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GEOTECHNICAL APPRAISAL

MINDEN AREA

WESTERN BAY OF PLENTY DISTRICT COUNCIL

Jor 1992

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January 1992

PREPARED FOR:

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32 Christopher Street
TAURANGA

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ACENZ

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REPORT

1.0 INTRODUCTION

This report presents the results of a geotechnical appraisal of the Minden area. This work has been undertaken at the request of Bruce Henderson Consultants Ltd, Tauranga, under the terms and conditions set out in Tonkin & Taylor letter dated 14 January 1991 and subsequent faxes dated 29 and 31 January and 3 February 1991. Authority to proceed with the work was given by Bruce Henderson on 8 February 1991.

A preliminary report was prepared in February 1991, with an addendum to that report prepared in March 1991 following a review of the preliminary report by the review panel. This report incorporates the March addendum and has been modified following further discussion with the review panel.

The objective of this geotechnical appraisal is to provide a report which will assist the Western Bay of Plenty District Council in its administration of subdivisional and building permit applications by delineating in general terms the degree of land instability existing in the various parts of the Minden area, and by setting out the extent of further investigations which should be carried out to support subdivisional and building permit applications in those delineated parts.

2.0 BACKGROUND

In 1981, following the Omokoroa landslip in 1979 and in response to Council's concern about stability on the Omokoroa Peninsular and other coastal areas, Tonkin & Taylor undertook an assessment of the stability of residentially zoned coastal land in Tauranga County and reported in July 1981. At that time Tonkin & Taylor noted that other areas of residentially zoned land, particularly the Minden area, exhibited evidence of instability, and the July 1981 report recommended a study of the remaining areas.

In July 1982 Tonkin & Taylor submitted a proposal to Council to undertake this stability assessment, and it was reported in the Bay of Plenty Times (3 August 1982) that the County Planner had been authorised to commission the investigation. It was not until mid-1984, however, that Council authorised Tonkin & Taylor to proceed with the stability assessment. In the interim, on 7 December 1983, a landslip occurred in the Minden area damaging a property in Corbett Drive owned by Mr & Mrs L. Miller.

The Minden landslip of December 1983 did not therefore lead to the 1984 study in the way that the Omokoroa landslip had led to the earlier study.

The workscope for the 1984 study comprised:

1. Specific and comparative air photo interpretation of stereoscopically paired vertical aerial photographs of the area taken in 1943, 1959, 1963, 1979 and 1982.

2. Walk over field reconnaissance of the area.

3. Inspection of exposures of subsurface materials and conditions in hillside cuttings.

4. Inspection of rock outcrops.

5. Geomorphological mapping at a scale of 1:5000 from 1, 2, 3 & 4.

6. Discussions with landowners on historical mass movement in the area:

7. Collation of subsurface information available from previous work in the area and environs.

Subsurface investigations, materials testing and stability analyses were not undertaken due to the high cost and doubtful benefit in quantifying the geotechnical risk.

Accordingly, the Minden area was delineated into three broad areas of relative risk on the basis of field (geologic and geomorphologic) evidence, subsurface information available from exposures and judgement based on previous experience in the area and with similar materials elsewhere in the Tauranga district.

In July 1984 Tonkin & Taylor reported to Council on matters of land stability in the Minden area, and this is included within this report as Appendix A. As with the earlier 1981 coastal areas study, the sole purpose of the 1984 study was to assist Council in its administration of subdivisional and building permit applications in terms of the Local Government Act 1974. The land was delineated into three relative land hazard classifications, A, B and C.

Area A: (Moderate to Severe Risk) was delineated where past or active soil erosion or mass movement is evident or where slope processes or factors influencing land stability were identified which indicated that soil erosion or mass movement is likely to occur and which presents or may present an identifiable hazard to structures within the delineated area.

Area A included, but was not restricted to, the scarp, midslope and debris toe areas of recent mass movement features and sloping ground on which active mass movement is evident.

Area C: (Very slight to Slight Risk) was delineated where no past or present accelerated erosion or mass movement is evident and where processes and factors appear to be such that instability is unlikely to occur. Area C included, but was not restricted to, essentially flat or gently sloping land remote from areas of apparent instability.

Area B: (Slight to Moderate Risk) was essentially the balance of the rural-residential area where processes or factors appear to be such that erosion or mass movement is possible.

In areas delineated A (moderate to severe risk), development would only be permitted if adequate provision was made to prevent erosion or landslippage, or if sufficient investigation was undertaken to satisfy Council that a building sited in a specific location and subject to specific criteria was unlikely to be damaged by landslippage.

In areas delineated B (slight to moderate risk), development applications would need to be supported by specialist advice.

In areas delineated C (very slight to slight risk), Council could allow complying development without special conditions.

3.0 STATUTORY REQUIREMENTS

The hazard zones and administrative criteria developed in 1984 were incorporated into the Tauranga County Council District Scheme, as required by the Town & Country Planning Act 1977. Several applications for resource consent, supported by specialist advice, have been made to Council in areas delineated A and B. In some cases, however, Council have not been satisfied that development should be allowed to proceed in terms of its statutory obligations under the now repealed Town & County Planning Act 1977 and the amended Local Government Act, 1976.

Part XX (Subdivision and Development of Land) of the Local Government Act has been repealed, and Council now has powers and duties as a consent authority under the Resource Management Act, 1991.

Under Section 92 of the Resource Management Act 1991, Council may commission a report on any matters raised in relation to an application, including a review of any information provided in an application under Section 88(4) or under Section 92 where Council is of the opinion that any significant adverse effect on the environment may result from an activity to which an application for a resource consent relates.

Section 106 of the Resource Management Act, 1991 states that:

(1) A consent authority shall not grant a subdivision consent if it considers that either:

(a) Any land in respect of which a consent is sought, or any structure on that land, is or is likely to be subject to material damage by erosion, subsidence, slippage, or inundation from any source; or

(b) Any subsequent use that is likely to be made of the land is likely to accelerate, worsen, or result in material damage to that land, other land, or structure, by erosion, subsidence, slippage, or inundation from any source.

unless the consent authority is satisfied that sufficient provision has been made or will be made in accordance with subsection (2).

(2) A consent authority may grant a subdivision consent if it is satisfied that the effects described in subsection (1) will be avoided, remedied, or mitigated by one or more of the following:

(a) Rules in the district plan:

(b) Conditions of a resource content, either generally or pursuant to section 220(1)(d):

(c) Other matters, including works.

Sections 641 and 641A of the Local Government Act, 1974, and set out in Appendix B, have not been repealed or amended by the Resource Management Act, 1991. The option of issuing building permits under Section 641A is not considered to be appropriate in the Minden area as landslippage is likely to be sudden. A background paper on this Section of the Local Government Act is included as Appendix B.

Accordingly, in terms of its Statutory obligations Council must be convinced that damage is unlikely to occur before it can consent to a resource use, and in this regard it is appropriate that Council undertake a geotechnical appraisal of the Minden area and appoint a Review Panel to consider information provided with specific resource use applications.

4.0 GEOTECHNICAL APPRAISAL

4.1 Scope of Work

The 1991 study has reviewed and refined the 1984 study by undertaking:

1. Specific and comparative air photo interpretation of stereoscopically paired vertical aerial photographs taken of the wider area in 1963, 1986 and 1988.

2. Walk over field reconnaissance of the wider area.

3. Inspection of subsurface exposures in hillside cuttings excavated after 1984.

4. Geomorphological mapping at a scale of 1:5000 from 1, 2 & 3, as shown on Drawing 10899-1 (attached).

5. Review of information supplied by the Western Bay of Plenty District Council, including reports submitted to Council between 1984 and 1991.

Land hazard mapping has been undertaken previously in the Tauranga area for the Tauranga City Council (DSIR Geological Survey) and the Tauranga County Council (Tonkin & Taylor/DSIR). These studies essentially mapped existing landslips and recommended restrictions on development. Land use capability surveys and factor mapping (e.g. geology, soils, vegetation, slope) have also been undertaken by DSIR Division of Land and Soil Sciences, Aokautere, but with a mapping scale of 1:63,360 and base factor maps of up to 1:250,000, the resulting information is very coarse. Even with the sophisticated LADEDA software, the available land inventory data is considered to be of little practical value in quantifying geotechnical risk.

From the 1984 study, and the 1991 updated review, the wider area shown on Drawing 10899-1 has been delineated into the same three broad risk categories A, B and C, but with the B category subdivided into two sub-categories B1 and B2 to take into account relative risk and possible development scenarios.

As with the 1984 study, no subsurface investigations, materials testing or stability analyses have been undertaken as part of the 1991 study. However, as with the 1984 study, the delineation of risk categories has taken into account information and material properties gathered from previous subsurface investigations, including effective strength testing and back analyses of previous landslips in the Tauranga area.

