

1987/06. Engineering geology report on five subdivisions at the Blackstone Heights Project, Launceston.

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Abstract

Five subdivisions at the Blackstone Heights project, located south of Lake Trevallyn near Launceston, were examined for landslide risk. Four of the subdivisions were small, with one a larger area with 25-30 blocks. The area had been assumed to be underlain by dolerite with rock close to the surface as elsewhere in the Trevallyn area, and unlikely to have any slope stability problems.

A thick mantle of clay and deeply weathered dolerite was exposed in some areas. Two clays are present; a brown clay, thought to be the Tertiary aged Launceston Beds; and a yellow clay derived from dolerite and frequently retaining an igneous rock texture. These clays are highly plastic and expansive, and composed dominantly of montmorillonite with an ϕ of 20° and c' of 1.9 kPa.

These clays have the potential, in some locations, to cause all or any of three engineering geology problems:-

- (1) Expansiveness causing cracking of houses.
- (2) Differential movements because of rapid internal changes from rock to clay, causing structural problems.
- (3) If an adequate thickness of clay is present there is a potential for landslides.

All of these problems are considered to be controllable by adequate investigations, careful house site selections and good foundation design in selected areas. Various recommendations were made for each subdivision.

INTRODUCTION

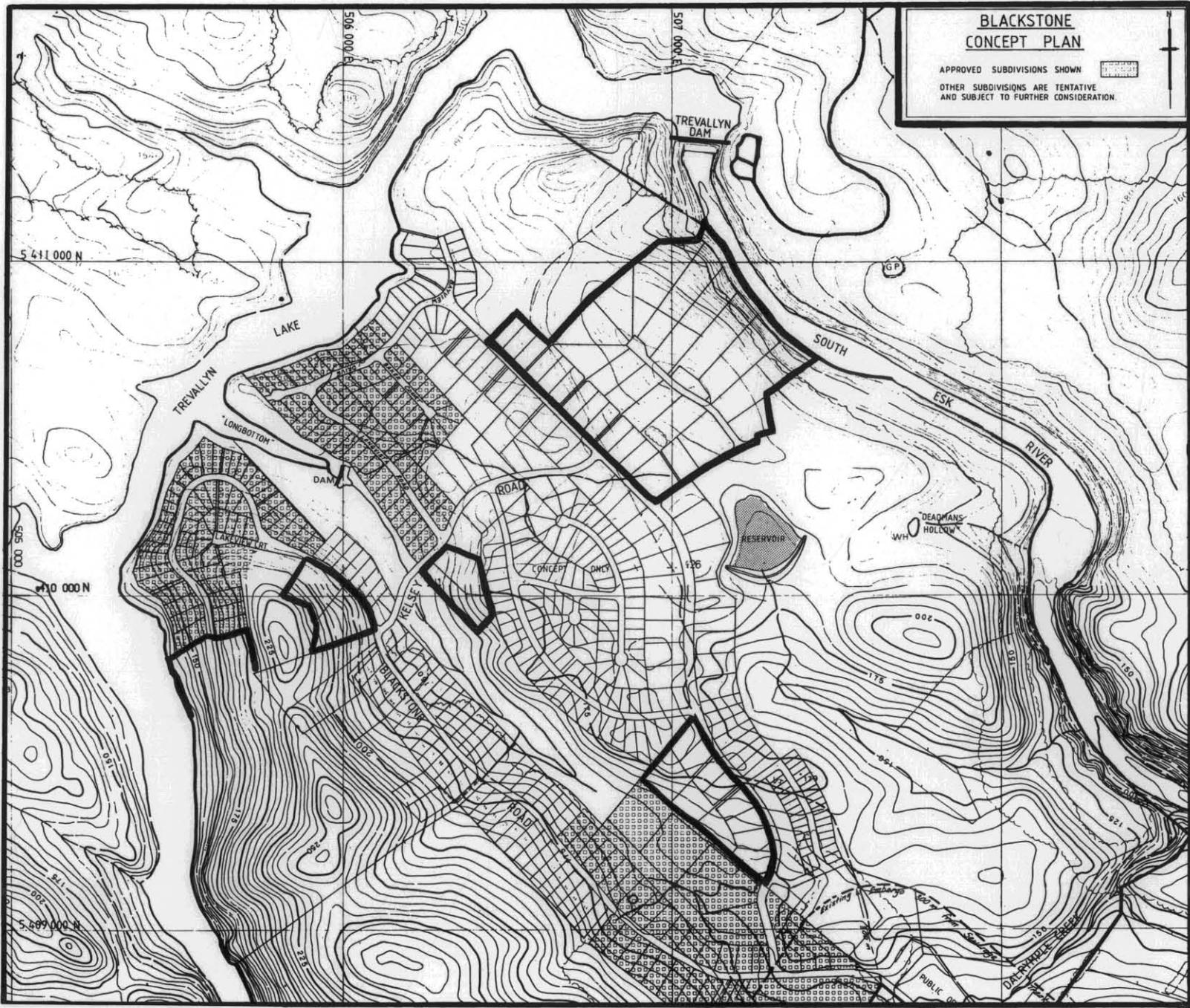
As requested in a letter of 1 December 1986 from Cohen and Associates, Surveyors and Town Planners, the writer visited the Blackstone Heights area (fig. 1) on 5 December in company with Mr C. Cohen. Approximately five hours were spent on the site, in which four subdivisions were examined as well as the reservoir site and the possible extension of Blackstone Road south of Lakeview Court, immediately south of Mr Moscott's house (Plate 1). A letter covering this visit was written to Mr Cohen on 10 December, who forwarded the letter to the Westbury Municipal Council and the subdivider.

