CANTERPRISE

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19 August 1997

Clark Fortune McDonald & Associates
Registered Surveyors & Planning Consultants
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QUEENSTOWN

Attention: Mr N McDonald

Dear Sir

re: **GEOTECHNICAL EVALUATION - MARINA HEIGHTS EXTENSION - FRANKTON**

1. Introduction

Further to your instructions I inspected the above property, which is located to the immediate east of the present Marina Heights subdivision on land owned by a Mr Bill Grant, on 26 June 1997. With assistance from Kate D Harvey, Department of Geological Sciences, University of Canterbury, I supervised the excavation and logging of a total of 12 test pits, and completed engineering geological mapping of the site on 27 June 1997. I have examined aerial photographs of the area, especially Run SN 3857 Photos C/14 & 15 dated 17/2/76, and have also reviewed my original engineering geology report on the adjacent Marina Heights subdivision (Bell, 1985). An engineering geology plan of the proposed development at a 1:500 scale is included as Figure 1, and two cross sections (A-A'; B-B') are given in Figure 2 at 1:500 together with summary trench logs at 1:100: the detailed trench logs are reproduced in Appendix 1. This report sets out my conclusions regarding the site engineering geology, including foundation conditions and land instability, and evaluates each of the proposed lots in terms of s106 of the Resource Management Act 1991. Specific recommendations are made concerning site development in relation to geotechnical constraints, and comments are also included about the large landslide which exists along the north-eastern boundary of the property.

2. Site Description

A. Bedrock Geology: In situ **schist bedrock** outcrops extensively in the lower-central part of the property (Figure 1), and was encountered in eight of the 12 test pits at depths between 0.2 and 2.1m (Appendix 1; Figure 2). The rock material is typically a grey, moderately strong, micaceous schist that is locally quartzo-

feldspathic, and the bedrock displays a consistent foliation attitude with a strike of 300 ± 15° and a dip of 25-30°. The schist bedrock therefore effectively dips downslope controlling the site geomorphology, and there is evidence for subvertical master joint sets that are generally widely spaced (0.3-1m). There is local opening to about 10mm on some joint surfaces adjacent to steep bluffs, whilst wedge failures controlled by the intersection of favourably oriented joints and foliation have occurred during ice scouring of the slopes in the last 10-25,000 years. Of particular note is the set of wedge failures that have taken place above the Marina heights subdivision and further to the east of the property, and which probably relate to ice retreat and/or episodic lake lowering in Postglacial times (Bell, 1992).

B. Surficial Geology: **Glacial till** is exposed on the upper slopes and exceeds 2m in thickness, although no test pits were excavated in the deposits above the highest lake beach (Figure 1), whilst in the central part of the property the till is only about 1m deep (Test Pits 8 & 9). It is typically a massive (ie unlayered) compact sandy gravel or gravelly sand with some silt, and schist and Caples Group boulders to about 300mm in size are present. **Lake beach deposits** occur at three different elevations, respectively about 42, 35 and 15m above present lake level, and record the progressive lowering of the lake during the last 10,000 years (Bell, 1992) which is preserved on many of the subdivision sites around Frankton Arm including the adjoining Marina Heights development (Bell, 1985; 1997). All three lake levels are cut into schist bedrock and the thickness of interlayered sands and gravels is typically of the order of 1-2m on the upper two beach levels, whilst on the lowest surface (c. + 15m) interlayered gravels, sands and silts exceed 2.5m in each of Test Pits 1, 2 & 3 and may be up to 5m thick (cross section A-A'; Figure 2). **Landslide deposits** have been mapped along the eastern boundary of the property (Figure 1), and were logged (Appendix 1; Figure 2) as overlying beach gravels in Test Pits 11 & 12 to a maximum depth of 2.3m (TP11). The materials consist of brown-grey gravelly sandy silts with some clay and rare angular schist blocks to about 1m in dimension, and represent deposits at the limit of a large wedge failure in schist bedrock on land to the east of the proposed subdivision. The nature of the landslide materials suggests derivation as a single movement event accompanying the latter stages of lake lowering or possibly following a major earthquake, and the presence of a weathering profile some 800mm thick in Test Pit 11 (Appendix 1) implies that the deposits are several thousands of years old and that some of the silt content may be loess-derived.

