provided in this report and future detailed foundation investigation and design.

7 Hazards/Neighbouring Structures

Natural Hazards: Known seismic hazards affecting the development are detailed in Section 4.1 and appropriate allowance should be made for seismic loading during detailed design of any proposed building, retaining walls and foundations.

The reservoir is located close to mapped landslide hazards. The risk of future movement affecting the reservoir is assessed as low, as discussed in Section 5.1.

Alluvial fan hazard present on the QLDC hazard mapping is considered in Section 5.2.

The regional groundwater level is anticipated to lie at moderate depth below the site and therefore the liquefaction risk is considered to be low for the proposed building platforms, as discussed in Section 5.3.

Construction of the proposed development is feasible from a rock fall risk perspective and no mitigation works are required, as discussed in Section 5.4.

Distances to adjoining structures: The subject property is bounded by a commercial quarry to the east and north, farmland to the south and a residential building platform to the west. No adverse effects are considered likely to neighbouring properties as long as silt, dust and noise control measures are instigated during construction.

Aquifers: No aquifer resource will be adversely affected by the proposed development.

Erosion and Sediment Control: The site presents some potential to generate silt runoff and this would naturally drain downslope. Effective systems for erosion control are runoff diversion drains and contour drains, while for sediment control, options are earth bunds, silt fences, hay bales, vegetation buffer strips and sediment ponds. Only the least amount of subsoil should be exposed at any stage and surfacing established as soon as practical. Details for implementation are given. Works should be completed in accordance with QLDC's Land Development and Sub-division Code of Practice, 'A Guide to Earthworks in the Queenstown Lakes District.

Noise: It is expected that earthmoving equipment, such as excavators, compactors and trucks will be required during construction. The construction contractor should take appropriate measures to control the construction noise, and ensure QLDC requirements are met in regard to this issue.

Dust: Regular dampening of soil materials with sprinklers should be effective if required.

Vibration: No vibration induced settlement is expected in the foundation soil types.

8 Conclusions and Recommendations

- Construction of the proposed reservoir is considered acceptable from a geotechnical perspective provided the recommendations of this report are followed;
- The stratigraphy beneath the proposed building platforms comprise surficial layers of topsoil, fan alluvium and outwash gravels overlying glacial soils;
- Groundwater seepage was observed within TPs 4, 5 and 6. Seepages were observed as minor to moderate;
- The regional groundwater table is expected to be at significant depth beneath the development;
- A natural hazard assessment has been undertaken for the mapped hazards affecting the site including landslide, alluvial fan, liquefaction and rockfall. We conclude that construction of the proposed development is feasible from a natural hazard risk perspective and no mitigation works are required;
- Temporary batters within the observed site soils are provided in Table 2, Section 6.4;
- Permanent slope batters that are associated with the proposed building platform are subject to specific geotechnical design;
- Fan alluvium (sandy gravel) and outwash gravels could be used as engineered fill however only during warmer months. The implications and considerations of using fan alluvium as engineered fill is discussed in Section 6.5;
- Permanent engineered fill slopes associated with the proposed building platform are subject to specific geotechnical design;
- Due allowance should be made during the detailed design of all retaining walls for forces such as surcharge due to the sloping ground surface behind the retaining walls, groundwater, seismic and traffic loads;
- Perched groundwater was observed within Test pits 4, 5 and 6, and is expected to be encountered during the bulk excavation. The presence of discrete seepages is likely to negatively impact on the stability of the soil slopes over time, and shallow slips, scour and erosion may develop;
- A slope stability assessment has been undertaken for the proposed building platform and engineered fill slopes associated with the proposed development, further details are provided in Section 6.8 of this report;
- Slopes able to impact the building platform should failure occur have been assessed as importance level 4. Due to the high seismic loads, stability criteria are not me in some cases and consideration will need to be given to final slope batters, structure set-backs, foundations and/or preparation of the building platform to achieve adequate long-term stability;
- The visual mitigation mound has been assessed as importance level 2. The proposed batters do not meet stability criteria. To achieve long term stability geogrid reinforcement, or regrading to a shallower, more stable batter will be required.
- The parameters used in the analysis are considered to be conservative. If desired, improvements in the slope stability results are expected to be achievable at the detailed design stage and would require detailed analysis of the surrounding quarry slopes, and/or completion of further ground investigation. Overall ULS Displacements are relatively low and considered to be manageable. Measures to

provide a stable tank foundation, e.g. structural engineering, ground improvement or set-back from the slopes, are expected to be readily achievable for the development.

- It is recommended that additional slope stability analysis is conducted if quarrying earthworks is proposed to be undertaken closer than 50 m from the toe of the terrace slope;
- It is recommended that the slope stability of the proposed building platform is reassessed at detailed design stage to confirm the recommendations of this assessment are adequately covered;
- All sources of slope saturation should be eliminated by cut off drain's upslope of the cuts and no storm water, wastewater and overflow water should be discharged directly to steep slopes. A stormwater drainage design is recommended at detailed design stage to ensure the platform are remains well drained;
- All unsuitable materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during construction. Any fill that is utilised as bearing for foundations should be placed and compacted in accordance with NZS 4431:1989 and certification provided to that effect;
- The soils present at the site will provide adequate bearing for foundations. Recommendations are provided in Section 6.9;
- It is recommended the foundation excavations be inspected by a suitably qualified and experienced geotechnical specialist to confirm the conditions are in accordance with the assumptions and recommendations provided in this report;
- A geotechnical practitioner should inspect any seepage, spring flow or under-runners that may be encountered during construction of the proposed new building platforms;

