

# **Auckland Council**

## **Code of Practice For Land Development and Subdivision**

### **Section 2**

### **Earthworks and Geotechnical Requirements**

**Version 1.6      24 September 2013**

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## SECTION 2: EARTHWORKS AND GEOTECHNICAL REQUIREMENTS

### Section 2

#### 2.1 Scope

This section sets out requirements for the assessment of land stability and the design and control of earthworks to ensure a suitable platform for the construction of buildings, roads, and other structures. A low impact design approach is preferred. Geotechnical assessment shall be undertaken by a geo-professional as defined in 1.2.2 of this Code of Practice where any of the following situations occur:

- a. The assessment of land stability requires specialist expertise.
- b. The construction of earthworks associated with any development requires initial planning and design to ensure that banks and batters remain stable and that fill material is placed in such a way that it remains stable and can support the future loads imposed on it.
- c. There is historical fill that has not been undertaken in accordance with any Code of Practice or where natural slopes, banks, or batters are involved.
- d. The assessment of ground for the foundations of buildings, roads, services, and other infrastructure requires specialist expertise (as weak ground may require special design).
- e. The wide range of soil types, physical conditions, and environment factors applying in different areas make it difficult to specify precise or prescriptive requirements for land stability assessment of earthworks. Refer to the details in the rest of this document.
- f. Land development and/or subdivision is being undertaken.

In setting design, construction requirements, or development limitations the designer shall take account of all relevant Standards and Unitary Authority (UA) requirements.

#### **C2.1**

*NZS 4431 is applicable to the construction of earth fills for residential development including residential roading.*

#### 2.2 General

##### 2.2.1 Objective

The objective of this Section is to set out some, but not necessarily all of the matters, which need to be considered in planning and constructing a land development project. The aim is to provide information for professionals involved in designing and constructing a land development project and to require geotechnical expertise in projects where land stability could be an issue or where earthworks other than of a minor nature will occur.

The geo-professional needs to be involved in the design of the final land form. The decision depends on many factors, which may be specific to the development. These include the relationship with surrounding landscapes, effects on neighbouring land, Drainage/services, the size of the development, the proposed and existing roading patterns, the preservation of natural features, wahi tapu, and other historic and archaeological sites, the land stability and underlying structural geology, the function and purpose of the development and the potential for flooding, and erosion and other natural hazards and events including earthquakes. The aim is to also give guidance on the identification of and assessment of the order of importance of the above factors, which will vary from project to project.

### 2.2.2 Referenced Documents

A selection of useful guidance material on geotechnical and geomechanical issues in land development is set out in the Referenced Documents section at the beginning of NZS 4404. Related Documents also at the beginning of NZS 4404 lists additional material that may be useful.

Geotechnical reference material for the Auckland region is also to be made available on the Council's website. These plans are indicative only for general overview use and are not site specific;

[www.aucklandcouncil.govt.nz](http://www.aucklandcouncil.govt.nz) > [About the council](#) > [Plans, policies and publications](#) > Technical publications and research.

Refer;

Final Report – Stage 1, Auckland Engineering Lifelines Project – Auckland Regional Council Technical Publication No. 112, November 1999, ISSN No. 1172 6415.

Note also the “Geological Sensitive Areas” map located within the Watercare Services Limited document “Water and Wastewater Code of Practice for Land Development and Subdivision” found on; [www.watercare.co.nz](http://www.watercare.co.nz) > Residential > Development and Connections > Engineering Standards > Wastewater (page 29)

### 2.2.3 Unitary Authorities' Requirements

The Council may require an assessment of land stability to meet the provisions of the Resource Management Act, Building Act, Local Government Act and Auckland Council District Plan and Auckland Council Regional Plan requirements. This includes the Engineering Approval consent process. The UA requires and relies on the assessment made by the geo-professional.

Special requirements apply when land is subject to erosion, avulsion, alluvium, falling debris, subsidence, liquefaction, slippage, rotation, creep, or inundation from any source. In such situations, reference needs to be made to s.106 of the Resource Management Act and for subsequent building work, s.71 of the Building Act.

The Council under its Statutory obligations may require a peer review, regulatory review or assessment of effects review (or combination thereof) of a geotechnical/earthworks assessment.

This Code of Practice sets out the minimum requirements for the methods used and investigations undertaken by the geo-professional.

The term “Design life” in reference to land development activities (including related structures) is normally bench marked by the Council as a minimum of 100 years. This is particularly important where the activity on the land being developed may extend in perpetuity despite structures being created on the land with 50-year design life expectancy as allowed by the Building Act/Code.

Structures constructed to protect land under s71(2)(a) of the Building Act shall have a minimum 100 year design life.

Geo-professionals involved in land development activities will need to ensure that they are sufficiently engaged or involved in the development or earthwork process where they are required to provide certification, verification and documentation to meet conditions or requirements of resource and engineering approval consents.

For subdivisional development it is an expectation of Council that design outcomes will deliver building platforms appropriate to the likely development. The building platform, and associated access and manoeuvring areas within the lot should be suitable for non-specific (NZS3604) design, particularly for residential development. Any specific design zones or no-development zones on any lot shall be reported on and lots subject to natural hazard should be avoided or mitigated for wherever possible.

#### **2.2.4 Geotechnical Requirements**

Where any proposed development involves the assessment of slope stability or the detailed evaluation of the suitability of natural or filled ground for the foundations of buildings, roading, and other structures, or the carrying out of bulk earthworks, then a geo-professional shall be appointed by the developer to carry out the following functions:

- a. Check Auckland Council District Plan, Auckland Council Regional Plan, publicly available Council records, for requirements relating to the geotechnical assessment;
- b. Prior to the detailed planning of any development, to undertake a site inspection and such investigations of subsurface conditions as may be required, and to identify geotechnical hazards affecting the land, including any special conditions that may affect the design of any pipelines, structures, or other utility services;
- c. Before construction commences, to review the drawings and specifications defining any earthworks or other construction and to submit a report (commonly an Investigation Report – refer schedule 2B, Table 2B1, Phase 2 or 3) to the UA on the foundation and stability aspects of the project;
- d. Before and during construction, determine the extent of further geo-professional services required (including geological investigation);
- e. Before and during construction, to determine the methods, location, and frequency of construction control tests to be carried out, determine the reliability of the testing, and to evaluate the significance of test results and field inspection reports in assessing the quality of the finished work;
- f. Any work necessary to manage the risk of geotechnical instability during the construction process;
- g. During construction, to undertake regular inspections consistent with the extent of geotechnical issues associated with the project;
- h. On completion, to submit a written report to the UA attesting to the compliance of the earthworks with the specifications and to the suitability of the development for its proposed use including natural ground within the development area. Where NZS 4431 is applicable, the reporting requirements of the Code of Practice shall be used as a minimum requirement

#### **C2.2**

*Guidance on geotechnical reporting which may be required by the Council is summarised in Section 2.6 of this Code of Practice. Additional guidance on geotechnical reporting which may be required by the UA is summarised in Schedule 2B.*

## **2.3 Design**

### **2.3.1 Design Factors**

The design process shall include, but not be limited to:

- a. Preliminary site evaluation including assessment of historical data for the area.

- b. Identification of special features to be retained/protected
- c. Low impact design considerations
- d. Selection of the choice of landform
- e. Stability assessment including underlying structural geology
- f. Assessment of special soil types where applicable
- g. Setting of compaction standards for fill material
- h. Erosion, sediment, and dust control
- i. Seismic considerations
- j. Geothermal issues where applicable
- k. Drainage
- l. Construction methodology
- m. Risk
- n. Coastal Cliffs

### **2.3.2 Preliminary Site Evaluation**

During the preliminary site evaluation phase the developer's professional advisor shall engage a geo-professional at an early stage to undertake a preliminary site evaluation and prepare a geotechnical assessment report where there is doubt about the stability or suitability of the ground for the proposed development, or there are any UA or local practice requirements for geotechnical involvement in the project (refer Table 2.B.1 in Schedule 2B).

In cases where more than a visual appraisal is deemed to be required, particular attention will need to be given to the following matters as appropriate, which should normally be considered prior to preparing a proposal for development.

#### **a. Low Impact Design:**

The preliminary site evaluation needs to take into account low impact design factors. These include consideration of maintaining and improving natural waterway features and optimising waterway crossing locations. Protection of well-drained soils and natural soakage areas also needs to be taken into account.

#### **b. Drainage:**

Identify the existing natural drainage pattern of any area and identify evidences of any natural springs or seepage. Where any overland flow paths, natural surface, or subsurface drainage paths are interfered with or altered by earthworks, then appropriate measures should be taken to ensure that adequate alternative drainage facilities are provided to ensure there is no increase of flood hazard risk to the site or adjoining properties.

#### **c. Slope Stability:**

Some natural slopes exist in a state of only marginal stability and relatively minor disturbance such as trenching, excavation for streets or building platforms, removal of scrub and vegetation, or the erection of buildings, can lead to failure. Signs of instability include cracked or hummocky surfaces, crescent-shaped depressions, crooked fences, trees or power poles leaning uphill or downhill, uneven surfaces, swamps or wet ground in elevated positions, plants such as rushes growing down a slope, and water seeping from the ground. In addition, a simple desktop study of aerial photographs may show indications of historic failures as well as faulting, resulting in linear ground features.

Refer to Branz Study Report 004, Crawford and Millar 1998, or the New Zealand Geotechnical Society publications Field description of soil and rock and Geotechnical issues in land development. Existing or potential surface creep effects also need to be investigated and reported upon. For a sample checklist for geotechnical assessments, refer to Schedule 2D.

d. Foundation Stability:

A study of the general topography of the site and its surroundings may indicate areas which have previously been built up as a result of natural ground movement or by the deliberate placing of fill material. Unless such fill has been placed and compacted under proper control, instability or long-term differential settlement could occur causing damage to superimposed structures, roads, services, or other structures.

e. Stream Instability:

There is a potential for instability through changes to the current ground conditions, such as stream erosion.

f. Local Conditions:

A wide range of soil types exist throughout New Zealand, which may need special consideration. Expansive soils, volcanic soils, soft alluvial sediments, and compressible soils are examples of these. Liquefaction of soils should also be considered. The UA may have information on the soil types in its area, including potentially contaminated land and other known conditions.

g. Peer Review:

Where risk for the land prior to development is assessed as being medium to very high risk, a peer review of the geotechnical assessment for the proposed development may be required and this would need to be carried out by an independent geo-professional. In regards to risk assessment, see also Section 2.3.12 and Schedule 2C of this Code of Practice.

h. Other reporting formats

The geotechnical reporting format and requirements for capital works may differ from Table 2.B.1 of Schedule 2B. The reporting requirements for road works are stated in Section 13 of this document whilst for storm water projects, Schedule 2B Sub-section 2B9.