On 6 January a further visit to the area was made by the writer and P. C. Stevenson of the Department of Mines with in company with Mr Pybus, the subdivider, and his consulting engineer, Mr P. Spratt. In this visit approximately one hour was spent discussing the letter of 10 December, with the remaining four hours in the area of the subdivisions.

Because of an ambiguity in the introductory section of the letter 'General Engineering Geological Comments with Recommendations concerning the entire Blackstone Heights Subdivision' a misinterpretation of the area covered by this letter occurred. This misled the Council staff as well as the subdivider and his engineer. This letter was not intended to cover the

06-2

Figure 1.



5 cm

entire Blackstone Heights project but the undeveloped shaded area, of which the five subdivisions examined form a major part (fig. 1). The ambiguity in the letter has been removed by enlarging and some rewriting of the following section.

GENERAL ENGINEERING GEOLOGICAL COMMENTS WITH RECOMMENDATIONS

As a general comment on the area of the subdivisions visited on 1 December and reported below, the area appears superficially geologically simple in that it is underlain by Jurassic dolerite. Unfortunately there are some serious potential engineering geology problems which possibly would not have been recognised without the existing construction associated with the Blackstone Heights project.

Surprisingly the dolerite rock on the nearby slopes and plains appears to be overlain by a thick mantle of brown and white to yellow clay, as seen in the many road embankments, drainage pits and borrow pits. The brown clay is considered to be possibly a residual deposit of the Launceston Beds of Tertiary age (Longman, 1966). The yellow clay is extremely weathered dolerite, with much still retaining the igneous texture of the original dolerite rock but which in composition is a clay (Plates 2 and 3).

The profiles between the extremely weathered to highly weathered dolerite (clay) and unweathered to slightly weathered dolerite (rock) are irregular, both in shape and depth. Some areas show deep concentric weathering with kernels of unweathered large dolerite boulders surrounded by clay (Plate 4). In other exposures the change is abrupt from unweathered dolerite to clay (Plate 5). This latter change appears to be the result of metasomatic alteration due to the extrusion of fluids possibly associated with Tertiary faulting in the dolerite. This alteration and weathering is thought to be re-exposed weathering of Tertiary age and not associated with present day weathering.

The present day weathering of the dolerite results in a generally granular brown and red with black clay soil with little to no thickness retaining the igneous rock texture. In contrast, the old 'Tertiary' weathering has a yellow to light green mottled texture representing what is thought to be oxidising conditions, and a mottled chloritic green and white texture from reducing conditions. Both types of dolerite-derived clay have been seen in the area excavated for the proposed reservoir and elsewhere in the area visited.

The entire Blackstone Heights project area was mapped regionally in the early 1960s by the Department of Mines at a scale of 1:63 360 (Longman et al. 1961). This mapping provided the geological basis for the concept study of the entire subdivision to the Westbury Council. Believing the area to be mainly underlain by dolerite rock, as much of it is, the Council concept study concluded that no landslide problems were likely to occur on the entire project and consequently no engineering geology inspection of it would be required.

W. L. Matthews, an engineering geologist with the Department, inspected Lot 70 Blackstone Drive on 20 September 1986 and thought the brown clay overlying the weathered dolerite at this location to be clay of the Launceston Beds. He reported in a letter that the clay contained the expansive clay mineral montmorillonite (Appendix 1).

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It is the widespread occurrence of the two clays, the brown clay and the underlying yellow clay, their variable thickness and the clay types that the writer considers are likely to create three potentially serious engineering geological problems.

These potential problems are:

1. With fluctuating moisture content in these expansive clays, house cracking is likely to occur and become a problem over time;
2. Differential movements from consolidation, and other movements in the clay where one section of a building is sited on clay and the other section on rock, or on very large dolerite boulders or highly weathered dolerite considered to be bedrock by the builders, can cause cracking and other structural problems in houses;
3. Given an adequate thickness of clay combined with sufficient slope, the landslide risk becomes high.

Investigation work to date indicates that all of these problems are controllable and their risk can be minimised to acceptable levels. This will, in specified locations, require adequate site investigations, followed, where necessary, by careful house site positioning and detailed planning restraints combined with good engineering design and construction methods.

From past experience, the writer believes that the first major step in the solution of any geological hazard problem is for the hazard to be recognised and understood by the personnel who are involved in all of the above multi-disciplinary functions. At the meeting between the subdivider, his consulting engineer, and the Department of Mines staff on 6 January, an appreciation of the geological problems appeared to be achieved.