9 Applicability

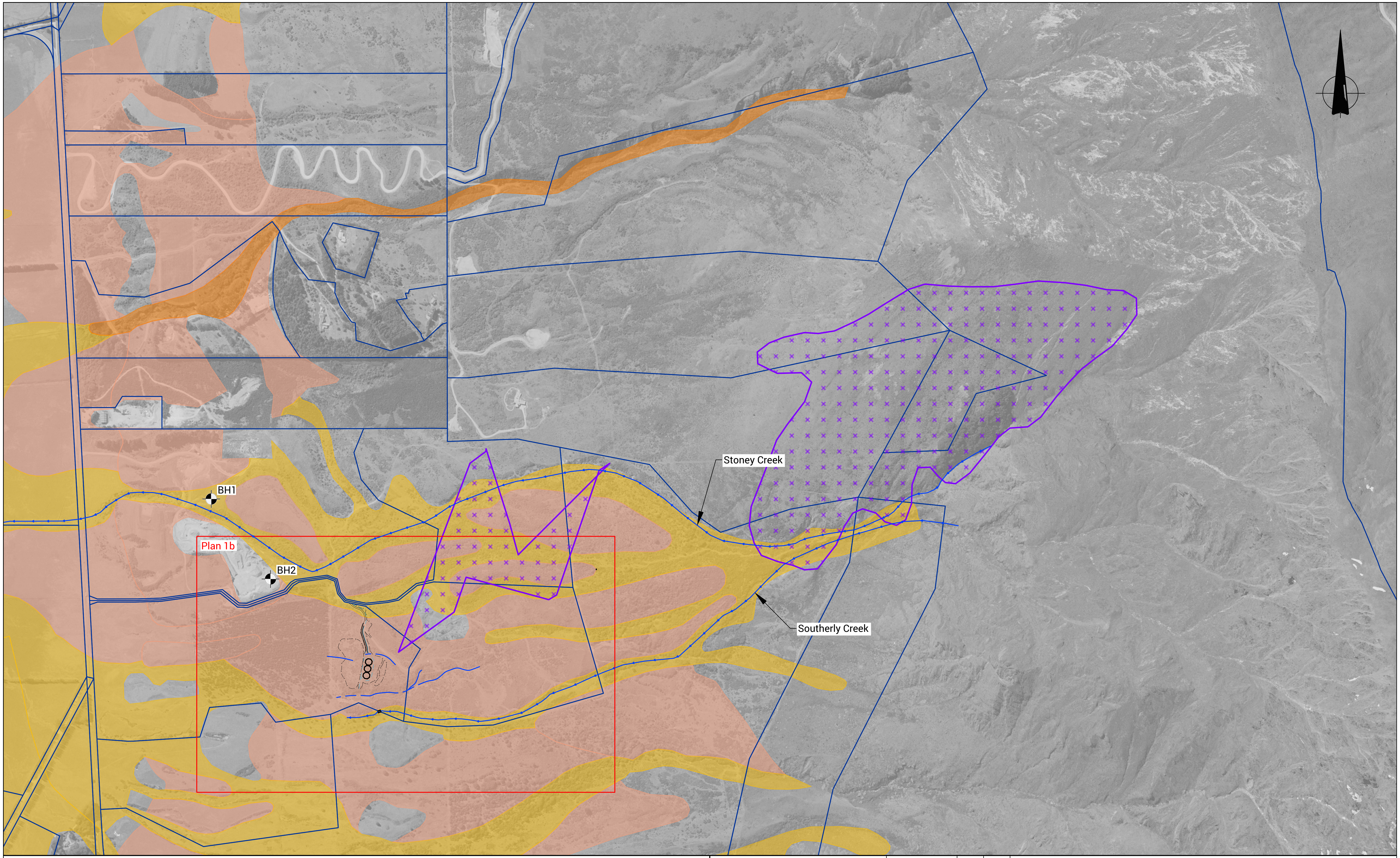
This report has been prepared for the benefit of Scope Resources Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

It is important that we be contacted if there is any variation in subsoil conditions from those described in this report.

Please do not hesitate to contact the undersigned if we can provide any further assistance with this project.

Report prepared by:	Reviewed for GeoSolve Ltd by:
....	....
Simon Reeves Engineering Geologist	Paul Faulkner Senior Engineering Geologist

Appendix A: Site Investigation Plans and Cross-Sections



Notes:
1. These drawings have been prepared for the benefit of Scope Resources Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Legend:

🟧	Alluvial Fan - Active Bed (ORC)	⊕	Machine Borehole (put down for Tonkin & Taylor May 2008 report for liquefaction assessment)
🟨	Alluvial Fan - Recently Active (ORC)	▨	Alluvial Fan - Less Recently Active(ORC)
		× ×	Landslide Areas - non verified (QLDC)

SCALE 1:10,000

0 100 200 300 400 500 (m)

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DRAWN	WCG	Aug.19
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APPROVED	PGF	Aug.19

