GEOSOLVE

ACENZ MEMBER

Telarc. Registered Quality ISO 9001

Geotechnical Report for Resource Consent

Northbrook Village,
Wanaka

Report prepared for:
Northlake Investments Ltd

Report prepared by:
GeoSolve Ltd

Distribution:
Northlake Investments Ltd
Paterson Pitts Group
GeoSolve Limited (File)

August 2020

GeoSolve Ref: 200270

Revision	Issue Date	Purpose	Author	Reviewed
0	11/08/2020	Client issue	MDP	FAW

GEOTECHNICAL WATER RESOURCES PAVEMENTS

Table of Contents

1 Introduction

1.1 General

This report presents the results of a geotechnical desktop review using existing geological data, in order to determine subsoil conditions and provide foundation and earthworks recommendations for the proposed Northbrook development at Outlet Road, Wanaka. Preliminary geotechnical design parameters and foundation bearing parameters are provided. Plans for the proposed development have been provided by Paterson Pitts Group and Three Sixty Architecture.

Photo 1 – Site Photo, view looking east across the proposed development area

The investigation was carried out for Northlake Investments Limited in accordance with GeoSolve Ltd.'s proposal dated the 3rd of August 2020, which outlines the scope of work and conditions of engagement. This report will supplement a resource consent application.

1.2 Proposed Development

Based on architectural plans provided by Three Sixty Architecture we understand the development comprises 100 residential units, a clubhouse building and a healthcare facility and this requires geotechnical assessment of the site to assess suitability for development and to identify any geotechnical issues.

Earthworks plans have been provided by Paterson Pitts Group, which indicate a maximum cut and fill of 4 and 2 m respectively. Topsoil stripping of 7,600 m^3 and cut to fill of 24,600 m^3 is proposed as part of the earthworks design.

Appendix A, Figures 1, 2 and 3 show the proposed development area and earthworks plans respectively.

Cross-sections of the proposed development are shown in Appendix A, Figures 4a-d.

2 Site Description

2.1 General

The subject property, legally described as Lot 2008 DP 545513, is located approximately 3 km northeast of central Wanaka, as shown in Figure 1 below. The property is accessed off Outlet Road.

Figure 1. Site location (blue marker) in relation to Wanaka township (Source: http://qldc.maps.arcgis.com/)

The site is currently being used as the earthworks contractor's yard for ongoing stages of the Northlake development and has previously had cut and fill earthworks undertaken within the eastern extents. The existing site cover comprises construction roading, soil stockpiles, grass, shrubs and trees.

The site is bounded by Outlet Road to the north and Northlake Investment Ltd land to the west, south and east.

2.2 Topography and Surface Drainage

The two isolated eastern areas of the development are sub-horizontal and have previously had cut and fill earthworks undertaken as part of Stage 15 of the Northlake development. The main development area is generally sub-horizontal; however, a number of large fill stockpiles and sediment ponds are present within the area.

The western area of the site slopes to the north towards Outlet Road. To the south of the site an approximately 3H:1V slope is present, up to 30 m in height. Future residential lots are under construction above the slope to the south.

Previous cut and fill earthworks contours are shown within the B F Whitham Stage 15 GCR report in Appendix C. Plans indicate cut and fill of up to 3.5 and 5 m respectively have been undertaken to construct the existing sub-horizontal surface.

No spring flows or seepages were observed during a site inspection of the development area completed by GeoSolve.

Existing topographic contours are shown in Figure 2, Appendix A.

3 Geotechnical Investigations

GeoSolve Ltd have reviewed existing geotechnical data held on the GeoSolve and Northlake database that has been completed by GeoSolve and Riley Consultants within and surrounding the development area.

The subsurface investigations reviewed for the purposes of this report are as follows:

- 14 test pits (TP 1-12), completed by GeoSolve, extending to a maximum depth of 7.0 m below ground level (bgl) to produce geological logs of the subsoils;
- 2 test pits (RTP 1-2), completed by Riley Consultants, extending to a maximum depth of 3.1 m bgl;
- 1 sonic borehole (RBH1), completed by Riley Consultants, extending to a depth of 10.64 m bgl.

Investigation locations and logs are presented in Appendices A and B respectively.

4 Subsurface Conditions

4.1 Geological Setting

The site is located in the Wanaka Basin, a feature formed predominantly by glacial advances. The schist bedrock within the basin has been extensively scoured by ice and lies at considerable depth below this site. Overburden material above the schist in this region includes glacial till, alluvial outwash sediments, lake sediments and beach deposits.

During the Mt Iron and Hawea Glacial Advances 18-23,000 years before present, the glaciers terminated upstream from Albert Town forming moraine loops and outwash terraces. Well-consolidated glacial till gravels were laid down on the flanks and beds of the glaciers. With the final retreat of the ice, about 16,000 years ago, Lake Wanaka formed and the Clutha River became entrenched in the glacial deposits.

No active fault traces were observed within the property. The Alpine Fault, located approximately 70 km away, runs along the western foothills of the Southern Alps, and is likely to present a significant seismic risk in the short term. There is a high probability that an earthquake of Magnitude 8 or more will occur along the Alpine Fault within the next 50 years and such a rupture is likely to result in strong ground shaking in the vicinity of Wanaka.

4.2 Stratigraphy

Results from the investigations indicate the sub-surface stratigraphy comprises:

- 0.2-0.6 m **topsoil**, overlying;
- 0.4 m of **uncontrolled fill** (TP3 only), overlying;
- 0.3-0.9 m of **loess**, overlying;
- 0.2-0.8 m of **colluvium**, overlying;
- 0.7 m of **pond sediment** (TP9 only), overlying;
- 0.4-6.4 m+ of **outwash sand and gravel**, overlying;
- 0.6-3.7 m+ of **glacial till.**
- Up to 5 m of **engineered fill** is present in the eastern site extents (refer to Appendix C).

Topsoil was observed at the surface of all investigation locations except TP3 and predominately comprises dark brown, organic SILT with roots and rootlets.

Uncontrolled fill was observed at the surface of TP3 only. Uncontrolled fill was observed to comprise brownish grey, loose sandy GRAVEL and extended to 0.4 m bgl.

Loess was observed to underlie the topsoil in seven investigation locations (TPs 1, 8, 9, 12, RTPs 1 and 2 and RBH 1). The loess predominately comprises brown to grey, firm to stiff/loose to medium dense, silty SAND, sandy SILT and SILT and extends to between 0.3 and 1.4 m bgl.

Colluvium was observed to underlie the topsoil and loess in TPs 1, 4-7, 13 and 14. The colluvium predominately comprises light brown, loose to medium dense/firm, silty GRAVEL, gravelly SILT with some sand, sandy SILT with some gravel, silty SAND with minor gravel and silty gravelly SAND and extended to a depth of between 0.7 and 1.1 m bgl.

Pond sediment was observed to underlie the loess in TP9 at 1.2 m bgl. Pond sediment was observed to comprise grey, very stiff SILT and extended to 1.9 m bgl.

Outwash Sand and Gravel was observed to underlie the topsoil, uncontrolled fill, colluvium, pond sediment and glacial till in TPs 1-3, 8-12, RTPs 1 and 2 and RBH 1. Outwash sand and gravel typically comprise grey, medium dense sandy GRAVEL, gravelly SAND, cobbly sandy GRAVEL and SAND. Outwash silt was additionally observed in TP12 at 4.9 m extending to 5.5 m bgl comprising brown to grey, firm SILT. Outwash sand and gravel was observed to extend to between 1.5 and 7 m bgl.

