BEFORE THE CHRISTCHURCH CITY COUNCIL

IN THE MATTER	of the Resource Management Act 1991 ('the Act')
AND	
IN THE MATTER	of a private plan change request by Highfield Park Limited to rezone approximately 260ha of land adjoining Redwood from Rural 3 (Styx-Marshland) to Living G (Highfield)
BETWEEN	HIGHFIELD PARK LIMITED Requestor
A N D	CHRISTCHURCH CITY COUNCIL Local Authority

SECOND SUPPLEMENTARY EVIDENCE OF GRAEME ROY HAMILTON ON BEHALF OF HIGHFIELD PARK LIMITED

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INTRODUCTION

1 My full name is Graeme Roy Hamilton (Roy Hamilton). My role, qualifications and experience are as described in my statement of evidence presented to the hearing on 27 November 2012

2 During the course of the hearing a number of questions have been raised regarding the proposed bulk earthworks and ground improvement work required for the Highfield Park development. In particular, I refer to paragraph 7 of the Commissioners' Minute No. 2 dated 6 December 2012.

3 I have prepared this supplementary evidence to expand on the context and nature of the proposed works when compared to other projects and to the typical scale, nature and timing of the works, effects of the works and the usual methods of management and mitigation. Where appropriate I have referred to the evidence of other witnesses for Highfield that provide more specific evidence on some of these matters.

SCOPE OF EVIDENCE

4 This evidence has been prepared to address the following matters:

(a) Examples of other land development projects I have been involved with that required significant construction works

(b) A summary of the sequential steps that will be undertaken after rezoning to achieve development of the Highfield site

(c) An explanation of matters that are currently unknown and which will impact on construction activities

(d) A description of the nature and scale of effects that will result from construction

(e) A summary of how and when these effects are typically addressed based on my experience with other projects.

PREVIOUS LAND DEVELOPMENT PROJECT EXPERIENCE

5 I have a wide range of experience with land development and construction. Table 1 below summarises some of the most relevant and recent previous projects that I have been involved with that illustrate the size and scale of the earthworks that is typically associated with land development. My role in these projects covered a range of areas of responsibility including designer and engineer to the contract, development manager, project manager and developer.

6 For various reasons all of these projects were staged in some way and were completed over a period of years. The staging was typically to ensure that only sufficient numbers of lots were developed to meet the demand from the market. For

example the 370 lots in Northwood at the commencement of the project was the largest stage to be undertaken in the South Island at the time it was built. The on-going stages were much smaller and typically stages of 50-100 are more common.

Table 1 – Example Projects

Type	Lots[1]	Volume[2]	Comments
Ashburton Aquatic Park (Lake Hood)	150	960,000m^3	80 Ha Lake and subdivision construction completed in multiple stages
Silverstream Estates (Kaiapoi)	1100	350,000m^3	Subdivision with post-earthquake ground improvement and work alongside waterways and ponds being completed in multiple stages
Meadow Estates (Kaiapoi)	210	175,000m^3	Subdivision completed in multiple stages
Northwood (Christchurch)	1000	350,000m^3	Subdivision completed in multiple stages
The Isaac Lakes at Clearwater (Christchurch)	27	30,000m^3	Subdivision with post-earthquake engineered fill around water and ponds
Lochinver Run (Tekapo)	69	40,000m^3	Subdivision completed in multiple stages
Kaiata Park (Dobson)	68Ha	600,000m^3	Industrial subdivision completed in multiple stages

POTENTIAL DEVELOPMENT PROGRAMME

7 Following the completion of the plan change process it is usual practice to proceed into completing the subdivision consent and engineering approval stages prior to commencing construction.

8 There are a range of other consents that are required such as discharge consents for stormwater and land use consents for construction in waterways that are usually obtained alongside the subdivision consent. In many cases the issue of the subdivision consent is contingent on having obtained these additional consents.

9 On larger projects it is sometimes beneficial to apply for land use consent for the earthworks so that the application can be processed to address the specific effects of

[1] Approximate number of lots created or to be created within the development.
[2] Approximate total quantity of material moved on site whether by stripping, cut to fill or imported material placed and compacted as fill.

the earthworks activity. This allows an approval to be obtained for earthworks prior to the completion and issue of the subdivision consent for the development.

10 Highfield will be developed in multiple stages of approximately 200 lots depending upon the demand from the market. At this stage we consider that it will take at least ten years to complete the project and that the required civil works will be spread over the drier months of each calendar year.

11 The potential effect on adjoining properties would be limited to that caused by the stage (s) alongside them and only then for the period of construction activity during the year. Thus the affect on any individual property cannot be considered to be that from the entire project.

12 A preliminary staging plan has been developed for Highfield to identify the potential first stages of construction, this plan will need to be reviewed and modified with feedback regarding demand from the market. We consider at this stage that works will initially commence in the northwest side of the zone and progress to the northeast and then south.

MATTERS TO BE DETERMINED

13 As the plan change does not include detailed engineering design work there will be a range of refinements and changes to the current preliminary design. These changes are not likely to be significant when it comes to the overall proposed scheme, but will provide a finer grain of engineering design details to allow definition of the works for approval and construction.

14 As there are a number of approvals and consents required we expect that there will be changes required to ensure compliance with the conditions of the various approvals.