CADFILE:
190413.dwg

SCALES (AT A3 SIZE):
1:10,000

PROJECT No:
190413

Scope Resources Ltd

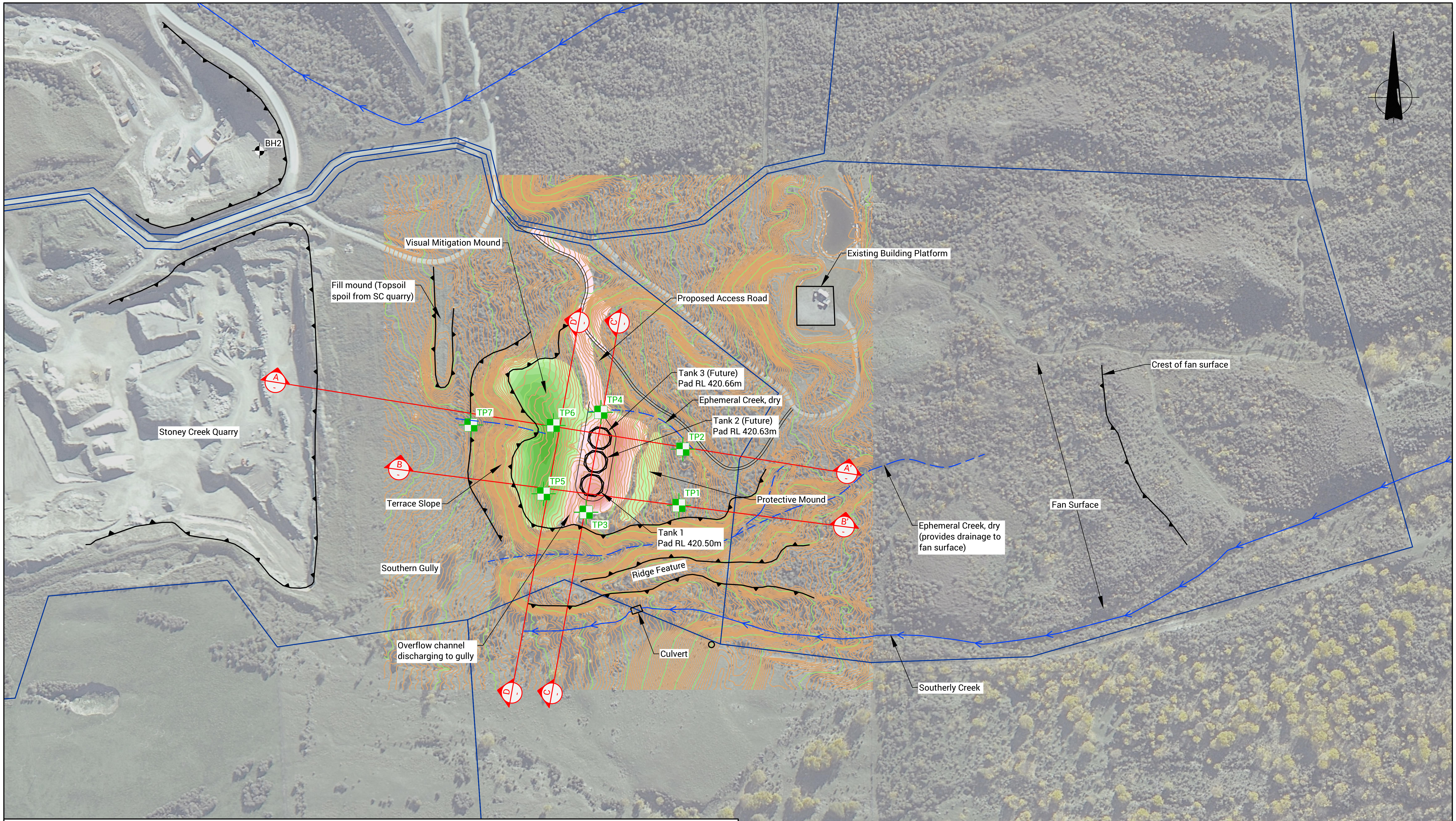
Water Reservoir Coneburn

Geotechnical Investigations

Hazards Plan

FIG No:
Figure 1a

REV.
0



Notes:
1. These drawings have been prepared for the benefit of Scope Resources Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.
2. Contour source is QLDC 2016 Wakatipu Lidar (2m).

Legend:

TP1	GeoSolve Test Pit	A	Geological Cross Section		Machine Borehole (put down for Tonkin & Taylor May 2008 report for liquefaction assessment)
🟥	Proposed Excavation	🟩	Proposed Filling		Change in Slope
	Approximate location of creek		Overland flowpath		

SCALE 1:3000
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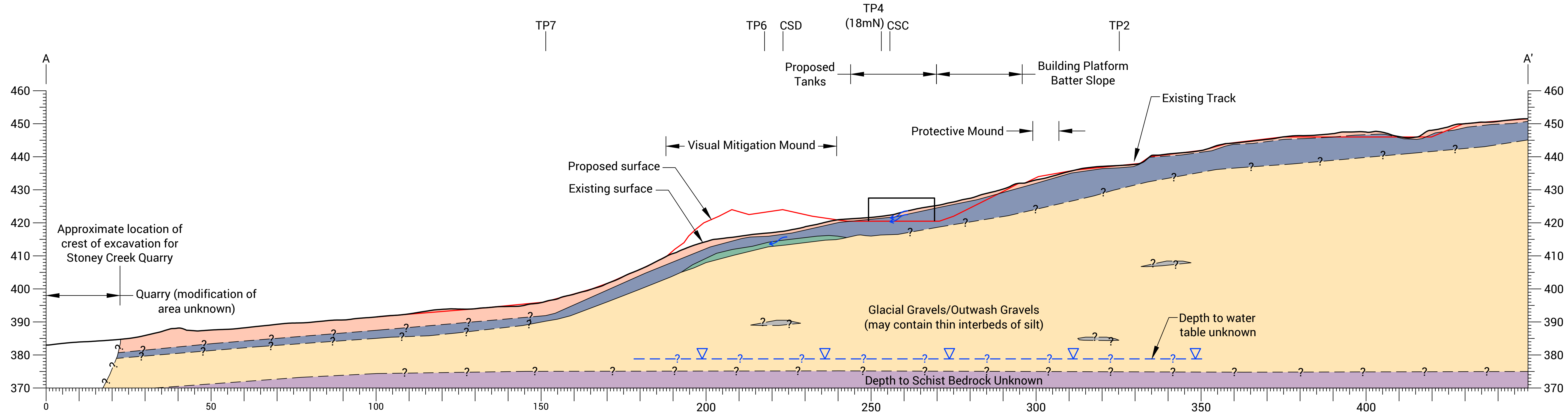
CADFILE: 190413.dwg
SCALES (AT A3 SIZE): 1:3000
PROJECT No: 190413

Scope Resources Ltd
Water Reservoir Coneburn
Geotechnical Investigations
Investigation Plan

FIG No: Figure 1b
REV. 0



Legend:

🟥 Fan Alluvium

🟩 Glacial Till

🟦 Outwash Gravels

🟨 Outwash Gravels/Glacial Gravels

🟪 Schist Bedrock

↙ Observed Seepage

Notes:

1. These drawings have been prepared for the benefit of Scope Resources Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

SCALE 1:1250

0 12.5 25.0 37.5 50.0 62.5 (m)

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APPROVED	PGF	Aug.19

CADFILE: 190413.dwg

SCALES (AT A3 SIZE): 1:1250

PROJECT No: 190413

Scope Resources Ltd

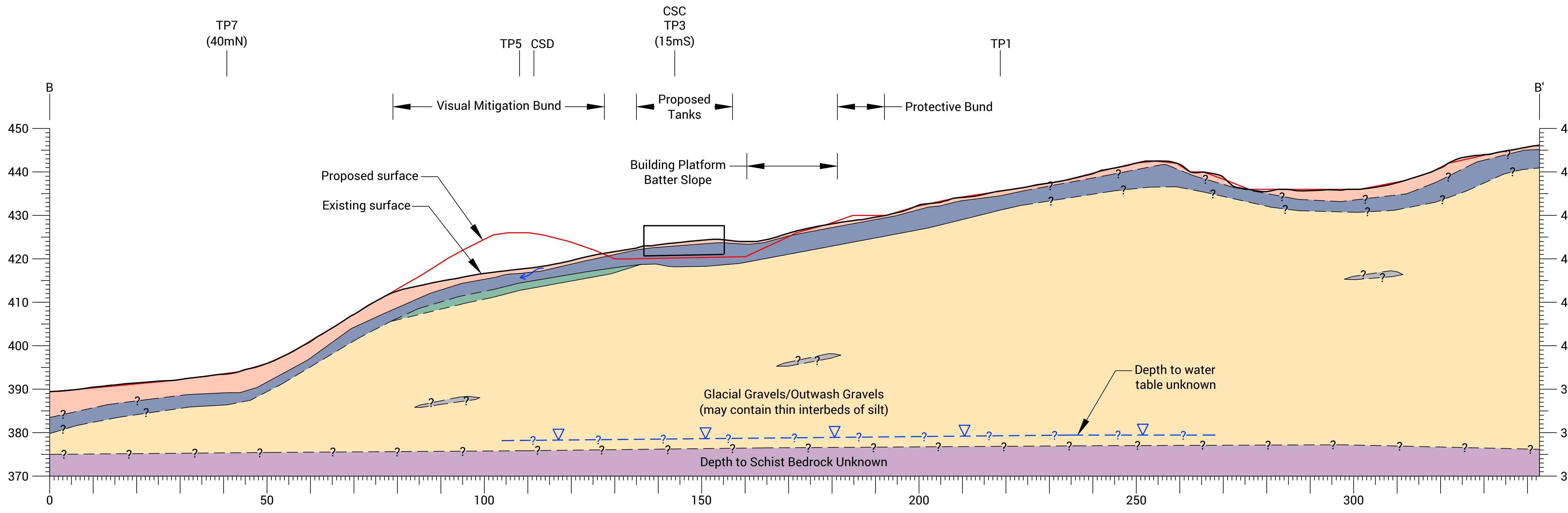
Water Reservoir Coneburn

Geotechnical Investigations

Cross Section A

FIG No: Figure 2a

REV. 0



Legend:

- ▨ Fan Alluvium
- ▨ Glacial Till
- ▨ Outwash Gravels
- ▨ Outwash Gravels/Glacial Gravels
- ▨ Schist Bedrock
- ↙ Observed Seepage

Notes:

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SCALE 1:1000

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APPROVED	PGF	Aug.19

CADFILE: 190413.dwg

SCALES (AT A3 SIZE): 1:1000

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Water Reservoir Coneburn

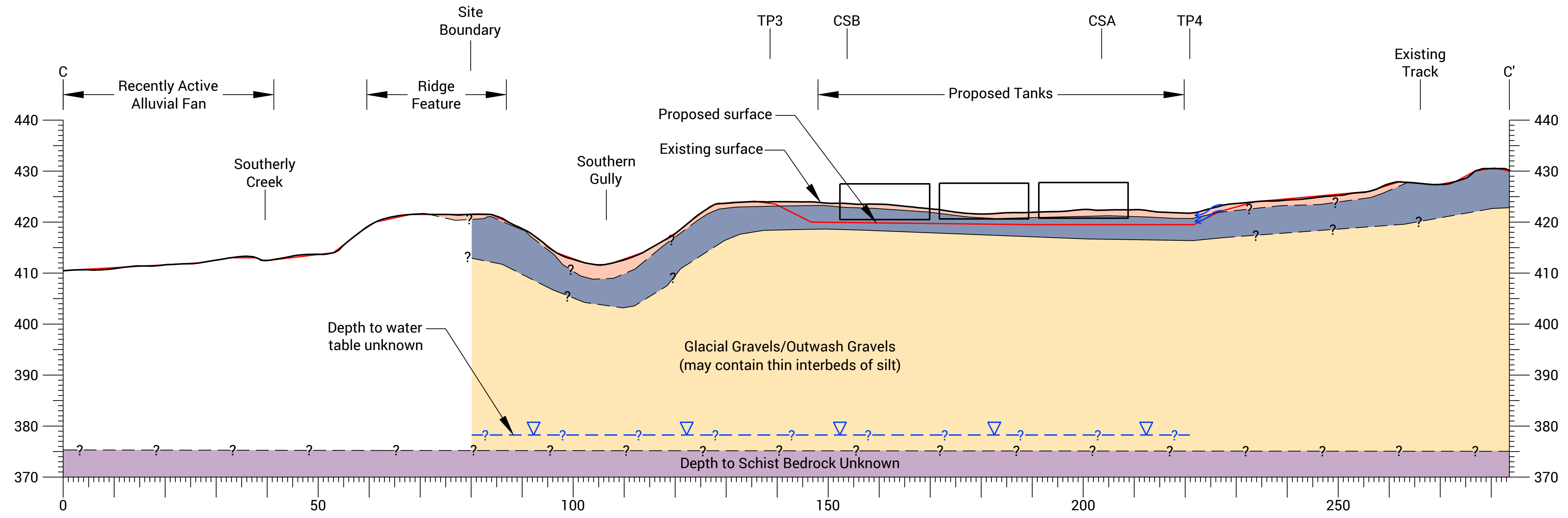
Geotechnical Investigations

Cross Section B

PROJECT No: 190413

FIG No: Figure 2b

REV. 0



Legend:

- ▨ Fan Alluvium
- ▨ Glacial Till
- ▨ Outwash Gravels
- ▨ Outwash Gravels/Glacial Gravels
- ▨ Schist Bedrock
- ↙ Observed Seepage

Notes:

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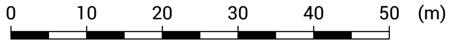
SCALE 1:1000



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APPROVED	PGF	Aug.19

CADFILE: 190413.dwg

SCALES (AT A3 SIZE): 1:1000

PROJECT No: 190413

Scope Resources Ltd

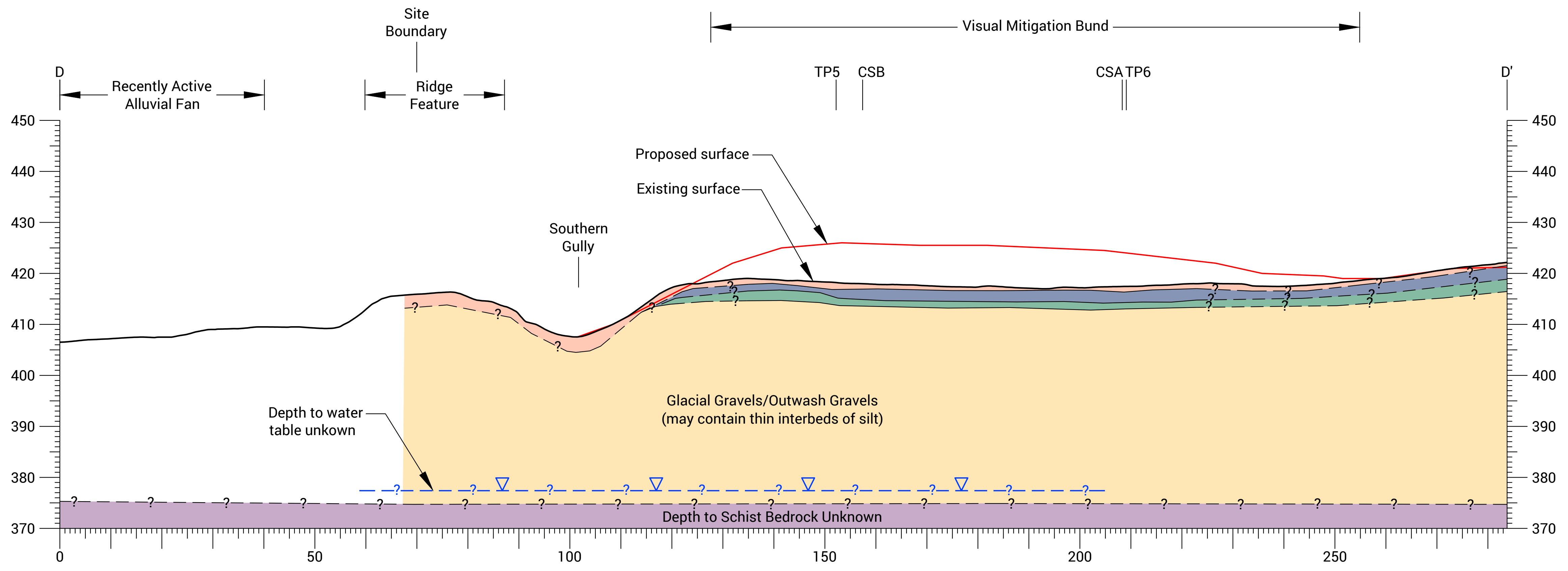
Water Reservoir Coneburn

Geotechnical Investigations

Cross Section C

FIG No: Figure 2c

REV. 0



Legend:

