Tasmania Department Of Resources and Energy

Division of Mines and Mineral Resources — Report 1990/17

Examination of a proposed subdivision at Huonville

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Abstract

A subdivision proposal for T. and P. Baron at Huonville is located on moderately sloping land with an overall slope of about 10 degrees. Locally, steeper slope segments (up to 24°) occur. Some topographic features are indicative of previous landslide activity.

Part of the proposed subdivision is underlain by *in situ* moderately weathered, closely jointed dolerite. This area is not considered at risk from landslide activity.

Stability analysis indicates that parts of the area are potentially unstable. Drainage measures considered necessary to ensure stability for building development are extensive, expensive and impracticable. Accordingly, these areas are excluded from building development.

INTRODUCTION

At the request of Brooks, Lark and Carrick an examination was made of a subdivision proposal for T. and P. Baron at Huonville. The property was initially inspected to determine the rock type and to assess if any further investigations were necessary. The initial inspection indicated variations in soil composition, identified some steep slope segments, and detected a drainage problem on lot 2. Back-hoe test pits were considered necessary to determine the sub-surface conditions.

GEOLOGY

The rock in the area has been mapped by Farmer (1981) as Triassic age dominantly medium to coarse-grained quartz sandstone with subordinate mudstone and minor clay pellet beds. Jurassic aged dolerite occurs to the west beyond Scenic Road. The property has an overall slope of about 10° but locally, short, steeper slope segments (up to 24°) are present.

Several back-hoe test pits were excavated at the approximate locations indicated on Figure 1. Slickensided sandy clays containing carbonaceous materials and boulders of sandstone were excavated in test pit 2. This test pit was located adjacent to a large sandstone boulder. These materials are considered to be ancient landslide debris.

At test pits 4 and 5 (refer Figure 1) the excavations encountered *in situ*, moderately weathered, closely jointed dolerite. The joints within the dolerite were sub-vertical in orientation and showed little infilling. The boundary between the dolerite and the sandstone may therefore extend further east than indicated on the published geological map. Alternatively, a feeder dyke of dolerite may have been encountered. The approximate eastern extent of the dolerite is shown on Figure 1. *In situ* dolerite is usually not associated with potential landslide activity.

The boundary between the dolerite and the sandstone may provide a barrier to groundwater movement. This could result in a build up of pore pressure which may have caused the initial (ancient) landslide.

LABORATORY TESTING

Two large block samples of slickensided sandy clay were submitted to the Division of Mines and Mineral Resources laboratory for cyclical shear box testing. This test provides strength parameters which are necessary for stability analysis of the slope. The effective residual angle of internal friction and the effective residual cohesion for the two samples are given below. These results indicate relatively low strength parameters for the material.

	Effective residual angle of internal friction	Effective residual cohesion
Sample 1, Test pit 2	14°	4 kPa
Sample 2, Test pit 2	15°	3 kPa

X-Ray diffraction analysis of the sandy clay present on the proposed subdivision indicates a relatively significant proportion of the clay mineral montmorillonite. This clay exhibits volume instability (i.e. it will swell when allowed to wet up and will shrink when allowed to dry out).

STABILITY ANALYSIS

Slope stability analysis is performed using the Factor of Safety concept. A commonly used definition is:

$$\text{Factor of safety} = \frac{\text{Sum of restoring forces on slope}}{\text{Sum of driving forces on the slope}}$$

The restoring forces include the strength parameters (cohesion and friction) and the mass of that part of the soil resisting movement. The driving forces include pore pressure, load on the soil, and the mass of that part of the soil provoking movement. It can be seen from the above equation that the driving and restoring forces are equal when the Factor of Safety (FS) equals one. The FS becomes less than one when the driving forces predominate and failure occurs.