3. Geotechnical Constraints

A. Access Roading: The proposed access for the subdivision involves an initial cut into in situ schist bedrock which is overlain by sandy till up to about 2m thick, and then through thin (c. 1m deep) beach deposits or till overlying bedrock. All batters can be expected to remain stable subject only to retention and/or drainage if required, although minor joint-foliation wedge failures should be anticipated if cuts into bedrock exceed 2m, and fill batter construction using a schist block wall should be considered to facilitate individual lot access. There are in my opinion no significant geotechnical constraints to the proposed roading layout, and I endorse the alignment shown in Figure 1 as being entirely realistic.

B. Groundwater Seepages: No seepages were identified on the property, and only in Test Pits 11 and 12 close to the landslide was groundwater encountered. This is most probably sourced from the landslide, and the water table recorded at 3.80m in Test Pit 11 suggests that bedrock was within 0.3-0.5m of the base of the excavation (Section A-A'; Figure 2). It will be necessary to provide some form of cutoff drain to facilitate the development of proposed Lot 9, and a trench about 2-2.5m deep taken at least 300mm into bedrock is recommended on or close to the Lot 8/9 boundary with discharge into the access road stormwater system. Apart from normal engineering prudence in the provision of stormwater and seepage control measures I do not consider that there are any other groundwater issues affecting the proposed development.

C. Foundation Materials: The schist bedrock either exposed or present at shallow depth beneath the property will ensure long-term site stability for individual dwellings, although normal prudence in excavating into foliated schist should be exercised especially if cuts exceed about 3m. The beach or till materials present on the upper lots (7, 8 & 9) have adequate bearing capacity for conventional house foundations without compaction, but any loose beach gravels should be identified and recompacted in accordance with Council's standards. The thicker beach deposits on the lower part of the property (2.5-5m ±) also have adequate bearing capacity for conventional dwellings without compaction, but the presence of silts beneath any proposed dwelling should be further evaluated at the time of building consent approval if this part of Lot 10 is used for dwelling construction.

D. Slope Stability: There is no instability presently affecting any of the proposed lots, but as noted elsewhere in this report the large wedge-failure to the east of the property has deposited materials up to about 2m thick along the eastern boundary of Lots 8 and especially 9 (Figure 1; section A-A', Figure 2). This large wedge failure has involved significant displacements of schist materials on foliation surfaces, with subvertical joints acting as head and lateral release fractures, and air-photo and field evidence indicates that a lobe of failed debris has extended down the western side of the failure (approximately as indicated in Figure 1). There is no evidence for subsequent reactivation of this failed mass affecting the proposed subdivision site, and the extent of weathering in the upper part of the profile in Test Pit 11 suggests that the original landslide is probably several thousand (3-5,000) years old. It can therefore be concluded that the slope failure to the immediate east of the property has been marginally stable for this period of time, and that seismic and climatic triggers have not caused any significant reactivation. However, any excavation into landslide materials during house construction on Lot 9 should be retained so as at least to reinstate existing marginal stability, and this geotechnical concern should be further addressed at the time of building consent approval for that lot.

4. Development Suitability

A. RMA Requirements: Under s106 of the Resource Management Act 1991 subdivision consent shall not be granted if *"any land..., or any structure on that land, is or is likely to be subject to material damage by* ***erosion, falling debris,***

subsidence, slippage or inundation *from any source"* unless sufficient provision has been made to avoid, remedy or mitigate the effects of any such hazard. In the present case erosion and inundation are not significant concerns, and ground subsidence is similarly not a geotechnical constraint or hazard to development given normal engineering prudence in subdivision design and construction. The only geotechnical constraints to develoment are therefore falling debris and slippage, and both of these relate specifically to any hazard posed by the existing landslide to the immediate east of the property. Given normal engineering prudence in the design and construction of lot and access roading, including batter retention and drainage, I do not consider that any of the proposed lots are subject to hazards arising from within the property boundaries.

B. Lot 6: Lot 6 is located below the proposed access road entirely on schist bedrock (Figure 1), and this has more than adequate strength for any house foundations (Figure 1). No geotechnical concerns exist with this lot, but attention is drawn to 1) a need for engineered access depending on the final grade and method of construction of the access road; 2) retention of any cuts into schist bedrock for house foundations because of the foliation attitude in particular; and 3) the likely impact of bedrock excavation on the costs of underground services.

C. Lots 7 & 8: These two lots involve shallow (≤ 1.5m deep) beach or till deposits overlying in situ schist bedrock, and relatively flat beach surfaces exist on each that are well suited to dwelling construction. No specific geotechnical constraints affect the residential use of either Lot 7 or Lot 8 unless excavations were to be carried out into the steeper till-covered areas (Figure 1), in which case retention and/or drainage would be required, whilst provision of an engineered rockfall protection fence should be considered as a precaution for the upper slopes of Lot 8 even though there is no evidence of recent rockfall debris on the site.