- 🟥 Fan Alluvium
- 🟩 Glacial Till
- 🟦 Outwash Gravels
- 🟨 Outwash Gravels/Glacial Gravels
- 🟪 Schist Bedrock
- ↙ Observed Seepage

Notes:

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SCALE 1:1000

0 10 20 30 40 50 (m)

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APPROVED	PGF	Aug.19
CADFILE: 190413.dwg		
SCALES (AT A3 SIZE): 1:1000		
PROJECT No: 190413		

Scope Resources Ltd

Water Reservoir Coneburn

Geotechnical Investigations

Cross Section E

FIG No: Figure 2e

REV. 0

Appendix B: Investigation Data

GEOSOLVE

EXCAVATION LOG

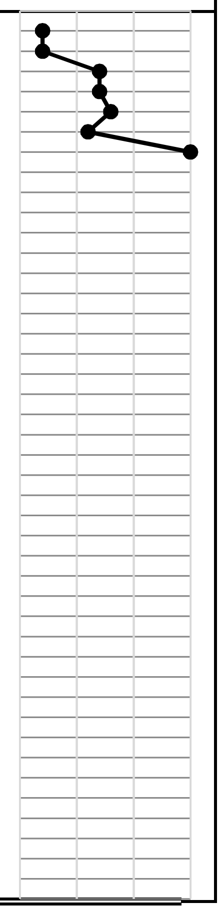
EXCAVATION NUMBER:

TP 1

PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator	OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.		COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.3	TOPSOIL		Dark brown, sandy SILT, organic, some gravel & rootlets. Sand is fine to medium. Gravel is fine to coarse; sub-rounded. Soft to Firm. Massive. Moist.			
0.7	FAN ALLUVIUM		Greyish brown, sandy GRAVEL, some silt with occasional cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Medium Dense. Bedded. Moist.			
1.1	FAN ALLUVIUM		Greyish brown, sandy GRAVEL, trace of silt with occasional cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Dense. Bedded. Moist.			
1.15	BURIED TOPSOIL/FAN ALLUVIUM		Dark brown, gravelly SILT with minor sand & rootlets. Gravel is fine to medium; sub-rounded. Sand is fine to medium. Stiff. Moist.			
4.4	OUTWASH GRAVEL		Brownish grey, mottled orange, sandy GRAVEL, trace of silt with occasional cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Very Dense. Well bedded. Moist.		NO SEEPAGE	



Total Depth = 4.4 m

COMMENT: Walls remained stable, test pit dry. Hard digging at base of excavation.	Logged By: SR Checked Date: Sheet: 1 of 1

EXCAVATION LOG

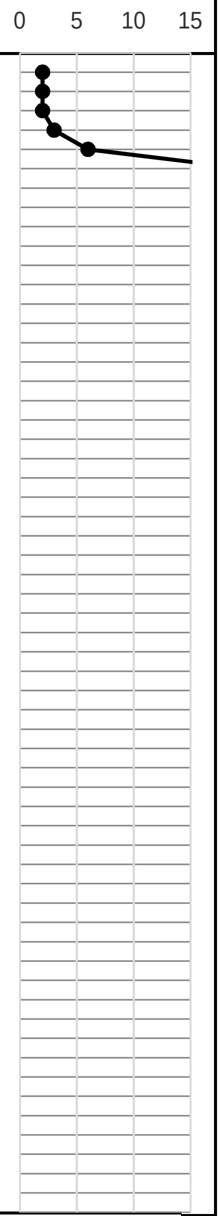
EXCAVATION NUMBER:

TP 2

PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator	OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.		COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm
0.3	TOPSOIL		Dark brown, sandy SILT with trace of gravel. Sand is fine to medium. Gravel is fine to coarse; sub-rounded. Soft to Firm.			
0.7	FAN ALLUVIUM		Orange brown, SILT with some sand & gravel. Silt is non-plastic. Oxidised. Sand is fine to medium. Gravel is fine to medium; sub-rounded. Stiff to Very Stiff. Massive. Moist.			
6.0	OUTWASH GRAVEL		Grey, sandy GRAVEL, trace of silt with occasional cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Dense to Very Dense. Well bedded. Moist.		NO SEEPAGE	



Total Depth = 6 m

COMMENT: Walls remained stable, test pit dry.

Logged By: SR

Checked Date:

Sheet: 1 of 1

GEOSOLVE

EXCAVATION LOG

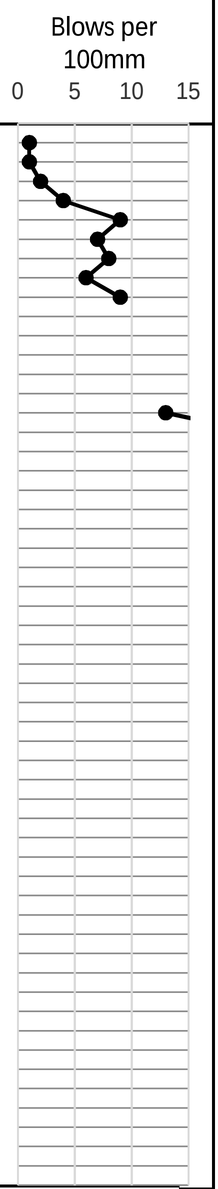
EXCAVATION NUMBER:
TP 3

PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator	OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.		COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.3	TOPSOIL		Dark brown, sandy SILT, organic with trace of gravel & rootlets. Sand is fine to medium. Gravel is fine to medium; sub-rounded.		
0.7	FAN ALLUVIUM		Brown, sandy SILT with some gravel. Silt is non-plastic. Sand is fine to medium. Gravel is fine to coarse; sub-rounded. Stiff to Very Stiff. Massive. Moist.		
5.5	OUTWASH GRAVEL		Grey to mottled orange, sandy GRAVEL, minor silt with occasional cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Medium Dense to Very Dense. Moderately bedded. Moist.		NO SEEPAGE

SCALA PENETROMETER



Total Depth = 5.5 m

COMMENT: Walls remained stable, test pit dry.	Logged By: SR
	Checked Date:
	Sheet: 1 of 1