4.2 Geomorphology and Subsurface Materials

A brief description of the geology and soils of the Minden area is presented in section 2.1 of Appendix A. The hills in the Minden area consist of rhyolite, an acid volcanic rock. This rock is mantled by volcanic tephra forming a cover deposit which is, in places, more than 6 m thick. Of this cover deposit, the upper, younger tephra are typically silts and sands comprising Rotorua Ash, Okareka Ash, Oruanui Formation, Mangaoni Lapilli and the basal Rotoehu Ash. The underlying older tephra are typically clays and silts comprising undifferentiated brown tuff (often referred to as Hamilton Ash) and the older Pahoia Tuffs.

The younger tephra are typically 2-3 m thick, non-plastic or of low plasticity, and erodible. The older tephra are typically 1-4 m thick, of moderate to high plasticity and not particularly erodible. The Minden rhyolite is typically highly weathered, but outcrops of moderate to slightly weathered rhyolite occur in places.

The stratigraphy of the Minden area therefore comprises numerous materials of varying texture, consistence, permeability and strength. The groundwater regime is similarly complex, with perched water tables and confined aquifers being common. In places, particularly ridge tops and broad spurs, the present topography conforms with, and is merely an expression of, older topographies developed in the underlying rhyolite or older tephra. In these areas the cover deposits are generally in-situ, although not all the tephra are present everywhere due to either non-deposition, or post-depositional erosion or landslippage.

4.3 Erosion and Landslippage

In many areas, particularly valley sides and lower slope areas, the present topography disguises a quite different paleotopography. Rainfall and stormwater runoff tends to infiltrate and follow old channels or flow along the weathered older tephra or weathered rhyolite surfaces. Tunnel, and tunnel-gully, erosion occurs locally where watercourses have become infilled with erodible tephra.

Over the steep valley sides mass movement is evident in the form of soil creep, slumps, debris slides and debris flows. In general, long slopes in the Minden area steeper than about 22 degrees exhibit some form of instability. Peak effective strength parameters c' (cohesion) and $\varnothing'$ (internal angle to friction) in the tephras typically range from $c' = 0$ to 10 kPa and $\varnothing' = 30$ to 35 degrees. The geotechnical investigation undertaken on Lot 5 of the Minden Heights subdivision by Worley Consultants Ltd produced effective strength parameters of $c' = 6$ kPa and $\Phi' = 30$ degrees.

These parameters confirm the field evidence that if the materials become saturated, then slopes steeper than about 20 degrees comprising these materials can fail. It must be recognised that the effective strength parameters are peak values, and in colluvial materials it may be more appropriate to take residual values.

The University of Auckland have undertaken ring shear testing of older ashes exposed in a cutting on State Highway 2 to the north of the Minden area, and obtained residual effective strength parameters of $c_r' = 0$ kPa $\Phi_r' = 26$ degrees. These lower values confirm the field evidence that where old ash colluvium is present, slopes as flat as 13 degrees can fail when piezometric levels approach ground level.

In the Minden area, landslippage has occurred at varying scales and over a long time period. Some large landslips, mainly slumps and debris slides, are evidently very old, being mantled, but not completely disguised, by recent tephra showers. Other large landslips, such as the deep seated debris slides and debris flows covering much of the steep north-west facing Minden hillslopes, are evidently more recent geologically with the younger tephras associated with the landslip debris as colluvium. Smaller, relatively shallow debris slides and debris flows are evident on the shorter, steep valley slopes to the east of Minden Road, and these too are relatively recent historically. Ground movement, in the form of soil creep and limited displacement landslippage, is also actively occurring on the steep hillslopes.

Landslippage, and to a lesser extent tunnel and tunnel/gully erosion, presents an identifiable hazard to development in the Minden area. Particularly at risk are any structures situated on, immediately above or below hillslopes susceptible to landslippage.

4.4 Land Hazard and Risk Assessement

In determining the suitability of land for subdivisional and building development Council has a statutory responsibility to assess the geotechnical risk associated with the proposed development.

Risk is evaluated in terms of "likelihood of damage", the time period for which is defined in Section 641 of the Local Government Act to be "within the useful life of the building". This useful life is generally accepted by most New Zealand Territorial Local Authorities to be 100 years.

Accordingly, with respect to hydrologic risk, most Councils will now not permit development within a 100 year return period floodway, and responsible Councils have delineated the location and extent of such risk areas on their District Plans.

A 100 year return period event (whether it be rainfall, flooding, landslip or earthquake) is one which occurs, on average, once every 100 years and is therefore a rare, or low frequency, event. It must be appreciated that such events are essentially random in time and 2 or more 100 year return period events can occur in any one year.

Landslip events, like flood events, are most commonly triggered by rainfall events and generally appear to be of about the same frequency. Historically, landslippage in the Minden area has resulted from rainfall events of higher frequency (i.e. more common) than 1 in 100 years. The assessment of geotechnical risk is, however, considerably less determinate than hydrologic risk, and cannot be defined on the ground with the same accuracy. But just as the flood plain provides qualitative field evidence of the hydrologic risk, mass movement on hillslopes provide evidence of the geotechnical risk.

In the Minden area the field evidence clearly suggests that, in places, landslippage occurred prior to human settlement, presumably under a full climax forest vegetation. These slopes are now mostly cleared and in scrub or pasture, and in terms of land stability are now worse off than they were before. Whilst the effect of trees on slope stability is primarily the apparent cohesion afforded by their root systems (hence protection against shallow landslippage), evapotranspiration can also have a significant influence on slope stability by lowering groundwater levels. Accordingly, slopes that were stable under a forest cover may now be unstable.

A major compounding problem to geotechnical risk assessment in the Minden area is the effect of development on land stability. The most significant factor influencing slope stability arising from land development in the area is the absence of sewerage or stormwater reticulation. The option of providing such reticulation is probably not economically feasible because of the rural-residential (i.e. low density) zoning. The area is therefore likely to remain dependent upon on-site ground disposal for stormwater and effluent waste water, and as such development will inevitably result in a decrease in slope stability, and an increased risk to damage arising from landslip.

The net effect of development will be to raise, both locally and more widely, groundwater levels such that, during periods of high intensity and/or prolonged rainfall, the incidence and frequency of landslippage will increase. The effect of development is therefore similar to antecedent rainfall, such that a high frequency rainfall event (say 5 year return period) may be sufficient to trigger a severe (say 100 year return period) landslip event.

In addition to rainfall, earthquakes can also trigger widespread landslippage, and for the Minden area the peak ground acceleration for a 100 year return period event is estimated to be about 0.2 g. Because of the elevated steep nature of the Minden hill, amplification effects could raise this value to 0.24 g. On steep saturated hillslopes this earthquake induced ground motion would probably result in debris slides and debris flows. Cutting and filling associated with land development can also be a major cause of landslippage, and development controls would be appropriate for most of the Minden area.

4.5. Delineation of Areas of Risk

From extensive field mapping and air photo interpretation, utilising low level aerial photography flown in 1986 and 1988 and examining exposures from cuttings undertaken since 1984, the 1984 "broad brush" assessment has been reviewed and refined.

As a result of the 1991 geotechnical appraisal, the Minden area has been delineated into the following four risk categories described in Table 4.1 and these areas are shown on the Resource Management Plan, Drawing 10899-1.

TABLE 4.1

MINDEN AREA RISK CATEGORIES

Area	Risk Categories
A	Land subject to or likely to be subject to instability
B1	Land potentially subject to instability
B2	Land potentially subject to instability but less so if there is no on-site disposal of sewage or stormwater, no significant vegetation removal and no significant cutting or filling
C	Land unlikely to be subject to instability.

This risk assessment takes into account possible development scenarios, and provides Council with a basis for development control or changes to zonation.

5.0 RESOURCE MANAGEMENT

The main issues arising from the geotechnical appraisal and risk assessment are to what degree are the risks acceptable or unacceptable, and to what extent are the areas suitable or unsuitable for development.

In general terms, based on the assessed likelihood of damage arising from mass movement, the areas delineated A would appear to be mostly unsuitable for development, grading to areas delineated C which would appear to be mostly suitable for development. Implicit in this assessment is a determination as to the unacceptability or acceptability of the geotechnical risk, as shown in Table 5.1.

TABLE 5.1

DEVELOPMENT SUITABILITY AND RISK ACCEPTABILITY

Area	Development	Risk
A	unsuitable	unacceptable
B1	possibly unsuitable	possibly unacceptable
B2	possibly suitable subject to limitations on water disposal, vegetation removal and earthworks	possibly acceptable
C	suitable	acceptable

In the Minden area it is reasonable to assume that subdivisional land development and building permit applications will be made in all areas within the rural-residential boundary delineated on Drawing 10899-1.