### **C2.3.2**

*The preliminary evaluation should be carried out in the context of the local surroundings of the site, and should not be influenced by details of land tenure, territorial, or other boundary considerations. Where the preliminary evaluation discloses the potential for slope instability, other geotechnical or geological hazards, or the need for major foundations or for earthworks, the geo-professional should be involved at an early stage in the planning of the development*

### **2.3.3 Landform Selection**

The final choice of landform and land remediation proposals shall represent the most desirable compromise between the development requirements and the preservation of natural features and the natural character and landscape amenity values of the site including the retention of natural of natural watercourses. Landform selection needs to take into account low impact design principles including retention of existing landforms and natural features where possible, and avoiding earthworks where there are existing habitats of

indigenous species, wetlands, or areas of high natural character. The design shall take into account the following factors in making the selection of the final choice of the landform:

- a. The choice of a suitable landform may be specific to a particular site. Considerations for carrying out earthworks include:
  - (i) The minimisation of the risk of damage to property occurring through ground movement in the form of slips, subsidence, creep, erosion, or settlement.
  - (ii) The minimisation of the risk of damage to property occurring through flooding, or surface water run-off and designing of works and land form appropriate to control secondary or overland flowpaths, or areas of inundation, so that lots or areas of development on any land are unlikely to be subject to an inundation hazard.
  - (iii) The development of a desirable roading pattern with good accessibility to and within the site and the creation of a better sense of orientation and identity for the area as a whole.
  - (iv) The efficiency of overall land utilisation including the quality of individual sites and amenity areas around buildings, the economics of providing engineering services, and the standard of roading and on-site vehicular access.
  - (v) The need to create suitably graded areas for playing fields and other community facilities and,
  - (vi) The enhancement of the general environmental character of the area

#### **2.3.4 Stability Criteria**

In making an assessment of the stability of slopes and earth fills, the geo-professional shall use acceptable criteria and analysis methods. Stability criteria applicable to land development in New Zealand are published or recommended by the New Zealand Geotechnical Society (see referenced documents at the beginning of this Code of Practice).

- a. Visual/site appraisal conducted by an experienced geo-professional is an invaluable exercise that provides insight to the stability of the site. Such appraisals are important and shall include;
  - (i) Existing site conditions (alignments of buildings, foundation types, trees, fences, retaining wall, etc).
  - (ii) Geomorphological features (Scarps, toe heave, hummocky surfaces, etc).
- b. Numerical models would be expected as part of the stability appraisal when the slope is suspect as assessed by the geo-professional and/or requested by Council. Key parameters used in constructing the models include soil strength, ground water and failure modes. Schedule 2E serves as a guide to typical shear strengths parameters (c and phi values) found in some Auckland soils. Traditionally, a factor of safety (FoS) of 1.5 is deemed acceptable against instability. Since the stability of the slope is a function of soil strength and ground water conditions, Schedule 2C provides further guidance concerning Factors of Safety and classification of risk.

#### **2.3.5 Special Soil Types**

If special soil types are known to exist in a locality or are identified, then a geo-professional shall be engaged to advise on appropriate measures for incorporation of these soils into a development. Special soil types include, but are not limited to:

- a. Soils with high shrinkage and expansion
- b. Compressible soils



- c. Volcanic soils
- d. Soils subject to liquefaction
- e. Soils prone to dispersion (such as loess)
- f. Highly sensitive (or quick) soils

Reference should be made to the geology maps provided by The Institute of Geological and Nuclear Sciences Ltd.

### **2.3.6 Compaction Standards for Fill Material**

The standard of compaction and method of determination shall be as set out in NZS 4431. Where NZS 4431 is not applicable, the methods and standards of compaction shall be specified by the geo-professional.

#### **C2.3.6**

*Commercial and industrial developments often have specialised requirements for fill materials and compaction. In these cases, the requirements of NZS 4431 may not be applicable. The geo-professional should set the fill standards and procedures for these developments.*

### **2.3.7 Erosion, Sediment, and Dust Control**

#### **2.3.7.1 Minimisation of effects**

Earthworks shall be designed and constructed in such a way as to minimise soil erosion and sediment discharge. Where necessary, permanent provision shall be made to control erosion and sediment discharge from the area of the earthworks.

Generation of dust during and after the earthworks operation shall be considered during the planning and design phase. If necessary, specific measures shall be incorporated to control dust.

#### **C2.3.7.1**

*Within the boundaries of Auckland Council design, implementation, staging and maintenance of erosion and sediment controls shall take account of:*

- *Auckland Council District Plan, Auckland Council Regional Plan*
- *Technical Publication 90 Erosion and Sediment Control Guidelines for Land Disturbing Activities in the Auckland Region, including changes advised in December 2007*
- *Related conditions of any issued Resource consent*
- *New Zealand Building Code, Clause E1 Surface Water*

#### **2.3.7.2 Protection Measures**

Where surface water could cause batter erosion or internal instability such as through infiltration into the soil, open interceptor drains shall be constructed in permanent materials, and benches in batter faces should be sloped back and graded longitudinally and transversely to prevent spillage of stormwater over the batter.

Water from stormwater systems shall be prevented from flowing into fill or into natural ground near the toe of slopes or sides of the fill.

No stormwater or wastewater soakage systems shall be constructed in fill or natural ground, which could impair the stability of the ground.

Protection measures shall include the following as appropriate:

a. Erosion control mechanisms:

- (i) Temporary drains to be constructed at the toe of steep slopes to intercept surface run-off and to lead away for treatment where required before discharge to a stable watercourse
- (ii) Surface water to be diverted away from or prevented from discharging over batter faces and other areas of bare earth by bunds. The bunds are to be formed to intercept surface run-off and treated where required prior to discharge through stable channels or pipes, preferably in to stable watercourses or piped stormwater systems
- (iii) The upper surface of fills to be shaped and compacted with rubber-tyred or smooth wheeled plant when rain is impending, or when the site is to be left unattended to minimise water infiltration
- (iv) The completed battered surfaces of fills to be topsoiled and vegetated, or otherwise resurfaced to reduce run-off velocities
- (v) Control of erosion and sediment discharge may require planting, environmental matting, hydroseeding, drainage channels, or similar measures at an early stage in the earthworks construction phase
- (vi) Dust control may require frequent watering during construction along with establishment of the permanent surface at an early stage in the construction phase

b. Sediment management devices:

- (i) The surfaces of fills and cuts to be graded to prevent ponding
- (ii) Sediment traps and retention ponds to be constructed where they are necessary. They should be cleaned out, as required, to ensure that adequate sediment storage is maintained, with appropriate plans for decommissioning
- (iii) Temporary barriers or silt fences using silt control geotextiles, to be used to reduce flow velocities and to trap sediment
- (iv) Sections of natural ground to be left unstripped to act as grass (or other vegetation) filters for run-off from adjacent sites

### **2.3.8 Seismic considerations**

The geo-professional shall consider the seismic effects on earthfills, slopes, and liquefiable ground and shall take these into account in design and construction of any development in accordance with the scale of the development. Reference should also be made to the New Zealand Geotechnical Society Inc. "Geotechnical Earthquake Engineering Practice" document issued July 2010 as a guide for assessing seismic impacts on slopes.

### **2.3.9 Geothermal Issues**

Refer to Schedule 2F for some of the well-known geothermal areas in Auckland Council's jurisdiction. This is a guideline only.

#### **2.3.10 Drainage**

Geotechnical investigation and reporting should consider existing and proposed primary drainage, secondary flow paths, overland flow paths, and subsurface drainage whether underfill, or within natural erosion tunnels e.g. "tornos", or related to land stability and control of water tables. Reporting should also cover drainage of retaining structures, and whether the structure is to be drained or undrained. (Potential for settlement effects on neighbouring buildings or services due to permanent or temporary ground dewatering needs to be considered.)

The geo-professional should assess proposed or existing trench lines and recommend any needed detailing related to bedding design, trench drainage or trench drainage barriers.

Reporting should cover specification of drainage metal and any associated geo-textiles or filter socks required by the geo-professional, with appropriate design.

Counterfort drains and drainage of shear keys should be designed so that a 100-year design life is likely to be delivered with no or little maintenance. Inspection and/or monitoring requirements are to be considered. Any subsoil drainage outlets not directly connected to public stormwater reticulation shall be designed with suitable concrete collars and aprons appropriate to a 100-year design life. Drilled drainage may be a needed added redundancy to a design, or suitable for temporary works. Drilled drainage is unlikely to be suitable for permanent works as the sole methodology for control of water tables.

Assessment may also have to consider the consequences of land development adjacent to drainage channels and watercourses where water levels, flows and scour risk may vary.

#### **2.3.11 Construction Methodology**

To ensure good geotechnical outcomes are achieved for a development, details of construction methods will often be required to be submitted with a consent or approval application to the Council. The construction methods can be incorporated into the geotechnical report or detailed in a separate report e.g. from a contractor, or building professional. If the latter this should be cross-referenced in the geotechnical report i.e. the Council needs to understand that the aspects of the construction methods pertaining to geotechnical matters align with the geotechnical report.

Geotechnical reports at the earlier stage of a development e.g. subdivision, where final locations of structures are uncertain, will still need to provide some details of construction methods and/or limitations of how the works reasonably anticipated for the site can be undertaken. A guide to what could be reasonably anticipated on the site can be sought from the town planning zoning for the site or locality.