15 There will be changes to the nature and scale of ground improvement works once more detailed investigation has been undertaken to achieve the testing densities required by the Department of Building and Housing guidelines. Consideration of the additional data and alongside reference to the evolving guidelines [3] for development and construction will enable us to micro zone the site for specific improvement methodologies.

16 The project will be developed in stages to meet the demand from the market and the practical needs for servicing the site. As this will be in constant review the areas of construction will vary over time and in location.

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[3] Proposed amendments to the Ministry of Business, Innovation and Employment Guidance Document "Repairing and Rebuilding Houses affected by the Canterbury Earthquakes" were presented to the Canterbury Technical Forum last Wednesday the 5th December, which modify the procedure for assessing liquefaction potential.

EFFECTS OF CONSTRUCTION

17 There are a range of common affects caused by construction activity. I have listed the most common below and described the usual mitigation methods that are applied based on my experience.

18 The effect on any one adjoining property will relate to the stage(s) of development that adjoin it and the type of works that are required for that stage. Therefore everyone will experience a different combination of effects for differing periods during the course of the development.

19 The most significant activities to be undertaken are the bulk earthworks and ground improvement works. All of the other activities can be readily observed in general development and construction activity occurring in multiple locations around Christchurch as a result of the earthquakes.

<u>Noise</u>

20 During construction there are a wide range of physical activities that will need to be undertaken on the site that will create noise. This noise will range from heavy earthworks equipment to civil works construction through to the construction activity to build the dwellings and infrastructure within the project.

21 Noise limits for construction are set in NZS: 6803 1984 "Measurement and Assessment of Noise from Construction, Maintenance, and Demolitions Work"

22 Monitoring of noise is typically required as a condition of consent for subdivision or earthworks. If limits are exceeded the activities on site will need to be modified by changing the type of equipment being used, or by providing sound attenuation barrier.

<u>Dust</u>

23 Dust is potentially created by the movement of vehicles over dry soils on site. It can also be generated by the activity of excavation and loading. Dust is a particularly sensitive issue during high winds and in particular the dry "north westerly" that blows commonly during hot dry periods.

24 Dust is usually managed by the provision of water carts or irrigation to dampen the ground. Areas of the site that are "open" for construction are usually limited to avoid having to manage large areas in dry or wet conditions. Traffic management is important to limit the distances and areas that vehicles need to travel.

<u>Vibration</u>

25 Vibration affects can be caused by the movement of vehicles and the general activity on site. In this case a range of ground improvement activities will cause varying levels of vibration in the soils. The effects of this activity will need to be managed and controlled with specific analysis as described in Mr Gary Chapman's evidence

Sediment and Erosion Control

26 During construction there is increased likelihood that rainwater will cause run off that includes high concentrations of sediment; such sediment could cause adverse effects in the receiving waterways such that natural habitats could be damaged.

27 In addition rainfall on sites that have excavation and filling work underway creates a higher risk of erosion of banks, cuts and surface soils that could lead to instability or the modification of natural landforms.

28 An erosion and sediment control plan will be prepared to manage the run off from stormwater during construction. This is usually achieved by creating retention bunds and flow channels that direct storm flow to retention ponds where sediment can be removed before discharge to the existing waterways and drains. It is also important to limit the areas of the site that are "open" at any one time. These matters are covered in more detail in Mr Andrew Brough's evidence.

Traffic and Access

29 Construction activities result in a range of vehicle movements to and from the site. These will include vehicles to establish the support services to operate the site, , delivery of heavy equipment to the site, vehicles delivering or removing materials from the site, support and service vehicles and vehicles relating to the monitoring and supervision of the works

30 The first stage of construction will include works to construct accessways to and from the site to ensure that entrances comply with the CCC engineering design standards. Shaker ramps and/or water troughs will be provided to ensure that dirt and dust do not create a nuisance outside the site. In addition, traffic will often be subject to a Traffic Management Plan that is imposed as a condition of consent, as discussed in the evidence of Mr Robert Nixon.

Groundwater and Surface Drainage

31 The construction of the subdivision needs to address the interception of groundwater, the interception of existing surface water drains, and runoff from those parts of the site under construction.

32 Consents are typically required from Environment Canterbury for any discharge or runoff. These matters are covered in more detail in Mr Brough's evidence.

ADRESSING EFFECTS

33 The issues and matters above are covered with increasing detail through the applications for land use consents, discharge consents, subdivision consent and engineering approval at which point a comprehensive set of construction drawings and specifications is available to ensure that construction can be completed in accordance with the requirements of the approvals.

34 A construction and environmental management plan is usually required to describe how all of the activities on site are to be carried out and controlled. These plans are usually prepared by an engineer and are submitted to the council for approval in accordance with conditions attaching to the subdivision and/or earthworks consent.

35 The works are usually completed under an overarching accidental discovery protocol that requires works to stop immediately upon the discovery of any evidence of items of historical significance.

36 The evidence of Mr Nixon discusses the City Plan consenting requirements that apply to construction activities in order to manage the effects. In addition, the CCC Infrastructure Design Standard imposes practical controls on construction activities. In particular, chapter 4 of the Standard relates to geotechnical matters and covers a range of issues including erosion, sediment and dust control for earthworks. I have attached a copy of this chapter of the Standard at **Appendix A** to my evidence.