One of the problems to date in evaluating supporting documentation has been the lack of guidelines as to what information is required and hence evaluation criteria. Fundamental to assessing the stability of land is understanding how it was formed (its geomorphology), what it consists of and how it behaves. The wider area must also be considered, as the risk to property from mass movement arising off site may be greater than the risk from on-site instability.

We consider the matters listed in Table 5.2 need to be addressed in any supporting documentation if Council is to assess whether or not to permit development in a particular area.

TABLE 5.2

SUPPORTING DOCUMENTATION FOR RESOURCE CONSENTS

Area	Requirement for Supporting Documentation
A	Geomorphological and geological evidence and a "stability analysis" demonstrating that the proposed development area will not be subject to instability or be inundated by debris from upslope, and how the proposed development will ensure that any structure will not become damaged by landslippage arising on or off the site
B1	As for (A) but it shall be sufficient to demonstrate that the risks of instability and damage are at an acceptable level
B2	A stability assessment demonstrating that the proposed development will not result in the risks of instability or damage being at an unacceptable level
C	No supporting documentation required

The technical requirements of a land stability investigation are well set out in the paper "Difficult Sites - An Engineering Viewpoint" by J.P. Blakeley. This paper was published in NZ Geomechanics News, Issue No. 23, November 1981 and a copy of this paper is attached as Appendix C.

From a geotechnical appraisal of the wider Minden area it is evident that the low lying land to the north and elevated land to the west, appears mostly suitable for residential development, whilst land to the east and south appears mostly unsuitable for residential development. Based on the geotechnical appraisal it may be appropriate to change the land zonation to take into account its land hazard potential.

TONKIN & TAYLOR LTD
Consulting Engineers

Report prepared by: N.W. Rogers

LEGEND

A — Land subject to or likely to be subject to instability

B1 — Land potentially subject to instability

B2 — Land potentially subject to instability but less so if there is no on-site disposal of sewage or stormwater, no significant vegetation removal and no significant cutting or filling

Land unlikely to be subject to instability

Landslip headscarp

Landslip debris

Soil creep, limited displacement

Subsurface exposure

Rhyolite outcrop

Recontoured land

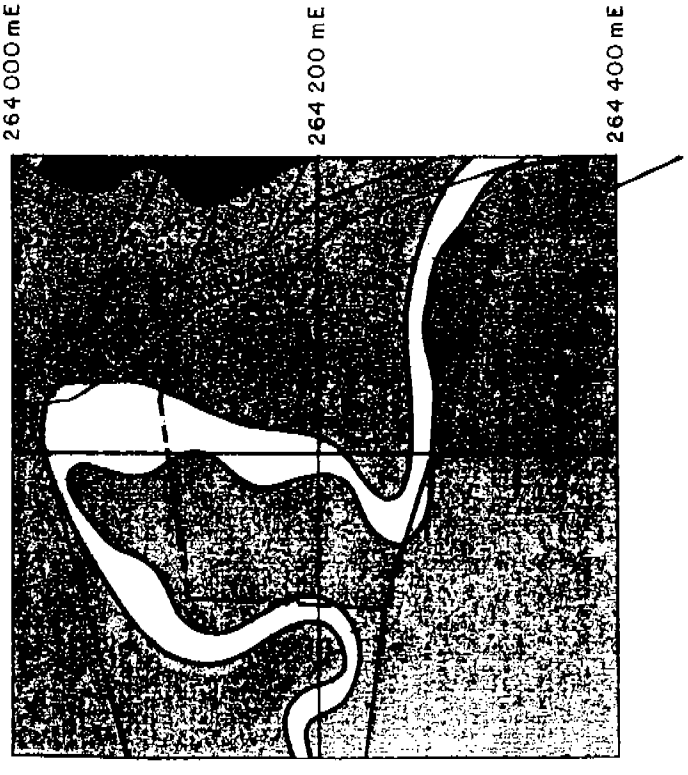
Watercourse

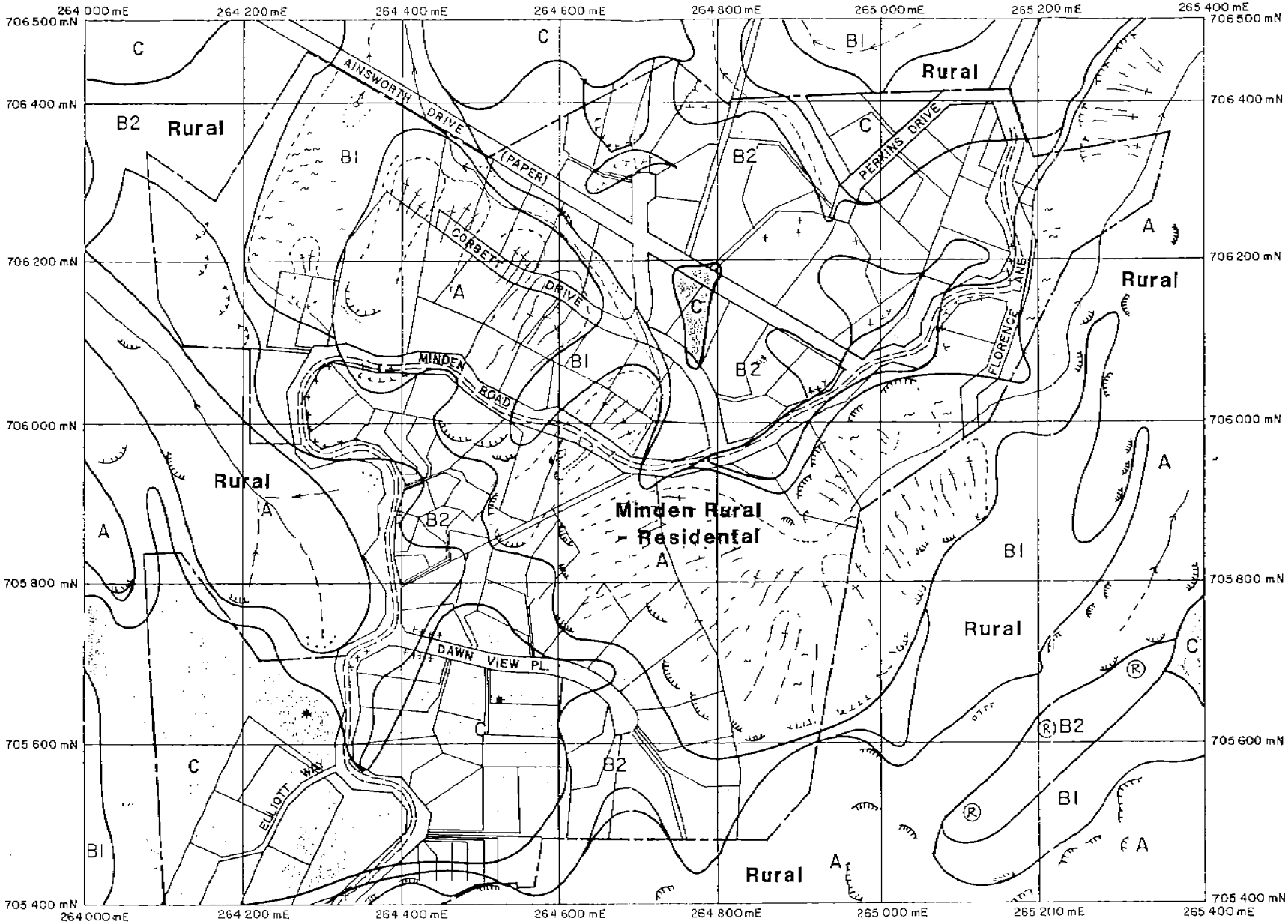
Spring/seepage

Sapping

Zone boundary between rural and rural-residential

Subdivisional lot boundaries





Scale 1:5000

0 100 200 300 400 500 m

WESTERN BAY OF PLENTY DISTRICT COUNCIL

MINDEN AREA

Resource Management Plan

TONKIN & TAYLOR
CONSULTING ENGINEERS, SURVEYORS, PLANNERS

Drawing No.	Rev.
10899-1	1
Date February 1991	
Drawn R.L.	Checked

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APPENDIX A

"Stability Assessment, Residential Land
Minden and Maketu, Tauranga County"

by

Tonkin & Taylor Ltd
July 1984

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STABILITY ASSESSMENT
RESIDENTIAL LAND
MINDEN AND MAKETU
TAURANGA COUNTY

REF : 5677

JULY 1984

PREPARED FOR:

Tauranga County Council,
Private Bag,
TAURANGA.