Some of the main items that are linked between construction methods and geotechnical considerations:

- Maximum and minimum depths, slopes/gradients, lengths or areas of cuts and fills
- Temporary props and battering requirements
- Key stages, locations and timing of engineering inspections

- Limitations in timeframes for exposed or unsupported excavations/filling
- The installation of ground anchors (temporarily or permanently) will require land owner approval where they cross boundaries
- Weather protection
- Surface and subsurface water management – temporary and permanent including related ground settlement issues

Typical earthworks guidelines for embankments may need to also include the following considerations:

- All fill batters shall be not steeper than 2 horizontal to 1 vertical with a bench of a minimum width of 2.0 metres every 6 metres of vertical height, with a fall inwards of 1 in 10.
- Cut batters shall be stable except for minor fretting and shall generally be not steeper than 1.0 horizontal to 1.5 vertical with a minimum width of 1.5 metres benching every 8 metres of vertical height.
- Fill batter faces should be compacted as a separate operation, or alternatively, overfilled and cut back
- The minimum compaction standard soil required is a min of 95% of the max dry soil density.
- Compaction of soils shall generally meet the requirements of NZS 4431:1989
- During construction, soil compaction shall be monitored based on:

In-situ density tests to determine whether the degree of compaction is up to the specific minimum

Test to determine the maximum dry density for the soil tested in each in-situ field density test.

- DURATION OF EARTHWORKS - The work shall be programmed so that the duration of earthworks, between commencing and finishing, on any one stage/area shall not exceed six months
- The normal working hours for the carrying out of the earthworks on the site and the transport of excavated material from the site, are to be limited to:

Monday to Saturday 7:30am to 6pm

- Adequate washing facilities or properly designed vehicle rumble pads shall be provided at all times on the construction site so that all vehicles are free from mud and debris when they pass onto the public streets.
- Areas of fill including batters and areas of cut but not including cut batters shall be prepared with topsoil. Minimum depth for topsoil is 300mm. This will depend on soil and species to be planted.

### **2.3.12 Risk Assessment**

### **2.3.12.1 Introduction**

The objective of considering risk assessment/management in slope assessment is to provide a systematic and practical approach to making informed and documented decisions so that stakeholders understand the potential threats and opportunities that exist. AS/NZS ISO 31000:2009 is a general guide to setting the principles, design and implementation of risk management. The Risk Classification Table in Schedule 2C can also be referred to. Some of the components that would be considered in risk assessment for slopes include:

- (i) Uncertainties in the design parameters
- (ii) Frequency analysis
- (iii) Consequence analysis
- (iv) Council's expectations
- (v) Normal and extreme events
- (vi) Other factors the geo-professional considers appropriate

### **2.3.12.2 Uncertainties in the Design**

The main uncertainties in slope analysis are:

- (i) Lack of information
- (ii) Variability of material properties e.g. shear strength, density, permeability, etc
- (iii) Position of groundwater level/table and the influence from rainfall
- (iv) Sampling errors from field tests
- (v) Modelling and human errors.

Using a process such as a risk matrix, the assessment shall identify the uncertainties in the design/analysis and make a qualitative judgement on the impact of the uncertainties on the outcome of the analysis.

### **2.3.12.3 Frequency Analysis**

It may be useful to adopt a frequency analysis technique appropriate to the level of study and complexity of the geotechnical model so that risk could be identified in terms of probability events.

*C2.3.12.3 The frequency analysis may be important in relation to the Building Importance level or criticality to ensure availability of essential services (refer Auckland Regional Council Technical Publication No 112, November 1999. For example, if it was assessed that the frequency of a particular slope failure is a 1 in 100 yr event, which affects a private way /shared driveway, the overall risk to the project may be considered minor.*

### **2.3.12.4 Consequence Analysis**

The assessment is to identify elements at risk such as property, people and services. Typical evaluation on the impacts on property include, extent of damage, indicative cost, impact on market value and other resulting consequences. An important aspect of this analysis is the assessment of the travel distance.

## **Travel Distance**

As part of the slope risk assessment, the geo-professional shall include an estimate of the travel distance of the slide soil/rock mass at failure. The objective is to determine the potential adverse effects on property and lives downslope of the instability. Typically, travel distance depends on the slope characteristics, modes of movement and the nature of the downhill path. (Guidance documents may include Fannin RJ and Wise MP (2001) and Saunders W and Glassey P (2007)).

### **2.3.12.5 Council's Expectation**

The geo-professional is expected to demonstrate that a risk assessment based on the above items has been undertaken and provided in an appropriate risk table as shown in Schedule 2C.

### **2.3.12.6 The 'definition' of normal and extreme events**

#### ***Normal***

The geo-professional shall consider a normal event as follows;

- (i) Static condition, where the groundwater is at steady state corresponding to a long term event as commonly defined in the geotechnical community ( see Lambe and Whitman, *Soil Mechanics* , Wiley: 1969, for reference) for permanent structures such as a residential house,
- (ii) Static conditions, where the groundwater and/or perched water tables are at steady state in a short-term event for temporary structure or works such as temporary excavation during the construction stage,
- (iii) Dynamic condition, where the groundwater may vary considerably with time such as a dam structure during rapid drawdown or similar event.
- (iv) Conditions that the geo-professional community considers as common events.

#### ***Extreme***

The geo-professional shall consider an extreme event as follows;

- (i) Static and dynamic conditions, where the groundwater/phreatic surface or confined groundwater has risen above normal levels as defined above. Such conditions could include fully saturated soils.
- (ii) Seismic events/effects

### **2.3.12.7 Other Additional Factors**

The geo-professional shall take account of any other additional and appropriate factors in undertaking the risk assessment. These may include consideration of the intended land use, any known or likely requirements of structural engineers for soil support of foundations or other structural elements, and the importance level of the likely or intended building development on the land. Classification of buildings in terms of 'importance level' is referred to in NZS 3604:2011 Section 1.2(b) and table 1.1 and AS/NZS 1170.0:2002 Section 3.4.2 and tables 3.1 and 3.2.

### 2.3.13 Coastal Cliffs

Assessment of coastal cliffs in the Waitemata and Manukau Harbour should consider regression of the cliff face and weathered mantel material likely to occur from natural coastal erosion processes over a 100-year period. Assessment of this regression should take account of site-specific investigation of the ground model, including its structural geology, and historical records or erosion processes. Cliff stability also needs to be considered and where machine bores and other investigation techniques lead to a complex ground model, additional assessment techniques such as “stereonet” analysis may be applicable.

Storm water disposal over or near coastal cliff/slopes for new developments shall have the following requirements;

- Private SW drainage within coastal section/lot to be determined and assessed
- Existing S/W disposal over coastal cliff – need to be controlled to ensure discharge flow is small and the outlet point is resistant to erosion ( existing use rights to be revisited if new works proposed)
- Mitigation and improvements to be investigated on existing dwellings currently discharging sw over the cliff. To consider “drained and undrained” surfaces within each lot including new kerb discharge points.
- Soakage pits if deemed viable on coastal cliff sites will require its location and construction is to be assessed and verified by a suitably qualified Chartered Professional Engineer via a comprehensive geotechnical reports at resource/building consent stage.

New developments located near coastal cliffs shall generally require;

- Comprehensive stability assessment of existing cliffs/slopes to be carried out by a Chartered Professional Geotechnical Engineer with the view of providing risk assessment of the development proposal including where applicable, specifying the restriction and limits to proposed building works on site. ( to be included in consent notices and GIS )
- Management and Maintenance Plan for Existing Slope/Cliff  
It is essential that the responsibility for future maintenance of “significant slopes” is clearly established and formal arrangements should be drawn up for regular inspection and maintenance.  
To accomplish proper slope maintenance, slope owners should set up their own Slope Maintenance Plan to maintain the slopes for which they are responsible. Guidelines for preparing the Plan may includes the following:

(I) List of Inspections and Maintenance Works Records;

- Routine Maintenance Inspection and repair works
- Regular Check of Buried Water-Carrying Services
- Geotechnical Engineer’s Inspection

(II) Routine Maintenance Inspection and slope repair works may include;

- clear accumulated debris from drainage channels and slope surface;
- repair cracked or damaged drainage channels, pipes or pavement;
- repair or replace cracked or damaged slope surfacing;
- unblock weepholes, subsoil pipes and outlet drain pipes;
- repair missing or deteriorated pointing in masonry walls;  
remove any vegetation causing severe cracking of slope surface cover and drainage channels;
- re-grass or re-vegetate bare slope surface areas;
- remove loose rock debris and undesirable vegetation from rock slopes;
- check and repair any damaged retaining walls affecting stability of slope;
- remove any dead loads placed near crest of slopes;

### (III) Regular Check of Buried Water-Carrying Services

Buried water-carrying services, if they leak, could also trigger landslips, and these should therefore also be maintained. Signs of possible leakage should be investigated by relevant parties and leakages repaired accordingly.  
(Private drainage and public infrastructure)

### (IV) Geotechnical Engineer's Inspection

Although proper routine maintenance of a slope or retaining wall can greatly reduce the probability of a landslide, the slope may still not be sufficiently safe for various reasons, such as inherent design or construction deficiencies, or changes that have taken place in the vicinity. Therefore, an Engineer Inspection for maintenance should be carried out on the slope by a qualified Geotechnical Engineer to look for all slope safety problems. The Geotechnical Engineer will advise on the maintenance of the slope and any required improvement works. He will also advise on the need for a Stability Assessment to check the slope's overall safety.

Note\* The lack of maintenance of slopes and retaining walls is the major contributory factor to many landslips. Many landslips are triggered by water ingress into slopes and by soil erosion during heavy rain. Man-made slopes normally have drainage provisions and protective surfacing to prevent water ingress and soil erosion. These measures need regular maintenance to ensure their proper performance.

#### **2.3.14 Underground Infrastructure**

Controls on the installation of underground Infrastructure( sw, waste, potable,etc) on ground with marginal stability shall consider the following:

- Location of Stormwater soakage device - Care must be taken to ensure the stability of the adjacent ground is not compromised by the soakage device.
- Slopes that have marginal stability could be significantly affected by the location of any underground infrastructure services, trenching or any building surcharge loads acting near the crest of the slope.
- Damaged underground infrastructure services carrying any fluids could have significant impact on slope stability. Regular damage assessment or integrity checks on all



underground service pipes that are located near significant slopes should be carried out periodically.