Glacial till was observed to underlie the colluvium and outwash sand and gravel in TPs 1-8, 10, 11, 13 and 14, and RTPs 1 and 2 and RBH 1. Glacial till was observed to comprise grey, medium dense/stiff silty SAND with some to minor gravel, silty gravelly SAND, sandy SILT with minor gravel, silty GRAVEL, SILT with some sand and some to trace gravel. Glacial till was observed to extend to between 0.9 and 10.64 m bgl.

Engineered fill comprising sandy SILT and silty GRAVEL has been placed within the two isolated eastern areas of the proposed development. Engineered fill has been placed in thicknesses of up to 5.0 m. The engineered fill within this area has been certified by B F Whitham with bearing capacity recommendations provided within the GCR attached in Appendix C.

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

Note that earthworks have been undertaken within and surrounding the proposed development area since the completion of investigations by GeoSolve and Riley Consultants. It is recommended that further investigations are undertaken during the detailed design stage to confirm the existing stratigraphy and the associated recommendations for the proposed development.

4.3 Groundwater

Minor seepage was observed within TPs 1, 8 and 9 at between 1.3 and 3.9 m bgl. In all cases the seepage was observed to be a low velocity flow tracking along or near the surface of a more permeable unit overlying a low permeability layer (e.g. high permeability outwash gravel comprising sandy GRAVEL overlying low permeability glacial till comprising sandy SILT).

The regional groundwater table is expected to lie more than 10 metres below the ground surface of this site, as it was not intercepted within a borehole completed by Riley Consultants in December 2015 to this depth.

4.4 Slope Stability

No instability features were observed at the site during investigations and the site inspection. This is supported by the absence of a shallow groundwater table and the predominately stiff/medium dense condition of the soils observed in test pits.

Earthworks plans have been reviewed by GeoSolve and slope stability is not considered an issue as long as the temporary and permanent cut and fill batters are undertaken in accordance with Section 5 of this report and that fill is engineered and certified in accordance with NZS 4431.

5 Engineering Considerations

5.1 General

The recommendations and opinions contained in this report are based upon ground investigation data 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.

It is recommended that additional investigations are undertaken at the detailed design stage to confirm the below recommendations.

5.2 Geotechnical Parameters

Table 1 provides a summary of the recommended geotechnical design parameters for the soils expected to be encountered during construction of any future buildings and retaining walls.

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 with roots)	0.2-0.6	16	To be removed from engineered fill footprints			
Uncontrolled Fill (loose sandy GRAVEL)	0.4	18	To be removed from construction areas			
Loess (firm to stiff/loose to medium dense, silty SAND, sandy SILT and SILT)	0.3-0.9	18	To be removed from engineered fill footprints or blended with suitable material and re-compacted			
Colluvium (loose to medium dense/firm, silty GRAVEL, gravelly SILT with some sand, sandy SILT with some gravel, silty SAND with minor gravel and silty gravelly SAND)	0.2-0.8	18	0	32-34	5,000	0.3
Pond Sediment (very stiff, SILT)	0.7	18	0	30	10,000	0.3
Outwash Sand and Gravel (medium dense, sandy GRAVEL, gravelly SAND,	0.4-6.4+	18	0	36 (32 in Sand)	10,000-20,000	0.3

cobbly sandy GRAVEL and SAND)						
Glacial Till (medium dense/stiff, silty SAND with some to minor gravel, silty gravelly SAND, sandy SILT with minor gravel, silty GRAVEL, SILT with some sand and some to trace gravel)	0.6-9.12+	19	0-2	34	20,000-40,000	0.3
Engineered Fill (certified by B F Whitham Stage 15 GCR - sandy SILT and silty GRAVEL)	0-5	19	0	34-35	20,000	0.3

5.3 Site Preparation

During the earthworks operations all topsoil, loess, organic matter and other unsuitable materials should be removed from the construction areas in accordance with the recommendations of NZS 4431:1989. These soil types will also need to be removed from areas where engineered fill is proposed. Loess in its natural state will not be suitable as an engineered fill subsoil and should either be removed or blended with other suitable material and re-compacted.

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 colluvium or silt soils then the construction and lining of drainage channels is recommended, e.g. with geotextile and suitably graded rock, or similarly effective armouring.

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. Note that the eastern areas as shown in Appendix A, Figure 1 have had previous cut to fill earthworks undertaken as part of Stage 15 of the Northlake development. Cuts and fills of up to 3.5 and 5.0 m within this area have been supervised and certified to meet 'good ground' standard as per NZS3604:2011 by B F Whitham. The GCR for this area is attached within Appendix C.

The loess, pond sediment, colluvium, glacial till, outwash soils and previous Stage 15 certified fill can be used as engineered fill on site. The topsoil is not suitable as a fill source. To use the loess and pond sediment material as a fill source it will have to be blended with a more granular soil source to be satisfactory, alternatively these materials can be cut to waste or stockpiled for reuse in landscaping areas to build up lawns or landscaping bunds. 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. Compaction of the fill sources at lab tested optimum moisture content is critical for these soil types. In areas where significant amounts of cobbles over

100 mm are observed the material should be blended with fine grained soil materials to create a well graded fill.

Any uncontrolled fill identified during construction should be removed and inspected by the civil or geotechnical engineer to confirm its suitability for reuse as engineered fill. If the fill material is identified as suitable to be reused as engineered fill it should be blended within the engineered fill stockpile, if the material is not suitable then this should be cut to waste or used within landscaping areas as directed by the geotechnical or civil engineer.

5.4 Excavations

Earthworks plans have been provided by Paterson Pitts with cuts expected to be made within topsoil, uncontrolled fill, loess, pond sediment, colluvium, outwash soils, glacial till and engineered fill.

Recommendations for temporary and permanent batter slope angles are described below in Table 2. Slopes that are required to be steeper than those described below should be structurally retained or subject to specific geotechnical design.

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 suitably qualified Chartered Professional Engineer.

The soils are anticipated to be excavated by conventional methods.

5.4.1 Cut Slopes in Soil Materials

Table 2 summarises the recommended batter angles for temporary and permanent slopes up to 8 m high, which are formed in the soil materials identified at the site.

Table 2 Recommended maximum batter angles for cut slopes up to 8 m high in site soils.

Material Type	Recommended Maximum Batter Angles for Temporary Cut Slopes Formed in Soil (horizontal to vertical)		Recommended Maximum Batter Angles for Permanent Cut Slopes Formed in Soil – dry ground only (horizontal to vertical)
	Dry Ground	Wet Ground	
Topsoil/Loess	2H: 1V	3H: 1V	3H: 1V
Colluvium, Glacial Till, Outwash and Engineered Fill	1H: 1V	2H: 1V	2H: 1V

5.5 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.

All un-retained fill slopes which are less than 8 m high should be constructed with a batter slope angle of 2.0H: 1.0V (horizontal to vertical) or flatter and be benched into sloping ground.

A 1H:1V slope of up to approximately 8 m is proposed within the northwest of the site. It is currently understood a "green faced" geogrid reinforced slope is proposed to be constructed in this area to achieve the required batter slope. A reinforced slope is generally constructed within engineered fill areas however based on Cross-section 2 this is proposed to be constructed in predominately cut. For the geogrid to be installed within the proposed batter slope within cut areas, over excavation and re-compaction of excavated fill will be required. If during the detailed design and costing this solution proves to be cost prohibitive then it is recommended that the following solutions are considered:

1. Construction of a retaining wall at the toe of slope with a 2H:1V batter and an additional retaining wall at the crest of the proposed slope to achieve levels. Based on Section 2 this will require a total of 3.6 m retained height between the two retaining walls. The two retaining walls can be constructed with standard retaining solutions including a timber pole wall, gabion basket wall or UC wall. This will allow cut/fill earthworks to be minimised for the slope area;
2. Construction of a 'green faced' terramesh wall up to 70 degrees with a 2H:1V batter upslope to intercept the proposed crest. Based on Section 2 a terramesh wall of up to approximately 4.5 m will be required. Note this will also require geogrid installation however as the batter can be constructed up to 70 degrees and only requires to be approximately 4.5 m high to meet the crest of the slope significantly less over excavation will be required to install the geogrid;
3. Construction of a soil nailed slope comprising short ground anchors with a mesh facing. The facing will be required to be mass planted or hydroseeded to provide surficial erosion protection resulting in a similar green face as the retained slope option.