DISTRIBUTION:

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REPORT

1.0 INTRODUCTION

1.1 GENERAL

This report summarises the results of a stability assessment of residentially zoned land in the Minden and Maketu areas of Tauranga County which has been undertaken at the request of, and in association with, the Tauranga County Council.

1.2 SCOPE OF STUDY

The stability assessment was defined at the outset as being essentially an overview, a "broad brush" investigation from which land use management plans of the Minden and Maketu residential areas would be produced.

2.0 MINDEN RESIDENTIAL AREA

2.1 GEOLOGY AND SOILS

The main strata which comprise the landforms of the Minden area can be subdivided into three discrete units.

The oldest unit, from which the elevated Minden area is derived, is rhyolite, a volcanic rock of Late Tertiary age. Some 75 - 300,000 years ago the landscape developed in the rhyolite rock (by weathering and erosion) was overlain by rhyolitic tephra (older ashes). These ashes weathered and developed a thick soil cover until some 42,000 years ago when this weathered ash mantled landscape was itself overlain by a series of rhyolitic tephra (younger ashes). These younger ashes consist of sands and silts from a variety of eruptive centres and, with numerous and regular episodes of volcanic activity over the past 42,000 years, these younger ashes are generally only slightly weathered.

The broad stratigraphic sequence in the Minden area is therefore:

UNIT	DESCRIPTION	LITHOLOGY
1	Younger ashes	silts and sands
2	Older ashes	clays and silts
3	Rhyolite	volcanic rock

The complete sequence is not always evident due to erosion or non-deposition of the tephras, and colluvial mixtures of the younger and older ashes occur in several localities.

2.2 LAND STABILITY

In assessing the relative stability of the Minden residential areas, stability analyses have not been undertaken in view of the high cost and difficulty in obtaining relevant soil strength parameters, paleo-topographic information, and groundwater and piezometric data. Accordingly the following assessments and area delineations are based upon precedent, field evidence, and previous experience in the area.

The Minden residential areas are shown on Drawing 5677-1. On the gently sloping elevated ridges and spurs of Minden Hill, and on the valley floors and foot-slope areas close to the state highway, we could find no evidence of any actual (past of present) or incipient instability. Within these areas the generally complete stratigraphic sequence of tephras over rhyolite rock suggests little erosion or mass movement has occurred since deposition of the tephras.

On the basis of low slope gradients and apparent stability we consider that the risk of instability in these areas is very slight to slight, and we have delineated such land on Drawing 5677-1 as AREA C.

In contrast to these gently sloping areas mantled with in-situ tephras, steep to precipitous slopes are evident which are characterised by mass movement. In particular, the north-east facing hillslopes of the Minden Hill area are characterised by numerous landslips, and field evidence indicates that the debris from these landslips still covers the mid to lower slope areas. Based upon the steepness of the slopes; the colluvial debris; and the evidence of recent mass movement we consider that the risk of instability in these areas is moderate to severe, and we have delineated such land on Drawing 5677-1 as AREA A.

Between these two distinct land areas, and on the elevated valley sides and lower hillslopes, moderately to steeply sloping land is evident which appears to be presently stable. However, within such broad areas, isolated areas of prior landslippage are evident which indicate that future erosion or mass movement is possible. Based on the slope gradient and occasional indications of prior landslippage we consider that the risk of instability in these areas is slight to moderate, and we have delineated such land on Drawing 5677-1 as AREA B.

3.0 MAKETU RESIDENTIAL AREA

3.1 GEOLOGY AND SOILS

As with the Minden area, the main strata which comprise the landforms of Maketu can be subdivided into three discrete units.

The oldest unit, which occurs above and, at least some distance, below the tidal/wave zone, consists of terrestrial sediments (silts, sands, gravels and interbedded pumiceous tuffs).

These sediments are overlain by the same older ashes which blanket the Minden area (and indeed, much of the central North Island), and are in turn overlain by a series of younger ashes. In contrast to the Minden area, however, the 'younger ashes' which blanket the Maketu area are characterised by coarse pumice lapilli (Oruanui Formation and Mangaoni Lapilli).

The broad stratigraphic sequence in the Maketu area is therefore:

UNIT	DESCRIPTION	LITHOLOGY
1	Younger ashes	silts, sands, pumice gravels
2	Older ashes	clays and silts
3	Terrestrial Sediments	silts, sands, gravels and pumiceous tuffs

The complete sequence is not always evident due to erosion or non-deposition of the tephras.

3.2 LAND STABILITY

As for the Minden area, the stability assessments and area delineations of the Maketu residential areas are based upon precedent, field evidence, and previous experience in the area.

The Maketu residential areas are shown on Drawing 5677-2. Maketu is characterised by an extensive gently sloping, elevated surface which faces west, and low lying essentially flat areas adjacent to the coast. These two distinct land areas are mostly separated by very steep to precipitous coastal cliffs (either present or relic).

The stability of the coastal cliffs have been assessed in our earlier study, and the relative stability of the land west of town point road is shown on Drawing 4879-8 dated August 1981.

The high steep coastal cliffs exhibit evidence of erosion and mass movement, and we consider the risk of instability of these slopes, including the areas immediately above and below which would be affected by any instability, to be moderate to severe and we have delineated such land on Drawing 5677-2 as Area A.

The balance of the Maketu area is predominantly very gently sloping (both elevated and low lying) and we could find no evidence of actual or incipient instability. Accordingly, we consider the risk of instability over much of the area to be very slight to slight, and have delineated such land on Drawing 5677-2 as Area C.

On the elevated gently sloping land gullies have been incised into the highly erodible coarse pumiceous tephras. From comparative examination of these gullies in 1948 and 1982 it appears that little headward or sideward erosion has occurred over the past 30-40 years. The gully slopes are, however, locally very steep and we consider that instability or rapid erosion of these gully slopes could occur. Accordingly we have delineated the gully areas on Drawing 5677-2 as Area B.

4.0 LAND USE MANAGEMENT CRITERIA

From our stability assesment of the Minden and inland Maketu residentially zoned land, Areas have been delineated either A, B or C. The Areas so delineated are land hazard classifications and indicate that within these Areas certain processes or physical factors occur or could possibly occur which may present a hazard to property within these areas.

The Area boundaries should not be inferred to be as sharply defined as the line suggests, as in many areas the relative degree of risk, or land hazard, is gradational.

The land hazard classifications are based on a 'broad brush' overview approach and this, together with the mapping scale, results in area generalisations. Accordingly, within broad Areas delineated 'A' there may be isolated sites of low risk, and conversely within Areas delineated C there may be isolated sites of high risk (though the latter is less likely to be so). All other things being equal, however, we consider that landslippage is more likely to occur in Area A than in any other Area, and that landslippage is more likely to occur in Area B than in Area C.

The land hazard delineations are based upon existing field evidence, air photo interpretation and factor overlay techniques, and do not take into account the influence of future development on land stability. With most of the Minden and Maketu areas dependent upon on-site ground disposal methods for stormwater and effluent waste water, development is most likely to increase the risk of instability. In some areas stormwater runoff from roadways is also directed either over or into the ground. Together with removal of vegetation and cutting for access ways, these man-induced changes will induce variable ground responses according to the geomorphic and subsurface conditions and the exact response is difficult to predict. It should be noted that no assessment of flood hazard has been made in this study and that some areas could be flood prone.

AREA A (Moderate to Severe Risk)

An area delineated on the land use management plans in which processes or factors have been identified which indicate that past or active erosion or mass movement is evident or is likely to occur and which presents or may present an identifiable hazard to structures within the delineated area.

This includes the scarp, mid slope and debris toe areas of recent mass movement features (slumps and landslides), and sloping ground on which active mass movement is evident.

Conditions which could be applied to this area are that no building, subdivision or other development, including cutting, filling, removal of vegetation, disposal of stormwater or domestic waste water into or over the area delineated, be permitted unless adequate provision is to be made to prevent erosion or landslippage or unless sufficient investigation has been undertaken to satisfy Council that a building sited in a specific location and subject to specific development criteria is unlikely to be damaged by landslippage.

AREA B (Slight - Moderate Risk)

An area delineated on the land use management plans in which processes or factors appear to be such that erosion or mass movement is possible.

This area includes steep land and land on which prior erosion or mass movement is evident but which does not appear to be presently unstable. Because problems could occur, either naturally or induced by development, we consider that these areas warrant more detailed investigation.

Conditions which could be applied to this area are that building, subdivision or other development, including cutting, filling, removal of vegetation, disposal of stormwater or domestic waste water into or over the area delineated only be allowed to proceed if supported by, and in accordance with, specialist advice.

AREA C (Very Slight Risk - Slight)

An area delineated on the land use management plans in which instability is not apparent and in which factors or processes appear to be such that instability is unlikely to occur.