Stability analysis is usually simplistic and does not take into account the variability of natural materials. For this reason, where the FS is less than 1.3 the slope is considered to be at high risk from landslide movement and building should not be allowed. For FS between 1.3 and 1.5, the slope has medium risk of landslide movement and extreme caution is required in allowing building to proceed. Where the FS is greater than 1.5, the slope is generally considered safe to build upon.

Stability analysis has been performed using SLIPCIRC (Weldon, 1987), a GW-BASIC program for Bishop's (1955) simplified slip circle stability analysis. The analysis has been performed on the slope profile shown on Figure 2. On this slope, an infinite number of potential circular failure arcs are possible. The end points of the failure arc shown on Figure 2 were carefully chosen after due consideration of the geology and geomorphology of the area. The failure arc shown on Figure 2 is the critical failure arc (i.e. the one which produces the lowest FS when all parameters other than the radius of the circular failure arc are held constant).

Figure 3 shows the results of the stability analysis using the strength parameters as determined by the shear box test on sample 1. These results produce lower factors of safety than the results for sample 2. The results of the stability analysis are shown as Factor of Safety in relation to pore pressure ratio. A pore pressure ratio of 0.5 occurs when the assumed slide is totally saturated, a ratio of 0.25 occurs when the assumed slide is half saturated, and a ratio of 0.0 occurs when the assumed slide is fully drained.

The most conservative stability analysis is for an effective residual cohesion of zero. This type of analysis is used to determine the long term stability of a slope. The assumption is that small movements of parts of the potential landslide mass over long periods of time tend to reduce the internal effective residual cohesion to zero. Under these circumstances, for the critical failure arc shown on Figure 2, FS is always less than 1.5 at any pore pressure ratio for the laboratory determined strength parameters of sample 1. FS is equal to 1.3 when the pore pressure ratio is about 0.03. This is equivalent to a slope which is drained to a depth of 7.1 m at the point where the assumed sliding mass is thickest. In summary, drainage of the slope must be assured to a depth of 7.1 m below natural ground level if an FS of 1.3 or better is to be obtained.

The laboratory tests indicate that some effective residual cohesion is available in the short term to resist slope movement. In mobilising this effective residual cohesion, a FS equal to 1.5 occurs at a pore pressure ratio of about 0.06. This pore pressure ratio is equivalent to a slope which is drained to a depth of 6.6 m. If a less conservative approach is adopted where a FS as low as 1.3 is considered acceptable, the pore pressure ratio must not exceed 0.21. This is equivalent to a slope which is drained to a depth of 4.5 m below natural ground level.

DISCUSSION

Lot 2 requires extensive drainage improvements before it can be built on. The ground is completely saturated in places. Part of the problem appears to be caused by an open drain which runs along the back boundary of the lot marked as "existing title" (refer fig. 1). The source of the water in the open drain is partly due to stormwater and sullage from existing houses along Scenic Road. The drainage may also be from natural seepage from a drainage line on lot 22. The open drain should be piped and the water diverted away from lot 2.

Council services and individual house connections on sloping sites with doubtful stability require separate comment. Drainage is of the highest importance in minimising the risk of landslide movements. Under no circumstances should the proposed subdivision proceed without connection to the town sewerage scheme. The risk of landslide movement can be reduced by ensuring that all drainage lines are set at a high angle to the contours (preferably at right angles, but in no case less than 30°). Backfilling of services or connections must ensure free drainage of any surface or subsurface water which enters. Service connections must therefore have a minimum fall of 3%.

The most important drainage requirements are associated with individual houses. No service line, stormwater or waste water disposal should be placed on the upslope side of a house. Placement is preferred at either side and at the highest possible angle to the contours.