- Periodical CCTV inspections required for all underground infrastructure located on significant slopes build from weak soil or fill.

## **2.4 Approval of proposed works**

The approval process for land development and subdivision design and construction shall be in accordance with Section 1 of this Code of Practice. Land stability assessments and the design and control of earthworks require approval from the UA.

Auckland Council has an Engineering Approval process available for works associated with land development and subdivision. This permission process is used for public assets created by developers for vesting with Council. It can also be used for gaining consent for works e.g. earthworks, not covered by the Building Act/Code and also for compliance with conditions of resource consents.

Geotechnical reporting may have to be provided in support of Engineering Approval applications for utilities and roading covering issues such as trenching, bedding and road/accessways construction.

Some parts of Auckland Council District Plans will have provisions already stipulated requiring engineering designs be submitted and approved within the resource consent application process.

## **2.5 Construction**

Earthworks shall be carried out to the standards detailed in the approved specifications and drawings, and any requirements in the Auckland Council District Plan or Auckland Council Regional Plan or consent issued by the UA.

The construction control testing shall be carried out by a testing laboratory or competent person under the control of the geo-professional, and to the recognised testing standards as deemed appropriate.

The testing laboratory shall have recognised registration or quality assurance qualifications.

Refer also to 2.3.11 Construction methodology above

## **2.6 Final documentation**

### **2.6.1 Geotechnical completion report**

- (i) For all developments where a geo-professional is engaged, the geo-professional shall submit a geotechnical completion report to the developer and the UA accompanied by a statement of professional opinion as set out in Schedule 2A. The geotechnical report shall identify any specific design requirements, which would necessitate the building design deviating from NZS 3604.
- (ii) The expected level of site movement from reactive soil (expansive soils) under AS 2870:1996 shall be identified by their respective class and included in the geotechnical completion report. The soil properties used in determining the class are to be recorded in the report. The site subsoil class to the provisions of NZS 1170.5 section 3 and NZS 1170.5 Supp 1 C3.1.3 shall be identified in the geotechnical completion report.

- (iii) The report shall describe the extent of inspection, revisit and review all inferences and assumptions made during the investigation, assess the results of testing and state the geo-professional's professional opinion on the compliance of the development with the standards set by the geo-professional. The report shall also include all geotechnical reports prepared for the development.
- (iv) Documentation on the testing of the soils for compaction shall be included in the geotechnical completion report. This documentation should clearly show the spatial location where where compaction met the required standards, as well as any areas requiring retesting, and areas which did not meet the standards.
- (v) For developments where there are no earthworks, the geotechnical completion report will comprise the geotechnical assessment report. For large or more complex developments where there may have been several stages of geotechnical reporting, all prior reports covering the subject area of land under certification shall be included in the geotechnical completion report.

The geotechnical completion report shall identify areas that provide good ground as defined in NZS 3604. Those areas that require specific design for stability and foundation design shall also be noted.
- (vi) Refer also to Schedule 2B

#### **2.6.2 As-Built drawings for earthworks and subsoil drains**

- (i) Where earthworks have occurred, an as-built plan shall be prepared showing finished contours. The plans shall also show original contours where earthworks have occurred to illustrate the extent and depth of cuts and fills, including the depths of any undercuts. Alternative methods of representing earthwork depths may be acceptable including plans showing lines joining all points of equal depth of cut and fill at appropriate vertical intervals.
- (ii) The as-built plans shall also record the position, type and size of all subsoil drains and their outlets, and show any areas of fill or natural ground, which the geo-professional considers, do not comply with the standard or areas where the standards have been varied from the original construction specification.
- (iii) As built plans shall be made available to the UA and the developer in conjunction with the geotechnical completion report.
- (v) Refer also to Schedule 2B.

## Schedule 2A: Statement of Professional Opinion on Suitability of Land for Building Construction

NZS 4404:2010

**SCHEDULE 2A**

## STATEMENT OF PROFESSIONAL OPINION ON SUITABILITY OF LAND FOR BUILDING CONSTRUCTION

Development .....

Developer .....

Location .....

I ..... of .....  
(Full name) (Name and address of firm)

Hereby confirm that:

1. I am a geo-professional as defined in clause 1.2.2 of NZS 4404:2010 and was retained by the developer as the geo-professional on the above development.
2. The extent of my preliminary investigations are described in my Report(s) number ....., dated ....., and the conclusions and recommendations of that/those document(s) have been re-evaluated in the preparation of this report. The extent of my inspections during construction, and the results of all tests and/or re-evaluations carried out are as described in my geotechnical completion report dated .....
3. In my professional opinion, not to be construed as a guarantee, I consider that (delete as appropriate):
  - (a) The earth fills shown on the attached Plan No..... have been placed in compliance with the requirements of the ..... Council and my specification.
  - (b) The completed works take into account land slope and foundation stability considerations, subject to the appended foundation recommendations and earthworks restrictions, (which should be read in conjunction with the appended final site contour plan).
  - (c) Subject to 3(a) and 3(b) of this Schedule, the original ground not affected by filling is suitable for the erection of buildings designed according to NZS 3604 provided that:
    - (i) .....
    - (ii) .....
  - (d) Subject to 3(a) and 3(b) of this Schedule, the filled ground is suitable for the erection of buildings designed according to NZS 3604 provided that:
    - (i) .....
    - (ii) .....
  - (e) The original ground not affected by filling and the filled ground are not subject to erosion, subsidence, or slippage in accordance with the provisions of section 106 of the Resource Management Act 1991 provided that:
    - (i) .....
    - (ii) .....

NOTE – These subclauses may be deleted or added to as appropriate, to include such considerations as expansive soils where excluded from NZS 3604, and site seismic characteristics as covered in clause 3.1.3 of NZS 1170.5.

4. This professional opinion is furnished to the TA and the developer for their purposes alone on the express condition that it will not be relied upon by any other person and does not remove the necessity for the normal inspection of foundation conditions at the time of erection of any building.
5. This certificate shall be read in conjunction with my geotechnical report referred to in clause 2 above and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

Signed .....

Date .....

.....

.....

.....

*(Name, title, and professional qualifications)*

Copyright waived

## Schedule 2B: Investigating and Reporting

Site investigations and reporting shall be carried out in accordance with Section 2 of this Code of Practice and:

- a. NZS 4402:1986 Methods of testing soils for civil engineering purposes
- b. NZS 4431:1989 Code of practice for earth fill for residential development
- c. NZS 4404:2010 Land development and Subdivision Infrastructure
- d. Field Description of Soil & Rock, NZ Geotechnical Society, December 2005
- e. Geotechnical earthquake engineering practice Module 1 – Guideline for the identification, assessment and mitigation of liquefaction hazards, New Zealand Geotechnical Society Inc, July 2010.
- f. Auckland Council supports best practice as set out in the NZGS document “Electronic Transfer of Geotechnical and Geoenvironmental Data, Issue 01 dated July 2007”. Consideration will be given to making factual soils data in such a format becoming a mandatory element of reporting when next revisions of this document are considered.

Together, these documents provide a rational approach to undertaking site investigations and preparing associated reports for projects involving bulk earthworks or to establish development limitations or remediation recommendations.

The Council may elect to require a peer review of part or the whole of any report.

**Table 2.B.1 Methodology for Investigations and Reporting For Earthworks Projects**

Phase	Investigations	Reporting	Regulatory
1	Preliminary investigation* **	Geotechnical Appraisal Report	Concept Plans and initial discussion
2	Comprehensive investigation	Geotechnical investigation report	Resource Consent application Scheme Plan Approval ***
3	Supplementary investigation*	Geotechnical Design Report	Engineering design submission supporting either a bulk earthworks approval or a building consent application
4	Construction observation of works in progress	Geotechnical Monitoring Report	Field reporting and feedback to design engineers or project engineers. To support Design amendments and re-approvals.
5	Construction observation and evaluation of completed earthworks and any development limitations	Geotechnical completion report, statement of professional opinion and as built	Subdivision release (Section 224c Certificate)
6	Performance evaluation	Geotechnical Supplementary Report	Ongoing reports on long term restrictions or requirements

**Notes:**

\* This investigation and associated reports may be integrated with the comprehensive investigation depending on the size and impact of the proposed development.

\*\* The Geotechnical Appraisal Report may be sufficient to support a resource consent application for minor developments where the construction difficulties and hazards are such that development limitations are likely to be minor. The geotechnical investigation and detailed engineering reporting would then be deferred until building consent application. Confirmation should be sought from the Council before following this alternate reporting process.

\*\*\* The geotechnical investigation report should include setting of future development limitations, particularly where no land remediation or substantive earthworks nor any subsequent geotechnical completion reporting is envisaged. Land development that depends on changes to the landform or land remediation works would require a Geotechnical Completion Report.

