The Auckland Code of Practice for Land Development and Subdivision

Chapter 2:

Earthworks and Geotechnical

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The Auckland Code of Practice for Land Development and Subdivision Chapter 2: Earthworks and Geotechnical

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Auckland Council

Document control

Document name	Auckland Code of Practice for Land Development and Subdivision Chapter 2: Earthworks and Geotechnical

Purpose	To provide minimum standards for the geotechnical design and construction of new assets which are to be vested in Auckland Council ownership, and to guide other geotechnical and land development work occurring in the Auckland region. Developers shall discuss alternative approaches with Auckland Council, should the minimum standards not be achievable for vested assets.

Version history

Version	Date
1.6	September 2013
2.0	May 2023

Approval for Version 2.0

Reviewed and recommended for publication	Branko Veljanovski, Head of Engineering Design and Asset Management
Approved	Paul Klinac, GM Resilient Land & Coasts

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Table of Contents

Tables

Figures

2.0 Earthworks and Geotechnical

2.1 Scope

This Earthworks and Geotechnical Code of Practice is Chapter 2 (CoP Chapter 2) of Auckland Council's Code of Practice for Land Development and Subdivision. This May 2023 revision of the CoP Chapter 2 supersedes the September 2013 edition. CoP Chapter 2 shall be read in conjunction with the Auckland Council's Code of Practice*, Chapter 1: General Requirements.*

The word 'shall' refers to practices which are mandatory for compliance with CoP Chapter 2. The words 'should' and 'may' indicate a recommended practice. Any guidance given in CoP Chapter 2, including references to technical publications and guideline documents, is provided to assist with meeting these minimum standards.

2.1.1 Purpose

The purpose of CoP Chapter 2 is to provide the minimum standards required by Auckland Council for the geotechnical design and construction of new assets which are to be vested in Auckland Council ownership, while ensuring these assets are:

CoP Chapter 2 is intended to ensure that the newly built vested assets are:

- Cost effective and durable
- Able to provide effective and consistent service throughout their life without onerous maintenance requirements or costs
- Safe to maintain, operate and ultimately, decommission.

As the minimum standards in this CoP Chapter 2 are generally accepted by Auckland Council for public works, or works on land to be vested, we also encourage its use by developers and their consultants to land development and subdivision projects which will not be vested to Auckland Council to support applications for resource or building consent.

Detailed design advice is available in a range of Auckland Council technical publications and other relevant industry best practice guidelines, rather than contained within this document.

2.1.1.1 Non-complying designs

Auckland Council recognises that in some cases, minimum standards may not be achievable, or alternative designs maybe deemed more desirable. Non-complying designs (or design components) may be considered by Auckland Council where no compliant alternatives exist. Approval shall be via the Engineering Approval Process (refer to Section 2.2.2.1), and subject to the proposed designs being demonstrated to meet all the objectives listed above, and providing an equivalent standard of service, durability and safety.

Developers shall discuss any proposed alternative approaches to development and ownership with Auckland Council.

2.1.2 Revisions

Auckland Council intends to revise CoP Chapter 2 periodically in response to changes in legislation, policies, technology and national standards, and industry feedback.

A feedback form is available to download along with this document. Please send all feedback to geotech@aucklandcouncil.govt.nz.

2.2 General

2.2.1 Objectives

Auckland Council requires that any new assets created by or on behalf of Auckland Council or which are to be vested in Council ownership, are safe to build, maintain, operate and decommission. Auckland Council also needs to ensure that its assets perform consistently throughout their design life without onerous maintenance risks or costs, and that their impact on the environment and climate change are minimised and have regard for the key principles of resilience and adaptation.

This document sets out the minimum requirements that will apply and defines processes that, when followed correctly, should result in Engineering Approval for the geotechnical aspects of a project.

Infrastructure that does not meet the minimum engineering standards within this CoP Chapter 2 and/or does not comply with conditions of consent may, in certain circumstances, still be accepted as a departure with specific Engineering Plan Approval. It is strongly recommended that discussions take place with Auckland Council as both asset owner and regulator as early as possible where there is a risk that the minimum standards may not be achieved.

Auckland Council also requires that developments be undertaken in a way that does not expose people to unacceptable risks. This document sets out recommendations for the management of geotechnical risks in development projects.

For the purposes of Resource Consent for geotechnical work, this document is to be read as a localisation and interpretation of NZS4404:2010[1] (Section 2, *Earthworks and geotechnical requirements)*.

For the purposes of Building Consent for geotechnical structures, this document provides Auckland-specific advice on efficiently achieving compliance with the Building Act 2004 and the Building Code.

This document is intended to be consistent with the Auckland Unitary Plan, the Building Act 2004 and the Building Code. In the case of any contradictions, these documents shall take precedence over the Code of Practice, except where this Code of Practice sets a higher standard required for vesting of assets. Following the advice in this document does not guarantee compliance with these documents, so they must also be understood and followed throughout the design and construction process.

[1] Land development and subdivision infrastructure

2.2.2 Auckland Council Requirements

2.2.2.1 Engineering Approval

Engineering Approval is required for works and assets that are to be vested in Auckland Council ownership. Assets that do not meet the minimum engineering standards within this CoP Chapter 2 shall require specific design and will be subject to approval by the asset owner.

Where there is a conflict between the requirements of this Code of Practice and any other requirements or conditions, this shall be discussed and resolved with Auckland Council. In general, the most stringent requirement shall prevail.

The recommended first step for most land-development projects is a pre-application meeting with Auckland Council. Its purpose is to identify a range of consent requirement issues, including those relating to the Engineering Approval process. Potential non-compliance with CoP Chapter 2 should be presented at this stage, and possible alternative solutions explored.

2.2.2.2 Auckland Unitary Plan

All land development activities are subject to assessment against the statutory requirements set out in the Auckland Unitary Plan (AUP). The AUP replaces the previous Regional Policy Statement and 13 legacy plans and provides the regulatory framework for the management of Auckland's natural and physical resources.

AUP provisions are implemented through the resource consent process. Some use and development activities are Permitted Activities under the Plan; however, other approvals may still be required, and Auckland Council should be consulted to ensure that all necessary approvals are identified and being sought.

The AUP sets out the requirements for every stage of development to promote sustainable management under the RMA through managing adverse effects on the environment.

2.2.3 Legislation and policy

Auckland Council may require an assessment of land suitability to meet the provisions of the Resource Management Act, Building Act, Local Government Act and Auckland Unitary Plan requirements. This includes the Engineering Approval consent process.

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

The Council under its statutory obligations may require a Peer Review, regulatory review or assessment of effects review (or a combination of these).

2.2.4 Defined terms

A list of defined terms can be found in the Glossary at the end of this Code of Practice chapter. Some defined terms are capitalised to assist with their identification.

2.2.5 Reference documents

The following list of reference documents is provided to support engineers and developers working in the Auckland region. Knowledge of these documents will assist with the design, construction and Engineering Approval of geotechnical work in Auckland.

2.2.5.1 National Standards

- AS/NZS 1170.0:2002 - Structural design actions, Part 0: General principles
- AS/NZS ISO 31000:2009 (ISO 31000) – Risk management – Principles and guidelines
- NZS 1170.5:2004 - Structural design actions, Part 5: Earthquake actions
- NZS 3604:2011 - Timber-framed buildings
- NZS 4402:1986 - Methods of testing soils for civil engineering purposes
- NZS 4404:2010 - Land Development and subdivision infrastructure
- NZS 4407:2015 - Method of sampling and testing road aggregates
- NZS 4431:2022 - Engineered fill construction for lightweight structures.

2.2.5.2 Other Standards, Codes and Legislation

- Acceptable Solutions and Verification Methods for New Zealand Building Code, Clause B1 Structure
- Acceptable Solutions and Verification Methods for New Zealand Building Code, Clause B2 Durability
- AS 2870:2011 – Residential Slabs and Footings
- Auckland Unitary Plan
- BS 1377 (Part 1-9) Method of Tests for Soils for Civil Engineering Purposes
- BS 5930:2015 - Code of Practice for Ground Investigation
- Building Act 2004
- Health and Safety at Work Act 2015
- Resource Management Act 1991

2.2.5.3 Further documents

A list of further relevant documents can be found in Appendix A.

2.2.5.4 Sources of data

- Geological maps published by GNS Science
- Auckland Council GIS
- Auckland Council Technical Reports
- Auckland Council Practice Notes
- New Zealand Geotechnical Database.

It should be noted that if new versions of standards, codes and guidance are issued, the up-to-date version will supersede the version listed above.

2.2.6 Role of the Geo-professional

A Geo-professional shall be appointed as early as possible by the developer (or their professional advisor) where a proposed development involves any of the following:

- Development where geohazards (including those described in Section 2.5) are suspected
- Detailed evaluation is needed to assess the suitability of natural or filled ground for:
  - Foundations of buildings, roading, and other structures
  - Retaining structures.
- Earthworks
- Any development where the building consent approach requires an alternative solution for the geotechnical design.

Auckland Council relies on the assessment made by or reviewed by the Geo-professional. The Geo-professional shall carry out the functions defined in the following sections of this CoP.

The Geo-professional may also take the role of Geotechnical Designer for the project when the design process commences.

Where this document refers to work to be undertaken by the geo-professional, it may be undertaken by others on their behalf provided that the geo-professional supervises and reviews their work and takes responsibility for its validity.

2.2.7 Role of the Geotechnical Designer

The Geotechnical Designer is a Geo-professional with overall responsibility for the geotechnical design of the project.

Where this document refers to work to be undertaken by the geotechnical designer, it may be undertaken by others on their behalf provided that the geotechnical designer supervises and reviews their work and takes responsibility for its validity.

2.2.8 Role of the Peer Reviewer

An independent Geo-professional shall be appointed by the developer to undertake a Peer Review of the geotechnical aspects of the development where any of the following apply:

1) A Peer Review is required by this Code of Practice.
2) Auckland Council Regulatory Services determines that there is potential for damage and economic loss as a result of geohazard exposure or significant risks in the geotechnical design of the proposed development.

The Geo-professional undertaking the Peer Review for the assets created by or on behalf of Auckland Council or which are to be vested in Auckland Council ownership, shall be listed in the Auckland Council Producer Statement Register for Geotechnical Work.

More details about the Peer Review Process can be found in Engineering New Zealand Practice Note 2: *Peer Review and AC2301 – Producer Statement Policy*.

2.3 Geotechnical appraisal, investigation and design process

Unforeseen ground conditions often have a significant impact on the cost and risk of a project. The extent of unforeseen conditions and resultant capital cost increases are commonly linked to underinvestment in site investigations. International research shows a strong correlation exists between low spend on ground investigation and high capital cost over-runs.

Geotechnical appraisal, investigation and design should be optimised to minimise the risk posed to the client and the public by unforeseen ground conditions (Figure 1).

These geotechnical aspects will form part of the larger engineering project and should not be treated in isolation. Coordination between project disciplines to understand the scope and risks is essential to managing these risks.

The communication of the geotechnical conditions shall be achieved by the creation of an Engineering Geological Model, developed in accordance with IAEG Commission 25 Publication No. 1. The requirements of this Code of Practice take precedence over the IAEG guidelines where there is any contradiction.

As noted in the IAEG guidelines:

> *"An Engineering Geological Model should be developed for all projects that interact with the ground and is equally applicable for very large and very small projects ... The EGM development should commence at the project inception stage and be revised throughout the life cycle of the project, potentially passing between multiple owners and consultants, and provides a transparent and logical framework for developing ground related project deliverables."*