37 In my view there is a clear process that Highfield will have to follow that will require significant detail to be provided to CCC for approval before any earthworks can commence, whether it is by way of separate earthworks consent application or as part of the subdivision consent application.

38 Mr Major has raised concerns in his evidence regarding the need to insert additional rules into the plan change to ensure that the effects of this project are managed. While I am sympathetic to Mr Major's concerns I believe that the stringent controls that will be applied to the next steps in the approvals process will ensure that an appropriate approach will be taken to managing and mitigating any potential effects on the residents within the PC67 site or close neighbours outside the site.

39 Once works are underway a process of auditing and monitoring will be undertaken to ensure that the conditions are being adhered to. Such monitoring will include review of access, roads, construction activity, and traffic management as required to achieve consistent compliance with consent conditions.

G. Roy Hamilton
13 December 2012

APPENDIX A

Infrastructure Design Standard – Part 4: Geotechnical Requirements

Part 4: Geotechnical Requirements

CONTENTS

Earthquake risk amendment:
Appendix IV Liquefaction Resistance Index (Zoning) of Christchurch at Water Table Depth - for application to underground infrastructure only

4.1 Referenced Documents

Planning and Policy

- The *Christchurch City District Plan* (*City Plan*)
  www.cityplan.ccc.govt.nz/NXT/gateway.dll?f=templates&fn=default.htm
- The *Banks Peninsula District Plan*
  www.ccc.govt.nz/CityPlan/BanksPeninsulaDistrictPlan/BPDistrictPlan.asp
- Resource Management Act (1991) Section 106
- Building Act (2004) Section 36
- Christchurch City Council *Water Related Services Bylaw* (2008)
  www.ccc.govt.nz/bylaws/ChristchurchCityCouncilWaterRelatedServicesBylaw2008.pdf
- Canterbury Regional Council *Natural Resources Regional Plan (NRRP)*
  www.ecan.govt.nz/Plans+and+Reports/NRRP/About-Nrrp.htm

Design

- Christchurch City Council *Waterways, Wetlands and Drainage Guide, Ko Te Anga Whakaora mō Ngā Arawai Rēpo* (WWDG) *(*2003)
- NZS 4431:1989 *Code of practice for earthfill for residential purposes*
- NZS 3604:1999 *Timber framed buildings*
- NZS 4404: 2004 *Land development and subdivision engineering*
- BRANZ (1987) *Assessment of slope stability at building sites, Study Report 4*
- Canterbury Regional Council *Erosion and sediment control guidelines* 2007
  www.ecan.govt.nz/Our+Environment/Land/ErosionAndSediment/ErosionSedimentControlGuidelines.htm
- Auckland Regional Council Technical Publication 90, *Erosion and sediment control: Guidelines for land disturbing activities in the Auckland Region* (1999)
  www.arc.govt.nz/albany/main/plans/technical-publications/technical-publications-51-100.cfm
- Auckland Regional Council Technical Publication 10, *Stormwater treatment devices: design guideline manual* (2003) www.arc.govt.nz/arc/environment/water/stormwater-tp10.cfm
- Ministry for the Environment *Contaminated Land Management Guidelines No. 1 – Reporting on Contaminated Sites in New Zealand*
  www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines/index.html
- *Geotechnical Issues in Land Development*, Proceedings of NZ Geotechnical Society Symposium, Hamilton (1996)
- New Zealand Geotechnical Society *Field Description of Soil and Rock (*December 2005) www.nzgeotechsoc.org.nz/guidelines.cfm

- Cook, D., Pickens, G.A., MacDonald, G., *The Role of Peer Review*, Report by S.A. Crawford, NZ Geomechanics News (Dec 1995)
- Landcare Research Report LC0203/111 *Soil Conservation Guidelines for the* Port Hills (May 2003)
- Australian Geomechanics Society (AGS) Sub-committee on Landslide Risk Assessment, *Landslide Risk Management Concepts and Guidelines*, Journal and News of the AGS, Volume 35, No. 1. March 2000 www.australiangeomechanics.org/

Construction

- Christchurch City Council *Civil Engineering Construction Standard Specifications Parts 1- 7 (CSS)* www.ccc.govt.nz/doingbusiness/css/

Where a conflict exists between any Standard and the specific requirements outlined in the Infrastructure Design Standard (IDS), the IDS takes preference (at the discretion of the Council).

4.1.1 Source documents

This Part of the IDS is based on Part 2 of NZS 4404:2004, by agreement, and with the consent of Standards New Zealand.

4.2 INTRODUCTION

This part of the IDS draws attention to the need for the assessment of land stability and the design and control of earthworks. Such assessment ensures a suitable platform for the construction of buildings, roads and other structures, as well as the minimisation or mitigation of any adverse environmental effects arising from such works. It should also include an early assessment of the site's soils and their potential to provide for on-site stormwater systems (e.g. detention basins, infiltration basins).

This is not a geotechnical standard but sets out some, though not necessarily all, of the matters to be considered in planning and constructing a land development project.

4.2.1 Relevant standards

NZS 4431:1989 applies to the construction of earthfills for residential development, including residential roading. It does not, however, deal with historical fill that has not been undertaken in accordance with any Standard and it does not cover natural slopes, banks and batters.

There is no Standard for earthfill for other than residential developments. Clause 4.7.3 - Compaction standards for fill material sets out the requirements in these situations.