## **2.B.1 Geotechnical Appraisal Report**

- a. The purposes of the preliminary investigation are:
  1. To establish the framework of a model of geological conditions to assess the general suitability of a site for its intended purpose
  2. To gain an appreciation of design requirements
  3. To ascertain possible construction difficulties
  4. To enable the preparation of a Geotechnical Appraisal Report and plans for initial discussions.
  5. To identify obvious hazards
  6. To determine the requirements or need for a comprehensive geotechnical investigation
  7. Applicability of the land for building in accordance with NZS3604
- b. The preliminary investigation should cover the following factors:
  1. Ownership of the land
  2. Regional geology
  3. Topography and predominant features, identifying previous slope failures and areas of surface creep, geomorphology.
  4. Drainage and groundwater regimes including seepage, swamps or other areas of either poor drainage or high groundwater conditions
  5. Local subsoil conditions, including structural geology.
  6. Consideration of likely stability conditions and development limitations
- c. The preliminary investigations should be based on:
  1. A visual inspection of the site
  2. A desk top study including review of information from published geology maps
  3. Existing geotechnical reports
  4. Aerial photographs
  5. Local knowledge including data from adjacent sites (where applicable). Reference should be made to the publicly available Council's records for any pertinent information already held on the subject site or adjacent sites

## 2.B.2 Geotechnical Investigation Report

- a. The purposes of the comprehensive geotechnical investigations which form the basis of the Geotechnical Investigation Report are:
  - (i) To investigate, examine and report on the geological history, geomorphology and groundwater regime, regional and local geological structure, soil profile and strengths, rockmass strength and conditions including defect conditions of the area to develop a geological model on which engineering assessments of proposed or likely developments can be made. The report will identify and assess soil creep, expansive soils and natural hazards as listed in s71(3) of the Building Act 2004 including erosion, subsidence and slippage or slope stability and recommend land remediation measures, including drainage and vegetation, and any maintenance implications of those recommended measures.
  - (ii) To enable the preparation of a detailed earthworks design or foundation design and to identify any need for further geotechnical reporting. However the normal expectation is that geotechnical investigation reports will be sufficient in detail to allow approval of bulk earthworks designs. Foundation design requirements should identify likely design scenarios so that it is demonstrated that development generally appropriate to the area and value of the land is readily achievable.
  - (iii) To enable the development of a construction methodology recognising risks associated with temporary works such as unsupported and/or unprotected cut faces.
  - (iv) To nominate suitable building platforms and where applicable, suitable areas of land application areas for on-site wastewater systems and /or stormwater dispersal. To recommend any changes to a subdivisional layout to achieve better use of the site, and or minimise construction difficulties.
  - (v) To provide parameters for design and recommendations for construction of building foundations, road pavements etc, and specific design zones, and to identify natural hazards that may occur from proposed temporary or permanent works such as excavation support, dewatering, settlement, loss of toe support, loading of slopes, inundation, armouring of new or relocated overland flow paths, spillways, rapid drawdown of stormwater treatment ponds, ingress of water into slopes from saturated trenchlines.
  - (vi) To set key performance or testing or acceptance criteria suitable for incorporating into a specification for undertaking the proposed earthworks or land remediation works
- b. The geotechnical investigation report (sometimes referred to as a Foundation Investigation Report) should cover the following factors:
  - (i) Any prior geotechnical report and the guidance for site appraisal in Section 2.B1 above for a Geotechnical Appraisal Report but in more detail. The report shall also take account of the Design Factors set out under 2.3 of NZS 4404:2010 as modified for inclusion in the standards of Auckland Council. Other useful guidance documents available include the "Checklist for Stability Assessments" dated 31 May 1998 mentioned in 2.3.2(c) (see Schedule 2D) – an appendix of the paper by Crawford, S A and Millar, PJ dated May 1998 entitled "The design of permanent slopes for residential building development" and also included in the current IPENZ Slope Engineering CPD course.
  - (ii) Slope stability, soil creep and expansivity assessment
  - (iii) Specific design zones, special foundation requirements and assessment of whether any part of any lot is likely to be subject to the natural hazards listed under s71(3) of the Building Act 2004
  - (iv) Existing or proposed buried services

- (v) Existing or proposed roading and accessways
- (vi) On site wastewater treatment proposals – siting of Land Application Areas
- (vii) Identification of any Non-engineered fills or contaminated land,
- (viii) If no earthworks are proposed, a statement of professional opinion as to the suitability of the land for its intended purpose – refer NZS 4404:2010 Schedule 2A
- (ix) The report shall include an index so that the complete content is understood. Schedule 2B8.1 gives guidance in respect to supporting drawings.

c. Subsoil Investigation.

The outputs of subsoil investigation required to provide a model of ground conditions shall be included in the report. Investigation and reporting should take account that:

- (i) Subsoil investigation may include hand auger boreholes, machine boreholes or test pits as appropriate. Where slope stability issues exist, boreholes will need to extend to competent strata to prove the stability model. In some instances, this requires extending boreholes beyond 5.0m depth. Machine boreholes, even on small sites where deep overburden profiles are present, may be needed.

Where hand auger borehole investigations are undertaken it is expected that hand shear vane tests should be taken at 0.5m intervals or more regularly as determined by variable soil conditions with readings taken for undisturbed and remoulded strengths; dial readings shall be corrected in accordance with the recommendations of the NZ Geotechnical Society. Where the corrected readings of undisturbed strength show shear strengths of less than 100kPa over the last 1.0m of the bore, then scala penetrometer testing should be carried out for a further depth of 2.0m measured from the bottom of the bore, or until three successive blow counts are 10 or more for a penetration of 50mm, whichever occurs first.

- (ii) Depth of ground water (if encountered) shall be recorded. A further record shall be made after sufficient time for the effects of drilling to have dissipated.
- (iii) Borelogs must be dated and a plan of borelog locations provided. Refer also 2.B.8.3.

d. Slope stability analysis.

The geotechnical investigation report shall include assessments of all existing slopes and proposed slopes with and without any proposed remediation works. Analysis must be carried out where the slope is steeper than 1V:4H, in areas where ground movement has occurred or where a factor of safety of less than 1.5 under common winter groundwater levels may be possible. A recognised and acceptable computer program shall be used for the analysis. Soil parameters must be derived from a site investigation and can be confirmed by either laboratory testing, and/or back analysis of slopes. In the case of proposed engineered fill, predicted soil parameters must be consistent with recommendations for placement of the fill. Soil strength parameters are accordingly assessed by the geo-professional. In the event that the adopted values are less conservative than the guidelines set out in Schedule 2E, the text of the report should include more robust discussion on the reason for the adopted soil strength parameters.

Slope stability reporting should include comment on travel distance of potential landslide movements.

## 2.B.3 Geotechnical Design Report



A supplementary investigation and design report may be required to support an application for bulk earthworks approval or building consent approval, where the geotechnical investigation report recommended the need for further investigation to support drawings submitted for engineering approval, or to take account of design changes to the final proposed landform or the proposed development on the land. It shall be based on the final earthworks design and reassess or confirm design details including any proposed subsoil drainage or shear keys and temporary or permanent works and include as appropriate reassessment and confirmation of design parameters and methodologies.

#### **2.B.4 Geotechnical Monitoring Report**

The requirement for a Geotechnical Monitoring Report (GMR) during the construction period would normally already be identified in a prior report. A GMR would address agreed monitoring requirements set out in prior reports and sometimes as specifically required in a consent condition. It would also identify any new or changed monitoring needs identified.

Reporting intervals would be as agreed with the Principal or design engineer or project engineer or Council and could be subject to review depending on the monitoring trends and prognosis of future.

Each report would confirm prior development recommendations as unchanged or identify any needed changes in work methodologies or development limitations etc for the design or project team to take account of.

#### **2.B.5 Geotechnical Completion Report**

This report is sometimes referred to as a Foundation Completion Report or Earthworks Completion Report).

The report shall take account of 2.6 of NZS 4404:2010 as modified for inclusion in the standards of Auckland Council, and the following guidance statements.

- a. The purpose of the Geotechnical Completion Report, is
  - (i). To provide a record of project monitoring and observations, verifying the quality of construction, confirming the validity of the geological model and recording any design changes that became essential where revision to the model or new field design information so required.
  - (ii) To describe all the activities associated with the extent of earthworks.
  - (iii) To provide a statement of professional opinion confirming the suitability of the land for building construction in the general form of Schedule 2A of this Code of Practice, but inclusive of opinion of the suitability of all lots including road or access lots within a subdivision for their intended purpose.
- b. The Geotechnical Completion Report should cover the following factors:
  - (i) Introduction and description of subdivision or projects
  - (ii) Summation of prior reports and bringing forward of any relevant recommendations and confirmation of the geological model
  - (iii) Outline of work undertaken, earthwork volumes, depth of fill, dates of work, methodologies and plant used
  - (iv) Quality controls in place and reporting on field controls
  - (v) Project Evaluation including comment on settlement and slope stability, expansive soils, soil creep, details of slope stability re-assessment and analysis where

appropriate, details of any subsoil or counterfort drainage, shear keys, retaining walls, palisade walls, nominated building platforms or specific design zones or any no-development zone, comment on road subgrades, reserves and accessways, comment on any stormwater ponds created, comment on trench lines, land drainage and top soil

- (vi) Assessment of whether any part of any lot is for a period of one hundred years from the date of the report, likely to be subject to the natural hazards listed in s71(3) of the Building Act 2004
- (vii) Plans showing location of all additional test sites, finished contours, cut/fill contour plan, specific design zones, underfill or counterfort drainage details, retaining wall or palisade walls, depths of topsoil and plans of buried services. Refer also 2.B.8.
- (viii) Appendices shall include test results, additional stability or other analysis. Where maintenance or monitoring of any constructed works is essential, an Operation and Maintenance appendix shall be added. For subdivisions, a spreadsheet of limitations that apply to each lot shall be provided. Test results may include auger logs, field density tests, penetration test results, laboratory lime stabilisation tests, CBR tests. (It is recognised that it is not the function of the geotechnical completion report to address pavement design). Inspection field notes.
- (ix) Append previous geotechnical reports relating to the area where appropriate.

### **2.B.6 Geotechnical Supplementary Report**

A supplementary report or reports may be required prior to, or during the course of a development. These reports may be required by the Council e.g. via conditions and consent notices and/or specified by the geo-professional.

Some of the common situations requiring supplementary reports are:

- (i) Where detailed design occurs at a later stage e.g. post subdivision or staged subdivision
- (ii) Where development works covered by a report are amended or changed
- (iii) Where a period of time has passed and engineering concepts or ground conditions may have changed
- (iv) Where ongoing monitoring and testing is required e.g. via conditions of resource consent
- (v) Where verification is required that specified works have been undertaken
- (vi) Where a geotechnical report provided for a building consent needs to be amended and/or broadened to cover another type of consent required by Council e.g. resource consent or engineering approval or other change in context.
- (vii) Where the geo-professional involved in a project becomes aware of changes in development works or conditions and wishes to advise or update the TA.

### **2.B.7 Producer Statements**

A Producer Statement Construction Review (PS4) may be a suitable means of establishing building consent compliance in regard to building foundation design or works on a lot to create a building platform. A Producer Statement would not meet geotechnical reporting standards set out in this Appendix. It is unlikely that a Resource consent would set a condition for a PS4.