CONCLUSIONS

- The upper part of the subdivision proposal is underlain by *in situ* moderately weathered dolerite. This land is therefore unlikely to be affected by slope instability.
- Test pit 2 encountered materials which are considered to be ancient landslide debris.
- Shear box laboratory testing of a sandy clay sample from test pit 2 showed a relatively low value of effective residual cohesion of 3–4 kPa and an effective residual angle of internal friction of 14–15 degrees.
- Stability analysis using these strength parameters and a carefully selected circular failure arc indicates that drainage of the slope to depths in excess of six metres must be installed and effectively maintained to obtain acceptable factors of safety.
- Drainage to the required depth is considered difficult to achieve, and the construction of drains may have a deleterious effect on stability due to removal of lateral support.

RECOMMENDATIONS

Slopes in excess of 14° which are underlain by sandy clay, derived from the weathering of Triassic age sandstone, have a high risk of landslide movement. Such areas are delineated on Figure 4. Building should not be permitted in these areas. It is also advised that council service trenches should not traverse these areas.

A revision of the subdivision layout will be necessary.

The sandy clay soil which occurs over the majority of the subdivision proposal contains the clay mineral montmorillonite which exhibits volume instability. House sites should therefore be classified according to Australian Standard 2870-1986 (Residential slabs and footings) which provides details for the appropriate footing design for the determined site classification.

REFERENCES

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Farmer, N. 1981. Geological Atlas 1:50 000 series. Sheet 88 [8311N]. Kingborough. *Department of Mines, Tasmania.*

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[15 June 1990]