4.2.2 Statute and City or District Plan requirements

Where there is a requirement for an assessment of land stability, to meet the provisions of the Resource Management Act and the Building Act, this is the responsibility of the geotechnical engineer. The Council relies on that assessment when granting the resource consent. The geotechnical engineer determines the methods used and investigations undertaken.

Special requirements apply when the land is subject to erosion, avulsion, alluvium, falling debris, subsidence, inundation or slippage. In such situations, refer to section 106 of the Resource Management Act and, for subsequent building work, section 74 of the Building Act.

Specific Council requirements include:

> no earthworks permission for work within Christchurch City unless it complies with the provisions of the *City Plan, Volume 3, Part 9, clause 5 – Filling, excavation and building adjacent to waterways* or the *Banks Peninsula District Plan, Chapter 38, rule 2*.

> no earthworks beginning on a subdivision that has been granted resource consent prior to final engineering acceptance, unless written permission from the Council is given, detailing conditions that must be adhered to.

4.3 Quality Assurance Requirements and Records

Provide quality assurance records that comply with the requirements in Part 3: Quality Assurance, during design and throughout construction.

4.3.1 The geotechnical engineer

The geotechnical engineer must be suitably experienced. Their experience must be to a level to permit membership in the relevant professional body. The geotechnical engineer may be a suitably experienced civil engineer or engineering geologist. Refer to clause 2.6.1 – Investigation and design (General Requirements) for further information.

4.3.2 Requirement for a geotechnical engineer

Engage a geotechnical engineer to provide geotechnical expertise where the following issues exist:

> the lack of, and limitations of, relevant Standards.

> 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 can support the future loads imposed on it.

> the assessment of ground for building foundations, roads, etc. requires specialist expertise e.g. weak ground may require special design.

> the wide range of soil types, physical conditions and environmental factors existing in different areas make it impossible to lay down precise requirements for land stability assessment or earthworks.

> the preliminary evaluation raises doubt about the stability, or suitability, of the ground for the proposed development.

> other geotechnical hazards are identified.

> the Council requires geotechnical expertise to assess the project.

4.3.3 Responsibilities of the geotechnical engineer

The geotechnical engineer will carry out the following functions:

- Undertake a site inspection and any preliminary site evaluation required, including investigations of sub-surface conditions and identifying geotechnical hazards affecting the land before the detailed planning of any development. These matters must be included in any assessment of environmental effects (AEE) associated with any consent application;
- Before work commences, be involved in the design or review the drawings and specifications defining any earthworks or other construction work, and submit a written report to the Council on the foundation and stability aspects of the project with the application for engineering acceptance;
- Set earthwork requirements, where no standard for earthworks is applicable to the project, to conform to the IDS and to subdivision or resource consent conditions (if any) that apply to the proposed development;
- Before work commences, and during construction, determine the extent of further geotechnical engineering services required (including investigation and geological work);
- Before and during construction, determine the methods and frequency of construction control tests to be carried out, determine the reliability of the testing, and evaluate the significance of the test results and field inspection reports in assessing the quality of the finished work;
- During construction, undertake regular inspections consistent with the extent of geotechnical issues associated with the project;
- On completion, submit a written report to the Council attesting to the compliance of the earthworks with the specifications and the suitability of the development for its proposed use. If NZS 4431 is applicable, the reporting requirements of that Standard must be used as a minimum requirement.

Earthquake risk amendments: Geotechnical Assessment report clause added

Where a development proposal has been submitted without geotechnical input and where, in the opinion of the Council, such input is required, the Council may direct that such advice is obtained before proceeding further with the proposal.

4.3.4 Design Report

Detail the key achievement criteria and assumptions in the Design Report, such as the chosen factors of safety, for the geotechnical aspects of the engineering design.

Provide the following design records to support the Design Report:

- the site inspection and evaluation;
- the foundation and stability aspects of the project;
- the extent of further geotechnical engineering services required (including investigation and geological work);
- the methods and frequency of construction control tests to be carried out.

4.3.5 Geotechnical Completion Report

For all developments where a geotechnical engineer is engaged, the geotechnical engineer must submit a Geotechnical Completion Report, accompanied by a statement of professional opinion as set out in Appendix I – Statement of Professional Opinion on the Suitability of Land for Building Construction.

The report must identify any specific design requirements that necessitate the building design to deviate from the relevant New Zealand standard. Describe the extent of inspection, the results of testing and include all geotechnical reports prepared for the development.

The professional opinion must indicate the degree of compliance of the development with the design or standards set by the geotechnical engineer.

Test areas of natural ground on planned subdivisions or developments that are not proposed to be filled or excavated, for soil strength and type. Wherever building sites on natural ground have soil strengths less than 100 kPa, or exhibit other specific characteristics that may require specific foundation design, note them in the report, along with any recommendations for strengthened or piled foundations for residential buildings.

Include documentation on both the testing of the soils for compaction and for soil strength and type, clearly showing the areas to which the tests relate. Include areas where compaction met the required Standards, any areas requiring re-testing and areas which did not meet the Standards.

For simple developments where there are no earthworks, the Geotechnical Completion Report will consist of the geotechnical assessment report. For large or more complex developments where there may have been several stages of geotechnical reporting, include all relevant geotechnical information in the Geotechnical Completion Report.