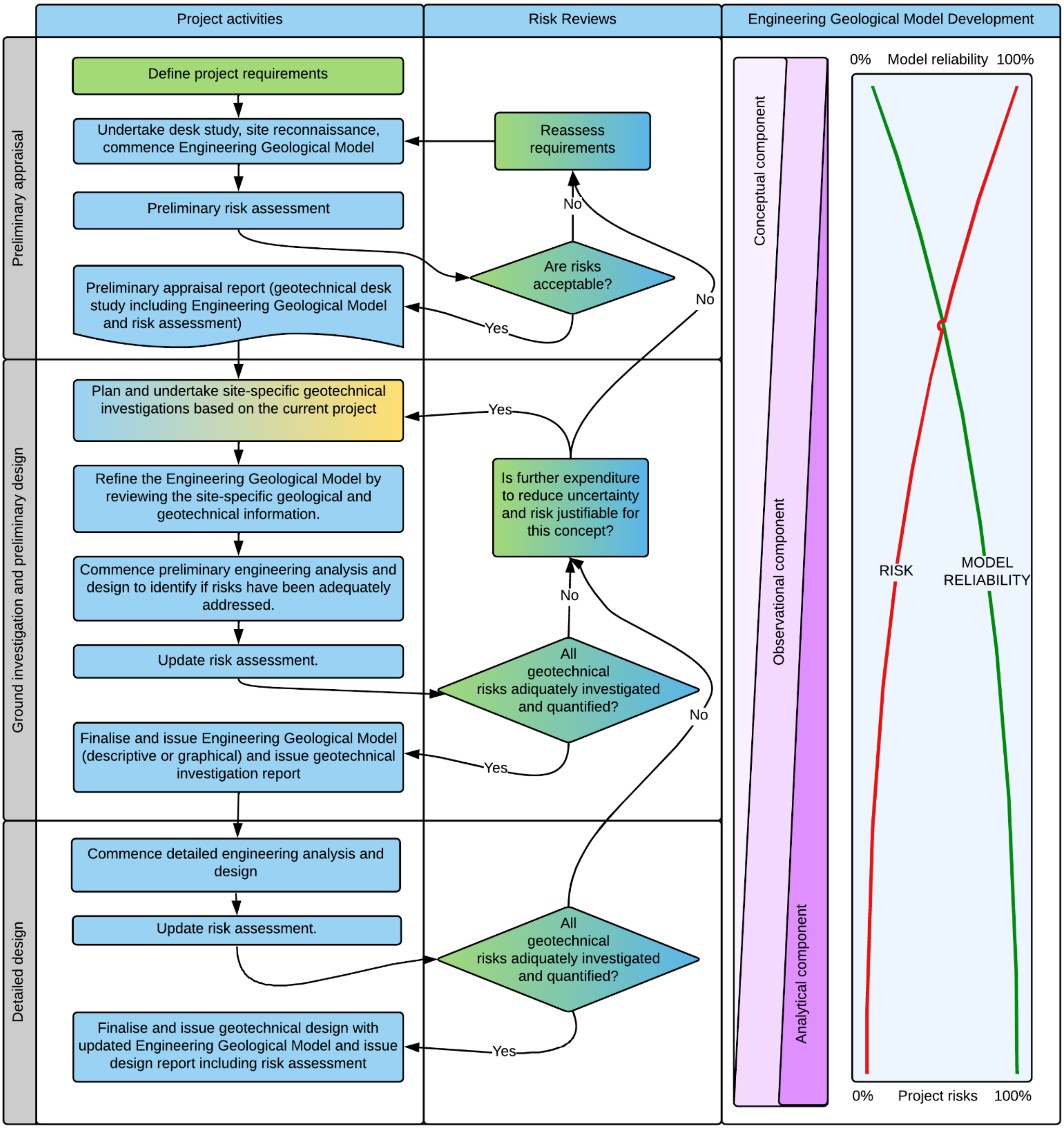

Figure 1: Typical project stages in the geotechnical appraisal and design process. See IAEG Commission 25 Publication No. 1 for further details about Engineering Geological Model Development. The level of detail and number of steps may be adjusted for larger or smaller scales of projects.

Tasks are colour coded by the organisation that is usually responsible. Green = client, blue = Geotechnical Designer (or other Geo-professional in preliminary appraisal phase), yellow = geotechnical contractor.

2.3.1 Preliminary appraisal

The preliminary appraisal should be carried out to assess the general suitability of a site for its proposed use, to identify risks to the project, and to gain an appreciation of the geotechnical design and testing requirements to manage these risks.

During the preliminary appraisal phase, the developer (or their professional advisor) shall engage a Geo-professional as per requirements described in Section 2.2.6. The Geo-professional shall start to develop an Engineering Geological Model. To achieve this they shall:

- Assess the scale of Engineering Geological Model required, following the advice set out in IAEG Commission 25 Publication 1 Table 1-1
- Undertake a preliminary site evaluation in the form of a desk study and visual inspections (sometimes referred to as site walkover survey)
- Identify possible geohazards (including all those defined in Section 2.5)
- Assess the suitability of the site for its intended purpose
- Gain an appreciation of design requirements, possible construction difficulties and consent requirements
- Determine the requirements or need for a ground investigation
- Assess the land for building in accordance with NZS 3604[2]
- Work with other engineering and planning professionals on the project to identify if there is a need for a Contaminated Land – Suitably Qualified and Experienced Practitioner (CL-SQEP) to assess the potential for contamination at the site. Where this is the case, the assessment should be in accordance with the Preliminary Site Investigation requirements of the Ministry for the Environment *Contaminated Land Management Guidelines No. 5*, and should recommend further investigation where appropriate
- Prepare a Geotechnical Appraisal Report (as per Section 2.9.5), a Risk Register (as per Section 2.4.4) and Drawings (as per Section 2.9.14).

2.3.1.1 Preliminary appraisal - desk study

A desk study shall be undertaken prior to visual inspection and physical investigation and shall consist of collection and review of available geological and geotechnical information about the site including:

- Topographic data
- Geological, engineering-geological and hydrogeological maps
- Geotechnical reports and ground investigation results from the site including those available on the New Zealand Geotechnical Database and property files
- Current and historical aerial photos.

[2] Timber-framed buildings

In addition, the Geo-professional shall check the Auckland Unitary Plan (and other plans where these are in effect) and publicly available Auckland Council records including hazard layers on Auckland Council GIS.

2.3.1.2 Preliminary appraisal - visual inspection

A visual inspection involves walking over the site and the surrounding area and recording any geotechnical and geological observations, including performance of any existing structures which may be relevant to the project. The visual inspection shall highlight any apparent geotechnical and geological features, presence of hazards, and issues which may be related to the proposed development.

In most cases, remote observations (e.g. use of Google Street View) are not acceptable as an alternative to a site walkover.

2.3.2 Ground investigation

A ground investigation serves two primary purposes:

1) Providing data for analysis and design
2) Reducing uncertainty about ground conditions and construction cost variations (i.e. control of risk).

The amount, location and method of ground investigation should be selected with both these aims in mind.

The extent of the ground investigation shall be defined by the Geotechnical Designer to appropriately manage project risks and provide high-quality design information, taking into consideration the minimum requirements and guidelines described in:

- NZS 3604:2011 *Timber Framed Buildings*
- MBIE "*Planning and engineering guidance for potentially liquefaction-prone land*"
- NZGS/MBIE Earthquake Geotechnical Engineering Practice Module 2 and 3; and
- NZGS/MBIE/Auckland Council "*New Zealand Ground Investigation Specification*".

The number, type and depth of the in-situ ground investigations and laboratory tests shall also reflect geohazards identified during the desk study and visual inspection and complexity of the proposed development (e.g. depth of the proposed cuts and fills, height of the proposed retaining structures, proposed surcharge etc.).

The investigation and testing shall follow New Zealand standards and guidelines.

Physical investigations should be undertaken in locations that:

1) Allow the best possible identification of the full range of conditions across the area to be developed
2) Manage the risks identified in the preliminary appraisal
3) Test the ground model prepared in the preliminary appraisal so that this is robustly defined beyond the vertical and horizontal extents of the proposed development
4) Provide design parameters at locations and depths appropriate for the design of the proposed structure(s) and the assessment of the stability of the site.

Ground investigations including groundwater monitoring shall be undertaken at times of the year that are representative of conditions that may have the most significant effect on the proposed development and shall be of sufficient depth that they extend beyond the zone of influence of foundations and retaining wall footings. The groundwater monitoring shall consider the potential for variable groundwater level across the site and presence of multi-layered aquifer systems, and the need for multiple piezometers in different levels. The groundwater monitoring shall start a minimum of two months, and in some cases a minimum of 12 months, prior to commencement of the geotechnical design. The duration of the monitoring should be proposed by the Geotechnical Designer based on the risk assessment and the need to understand the seasonal groundwater range and shall be agreed with Auckland Council.

Where groundwater drawdown induced settlement is a potential issue this will normally require monitoring during summer and autumn to measure the seasonal low. For floatation, liquefaction, retaining wall / slope design or stormwater disposal the seasonal high will be more critical.

Ground investigations are commonly undertaken in multiple phases, with the first phase often coinciding with preliminary design on smaller projects.

The risk assessment process and the Risk Register shall be used to identify where additional ground investigation is needed to understand, reduce or control risks.

2.3.3 Preliminary design

During preliminary design, the general site layout shall be determined, and the most appropriate landform selected. The choice of a suitable landform will be specific to each site. The following shall be considered:

- Minimising risk to life, property and infrastructure from geohazards including all those defined in Section 2.5.
- Minimising risk to property and infrastructure occurring through flooding or surface water run-off and designing works and landform 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 erosion or an inundation hazard.
- Minimising the risk of slope instability through careful control of stormwater and groundwater.

- Minimising whole-of-life costs by balancing long-term maintenance requirements and up-front construction costs including minimisation of the use of structural elements (such as retaining walls) which will require ongoing maintenance.
- Using low-impact design principles including retention of existing landforms and natural features where possible, minimising the alteration of landforms as far as practicable, and avoiding earthworks where there are existing habitats of indigenous species, wetlands, or areas of high natural character.
- Protection of existing natural resources including topsoil, well-drained soils and natural soakage areas.
- Minimisation of the use of high-value resources by reducing the total volume of earthworks required, or by enabling the use of less valuable natural resources (e.g. by reducing slope angles).
- Minimising the whole-of-life carbon cost of the design.

As a part of preliminary design, the Risk Assessment shall be updated.

Where part of the site or adjacent land is potentially unstable, a Geo-professional shall define a proposed Building Line Restriction and Specific Design Zone. When proposing these lines / zones, the Geo-professional shall consider:

- Slope regression (including coastal erosion taking into account sea level rise where relevant) over a 100-year period
- Slope stability under normal, extreme and seismic loadings, taking into account climate change effects (e.g. increased rainfall intensity, more variable groundwater conditions, more frequent droughts).

The Preliminary Geotechnical Design shall be reported as defined in Section 2.9 either as a section in a Geotechnical Interpretative Report, as a preliminary issue of the Geotechnical Design Report, or as a section in a multi-disciplinary Preliminary Design Report.

2.3.4 Detailed design

During the Detailed Design Stage, the preliminary design shall be optimised taking into account ease of long-term operation and maintenance of the site and future demolition of structures, including those supporting the land.

The detailed design shall be reported as defined in Section 2.9 (Geotechnical Design Report).

Consideration shall be given to the lifespan of a Building Platform, which may be longer than the design life of soil drains or supporting structures such as retaining walls. Where these drains or structures are on or cross a boundary, the ownership and responsibility for maintenance of the structures shall be made clear. It is generally preferable to locate these features clearly within the lot which benefits from their presence.

2.4 Risk assessment and communication

2.4.1 Risk assessment process

Many sites in Auckland are at risk from geohazards. In most cases, the risk posed by these hazards is best assessed by a Geo-professional.

The likelihood of the hazard occurring, and the vulnerability and exposure of elements at risk (including land development activities) to the hazards should be considered to understand the risk and to determine how best to reduce possible consequences.

The objective of this section is to provide a systematic and consistent approach to address and manage geohazards in a way that clearly and consistently documents decisions so that stakeholders understand the potential threats and opportunities that exist.

AS/NZS ISO 31000:2009 (ISO 31000)[3] and the companion handbook provide general guidance to setting the principles, design and implementation of risk management. The risk management process, as it applies to land development activities is shown in Figure 2.

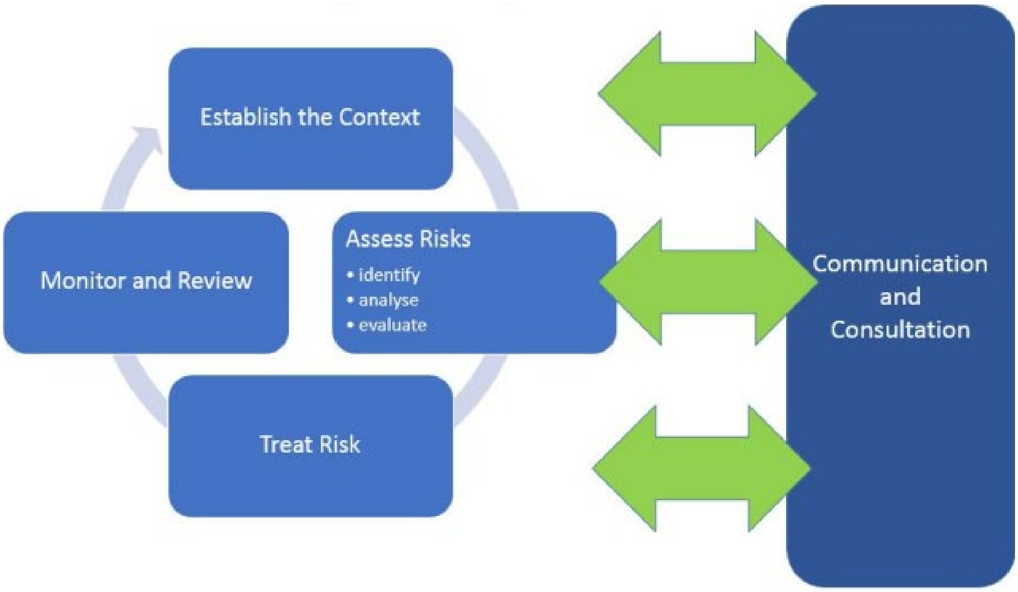

Figure 2: Excerpt from ISO 31000 (Risk Management Process)

[3] Risk management – Principles and guidelines

2.4.2 Identifying hazards and opportunities

Safety in Design shall be part of a design process and follow requirements described in the Health and Safety at Work Act 2015, in particular Section 39 (design responsibilities), and Section 34 (consultation), and SiteSafe, Safety in Design in Construction.

The design shall consider the whole project life cycle and appropriately manage risk to the safety of those who build, use, maintain and decommission the structure, and any other people who could be affected by the work. This includes reviewing how the proposed development (including earthworks and temporary works) can be constructed, operated, maintained, decommissioned and/or demolished safely. For more details please refer to the Auckland Council Code of Practice*, Chapter 1: General Requirements,* Section 1.3.1 Safety in Design.

