

Subsurface investigation and slope stability of Haack's sub-division at Underwood, Lilydale Municipality.

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Abstract

A geological examination of W.F. Haack's proposed subdivision indicates that much of the area is a recent shallow planar landslide. Active small scale slumping and earth flows are apparent around the margins of the planar slide. Two flat benches are suspected of having been formed by an older slip circle type of slumping from a talus slope, which forms a steep scarp-like area bordering a spur.

Trenches and auger drilling confirm that these benches are covered with talus deposits of dolerite boulders overlying clay and mudstone of Triassic age and the benches are most likely the result of slumping which has rotated these deposits into a near horizontal position.

The planar slide and steep scarp area are not suitable for building, but the benches on the spur may be a possible home site. This requires further investigation.

PREVIOUS INVESTIGATIONS

At the request of the Lilydale Municipal Council, W.F. Haack's proposed subdivision at Underwood [EQ182294] was first examined for stability by W.L. Matthews in 1975. Matthews examined the western margin of Lot 1 (fig. 1) and reported a recently active earth flow on this lot and in an adjoining area and suggested that the proposed house site be moved to the flat area close to Lilydale Road.

In 1977, the writer examined Lot 3 of the subdivision at the request of the owner and the Lilydale Municipal Council. A large, recently active landslip covered the cleared southern section of this lot. The only possible stable area in the cleared section of the lot was the two tiered benched spur bordering the active earth flow area to the north.

Even this area was suspected of having suffered mass movement by slip circle slumping, although it appeared that this event had occurred at an earlier period of time compared with the recently active shallow planar landslide. Because of this possibility, a subsurface investigation was requested which included augering and trenching followed by shear box testing of some of the clay samples collected. In 1978, a request was received to include Lot 2, which is situated east of Lot 1, in the investigation.

Terms of reference

This report only covers Lot 3 of the subdivision (fig. 1). Lot 1 is considered to have been covered adequately by W.L. Matthews. Lot 2 is a high, heavily-bushed divide between two valleys and is surrounded by steep slopes. The lot is 450 m from the Lilydale Road and approximately 76-91 m above it and has no existing access. It is difficult to see this lot being used for settlement with the existing level of development in the Lilydale-Underwood rural area. It would be more appropriate to examine the area for suitability of settlement if and when development should occur.