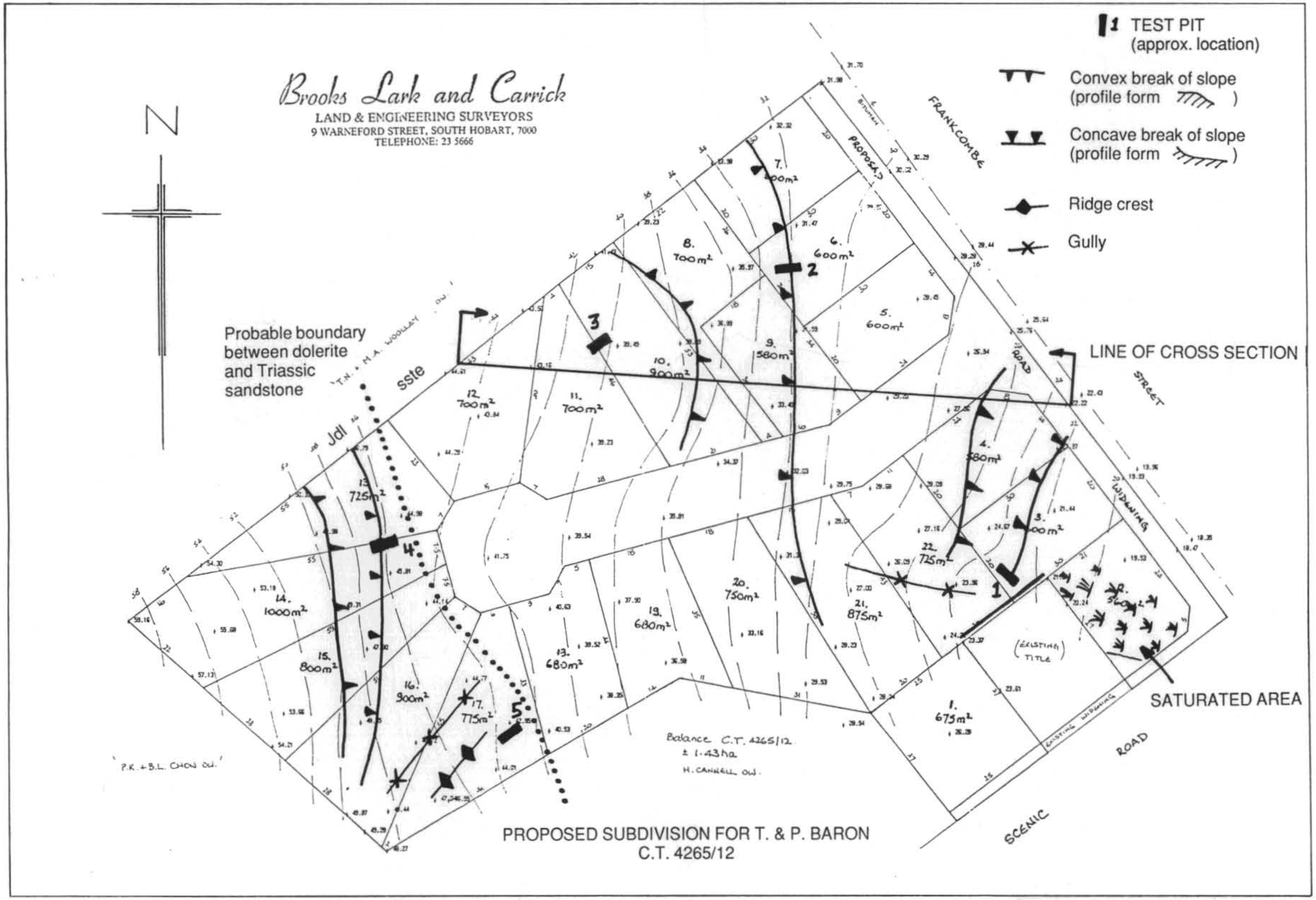

Figure 1. *Site plan showing slope morphology, approximate test pit locations, and line of cross section used for stability analyses.*

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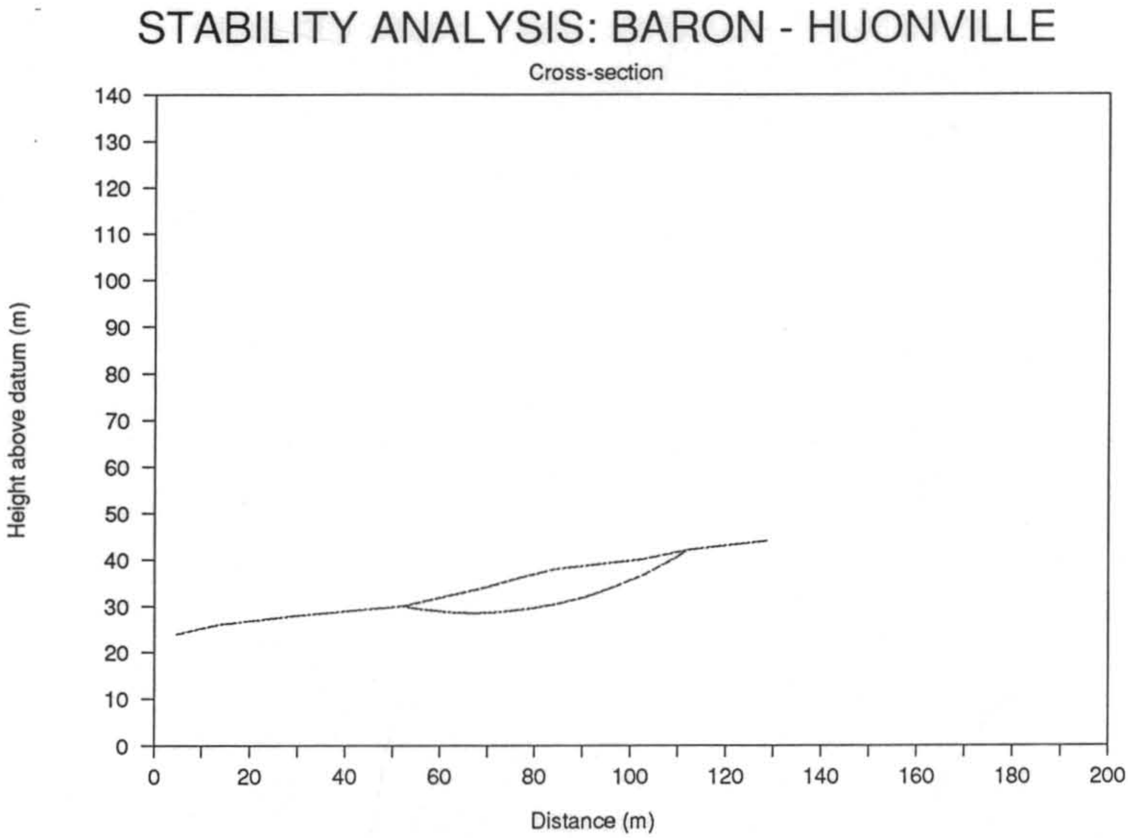