It is recommended that the above solutions are assessed to confirm the required geogrid length for the 1H:1V and 70-degree terramesh faced slope as this will be determine the amount of over excavation required to construct each of these solutions. GeoSolve can provide conceptual designs for each of the batter/retaining solutions if required for costing purposes.

5.6 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.

Minor groundwater seepage was encountered within TPs 1, 8 and 9, additionally 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 building to stop 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.

5.7 Slope Stability

No evidence of existing slope instability was identified during our walkover inspection of the site. Earthworks plans have been provided to GeoSolve. Slope stability is not considered to be an issue for this development assuming the recommendations of Section 5 are implemented during construction.

5.8 Groundwater Issues

Minor seepage was observed within TPs 1, 8 and 9 at between 1.3 and 3.9 m bgl. In all cases the seepage was observed to be a low velocity flow tracking along or near the surface of a more permeable unit overlying a low permeability layer (e.g. outwash gravel comprising sandy GRAVEL overlying glacial till comprising sandy SILT). The encountered seepages are not anticipated to cause wider issues during construction and are anticipated to be able to be controlled by a subsoil drain connected the site stormwater system if identified to be consistent flows requiring remediation during construction.

Minor seepages encountered are not considered to be the regional water table which is expected to lie at depth (not identified in RBH1 which extended to 10.64 m bgl) below any future foundation levels and is not expected to be encountered during any future construction at this site. Dewatering and other groundwater-related construction issues are therefore unlikely to be required.

It is recommended that a geotechnical or civil engineer should inspect any seepage, spring flow or under-runners if they are encountered during construction.

5.9 Foundation Considerations

Topsoil and loess should be stripped from the buildable areas. It is anticipated that foundation loads will be transferred to the outwash gravel and glacial till deposits or engineered fill in most cases.

All unsuitable soil materials identified in foundation excavations, particularly those softened by exposure to water, should be undercut and replaced with engineered fill during foundation 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.

Note that bulk earthworks have already been undertaken within the isolated eastern areas of the proposed development (as shown in Appendix A, Figure 1). Previous earthworks within these areas comprised of cut and fill of up to 3.5 and 5.0 m respectively. These earthworks have been supervised by B F Whitham and recommendations are provided within the GCR attached in Appendix C. The GCR recommends 'good ground' bearing as per NZS 3604:2011 for both the eastern areas of the proposed development.

To minimise the effects of freeze-thaw cycles in footings founded on soil, all shallow foundations should be founded a minimum of 0.4 m below the adjacent finished ground surface.

Figure 2 summarises the recommended working stresses for shallow footings, which bear upon glacial till, outwash gravel and engineered fill. It should be noted the foundation working stresses presented on Figure 2 are governed by bearing capacity in the case of narrow footings and settlement in the case of wide footings.

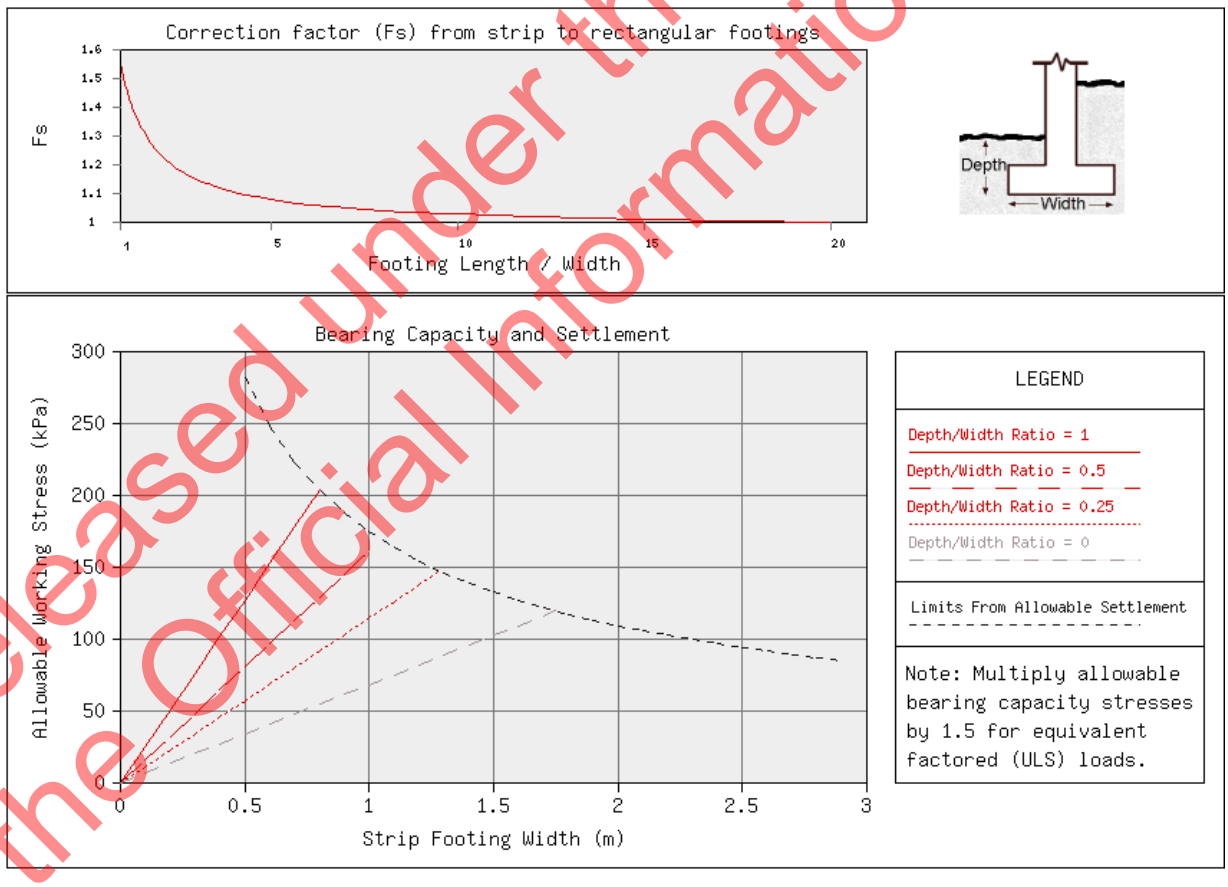


Figure 2. Recommended Bearing for Shallow Footings on Glacial Till, Outwash Gravel and Engineered Fill.

From Figure 2 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 glacial till,

outwash gravel and engineered fill. This corresponds to a factored (ULS) bearing capacity of approximately 150 kPa and an ultimate geotechnical bearing capacity of 300 kPa.

Inspection and testing (dynamic probe/Scala penetrometers) should be completed along footing alignments during construction to confirm the above values are applicable and that the soil has not been softened by weather or excavation, particularly in the fine-grained glacial till. Plate compaction or rolling is recommended following building platform and footing excavation.

It is recommended that additional geotechnical investigations are completed surrounding the proposed development at detailed design to confirm specific bearing capacity recommendations for the proposed development areas.