This area includes essentially flat or gently sloping land remote from areas of apparent instability.

Within the scope of the study we consider that no special conditions need be applied to this area other than those normally required by Council.

ADMINSTRATION OF AREAS

Where a property is entirely within only one Area, subdivisional and building permit applications should be administered in terms of the criteria pertaining to that particular Area.

Where a property is within two or more Areas we consider that the following administrative procedures should be adopted: -

Development of a property which incorporates Area A should only be allowed if adequate provision is made to prevent erosion or landslippage or that sufficient investigation has been undertaken to satisfy Council that a building sited in a

specific location and subject to specific development criteria is unlikely to be damaged by landslippage.

Development of a property which incorporates Area B should only be allowed if supported by specialist advice.

In essence Area B will, on specialist advice, be redefined as either A or C.

5.0 SUMMARY AND RECOMMENDATIONS

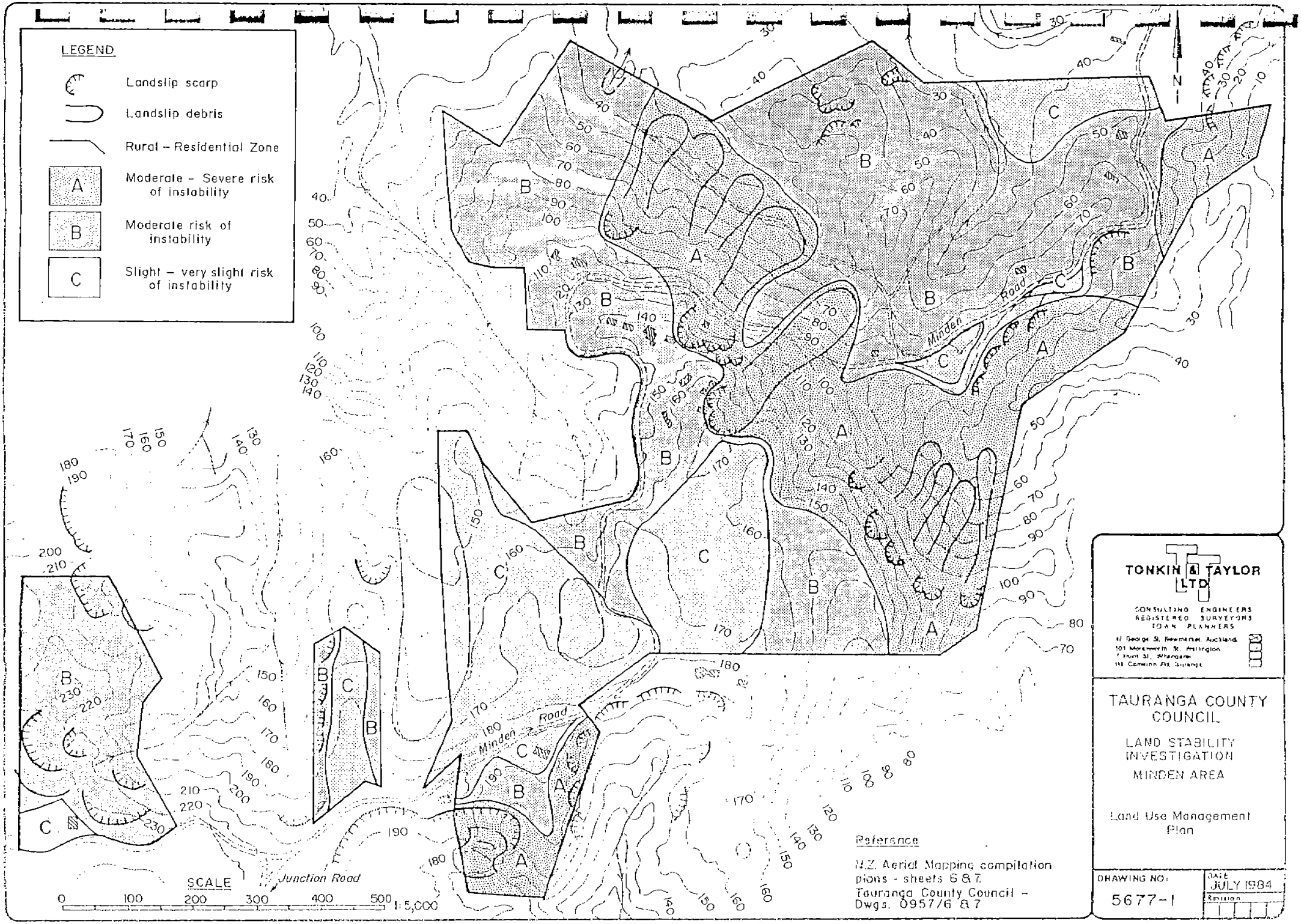
Instability in the Minden area was identified during our 1981 study and specifically included in the stage 2 proposal submitted in July 1982. The 'Minden Landslip' of December 1983 did not therefore lead to the present study in the same way that the 'Omokoroa Landslip' had led to the previous study. The Minden and Omokoroa Landslips do have parallels, however, as both landslips occurred in areas exhibiting clear evidence of numerous previous, almost identical, landslips which occurred prior to land development.

Based on air photo interpretation, field evidence and previous experience, the Minden and Maketu residential land has been delineated into areas of relative risk of land instability. Land use management criteria have been suggested for the various areas of hazard.

The stability assessments have been made on the assumption that development does not adversely affect the land stability. As much of the residential land is unserviced by either stormwater or sanitary sewer we consider that future development should proceed cautiously as an increase in water through the ground injection of domestic waste water and stormwater can be expected to reduce the present land stability.

TONKIN & TAYLOR LTD
Consulting Civil Engineers,
& Registered Surveyors.

Prepared by: N.W. Rogers.
Enclosures: Drawing 5677-1 & 2


LEGEND
Landslip scarp
Landslip debris
Rural – Residential Zone
A
Moderate – Severe risk of instability
B
Moderate risk of instability
C
Slight – very slight risk of instability
N
Minden Road
Junction Road
SCALE
0 100 200 300 400 500
1:5,000
Reference
N.Z. Aerial Mapping compilation plans - sheets 6 & 7.
Tauranga County Council - Dwgs. 0957/6 & 7
TONKIN & TAYLOR LTD
CONSULTING ENGINEERS
REGISTERED SURVEYORS
TOWN PLANNERS
TAURANGA COUNTY COUNCIL
LAND STABILITY INVESTIGATION
MINDEN AREA
Land Use Management Plan
DRAWING NO:
5677-1
DATE
JULY 1984

APPENDIX B

"Everything You Ever Wanted To Know
About Section 641A
But Were Too Afraid to Ask"

by

N.W. Rogers

EVERYTHING YOU EVER WANTED TO KNOW ABOUT SECTION 641A BUT WERE TOO AFRAID TO ASK

N.W.Rogers

In late 1979, as a direct result of the Abbotsford Landslip Disaster, Section 641 of the Local Government Amendment Act was enacted which gave the Local Authority the power to refuse a building permit if, in the opinion of the Council -

> "The land, or any part of it, is subject to erosion or subsidence or slippage, or inundation by the sea or by a river, stream, or lake or by any other source; or
>
> The erection or alteration is likely to accelerate, worsen, or result in erosion or subsidence or slippage, or inundation by the sea or by a river, stream, or lake, or by any other source, of other land, -
>
> the council shall refuse to grant a permit to erect the proposed building or to make the alteration, unless the council is satisfied that provision has been made or is to be made for the protection of the land from erosion or subsidence or slippage or inundation."

In November 1980 the Commission of Enquiry into the Abbotsford Landslip Disaster officially reported. In their (Gallen et al) examination of local government responsibilities with regard to development they concluded

> "we do not consider any change should be made to local government powers in respect of land subdivision and development and building construction until there has been sufficient time to assess the effect of the Local Government Act 1974 and the Local Government Amendment Acts of 1978 and 1979."

In making recommendations they stated

> "we do not recommend any change to the law relating to the liability of local authorities in respect of the control of subdivision development and building construction."

However, on 23 October 1981, an amendment to the Local Government Act was enacted which gives the Local Authority the power to issue a building permit where the land is subject to erosion, subsidence, slippage or inundation and not be under any civil liability.

Under Section 641(A),

> "Council may issue a building permit for the erection of a building that is designed to be relocatable on any land or any part of land that is or will be subject to erosion, subsidence, or slippage, if it is satisfied that the building can be relocated from that site.
>
> If a building is, or within its useful life likely to be, subject to damage arising directly or indirectly from the erosion, subsidence, or slippage, of the land on which it is erected or any other land, or inundation arising from such erosion, subsidence, or slippage the council may issue a building permit for the alteration or resiting of that building on the allotment on which it is situated, for the erection of any other building on the same allotment consistent with the use and occupation of the existing building, or for the restoration of any damage suffered by that building."