GEOLOGICAL ENGINEERING PROBLEMS

From the limited amount of work done to date, outcrop of dolerite rock appears to be confined to the ridge and hill tops, and to the lower slopes bordering Lake Trevallyn and the South Esk River. On the higher levels of the slopes are talus deposits of large dolerite boulders and clay, with boulders appearing to cover a high percentage of the ground surface, whereas on the remainder of the slopes the clay appears to dominate. The thickness of the clay and the depth to the unweathered or slightly weathered dolerite is unknown but appears considerable and variable in the borrow pits examined (Plate 6).

The outcrops seen would appear to indicate that a considerable thickness of clay and weathered dolerite may be present in the area. Similar clays and deep weathering of dolerite have been investigated elsewhere in Tasmania. At Victoria Bridge and the cement silos on the Mersey River at Devonport, 10-11 m of these clays were drilled (Moore, 1968a, b).

The closest known location to Blackstone Heights where deep weathering of dolerite and dolerite clay occurs is at Sophie Place, three kilometres to the east on the southern slopes of the First Basin, Trevallyn. Here eight metres of clay and weathered dolerite were drilled with a projected seismic depth of eleven metres (Moore, 1985).

The clay at Sophie Place is composed dominantly of montmorillonite and is highly plastic and expansive. Shear box testing showed the clay to have low angles of friction and low cohesion. The liquid limit range of the many clay samples collected was 60-127 with an average of 97, linear shrinkages ranged from 14-27% with an average of 22.5%, angles of friction ranged from 15°-17°, and effective cohesions ranged from 6-11 kPa.

The brown clay and yellow-green dolerite-derived clay samples collected in a drain at the Kelsey Road subdivision, Blackstone Heights (fig. 5) have now been tested and show a close relationship to those from Sophie Place.

The Kelsey Road clays have a liquid limit range of 89 to 103, with an average of 91, linear shrinkages of 22-24, and an angle of friction of 20° and effective cohesion of 1.9 kPa in the sample shear-box tested to date (Table 1). For comparison the soil laboratory results from Sophie Place are shown in Table 2 and shear box tests for clay samples in Table 3. The brown clay X-rayed by Matthews from Lot 70 Blackstone Drive contained the expansive montmorillonite 'in fairly large proportions' (Appendix 1).

The slope stability investigation at Sophie Place required a seismic survey followed by trenching and auger drilling before building could be recommended to the Council on the 14°-15° slopes where foundations would be situated in the dry clay, and on the steeper 19° slopes where the foundations would be in bedrock of slightly or unweathered dolerite. Further recommendations stressing the importance of drainage and foundation construction were made.

A similar type of investigation is envisaged for the Blackstone Heights subdivisions. It is hoped that this investigation will make it possible to delimit areas into three classes:

- (a) areas with no slope stability problems;
- (b) areas which have potential slope stability problems and which will require investigation;
- (c) those slopes which are too steep for conventional building and will require the foundations to be situated in bedrock or tied into unweathered rock.

Because of staff shortages in the Engineering Geology section of the Department of Mines, the various areas of Blackstone Heights to be developed will now be examined separately rather than as one large unit, the order of priority having been established between the subdivider and P. C. Stevenson of the Department of Mines. It is hoped that liaison will be established with the building inspectors of the Westbury Council when mapping the subdivisions, so that any future engineering problems can be discussed in the field rather than in isolation.

A general conclusion is that engineering geological mapping and resultant landslide risk zoning of the subdivision should have, ideally, been undertaken earlier in the planning stage of the development than now. This could have avoided some of the investigation duplication that is now considered necessary in some of the subdivisions and may have resulted in a more efficient utilisation of the land and possibly resulted in a greater available number of blocks if so desired by the Council and subdivider. Even though access construction is well advanced and the layout of much of

the area completed, with some houses already built, it would appear prudent for the Council to have the area to be developed investigated and mapped for landslide risk rather than by investigating small individual blocks.

PANORAMA ROAD SUBDIVISION (fig. 2)

The east-west ridge which forms the highest section of the proposed subdivision is capped by outcropping dolerite. The rock forms a series of stepped ledge outcrops followed by long slopes down to the valley floor. The highest measured slope on the subdivision was 7° with most slopes 5° or less. These slopes are gentle and even, and should give no stability problems even if a thick mantle of clay is present.

The lack of soil cover on the highest blocks in the rock outcrop area would make it difficult for soakage drains and septic tank overflow pits to function. In this area some drains may even require blasting.

There are localised moist areas, which are probably formed by pockets of clay, which will require drainage. Any house site founded on clay should have the expansive properties of the clay tested.