LOCATION

Lot 3 is situated on the northern side of the low col that joins Mount

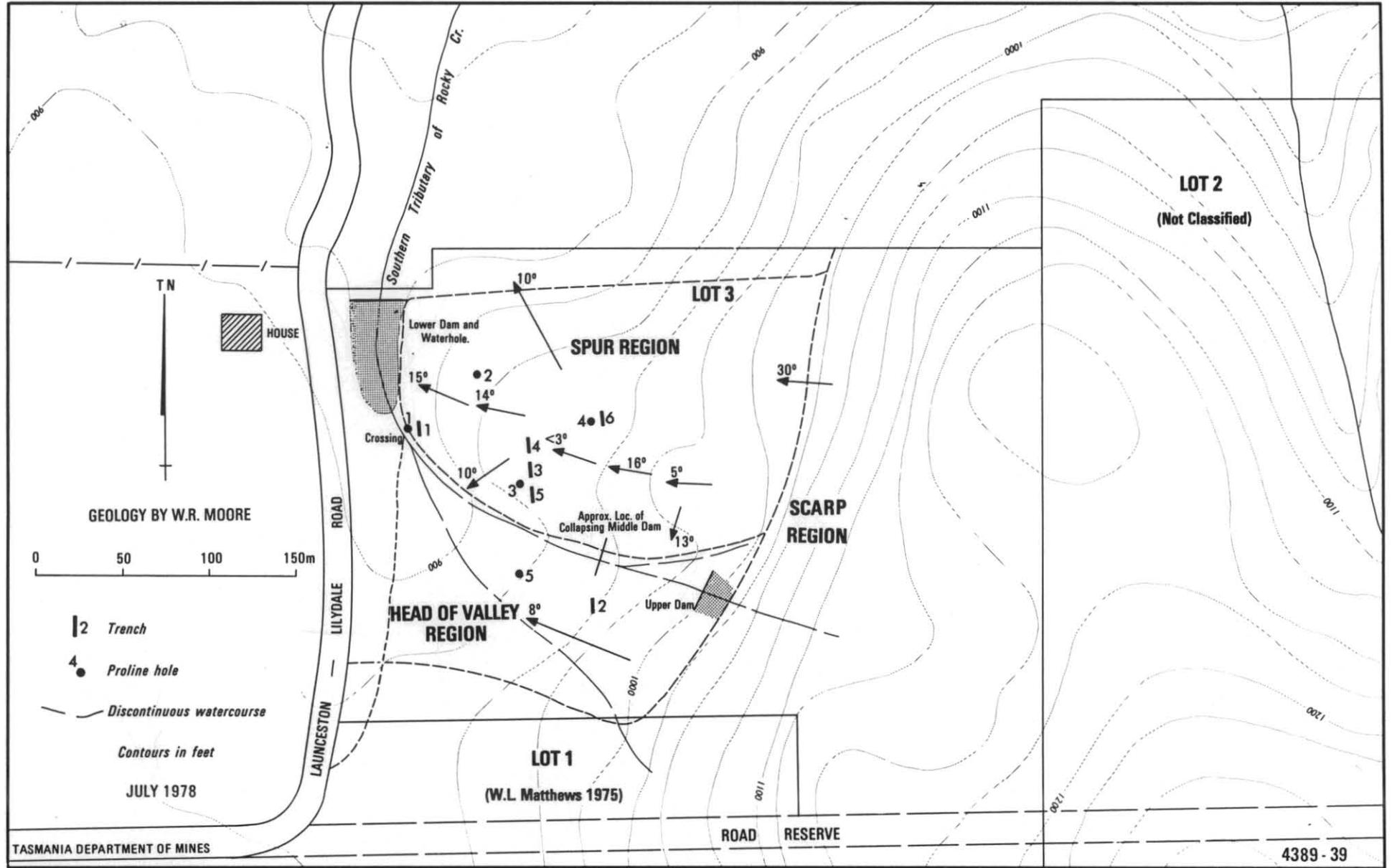


Figure 1. Location of test pits and auger holes

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Arthur to Browns Hill. This ridge forms the drainage divide between the Pipers River system to the south-west and the Lilydale valley to the north. The subdivision is approximately 3 km south of Lilydale on Lilydale Road, which forms the western boundary of the subdivision.

TOPOGRAPHY

Lot 3 can be subdivided into three distinct topographic regions (plate 1, fig. 1).

- (1) Steep scarp slope
- (2) Two tier benched spur.
- (3) Shallow curved head of valley.

STEEP SCARP SLOPE

This area comprises a heavily bushed steep face which rises 46 m then flattens to a spur ridge at its eastern border. No attempt has been made to locate this eastern boundary on the ground and its position has been plotted from the survey plans (fig. 1).

The steep face has a slope mostly in excess of 30° and appears to be underlain mainly by dolerite scree. No rock outcrops occur. Because of its steepness it is considered to have little potential as a building site. On the adjoining property, sandstone outcrops as 2 m high benches dipping approximately 20° S.

TWO TIER BENCHED SPUR

This spur separates the head of the valley of a small tributary of Rocky Creek from another tributary valley to the north. The spur is rounded with two flat benches at 15 and 30 m. The slope of the spur from the stream is 15°, but flattens to 13° near the lip of the lower bench, with the bench surface having a slope of 3°. The slope to the upper bench is 16° with a 4° slope on the surface of the bench (fig. 1). The slope on the sides of the benches is 9°-10° on the lower bench and 13° on the upper bench.

At the eastern end of the benches, toward the toe of the higher bench and at the foot of the scarp face, are two marshy hollows. These hollows give the benches the appearance of tilting backward towards the east. The contours of these benches show a marked discordance from the scarp face contours (fig. 1). No rock outcrops were visible, but dolerite boulders are scattered all over the benches and spur slope. Small active landslips on the southern margin at the abutments of the small middle dam expose a yellow clay and mudstone which appears to be derived from Triassic sediments.

There appear to be four possible explanations for the origin of the two benches on the spur:

- (1) They are old stream terraces covered by terrace gravel deposits.
- (2) They are structural terraces formed by thick and harder sandstone beds capped by talus deposits.
- (3) They are the remnants of two talus fans modified and isolated by the subsequent headward erosion of the valley.
- (4) They are the slumped toe of a talus slope occurring at the foot of the scarp area. Two slip circle slumps have rotated their original sloping surface to form the two near horizontal benches.