The Geo-professionals shall work with other disciplines to identify hazards and opportunities that may affect the design, construction, operation, maintenance and decommissioning of the proposed development or structure.

As a minimum, the following hazards and opportunities shall be assessed by the Geotechnical Designer:

- Geohazards listed in Section 2.5. Where the hazard is not present at the site, this should be stated in the risk assessment
- Other geohazards the Geo-professional considers applicable
- Ground model and geotechnical parameter uncertainty
- Changing conditions over the design life (e.g. due to climate change or land use change)
- Buried services
- Adjacent structures and land-use
- Temporary geotechnical works (e.g. temporary cut slopes, trenches)
- Permanent geotechnical works (e.g. Engineered fill, foundations)
- End-of-life (e.g. foundation re-use, material recycling).

2.4.3 Analysing and assessing risks

Risks are assessed by assigning a likelihood and consequence to each of the identified hazards. Risks that have been identified as having the potential to impact on the proposed development or stakeholders can be analysed using the risk classification table (Table 1).

Table 1: Risk classification

		Consequence				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Extreme 5
Likelihood	Almost Certain 5	Medium 5	High 10	Very high 15	Extremely high 20	Extremely high 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extremely high 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

Some risks will have multiple possible combinations of likelihood and consequence. For example, a marginally stable slope near a proposed residential development may be likely to fail in a way that causes minor damage (Likelihood = 4, Consequence = 2, Risk = 8), or it may fail catastrophically in a way that causes extreme damage, but only in rare circumstances (Likelihood = 1, Consequence =5, Risk = 5). In these cases, the Geo-professional shall assess each combination as they may have different mitigation requirements.

Likelihood can be defined as presented in Table 2. For most projects it is expected that a Qualitative Risk Assessment will be undertaken using expert judgement. In rare cases where good data is available and the consequences are significant, a Quantitative Risk Assessment may be appropriate. In this table, the term “Period of Exposure” means:

- For temporary works, the duration of the works
- For buildings, structures, earthworks and other elements, the design life.

Table 2: Likelihood classification

	Definition
Almost certain: 5	The risk or event has a greater than 90% chance of occurring during the period of exposure.
Likely: 4	The risk or event has a 50% to 90% chance of occurring during the period of exposure.
Moderate: 3	The risk or event has a 25% to 50% chance of occurring during the period of exposure.
Unlikely: 2	The risk or event has a 10% to 25% chance of occurring during the period of exposure.
Rare: 1	The risk or event has a less than 10% chance of occurring during the period of exposure.

Generic consequences are defined in Table 3. Where other consequences are relevant to the project but are not defined in the table, they should be given a rating based on expert judgement equivalent to comparable consequences in this table. In each case, the worst outcome identified in the definitions should provide the score used in the risk assessment.

Table 3: Consequence classification (note 1: "Assets" refers only to Auckland Council family-owned infrastructure assets)

	Definitions		
	Assets[1] & economy	**Safety & disruption**	**Environment**
Extreme **5**	Economic loss >$100M *OR* asset damage >$1M *OR* Total loss of asset that cannot be replaced	Fatality likely. *OR* Major community (e.g. sociological or cultural) concerns causing major re-think or complete failure of plans. Localised or widespread damage and disruption to the community (any duration), with potential for loss of life.	Extensive irreversible damage (widespread) to the environment. *OR* Widespread, irreversible damage to land and/or water ecosystems. *OR* Permanent loss of one or more species. *OR* Destruction of property / widespread flooding. Recovery time exceeding 6 months. *OR* No recognition of the intent of legislation, Auckland Plan.
Major **4**	Economic loss $10M-$100M *OR* asset damage $100k-$1M *OR* Assets not useable / available for the long term	Injury or permanent disability likely. *OR* Widespread significant community (e.g. sociological or cultural) causing significant delays and modifications to plans. *OR* Localised or widespread long term (greater than 3 weeks) reversible or irreversible damage; disruption to community.	Irreversible localised damage (major) to the environment *OR* Widespread, long term reversible damage to land and/or water ecosystems *OR* Significant reduction in one or more species *OR* Severe erosion and/or damage to property. Recovery time up to 6 months *OR* Repeated and significant inconsistency with the intent of legislation, Auckland Plan.

	Definitions		
	Assets[1] & economy	**Safety & disruption**	**Environment**
Moderate **3**	Economic loss $1M-$10M *OR* asset damage $10k-$100k *OR* assets not useable / available for the medium term	Injury or illness likely. *OR* Significant community (e.g. sociological or cultural) concerns causing delays and modifications to plans. *OR* Localised medium term (1 to 3 weeks) reversible damage and disruption to the community, with some potential safety issues.	Measurable damage to the environment; significant corrective action. *OR* Localised, medium term reversible damage to land and/or water ecosystems *OR* Moderate reduction in one or more species *OR* Moderate erosion and/or damage to property. Recovery time 1 month. *OR* Repeated inconsistency with the intent of legislation, Auckland Plan.
Minor **2**	Economic loss 0.5M-$1M *OR* asset damage $5k-$10K *OR* assets not useable / available for short undefined period	Local community (e.g. sociological or cultural) concerns that can be dealt with. *OR* Localised minor reversible damage and disruption to the community, with no potential public safety issues or long-term effect.	Contained and reversible (minimal) environmental impact. *OR* Localised minor reversible damage to (use of) land and/or water *OR* Localised minor reversible damage to land and/or water ecosystems. *OR* Temporary reduction in one species *OR* Minor erosion and/or damage to property. *OR* Minor inconsistency with the intent of legislation, Auckland Plan.
Insignificant **1**	Economic loss <$0.5M *OR* Damage / loss of a minor asset worth <$5k *OR* Assets not useable / available for short defined period	No significant community (e.g. sociological or cultural) issues. Localised short term reversible disruption to the community, resulting in no noticeable damage.	Small localised and reversible environmental impact: • Slight, short-term damage to use of land and/or water • Slight short-term damage to land and/or water ecosystems • No noticeable species reduction • Occasional inconsistency with the intent of legislation, Auckland Plan.

2.4.4 Risk communication – Risk Register

A Risk Register shall be presented to Auckland Council to communicate the risk assessment undertaken. It shall include, as a minimum, a line for each of the issues defined in Section 2.4.2.

The Risk Register shall present:

1) The risks that have been assessed.
2) The assessed risk rating for each of these risks showing the untreated risk (i.e. before any mitigation), using the criteria defined in Section 2.4.3. If additional criteria have been used, these must be presented alongside the Risk Register.
3) The proposed mitigation measure(s).
4) The residual risk.
5) The owner of the risk (i.e. the individual or organisation responsible for implementing the proposed mitigation measure(s)).

The Risk Register shall be used in the Safety in Design process. See the Auckland Code of Practice, *Chapter 1: General Requirements,* Section 1.3.1 Safety in Design for more details.

Where the untreated risk is Very High or Extremely High (as per Table 1) a Peer Review will normally be required to confirm that the proposed mitigation measures are appropriate.

2.4.5 Risk communication – Drawings

It is an expectation of Auckland Council that the design will deliver Building Platforms and associated land and infrastructure that are appropriate to the likely development, and resilient against natural and geohazards. To allow these to be assessed, the hazards need to be shown on a plan which also shows elements potentially at risk.

See Section 2.9.14 for more details.

2.5 Geohazards

During the risk assessment and design process, each of the hazards described in this section, and any other hazards the Geo-professional considers are relevant, shall be considered and the potential risk from each addressed by the Geotechnical Designer in the design of the proposed development.

The presence or absence of each of these hazards shall be documented in the Risk Register and the appropriate geotechnical reports along with details of proposed mitigation measures.

2.5.1 Seismic hazards

The site subsoil class, peak ground acceleration, and the effects of seismic shaking on fill, slopes and potentially liquefiable ground shall be assessed by preference following the Earthquake Geotechnical Engineering Modules published by the New Zealand Geotechnical Society and the Ministry for Business, Innovation and Employment (MBIE). Where appropriate, the relevant elements of AS/NZS 1170.0:2002, NZS 1170.5[4], and Waka Kotahi's current Bridge Manual SP/M/022 may also be used where deviation from the MBIE guidance can be justified.

2.5.1.1 Liquefaction

Determination of liquefaction vulnerability category shall be in accordance with the methods detailed in the MBIE document "*Planning and engineering guidance for potentially liquefaction-prone land Resource Management Act and Building Act aspects*" (2017). A region-wide liquefaction assessment has been carried out by Auckland Council which has assigned desktop-based liquefaction vulnerability categories to the Auckland Council area. This assessment information is available to view on the Auckland Council GeoMaps web viewer.

Because of the limited amount of subsurface ground information available for the area-wide liquefaction mapping on the Auckland Council GeoMaps web viewer, significant uncertainty remains regarding the level of liquefaction-related risk, how it varies across each mapped area, and the delineation of boundaries between different areas. Accordingly, further site-specific ground investigation and liquefaction assessment may be required for developments, dependent on the initial site vulnerability category and the proposed development type. The methods detailed in the MBIE document "*Planning and engineering guidance for potentially liquefaction-prone land Resource Management Act and Building Act aspects*" (2017) shall be used to determine the requirements for further liquefaction assessment and liquefaction resilient design.

[4] Structural design actions - Part 5: Earthquake actions

2.5.2 Compressible soils

The effect of the proposed development on compressible soils shall take into account settlement caused by direct loading and permanent or temporary changes in groundwater. Consideration should be given to all likely causes of groundwater level change including construction activities, changes in infiltration rates due to land use change, and climate change.

The following potential consequences shall be addressed:

- Potential damage to buried infrastructure within and adjacent to the site
- The impact on structures within the zone of influence of the activities on the site from time-dependent primary and secondary consolidation
- The potential impact of changing groundwater levels relative to the ground surface on other hazards such as - liquefaction.

Where pre-existing buried infrastructure is present and may be affected by soil compression, a condition survey should be undertaken to enable the vulnerability of the infrastructure to be assessed.

Special attention should be paid to soft/very soft organic soils including peat. These soils typically exhibit high magnitude, time-dependent settlements (usually described as a primary and secondary consolidation) that require specific engineering design and careful mitigation measures to ensure that land development is undertaken in compliance with the Auckland Unitary Plan.

2.5.3 Acid sulphate soils

Acid sulphate soils are naturally occurring soils originally deposited in anaerobic marine conditions. If left undisturbed, sulphides remain in the soil without causing any major issues. If the soils are disturbed and exposed to air, e.g. by earthworks or by groundwater level changes, the sulphides can react with oxygen and release sulphuric acid causing the groundwater to become acidic.

The potential for acid generation as a result of earthworks or groundwater level changes shall be considered. Where there is potential for acidification, management strategies shall be put in place.

The assessment methodology and mitigation options shall be consistent with the Queensland Acid Sulfate Soil Technical Manual: *Soil Management Guidelines*, 2014.

2.5.4 Expansive soils

The expansivity of the soils at the site shall be assessed and taken into account in the design in accordance with B1/AS1 (which refers to AS 2870:2011[5] and BRANZ Study Report 120A[6] (2008)), or any other standards and/or guidelines which will officially supersede these documents.

All developments on sites with clay or clay-like soils shall be tested for moisture content, Liquid Limit and Plastic Limit (NZS 4402:1986[7] Tests 2.1 to 2.4), and the results presented in the Geotechnical Interpretative Report on a plasticity chart.

The Geotechnical Designer shall clearly define the following:

- Whether expansive soils are present on the site
- The method by which expansive soil classification has been carried out.

Geotechnical assessments shall also provide advice on the effects of tree removal and/or planting on the proposed foundations system.

2.5.5 Sensitive soils

The sensitivity of soils at the site shall be assessed following the NZGS field description of soil and rock (New Zealand Geotechnical Society, 2005). Where sensitive soils are present, re-working of the soils shall be minimised, and management strategies presented in the Geotechnical Interpretative Report.

2.5.6 Collapsible soils

The presence of collapsible soils (both naturally occurring at the site or imported as fill) shall be assessed. Collapsible soils are usually moisture sensitive and the primary triggering mechanism for the volume reduction of these soils is increase in moisture content. The assessment shall consider how changes in groundwater levels (which may be caused by the proposed development, climate change etc.) may increase the risk of collapse compression.

Collapsible soils can also be susceptible to dynamic settlement and liquefaction. Where collapsible soils are present on the site, in-situ and/or laboratory collapse testing shall be undertaken to assess the risk, e.g. field plate-load collapse test or one-dimensional response-to-wetting tests.

Where potentially collapsible materials are proposed to be used as fill, this shall be identified in the Geotechnical Interpretative Report and the risk managed with a comprehensive programme of fill testing defined in the Earthworks Specification.

[5] Residential slabs and footings

[6] Soil expansivity in the Auckland region

[7] Methods of testing soils for civil engineering purposes – soil strength tests

2.5.7 Landslide susceptible ground

Where there is the presence of a landslide, an unstable slope, or there is potential for future instability (whether caused by the development or other drivers), the risk shall be assessed by the Geotechnical Designer.

The stability of the slope shall be analysed using generally accepted quantitative methods (as described in Section 2.6.8) and the results used to inform the risk assessment described in Section 2.4.