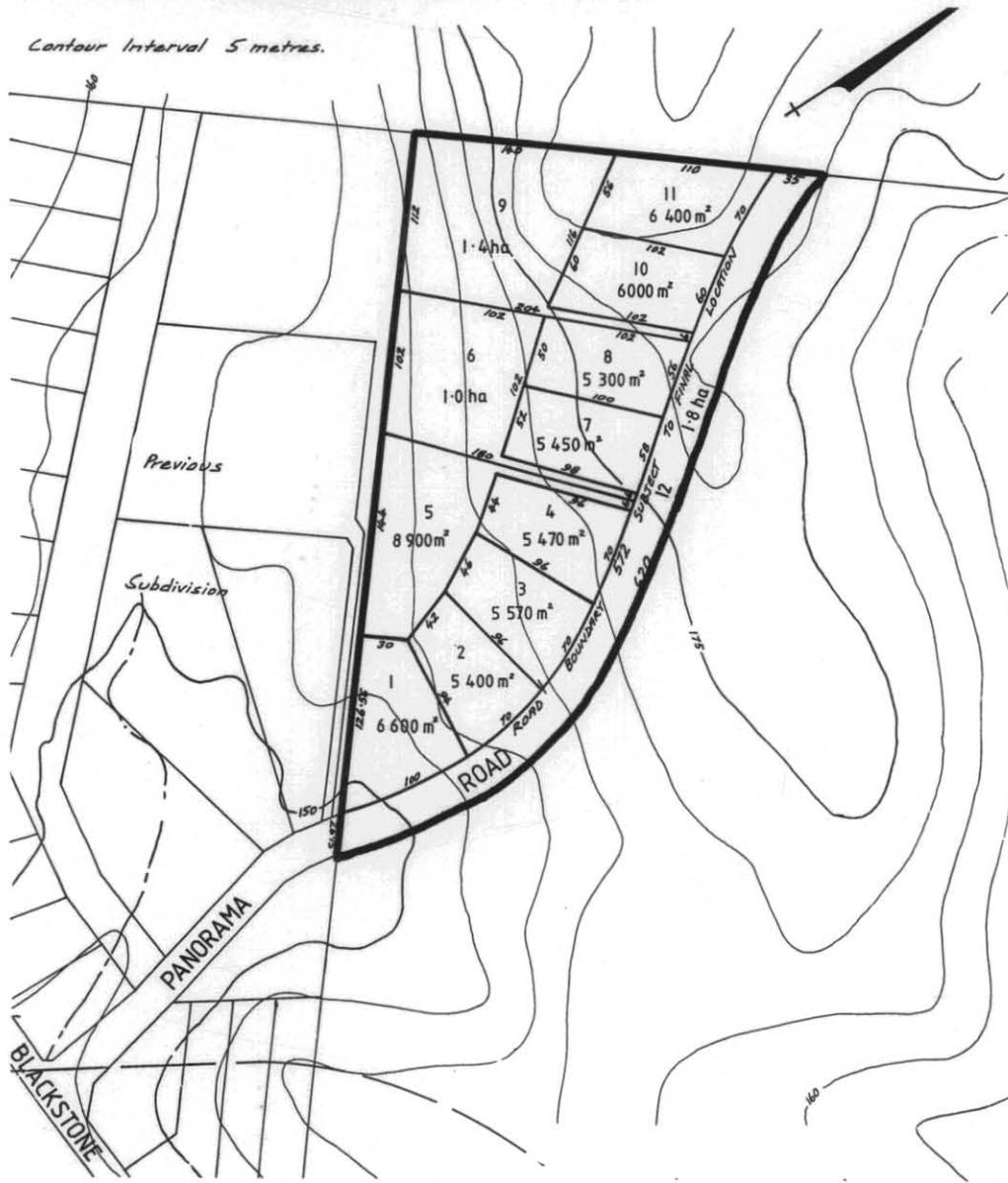


Figure 2. Panorama Road subdivision

SOUTH ESK SUBDIVISION (fig. 3)

This large subdivision was not examined in any great detail, as it is only in the preliminary planning stage. The area comprises a rock-capped ridge overlooking the South Esk River to the north and Panorama Road valley to the south. From Panorama Road, the slopes of 3° and 5° of the valley flats steepen rapidly to 10°, then to greater than 15° below the rock ledge along the top of the hill on the south side.

The rock capping the ridge of the hill is mapped as Jurassic dolerite on the Launceston 1:63 360 geological map (Longman et al., 1964).

In the shallow reservoir excavations immediately south of the subdivision, clay-like sediments, possibly of Tertiary age, and suspected basanite or Tertiary-age dolerite boulders were found.

If a similar sequence of basanite underlain by soft Tertiary-age sediments forms the ridge and steeper slopes of the ridge of this subdivision, rather than Jurassic dolerite, then the landslide risk on this hill section is going to be higher. Clearly this subdivision requires more investigation and should be zoned for landslide risk followed by redistribution of the blocks. In the existing concept plan the access road occupies the most stable zone along the rock ridge.

It is estimated that the field work for this mapping would be between 5-6 hours followed by some seismic work and possibly trenching. Most of this recommended work was carried out on 14-15 January when the slope and geological mapping was completed, three seismic spreads fired, and one magnetometer traverse completed.

The seismic and magnetometer work indicate that the hill forming the major part of this subdivision is capped with a thick and very hard (high seismic velocity) layer of rock, thought, from surface mapping, to be all Jurassic dolerite. The layer is thick and extends well down the slope on the south-east face, as indicated from what is thought to be outcrops and from the magnetometer traverse. If this capping happens to be basanite (Tertiary basalt lava with the physical appearance and mineralogical composition of dolerite) then any Tertiary sediments underlying this thick capping are likely to be very thin. The magnetometer traverse indicates that these sediments (clays) are likely to be located near the foot of the slopes at approximately the same level as the reservoir to the south-east. On such low slopes (<13°) such a thickness of clay is unlikely to give any future landslide problems.