Provided that in issuing such permits council has notified the District Land Registrar accordingly, then if the building or alteration to which the permit relates later suffers damage arising directly or indirectly from erosion, subsidence, or slippage, or inundation arising from such erosion, subsidence, or slippage, the council and every member, employee or agent of the council shall not be under any civil liability.

Section 641(A) was clause 22 of the Local Government Amendment Bill. The Local Government Amendment Bill went to three readings in the House and was referred to the Local Bills Committee where it received 35 submissions, one of which came from the Geomechanics Society. After reporting back to the House, the apparent turn about (from 641 to 641(A)) was raised by Mr. Caygill, and I quote from Hansard, 30 September 1981

"Two years ago the House was persuaded that it should be difficult, if not impossible, for local authorities to issue building permits for building on land that might be subject to subsidence, erosion, or slippage, and even, in some cases, inundation. I am sure that Parliament agreed to that 2 years ago because parliamentarians were anxious to protect property owners from the considerable loss that could result if land disappeared underneath them. Now it is suggested that there should be more flexibility. It was clear from the submissions that the practice differs widely from one local authority to another. Some local authorities readily issue building permits for land that is subject to erosion, slippage, or subsidence, and some take much persuading to issue building permits under those conditions."

Why did Section 641(A) come into the statutes?

Unlike Section 641, Section 641(A) does not appear to have come into existence because of a landslide disaster. Many people, rather, consider that 641(A) is a disaster.

The Local Government Amendment Bill was introduced into the House on 18 August 1981 by the Hon D.A. Highet (Minister of Local Government) who stated, and I quote from Hansard of that day,

"Probably the clause of greatest immediate concern to local authorities, because it deals with overly restrictive provisions in the present law, is clause 22, which deals with the issue of building permits. That clause amends section 641 of the principal Act, to make that section much more flexible."

"The amendments will introduce a great deal of flexibility into the operation of section 641, which was, perhaps, originally enacted too soon after the disastrous events at Abbotsford to enable a sufficiently objective approach to be adopted."

"The proposals in the Bill have been discussed in the local government consultative group, and they meet with the general approval of the national local authority associations. There are some details on which individual authorities and associations may wish to make submissions, but that is normal with a local government Bill."

I quote Mr. Caygill from Hansard 18 August 1981

> "Can the Minister explain why this particular formula has been proposed, why it is appropriate, and whether local authorities have approved it, or indeed, have sought it?"

Mr. Highet replied that

> "It is a practical application on the grounds of the experience of local authorities, the Municipal Association and many landowners."

I quote the Hon P.I. Wilkinson (Kaipara), Hansard 18 August 1981

> "I thank the Minister sincerely for his assistance with a local problem I have had, which might, I think, be the reason for amending section 641 of the principal Act relating to the power to refuse building permits. The amendment in clause 22 makes that part of the law more flexible. Everyone appreciates the need for a power to refuse building permits to avert further tragedies such as the Abbotsford tragedy. Clearly there is a need for greater flexibility to avoid the opposite position, whereby progress in an area is quite unreasonably held up because of the refusal of permits, rendered possible because the present law greatly restricts the room for individual cases and situations to be examined according to their own special circumstances.
>
> This provision is of special concern to the residents of Algies Bay on the Mahurangi Peninsula, the case which, I think, probably triggered off this legislation. Because of alleged land instability in that district, severe building restrictions - in some instances total restriction have been applied by the Rodney County Council. As a result, property values have been severely and adversely affected, and this has caused considerable distress to the local residents. Comments by some valuers and solicitors - and even by some members of the council staff - have done nothing to alleviate the position.

As a result, development in the area has been stifled, as has confidence. Last year the Rodney County Council initiated a land stability investigation of the area by Beca Carter Consultants. Many residents considered that the conclusions of that detrimental report were far greater than actual fact.

There is no visible evidence of structural damage to buildings in this area, some of which were built 20 or more years ago, nor is there evidence of major landslips. I can attest to this, having a property of my own very near to Algies Bay. For a long time, land movements have been a feature of the residential problems in nearby Martins Bay and adjoining areas. However, I can recall no case in which the land movement has caused more than minor structural problems. The residents are asking for more flexibility in this provison. The Minister will be aware that they are now asking him whether the fine details of the legislation will effectively cover this situation in every respect. I thank the Minister for listening to, and giving justice to, a small group of my constituents. That was appreciated."

I quote the Hon D.A. Highet, Hansard 18 August 1981

"I am grateful to two members in particular. The member for Kaipara is very interested in the area around Algies Bay, where his constitutents are affected. I hope that the member feels that the Bill has been made much more flexible, and that the landowners in his electorate will be satisfied."

"The Deputy Prime Minister is concerned about the East Cape area. I thank the Minister of Justice for his co-operation. The wording of the clauses was discussed by the Deputy Prime Minister, the Minister of Justice, and myself, and the member for Kaipara was brought in on some of the discussions. As a result of those discussions we now have some very good legislation."

..."I shall give an example. Houses have existed at Wainui Beach, in Gisborne, for 30 years. It is now known that erosion is taking place. If a house in that area burns down and the owner wants to re-erect on the property, the council will inform him that he can re-erect, but if there is any damage because of erosion an owner will not be able to go to the council. The liability will be his. That is what is stated in the proposed new subsections."

Mr. Comber reported the Bill back to the House and I quote Hansard, 30 September 1981

> "Not unexpectedly, the proposed new section 641 in clause 22 was the subject of most of the 35 submissions received. It was given particular attention by members of the committee, and I thank them for their earnest consideration of a very complex and, at times, for the individuals concerned, a very personal question. It should also be said that the committee received a very positive input from some individual members. I think of the Deputy Prime Minister, the member for Kaipara, and the member for Albany. The first two members were in particular concerned about developments at Wainui Beach outside Gisborne and at Algies Bay." ...

> "The result is that the committee has completely redrafted the clause to take account of the very sound submissions made by local authorities that have had sufficient experience of operating the present law on this subject to point to its limitations. Those limitations have now been removed, and the clause introduces to the law a most desirable degree of flexibility. The main amendments lie first in the change in emphasis from danger to and protection of land, to danger to and protection of buildings. That makes sense because, after all, the clause deals with the issue of building permits."

Mr. McKinnon (Albany) commented that it would "be good for Orewa".

> (A recent case before the Town and Country Appeal Board had to do with six sections in Orewa, which, in the opinion of the council, were in danger of being washed away. When the council expressed that opinion the people took a case to the Town and Country Appeal Board questioning the council's opinion in that instance. The board upheld the council.)

I quote Mr. McLean (Tarawera)

> "My colleague the Minister of Agriculture has for some time been pressing for a measure, such as the proposed new section 641 in clause 22, because of the problems in his electorate from Wainui Beach northwards, where a black line has been drawn on the map. It has been assessed that within 100 years erosion could remove the land between that black line and the sea. It might be 10 years or 1000 years, yet local authorities find themselves unable to issue building permits, even if a building burns down. The proposed new section 641 in clause 22 will remedy that. I know that the Minister of Agriculture will be particularly glad that this has happened."

The Bill went before the House for a third reading on 20 October 1981, and I quote the Right Hon D. MacIntyre (Minister of Agriculture) from Hansard

> "The main clause in the Bill is clause 22. It affects many people, because recent studies of the law on soil erosion have meant that several properties around the country have been under threat. The committee and the Minister have done a good deal of work on the Bill. It has been substantially amended since it was introduced, and I believe it will solve most of the problems. However, the Bill may not cover one or two isolated cases in my electorate. I have had discussions with the Minister, and I shall inform the people affected that next year a private member's Bill might have to be brought before the House. Apart from those points, I support the Bill."

It appears that Section 641(A) arose out of loss of land value and refusal of building permits in particular areas of Wainui Beach, Algies Bay and Orewa (respective electorate areas of MacIntrye, Wilkinson and McKinnon) because the local authorities considered the particular areas hazardous and refused building permit approval under Section 641. It should be noted that these areas had recently had land hazard studies undertaken by consulting engineers and the Ministry of Works which delineated areas of hazard, and that upon appeal the Town and Country Appeal Board had found in favour of the Council and its expert advisors. It is also interesting to examine the timing of the legislation and the status of the electorates. 641 arose out of a landslide - was 641(A) enacted to prevent another landslide?

One of the main suggestions in the Geomechanics Society's submission to the Local Bills Committee was that Council's be required to commission urban capability studies to identify areas of land subject to erosion, landslip, subsidence and inundation.