For sites with existing landslides where the risk (based on the definitions in Section 2.4) is high or above, the assessment of the risk shall be in accordance with the Australian Landslide Risk Management Guidelines 2007. The Geotechnical Interpretative Report shall present for each landslide:

- The likelihood of each landslide becoming active (with justification including an estimate of uncertainty)
- The likely consequence to property and life (with justification including an estimate of uncertainty)
- The resulting risk
- The assumptions made in assessing the risk
- A risk assessment in relation to tolerable risk criteria (using an annual individual fatality risk of 10-4 for people in existing structures and 10-6 for new structures unless otherwise defined in the project requirements)
- Risk mitigation measures and options, including reassessed risk once those measures are implemented.

Deep ground investigations and groundwater monitoring are likely to be required to properly assess unstable and Significant Slopes or potential for future instability. These assessments shall consider possible future climate changes including the potential for increased rainfall intensity, more severe droughts, and changes in groundwater levels.

2.5.8 Stream instability and erosion

Where watercourses including ephemeral streams are present at or adjacent to a site, the potential for erosion over a 100-year period shall be taken into account in the design, including consideration of changes to water flow resulting from the proposed development, from other likely developments in the catchment, and from climate change. Where data to support such an assessment is unavailable, conservative assumptions should be made and the level of uncertainty documented in the Risk Register.

2.5.9 Coastal instability and erosion

A preliminary indication of the susceptibility of a site to coastal instability and erosion shall be identified using the results of Auckland Council, technical report, TR2020/021[8], and the associated maps available on Auckland Council's GIS website. Where more detailed site-specific studies are available, these may be used as an alternative but must be provided as supporting evidence and their validity must be robustly demonstrated.

Where there is potential susceptibility to coastal instability or erosion within a 100-year period, a more detailed assessment will be required unless it can be demonstrated that the risk is low (e.g. due to the short lifespan of the structure or the intended use).

This more detailed assessment of coastal cliffs shall consider regression of the cliff face and weathered mantle 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 of erosion processes. The assessment of cliff regression shall take into account the impact of sea level rise using the latest sea level rise predictions produced by NIWA for the RCP8.5M scenario using the methodology defined in Auckland Council guideline document, GD2021/010[9].

The assessment of the stability of the weathered mantle shall take into account the effects of increasing rainfall intensity and increasing drought frequency in line with predictions for the RCP8.5M scenario.

2.5.10 Geothermal issues

Where geothermal activity may be present on the site, the following hazards shall be considered:

- Steam and toxic gases including, but not limited to carbon dioxide (CO_2), hydrogen sulphide (H_2S), and sulphur dioxide (SO_2)
- Rapidly increasing temperature with depth
- Scalding hot water
- Geyser eruptions
- Amoebic meningitis
- Geothermal chemicals in water
- Boiling mud
- Geothermally altered ground
- Hydrothermal eruptions.

[8] Predicting Auckland's exposure to coastal instability and erosion

[9] Coastal hazard assessment in the Auckland region

Ground investigations in geothermal areas shall be undertaken by a contractor experienced in geothermal drilling with the requirements as to:

- Preventing release of highly pressured hot geothermal fluids during drilling
- Monitoring presence of toxic gases
- Sealing boreholes after drilling to prevent any geothermal eruptions
- Tracking geothermal fluids to the surface
- Providing a back-up blowout preventer, etc.

Special attention shall be paid to geothermally altered ground during geotechnical and structural design since the geothermally altered ground can be prone to subsidence and landslides and is often corrosive.

2.5.11 Soil erosion

The risk of soil erosion shall be assessed by the Geotechnical Designer or a civil engineer. Soil erosion is defined as the removal and transportation of soil materials by water, wind or waves. The impact of the proposed development on soil erosion shall be addressed in the design of permanent and temporary works, and in the site management plan. Activities that increase the risk of soil erosion (e.g. disposal of stormwater through drainage pipes on a slope or cliff, permanent de-vegetation of the slope etc.) shall be avoided.

2.5.12 Rockfall or falling debris

Where a rockfall or falling debris hazard is present on the site, or could impact on the site, a risk assessment shall be undertaken by the Geotechnical Designer. If an active or passive rockfall protection system is required, the design of the system shall be undertaken by the Geotechnical Designer. The rockfall risk mitigation process shall be in accordance with *Rockfall: Design considerations for passive protection structures* (MBIE and New Zealand Geotechnical Society).

2.5.13 Uncontrolled fill

Uncontrolled fill is soil, rock or equivalent materials placed by human activity without engineering controls. It commonly consists of a mix of natural and/or artificially altered material such as loose or poorly compacted soils, buried demolition debris, domestic, building, industrial and soil waste, wood, etc. Uncontrolled fill is usually not suitable as a foundation material due to the risk of high total and differential settlement, poor bearing capacity, possible contamination and, in some cases, the emission of gases.

Where uncontrolled fill is encountered during the ground investigation, the fill shall be either excavated and replaced by Engineered Fill, or specific geotechnical investigation and design shall be undertaken to confirm the extent to which uncontrolled fill will be suitable as a foundation material and/or provide specific foundation design (e.g. piling foundation, stone columns etc.).

2.5.14 Contamination

Any historical or current activities that could have resulted in contamination shall be addressed during a desk study (Geotechnical Appraisal Report, or equivalent section in a combined report) and a site visit. This study should take place prior to any physical ground investigation as a part of health and safety risk management. Where this study identifies the potential for contamination, a Preliminary Site Investigation shall be undertaken to identify if the land is in a category under the Ministry for the Environment's Hazardous Activities and Industries List (HAIL). The Preliminary Site Investigation shall be undertaken and reported in accordance with Ministry for the Environment "*Contaminated land management guidelines No. 1: Reporting on contaminated sites in New Zealand"* by a Contaminated Land – Suitably Qualified and Experienced Practitioner (CL-SQEP).

Even if the site has not been identified as HAIL, the geotechnical works shall proceed under precaution operation under Accidental Discovery Protocols required by the Auckland Unitary Plan in the following sections:

- E11 Land Disturbance – Regional, Section E11.6.1 Accidental discovery rule
- E12 Land Disturbance – District, Section E12.6.1 Accidental discovery rule

If contaminated land is present on the site, the geotechnical works shall proceed as per the Auckland Unitary Plan, *Section E30 Contaminated Land, and the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2011*. The Health and Safety at Work – Asbestos Regulations, 2016, may also be applicable.

2.6 Design considerations

The purpose of this section is to present typical geotechnical design considerations, but not to cover all geotechnical designs and practices. Auckland Council requires that all geotechnical design processes shall follow appropriate New Zealand and international standards and guidelines. Where appropriate standards and guidelines are not available or applicable, published peer reviewed papers may be suitable as a reference to guide the design.

Designs which have not followed New Zealand or international standards may require referral to an Auckland Council geotechnical specialist and/or external Peer Review.

2.6.1 Design life

A minimum 100-year design life is required for all geotechnical works to be vested in Auckland Council, and all geotechnical works and geotechnical structures (e.g. retaining walls) supporting assets owned or to be vested in Auckland Council.

A shorter design life may be accepted by exception where a renewal methodology is given within the design documentation, and where the shorter design life is justified by reduced whole-of-life costs and sustainability considerations. Such decisions must be justified by a robust risk and impact assessment and shall be presented to Auckland Council for approval.

2.6.2 Selection of geotechnical design parameters

The level of uncertainty that is appropriate to tolerate in geotechnical design should be a function of the potential consequences of failure. As described in Section 2.4.2, uncertainty in geotechnical parameters shall be documented in the risk register.

The parameters selected to represent the behaviour or performance of soil or rock for use in geotechnical design shall be selected as a cautious estimate of the value affecting the failure mode or limit state. For parameters for which the relevant values in the field are well established with little uncertainty, the design value may be taken as a moderately conservative estimate of the value in the field. Where there is more uncertainty, the design value shall be more conservative. The Geotechnical Designer shall select design parameters using their engineering judgement that take into consideration:

1) The uncertainty in the parameters (e.g. because of variability in the ground or uncertainty in the testing methods used).
2) The criticality of the parameter to the failure modes being assessed. Sensitivity testing of the design may be required to determine this.

The following options are provided as a general guide to parameter selection. These should be amended based on engineering judgement where this can be robustly justified through the risk assessment process:

- Where the parameters are directly tested with a reliable test method at the location of the design, with a sufficient quantity of testing to assess the range of values and determine a mean, the design value should normally lie between the 25th percentile and the 50th percentile of test results. In general, lower values will be selected where the testing gives results that are abnormal for the tested geology and may be at the higher end where they are consistent with similar nearby sites. Lower values would also be selected where the design is particularly sensitive to the specific parameter.
- Where the parameters are indirectly tested on site (e.g. by correlation with other tests), the design value should not normally exceed the 25th percentile of test results. Lower values would be selected where the design is particularly sensitive to the specific parameter.
- Where a parameter has been directly tested on site, but there is insufficient data available from on-site investigations to calculate percentiles of test results, values shall be selected based on combining site testing results with published data from equivalent locations. The Geotechnical Designer shall include in their reports the sources of information used and explain why the data is considered relevant for the site. Parameters should not normally exceed the 25th percentile of test results available for sites believed to have comparable geotechnical conditions. Lower values would be selected where the design is particularly sensitive to the specific parameter.
- Where the parameters are not tested on site but are assessed by correlating the soil or rock description with test results from nearby similar sites (including published compilation datasets), the parameters shall generally take the worst known plausible values and should not normally exceed the 5th percentile of test results available for sites believed to have comparable geotechnical conditions. The Geotechnical Designer shall include in their reports the sources of information used and explain why the data is considered relevant for the site. This would apply to any values estimated from general experience, published tables etc. which have not been validated with a site-specific ground investigation. This approach is not usually appropriate and is only acceptable for the very lowest risk projects.

The values suggested above are based on a low value being conservative. For parameters where a high value may be conservative (e.g. pore water pressure) the percentiles should be inverted (e.g. take 75th percentile instead of 25th percentile). The percentiles proposed here align with generally accepted good practice but should be reviewed to take into consideration site variability and the quality of information available. The selection of design values should be based on a careful evaluation of site-specific conditions, engineering judgment, and accepted standards and guidelines.

Key factors that should be considered include

- The spatial relevance of the data to the project – location and scale
- The quality of the available data sources
- The representativeness and volumetric adequacy (quantity) of available data
- The geotechnical complexity.

The decisions taken during the conceptualisation process can introduce bias and uncertainty into the model, the most relevant being:

- Availability bias: an interpretation that comes most readily to mind and is familiar
- Anchoring bias: accepting 'expert' or dominant published opinion, or past experience
- Confirmation bias: seeking only opinions or facts that support one's own hypothesis, or similarly interpreting the data to fit the hypothesis
- Optimistic bias: interpreting in a manner that produces a more positive outcome for a study, or preferring to ignore conflicting data that may reduce positive project outcomes.

More complex statistical methods may be employed in the selection of design values for ground properties where the project complexity warrants this approach and where the Geotechnical Designer has appropriate skills and experience. Such methods should allow knowledge of comparable experience with ground properties to be considered (e.g. by means of Bayesian statistical methods).

If statistical methods are used:

- The design value should be derived such that the calculated probability of a worse value governing the occurrence of a limit state is not greater than 5%
- Such methods should differentiate between site-specific, local and regional sampling
- The statistical method selected shall be robustly justified, noting that many geotechnical parameters are not normally distributed.

For each geotechnical parameter used in the design, the rationale for the selection of the design value shall be presented in the report. Design values may be presented as single values, or as variable values in graph or equation form (e.g. values that vary with depth).

2.6.3 Load cases and factors of safety

Design loadings shall consider temporary, normal, extreme, and seismic load cases, and compound loading where multiple loads are likely to be applied at the same time.

Temporary load cases are short-term imposed loads or reductions in support. Examples include excavations at the toe of a slope for service installation, unusual traffic loading, sudden drawdown of dammed water or seasonal high or low groundwater levels. These should be considered in addition to normal loads where this combination is realistic.

Normal load cases are defined as those which represent the most common or typical loadings.

Extreme (or 'worst credible') load cases are those that are the most extreme to be considered in the design of the earthworks or structure. These should be considered in addition to normal loads and may also consider temporary loads where it is likely that these loads will occur at the same time.

All load cases (and factors applied to the loads) shall be clearly defined in the design report.

Seismic load cases shall be assessed in accordance with Section 2.5.1.

Where Load and Resistance Factored Design is being undertaken, the factors used should be in accordance with the AS/NZS 1170.0:2002, B1/VM4 and/or Waka Kotahi Bridge Manual SP/M/022, unless the Geotechnical Designer can demonstrate that alternative factors are more appropriate. A Peer Review may be required if alternative factors are used.

Additional scenario-specific factors of safety are presented in the relevant sections of this document.

2.6.4 Geotechnical calculations and modelling

Calculations and modelling undertaken to support the design must be documented and presented with the design report. This shall include:

- The selected design methodology shall be described and accompanied with a justification for use of the approach and reference to the used national or international geotechnical standards and/or guidelines. If alternative methods are used, the report shall clearly refer to the published peer reviewed papers used as a reference to alternative solutions.
- The calculation method or modelling technique shall be described, and justification given as to why this approach is the most appropriate.
- The geotechnical parameters used in any calculation or modelling shall match those presented in the report and shall be established in accordance with Section 2.6.2.

2.6.5 Displacement based seismic design

Earth-retaining structures and slopes may be designed to remain elastic under the design earthquake load or to allow limited controlled permanent horizontal displacement under strong earthquake shaking. The structures and slopes designed on the basis of permissible permanent horizontal displacement under strong earthquake shaking shall comply with all relevant recommendations of the latest edition of Waka Kotahi's Bridge Manual.