This subdivision has now been mapped for landslide risk on the classification outlined previously in this report (fig. 4). The details of the above investigation will be forwarded as a separate report.

KELSEY ROAD SUBDIVISION (fig. 5)

The precise boundaries of these two blocks could not be found on the ground. From the survey pegs located, the dolerite outcrops on the ridge are outside this subdivision's boundaries. The high eastern section of the two blocks is underlain by dolerite talus, with dolerite boulders covering most of the ground surface. Scattered dolerite boulders are present over the remaining lower area.

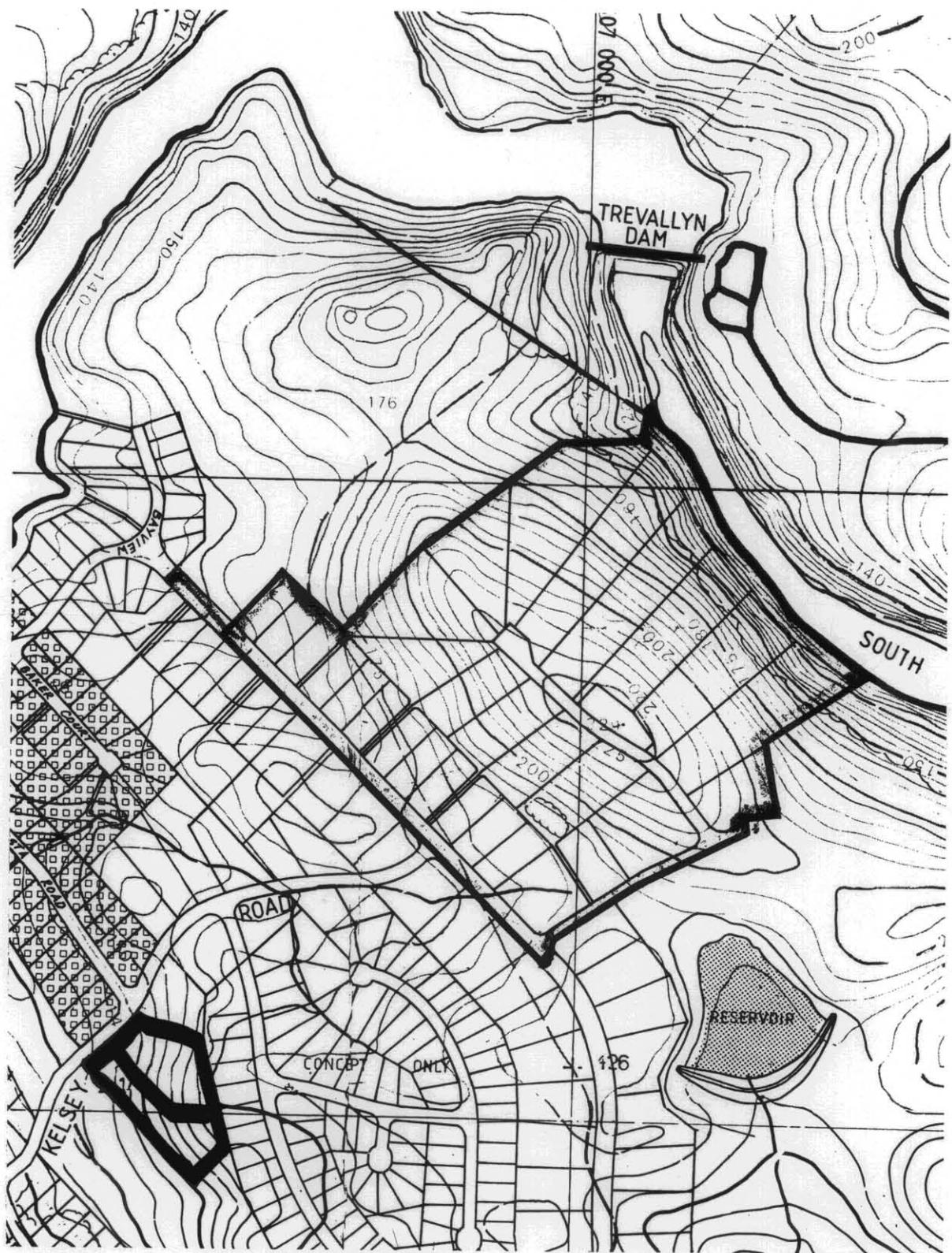


Figure 3. South Esk subdivision.