D. Lot 9: Lot 9 comprises parts of the highest two beach terraces on this property separated by shallow till-covered bedrock to form upper and lower "benches", whilst a thin veneer of landslide deposits extends up to 10m from the eastern lot boundary (Figure 1). As previously discussed groundwater was encountered in Test Pits 11 & 12 on this lot, and subsurface control will be required (as indicated in Section 3B of this report) by a deep cutoff trench essentially along the Lot 8/9 boundary. Whilst it would be preferable to locate any dwelling on the lake beach deposits and/or till-covered bedrock slopes away from the landslide materials, it is certainly feasible to build closer to the eastern lot boundary provided that any excavation exceeding 1m into the landslide materials is retained and drained (if necessary). The possibility of rock debris entering this property from the landslide area to the northeast is also noted, and a protection fence along the boundary should be considered at the building consent stage once the house location and means of access are finalised. In view of the geotechnical constraints to residential use of this lot I recommend that specific engineering design be required, although I reiterate that I consider it suitable for house construction subject to subsurface drainage, retention of cut and filled ground, and rockfall protection if considered necessary at the building consent stage of development.

E. Lot 10: Proposed Lot 10 is significantly larger than the others, and incorporates an area of in situ schist bedrock as well as the lowest lake beach surface (Figure 1). In my opinion it would be feasible to locate two dwellings on this lot subject to suitable access, which could be obtained by providing a short right-of-way along the existing track below the Lot 9/10 boundary, and I recommend that this option be further evaluated. The bedrock slopes are steep and would require appropriate engineering design if a dwelling was to be located on the schist exposures, whilst the lake beach surface is flatter but is locally underlain by thick silt deposits which might require drainage or alternative foundation design. I am satisfied that Lot 10 is suited to the construction of at least one dwelling, and that there are no significant geotechnical constraints to its use for residential purposes.

5. Further Investigations

As previously discussed there are few geotechnical constraints to the development as proposed, and I consider that all identified issues can be satisfactorily resolved by appropriate design and construction measures. Specifically, further investigation is considered necessary for Lot 9 at the building consent stage to provide for subsurface drainage of groundwater, rockfall protection, and possible retention of any excavation into landslide materials. Further evaluation of Lot 10 is also recommended at the building consent stage depending on the final house location because of steep schist bluffs and the presence of lake silts at depth beneath the lower terrace, whilst the possibility that two dwellings could be constructed on this section is also noted.

6. Conclusions

1) In situ schist bedrock is exposed in the central part of the proposed subdivision, and the upper slopes are covered by sandy till deposits generally greater than 1m thick: three lake beach terraces underlain by gravels, sands and/or silts have been identified, these corresponding to the +42, +35 and +15m surfaces which have previously been recorded along Frankton Arm.

2) A large landslide feature is present to the immediate east and north-east of the property, and formed by wedge movements involving displacements on the schist foliation dipping at 25-30° with joint release: gravelly sandy silts from the landslide event up to about 2m in thickness occur on part of the proposed subdivision, but the degree of weathering and air-photo studies indicate present stability with a probable age of several thousand years for the failure.

3) No significant geotechnical constraints exists for the development of Lots 6, 7, 8 and 10, and the roading proposal is entirely realistic: further investigations are recommended for Lot 9 at the building consent stage because of a need to control groundwater, and to provide rockfall protection measures.

4) In my opinion the subdivision as proposed is entirely appropriate, and I recommend approval in terms of s106 of the Resource Management Act 1991: I also recommend that the possibility of further subdividing Lot 10 for two dwellings

be evaluated.

7. References

BELL, D H (1985) Engineering Geology Report on Proposed Subdivision - Bishop Property - Frankton *Unpublished Consultant Report to J R Bishop dated 20 February 1985: 19pp + 1 fig*

BELL, D H (1992) Geomorphic Evolution of a Valley System: the Kawarau Vallley, Central Otago *Chapter 21 in "Landforms of New Zealand", ed J M Soons & M J Selby, 2nd edition, Longman Paul: 456-481*

BELL, D H (1997) Remarkables View Subdivision - P & G Hensman - Frankton Arm *Unpublished Consultant Report to Clark Fortune McDonald & Associates dated 8 August 1997: 13pp + 2 figs*

BELL, D H; PETTINGA, J R (1984) Presentation of Geological Data in *"Engineering for Dams and Canals", Proceedings of Technical Groups IPENZ Volume 9 Issue 4(G): I 4.1 - 4.35*

I trust that the above report is sufficient for your needs, but do not hesitate to contact me if I can be of further assistance in this matter.