4.3.6 As-Built records

Prepare as-built records, which comply with Part 12: As-Builts. Present the as-built records in conjunction with the Geotechnical Completion Report and tabulated results.

4.4 Preliminary Site Evaluation

Consider the total surroundings of the site, without being influenced by details of land tenure, territorial or other boundary considerations.

In simple cases, a visual appraisal may be sufficient. In other cases, depending on the nature of the project, its locality, the scale of development proposed and individual site characteristics, consider the following matters before preparing a proposal for development.

4.4.1 Existing landforms

Study the general nature and shape of the ground and take particular note of:

- the geological nature and distribution of soils and rock.
- existing and proposed drainage conditions and the likely effects on groundwater.
- the previous history of ground movements in similar soils in the area.
- where earthworks are involved, the performance of comparable cuts and fills (if any) in adjacent areas.
- air photography and other sources of information that should be reviewed and incorporated into any slope stability assessment.

4.4.2 Drainage

Identify the existing natural drainage pattern of any area, and locate any natural springs or seepage. Wherever any natural surface or subsurface drainage paths may be interfered with or altered by earthworks, assess the wider implications e.g. the impact on springs in nearby waterways. Sealing areas to preserve these drainage paths may be preferable to providing alternative drainage paths. Consider also the stormwater needs of the site and sedimentation control during development.

4.4.3 Slope stability

Some natural slopes exist in a state of only marginal stability and relatively minor works such as trenching, excavation for streets or building platforms, removal of scrub and vegetation, or the erection of buildings, can lead to failure. Look for signs of instability, such as 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. Incorporate the special requirements that are needed for Port Hill developments in dispersive loess soils.

Refer to the *Assessment of slope stability at building sites, WWDG* and *Soil Conservation Guidelines for the Port Hills* for further guidance.

4.4.4 Rock fall potential

In some circumstances, a potential hazard from rock fall within or beyond the site boundaries may exist. Assess the risk for any proposed development on such sites. Provide:

- details of source areas of rock fall hazard;
- a full geological description of potential sources of rock;
- likely rock sizes.

4.4.5 Foundation stability

Study the general topography of the site and its surroundings for indications of areas that have previously been built up; either 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, long-term differential settlement could occur, causing damage to superimposed structures, roads, services or other structures.

4.4.6 Unsuitable historical fill

Council records may (or may not) indicate that a site has been filled with unsuitable, uncontrolled or contaminated material. Discuss any remediation proposals for such fillings with the Council at an early stage of the investigation.

4.4.7 Contaminated sites

Sites known to be, or subsequently found to be, contaminated as a result of previous activities may require the services of a specialist environmental scientist for a site evaluation. Ascertain, at an early stage, the extent of any contamination and gain a reasonably accurate picture of the cleanup needed to meet the required standards. Refer to *Contaminated Land Management Guidelines* for information on reporting requirements.

4.4.8 Local conditions

Consider the range of soil types which exist within Christchurch and Banks Peninsula e.g. expansive soils, volcanic soils, dispersive soils, soft alluvial sediments and compressible soils. Also consider the liquefaction of saturated non-cohesive soils. The Council and Canterbury Regional Council (Environment Canterbury) may have information on the soil types of particular areas.

Earthquake risk amendments: Liquefaction clause with reference to guidelines, maps and Appendix IV added

4.4.9 Peer review

If the risk to the land is assessed as being medium to very high, obtain a peer review of the geotechnical assessment for the proposed development before development. An independent geotechnical engineer must carry this out. *The Role of Peer Review* provides guidance on this process. Refer to clause 3.3.2 – Design report (Quality Assurance) for further information.

Consider using *Landslide Risk Management Concepts and Guidelines* to aid in the risk assessment.

The Resource Consent Application must make reference to, and give an evaluation of, these matters.

4.5 Ground Investigations

Make sufficient borings, probings or open cuts to:

> classify the soil strata by field and visual methods;
> evaluate the likely extent and variation in depths of the principal soil types;
> establish the natural long-term seasonal groundwater levels;
> characterise the natural ground water environment.

Obtain an indication of the seasonal variation in groundwater levels from a review of historical data held by the Council or Canterbury Regional Council, or by an extended period of monitoring. At least one year's readings may be required wherever groundwater levels are critical, or could have a long-term effect on the development.

4.5.1 Soil data

In addition to the general assessment of the suitability of the site for its intended use (buildings, roads), obtain soil data for areas that are intended to:

> form in-situ bases for fills.
> yield material for construction of fills.
> be exposed as permanent batters.
> remain as permanent slopes or cut areas.
> be used for stormwater disposal to ground.

Earthquake risk amendments: reference to Guidelines and Appendix III added

Special consideration of erosion potential is required wherever excavation and filling is made in Port Hills loess soils, because of their highly dispersive properties.

For consistency in the reporting of soils to the Council, use the *Field Description of Soil and Rock*.

4.5.2 Further investigation

The soil information thus obtained forms the basis for:

> further sampling and testing which may be required on representative soil types.
> relating subsequent soil test properties to relevant strata over the site.
> assessment of, or calculations for, slope stability.
> assessment of, or calculations for, foundations suitable for the finished site.
> assessment of, or calculations for, road pavements.

Determine the test data that is appropriate for different areas.