The horizontal displacement likely at the design ultimate limit state seismic response, and under the Maximum Considered Earthquake (MCE), shall be assessed using moderately conservative soil strengths consistent with the anticipated strain and a Newmark sliding block displacement approach. Displacements may be assessed using the methods described by Ambraseys and

Srbulov, Jibson, Martin & Qiu or as outlined in NZGS/MBIE Earthquake Geotechnical Engineering Practice Module 3.

Where a Newmark sliding block method is applied, the 50th percentile displacements shall be derived for both the ultimate limit state and the MCE events. At least three different commonly accepted methods for the assessment of the displacement and the range of predicted displacements (rather than a single value) shall be used in the design process. In general, the upper bound values should be adopted.

In the design of earth retaining structures and slopes that are allowed limited permanent horizontal displacement in the design earthquake:

- The soil strength parameters used for assessment of sliding horizontal displacement shall be large-strain soil strength parameters (and not peak strengths), consistent with magnitude of the soil strains from the predicted displacements.
- The probable ranges of soil parameters shall be considered when estimating the upper and lower bounds of threshold acceleration to cause wall or slope horizontal displacement.
- Walls shall be proportioned to ensure sliding, rather than overturning or internal instability (in the case of mechanically stabilised earth structures).
- The expected horizontal displacement due to the design earthquake shall not encroach into minimum clearances from road carriageways and railway tracks or infringe property boundaries, or cause damage to services that may exacerbate movements or cause instability.
- The design shall cater for larger horizontal displacements than those predicted using horizontal peak ground accelerations alone, to account for the effect of vertical seismic accelerations as per Section 6.6.9 of Waka Kotahi's Bridge Manual.
- The assessed likely horizontal displacements and settlements of the structure or slope that would arise from sliding due to the design earthquake shall not exceed the values given in Section 6.1.2 'Performance requirements' of the Waka Kotahi's Bridge Manual

2.6.6 Bearing capacity and foundation design

Foundation design shall be based on appropriate design methods and adequate ground investigation and shall satisfy the Building Code.

Foundations for structures (including soil structures) shall be designed for bearing capacity and stability to resist combined horizontal and vertical loadings with acceptable displacements and settlement. Consideration shall be given to the behaviour of the founding soils under static and dynamic loading and during construction where appropriate. Deep foundations shall be designed to resist loads that may arise from settlement or ground subsidence and associated negative skin friction (down-drag). Lateral loads associated with slope movements, lateral spreading and seismic loadings shall be considered, although wherever appropriate, the Geotechnical Designer shall isolate the structure and foundations from such forces. The effect of live loads and their repetitive nature shall be taken into consideration, where they have the potential to affect foundation performance.

Strength reduction factors shall be applied in the design of shallow and deep foundations. The strength reduction factors for shallow foundations shall be applied in accordance with B1/VM4. The strength reduction factors for bearing capacity of deep (pile) foundations shall be derived using the risk-based methodology set out in AS 2159 Section 4.3 or B1/VM4.

If screw piles are used as a deep foundation, design shall be undertaken in accordance with Engineering New Zealand Practice Note 28 "*Screw Piles: Guidelines for Designs, Construction & Installation*".

The foundation conditions shall always be verified during construction against the ground conditions assumed in the design, as site investigations cannot fully define the actual ground conditions at each foundation. The Geotechnical Designer shall specify the measures to be used to verify the ground conditions during construction.

2.6.7 Settlement assessment

If the settlement hazard has been identified on the site by the Geotechnical Designer, the following shall be included in the Geotechnical Design Report:

- Detailed settlement calculations including an assessment of a total and differential settlement
- Time required for 90% of primary consolidation (t90)
- Estimation of the secondary consolidation (sometimes referred as secondary compression or creep) for the design life of the proposed development
- The settlement criteria to be met on completion of works
- Details of the proposed method/methods for stabilisation.

For soft to very soft soils, to adequately define a site geotechnical model and provide soil parameters for geotechnical design, advanced investigation techniques such as machine drilled boreholes with sampling, Cone Penetrometer Test (CPT), Dilatometer Marchetti Test (DMT), Seismic CPT and DMT, and laboratory testing are recommended. The groundwater monitoring shall start a minimum of two months, and in some cases a minimum of 12 months, prior to commencement of the geotechnical design. The duration of the monitoring should be proposed by the Geotechnical Designer based on the risk assessment and the need to understand the seasonal groundwater range and shall be agreed with Auckland Council prior to monitoring equipment installation works.

If the fill or embankments are proposed on the soft to very soft soils close to the lot boundaries or close to any existing structures, the anticipated effects on neighbouring properties, infrastructure and utilities shall be assessed and documented in cooperation between the Geotechnical and Structural Designers. For more details refer to Section 2.9.8.

Settlement of compressible soil areas are to be monitored during and after construction works. The Groundwater and Settlement Monitoring Plan shall be prepared during the design process. For more details refer to Section 2.8.4.

2.6.8 Slope stability assessment

In making an assessment of the stability of slopes, cuts and Engineered Fills, the Geotechnical Designer shall use commonly accepted criteria and analysis methods such as limit equilibrium analysis, finite element analysis or kinematic analysis.

The modelling approach shall be described in the report, and the choice of calculation method justified. For limit equilibrium analysis, this shall include explanation of why the calculation method used (e.g. Bishop, Janbu, Morgenstern-Price etc.) is appropriate for the project. For finite element analysis, this shall include an explanation of why the constitutive model used (e.g. linear elastic, Mohr-Coulomb, strain hardening etc.) is appropriate for the project.

Where global factors of safety are used in calculations for slope stability, the following minimum factors of safety will be required unless, in the opinion of the Geotechnical Designer, a lower Factor of Safety is justified when taking into account the potential consequences of failure, including consideration of potential changes in land use during the design life. The rationale for a reduced Factor of Safety must be demonstrated through a risk assessment and may be rejected by Auckland Council. Auckland Council may require a Peer Review to validate any assumptions made. Design based on maximum allowable horizontal displacement may be accepted for seismic load cases where an assessment of the likely deformation as per Section 2.5.1 show the risk to be low.

Development scenario / Load case	Residential subdivision			Roads and buried services	Work within influencing distance of a neighbouring lot[2]	Low risk parks, bush
	Building Platform	Services and maintenance access area[1]	Amenity Area[1]			
Normal groundwater	1.5	1.4	1.2	1.5	Either as per Building Platform requirements (where a building is present in influencing distance) or no decrease on pre-existing Factor of Safety	1.2
Worst credible groundwater[3]	1.3	1.2	1.1	1.3		1.1
Pseudo-static seismic loading using ULS PGA	1.0	1.0	N/A	1.0		1.0

Notes:

1) *For definition refer to the glossary.*
2) *Any earthworks which can potentially influence stability of the neighbouring lot.*
3) *This should reflect design life of the proposed development.*

Higher factors of safety may be required where the risk to life is high, for essential utilities and facilities, and for dams or earthworks which could act as a dam in some scenarios.

Where different methods of modelling produce significantly higher factors of safety than the equivalent 2D limit equilibrium modelling this shall be explained in the analysis and robust evidence given for relying on the modelling.

Where embankments may act as water-retaining structures during flooding, the embankment shall remain stable under the lateral pressure and the ability of the embankment to sustain the effects of seepage and rapid drawdown shall be assessed. In such cases, the embankment shall have a minimum Factor of Safety against failure of 1.25 unless there is potential for significant downstream damage or loss of life, in which case a minimum Factor of Safety of 1.5 shall apply. The NZSOLD New Zealand Dam safety guidelines provide guidance that shall be followed for embankments that may act as water retaining structures.

If maintenance of cuttings, fill or natural slopes is required, the responsibility for regular inspections and maintenance shall be clearly established in the consent application documents and formal arrangements should be drawn up for approval. The maintenance requirements shall be defined by the Geotechnical Designer. The form of the slopes (including slope angle, benches etc) shall allow for safe access to maintain the slope where required.

2.6.9 Earthworks for roads

Earthworks for roads shall be designed and constructed in accordance with the requirements listed in the Auckland Council Code of Practice, Chapter 3: *Transport*, and the requirements of this Geotechnical CoP.

2.6.10 Earthworks specification

The Earthworks Specification including testing and verification requirements shall be prepared in accordance with NZS 4431:2022[10].

The earthworks design shall, as far as practicable, minimise the volume of imported clean fill or exported excavated soil and maximise the re-use of site-won and recycled materials. Compaction of soils shall meet the requirements of NZS 4431:2022 where applicable.

Where NZS 4431 is not applicable, the selection of fill, and the methods and standard of compaction must be specified by the Geotechnical Designer in an Earthworks Specification and included in the Geotechnical Design Report to allow for review by Auckland Council.

[10] Engineered fill construction for lightweight structures

2.6.11 Deep excavations and excavations on the site boundaries

The anticipated effects on neighbouring property, infrastructure and utilities due to the excavation process and deformation of temporary and permanent excavation support shall be assessed and documented in cooperation between the Geotechnical and Structural Designers. This will require assessment of existing property, infrastructure and utilities potentially affected by the proposed excavations. Maximum allowable horizontal deformation and induced total and differential settlement behind temporary and permanent supports to maintain serviceability of affected structures shall be specified by the designer prior to commencement of excavation works.

A Settlement Monitoring and Contingency Plan shall be prepared where there is potential for detrimental effects on adjacent structures or property. If excavations are proposed which extend below the existing groundwater level, a combined Groundwater and Settlement Monitoring and Contingency Plan shall be prepared. For more details refer to Sections 2.6.16 and 2.8.4. and 2.9.8.

2.6.12 Retaining structures

All retaining structures shall be designed in accordance with New Zealand standards and guidelines. The seismic design of retaining structures shall be undertaken in accordance with the requirements of Earthquake Geotechnical Engineering Practice Modules, MBIE and the New Zealand Geotechnical Society. The applied surcharge behind the proposed retaining structures shall follow requirements described in AC2231.[11]. A global stability assessment shall be part of the design of retaining structures on slopes, tiered walls, gravity retaining walls and Mechanically Stabilized Earth (MSE) walls.

Retaining structures shall, where reasonably possible, be located within the lot which they support so that the landowner who benefits from the wall support is also clearly responsible for its maintenance.

Where a retaining structure is to be vested to Auckland Council, the Geotechnical Designer shall define the inspection and maintenance requirements. The design shall, where possible, avoid the use of ground anchors extending into private land and shall allow for suitable access for inspection and maintenance.

2.6.13 Development on Significant Slopes and near cliffs

A Peer Review will be required for development on Significant Slopes identified during risk assessment or within the zone of influence of a cliff where the unmitigated risk (as documented in accordance with Section 2.4) is identified as high or above.

The responsibility for future maintenance of Significant Slopes shall be clearly established in the consent application documents and formal arrangements should be drawn up for regular

[11] Retaining walls

inspection and maintenance after construction. The maintenance requirements shall be defined by the Geotechnical Designer and documented in the Geotechnical Design Report.

2.6.14 Dams, stop banks and flood detention bunds

Dams, stop banks and flood detention bunds shall be designed in accordance with Auckland Council TP109.[12] (for small dams) or the most current NZSOLD guidelines (for large dams).

If the embankment can be considered a dam under the Building (Dam Safety) Regulations, the requirements of those regulations shall take precedence over those stated here. Further details are provided in Auckland Council Code of Practice Chapter 4: *Stormwater*

2.6.15 Groundwater pressure on geotechnical structures

The assessment of groundwater pressures on geotechnical structures shall be based on the groundwater levels and pressures measured from an appropriate programme of site investigations and monitoring, with allowance for seasonal, tidal, long-term and weather-dependent fluctuations, and considering the reliability and robustness of any drainage measures incorporated in the design. Consideration shall also be given to flood situations and incidents such as possible breaks in any water pipes or other drainage services.

A design case shall consider a groundwater pressure corresponding to the worst credible groundwater level within the design life of the proposed geotechnical structure. For more details about groundwater monitoring refer to Section 2.3.2.

2.6.16 Groundwater drawdown

Groundwater drawdown caused by temporary or permanent excavations below groundwater level shall be subject to geotechnical assessment by the Geotechnical Designer and should be avoided where practicable as it may cause ground settlement and impact on water abstraction points, springs, wetlands and waterways. Where a development may result in temporary or permanent changes to the groundwater level or flow, the minimisation of the changes shall be prioritised unless they are a function of the design. The groundwater assessment shall be undertaken in accordance with the Auckland Unitary Plan, Section E7 - Assessment of taking, using, damming and diversion of water and drilling.

To assess the groundwater drawdown, good quality groundwater monitoring data must be available prior to the groundwater drawdown assessment. It shall not be assumed that measured groundwater is part of a perched water table without robust justification by the Geotechnical Designer or clear evidence provided by groundwater monitoring. Further information about groundwater monitoring requirements is presented in Section 2.3.2.

[12] Dam safety guidelines

The anticipated effects on adjacent properties, infrastructure and utilities shall be assessed and documented in a Geotechnical Effects Report prior to Resource Consent application. Where the Geotechnical Designer considers that groundwater drawdown and associated settlement will have minor, or less than minor effects, a statement to this effect with justification shall be put in the report.