### **2.B.8 Drawings supporting geotechnical reports**

1. Drawings should normally include details of
  - (i) proposed cut and fill depths at 0.5m intervals,
  - (ii) existing and proposed topography at 0.5m contour intervals,
  - (iii) proposed land remediation features such as counterfort drainage, shear key features and all subsoil drainage systems,
  - (iv) palisade or retaining walls required to develop the proposed land form

A geotechnical appraisal report may include less information.

#### **2. Geotechnical Completion reports (GCR)**

In addition to As Built status of any Proposed status information in “.1” above and 2.6.2, the GCR drawings should include, as appropriate:

- (i) For subdivisional works, a plan recording depths of top soil on each lot to the nearest 50mm.
  - (ii) Plans showing final cut and fill depths shall also show any undercut of natural soils.
  - (iii) Isopak plans shall be provided where fill is placed over a pre-existing depth of engineered fill.
  - (iv) Location of any subsoil bores or other tests undertaken subsequent to the Geotechnical Investigation Report, with surface RL of the bore where different from the final topography.
  - (v) A plan showing any portion of the land with particular development limitations or zoned for specific design or no-development. In some cases, nominated building platforms should also be shown.
  - (vi) Subsoil drainage including spot pipe invert levels
  - (vii) Consider inclusion of As Built details of stormwater and wastewater services, secondary or overland flow paths, drained trenchlines.
3. Drawings of any sections developed for stability analysis should also show relevant bore log information to scale, including water table levels and information that supports the geological model. Such sections shall also show existing / proposed property boundaries.

### **2.B.9 Geotechnical Report ( Interpretative and Factual) for Storm water Capital works**

All geotechnical investigation and completion reports shall be prepared by a

Professional Engineer who is experienced in the practice of geotechnical engineering

and registered under the Chartered Professional Engineers of New Zealand Act 2002 and who has professional indemnity insurance.

- A Geotechnical Report must document:

A description of the site and proposed development;

A description of the existing conditions of the development site, including assessment of land stability and geotechnical constraints to development; The suitability of the site for the proposed development, having regard to the existing geological and topographic conditions. This includes an assessment of likely effects or impacts of the development upon slope stability and landslide potential;

Measures recommended to mitigate impacts, including siting, engineering and other measures required to ensure a satisfactory form of development. Such measures must not require high whole-of-life cycle costs, particularly deep soil drainage within single residential lots or public land; and

Conclusions and recommendations.

The extent and detail of investigation will depend upon the particular site characteristics and the nature of the development being proposed. Council will require each report to demonstrate a scope and depth of investigation appropriate to the specific proposal. The extent of the work carried out is to be determined by the Geotechnical Engineer, provided the investigation concludes that the site, house, retaining wall or other features under assessment have a stability risk acceptable to Council.

**Table 2.B.2 Format of Geotechnical Reports (Guidelines)**

<b>Interpretative Report</b>	<b>Contents</b>
1. Introduction	<p>1.1 Details of Development</p> <p>1.2 Site Location and Description (including survey co-ordinates/co-ordinate system)</p> <p>1.3 Method and Scope of Investigations</p> <p>1.4 Qualifications of Responsible Individuals(s) and/or Company</p>
2. Description of Existing Conditions	<p>2.1 Geology (Local and Regional)</p> <p>2.2 Topography</p> <p>2.3 Groundwater</p> <p>2.4 Surface Drainage</p> <p>2.5 Vegetation</p> <p>2.6 Buildings, Other Structures, etc</p>

<p>3. Assessment of Land Stability</p>	<p>3.1 Existing conditions on site</p> <p>3.2 Geotechnical Constraints, limitations, Restrictions applicable to land stability</p> <p>Definitions:</p> <p>A Building Line Limitation, represents the closest proximity to a slope or other significant feature for any building footprint</p> <p>A zone, defined as the Specific Design Zone, extending from the Building Line Limitation to the Building Restriction Line, within which building development requires specific design by a Chartered Professional engineer either experienced in soil mechanics, or with the assistance of an engineer experienced in soil mechanics, and in particular, slope stability</p> <p>A zone (the Non Specific Design Zone) delineated by the Building Line Limitation, extending beyond the Specific Design Zone in which building development can be carried out in accordance with the appropriate Code of Practice without risk from slope instability or any geotechnical hazards</p> <p>A Building Restriction Line represents a line beyond which no development is allowed.</p> <p>3.3 Qualitative and quantitative assessments of proposed slope grades, earthwork design and applicable Safety Factors.</p> <p>3.4 Impacts of ground water level and surface drainage on land stability</p>
<p>4. Description of Proposed Development</p>	<p>4.1 Site Layout and scale of proposed work</p> <p>4.2 Proposed Development Components</p> <p>4.3 Potential Geotechnical Effects</p>
<p>5. Assessment of Development Impacts</p>	<p>5.1 Site Layout and existing contours</p> <p>5.2 Roadworks, Driveways and Other Pavements</p> <p>5.3 Earthworks – proposed earthwork levels</p> <p>5.4 Suitability of foundations and design criteria applicable</p> <p>5.5 Surface Drainage during construction and on completion</p> <p>5.6 Overall Effect of Development on Stability</p>

<p>6. Recommendations</p>	<p>The Geotechnical Report must include recommendations that outline the following:</p> <ul style="list-style-type: none"> <li>• Whether the site has any history of landslips or instability</li> <li>• Whether the proposed development (including all applicable lots and buildings) will alter the present state of stability of the site</li> <li>• Whether any portion of the site should be excluded from the development and included in natural, undisturbed or rehabilitated areas</li> <li>• Whether the proposed development (including all lots and buildings where applicable) will adversely affect the current state of stability of adjoining land</li> <li>• Whether the proposed development (including all lots and buildings where applicable) should allow cuts and fills and if so, to what depth</li> <li>• Whether retaining structures are required and if so, provide necessary foundation design parameters, including drainage requirements</li> <li>• Whether any special design features are required to improve or maintain the stability of the site, or portions of the site (including each lot where applicable)</li> <li>• Whether any special surface and/or subsurface drainage measures need to be taken to improve or maintain the stability of the site, or portions of the site (including each lot where applicable)</li> <li>• Whether any follow-up inspections are required by the Geotechnical Engineer during construction.</li> </ul> <p>The recommendations must also provide guidance on appropriate measures required to make the site suitable for the proposed development, including:</p> <ul style="list-style-type: none"> <li>• Preferred locations for buildings, other structures, driveways, etc;</li> <li>• Footing requirements such as allowable bearing pressures, pile design parameters, special techniques for expansive clays, etc;</li> <li>• Pavement types and design;</li> <li>• Construction methods to avoid problem areas associated with loose materials and groundwater seepage;</li> <li>• Preferred excavation/retention/stabilisation techniques and</li> </ul>
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	<p>suitability of excavated materials for use in on-site earthworks;</p> <ul style="list-style-type: none"> <li>• Surface and subsurface drainage requirements. Deep soil drainage within single residential lots or public land is not acceptable to Council;</li> <li>• Vegetation protection and re vegetation requirements</li> <li>• Any appropriate measures, methods or techniques to mitigate land instability</li> </ul>
Conclusions	<p>The Geotechnical Report must include conclusions about the overall suitability of the land for the proposed development. These are to include clear statements on whether:</p> <ul style="list-style-type: none"> <li>• all existing/proposed lots are presently stable; <ul style="list-style-type: none"> <li>• all lots, and associated completed buildings (e.g. detached house) and infrastructure, will have an acceptable stability risk if constructed in accordance with the geotechnical recommendations - in accordance with Australian Geomechanics Society AGS 2007 Guidelines ; and</li> </ul> </li> <li>• any conditions need to be placed on the development of lot/s to maintain an acceptable risk of long term stability.</li> </ul>
<b>Factual Report</b>	<b>Content</b>
Can be included as an Appendix to the Interpretative Report – Field and Laboratory Test Results, bore logs	<p>Field investigations and tests describing methods such as use of excavators, drill rigs and/or seismic techniques will be required, particularly to assess the following factors:</p> <ul style="list-style-type: none"> <li>• Subsurface profile within proposed works areas (including roads, infrastructure, building sites, potential swimming pools, tennis courts, garage, access driveways and the like);</li> <li>• Classification of surface and subsurface materials:</li> <li>• Erosion potential;</li> <li>• Foundation conditions that could affect structural performance;</li> <li>• Other site characteristics relevant to slope stability;</li> <li>• Evidence of previous instability (e.g. irregular contours, hummocky topography, scarp faces in area of tension crack(s), curved and/or non-vertical tree trunks, broken kerbs and gutters, cracked or uneven roadway surfaces, distressed</li> </ul>

	<p>houses or other buildings). The classification of any existing slips (type, severity and likely mode of failure) should be determined;</p> <ul style="list-style-type: none"> <li>• Extent and type of any existing occurrences of erosion;</li> <li>• Surface drainage patterns and characteristics (rapid surface runoff, presence of pools/ponds); Sub-surface drainage characteristics (e.g. presence of water table, springs, swampy areas, wet grass types, groundwater (such as presence of, depth to and any special conditions (artesian)), and possible presence of confined aquifer beneath site) and the likelihood of this occurring as a result of high rainfall events;</li> <li>• Existing vegetation cover; and</li> <li>• Any existing site improvements (e.g. buildings, other structures, earthworks).</li> </ul> <p>The results of all field and laboratory tests must be included in the geotechnical reports, including the location and level (including datum) of field investigations such as boreholes and trench pits.</p>
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#### \*Certifications by Geotechnical Engineer

Formal certifications by a Chartered Professional Geotechnical Engineer will be relied upon by Council to make judgements on the suitability of developing land for residential/commercial/infrastructure purposes and on approving stages of developments.



## Schedule 2C: Factors of Safety and Risk Guideline

### 2.C.1 Factor of Safety Guideline

#### Introduction/Explanatory Notes

The objective of this Factor of Safety (FoS) guideline is to provide applicants and geo-professionals with Council's perspective when Council engineers process consents with a slope stability assessment. Council would also generally take into consideration the collective wisdom and experience of the geotechnical community and associated researches such as Project 95/183 for the EQC Research Foundation.