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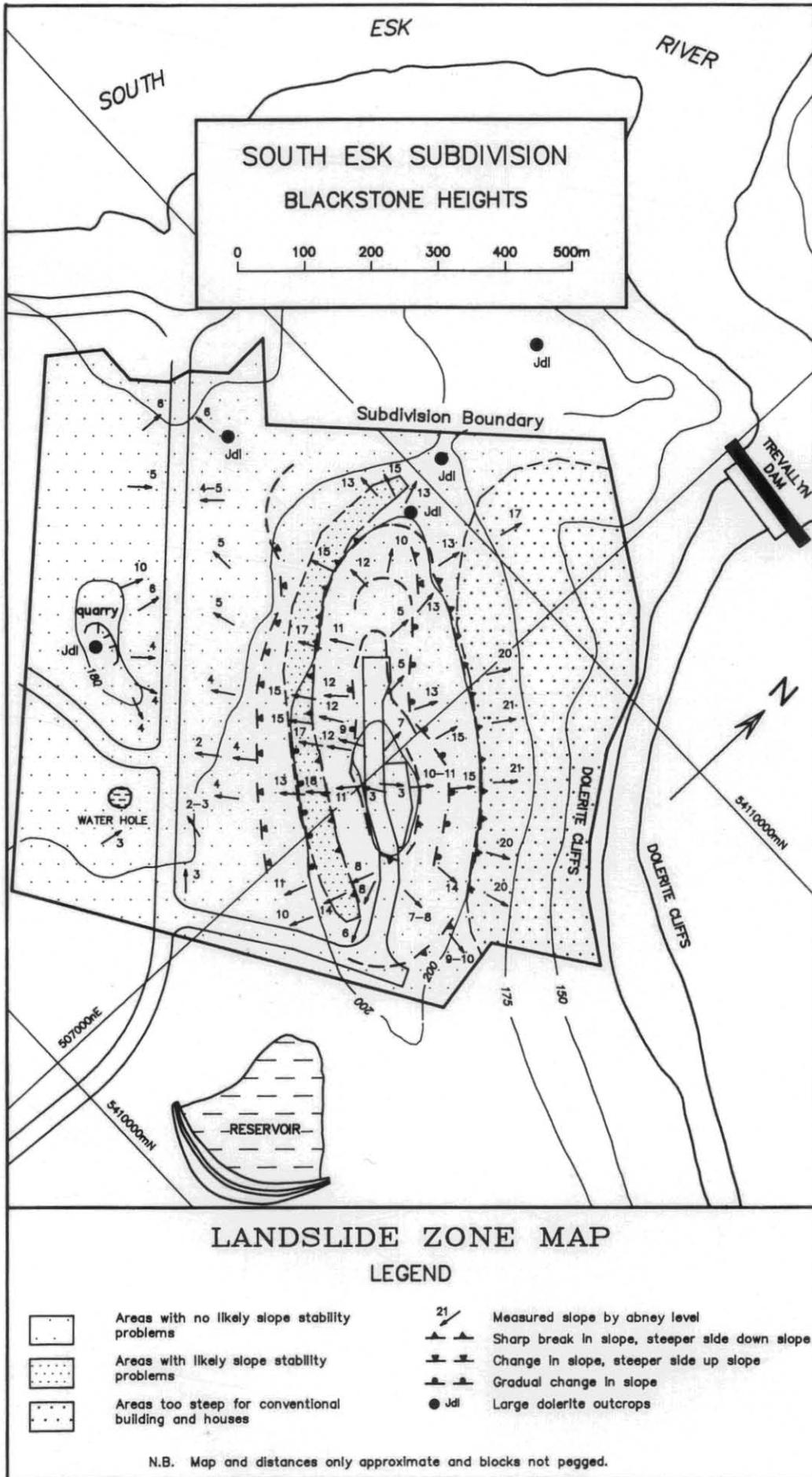


Figure 4.

The slopes on the block are long and average 10°, with 11-12° slopes in the higher section and 8-9° close to Kelsey Road. There are large moist areas below the talus. Brown clay is exposed in a freshly dug drain up the slope on the northern extension of Kelsey Road. This clay with dolerite boulders is thought to underlie the even slopes of the block below the talus. It is in this steeper area that houses are likely to be sited in order to obtain a view of Lake Trevallyn.

In a freshly dug drainage pit at the junction of Kelsey and Longvista Roads is a 1.5 m deep exposure of clay. The brown clay below a thin black clay soil with dolerite boulders overlies a yellow-green clay showing an igneous rock texture. Two clay samples were collected from this pit for testing in the soil mechanics laboratory of the Department. On the opposite side of the road, 15 m distance from the above pit, is a 1.5 m high outcrop of dolerite which is so completely unweathered that it had to be blasted for the road construction.

With slopes of only 9-11° there is little risk of landslide but with the possibility of clay of a considerable thickness, and the variation of rock types occurring within such short distances, each house site should be investigated. The samples collected at road level at this subdivision (fig. 5) show the clay to be expansive (22-24%), highly plastic, with liquid limits of 89-103, and dominantly montmorillonite (90%) in composition. Shear box testing showed the angle of friction to be reasonably high (20°) but the effective cohesion was low (1.9 kPa).

A backhoe pit on each preferred house site, when selected, should be examined by an engineering geologist and, if required, the clay tested. This work will allow the engineer to design foundations and drainage suitable to each site.