Depending on the identified risks, a Groundwater and Settlement Monitoring and Contingency Plan shall be prepared by the Geotechnical Designer in the design process. For more details refer to Section 2.9.8.

A Peer Review will be required if the development is likely to cause long-term changes to the groundwater which would have an impact on springs, wetlands, waterways or on other users of the groundwater.

2.6.17 Soil expansivity

The soil expansivity site classification shall use either the acceptable solutions and verification methods for the New Zealand Building Code, Clause B1 Structure, or an alternative solution. If alternative methods are used, the Geotechnical Designer shall clearly refer to the published peer-reviewed methods used as a reference for the chosen alternative solution. Alternative solutions shall require referral to an Auckland Council geotechnical specialist and may require external Peer Review.

2.6.18 Soakage devices

Soakage devices shall be designed in accordance with Auckland Council guidance document GD2021/07 *Stormwater Soakage and Groundwater Recharge in the Auckland Region*.

A Peer Review will be required for use of soakage devices on sites which:

- Have, or are adjacent to, unstable slopes
- Are adjacent to cliffs.

Geotechnical reports shall avoid ambiguous recommendations (such as ”saturation of soils should be avoided” or “disposal of excess stormwater to ground should be avoided”) and instead provide explicit statements (such as “disposal of excess stormwater to ground is not appropriate”) or recommendations for where soakage is acceptable, and what forms of soakage are acceptable.

2.6.19 Buried services

Where buried services may require inspection and maintenance, the location of these services shall be selected to enable this to be undertaken safely.

All construction over and close to underground stormwater pipes, wastewater pipes and other underground services shall follow requirements listed in Auckland Council, Code of Practice Chapter 4: *Stormwater*; and Watercare, Chapter 5*: Wastewater.*

2.6.20 Drainage of trenches

The Geotechnical Designer shall assess proposed or existing trench locations 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 geotextiles or filter socks required by the Geotechnical Designer, with appropriate design.

2.6.21 Drainage of slopes

Subsoil drains, counterfort drains, and drainage of shear keys should be designed so that a design life is likely to be delivered with no or little maintenance. The maintenance requirements shall be defined by the Geotechnical Designer and presented in the Geotechnical Design Report.

All subsoil drains to provide land stability are considered private and should be self-contained within the individual lot.

2.6.22 Drainage outlets and connections

All subsoil drains shall be connected to a cleanable silt trap (e.g. catch pit with sump) before connecting to the public line via the private connection pipe. For more details refer to Code of Practice Chapter 4: Stormwater.

2.6.23 Bridges

Bridge foundations and associated structures on public roads or otherwise within the scope of NZ Transport Agency's Bridge Manual SP/M/022 shall be designed in accordance with the requirements of the Bridge Manual.

2.6.24 Construction methodology

Preliminary and detailed construction methodology documents shall be prepared or reviewed by the Geo-Professional for all deep excavations and/or excavations on or near the lot boundaries during preliminary and detailed design stages. Construction methodology documents may also be required for geotechnical works such as construction of shear keys, pre-loads, embankments, soil improvement, reinforced soil etc.

The construction methodology shall consider and include, but not be limited to, the following items:

- Maximum and minimum depths, slopes/gradients, lengths or areas of cuts and fills
- Temporary support or battering requirements
- Key stages, locations and timing of engineering inspections
- Limitations in timeframes for exposed or unsupported excavations/filling

- The installation of ground anchors or soil nails (temporarily or permanently)
- Weather protection
- Surface water and dewatering management (temporary and permanent), including related ground settlement issues
- The anticipated effects of construction on adjacent properties, infrastructure and utilities due to vibration, movement of temporary support etc.
- Constructability.

2.7 Approval of proposed works

The approval process for land development and subdivision design and construction shall be in accordance with the Auckland Code of Practice, *Chapter 1: General Requirements.*

2.8 Construction

2.8.1 Compliance with consent conditions

It is common practice for controls on geotechnical (including earthworks and groundwater) and construction activities to be defined in the conditions of the Resource Consent.

The following section provides general requirements which may be superseded by project-specific conditions of consent.

2.8.2 Erosion, sediment and dust control

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 earthwork's operation shall be considered during the planning and design phase. If necessary, specific measures shall be incorporated to control dust.

The erosion, sediment and dust control shall follow requirements listed in:

- Auckland Unitary Plan, Sections E11. Land disturbance – Regional and E12. Land disturbance – District, and
- Auckland Council, *Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region*, Guideline Document 2016/005, June 2016.

2.8.3 Noise and vibration

The noise and vibration requirements shall follow Auckland Unitary Plan, Sections E25 Noise and vibration.

2.8.4 Settlement and groundwater monitoring

If the need for monitoring has been identified by the Geotechnical Designer or by a condition of consent, excavations shall be monitored, including deflection of temporary supports and the total and differential settlement behind excavations. These shall be monitored at nominated locations together with groundwater levels. If the excavation is above the highest likely groundwater level, groundwater monitoring would not normally be required.

Settlement of compressible soil areas identified in the Geotechnical Investigation Report are to be monitored at nominated locations together with the groundwater levels.

Settlement and groundwater monitoring shall be defined in a Groundwater and Settlement Monitoring and Contingency Plan (see in Section 2.9.9).

Groundwater monitoring shall start a minimum of two months and in some cases, a minimum of 12 months prior to commencement of geotechnical design, to allow seasonal changes to be considered in the settlement assessment. Monitoring shall continue through the development construction phases, post-construction, and continuing for sufficient time to confirm that the natural groundwater levels have stabilised. The Monitoring Plan must take account of seasonal changes so that levels are compared over the same calendar period to avoid natural variations influencing the interpretation of the results. The groundwater monitoring on site shall only be ceased upon the approval from Auckland Council.

Settlement monitoring shall start prior to commencement of earthworks on the site and shall be monitored at the site for a period commencing from the initial baseline measurements prior to construction, until the post-construction condition survey or the time when all the specific design settlement criteria have been met in accordance with the Geotechnical Report and subject to Auckland Council's approval. Geotechnical certification that the settlement criteria have been met is to be provided to Auckland Council prior to issue of a Section 224(c) certificate as part of the Geotechnical Completion Report (GCR). Post-construction monitoring may be requested by Auckland Council.

2.8.5 Condition surveys and inspections

Where required by consent conditions, detailed condition surveys and inspections of the properties and structures which may be affected by the proposed development, shall be undertaken prior to, during and after the works. These shall be prepared and reported by a suitably qualified and experience person (SQEP) and submitted to Auckland Council.

2.8.5.1 Pre-construction condition survey

The pre-construction condition survey typically includes the following:

- A description of:
  - The type of structure foundations and an assessment of their likely depths
  - Existing levels of damage considered to be of an aesthetic or superficial nature
  - Existing levels of damage considered to affect the serviceability of the building where visually apparent, without recourse to intrusive or destructive investigation
- An assessment as to the cause of any existing damage and an assessment of the susceptibility of the buildings/structures to further predicted ground movement
- Photographic evidence of existing observable damage
- A pre-construction condition survey (CCTV) of potentially affected utilities shall be undertaken in consultation with the relevant service provider. The CCTV shall be provided to the satisfaction of Auckland Council.

2.8.5.2 External visual inspection

Regular external visual inspections should be undertaken of the surrounding ground, neighbouring buildings and structures for the purpose of detecting any new external damage or deterioration of existing external damage. Inspections are usually to be carried out monthly from the commencement to completion of works.

Appropriate photographic record shall be kept of the time and date of each inspection and all observations made during the inspection.

2.8.5.3 Post-construction condition survey

The post-construction condition survey shall be undertaken within four weeks from the completion of the works and shall include survey of the existing buildings, structures, land and/or services surveyed in the pre-condition survey. The outcomes of the survey shall be summarised in a written report prepared by the suitably qualified and experienced person responsible for overviewing the surveys which must include comments on any changes to the existing building(s), structure(s) and/or service(s) within the area and completed remedial works to the satisfaction of the Council.

2.8.6 Earthworks testing

Earthworks testing shall follow the Earthworks Specification defined in Section 2.6.10.

Construction control testing shall be carried out by a testing laboratory or competent person under the control of the Geotechnical Designer or Certifier. The testing laboratory shall be accredited by the International Accreditation of New Zealand.

The Geotechnical Designer shall set the testing and inspection regime and the Certifier shall review the results.

No filling shall commence until the Certifier has undertaken the proposed formation inspections and given approval.

The Geotechnical Designer shall consider the need to engage a Contaminated Land – Suitably Qualified and Experienced Practitioner (CL-SQEP) for chemical testing of site-won and imported materials to manage risks including corrosion and human health impacts and to define appropriate testing in the Earthworks Specification.

2.9 Documentation

2.9.1 Overview

To facilitate rapid processing of consents it is important to present accurate information in a recognised format and an appropriate level of detail for the project and consent type. This section provides guidance on the typical reporting type based on the risk assessment and classification approach described in Section 2.4. The risk classification used for an identification of the overall project risk level shall be based on the most critical geohazard identified on the site. Any departures from this guideline shall be agreed with Auckland Council.

For the Engineering Plan Approval requirements, please refer to the Auckland Code of Practice, *Chapter 1: General Requirements.*

Table 4: Typical reporting requirements by application stage for subdivision and earthworks projects

Project stage	**Risk classification**		
	Very low to Low	**Medium**	**High to Extremely high**
Pre-application meeting		Geotechnical Appraisal Report	Preliminary investigation with Geotechnical Appraisal Report
Resource Consent application	Combined Geotechnical Appraisal, Factual, Interpretative and Design Report	Combined Geotechnical Factual and Interpretative Report Geotechnical Effects Report [1]	Separate Geotechnical Factual, Interpretative and Effects Report
Building consent application for geotechnical structures / supporting earthworks	Producer Statement PS1 – Design [2]	Geotechnical Design Report & Earthworks Specification with Producer Statement PS1 – Design [2]	Geotechnical Design Report & Earthworks Specification with Producer Statement PS1 – Design Peer Review with Producer Statement PS2 – Design review
Settlement and Groundwater monitoring	Geotechnical Monitoring Report (if applicable)		
Completion & subdivision release (Section 224(c) Certificate)	Geotechnical Completion Report (if applicable) Producer Statement PS4 – Construction review [3]	Geotechnical Completion Report with Producer Statement PS4 – Construction review [3]	
Performance evaluation		Geotechnical Supplementary Report (if applicable)	

Notes:

1) *Only in the case of groundwater drawdown and/or earthworks affecting adjacent properties, infrastructure and utilities.*
2) *A Peer Review with Producer Statement PS2 – Design review may be required depending on the complexity of the proposed geotechnical structures.*
3) *Producer Statement PS4 – Construction review is required if a Building consent application for geotechnical structures supporting earthworks with PS1 is part of the project. The PS4 shall include all geotechnical inspection records including documentation on the soil testing.*

The combined reports shown in Table 4 for Very Low to Medium risk projects allow for greater efficiency on smaller projects. For larger projects, even where the risks are relatively low, separate reports are normally more appropriate.

2.9.2 Authorisation of reports

All geotechnical reports submitted to Auckland Council must be reviewed, approved and signed by a Geo-professional.

Formal certifications by a Geotechnical Designer or Geo-professional will be relied upon by Auckland Council to make judgements on the suitability of developing land and on approving stages of developments.

2.9.3 Generic requirements for all reports

Every report shall include the following items to enable the context of the report to be fully understood:

Project description	A summary of the proposed development or project for which the report has been procured. This is used to assess whether the report meets the project requirements.
Brief	Details of what the report author was instructed to produce, including a description of any elements that were instructed to be out of scope.
Purpose of report	A description of the intended use of the report (e.g. to support a Resource Consent application) and where relevant, details of what the report should not be used for (e.g. if further work is required before Building Consent application this shall be explicitly stated).
Site location and description	A figure showing the site location relative to nearby landmarks, and a close view showing the site boundaries, including the outline of the development (may alternatively be presented in an appendix), and either the street address or grid reference in the New Zealand Transverse Mercator.
Previous reports	A list of previous geotechnical reports produced for the site or project.

Every report shall include the following items to enable the reader to assess the validity of the report:

Names and Qualifications	Full names (not initials), qualifications and professional registrations of the author(s) and reviewer(s) of the report.
Revision and status	The revision number and issue date of the report, and the report status (e.g. draft, final etc.).
QA records	Evidence that the report has been reviewed and approved.

Where valid, all of the following should be included:

- The source of all data
- Commentary on the validity and relevance of all data
- Reference to relevant national and international standards and guidelines, and published peer reviewed papers
- A description of any analytical methods used, including details of any weaknesses and how these were addressed.

2.9.4 Combined reports

Combined reports are a simple way to present geotechnical information for small projects with Very Low to Medium Risk levels, without the additional cost of producing separate reports. Wherever a combined report is produced, it shall contain the contents of each of the individual reports as described in the subsequent sections. Each element shall be described in a separate section of the combined report to allow a clear distinction between historical information, factual data, interpretations, designs, conclusions and recommendations.