Figure 2. *Cross section showing critical circular failure arc for stability analysis.*

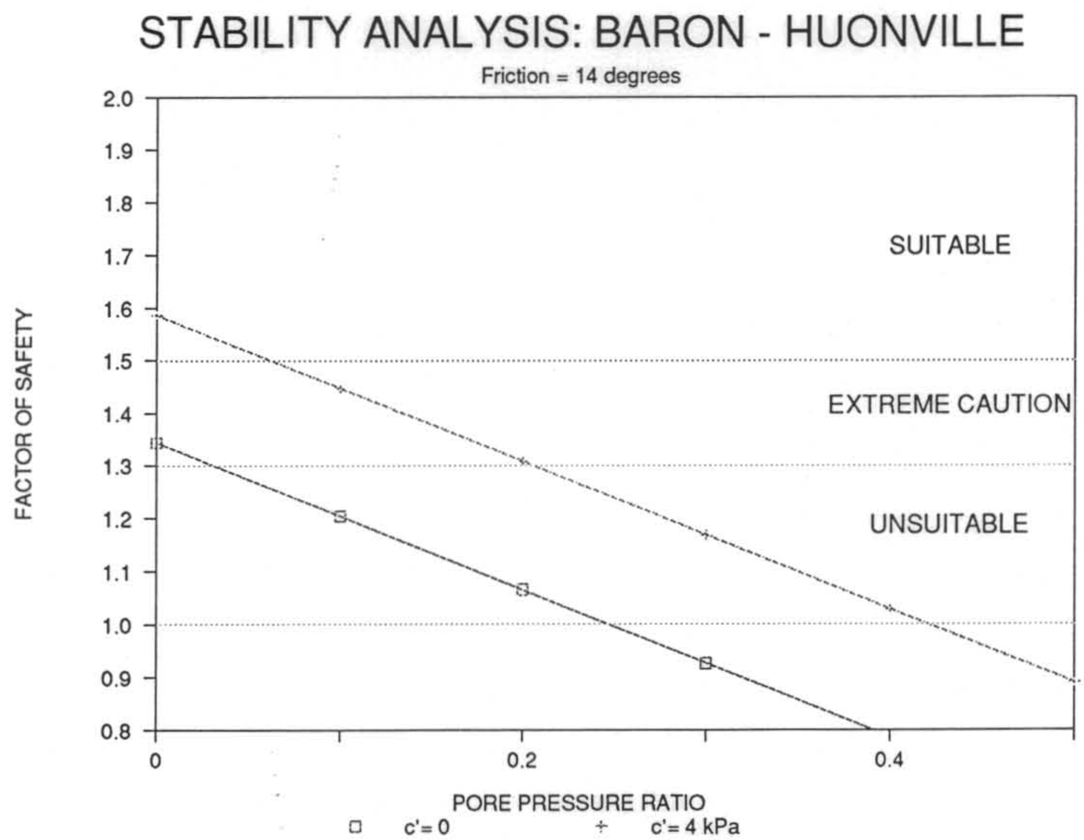

Figure 3. *Results of stability analysis for critical failure arc at effective residual angle of internal friction, showing variation in factor of safety with pore pressure ratio at effective residual cohesion of zero and 4kPa.*