From surface geological evidence, the latter explanation appeared to



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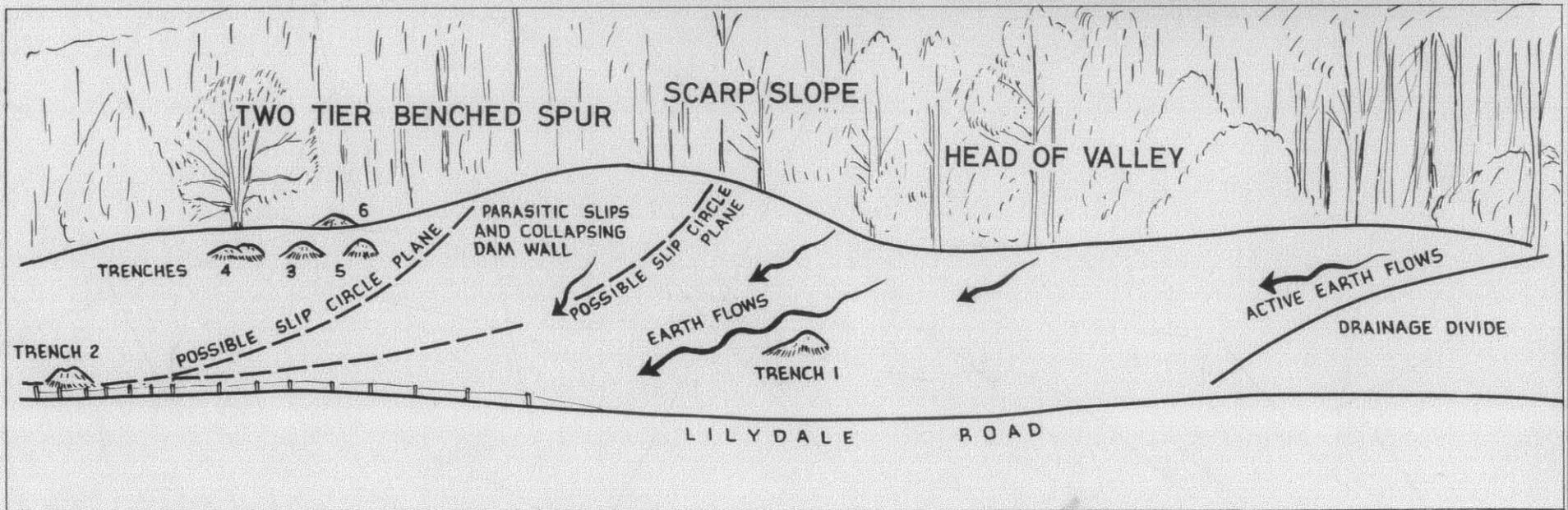


Plate 1. Panoramic view of area under investigation

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be the most likely, but required subsurface investigation to attempt to obtain further evidence in support of this hypothesis.

VALLEY HEAD REGION

This topographic region is the curved wide headwater area of the Rocky Creek tributary. Above the dam located in the narrow stream valley at the northern boundary of Lot 3, the stream subdivides into several small streamlets (fig. 1). The valley widens and changes direction and the slope flattens, forming a shallow, amphitheatre shaped basin.

In this area, the streamlets are a series of small, shallow, narrow discontinuous gutters connecting a series of marshy hollows. Small dams have been constructed on two of the streams. The upper dam near the bush line at the foot of scarp slope holds little water and is almost completely silted up and overgrown. The middle dam has a small shallow pool of water behind it, but the bank at the southern end has collapsed and an active slump area is present at the other end (plate 2). The overall slope on the valley floor is 7°-8°.

The most conspicuous feature of this area is a series of small discontinuous pressure ridges (plate 3). These features are characteristic of the shallow planar landslide or earth flow that occupies most of the valley and extends into the neighbouring Lot 1. It is difficult to know if the area is all one large flow or a series of small earth flows around the valley margins that have coalesced, filling the head of the valley. Dolerite boulders occur in this area but are not as obvious and appear scattered compared with the spur area. Small outcrops near the middle dam indicate that the area is underlain by clay, sandstone and mudstone of Triassic age.

Stability of valley head region

The number of trees in the headwaters of the valley is not great; some have been recently tilted and are associated with the small active areas (plate 2). These shallow slumps or parasitic landslips are continuing to extend the valley by headward erosion into the spur and scarp areas. Elsewhere in the headwaters, there was no obvious tilting of large trees. The age of the shallow flow in the valley floor is uncertain but appears to be recent. No tension cracks were found.