5.9.1 Outwash Sand and Colluvium Bearing

Lenses of outwash sand and silty sand and colluvium have been observed in test pits. Foundations constructed directly upon outwash sand and colluvium or thin engineered fill overlying the same are expected to provide between half and three quarters of 'good ground' bearing capacity as per the recommendations of NZS3604:2011. A minimum thickness of engineered fill underlying foundations can be provided at detailed design following confirmation of foundation dimensions to achieve 'good ground' bearing capacity if required.

It is recommended this is assessed with further investigations surrounding the proposed development at detailed design.

5.10 Settlement

Settlement and differential settlement of shallow foundations are expected to be within structurally acceptable limits provided the recommendations of Section 5.9 are followed and all unsuitable materials, particularly those softened by water, are undercut and replaced with engineered fill during construction.

5.11 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 "Class D" (deep soil) in accordance with NZS 1170.5:2004 seismic provisions.

5.12 Additional Investigations

It is recommended that additional investigations are undertaken at detailed design to assess the subsoil conditions surrounding the proposed buildings. Investigations should include test pits and Scala penetrometers to review the underlying geology and soil relative density at the site and heavy dynamic probe testing to assess the relative density of the underlying site soils, particularly in the vicinity of the proposed clubhouse and healthcare facility.

6 Neighbouring Structures/Hazards

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 the future building, foundations, and retaining walls.

The development is not located within any mapped slope instability features, liquefaction susceptibility areas or any other hazard features on the QLDC or GeoSolve databases.

There is no liquefaction risk due to the depth to groundwater and observed relative density of the site subsoils.

Distances to adjoining structures: No adverse geotechnical implications apply for neighbouring properties during construction provided appropriate vibration, sediment and dust mitigation measures are taken during construction.

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

Erosion and Sediment Control: The site presents some potential to generate silt runoff during heavy rainfall events and this will 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, vegetation buffer strips and sediment ponds.

Compliance with local and regional erosion and sediment control regulations is required.

Noise: It is expected that conventional earthmoving equipment, such as excavators, trucks and rollers will be required during construction.

Dust: Regular dampening of soil materials to meet QLDC standards should be completed where required.

Vibration: No vibration induced settlement is expected in these soil types. The effects of vibrations from rollers and plate compactors on adjacent structures will need to be considered if fill is compacted within 20 m of an existing structure.

7 Conclusions

- The site is underlain by surficial topsoil, uncontrolled fill, loess, colluvium and pond sediment, which overlies outwash sand and gravel and glacial till, which extends to at least 10.64 m beneath the surface of the proposed development area.
- Minor groundwater seepage was observed in TPs 1, 8 and 9 during site investigations; however, the regional groundwater table is expected to lie more than 10 m below the proposed foundation areas therefore it is unlikely to be encountered during earthworks.
- No evidence of existing slope instability has been identified on site. Earthworks plans have been developed by Paterson Pitts Group that include cuts of up to 4.0 m and engineered fills of up to 2.0 m. Assuming cut and fill slopes are implemented as per Section 5 of this report slope stability is not considered to be an issue.
- Bearing on the site will predominantly be governed by the outwash gravel, glacial till and engineered fill. The outwash gravel, glacial till and engineered fill will provide good bearing (100 kPa allowable), for 400 mm wide by 400 mm deep shallow footings.
- Foundation bearing capacity on outwash sand and colluvium or thin engineered fill overlying the same is expected to provide between half and three quarters of 'good ground' as per the recommendations of NZS3604:2011. It is recommended that additional investigations are undertaken at detailed design to confirm bearing recommendations across the site.
- The eastern areas of the site have had previous earthworks undertaken, which have been supervised by B F Whitham. The GCR which provides bearing capacity recommendations for these areas is attached in Appendix C.
- Recommendations for temporary and permanent batter slope angles are described in Table 2. Slopes that are required to be steeper than those described should be structurally retained or subject to specific geotechnical design.
- All retaining walls should be designed by a Chartered Professional Engineer using the geotechnical parameters recommended in Table 1 of this report.
- The colluvium, glacial till, outwash soils and Stage 15 certified fill are considered suitable for use as engineered fill (in accordance with an earthfill specification).
- Loess and pond sediment soil will need to be mixed with granular soils prior to use as an engineered fill source. Alternatively, this can be stockpiled and reused for landscaping purposes within lawn areas and bunding.
- Any uncontrolled/uncertified fill identified during construction should be removed and reviewed by the civil or geotechnical engineer to confirm its suitability for reuse. Any uncertified fill that is not considered suitable for reuse should be cut to waste or stockpiled for reuse in landscaping areas only.

- In areas where significant amounts of cobbles over 100 mm are observed the material should be blended with fine grained soil materials to create a well graded fill.
- All unsuitable soils 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.
- For detailed design purposes it is recommended that the site is classified "Class D – Deep subsoil" in accordance with NZS 1170.5:2004 seismic provisions.
- A Chartered Professional Engineer should inspect all excavations, foundation subsoil, batter slopes and spring flow or under-runners that may be encountered during construction.

8 Applicability

This report has been prepared for the benefit of Northlake Investments 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.

Report prepared by:	Reviewed for GeoSolve Ltd by:
	
.....	.....
Mike Plunket	Fraser Wilson
Geotechnical Engineer	Senior Engineering Geologist

Appendix A: Site Investigation Plan, Topographic and Earthworks Plans

Note all investigations were undertaken prior to bulk earthworks at the site

Areas where previous earthworks have been undertaken as supervised by B F Whitham GCR attached in Appendix C

Test pits undertaken from original ground surface prior to bulk earthworks

TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP10
TP11
TP12
TP13
TP14
RTP1
RTP2
RBH1

Outlet Road
Riverslea Road
Riverslea Road
Cambrian Street
Cambrian Street
Bonspiel Road
Bonspiel Road
Hawkdun Place
Lindis Road
Lindis Road
Malvern Road
Cottlesbrook Street
Cottlesbrook Street
Cairnmuir Street

SCALE 1:2000
0 20 40 60 80 100 (m)

Key
= Proposed development area
= Riley Consultants borehole location
= GeoSolve test pit location
= Riley Consultants test pit location