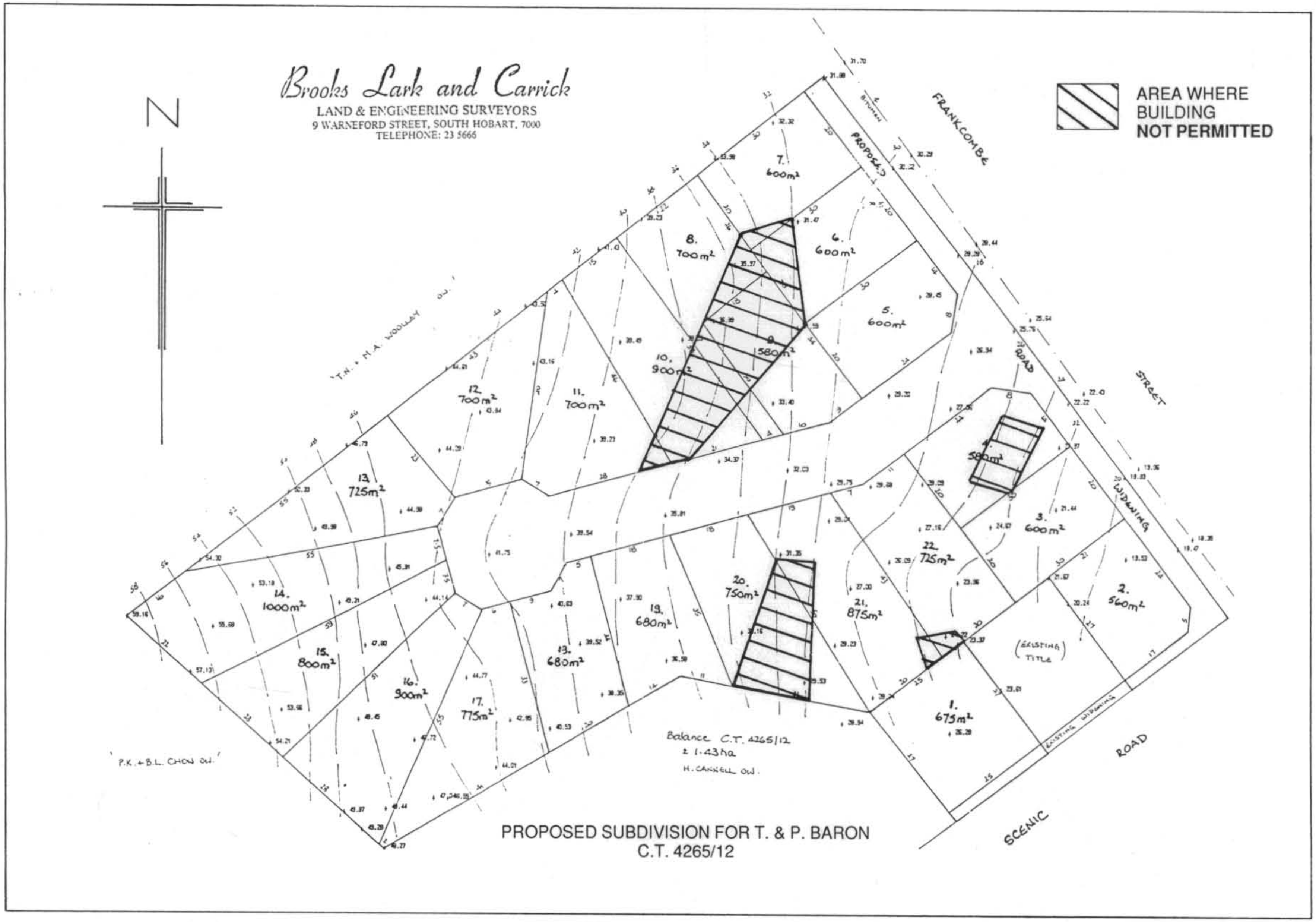

Figure 4. *Areas where building is not permitted.*

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