Any housing developed on this area would increase the amount of groundwater from sullage and septic tanks and would probably cause local failures, as has occurred at the small dams. The risk of reactivation of the existing slip appears high and a conventionally constructed house would be unlikely to survive such movement. Therefore on the surface evidence alone, the valley head area should be classified as an active landslip zone. As a subsurface investigation was required for the spur area, some subsurface investigation was undertaken in this area.

SUBSURFACE INVESTIGATION

Valley head area

One trench and one auger hole (Trench 1, Hole 5) were sited in the middle of the large shallow slide area in the valley floor. For comparison, another auger hole and trench (Trench 2, Hole 1) were sited in what appeared to be a stable area bordering the landslip at the foot of the spur (fig. 1). No gravel was encountered in these holes and they passed quickly through a

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Plate 2. *Middle dam with active parasitic slump and collapsing embankment.*



Plate 3. *Small pressure ridges in amphitheatre shaped head of valley area*

sequence of clay to sandstone and mudstone of Triassic age (plate 4). The clay layer was 3.5 m thick in the landslip area compared with 1.5 m at the foot of the spur (Appendix 1, 2). The water table was at approximately the same level below ground surface for both trenches and the trenches made very little water in the time they were left open. Any subsurface movement is likely to be confined to the upper horizon of the clay and the upper weathered zone of the mudstone-sandstone sequence. Any future movement is likely to be shallow and at depths no greater than 3.5 m. No slip planes, slickensides, or shear polish were found in the trenches to indicate the level of any past movement.

Samples taken from Holes 1 and 5 for shear testing gave angles of friction of 17°-19°. The calculated factor of safety for a slope of 10° and with the water table below the slip plane was 1.84. When the water table overlies the slip plane, the factor of safety is reduced to 1.5 for a 10° slope and below 1 for a 15° slope.

The water table in Trenches 1 and 2 was low and these holes made only 170-210 mm of water in the 3-4 hours that they were left open. However in winter, the water table is likely to be close to the ground surface and the clay saturated in this location. From these tests and calculations, the clay is likely to be close to failure in winter on the existing valley floor slope of 8°.

The shear tests on the clay and calculations of the factor of safety under varying slope angles and water table levels confirm the geological evidence that the valley head area is unsuitable for building. The process of gradual headward gully erosion is likely to continue, as is apparent by the active slips near the tree line at the foot of the scarp in Lot 1 as well as Lot 3 and on the southern flank of the spur area near the middle dam.

Spur area

Three auger holes were drilled on the lower bench of the spur. Holes 2 and 4 encountered dolerite boulders which the drill was unable to penetrate. No dolerite boulders were encountered in Hole 3, where a sequence of yellow clay, weathered mudstone and micaceous mudstone with some fine sandstone of Triassic age were penetrated to a depth of 9.1 m (Appendix 2). The water table was not encountered in this hole.

As the data obtained from this drilling were not considered sufficient, a back-hoe was used to dig four trenches on the lower bench. Unfortunately time did not allow for any investigation of the higher bench. Trench 3, excavated on the site of Hole 3, showed a yellow clay overlying weathered, bedded Triassic mudstone at the southern end of the trench. No boulders were encountered. A contact between the yellow clay and a boulder bed was exposed in the northern end of the trench; the contact dipped 60° from the surface to a depth of 2.8 m below the boulder bed (plate 5) where it became flat. The boulders comprised iron stained and fresh dolerite, irregular in shape and up to one metre in size in a mottled grey-brown clay matrix. This clay is frequently found above dolerite and differs from the yellow clay derived from the Triassic mudstone. A thin, discontinuous horizontal iron pan layer was present in the boulder bed at 1.1 m depth. This layer could not be traced in the yellow clay and mudstone at the southern end of the trench.

Trench 4 was excavated 5 m north of Trench 3 to a depth of 2.8 m. Dolerite boulders in a matrix of grey mottled clay were exposed to 2.8 m. No iron pan was seen in the boulders in this trench nor was the contact with the clay and Triassic mudstone exposed.