4.5.3 Stability criteria

When making an assessment of the stability of slopes and earthfills, use accepted criteria and analysis methods. Stability criteria applicable to land development in New Zealand are published or recommended by the New Zealand Geotechnical Society. Refer to *Geotechnical Issues in Land Development*.

4.5.4 Special soil types

Wherever special soil types are known to exist in a locality or are identified, advise on appropriate measures for incorporation of these soils into a development.

Special soil types include, but are not limited to:

> soils with high shrinkage and expansion.

> compressible soils.

> volcanic soils.

> soils subject to liquefaction.

> soils prone to dispersion (eg loess).

> marine or estuarine soils.

Contact the Council for hazard maps and information on special soil types in the locality if unfamiliar with the area.

4.6 Planning and Design

4.6.1 Suitability of landform

The choice of a suitable landform is dependent on many factors that may be specific to a particular site. Refer to clause 2.5.4 – Balancing landform choices (General Requirements) for these factors.

Avoid unnecessary earthworks, aim to protect original soils and drainage patterns and to minimise disturbance, compaction, earthworks and the importation of topsoil, although earthworks may be justified in the following circumstances:

> to minimise the risk of property damage through ground movement in the form of rock fall, debris slides, slips, subsidence, creep, erosion or settlement.

> to minimise the risk of property damage through flooding, or surface water run-off.

> to lessen tunnel gully erosion within Port Hill developments.

> to develop a more desirable roading pattern with improved accessibility to and within the site, and to create a better sense of orientation and identity for the area as a whole.

> to increase the efficiency of overall land use, 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.

> to create, where needed, suitably graded areas for playing fields and other community facilities.

> to enhance the general environmental character of the area by softening the landscape or by artificially creating or emphasizing landforms of visual significance, particularly on flat sites or on areas devoid of landscape features.

Note that some Port Hill developments require soil conservation measures such as plantings and revegetation of areas liable to tunnel gully erosion, sheet erosion, slips and existing stream bank/bed erosion. Refer to the *Soil Conservation Guidelines for the Port Hills*, for guidance on erosion prone areas and measures to prevent or control erosion. Refer to clause 10.8.8 - Revegetation, restoration and connection of habitats (Reserves, Streetscape and Open Spaces) for an explanation of revegetation.

Tunnel gully exposed by earthworks

4.6.2 Seismic considerations

Consider the seismic effects on earthfills, foundations, slopes and liquefiable ground, and take these into account in the design and construction of any development.

Earthquake risk amendments: clause substantially rewritten

4.6.3 Rock fall hazard mitigation

Determine possible protection and/or remedial measures to mitigate the assessed risk for any proposed development. Provide results by appraisal of bounce height and velocity for typical annual events and 100 year events for the likely rock sizes as assessed in clause 4.4.4 - Rock fall potential.

Mitigation could include:

> catch fences or other forms of protective measures;

> benching, bunding, excavation or filling;

> establishment and retention of an effective vegetation barrier.

Determine the rock energy in kilojoules and demonstrate how the protective barrier will arrest them. Protective barriers must:

> be accessible for inspection, rock removal and repair;

- not be compromised where gates or accessways are included;
- be designed by suitably experienced designers;
- be and remain effective over their design life.

State the growth time until vegetation is an effective barrier and the vegetation's life expectancy. Where protective barriers are used, the materials must have a 50-year design life.

Ensure the design addresses erosion potential and any impact on natural surface flow.

4.6.4 Peat

Ensure the geotechnical design in peat or organic compressible material areas will achieve the infrastructure design life required by all other parts of the IDS. Preserve the flow of groundwater through the peat at pre-development levels.

Special care is required in any development over peat areas to:

- maintain uninterrupted groundwater flow;
- preserve existing natural groundwater levels to avoid area wide settlement;
- avoid settlement of any surface works or structures;
- ensure the continued operation of infrastructural services and service connections to buildings throughout their design life.

4.6.5 Debris slides

Confirm that any proposed building platform is unlikely to be affected by debris slides. Refer to WWDG Part B clause 20.4.5 for further information.

Debris slide in Orton Bradley Park

4.6.6 Reducing waste

When designing the development, consider ways in which waste can be reduced.

> Design to reduce waste during construction eg minimise earthworks, reuse excavated material elsewhere.

> Use materials with a high recycled content eg recycled concrete subbase. Proposed recycled materials will need approval from the Council to ensure that environmental contamination does not occur.

See the Resource Efficiency in the Building and Related Industries (REBRI) website for guidelines on incorporating waste reduction in your project www.rebri.org.nz/.

4.7 Construction

4.7.1 Underrunners and springs

In hill catchments, underrunners are often encountered. Where practicable and considered necessary, intercept these and bring them to the surface, with a free outfall into the stormwater system wherever possible. If possible, locate the source and redirect or eliminate the underrunner.

4.7.2 Control testing

A testing laboratory, or a competent person under the control of the geotechnical engineer, must carry out the construction control testing. The testing laboratory must have recognised registration or quality assurance qualifications.

4.7.3 Compaction standards for fill material

The standard of compaction and method of determination is as set out in NZS 4431, except where NZS 4431 is not applicable. For example, industrial and commercial developments often have specialised requirements for fill materials and compaction.

Set the fill and compaction standards, procedures and methods of determination for the development in these cases. Use NZS 4431 as a basis where appropriate.