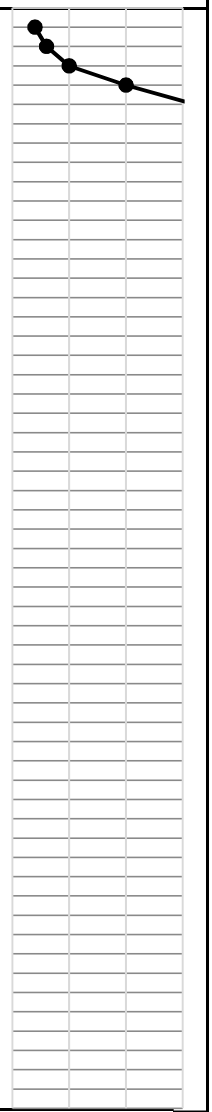
EXCAVATION LOG

EXCAVATION NUMBER:

TP 4

PROJECT:	Coneburn Reservoir		JOB NUMBER: 190413
LOCATION:	See Site Plan	INCLINATION: Vertical	

EASTING:		mE	EQUIPMENT:	20t excavator		OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.			COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:			HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:			HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.3	TOPSOIL		Dark brown, sandy SILT, organic with trace of gravel & rootlets. Sand is fine to medium. Gravel is fine to medium; sub-rounded.		Seepage @ 0.9 m	
0.9	FAN ALLUVIUM		Brown to mottled orange, sand silty GRAVEL with iron staining. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded. Cobbles approx. 200mm. Medium Dense to Dense. Moderately bedded sub horizontal. Wet.			
5.7	OUTWASH GRAVEL		Brownish grey, sandy GRAVEL, minor silt with cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Dense to Very Dense. Moderately bedded sub horizontal. Wet. At 1.5m becomes moist.		Seepage @ 1.4 m	

Total Depth = 5.7 m

COMMENT: Walls remained stable unless in contact with seepage. Test pit in overland flow path. Seepage at 0.9 & 1.4m ~0.75 litres per min.	Logged By: SR Checked Date: Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 5

PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator		OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.			COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:			HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:			HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm 0 5 10 15
0.3	TOPSOIL		Dark brown, sandy SILT, organic with trace of gravel & rootlets. Sand is fine to medium. Gravel is fine to medium; sub-rounded. Soft. Moist.			
1.0	FAN ALLUVIUM		Brown to mottled orange, GRAVEL, minor silt, trace of sand & cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded. Cobbles up to 200mm. Medium Dense to Dense. Moderately bedded. Moist.			
3.2	OUTWASH GRAVEL		Brownish grey, sandy GRAVEL, minor silt with cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Dense to Very Dense. Moderately bedded. Moist, Wet @ 2.1m.		Seepage @ 2.1 m	
4.9	GLACIAL TILL		Brown, sandy SILT. Sand is fine to medium. Silt is non-plastic. Very Stiff to Hard. Massive. Dry to Moist.			
5.3	GLACIAL GRAVEL		Greyish brown, sandy GRAVEL with cobbles & trace of silt. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Cobbles up to 200mm. Dense to Very Dense. Moist.			

Total Depth = 5.3 m

COMMENT: Walls remained stable unless in contact with seepage. Seepage in upslope wall at 2.1m bgl. Very minor.

Logged By: SR

Checked Date:

Sheet: 1 of 1

EXCAVATION LOG

EXCAVATION NUMBER:

TP 6

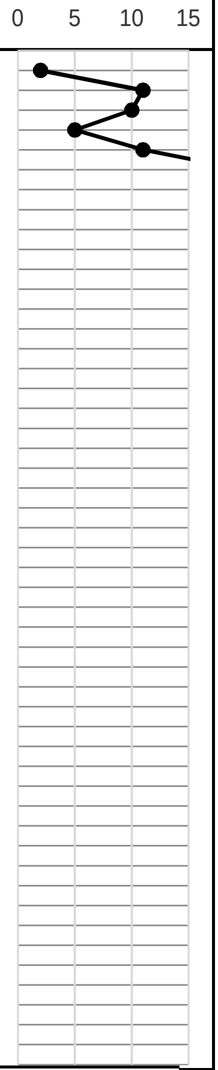
PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator	OPERATOR:	Warren
NORTHING:		mN	INFOMAP NO.		COMPANY:	Beaver Contractors
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	24-Jul-19
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	24-Jul-19

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE
0.3	TOPSOIL		Dark brown, sandy SILT, organic with trace of gravel & rootlets. Sand is fine to medium. Gravel is fine to medium; sub-rounded.		
0.9	FAN ALLUVIUM		Brown, sandy GRAVEL with some silt & cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded. Cobbles up to 200mm. Medium Dense to Dense. Moderately bedded. Moist.		
1.2	FAN ALLUVIUM		Greyish brown, sandy GRAVEL with trace of silt & cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded. Cobbles up to 200mm. Medium Dense to Dense. Moist.		
2.6	OUTWASH GRAVEL		Grey, sandy GRAVEL, minor silt with cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Dense to Very Dense. Moderately bedded. Moist.		
2.8	OUTWASH GRAVEL		Grey, sandy GRAVEL, minor silt with cobbles & boulders. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Boulders up to 500mm. Dense to Very Dense. Moderately bedded. Wet.		Seepage @ 2.8 m
4.2	GLACIAL TILL		Brown, sandy SILT. Sand is fine to medium. Silt is non-plastic. Very Stiff to Hard. Massive. Moist to Wet.		
5.1	GLACIAL GRAVEL		Greyish brown, sandy GRAVEL with cobbles & trace of silt. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Cobbles up to 200mm. Dense to Very Dense. Moist to Wet.		

SCALA PENETROMETER

Blows per 100mm



Total Depth = 5.1 m

COMMENT: Test pit walls remained stable unless in contact with seepage. Test pit on true right bank of overland flow path. Seepage at 2.8m on upslope side of test pit - 2-4 litres per min.