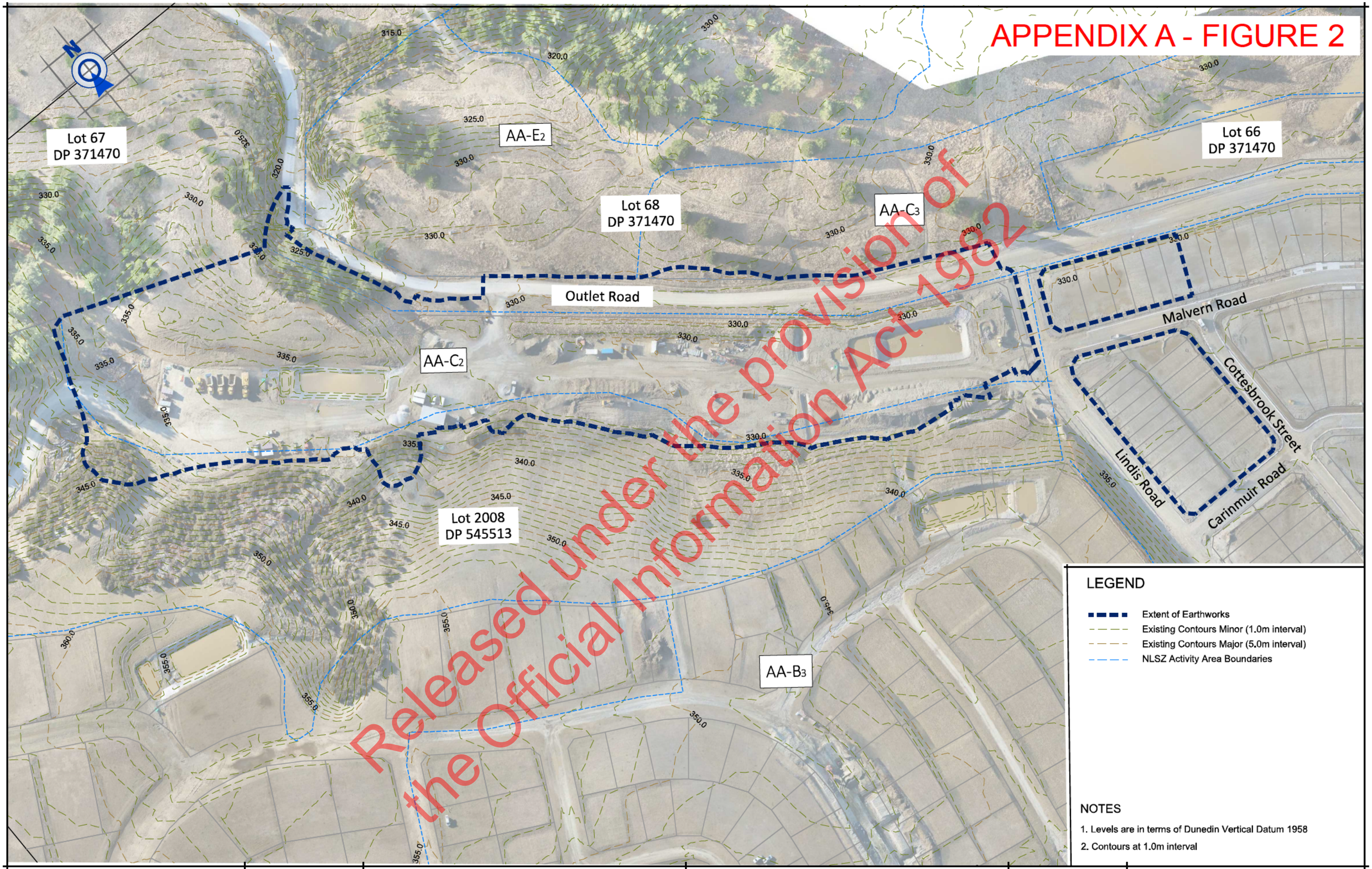
CADFILE:	Site Plan.xar	DRAWN	MDP	08/2020
SCALE: (AT A3 SIZE)	AS SHOWN	DRAFTING CHECKED	FAW	08/2020
PROJECT No.:	200490	APPROVED	FAW	08/2020

GEOSOLVE ENGINEERING CONSULTANTS
GEOTECHNICAL WATER RESOURCES PAVEMENTS

Northlake Investments Ltd
Northbrook Village, Wanaka
Geotechnical Investigation
Site Plan

FIG No: Appendix A, Figure 1
REV. 1

APPENDIX A - FIGURE 2



LEGEND

- Extent of Earthworks
- Existing Contours Minor (1.0m interval)
- Existing Contours Major (5.0m interval)
- NLSZ Activity Area Boundaries

NOTES

1. Levels are in terms of Dunedin Vertical Datum 1958
2. Contours at 1.0m interval

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T 03 443 0110
E wanaka@ppgroup.co.nz

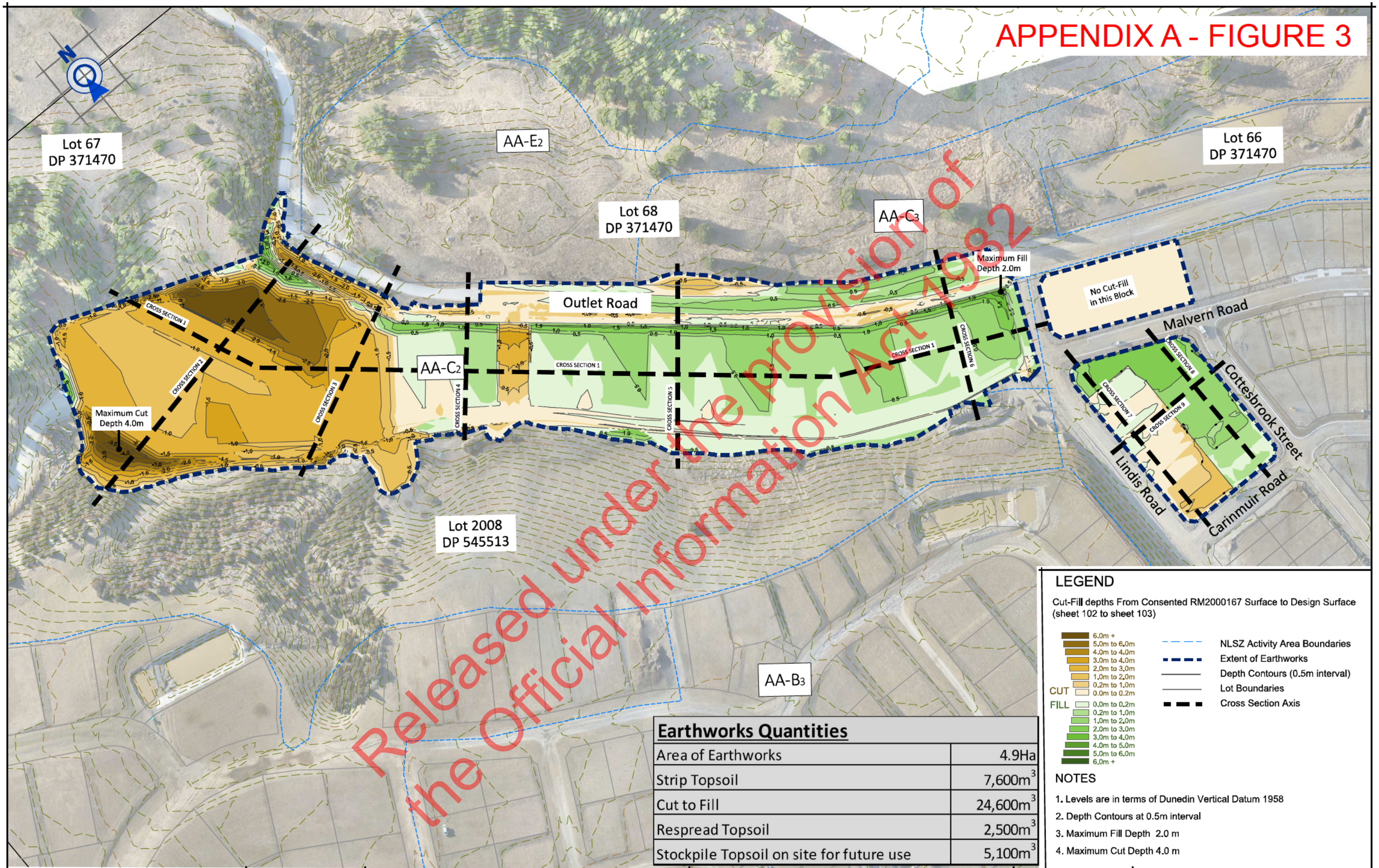
Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plans
Existing Contours

Surveyed by:	PPG/OS	Original Size:	Scale:
Designed by:	PPG/Client	A3	1:1750 @ A3
Drawn by:	AGM		
Checked by:	DA		DO NOT SCALE
Approved by:	AGT		
Job No: W6211	DWG No: 005	Sheet No: 101	Revision No: 1
			Date Created: 07/08//2020