4.8 Erosion, Sediment and Dust Control

4.8.1 Minimisation of effects

Design and construct earthworks to minimise soil erosion and sediment discharge. Where necessary, make permanent provision to control erosion and sediment discharge from the area of the earthworks.

At the planning and design phase, consider the generation of dust during and after the earthworks operation. If necessary, incorporate specific measures to control dust.

Requirements for erosion, sediment and dust control will be set in the resource consent conditions for the project. Refer to these conditions and take into account in the early stages of planning a project. Refer also to the requirements of *CSS: Part 1*.

4.8.2 Site-specific erosion and sediment control plan requirements

For all developments where erosion could result in contaminants in sediments entering the groundwater, surface waters or the Council's stormwater system, provide a site-specific Erosion and Sediment Control Plan (ESCP) to the Council at least two weeks before any works on site. Note that, even where the Council has accepted an ESCP, the developer remains entirely responsible for all adverse effects associated with the site development.

Earthquake risk amendments: timing of plan presentation extended

Develop the ESCP to eliminate or reduce the following issues:

> ecological damage to waterways;
> channel infilling;
> disturbed or uncompacted surfaces and potential sediment yield;
> contaminated runoff.

Earthquake risk amendment: dewatering and bituminous materials added

The ESCP must include the following assessment factors:

> a description of the pre-development surface water runoff regime;
> the development area (hectares);
> the catchment area passing through the site (hectares) marked on drawing;
> a plan of the development area, identifying discharge points to waterways or pipelines;
> calculated flow rates, and velocities through from the site (dry weather, two-year flood and typical water levels);
> a site plan showing the proposed earthwork strategy;
> the earthworks engineering drawings;
> a statement on how the exposed soil surface will be minimised;
> a statement (with sketches as appropriate) on how sediment runoff will be trapped and disposed of;
> a statement on potential tracking of soils on and off site by machinery;
> a statement on other contaminants and how they will be controlled;
> a statement on how ground water will be treated and discharged (if required).

The ESCP must comply with the standards:

- as specified by Canterbury Regional Council e.g. *Erosion and sediment control guidelines*;
- *Water Related Services Bylaw*;
- *Soil Conservation Guidelines for the Port Hills*,
- *Erosion and sediment control: Guidelines for land disturbing activities in the Auckland Region.*

4.8.3 Protection measures

Take the following protection measures, unless incompatible with Canterbury Regional Council resource consent conditions:

- Construct stabilised construction entrances and detail proposed remedial works to mitigate contaminants moving off site e.g. mud on streets or silt in existing sumps in streets.
- Construct sediment traps and retention ponds where necessary. These should be cleaned out, as required, to ensure that adequate sediment storage is maintained.
- Use temporary barriers, or silt fences using silt control geotextiles, to reduce flow velocities and to trap sediment.
- Leave sections of natural ground unstripped to act as grass (or other vegetation) filters for run-off from adjacent areas.
- Construct temporary drains at the top and toe of steep slopes to intercept surface run-off and to lead drainage away to a stable watercourse or piped stormwater system.
- Slope benches in batter faces back and grade (both longitudinally and transversely), to reduce spillage of stormwater over the batter wherever surface water could cause erosion of batters, or internal instability through infiltration into the soil.
- Prevent surface water from discharging over batter faces by constructing open interceptor drains in permanent materials formed to intercept surface run-off and discharge via stable channels or pipes, preferably into stable watercourses or piped stormwater systems.
- Grade the surfaces of fills and cuts to prevent ponding.
- Shape and compact the upper surface of intermediate fills with rubber-tyred or smooth-wheeled plant when rain is impending or when the site is to be left unattended, to minimise water infiltration.
- Topsoil and grass the completed battered surfaces of fills to reduce run-off velocities.

> Re-topsoil and grass (or hydroseed) all earthwork areas as soon as possible after completion of the earthworks and drainage works.

> Use planting, environmental matting, hydroseeding, drainage channels or similar measures at an early stage in the earthworks construction phase as a permanent control of erosion and sediment discharge.

> To control dust or encourage early vegetation growth, water the site frequently during construction.

> Establish the permanent surface at an early stage of the construction phase.

Possible treatment methods are provided in the *Stormwater treatment devices: design guideline manual*.

Earthworks for developments on hillside land are not to be undertaken between 1 May and 31 August in any year, without the express written permission of the Council. This may be in the form of either conditions of subdivision, building or resource consent.

Ensure a satisfactory grass strike is obtained on all completed earthworks surfaces as soon as practicable. The intention is to provide early vegetative cover, particularly before the onset of winter, to minimise erosion and sedimentation. Suitable irrigation methods may be required to assist grass growth in the summer months.

Prevent water from stormwater systems flowing into a fill or into natural ground near the toe or sides of a fill. Do not construct stormwater or wastewater soakage systems in a fill, which could impair the fill's stability. Take into account the effect of utility services laid within the fill.

APPENDIX I

Statement of Professional Opinion on the Suitability of Land for Building Construction

ISSUED BY: ____

(Geotechnical engineering firm or suitably qualified engineer)

TO: ____

(Owner/Developer)

TO BE SUPPLIED TO: ____

(Territorial authority)

IN RESPECT OF: ____

(Description of infrastructure/land development)

AT: ____

____

(Address)

I ____ on behalf of

(Geotechnical engineer)

____

(Geotechnical engineering firm)

hereby confirm that:

1. I am a suitably qualified and experienced geotechnical engineer and was retained by the owner/developer as the geotechnical engineer on the above development.