2.9.5 Geotechnical Appraisal Reports

The Geotechnical Appraisal Report (GAR) shall include the following sections (unless not appropriate for the specific project):

- A section summarising factual information found in the desk study and site walkover, without interpretation, including:
    - Topography (including slope height, shape, gradient etc.)
    - Seismic setting
    - Regional and local geological setting
    - Evidence of instability (including slope irregularities, terraces, erosion, cracks etc.)
    - Vegetation
    - Waterways, overland flow paths, seepages and wet ground

    - Overhead and buried services
    - Ownership of the land, site boundaries and legal description
    - Current land use and structures, with commentary on their performance
    - A chronological history of land use including previous land alteration, activities and processes on the site, including any chemicals or products used, stored or disposed of at the site
    - A summary of previous investigations.
- A section providing an interpretation of the facts presented in the previous section. This shall include an initial Geological Model (as defined in IAEG Commission 25 Report 1)describing the anticipated geology, groundwater and geotechnical conditions with a description explaining the landform history and origin. The description of the groundwater shall include:
    - The extent and use of groundwater aquifers in the area
    - Local and regional direction of groundwater flow
    - Anticipated depth to groundwater
    - Seasonal or tidal influences
    - Springs
    - Local groundwater abstraction and use
    - Local groundwater and/or surface water monitoring information
    - Preferential pathways to groundwater (soak holes, etc.).
- A commentary on all geohazards presented on site can be found in Section 2.5. If any of these hazards could affect the development, the report should provide an assessment which addresses:
    - Type, frequency and scale of the hazard and whether adverse effects on the development will be temporary or permanent
    - Type of activity being undertaken and its vulnerability to natural hazard events
    - The consequences of a hazard in relation to the proposed activity
    - The potential effects on public safety and other property
    - Any exacerbation of an existing hazard or creation of a new hazard
    - The ability to use non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate the hazard, rather than hard engineering solutions protection structures
    - Recommendations on options for the design and construction of buildings and structures to mitigate the effects of natural hazards, such as raising habitable floor levels or making relocatable in case of coastal erosion
    - The potential effects of structures used to mitigate hazards on landscape values and public access

    - Potential site layout and management options to minimise the environmental impact of the development and to avoid or mitigate the adverse effects of hazards, including access and exit during a natural hazard event.
- Comment on design requirements including:
    - Suitability of the site for the proposed development
    - Likely site classification in accordance with NZS 3604:2011 Timber framed buildings
    - Risks to be addressed in design including:
        - Options to minimise the impact of the development on the natural drainage and slopes, and to avoid impacts beyond the site boundaries such as increased flooding risk
        - Scope of ground investigations needed for consenting, design and to minimise the risk of unforeseen ground conditions during construction.
        - Potential construction difficulties.
- Conclusions
- Appendices, including:
    - Risk Register as per Section 2.4.4
    - Historical aerial photography showing the site boundaries
    - Geological map(s)
    - Drawings as per Section 2.4.5 and 2.9.14 (3D models or similar are welcomed where the ability to view these to scale without proprietary software is readily available)
    - Walkover photographs
    - Historical bore logs and previous reports.

2.9.6 Geotechnical Factual Reports

The Geotechnical Factual Report (GFR) shall document the site geotechnical investigation (as described in Section 2.3.2) and shall meet the requirements defined in the New Zealand Ground Investigation Specification, Volume 1, Section 17.

The Factual Report should not contain any interpretation of the investigation. Cone penetration test results shall show interpretation (other than calibration or error corrections) separately from raw data.

Where interpretation is needed to satisfy the brief (e.g. in the preparation of geological mapping), the basis of the interpretation shall be clearly identified on the item in question (i.e. within the report or upon the drawing/map) in order that future uses of the information have a clear understanding of its basis.

The Geotechnical Factual Report shall include the following components:

- Number and type of exploratory locations
- Name and contact details of the Contractor(s) undertaking the works
- Name(s) of the individuals undertaking logging and of the Geo-professional who reviewed the logs
- Date and duration of the work
- Prevailing weather conditions and any notable weather conditions prior to investigations being conducted that may impact on the results (e.g. heavy rainfall or drought)
- Commentary on how the co-ordinates and elevation of each exploratory location were determined, and the accuracy of this survey
- Details of equipment used, testing methodology, standards adopted, calibration undertaken and any deviation from accepted practice or suspected errors and inconsistencies
- For groundwater level monitoring conducted during the investigation period, tabulated measurements referenced to ground level and the elevation of the ground surface together with commentary on installation (e.g. during drilling, within standpipe, by piezometer etc.)
- For any laboratory testing completed, tests undertaken, standards adopted and a summary of results.

The detailed results of the investigation shall be presented in a series of appendices including:

- A map (to scale) showing testing locations using symbols (a different symbol being used for each test type) explained in a legend, a north arrow, a scale bar and lot boundaries. The map shall also show existing buried services
- A schedule of exploratory holes stating depth achieved below existing ground level, elevation of the ground surface (related to the adopted site datum), location co-ordinates and datum used
- Exploratory hole logs and associated images (photographs)
- A key sheet explaining all symbols and acronyms used on the exploratory hole logs
- Field observations/mapping with photographs
- As-built construction details of all monitoring installations and standpipes
- All laboratory testing and analysis results in full
- Monitoring undertaken during and immediately after the investigation period
- Calibration certificates for field equipment used.

All factual geotechnical data including, borehole logs, sCPT/sDMT data and laboratory test data shall be uploaded to the New Zealand Geotechnical Database, including AGS4.0NZ format data, within one month of the consent approval and before any vested assets are accepted.

2.9.7 Geotechnical Interpretative Reports

A Geotechnical Interpretative Report (GIR) presents the interpretation of the geotechnical conditions for the proposed development based on all available data, taking into consideration the relevance of this information for the proposed geotechnical design of the earthworks and preliminary design of geotechnical structures. If the GIR is combined with Geotechnical Factual Report, the report is sometimes referred to as a Geotechnical Investigation Report.

The GIR shall update the Geotechnical Appraisal Report (if applicable) taking into account the information gained from the ground investigation. The contents of the GIR shall include the following sections (unless not appropriate for the specific project or covered by GAR):

- A section summarising the findings of the earlier Geotechnical Appraisal Report and commenting on any changes identified since the GAR was written. If no Geotechnical Appraisal Report is available, the contents that would normally be found in the GAR should form the first section of the GIR.
- A Geotechnical Model (as defined in IAEG Commission 25 Report 1) describing the anticipated geology, groundwater and geotechnical conditions with a description explaining the landform history and origin, and geotechnical parameter values for all geotechnical layers that may be relevant to the design. The ground model shall include geological cross section(s) through the site showing location and depths of the completed ground investigation, position of the proposed Building Platforms and retaining walls, location of the site boundaries, estimated groundwater level(s), and the existing and proposed ground levels.
- An assessment of the degree of uncertainty in the Geotechnical Model (which should align with the risk register).
- A detailed commentary on all geohazards present. If any of these hazards could affect the development, the report should provide a detail assessment which addresses:
    - Type, frequency and scale of the hazard and whether adverse effects on the development will be temporary or permanent
    - Type of activity being undertaken and its vulnerability to natural hazard events
    - The consequences of a hazard in relation to the proposed activity
    - The effects on public safety and other property
    - Any exacerbation of an existing hazard or creation of a new hazard
    - Recommendations for the design and construction of buildings and structures to mitigate the effects of natural hazards, such as raising habitable floor levels or making relocatable in case of coastal erosion
    - The effect on landscape values, public access etc. of any structures proposed to mitigate hazards
    - Recommendations for further geotechnical works (e.g. inspections during earthworks, supplementary geotechnical investigation).

The GIR shall present the following geotechnical assessments (unless not appropriate for the specific project):

- Preliminary slope stability assessment
- Preliminary settlement assessment
- Soil expansivity assessment
- Seismic assessment of the site including comments on liquefaction and lateral spreading risk
- Shallow and deep foundation recommendations including allowable bearing pressures, pile design parameters, specific techniques for expansive clays etc.
- Assessment in accordance with the Auckland Unitary Plan, Section E7 - Assessment of taking, using, damming and diversion of water and drilling
- Preliminary groundwater drawdown assessment [1]
- Preferred excavation/retention/stabilisation techniques and suitability of excavated materials for use in on-site earthworks
- Preliminary design of temporary and permanent retaining structures in the case of deep excavations or excavations on the lot boundaries requiring building consent application are present
- Assessment of the effects on adjacent properties, infrastructure and utilities due to dewatering and temporary and permanent wall deflections [1]
- Preliminary Groundwater and Settlement Monitoring and Contingency Plan [1]
- Preliminary construction methodology [1]
- Any appropriate measures, methods or techniques to mitigate land instability
- Preliminary earthworks geotechnical design including design of surface and subsoil drains
- Draft Earthworks Specification
- High level recommendations for weather protection
- High level recommendations for surface water and groundwater management.

Notes:

Items marked with [1] can be separately covered by the Geotechnical Effects Report. For more details, refer to Section 2.9.8.

The Risk Register and drawings (updated from the GAR), and all geotechnical calculations, e.g. settlement assessment, slope stability assessment, liquefaction assessment etc. shall be presented in a series of Appendices.

2.9.8 Geotechnical Effects Report

A Geotechnical Effects Report can be used to support the Geotechnical Interpretative Report during Resource Consent application in the case of groundwater drawdown, deep excavations or excavations on the lot boundaries requiring building consent application, or earthworks and constructions on the very soft to soft soils are present on the site. The Geotechnical Designer shall summarise the implications of the proposed permanent and temporary works and assess the likely effects of the work on adjacent property.

The Geotechnical Effects Report shall present the following (unless not appropriate for the specific project):

- Determining the groundwater drawdown “zone of influence” due to the proposed trenching, tunnelling, the construction of shafts, cuts or the basement excavations etc. based on likely construction methodologies and identifying properties, structures and infrastructure that may be at risk of damage from groundwater drawdown induced settlement.
- Determining the “zone of influence” of soil volume loss or soil relaxation due to the proposed deep excavations or excavations on the lot boundaries requiring building consent application based on likely construction methodologies and identifying properties, structures and infrastructure that may be at risk of damage from any resulting settlement.
- Determining the “zone of influence” of soil movement due to the proposed construction on soft to very soft soil (high embankments etc.) based on likely construction methodologies and identifying properties, structures and infrastructure that may be at risk of damage from any resulting soil vertical and lateral movement.
- Calculating the likely total and differential movement of ground surfaces and at-risk structures and infrastructure within the zone of influence.
- Undertaking a damage risk assessment of at-risk structures and infrastructure and recommending appropriate risk mitigation strategies including construction monitoring and reporting requirements.
- Preliminary construction methodology.
- Preliminary Groundwater and Settlement Monitoring and Contingency Plan, Settlement Monitoring and Contingency Plan or Groundwater and Settlement Monitoring Plan, depending on the proposed development and present geohazards.
- Any other aspects the geotechnical professional considers relevant.

The report and drawings shall be prepared in a format and style suitable to accompany a Resource Consent application.

2.9.9 Groundwater and Settlement Monitoring and Contingency Plan

A Groundwater and Settlement Monitoring and Contingency Plan shall be prepared by the Geotechnical Designer and include (unless not appropriate for the specific project):

- Drawings showing the proposed location (including coordinates) and installation of all groundwater monitoring instruments
- Drawings showing the proposed location (including coordinates) and installation of all ground surface, retaining structures and building deformation monitoring instruments
- Details of the proposed groundwater monitoring programme
- Details of the proposed ground surface and building deformation monitoring programme
- Proposed alert and alarm trigger levels for the groundwater monitoring including the methodology for their determination. Groundwater alert and alarm levels shall consider seasonal groundwater variability
- Proposed alert and alarm trigger levels for all ground surface and building deformation marks as determined by ground settlement predictions and appropriate differential settlement limits for the particular at-risk properties, structures and infrastructure
- Details of contingency measures to be implemented if alert or alarm trigger levels are exceeded.
- Define the settlement criteria to be met on completion of works.

The plan shall be prepared in a format and style suitable to accompany a consent application and in accordance with project-specific conditions of consent. Note that the detailed Monitoring and Contingency Plan needs to align and be read in conjunction with the Geotechnical Effects Report (refer to Section 2.9.8).

Depending on the proposed development and geohazards present, the Groundwater and Settlement Monitoring and Contingency Plan can be referred to as a Settlement Monitoring and Contingency Plan or Groundwater and Settlement Monitoring Plan.

For more details about settlement and groundwater monitoring refer to Section 2.8.4.

2.9.10 Geotechnical Design Reports

The Geotechnical Design Report (GDR) may be a stand-alone document or a section in a multi-disciplinary design report. This will be defined by the client for each project.

The GDR shall present the following (unless not appropriate for the specific project):

- The design approach used, and the design codes, standards and guidelines followed (including any departures from those standards)
- The design life and durability

- A description of the natural and geohazards addressed by the design, (including the Risk Register as an Appendix)
- All soil and rock parameters used in the design or supporting calculations, giving a justification for each parameter and noting the likely uncertainty
- All design inputs including assumed loads and factors
- The design Geotechnical Model, including a commentary on the uncertainty within the model and recommendations to manage the risks posed by this uncertainty
- All assumptions made about the ground conditions, and comment on the risk of these assumptions not being accurate
- All failure modes assessed
- Commentary on geotechnical issues which could impact on construction, operation, maintenance or decommissioning and may need to be addressed during these phases
- Updated preliminary construction methodologies and assessment of the temporary works
- Updated preliminary design of temporary supports and batters
- Detailed design of permanent retaining structures
- Detailed design of shallow and deep foundation
- Key stages, locations and timing of engineering inspections
- Permissions required for any permanent works which cross lot boundaries
- Detailed Groundwater and Settlement Monitoring and Contingency Plan
- Detailed design drawings
- A detailed section on Safety in Design.