It should be noted when using the guidelines, it does not absolve the geo-professional from any responsibility in respect to the modelling of the slope or analysis. However, if the FOS chosen is radically different from the guidelines, the variance from the guidelines should be explained, and Council has the right and discretion to have the analysis peer reviewed.

**Table 2.C.1 Factors of Safety**

I. Residential Subdivision/Development	
	Factor of Safety (FoS)
Normal ground water condition	1.5
Extreme (worst credible) groundwater condition	1.3
Seismic condition with 150 yr event	1.2
II. Low risk areas such as Parks and Bush Reserve Land	
	Factor of Safety (FoS)
Normal ground water condition	1.2
Extreme saturated condition	1.1
Seismic condition with 150 yr event	1.1
III. High Risk Areas that may result in loss of life/ national interest	
i. Refer to the appropriate legislations/guidelines where applicable e.g. TP109/NZSOLD for dams where the return period used is pmf	
ii. A FOS > 1.5 may be required for categories that include essential utility services and infrastructures that have been identified as critical by Civil Defence.	
iii. Discussion with Council engineers to establish an agreed FoS	

### 2.C.2 Risk Classification Guideline

#### **Risk Classification for Sites Subject to Instability**

(This table has been produced to provide a simplified classification which can be readily understood by a lay person and to provide a uniform code of terms for geotechnical professionals)

**Table 2.C.2 Risk Classification\***

RISK	Evidence/Type of	Consequences of	Implications for	Extent of
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	<b>Instability</b>	<b>Instability</b>	<b>development</b>	<b>Investigation</b>
<b>Very High</b>	Evidence of active or historic instability – landslide or rock face failure, extensive instability may occur within site or beyond site boundaries	High risk of loss of life. Catastrophic or extensive significant damage or economic loss	Unsuitable for development unless major geotechnical work can satisfactorily improve stability. Risk after development may be higher than normally accepted (includes Section 36(2))	Extensive geotechnical investigation required
<b>High</b>	Evidence of active creep, ancient instability, potentially progressive/regressive/minor slips or minor rock face instability, significant instability may occur during and after extreme climatic conditions and may extend beyond the site boundaries	Low risk of loss of life. Significant damage or economic loss	Development restrictions and/or geotechnical works required. Risk after development may be higher than normally accepted (may include Section 36(2))	Engineering Geological assessment, drilling investigation required
<b>Medium</b>	Evidence of possible soil creep or a steep soil covered slope; significant instability can be expected if the development does not have due regard for the site conditions	Virtually nil risk of loss of life. Moderate damage and economic loss	Development restrictions may be required. Engineering practices suitable to hillside construction necessary. Risk after development generally no higher than normally accepted	Visual assessment. Hand and possible drill investigation methods
<b>Low</b>	No evidence of instability observed; instability not expected unless major site changes occur	Minor damage, limited to site unless major development occurs	Good engineering practices suitable for hillside construction required. Risk after development normally acceptable	Visual assessment. Possible hand investigation methods
<b>Very Low</b>	Typically shallow soil cover with flat to gently sloping topography	Virtually nil	Good engineering practices should be followed	Visual assessment

\* Taken from Crawford and Millar Paper dated 1998 titled “The Design of Permanent Slopes for residential Developments. Table 1.”

# Schedule 2D: Checklist

## CHECKLIST FOR STABILITY ASSESSMENTS

### FACTUAL INFORMATION

#### 1. INTRODUCTION

- ☐ Report prepared for who?
- ☐ Site Location
- ☐ Outline of proposed development<sup>(b)</sup>
- ☐ Comment on need for earthquake assessment

#### 2. TOPOGRAPHY

- ☐ Outline current landform (slope shape, height gradient, irregularities, erosion, soil creep/terraces)
- ☐ Outline surface drainage patterns<sup>(b)</sup>
- ☐ Review aerial photos
- ☐ Comment on any previous earthworks
- ☐ Comment on any existing instability<sup>(c)</sup>
- ☐ Additional site features (e.g. vegetation/trees structures<sup>(b)</sup> retaining walls, roads/driveways, services)

#### 3. SITE HISTORY

- ☐ Outline current/previous landuse
- ☐ Comment on previous siteworks<sup>(b)</sup>
- ☐ Reference "District Hazard Map"/GIS
- ☐ Comment on previous instability<sup>(c)</sup>
- ☐ Performance of existing structures
- ☐ Review aerial photos
- ☐ Comment on previous contamination<sup>(c)</sup>

#### 4. GEOLOGY

- ☐ Describe geological setting
- ☐ Refer to relevant maps
- ☐ Geological influences on stability (e.g. bedding, weak materials, faults)
- ☐ Describe seismic setting

#### 5. INVESTIGATIONS

##### ► FIELD

- ☐ Inspection by geotechnical specialist
- ☐ Descriptions of soils/rock in borelogs (Ref.1)
- ☐ Outcrop/cutting descriptions<sup>(c)</sup>
- ☐ Record Extent of any cracking<sup>(c)</sup>
- ☐ Other field tests (e.g. CPT, etc.)
- ☐ Monitoring of ground movements<sup>(c)</sup>
- ☐ Groundwater measurements and observations (seepage, subsurface erosion)<sup>(c)</sup>

##### ► LABORATORY

- ☐ Outline tests undertaken
- ☐ Summarise results
- ☐ Previous testing in local area

#### 6. SUBSURFACE CONDITIONS

- ☐ Geological interpretation<sup>(c)</sup>
- ☐ Summarise subsoil conditions, e.g. extent of fill<sup>(c)</sup> topsoil, nature and distribution of soils/rock
- ☐ Describe soil strengths/density, likely behaviour - refer to tests and logs
- ☐ Highlight weak/sensitive/loose soils or rock defects
- ☐ Describe groundwater conditions, subsurface drainage, expected seasonal fluctuations

### APPENDICES

- ☐ Borelogs, Testpit Logs, Logs of Exposures (Ref.1)
- ☐ Laboratory Results
- ☐ Specifications for Remedial Works/Fills
- ☐ Site Photos

### REFERENCES

1. Guidelines for the Description of Soils & Rock, NZ Geomechanics Society (1985)
2. Assessment of Slope Stability at Building Sites, BRANZ Study SR4, (1987)
3. Slope Stability in Urban Development, DSIR Series 122 (1981)
4. Stability of House Sites & Foundations, Earthquake & War Damages Commission, NZ Geomechanics Society (1980)
5. Land Assessment for Development Suitability, Burns & Farquhar, NZ Geotechnical Symposium (1996)

### NOTES

- (a) This checklist is intended as a guide for typical stability investigation & assessments for residential developments. There may be additional requirements for specifically difficult sites, large scale developments and regional hazards
- (b) Indicate on site plan
- (c) Indicate on site engineering geological map
- (d) These plans/maps are best combined if possible
- (e) Ref.3 provides a valuable outline of stability problems peculiar to selected areas of NZ
- (f) Refer BRANZ document Fig 3 (ref.2 above), Stability House Sites and Foundations (ref. 4 above)
- (g) See 6.6 - "Risk Rating", Design of Permanent Slopes for Residential Development, Crawford & Millar for EQC (1998)

### INTERPRETATION/DISCUSSION

#### 7. SLOPE STABILITY (Ref. 2,3,4)

##### ► ENGINEERING GEOLOGICAL ASSESSMENT:

- ☐ Discuss site features
- ☐ Discuss geological setting/influences<sup>(a)</sup>
- ☐ Influence of rainfall/groundwater
- ☐ Reasons for landform (local, regional)
- ☐ Likely slope failure mechanisms
- ☐ Potential for Instability
- ☐ Effects of the development on slopes<sup>(f)</sup>
- ☐ Consequence of instability
- ☐ Empirical assessment (qualitative)
- ☐ Risk rating applied<sup>(g)</sup>
- ☐ State whether stability analyses are required

##### ► GEOTECHNICAL ENGINEERING ANALYSES

- ☐ Geotechnical slope model correct?
- ☐ Analytical method stated
- ☐ Determination of critical section of slope
- ☐ Assessment of strength parameters
- ☐ Assessment of groundwater profile/rainfall
- ☐ Back analysis of any existing failures
- ☐ External loads due to the development
- ☐ State need for seismic analysis
- ☐ Normal FOS requirements:
  - Static (Design gwt) FOS  $\geq 1.5$
  - Static (Extreme gwt) FOS  $\geq 1.2$
  - Seismic (150 year EQ) FOS  $\geq 1.2$
- ☐ Sensitive analyses for parameters required?
- ☐ Results and comments

#### 8. GEOTECHNICAL EFFECTS OF DEVELOPMENT

- ☐ Slope stability risk increased or reduced?
- ☐ Is the development feasible?
- ☐ Need to drain slopes (surface/subsurface)?
- ☐ Need to remove/upgrade fill?
- ☐ Subsurface drainage beneath fills?
- ☐ Need to retain slopes/secure rock faces?
- ☐ Foundation conditions/requirements
- ☐ Effect of stormwater/effluent disposal
- ☐ Effect of service lines rupture (e.g. SW, sewer)
- ☐ Effect of river/coastal erosion
- ☐ Seismic effects on development and slope
- ☐ Maintenance requirements for life of the development

#### 9. CONCLUSIONS AND RECOMMENDATIONS

#### 10. STATEMENT BY GEOTECHNICAL ASSESSOR AS TO THEIR ABILITY & QUALIFICATIONS TO PREPARE THIS GEOTECHNICAL ASSESSMENT

### DRAWINGS/FIGURES

- ☐ Site Plan<sup>(d)</sup>: ☐ Borehole/Testpit Locations
- ☐ Outline of Proposed Development
- ☐ Site Engineering Geological Maps<sup>(d)</sup>
- ☐ Site Contours Maps<sup>(d)</sup> } Cuts and fills
- ☐ Cross Sections } indicated
- ☐ Geotechnical Model
- ☐ Stability Analyses Results

## Schedule 2E: Soil Strength Parameters

Soil strength parameters adopted by the geo-professional shall be based on site investigation. These tabulated soil strength parameters for cohesive soils reflect values often reported on for Waitemata Group materials and adopted in the Auckland region but are not necessarily acceptable for any specific site. The values will give geo-professionals a sense of when Council may request more comment. Generally, in the event that the adopted values are less conservative than tabulated in this schedule, the reasons should be outlined in the geotechnical report. Examples of soils outside the guidance of this schedule include Waitakere cemented volcanics and Northland Allochthon.