Logged By: SR

Checked Date:

Sheet: 1 of 1

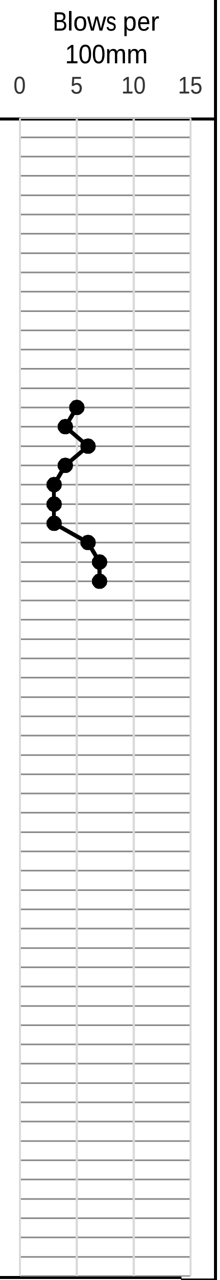
EXCAVATION LOG

EXCAVATION NUMBER:	TP 7

PROJECT:	Coneburn Reservoir	JOB NUMBER:	190413
LOCATION:	See Site Plan INCLINATION: Vertical		

EASTING:		mE	EQUIPMENT:	20t excavator	OPERATOR:	Warren	
NORTHING:		mN	INFOMAP NO.		COMPANY:	Beaver Contractors	
ELEVATION:		m	DIMENSIONS:		HOLE STARTED:	24-Jul-19	
METHOD:			EXCAV. DATUM:		HOLE FINISHED:	24-Jul-19	

DEPTH (m)	SOIL / ROCK TYPE	GRAPHIC LOG	DESCRIPTION	USCS GROUP	GROUNDWATER / SEEPAGE	SCALA PENETROMETER Blows per 100mm
0.3	TOPSOIL		Dark brown, sandy SILT, organic with trace of gravel & rootlets. Sand is fine to medium. Gravel is fine to medium; sub-rounded.			
1.8	FAN ALLUVIUM		Greyish brown, sandy GRAVEL with trace of silt & occasional cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Cobbles up to 200mm. Medium Dense. Moist.			
4.3	FAN ALLUVIUM		Brown, sandy GRAVEL with trace of silt & occasional cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Cobbles up to 200mm. Medium Dense. Bedded. Moist.			
6.0	OUTWASH GRAVEL		Grey, sandy GRAVEL with occasional cobbles. Sand is fine to coarse. Gravel is fine to coarse; sub-rounded to sub-angular. Cobbles up to 200mm. Medium Dense to Dense. Moderately bedded. Moist.		NO SEEPAGE	



Total Depth = 6 m

COMMENT: Walls remained stable. Test pit dry.	Logged By: SR
	Checked Date:
	Sheet: 1 of 1

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH01
Hole Location:
SHEET 1 OF 1

PROJECT: CFM Stoney Oasis
LOCATION: Stoney Creek, Frankton
JOB No: 880077.100

CO-ORDINATES mN
mE
R.L. m
DATUM

DRILL TYPE: UDR650
DRILL METHOD: TUBEX
DRILL FLUID:

HOLE STARTED: 20/2/08
HOLE FINISHED: 20/2/08
DRILLED BY: McNEIL
LOGGED BY: SCWW CHECKED:

GEOLOGICAL GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	ENGINEERING DESCRIPTION SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
Glacial outwash gravels												DRY	MD - D				Coarse Silty Gravels
									1								
									2								
									3								
									4								
		Dry	N/A	TBX					5								
									6								
									7								
									8								
									9								
									10								
																	End of borehole - 10.5 m
									11								
									12								
									13								
									14								
									15								

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: BH02
Hole Location:
SHEET 1 OF 1

PROJECT: CFM Stoney Oasis
LOCATION: Stoney Creek, Frankton
JOB No: 880077.100

CO-ORDINATES mN
mE
R.L. m
DATUM

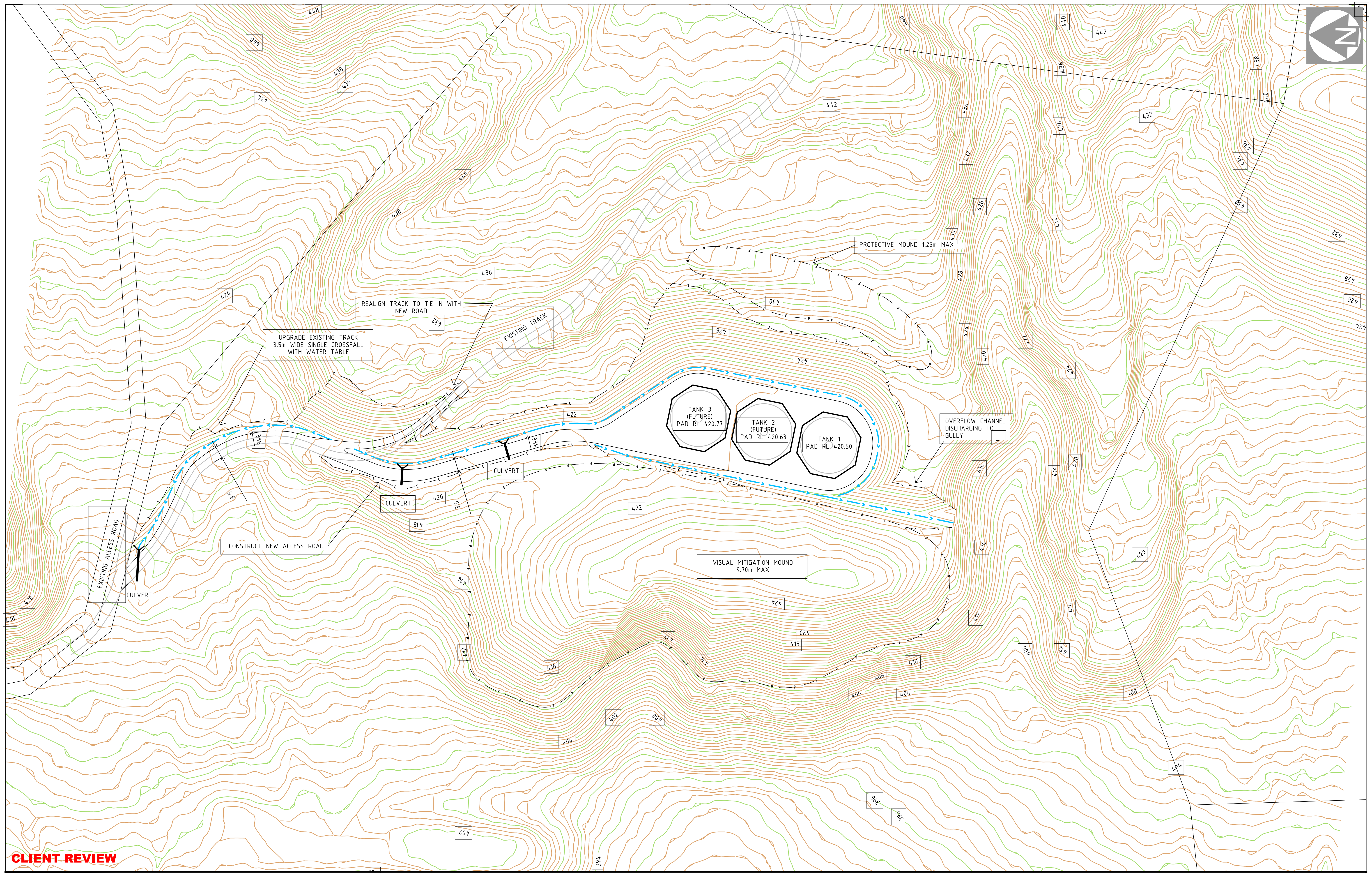
DRILL TYPE: UDR650
DRILL METHOD: TUBEX
DRILL FLUID:

HOLE STARTED: 20/2/08
HOLE FINISHED: 20/2/08
DRILLED BY: McNEIL
LOGGED BY: SCWW CHECKED:

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SHEAR STRENGTH (kPa) 10 25 50 100 200	COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250	DEFECT SPACING (mm) 50 250 1000 2000	SOIL DESCRIPTION Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
Glacial outwash gravels		DRY	N/A	TBX								DRY	MD - D				Coarse Silty Gravels
Boulder																	Boulder
Glacial outwash gravels																	Coarse Silty Gravels
									12								End of borehole - 12 m

DEPTH (m): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Appendix C: Earthworks Plan



CLIENT REVIEW

Shotover Design Limited trading as

Clark Fortune McDonald & Associates

Licensed Cadastral Surveyors - Land Development - Planning Consultants

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Unit 6B, Level 1, 480 Moray Place, P.O. Box 5960, Dunedin
Tel. (03)470-1582, Fax (03)470-1583, Email admin@cfma.co.nz

Rev.	Date	Revision Details	By
-	-	-	-

SCOPE RESOURCES
PROPOSED ACCESS ROAD, WATER TANKS AND MOUNDING

Client
SCOPE RESOURCES LTD

Notes:
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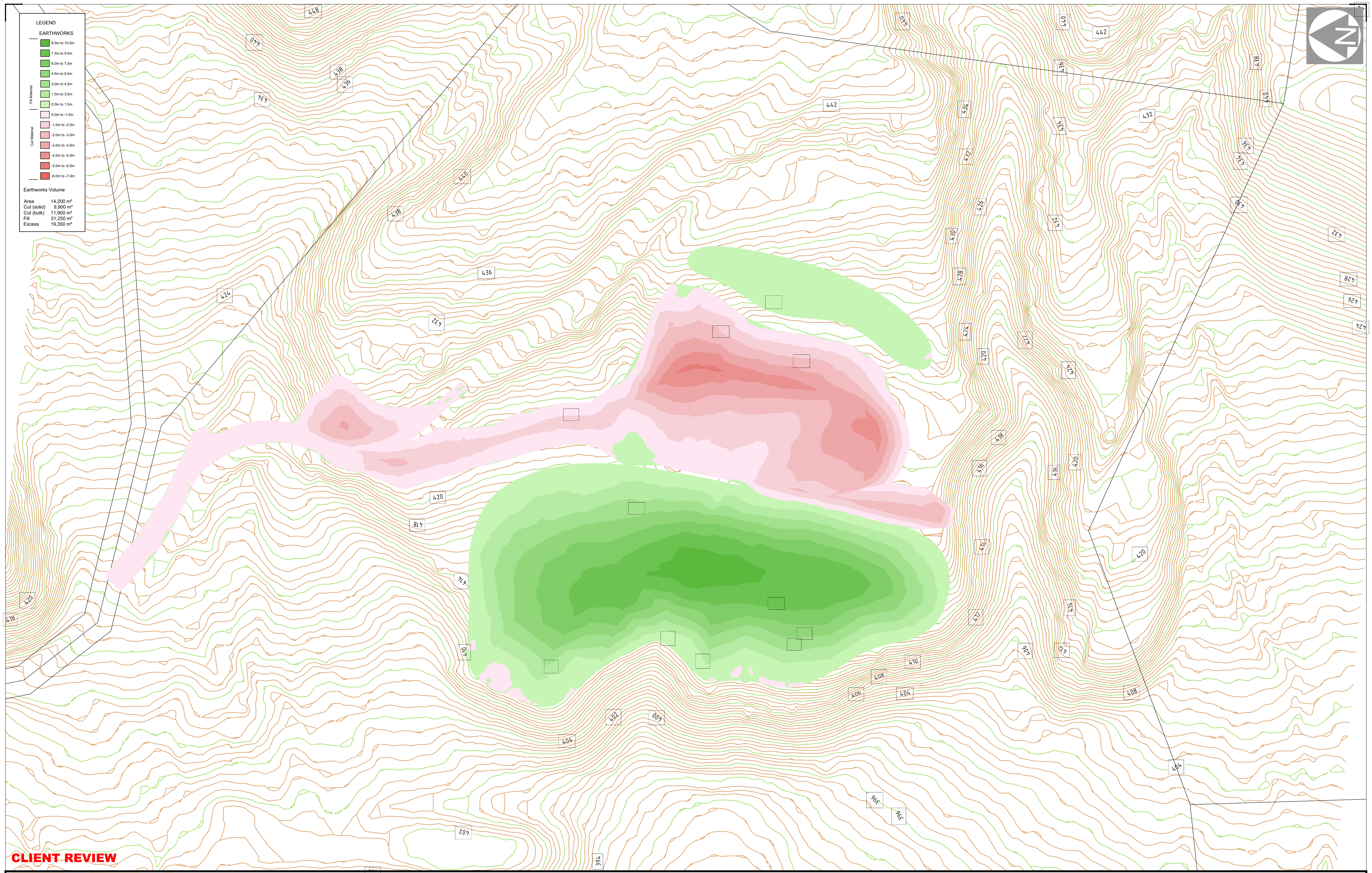
	Signed	Date
Surveyed		
Drawn DH		05/19
Designed DH		05/19

Job No. **11014**
Drawing No. **15** **SHEET 001**
Scale **1:500 @ A1** **1:1000 @ A3**
Datum & Level **MSL**
Rev. A



LEGEND

EARTHWORKS

Fill Material	🟩	9.0m to 10.5m
	🟩	7.5m to 9.0m
	🟩	6.0m to 7.5m
	🟩	4.5m to 6.0m
	🟩	3.0m to 4.5m
	🟩	1.5m to 3.0m
	🟩	0.0m to 1.5m
Cut Material	🟥	0.0m to -1.0m
	🟥	-1.0m to -2.0m
	🟥	-2.0m to -3.0m
	🟥	-3.0m to -4.0m
	🟥	-4.0m to -5.0m
	🟥	-5.0m to -6.0m
	🟥	-6.0m to -7.0m

Earthworks Volume

Area	14,200 m²
Cut (solid)	9,900 m³
Cut (bulk)	11,900 m³
Fill	31,250 m³
Excess	19,350 m³

CLIENT REVIEW

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Rev.	Date	Revision Details	By
-	-	-	-

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Surveyed	Signed	Date
Drawn	Signed	Date
DH		05/19
Designed	Signed	Date
DH		05/19

Job No. **11014**

Drawing No. **15**
SHEET 002

Scale **1:500 @ A1**
1:1000 @ A3

Datum & Level **MSL**

Rev. A