C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG

APPENDIX A - FIGURE 3



Earthworks Quantities

Area of Earthworks	4.9Ha
Strip Topsoil	7,600m^3
Cut to Fill	24,600m^3
Respread Topsoil	2,500m^3
Stockpile Topsoil on site for future use	5,100m^3

LEGEND

Cut-Fill depths From Consented RM2000167 Surface to Design Surface (sheet 102 to sheet 103)

CUT
- 6.0m +
- 5.0m to 6.0m
- 4.0m to 4.0m
- 3.0m to 4.0m
- 2.0m to 3.0m
- 1.0m to 2.0m
- 0.2m to 1.0m
- 0.0m to 0.2m

FILL
- 0.0m to 0.2m
- 0.2m 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 +

- NLSZ Activity Area Boundaries
- Extent of Earthworks
- Depth Contours (0.5m interval)
- Lot Boundaries
- Cross Section Axis

NOTES

1. Levels are in terms of Dunedin Vertical Datum 1958
2. Depth Contours at 0.5m interval
3. Maximum Fill Depth 2.0 m
4. Maximum Cut Depth 4.0 m

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

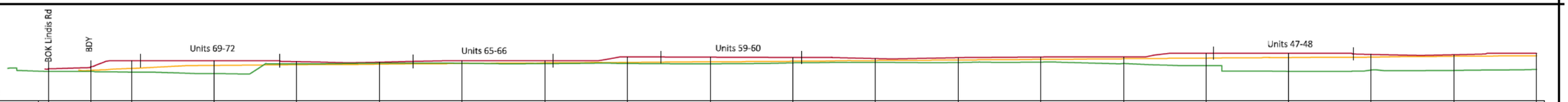
WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T 03 443 0110
E wanaka@ppgroup.co.nz

Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plans
Cut-Fill Plan

Surveyed by:	PPG/OS	Original Size:	Scale:
Designed by:	PPG/Client	A3	1:1750 @ A3
Drawn by:	AGM		
Checked by:	DA		DO NOT SCALE
Approved by:	AGT		
Job No:	DWG No:	Sheet No:	Revision No: / Date Created:
W6211	005	104	1 / 07/08//2020

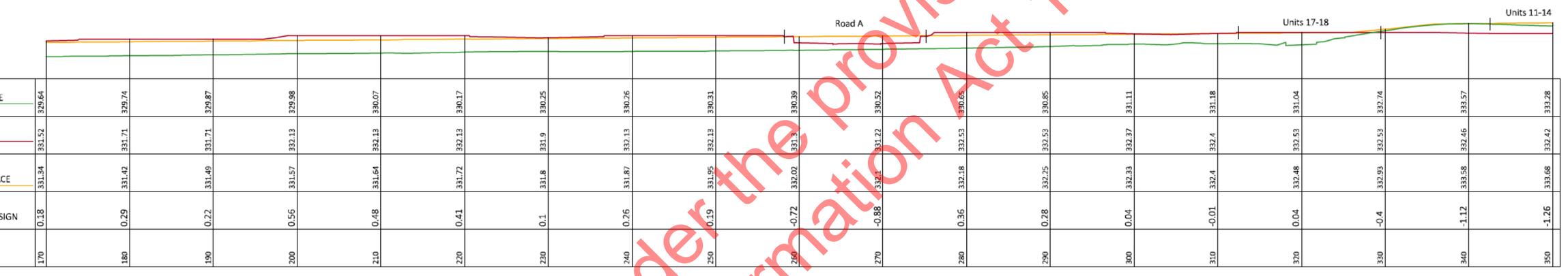
C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG



DATUM RL 326.0

EXISTING SURFACE	329.48	329.48	329.43	329.24	330.41	330.52	330.49	330.46	330.47	330.42	330.53	330.6	330.58	330.64	330.45	330.21	329.52	329.67	329.64	329.74						
DESIGN SURFACE	329.83	330.07	330.81	330.81	330.69	330.64	330.81	330.81	331.26	331.23	331.2	331.07	331.19	331.27	331.29	331.71	331.71	331.56	331.52	331.71						
CONSENTED RM200167 SURFACE		329.63	329.88	330.24	330.31	330.39	330.46	330.54	330.6	330.67	330.75	330.83	330.9	330.97	331.04	331.12	331.19	331.27	331.34	331.42						
-CUT / +FILL RM200167 TO DESIGN		0.43	0.93	0.57	0.38	0.26	0.35	0.27	0.66	0.56	0.45	0.25	0.3	0.3	0.25	0.6	0.52	0.3	0.18	0.29						
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180						

Cross Section 1
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 327.0

EXISTING SURFACE	329.64	329.74	329.87	329.98	330.07	330.17	330.25	330.26	330.31	330.39	330.52	330.65	330.85	331.11	331.18	331.04	332.74	333.57	333.28							
DESIGN SURFACE	331.52	331.71	331.71	332.13	332.13	332.13	331.9	332.13	332.13	331.3	331.22	332.53	332.53	332.37	332.4	332.53	332.53	332.46	332.42							
CONSENTED RM200167 SURFACE	331.34	331.42	331.49	331.57	331.64	331.72	331.8	331.87	331.95	332.02	332.1	332.18	332.25	332.33	332.4	332.48	332.93	333.58	333.68							
-CUT / +FILL RM200167 TO DESIGN	0.18	0.29	0.22	0.56	0.48	0.41	0.1	0.26	0.19	-0.72	-0.88	0.36	0.28	0.04	-0.01	0.04	-0.4	-1.12	-1.26							
CHAINAGE	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350							

Cross Section 1
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250

DATUM RL 328.0

EXISTING SURFACE	333.57	333.28	333.19	333.86	334.5	334.5	334.34	334.76	335.67	336.4	336.81	337.3	336.79	335.79	334.62	333.11	332.28									
DESIGN SURFACE	332.46	332.42	332.42	331.48	332.3	332.8	332.97	333.01	333.06	333.1	333.15	333.19	333.23	334.1	334.65											
CONSENTED RM200167 SURFACE	333.58	333.68	333.79	333.88	333.98	334.06	334.12	334.17	334.22	334.27	334.32	334.38	334.43	334.88												
-CUT / +FILL RM200167 TO DESIGN	-1.12	-1.26	-1.37	-2.4	-1.68	-1.56	-1.15	-1.15	-1.16	-1.17	-1.18	-1.19	-1.2	-0.78												
CHAINAGE	340	350	360	370	380	390	400	410	420	430	440	450	460	470	474	480	484									

Cross Section 1
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250

APPENDIX A - FIGURE 4a

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

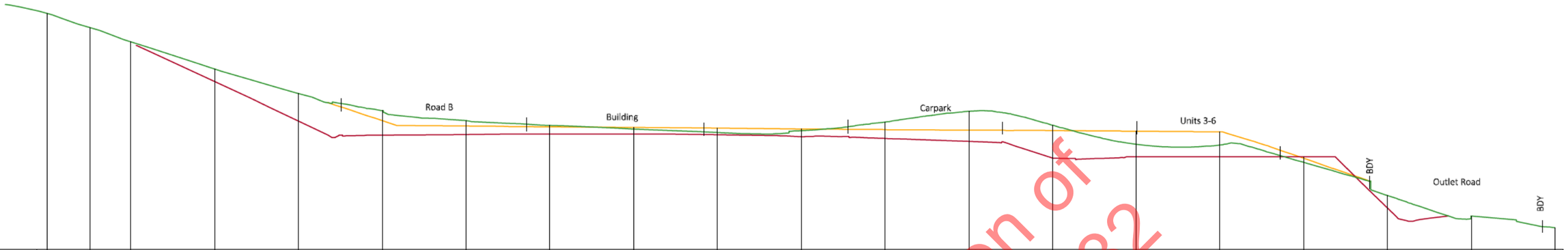
WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T 03 443 0110
E wanaka@ppgroup.co.nz

Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plans
Cross Sections 1

Surveyed by:	PPG/OS	Original Size:	Scale:
Designed by:	PPG/Client	A3	See Plan
Drawn by:	AGM		
Checked by:	DA		DO NOT SCALE
Approved by:	AGT		
Job No: W6211	DWG No: 005	Sheet No: 105	Revision No: 1
			Date Created: 07/08/2020

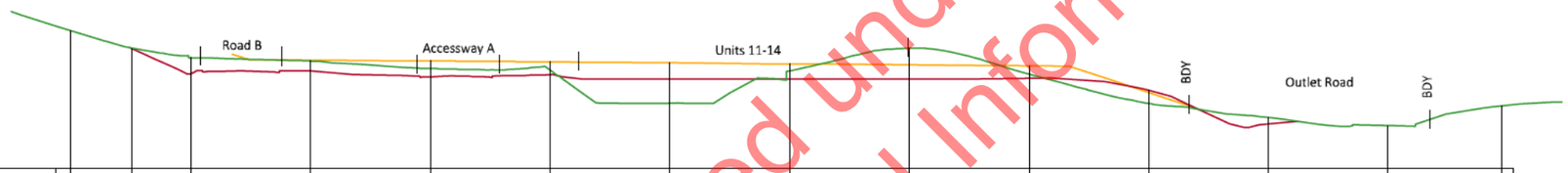
C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG



DATUM RL 320.0

EXISTING SURFACE	348.11	346.43	344.71	341.48	338.54	336.52	335.34	334.75	334.33	333.91	334.12	335.15	336.48	334.78	332.51	332.41	330.33	326.39	323.92	322.53
DESIGN SURFACE				339.98	335.26	333.59	333.66	333.7	333.7	333.62	333.42	333.2	332.84	330.86	331	331	331	324.86		
CONSENTED RM200167 SURFACE						335.32	334.67	334.59	334.5	334.42	334.33	334.25	334.19	334.14	334.06	333.97	330.83			
-CUT / +FILL RM200167 TO DESIGN						-1.73	-1.02	-0.89	-0.8	-0.8	-0.92	-1.05	-1.34	-3.27	-3.06	-2.97	0.17			
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180

Cross Section 2
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 325.0

EXISTING SURFACE	336.45	334.99	334.21	333.93	333.31	333.17	330.41	333.09	335.01	332.84	330.38	329.22	328.55	330.19						
DESIGN SURFACE		334.96	332.84	333.11	332.62	332.78	332.42	332.42	332.42	332.48	331.48	326.68								
CONSENTED RM200167 SURFACE				334	333.94	333.87	333.78	333.7	333.61	333.52	331.31									
-CUT / +FILL RM200167 TO DESIGN				-0.89	-1.32	-1.08	-1.36	-1.28	-1.19	-1.04	0.17									
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	100	110	120						

Cross Section 3
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250

APPENDIX A - FIGURE 4b

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

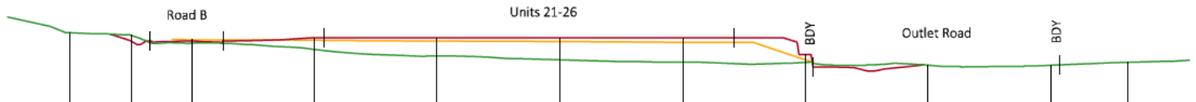
WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T 03 443 0110
E wanaka@ppgroup.co.nz

Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plans
Cross Sections 2

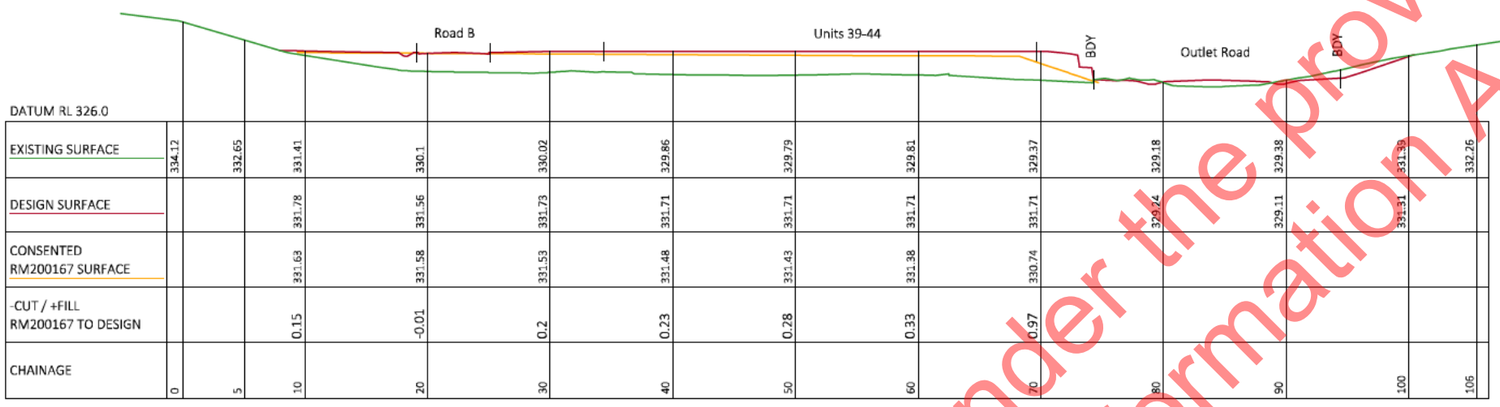
Surveyed by:	PPG/OS	Orginal Size:	Scale:		
Designed by:	PPG/Client	A3	See Plan		
Drawn by:	AGM				
Checked by:	DA		DO NOT SCALE		
Approved by:	AGT				
Job No:	DWG No:	Sheet No:	Revision No:	Date Created:	
W6211	005	106	1	07/08/2020	

C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG



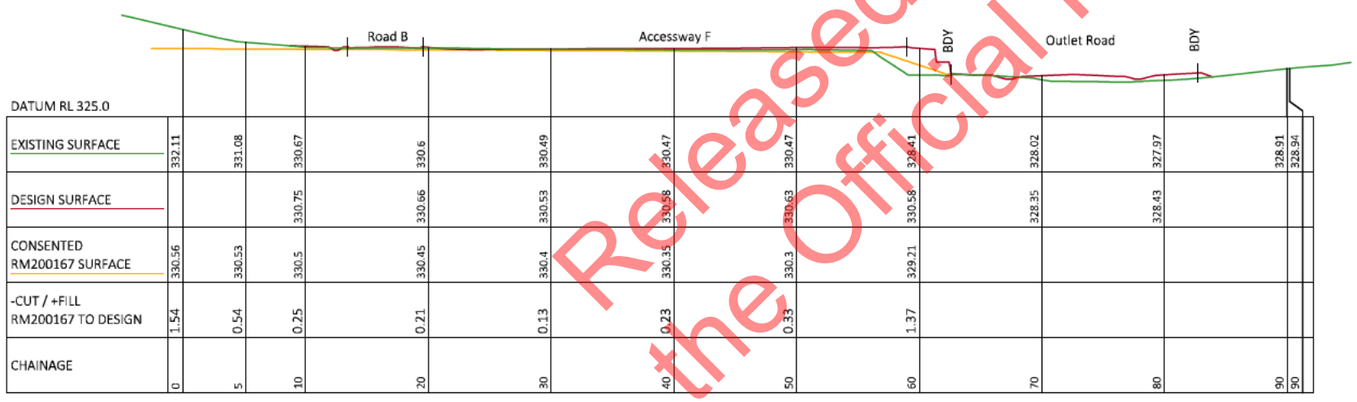
DATUM RL 327.0											
EXISTING SURFACE	332.96	332.75	332.1	331.6	331.07	330.74	330.55	330.53	330.31	330.31	330.54
DESIGN SURFACE		332.26	332.29	332.53	332.53	332.53	332.53	331.19			
CONSENTED RM200167 SURFACE			332.4	332.34	332.29	332.24	332.19	330.75			
-CUT / +FILL RM200167 TO DESIGN			-0.11	0.19	0.24	0.29	0.34	0.44			
CHAINAGE	0	5	10	20	30	40	50	60	70	80	86