Yours sincerely

DAVID H BELL
Senior Lecturer in Engineering Geology

APPENDIX 1

ENGINEERING GEOLOGY LOGS

OF

INVESTIGATION TRENCHES

Proposed Subdivision - Marina Heights Extension

FRANKTON ARM - QUEENSTOWN

Note: Descriptive terminology follows Bell & Pettinga (1984)

INVESTIGATION TRENCH - 1

Orientation: 185°

Depth (mm)	Description	Unit
0 - 150	Moist, firm, slightly plastic, dark grey, massive, silty SAND with some clay and schist gravels to 15mm	TOPSOIL
150 - 450	dry, loose, brown, sandy GRAVEL, Caples Group subrounded, quartz subangular to subrounded to 60mm, median size 10mm.	LAKE GRAVEL
450 - 2900+	moist, loose, moderately layered, grey, medium sand with rare quartz and schist pebbles to 50mm,gravel layer 50mm thick at 2200, increasing gravels below 2200.	LAKE BEACH SANDS

Comment: – Hole dry

INVESTIGATION TRENCH - 2

Orientation: 165°

Depth (mm)	Description	Unit
0 - 400	moist, firm, massive, dark grey, gravelly silty SAND with some clay.	TOP SOIL
400 - 650	moist, firm, brown, gravelly clayey SILT with some sand, angular schist and subrounded Caples Group to 50mm	LAKE SILTS
650 - 800	moist, loose, grey brown fine GRAVEL, dominant schist to 100mm, rare Caples Group to 200mm, subangular to subrounded.	LAKE BEACH GRAVEL
800 - 1000	moist, firm, light grey, fine sandy SILT with some clay and gravels, angular schist to 75mm, Caples Group to 130mm	LAKE SILTS
1000 - 2600+	moist, loose, light brown, gravelly medium to coarse SAND, gravels are angular to subangular schist typically less than 150mm, rarely up to 300mm+, subrounded Caples Group to 150mm.	LAKE SANDS

Comment: – Hole dry

INVESTIGATION TRENCH - 3

Orientation: 295°

Depth (mm)	Description	Unit
0 - 300	moist, firm, dark grey, sandy GRAVEL with some silt.	TOP SOIL
300 - 550	moist, loose, brown, sandy fine to medium GRAVEL, angular to subangular schist to 150mm, rounded to subrounded Caples Group to 200mm.	LAKE BEACH GRAVEL
550 - 1420	moist, loose, grey, medium SAND with rare rounded to subrounded Caples Group boulders to 250mm and subrounded to subangular schist to 200mm.	LAKE SANDS
1420 - 2650+	moist, firm, slightly plastic, grey, clayey SILT.	LAKE SILTS

Comment: – Hole dry

INVESTIGATION TRENCH - 4

Orientation: 305°

Depth (mm)	Description	Unit
0 - 250	moist, firm, dark grey, gravelly SILT with some clay.	TOP SOIL
250 - 800	moist, loose, oxidised, brown, sandy GRAVEL, angular to subangular schist to 75mm, typically 15mm - 20mm,very rare Caples Group to 50mm.	LAKE BEACH GRAVEL
800 - 1000+	in situ, moderately strong, grey, micaceous SCHIST, attitude: 292/25 S.	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 5

Orientation: 110°

Depth (mm)	Description	Unit
0 - 200	moist, firm, dark grey, clayey SILT with some gravel.	TOP SOIL

200 - 600	moist, loose, brown sandy fine GRAVEL, angular to subangular schist to 150mm, typically 15mm to 20mm, very rare rounded to subrounded Caples Group to 30mm.	LAKE BEACH GRAVEL
600+	in situ, moderately strong, grey schist, attitude: 292/30 SW, open joint at 296/29 SW	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 6

Orientation: 185°

Depth (mm)	Description	Unit
0 - 275	moist, firm, dark grey, clayey SILT with some gravel.	TOP SOIL
275+	in situ, moderately strong, grey, quartzo-feldspathic SCHIST, attitude: 285/26 S.	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 7