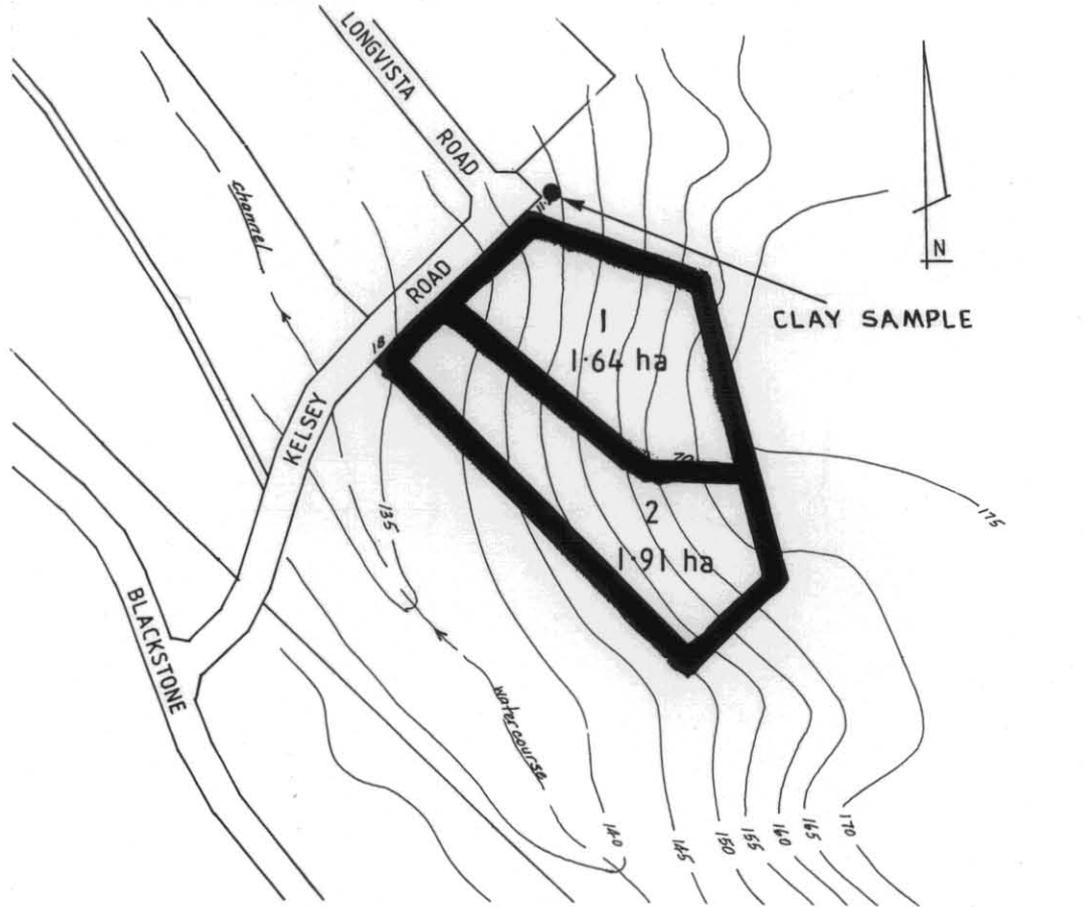


Figure 5. Kelsey Road subdivision

BLACKSTONE ROAD SUBDIVISION - SOUTH OF LAKEVIEW COURT (fig. 6)

This subdivision contains two large blocks on the upslope side of Blackstone Road (Plate 7). On both blocks the slopes are very steep (22°). Exposed on the ground surface are talus deposits of dolerite, possibly with some outcrops of dolerite.

The lower boundary of the subdivision is a road embankment some 2.0-2.8 m high. On this bank is a thin surface soil of talus and dolerite boulders underlain by one metre of brown clay, which is underlain by 1.5 m of yellow and white clay of extremely to highly weathered dolerite. In the yellow clay are some unweathered kernels of large dolerite boulders surrounded by clay formed by concentric weathering. Pinnacles of unweathered dolerite of the bedrock profile protrude up into the clay. Some of this unweathered dolerite has been blasted to cut the embankment. As the road climbs higher towards Lakeview Court the depth of weathering becomes marginally less deep.

On slopes as steep as 22° it is preferable that the house foundations be tied to unweathered or slightly weathered dolerite rock. To cut into such a steep bank and level a house site by pushing the material cut out as fill, over the existing slope and vegetation, is considered a very dangerous practice. The risk of a future slope failure and consolidation movements is considered to be too high. These blocks require a full site investigation with soil testing of the material, and slope stability analysis etc., to be followed by correct site preparation, adequate consolidation and permanent drainage installation if the material encountered is the clay exposed along the road embankment.



Figure 6.

PROPOSED EXTENSION OF THE SUBDIVISION
- SOUTH END OF BLACKSTONE ROAD (fig. 7)

Three of what appear to be future house sites have been constructed at the southern end of Blackstone Road (Plate 8). One of these sites is above and overlooks an existing house. The other two are situated further south; one is at road level and the other downslope below it (Plate 9).

The road has been cut into the slope and the fill pushed over the slope. The road cutting gives continuous exposures of dolerite and dolerite-derived clay, approximately 2.0-2.5 m high. The extremely weathered dolerite forms a 16 m long exposure which ends in unweathered dolerite at the south end of the road.

The slope above the road is 22° and south of the road, the natural slope below the road level is $32-35^\circ$. The slope is mainly covered by dolerite boulders, some large. Flat and stepped outcrops or near-outcrops are visible from the road. The depth to dolerite does not appear great, but this can only be established by further investigation.