Plate 4. *Clay overlying Triassic sandstone-mudstone - Trench.2.*



Plate 5. *Gravel overlying mudstone with dipping interface - Trench 3.*

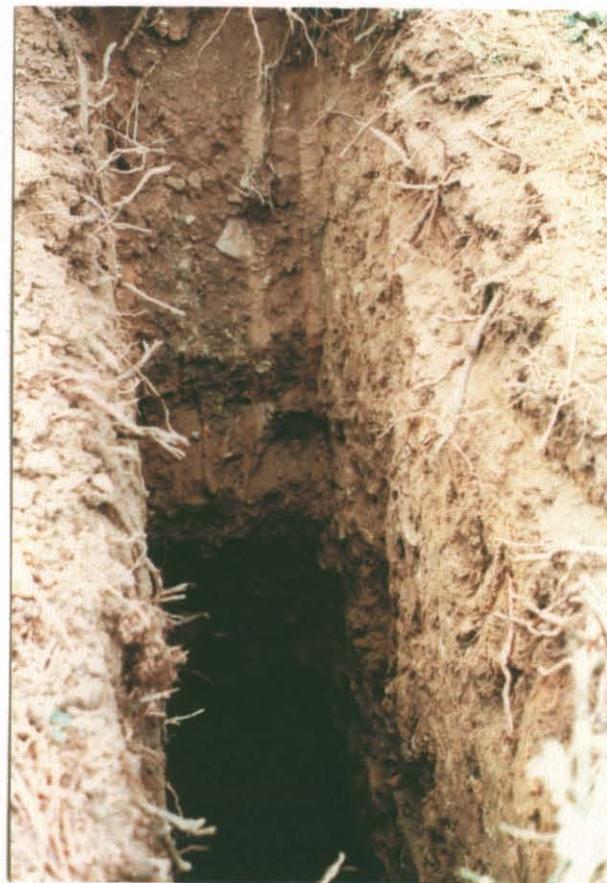


Plate 6. *Soil horizon developed on gravel - Trench 6.*

Trench 5, excavated south of Trench 3 to 2.5 m depth exposed 1.1 m of boulders in grey mottled clay overlying a sequence of yellow clay and mudstone. A thin horizontal iron pan separated the yellow clay from the overlying boulder bed.

Trench 6 was excavated at the foot of the second bench in the marsh area. A boulder bed was exposed to a depth of 2.3 m but no iron pan layer was seen. A well developed soil profile was exposed at the surface indicating the area had been stable for a long time (plate 6).

The trenches showed that the boulder beds were talus deposits and not river terrace gravels and that no thick sandstone beds underlie them to form structural terraces. No noticeable difference existed between the size of the boulders, the degree of weathering or the ratio of boulders to clay in any of the four trenches excavated on the bench area. The thickness of the boulder deposit varied between trenches and two layers separated by an iron pan were present in Trench 3. There was no noticeable difference in the state of weathering and size of the boulders between the two layers.

The iron pan layer formed the contact between the boulder bed and clay and mudstone sequence in Trench 5. The clay and mudstone surface on which the boulders were deposited was irregular, as exposed between Trenches 3, 4 and 5. The bedding in the underlying mudstone, where exposed, was flat. No slickensides, shear polish, or shear plane was visible at the contact between the gravels and the underlying sediment.

A slip circle landslip mechanism appears the most likely of the four possible origins for the two benches on the spur. The lower level talus deposits from the scarp were deposited on the spur where two parallel rotational slumps rotated the deposits into a near horizontal position.

STABILITY ANALYSIS

A clay sample from 3.4 m depth from Hole 3 gave a very low angle of friction on shear testing. The calculated factor of safety was below 1, even with water below the sample level and with slopes as low as 10°.

This result indicates that the existing small slumps at the southern margin of the bench near the middle dam are likely to expand until the shoulder of the spur is reached. Further sampling is required for a more representative area away from the shoulder of the spur where Hole 3 was located. This will require drilling through gravels at the site where a future house is likely to be sited. Such a drilling programme will require a heavier drill, capable of penetrating the gravel, than was available for this investigation.

CONCLUSIONS

The scarp area is steep with slopes in excess of 29°. Shallow earth flows are present at the foot of this scarp near the bush line in the head of the valley region of Lot 3 and extend into Lot 1. This headwater gully erosion will continue to extend into this scarp area as a normal erosional process by shallow sliding. Large older mass gravity movements must have occurred from this scarp region to deposit the talus boulder deposits on the spur benches and could possibly re-occur. For these reasons, the scarp slope is not considered a suitable building area up to the 350 m (1150 ft) contour level.