It appears, however, that it was the commissioning of just such land hazard studies which initiated 641(A). It is rather ironical that land hazard studies initiated by Local Authorities in order to assist in its duty of care in issuing building permits should have resulted in legislation which enables Councils being able to absolve themselves of civil liability upon issuing building permits in hazardous areas.

Undoubtedly the best way to reduce damage to buildings and minimize the danger and distress to people is to identify areas of hazard and prevent development. Experience in the U.S.A. indicates that where legislation has been introduced requiring geotechnical engineering and geological surveys to be made and certain standards to be met, damage from landslip arising during land development has been reduced by 80%. With the enactment of 641(A) the role of the consultant in undertaking land hazard studies has altered. It is now no longer sufficient to merely delineate areas of actual or potential land hazard. The nature and degree of risk of damage to buildings must now also be evaluated.

Tonkin & Taylor Ltd recently undertook a stability study of the Moeraki township for the Waitaki County Council, and as a result of the study prepared a map delineating the township into areas of relative risk with respect to level of mass movement, potential damage to buildings and roading, and deformation and movement of legal boundaries. Like other land hazard evaluations, this particular study was initiated because the Council became aware that a large part of the township area was actually or potentially unstable. Council sought specialist advice and, in the interim, put a total ban on the issue of building permits in the township. With the relative risks now broadly assessed, Council is in a better position to decide where to refuse a permit, where to issue a permit under 641(A) and where to issue a permit in the normal way.

In undertaking such evaluation the consultant must now be particularly careful. Section 641(A) makes consultants more susceptible to legal action, for if people cannot sue the Councils they will be looking for someone else to sue. In the past, liability may have been apportioned between Council and other parties; - now the liability will presumably all be on the other parties. The consultant is not the only one likely to be disadvantaged when building permits get issued under 641(A). Issue under 641(A) implies that the building or alteration is either likely to sustain damage within the useful life of the building or likely to be required to be relocated elsewhere. If damage occurs the owner is unlikely to be insured by Earthquake & War Damage cover. With 641(A) being recorded on the title, the property may be difficult to sell, and loss of value is likely. If the building is required to be designed (note: not deemed) to be relocatable, this usually precludes substantial, complex or permanent (i.e. rigid) building materials (e.g. bricks and blocks), or any building on a narrow right of way or otherwise awkward section. Relocatable implies that there is something left to relocate, (although the Act does not say undamaged) and this probably precludes such buildings from above and below cliffs, foredune beach areas on eroding shorelines and gully heads in erodible soils because in such areas damage is likely to occur with little (if any) advence notice. Any alterations or the erection of another building on site under 641(A) are not required to be relocatable,which implies damage can be expected to these structures. The question must therefore be raised that it is not only the damage to buildings which requires assessment but also the danger to the occupants. In this regard, therefore, the consultant must exercise caution.

It is very easy for a consultant to accept, or to be coerced into accepting, considerable risks on behalf of individual property owners or local authorities. With respect to land hazards it is the consultants role to assess the risks so that Council can act in an informed manner in the communities interest. Assessing risks from land hazards is the role of professional advisors. Taking risks on behalf of others is the role of professional gamblers.

All living involves risk taking, and from a geological point of view New Zealand is a dangerous place to live, with almost every part being at risk from some natural disaster or other. No amount of geotechnical expertise or planning control can produce absolute safety in the urban setting and one doesn't believe that the community expects that to be achieved. What the community can rightly expect is that actual and potential land hazards are identified.

It is unfortunate that the technology of geotechnical hazard detection and evaluation, while not always precise, is evidently far ahead of our social capacity to accept the warnings and to act upon them.

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APPENDIX C

"Difficult Sites - An Engineering Viewpoint"

by

J.P. Blakeley
November 1981

DIFFICULT SITES - AN ENGINEERING VIEWPOINT

J.P. Blakeley

1. Introduction

This paper will discuss principally the problems associated with sites which are difficult to develop because of a known or potential land instability problem. Difficult sites of this nature are within the author's field of knowledge and experience. However, much of what is said can be applied to sites which are difficult to develop because of likely flooding problems or problems with coastal erosion.

2. Recent Developments

In the author's opinion, the most significant recent development in this area of civil engineering is that the standard of care expected of the civil engineer in giving a professional opinion of land stability has been steadily increasing over the past few years (i.e. the standard of technical skill which is regarded as being necessary before such professional opinions should be given). In addition the degree of risk which the engineer runs of being sued for professional negligence in giving such an opinion, if a land stabilty problem subsequently occurs, has risen significantly because of recent court decisions. This risk applies both to the engineer preparing and signing a stability report and also to the Local Authority engineer responsible for approving a housing subdivision or permission to build a house on a specific site.

No longer is the risk of purchasing a site which may have a stability (or a flooding or coastal erosion problem) principally the risk of the purchaser of the site, but increasingly the purchaser seeks to share the risk with his consulting engineer and with the Local Authority engineer who issued a building permit.

3. Who accepts the Risk?

On the majority of potential building sites, it is possible for a consulting engineer to provide a statement that there is a building platform which can be relied upon to remain stable in all reasonable and foreseeable circumstances without him considering that he himself is running an unacceptable risk of being sued by providing such a statement.

On a limited number of sites, it is possible for the consulting engineer to state quite categorically that, because of past land instability or for some other reason, it is not possible to provide a stable building platform, bearing in mind the economic limits of site stablisation works which might be considered. However, as cities grow and land becomes more and more valuable and most of the desirable sites are already built on, even such sites as these become increasingly attractive to developers. This results in pressure being applied on engineers to prepare stability reports or statements of land stability which will enable such sites to be built on. The consulting engineer must resist this pressure and be very sure that he is aware of existing information (especially with regard to past instability in the area) before committing himself to carry out investigations for the preparation of a stability report. This is because once he has accepted the commission, unless he has specifically warned his client of the possibility, he will have a most dissatisfied client if the report is unfavourable.

If the report prepared is favourable, the Local Authority engineer then has the dilemma of either accepting the recommendations of the stability report or statement and thereafter running the risk of being sued (along with the consulting engineer) if instability subsequently occurs, or refusing to accept the report and coming into direct conflict with both the developer and the consulting engineer who has prepared the report. This matter of acceptance of signed stability statements is discussed further in section 4 below.

The situation becomes even more complex in the case of sites on which it is probably safe to build a house (subject to certain provisos regarding drainage works, types of house construction and possible future maintenance of the site surface, such as filling in tension cracks in the ground surface or providing a cover of vegetation) but where there is recognised to be a small risk (either quantifiable or not) in building. The consulting engineer justifiably believes that since he has identified the risk, if a stability failure does occur he should not be sued. In these situations, the engineer's client will often state that he is prepared to accept this small risk but the Local Authority engineer, while recognising that the risk may be small is not prepared to accept it. This is because there is no reliable mechanism for alerting subsequent owners that they are "taking over" such a risk when they purchase the property. As a result, subsequent owners will believe that they are justified in sueing the Local Authority who issued the building permit if a slip subsequently occurs.

This problem can only be overcome if a mechanism is available whereby all subsequent potential purchasers can be alerted to the risk which the original owners of the property accepted when permission to build was granted by the Local Authority. The normally suggested method of doing this is by noting on the title of the property that, either a stability report exists or that there are definite stability hazards (or other types of hazards) which are actually spelled out on the title. The former is preferable to the latter, if only because it may not have quite such a depressing effect on the value of the land.

Apart from this factor, there is other strong opposition to placing this information on legal titles from those responsible for the administration of the title system, as it is stated that this is not within the purpose for which titles are meant to be used. The searching of the legal title is one step which is nearly always carried out prior to purchase of property and hence anything written on the title will definitely be brought to the potential purchaser's attention. No other effective way of achieving this aim has yet been proposed.

Indirect methods have been used already in some cases to circumvent the opposition to registration of this type of information on legal titles and to make sure the information is brought to a purchaser's attention. However, a recent legal decision has brought the legality of such methods into question.

In recent months the Abbotsford Commission of Inquiry recommended that such information be placed on legal titles. Subsequently by a majority vote, the Municipal Association recommended that this be done, but to the author's knowledge no legislation has yet been brought forward to bring this into effect.

Unless a solution to this problem can be found, there will be many building sites within New Zealand cities which will not be developed and which probably the community at large would believe should be developed. People would be prepared to accept the risk of building or purchasing a property on this land if a report by a consulting engineer spelt out clearly the degree of risk which they were taking and precautionary or maintenance measures which must be adopted. The present situation is that the Local Authority engineer cannot take this risk

on behalf of subsequent owners in granting a building permit. Many consulting engineers are also reaching the position where they are concluding it is not good business to write stability reports or stability statements for marginal sites as the risk they run of being sued if a stability failure occurs is out of proportion to the income received from being involved in such work. Their concern is increased because the site may develop in a manner over which they have no control and which also may not be in accordance with their recommendations.