The prepared sites are cut into the weathered dolerite with the material excavated being pushed over on the slope, forming high embankments with $26-32^\circ$ slopes comprising clay, rock, boulders and timber all mixed (Plate 10). The material has been pushed onto the existing soil and vegetation with no slope preparation or drainage. The location of the fill and rock boundary on the sites is difficult to establish, as is the original natural slope, which appears to be at least 26° and may be as high as 30° .

Serious thought should be given by the Westbury Council as to the suitability of these sites for housing because of the high potential risk from slope failure and boulder toppling. Further subdivision southwards should be dependent upon the results of detailed geological analysis.



Figure 7.

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[28 January 1987]

Table 1. RESULTS OF SOIL TESTING, KELSEY ROAD SUBDIVISION

Sample No.	Depth (m)	MC (%)	PL	LL	PI	LS (%)	Composition		Total sample quartz
							M	K	
1	1.0	49	22	103	81	24	90	10	5
2	1.5	53	20	89	69	22	90	10	10

M = montmorillonite; K = kaolinite

MC = moisture content; PL = plastic limit; LL = liquid limit
LS = linear shrinkage

Shear box test -
Sample angle of friction 20°; Effective Cohesion 1.9 kPa

Samples collected *in situ* from a drainage trench at Kelsey Road and Panorama Road junctions (see fig. 5).

Table 2. RESULTS OF SOIL TESTING, SOPHIE PLACE, WEST LAUNCESTON

Trench	Sample	Depth (m)	Field class.	Laboratory class.	Laboratory Result					
					MC (%)	PL	LL	PI	LS (%)	XRD < 2µm (%)
1	1	0.2	OH	CH	25	27	94	67	25	
	2	0.6	CL		25					
	3	1.8	CL	CH	22	26	95	69	27	M 80-85 K 15-20
2	1	0.4	OH							
	2	2.0	CL							
3	1	0.2	CH	CH	-	28	105	77	26	M 85-90 K 10-15
	2	0.5	CL-CM	CH		29	108	79	25	
	3	0.7	CL	CL			45			
4	1	0.3	CL							
	2	0.5	CL							
5	1	0.4	OH	CH	27	32	117	85	21	
	2	1.0	CH	CH	24	25	83	58	22	M 80-85 K 15-20
6	1	0.2	CH	CH	36	28	104	76	24	M 90-95 K 5-10
	2	0.4	CH	CH	22		106			
	3	0.7	CL-CM	CH	25	27	91	64	23	M 85-90 K 10-15
7	1	0.3	OH	CH	20	29	71	42	18	M 80-85 K 15-20
	2	0.6	CH	CH	28		127			M 90-95 K 5-10
	3	1.5	CL-CM	CH	30	25	60	35	-	
8	1	0.4	OH							
	2	1.0	CL							
	3	1.5	Jdl							

M = montmorillonite; K = kaolinite

Table 3. RESULTS OF SLOW SHEAR BOX TESTS, SOPHIE PLACE

Trench	Sample	Residual angle of friction (φ°)	Effective cohesion c' (kPa)
1	3	17	8.3
5	2	15	6.0
6	1	16	11.6

Shear box testing by R.N. Woolley, Department of Mines

APPENDIX 1

Letter to H. Trevena by Senior Geologist W. L. Matthews

LOT 70 BLACKSTONE DRIVE

An inspection of the above lot has been made recently as requested.

The land consists of two low sloping benches at the front and rear of the land with a slightly steeper portion in the middle. Deeply weathered dolerite in the form of hard red clay is exposed along road edge and in the cutting at the front of the lot. Unweathered dolerite boulders occur over the surface of the remainder of the lot. At first sight it appears that unweathered *in situ* dolerite would occur at shallow depth but on closer inspection it was noted that a considerable amount of clay is present, between the boulders. Solid dolerite may be at least a few metres below the surface.

Care should be taken with the development of the lot. Sites on the flatter areas at least a few metres away from the steeper sloping areas should be selected. Good drainage should be ensured and deep excavations should be avoided. With these precautions the chance of landslip affecting the property should be low and development should be possible without undue risk.

The brown clay that is present in excavations around the lot contains the clay mineral montmorillonite in fairly large proportions. This is an expansive clay and in designing foundations where there may be a large proportion of this clay, the expansive nature should be taken into consideration.

[30 September 1986]



Plate 1. *General view of area south of Blackstone Road, looking north.*



Plate 2. *Yellow clay retaining igneous texture, exposed in a drain.*



Plate 3. *Fresh dolerite rock bounded by yellow clay.*



Plate 4. *Kernels of unweathered large dolerite boulders surrounded by clay.*



Plate 5. *Exposure showing abrupt change from fresh dolerite to clay.*



Plate 6. *Exposure in borrow pit, showing depth of weathering in dolerite.*



Plate 7. *Steep slope bordering blocks in Blackstone Road subdivision south of Lakeview Court.*



Plate 8. *Prepared sites for future development south of Blackstone Road.*



Plate 9. Lower site cut into bank, with embankment of fill separating lower site from upper site.



Plate 10. *Embankment material of clay and boulders, showing tension crack near edge.*