Cross Section 4
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 326.0												
EXISTING SURFACE	334.12	332.65	331.41	330.1	330.02	329.86	329.79	329.81	329.37	329.18	329.38	331.59	332.26
DESIGN SURFACE			331.78	331.56	331.73	331.71	331.71	331.71	331.71	329.24	329.11	331.31	
CONSENTED RM200167 SURFACE			331.63	331.58	331.53	331.48	331.43	331.38	330.74				
-CUT / +FILL RM200167 TO DESIGN			0.15	-0.01	0.2	0.23	0.28	0.33	0.97				
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	100	106

Cross Section 5
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 325.0												
EXISTING SURFACE	332.11	331.08	330.67	330.6	330.49	330.47	330.47	328.41	328.02	327.97	328.91	328.94
DESIGN SURFACE			330.75	330.66	330.53	330.58	330.63	330.58	328.35	328.43		
CONSENTED RM200167 SURFACE	330.56	330.53	330.5	330.45	330.4	330.35	330.3	329.21				
-CUT / +FILL RM200167 TO DESIGN	1.54	0.54	0.25	0.21	0.13	0.23	0.33	1.37				
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	90

Cross Section 6
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250

APPENDIX A - FIGURE 4c

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

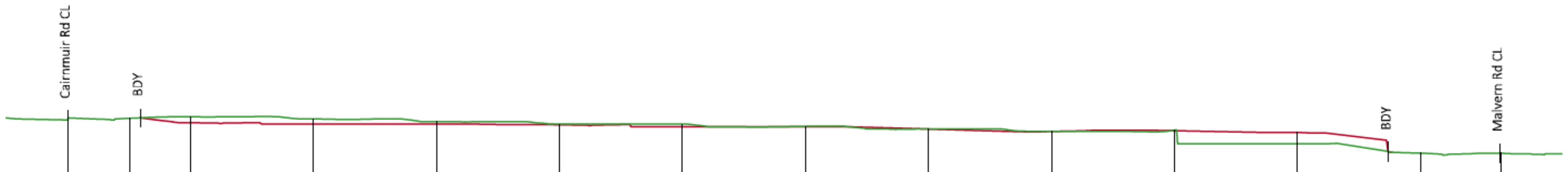
WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T [redacted]
E wanaka@ppgroup.co.nz

Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plan
Cross Sections 3

Surveyed by:	PPG/OS	Original Size:	Scale:		
Designed by:	PPG/Client	A3	See Plan		
Drawn by:	AGM				
Checked by:	DA		DO NOT SCALE		
Approved by:	AGT				
Job No:	DWG No:	Sheet No:	Revision No:	Date Created:	
W6211	005	107	1	07/08/2020	

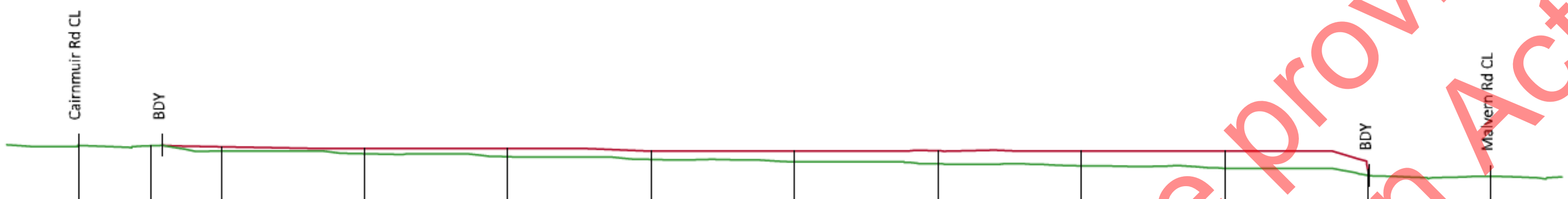
C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG



DATUM RL 327.0

EXISTING SURFACE RM190505	333.24	333.36	333.5	333.31	333.11	332.9	332.88	332.7	332.5	332.31	332.41	331.28	330.52	330.53
-CUT / +FILL TO DESIGN	0	0	-0.48	-0.41	-0.21	-0.05	-0.18	-0	-0.01	-0.01	-0.04	0.93	0	0
DESIGN SURFACE			333.02	332.9	332.9	332.86	332.7	332.7	332.49	332.3	332.37	332.2		
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	100	110	117

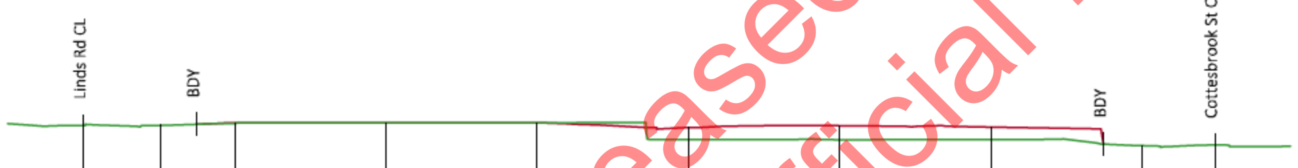
Cross Section 7
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 328.0

EXISTING SURFACE RM190505	332.9	332.86	332.5	332.31	332.1	331.9	331.74	331.61	331.46	331.29	330.8	330.74
-CUT / +FILL TO DESIGN	0	0	0.31	0.39	0.6	0.6	0.76	0.9	1.04	1.21	0.43	0
DESIGN SURFACE			332.81	332.7	332.7	332.5	332.5	332.5	332.5	332.5	331.23	
CHAINAGE	0	5	10	20	30	40	50	60	70	80	90	99

Cross Section 8
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250



DATUM RL 328.0

EXISTING SURFACE RM190505	332.51	332.55	332.67	332.7	332.7	331.58	331.61	331.6	331.21	331.26
-CUT / +FILL TO DESIGN	0	0	0.02	-0	-0	0.81	0.9	0.82	0	0
DESIGN SURFACE			332.7	332.7	332.7	332.39	332.51	332.41		
CHAINAGE	0	5	10	20	30	40	50	60	70	75

Cross Section 9
A3 HORZ SCALE 1:250
A3 VERT SCALE 1:250

APPENDIX A - FIGURE 4d

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

WANAKA BRANCH
19 Reece Crescent
or P.O. Box 283
Wanaka 9343
T 03 443 0110
E wanaka@ppgroup.co.nz

Client & Location:
Northbrook

Purpose & Drawing Title:
Earthworks Plan
Cross Sections 4

Surveyed by:	PPG/OS	Original Size: A3	Scale: See Plan
Designed by:	PPG/Client		
Drawn by:	AGM		
Checked by:	DA		
Approved by:	AGT		DO NOT SCALE
Job No: W6211	DWG No: 005	Sheet No: 108	Revision No: 1
Date Created: 07/08/2020			

C:\USERS\DANDERSON\APPDATA\LOCAL\TEMP\BRICSCAD\BP_26\W6211 005 EARTHWORKS PLANS.DWG