2. The extent of my inspections during construction, and the results of all tests carried out are as described in my/the geotechnical completion report, dated ________________

3. In my professional opinion, not to be construed as a guarantee, I consider that (delete as appropriate):

(a) the earthfills shown on the attached Plan No ________________ have been placed in compliance with the requirements of the________________Council and my/the specification.

(b) the completed works give due regard to land slope and foundation stability considerations.

(c) the original ground not affected by filling is suitable for the erection thereon of buildings designed according to NZS 3604 provided that:

(i) ____

(ii) ____

(d) the filled ground is suitable for the erection thereon of buildings designed according to NZS 3604 provided that:

(i) ____

(ii) ____

(e)The original ground not affected by filling and the filled ground are suitable for the construction of a development/subdivision and 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: The sub-clauses in Clause 3 may be deleted or added to as appropriate.

4. This professional opinion is furnished to the territorial authority and the owner/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/the geotechnical report referred to in Clause 2 above, and shall not be copied or reproduced except in conjunction with the full geotechnical completion report.

6. The geotechnical engineering firm issuing this statement holds a current policy of professional indemnity insurance of no less than $________________.

(Minimum amount of insurance shall be commensurate with the current amounts recommended by IPENZ, ACENZ, TNZ, INGENIUM.)

______________________________________ Date:____________________________________

(Signature of engineer)

Qualifications and experience

____

____

APPENDIX II Soil Log

Project: Project No: Bore ID:

Client:

Bore Depth: Ground Level: Recorded by: Date:

Location: WaterTableDepth:

Elevation	Depth	Symbol	Material Description	Scala Penetrometer (mm/blow)	Depth
	0.0		Soil Type + Colour + Strength + Moisture + Grading + Organics	0 10 20 30 40 50 60 70 80 90 100	0.0
	0.1				0.1
	0.2				0.2
	0.3				0.3
	0.4				0.4
	0.5				0.5
	0.6				0.6
	0.7				0.7
	0.8				0.8
	0.9				0.9
	1.0				1.0
	1.1				1.1
	1.2				1.2
	1.3				1.3
	1.4				1.4
	1.5				1.5
	1.6				1.6
	1.7				1.7
	1.8				1.8
	1.9				1.9
	2.0				2.0
	2.1				2.1
	2.2				2.2
	2.3				2.3
	2.4				2.4
	2.5				2.5
	2.6				2.6
	2.7				2.7
	2.8				2.8
	2.9				2.9
	3.0				3.0

Locality Diagram

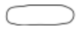
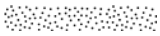
Other Comments:

Material Descriptions

Examples: Sandy GRAVEL, with some clay
Clayey SILT, with trace of peat, light grey, firm, moist

SOIL TYPE

Lesser Fraction	
20-50% volume	
Soil Type Term	
Coarse	gravelly
Medium	
Fine	
Coarse	sandy
Medium	
Fine	
Silty	
Clayey	
Peaty	

Dominant Fraction			
> 50% volume			
Soil Type term		**Particle size (mm)**	**Graphic Symbol**
Boulders		> 200	
Cobbles		60 - 200	
Coarse	Gravel	20 - 60	
Medium		6 - 20	
Fine		2 - 6	
Coarse	Sand	0.6 - 2.0	
Medium		0.2 - 0.6	
Fine		0.06 - 0.2	
Silt		0.002 - 0.06	
Clay		< 0.002	
Peat		N/A	

Minor Fraction		
12 - 20%	5 - 12%	< 5%
with some	**with minor**	**with trace**
Boulders		
Cobbles		
Coarse	Gravel	
Medium		
Fine		
Coarse	Sand	
Medium		
Fine		
Silt		
Clay		
Peat		

COLOUR

Adjective1	Adjective2	Main Colour
light	pinkish	pink
dark	reddish	red
	yellowish	yellow
	brownish	brown
	olive	olive
	greenish	green
	bluish	blue
	greyish	white
		grey
		black

STRENGTH

Cohesive Soil Consistency

Consistency	Undrained Shear Strength (kPa)	Characteristic
very soft	< 12	Easily exudes between fingers
soft	12 - 25	Easily moulded by fingers
firm	25 - 50	Can be moulded with fingers with some effort
stiff	50 - 100	Impossible to mould with fingers, but will change shape with heel pressure
very stiff	100 - 200	As for stiff, but considerable heel pressure is required
hard	200 - 500	Brittle, very tough

Non Cohesive Soil Density

Density	Characteristic
very loose	Very easy to excavate by hand
loose	Easy to excavate by hand
medium dense	Between loose and dense
dense	Very difficult to excavate by hand
very dense	Particles bound together

MOISTURE

Moisture	Description
dry	Cohesive soils usually hard or powdery Granular soils run freely through hands
moist	Some moisture present – usually darkens the colour
wet	Strong squeezing in the hand will drive some water out
saturated	Squeezing will drive water out

SAND/GRAVEL GRADING

well graded
poorly graded

ORGANIC CONTENT

Adjective	Organic Type
trace	fibrous
little	wood pieces
some	root fibres
and	vegetation

For full descriptions see: *Field Description of Soil and Rock*, NZ Geotechnical Society, Dec 2005