Cohesive Soils						
Natural Soils						
Soil Consistency (silts/clays)	Density (kN/m <sup>3</sup> )	C <sub>u</sub> (kPa)	SPT (Blows / 300mm)	Scala Penetrometer (Blows / 150mm)	C' (kPa)	Ø (degree)
Hard		>200	30	>10	10	34
Very Stiff		100-200	15-30	5-10	7	32
Stiff	17.5	50-100	8-15	2.5-5	5	30
Firm		25-50	4-8	1-2.5	3	28
Soft		12-25	2-4	0.5-1	0	26
Very soft		<12	0	0	0	20-22
Engineered Soils						
Description	Density	C <sub>u</sub>	C'	Ø		
Engineered Fill	18.5kN/m <sup>3</sup>	100	5	32		
Shear Keys		120	10	35		

Guidance for Engineered Fill Specifications				
Description	Air Voids Percentage (1)		Undrained Shear Strength	
	Max Single Value	Average Value	Minimum Single Value	Average Value (2)
General Fill	12%	10%	110 kPa	140 kPa
Fill slopes / Shear Keys (3) / within 500mm of carriageway subgrade	10%	8%	120 kPa	150 kPa

Note: Project risk assessment and/or design requirements may lead to stricter fill specification criteria

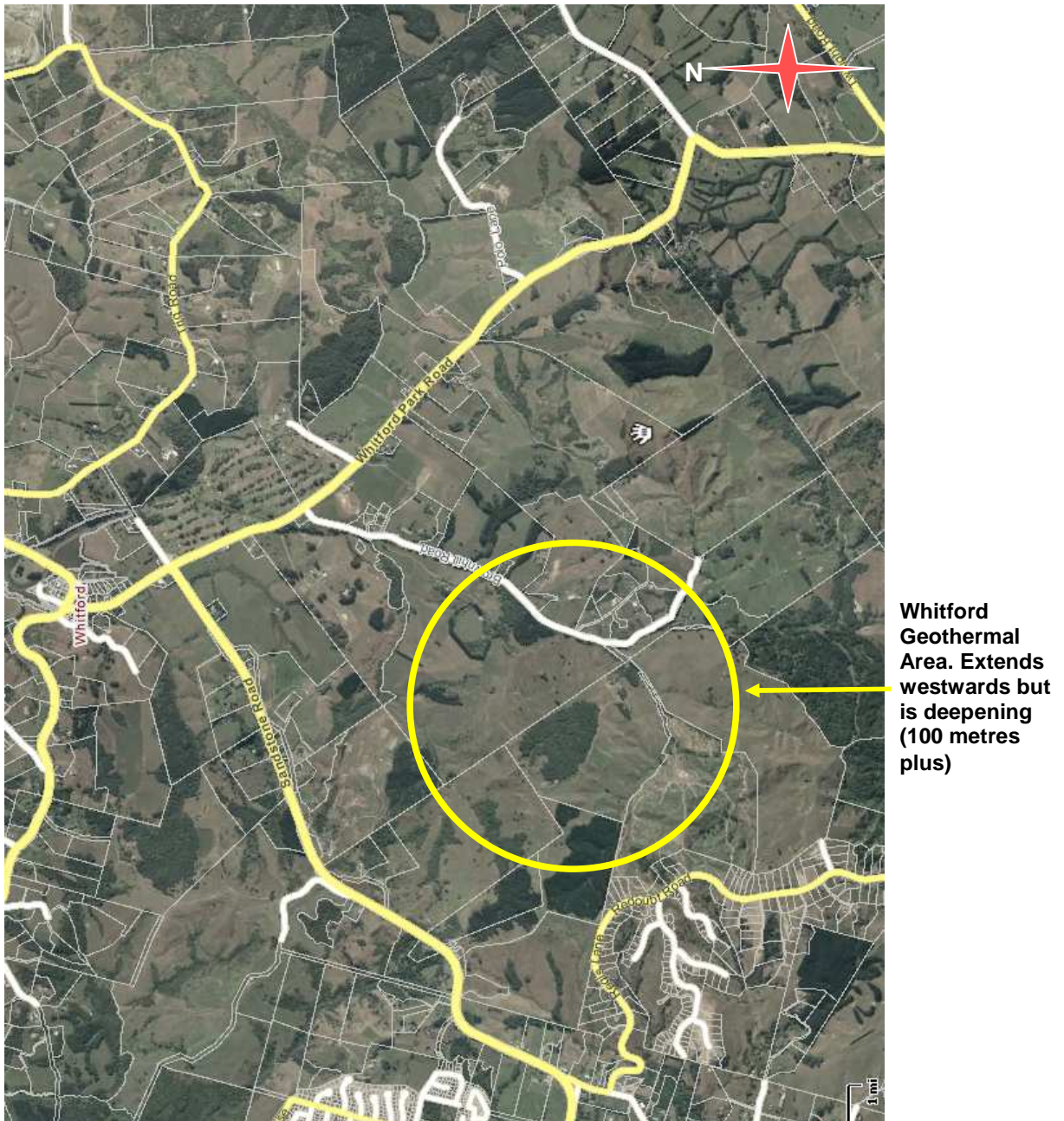
Footnotes:

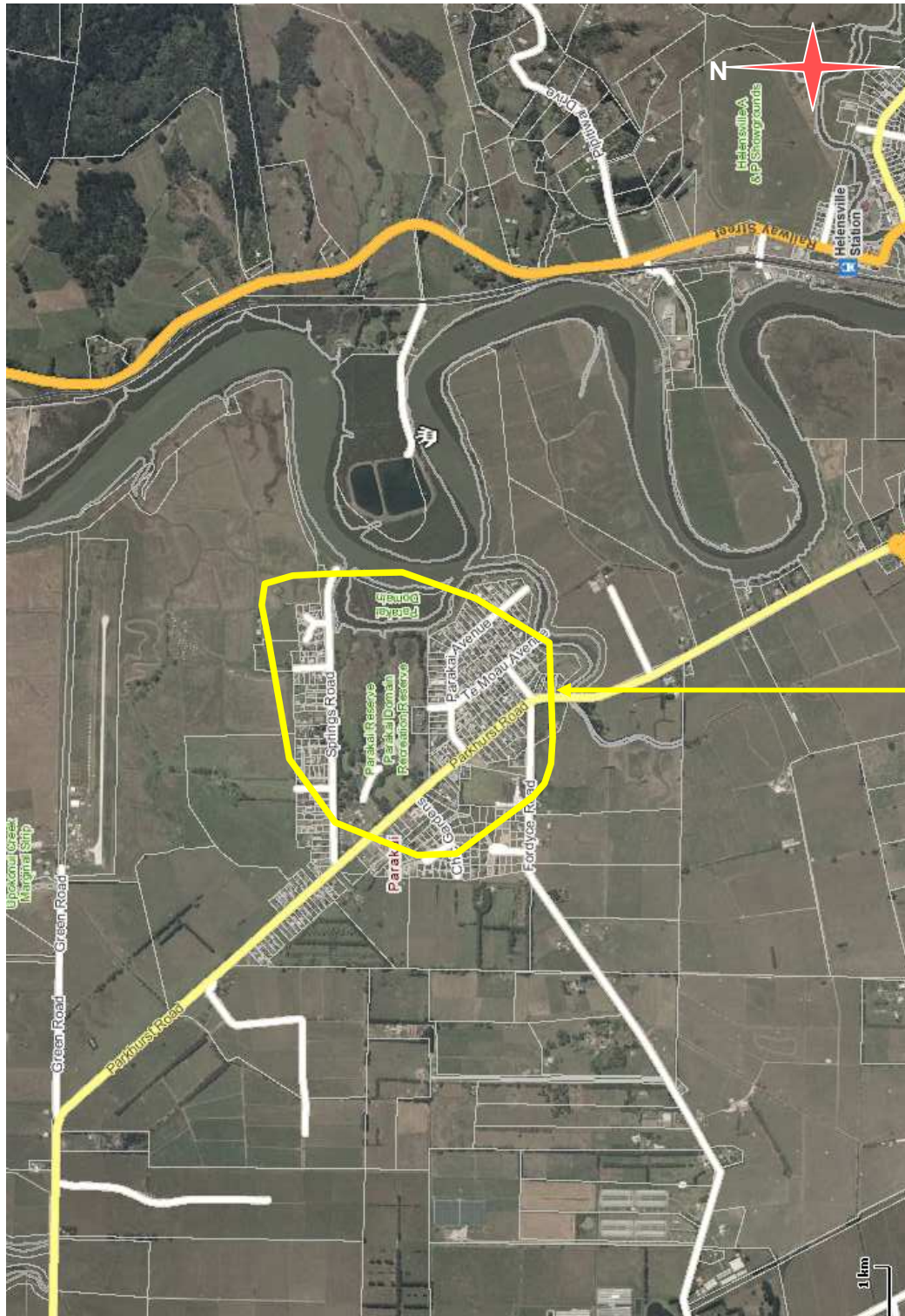
1. Refer also NZS4402:1986, NZS4407:1991 (nuclear densometer test method) and NZS4431:1986 for guidance on specifications and test methodologies. Fill specifications will commonly include additional test criteria
2. One set of tests per 500 m<sup>3</sup> of fill; average of four tests within 1m of each other, frequency could be adjusted for larger bulk earthworks projects.
3. Specifications for shear keys could vary according to the design width of the key. The table also excludes guidance in respect of granular fill.



## Schedule 2F: Geothermal Areas In Auckland

(Guideline only)





**Parakai Geothermal Area. Potential risk to foundations in Spring Road as geothermal gradient close to surface**





**Geothermal  
Area at  
Waiwera**