In the head of the valley, a shallow planar slump has occurred in the immediate past and small planar slides are active around the margins of the

area. With the inevitable increase in groundwater associated with a house, the risk of re-activating the planar slide is high. This risk makes this area unfavourable for building.

In the spur area, slip circle slumping appears to have occurred in the past to produce the two flat benches covered by horizontal talus boulder deposits. The area appears to have been stable for a long period of time. Active parasitic shallow slumps are present on the southern edge of the lower bench of the spur and these appear likely to expand higher up the spur with time. Given adequate precautions concerning the removal of water and sullage from the spur, house construction may still be possible on one of the benches. Further samples are required from the clay below the gravels for testing. A cored diamond drill hole should also be drilled to attempt to locate a slip plane or a change in the dip of the mudstone at depth. This hole should be drilled to below the water table.

RECOMMENDATIONS

The head of the valley region and the scarp region should both be classified as active landslip zones where no buildings should be sited.

The benched spur region should be classified as a potential landslip zone where further investigation is required before building should occur. Certain requirements concerning the removal of all sullage and sewage water from this bench area would be a prerequisite before any building should be permitted. The access track to the benched spur should not follow the existing track around the foot of the spur, because any excavation into the toe of the spur associated with upgrading of this track could possibly cause reactivation of the large scale slumping. If this does not occur, small parasitic slumps will give continued difficulties on this route. A less hazardous route would be along the foot of the scarp from the proposed road reserve access to Lot 2.

The writer wishes to acknowledge the assistance given by R.C. Donaldson who supervised the shear testing of the clay samples and stability analysis calculations.

[26 June 1978]

APPENDIX 1

Logs of test pits

Trench 1

Depth (m)	Description
0-0.2	Grey sandy soil
0.2-2.3	Mottled grey clay
2.3 -3.5	White micaceous clay with some graphite grains
3.5 -3.8	White and brown fine sandstone and micaceous mudstone well bedded and both showing horizontal bedding. This layer moist. This trench made 210 mm of water in the 4 hours it was open.

Trench 2

0-0.2	Grey soil
0.2-1.48	Mottled grey clay (as in trench 1)
3.3 -3.47	Grey iron stained closely bedded micaceous mudstone. This trench made 170 mm of water in the 3 hours it was open.

Trench 3 (north side)

0-2.7	Gravels of dolerite pebbles and boulders mixed in a matrix of mottled grey-brown clay. Boulders up to one metre in size dominant. Boulders iron stained. Unweathered clay is grey-brown and derived from weathering of dolerite. A discontinuous carbonaceous iron pan at 1.1 m depth. This layer not distinguishable in Triassic mudstone at southern end of the trench.
2.7-3.15	Yellow Triassic mudstone.

Trench 3 (south side)

0-3.15	Yellow clay and mudstone with no bedding visible, then yellow-grey Triassic mudstone. Horizontal bedding visible but not particularly disturbed at base of trench. Contact between gravels and mudstone sharp and dips at 60° W and then flattens to go below gravel at 2.7 m.
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Trench 4

0-2.8	Dolerite pebbles in grey-brown mottled clay matrix.
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Trench 5

0-1.1	Dolerite pebbles in grey-brown mottled clay. Thin carbonaceous and iron pan layer at base.
1.1-2.5	Yellow clay, bedded micaceous mudstone. Triassic micaceous mudstone - appears <i>in situ</i> .

Trench 6

0-0.3	Grey sandy soil with a well developed soil profile.
0.3-2.3	Deeply iron stained and superficially weathered dolerite boulders in dark grey-brown clay. Pebbles iron stained, hard and unweathered.

APPENDIX 2

Logs of auger holes

Hole 1

<i>Depth (m)</i>	<i>Description</i>
0-1	Dolerite boulders soil and clay
1-2	Rubbly brown clay
2-3.6	Grey-yellow clay, mudstone and sandstone.

Hole 2

0-1	Soil and dolerite boulders
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Hole 3

0-1.8	Yellow-brown clay
1.8-5.4	Yellow clay and mudstone
5.4-9.1	Grey-yellow mudstone of Triassic age.

Hole 4

0-1	Grey sand soil and dolerite boulders
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Hole 5

0-1.8	Brown clay, iron stained and ferruginous
1.8-4.3	Brown-yellow clay