In such situations, some consulting engineers have used a disclaimer of responsibility clause in an attempt to lessen their risk of being sued. This is not necessarily the case, especially if a third party is affected and brings a claim in court, and in any event such disclaimer clauses when tested by the courts may be found to be invalid.

In summary therefore, the author believes that although the consulting engineer can spell out the risks involved in developing a site, it is the purchaser of a property who should be responsible for accepting such a risk, but the Local Authority engineer will be only able to accept this position if a method is found whereby every potential purchaser of a property can be alerted to the risks he is running in purchasing the property. It is hoped that a solution to this conundrum can be found in the next year or two.

4. Engineers' statements of land stability using the format proposed by the Earthquake and War Damages Commission

In 1977 the Earthquake and War Damages Commission produced three standard formats for statements by engineers regarding land slope stability. Two of these three formats require statements from a registered engineer experienced in the field of soils engineering and more particularly land slope and foundation stability. This recognises the fact that it is no longer considered acceptable for any registered engineer, or indeed any registered civil engineer, to sign such statements. The assessment of land slope stability does require specialist knowledge and experience.

However since there is no recognised formal qualification in this area, it is now up to the Local Authority engineer who receives such statements whether or not he is prepared to accept them. This places a considerable responsibility on the Local Authority engineer in rejecting such statements and he is then being placed in a judgmental situation when he himself may have no specialist knowledge in this field. Presently the Local Authority Engineer cannot avoid being placed in this position and in the course of time evaluation panels may be set up in the main metropolitan areas of New Zealand to decide which registered engineers have the qualifications and experience to sign such statements. This would remove some of the burden from the Local Authority engineer.

Even so, the ultimate decision as to whether to accept a stability statement and allow a building permit to be granted must rest with the Local Authority engineer. From time to time he may find himself in disagreement with the engineer who has signed the stability statement. He must then decide whether he believes his legal responsibilities are such that he must override the recommendation of the engineer providing the stability statement.

5. Technical Requirements of a Land Stability Investigation

The fundamental dilemma usually faced in assessing the stability of a difficult site is the extent of investigations it is financially practicable to carry out on which to base conclusions. It is often said that the extent of engineering judgement required in relation to the available investigation budget is many

times higher for a house site than for (say) the soils investigation for a major industrial project.

In the event of a stability failure subsequently occurring and the consulting engineer being sued for negligence, his defence will usually be that the standard of care which he exercised would be comparable with that of his peers with the requisite training and experience. As mentioned in section 2, the standard of care expected of a civil engineer in giving a professional opinion on land stability has been steadily increasing over the past few years to the point where such professional opinions are moving out of the realm of the "general practitioner" and into that of the geotechnical specialist.

About 15 years ago, an adequate soils investigation on a difficult house site might have been regarded as putting down (say) 3 hand auger bores, each to a depth of 4-5 m, and taking some "undisturbed" samples in 40 millimetre diameter tubes. Some quick undrained triaxial tests were then carried out and the results used to perform a hand slip circle analysis using the method of slices. The whole process came up with a factor of safety equal to or greater than 1.5.

In the author's view, such an investigation would today be regarded as quite inadequate for a number of reasons as follows:

(i) The investigation bores must be taken down to a hard base - either bedrock or a very strong soil beneath which the possibility of any weak layer along which a failure plane could develop is negligible. Often this will be at a greater depth than it is possible to reach with hand auger bores.

(ii) If there is any possibility of a "greasy back" situation being present in which a thin, very weak soil layer may cause failure, then the bores must be continuously cored. This can only be done readily by using a machine drilling rig. Hand augering produces a very disturbed sample and a thin weak layer can easily be missed.

(iii) If a slope stability analysis is to be carried out to determine the long term stability of the slope, then the analysis must be carried out using effective stress. This will involve either assessing suitable soil shear strength parameters or carrying out several sets of consolidated=undrained triaxial tests with measurement of pore-water pressure which is expensive.

(iv) In the case of brittle soil (in which the peak shear strength is considerably higher than the residual shear strength) then stability analysis using peak shear strength parameters may give a false sense of security. The ratio between peak shear strength and residual shear strength can only be readily determined by means of carefully controlled direct shear tests.

(v) In effective stress stability analysis, the position of the ground water table level must be carefully defined as this can be a critical factor in the results obtained from the analysis. This will normally require investigation bores to be left open for observation in holes with perforated liners over a winter period. If time does not permit this, then in the slope stability analysis the water table level must be assumed to be close to the ground surface, unless permanent subsoil drainage can be assumed to hold the water table down to a lower level. If there is a possibility of artesian pressure developing in any soil layer, then it may be necessary to install piezometers in such layers to measure any artesian pressure.

(vi) The slope stability analysis should be carried out by computer using one of the more recent programmes which are more sophisticated than the original methods of analysis and also enable analysis of non-circular failure surfaces (where the soil profile indicates that this is likely).

(vii) Up until a few years ago, it was generally regarded that a factor of safety of 1.5 in such stability analyses could generally be regarded as sufficient in a land stability evaluation. However, the author believes that it is now essential to review the possible variations in soil parameters and other uncertainties in the analysis before deciding what is an acceptable factor of safety.

In very many situations the above procedure will be prohibitively expensive for the evaluation of stability of residential land. In such situations, the author believes that it is much better for the engineer to rely on his observation and judgement (often backed up by the opinions of an engineering geologist) than to carry out investigations and stability analyses which are not up to an acceptable standard. This does, of course, throw a greater weight of responsibility on to the engineer in using his judgement and this is discussed further in section 7 below.

6. Minotoring of Ground Movement

In some situations where land instability is suspected, monitoring is carried out by means of pegs installed near the ground surface and regularly surveyed. This is a costly and time consuming procedure and also has difficulties when it is possible the pegs may be disturbed in some way (e.g. by animals or construction operations). In such situations consideration of the use of slope-meters is recommended, as often the cost of installing and monitoring these instruments may not be much greater than the cost of continual surveying of the area. They also have the distinct advantage that they can show the depth at which the ground movement is actually occurring.

In the case of an area where ground movements have occurred and remedial works which the engineer believes are satisfactory have subsequently been carried out, then it is the author's opinion that the effectiveness of such remedial works should be monitored by measurement of any ground movement and by water table measurements (where appropriate) for at least two winters before a good judgement can be made on the effectiveness of such works. The cost associated with this delay must be added to the cost of carrying out the remedial works in deciding whether such measures are an economic solution to a land stability problem.

7. Land Stability Assessment by Observational Methods

There has been a very definite trend over the past five years away from conducting soils investigations which are mainly site specific towards the evaluation of the stability of the area surrounding the site as a whole. This is because engineers are coming to the conclusion that it is not possible to consider the stability of a small area or one building site in isolation as it will be very much affected by what goes on around it.

As a result of this, there has been less emphasis on physical investigation within the site itself and much more emphasis on observations of the surrounding area.

Such procedures will involve:

(i) A careful ground surface observation of the surrounding area and consideration of the likely subsurface geology carried out by an experienced engineering geologist with attention being given to any existing geological reports, exposures in cliffs of the soil/rock profile and any existing investigation borehole information.

(ii) Careful study using stereo pairs of all available aerial photographs of the area for any signs of instability or land subsidence. These will show up much more readily in three dimensional viewing than on a photograph. If photographs are available at different times over (say) a twenty year period, this can be most useful in detecting any changes in the landform that have recently occurred.

(iii) If insufficient information is available from existing aerial photographs and the time and/or cost of obtaining new aerial photographs is considered to be prohibitive, then consideration should be given to hiring a helicopter or light plane to view the land from above for any signs of instability. This is seldom done but if there are any existing land stability problems, they are likely to be much more apparent from the air than they are on the ground.

(iv) The Local Authority should be consulted regarding any part instances of land instability in the area which they are aware of. In some Local Authorities, land stability maps of their territorial area are now being prepared on which all recorded cases of land instability are being recorded and these Local Authorities are to be applauded in taking this action. Otherwise, with changes of personnel which are bound to occur, if such information is only stored in people's heads, then it is bound to be lost over a period of even a few years.

In summary, a close observation of nature can often be worth many thousands of dollars spent on physical investigations in coming up with a good assessment of the stability of an area of land.

8. Conclusion

The assessment of difficult sites for their suitability for building on is not so much a science as a "developing art". Also the legal consequences on the engineer of errors being made in such assessments should be of great concern and are likely to become more so. Hence the author strongly believes that civil engineers working in this field and responsible for making stability assessments must be fully aware of their responsibilities and of the present "state of the art".