Orientation: 175°

Depth	Description	Unit
0 - 300	moist, firm, dark grey, sandy SILT, with some clay and rare gravel.	TOP SOIL
300 - 500	moist, firm, gravelly SILT with some clay, subangular schist to 75mm and rare Caples Group to 50mm.	LAAKE SILTS
500 - 1100	moist, loose, brown (to grey with increasing depth), coarsely layered, sandy GRAVEL, angular to subangular schist to 150mm, typically 25mm, rounded to subrounded Caples Group to 50mm.	LAKE BEACH GRAVEL
1100+	in situ, moderately strong, grey, micaceous SCHIST, attitude: 295/25 SW.	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 8

Orientation: 200°

Depth (mm)	Description	Unit
0 - 300	moist, firm, dark grey, sandy SILT with some clay and fine gravels	TOP SOIL
300 - 1250	moist, compact, brown grey, massive, gravelly medium to fine SAND with some silt, schist and Caples Group gravels to 100mm.	SANDY TILL
1250 - 1700	in situ, moderately strong, grey, micaceous SCHIST, attitude: 275/28 S.	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 9

Orientation: 308°

Depth (mm)	Description	Unit
0 - 600	moist, compact, grey, massive, sandy GRAVEL with some silt, angular to subangular schist to 300mm,numerous rounded to subrounded Caples Group boulders typically 150mm tto250mm.	SANDY TILL
600+	in situ, strong to moderately strong, grey SCHIST, attitude: 300/28 SW.	SCHIST BEDROCK

Comment: – Hole dry
– Up to 0.5m topsoil stripped for construction of existing track.

INVESTIGATION TRENCH - 10

Orientation: 106°

Depth (mm)	Description	Unit
0 - 300	moist, firm, dark grey, sandy SILT with some clay and gravel.	TOP SOIL
300 - 750	weathered, moist, firm, slightly plastic, brown, sandy SILT with some clay and gravel, angular schist to 75mm, rounded Caples Group to 40mm, gravels concentrated from 600mm to 750mm.	LAKE SILTS

750 - 950	moist, firm, light grey, sandy SILT with some clay and gravel, angular schist to 75mm rounded Caples Group to 40mm.	LAKE SILTS
950 - 1300	dry, loose, brown grey, coarsely layered, sandy GRAVEL, angular to subangular schist to 75mm, typically 25mm, very rare rounded to subrounded Caples Group to 50mm.	LAKE BEACH GRAVEL
1300 - 2100	moist, loose, grey (brown), gravelly medium to coarse SAND, angular to subrounded schist to 700mm, typically 30mm to 40mm, rounded to subrounded Caples Group to 200mm, typically 50mm to 150mm.	LAKE BEACH SAND
2100+	in situ, strong to moderately strong, grey, quartzo-feldspathic SCHIST, attitude: 315/28 SW.	SCHIST BEDROCK

Comment: – Hole dry

INVESTIGATION TRENCH - 11

Orientation: 225°

Depth (mm)	Description	Unit
0 - 300	moist, firm, dark grey, sandy SILT with some clay and gravel.	TOP SOIL
300 - 800	moist, firm, brown, gravelly sandy SILT, angular schist to 250mm.	LANDSLIDE DEBRIS
800 - 2300	moist, firm, brown grey, gravelly sandy SILT with some clay, angular schist to1000mm, typically 50mm to 150mm, no Caples Group.	LANDSLIDE DEBRIS
2300 - 2600	moist, loose, brown grey, coarsely layered, fine GRAVEL with some sand, angular to subrounded schist to 100mm, typically 20mm, no Caples Group.	LAKE GRAVELS
2600 - 3900	moist to wet, loose, brown grey, coarsely layered, gravelly SAND and sandy GRAVEL, layers of medium to fine sand 50mm to 100mm thick, angular to subangular schist to 300mm, typically 50mm to 100mm, rounded to subrounded Caples Group to 250mm, typically 50mm to 100mm.	LAKE BEACH GRAVELS AND SANDS

Comment: – Water table at 3800mm.

INVESTIGATION TRENCH - 12

Orientation: 148°

Depth (mm)	Description	Unit
0 -300	moist, firm, dark grey, sandy SILT with some clay and gravel.	TOP SOIL
300 - 850	moist, firm, brown grey, gravelly sandy SILT with some clay, angular schist to 200mm, no Caples Group.	LANDSLIDE DEBRIS
850 - 1250	moist, loose, brown, gravelly coarse SAND, subangular to subrounded schist to 75mm, typically 35mm, rare rounded to subrounded Caples Group to 50mm.	LAKE BEACH SAND
1250+	in situ, moderately strong, grey, micaceous SCHIST, attitude: 315/35 SW.	SCHIST BEDROCK

Comment: – Seepage from basal 50mm of beach sands.