If a supplementary ground investigation has been undertaken, the GDR shall include reassessment and confirmation of the site ground model including geological cross section(s), design parameters and construction methodologies.

All calculations used in the design (including slope stability, bearing capacity, pile capacity, retaining structure design, settlement calculations etc) shall be appended in full to the main report and shall include evidence of having been checked and approved by the Geotechnical Designer. Calculations undertaken by software shall be summarised, and the summary shall include:

- Software used
- Calculation method used
- All input parameters
- Ground model used
- Output / results
- Note on quality assurance undertaken.

2.9.11 Geotechnical Completion Reports

Once the earthworks are completed, the Geotechnical Completion Report (GCR) shall be prepared by the Geotechnical Designer in accordance with requirements described in NZS 4404:2010[13]. Where the Geotechnical Designer is unable or unwilling to prepare the Geotechnical Completion Report, an alternative Geo-professional familiar with all geotechnical documentations supporting the earthworks and involved in the geotechnical inspections during the earthworks may prepare this report. The GCR shall include a section explaining the reason for the change in roles, list any technical concerns raised by the Geotechnical Designer and describe how these concerns have been addressed.

The GCR shall present the following (unless not appropriate for the specific project):

- Confirmation that the works were undertaken in accordance with NZS 4431:2022[14], this CoP and the site-specific designs outlined in the Geotechnical Interpretative and Geotechnical Design Report.
- Confirmation of the geological model including confirmation of the groundwater level.
- Confirmation of the soil expansivity classification and the site subsoil class to the provisions of NZS 1170.5:2004[15] for each lot.
- Review of geotechnical recommendations and risk assessment provided in GIR and GDR.
- Outline of work undertaken including dates of work, methodologies and plant used.
- As-built plans showing the depth and extent of all fill prepared in accordance with NZS 4431:2022.
- Details of any subsoil or counterfort drainage, shear keys, retaining walls, palisade walls including as-built plans. If applicable, the GCR shall include all PS4 for geotechnical structures constructed with the earthworks.
- Reference where details of road subgrades, stormwater dams, trench lines, land drainage and topsoil are provided if they are not documented in the GCR.
- Additional stability or other analysis undertaken as a result of changes during construction.
- Recommendations for each lot, including any specific design requirements, which would necessitate the building design deviating from NZS 3604:2011[16].
- Drawings with nominated Building Platforms or Specific Design Zones or any Building Line Restrictions.
- The extent to which settlement of the site is expected and its impact on future structure construction.

[13] Land development and subdivision infrastructure

[14] Engineered fill construction for lightweight structures

[15] Structural design actions - Part 5: Earthquake actions

[16] Timber-framed buildings

- Confirmation that settlement and groundwater criteria as defined in the Monitoring and Contingency Plan have been met prior to commencement of subsequent construction.
- All geotechnical inspection records including documentation on the testing of the soils for compaction, settlement monitoring and groundwater monitoring (if applicable). This documentation should clearly show the spatial location where compaction met the required standards, as well as any areas requiring retesting, and areas which did not meet the standards.
- Details of the plant used for earthworks compaction.
- Details of the material types and quantities excavated and the locations these materials were placed.
- Specific requirements for future earthworks, building foundations, retaining walls and other works which may occur in each lot. This shall include requirements for works which may take place within the vicinity of subsoil drains.
- Any maintenance required to ensure efficient functioning of the privately-owned subsoil drains and subsoil drain outlets.
- If subsoil drains are installed to a ‘zero maintenance’ standard, the Completion Report shall include requirements to avoid damage to the subsoil drains including the extent to which modifications can be made to the capping (covering) at ground level.
- Any related matters that are identified in other conditions of this consent.
- A statement of professional opinion as set out in Schedule 2A of NZS 4404:2010[13].

All final copies of the as-built plans must include a signed certification statement by the chartered professional engineer or licensed cadastral surveyor responsible for the as-built.

The information presented in the GCR, including a statement of professional opinion, Specific Design Zones, Building Line Restrictions, individual lot requirements etc., shall be used by the Geotechnical Designer during the building consent stage for a detail geotechnical design.

2.9.12 Geotechnical Monitoring Report

A Geotechnical Monitoring Report presents the outcome of the settlement and/or groundwater monitoring following requirements and methodology presented in the Monitoring and Contingency Plan (see Section 2.9.9). The Geotechnical Monitoring Report should also provide comments on the monitoring data in relation to the settlement criteria to be met (if applicable), any damaged monitoring points and identify any new or changed monitoring needs.

Reporting intervals would be as agreed with the Geotechnical Designer, Auckland Council or defined by project-specific conditions of consent and could be subject to review depending on the monitoring results.

2.9.13 Supplementary Geotechnical Report

A supplementary report or reports may be required prior to, during, or post-development (Section 224(c)). These reports may be required by Auckland Council, e.g. via conditions and consent notices and/or specified by the Geotechnical Designer.

Some of the common situations requiring supplementary reports are:

- Where detailed design occurs at a later stage, e.g. post subdivision or staged subdivision
- Where development works covered by a report are amended or changed
- Where a period of time has passed, and engineering concepts or ground conditions may have changed
- Where ongoing monitoring and testing is required, e.g. via conditions of a Resource Consent
- Where verification is required that specified works have been undertaken
- Where a geotechnical report provided for a building consent needs to be amended and/or broadened to cover another type of consent required by Auckland Council, e.g. Resource Consent or Engineering Approval or other change in context
- Where the Geotechnical Designer or other Geo-professional involved in a project becomes aware of changes in development works or conditions and wishes to advise or update the GIR, GER and/or GDR
- Where individual lot development requires specific geotechnical investigation and/or design.

2.9.14 Geotechnical Drawings

All geotechnical drawings shall comply with the following requirements:

- All drawings shall be to scale, with a scale bar for all scales used
- All cross sections shall be to scale (a different vertical scale is acceptable if clearly marked)
- All cross sections shall have an accompanying plan showing their location
- Existing and proposed topography shall be shown with contours at 0.5 m intervals
- Proposed cut and fill depths shall be shown with contours at 0.5 m intervals
- Bore logs used to inform the geological model shall be shown on the drawings. On sections, they shall be to scale, at the correct elevation, with the logged soil/rock materials and geological units shown
- The Geotechnical Designer shall clearly state on the drawings and in the specifications the foundation conditions assumed in the design.

At Resource Consent stage, geotechnical drawings will show:

- Any Building Line Restriction(s)
- Any hazard zones
- Specific Design Zone
- Preliminary/conceptual locations of Building Platforms, driveways, buried services, stormwater systems and wastewater systems
- Locations of buried services, wastewater disposal etc.

At building consent stage geotechnical drawings will show final positions of:

- Any Building Line Restriction(s)
- Any hazard zones
- Specific Design Zone
- Building Footprint(s)
- Services and maintenance access area
- Locations of buried services, wastewater disposal etc.

Any areas susceptible to hazards, Amenity Areas, Specific Design Zones, Building Line Restrictions or Significant Slopes on any lot shall be identified on the site plans and explained in the accompanying report.

3D models or similar are welcomed where the ability to view these to scale without proprietary software is readily available.

2.9.15 Producer Statements

Where a Producer Statement is required, this will be set by Auckland Council as a Condition of Consent. All geotechnical producer statements submitted to Auckland Council must be authorised by a geotechnical professional on the Auckland Council Producer Statement Authors Register.

https://www.aucklandcouncil.govt.nz/building-and-consents/building-consents/producer-statement-authors/Pages/find-producer-statement-author.aspx

For more information, please refer to AC2301 *Producer Statement Policy.*

Glossary

Term	Definition
Amenity Area	An area of land extending 8 m from the Building Footprint, or to the lot boundary, whichever is closest. This land will require engineering assessment to ensure that, where instability may be present on the site, it does not detrimentally affect the amenity of the building. The extent of the Amenity Area may be altered (subject to agreement with Auckland Council) where site constraints make an 8 m wide area impractical to achieve. In such circumstances the risk shall be added in the Risk Assessment and a notice may need to be added to the site title.
Building Footprint	The area of land upon which a building is founded, bounded by the outer walls and foundations of the structure. This includes cantilevered portions of the building. Where cantilevered portions are constructed to isolate the building from geohazards this shall be clearly documented in the design report.
Building Line Restriction	For the formal definition see the Auckland Unitary Plan. This is a line established by Auckland Council to prevent buildings being erected between the Building Line Restriction and the relevant site boundary. These are commonly used to prevent development too close to a road (or other asset) in order to allow for access, potential future widening etc. They may also be used to limit development for other reasons such as environmental effects or natural hazard exposure. The Geotechnical Designer shall propose additional Building Line Restrictions where they are required to make development safe from a natural or geohazard.
Building Platform	An area of land suitable for buildings to be constructed. This area is shown in the drawings associated with a geotechnical completion report or equivalent document. The area is commonly larger than the Building Footprint, to allow for flexibility in the future design of the building which is commonly not commenced until after earthworks are completed.
Certifier	The independent professional engineer or engineering geologist responsible for the certification of the completed earthworks as defined in NZS 4431.
Contaminated Land – Suitably Qualified and Experienced Practitioner (CL-SQEP)	A suitably qualified and experienced practitioner as per the Ministry for the Environment's *Contaminated Land Management Guidelines no. 1*
Earthworks	The act of excavating natural soil and rock materials, transporting these materials, and placing these materials (or manufactured equivalents) in a controlled manner with or without the addition of reinforcement to form the Engineered Fill. The term 'earthworks' can also refer to the finished product (a structure made from fill). Earthworks can be controlled (producing Engineered Fill) or uncontrolled.

Term	Definition
Earthworks Specification	The specification approved by the Geotechnical Designer providing details of the classification, testing, and compaction requirements for the Engineered Fill. This shall be developed in accordance with NZS 4431. In the absence of a site-specific Earthworks Specification developed by the Geotechnical Designer, this shall be the New Zealand Earthworks Specification published by the New Zealand Geotechnical Society (NZGS).
Engineered Fill	Soil, rock, or manufactured equivalents that have been placed in a controlled manner and tested to demonstrate compliance with the design.
Engineering Geological Model (EGM)	A comprehensive knowledge framework that allows for the logical evaluation and interpretation of the geological, geomorphological and hydrogeological conditions that could impact a project and their engineering characteristics. The EGM comprises both conceptual and observational components and may consist of a number of interrelated models and approaches. The Geological Model, the Geotechnical Model and a Geohazard Assessment are outputs from the EGM knowledge framework. See IAEG Commission 25 Report 1 for more details.
Engineering Plan Approval	Engineering Plan Approval (EPA) is required for works that are to be vested in Auckland Council's ownership, e.g. infrastructure that will become public and under the control and responsibility of Auckland Council. This includes public stormwater, wastewater, water supply, roading and park assets. Engineering Plan Approval may also be required in other circumstances, such as a condition of a resource or building consent.
Factor of Safety	A Factor of Safety (FoS) is a safety margin used in engineering design to allow for uncertainty and ensure that the design will be safe. Many geotechnical designs use a global FoS, which is defined as the "ability of a system's capacity to be viable beyond its expected or actual loads". The global FoS in geotechnical engineering is usually expressed as a ratio that compares the acting and resisting forces. The global FoS is commonly specified as a constant value that a design must meet or exceed. More modern approaches use partial factors, or Load and Resistance Factor Design (LRFD). In these cases, an individual safety factor is applied to each of the resistances and loads. These factors will vary depending on the application, the risks and the project uncertainties. There is no global Factor of Safety resulting from these approaches; the result is either a pass or fail. In some cases (e.g. in the Eurocodes) the input parameters are factored instead of the resistances to more directly represent the uncertainty in these inputs. For any design there will be many potential modes of failure, each of which will have a unique global Factor of Safety and/or a unique set of partial factors of safety.
Fill	Soil, rock, or manufactured equivalents that have been placed by human activity.
Geohazard	A geological, hydrogeological or geomorphological event, process or condition that poses an immediate or potential future risk that may lead to damage or harm.

Term	Definition
Geo-professional	A suitably qualified individual with experience in land development. They must be a Chartered Professional Engineer (CPEng) with accreditation in the geotechnical practice field and area as administered by Engineering New Zealand and/or a Professional Engineering Geologist with current registration on the Engineering New Zealand PEngGeol register.
Geotechnical Designer	The authorised representative of the organisation undertaking or reviewing the geotechnical design (including the earthworks specification, if there is one). The Geotechnical Designer shall be a geotechnical engineer and/or engineering geologist who holds a current chartered registration under the Chartered Professional Engineers of New Zealand Act 2002, or equivalent as appropriate. Currently, the Chartered Professional Engineer (CPEng) and Professional Engineering Geologist (PEngGeol) quality marks are registered as assessed and administered by Engineering New Zealand. The Geotechnical Designer can also take the role of Certifier. The Geotechnical Designer shall have suitable experience of land development in similar materials.
Land Use Consent	A form of Resource Consent required for an activity that affects the environment including building and alterations, earthworks, retail, horticulture and vegetation removal. For detail definition please refer to RMA Section 87 and the Auckland Unitary Plan.
Non-Specific Design Zone	Land with few or no geotechnical constraints or hazards. In this zone building development can be carried out in accordance with the appropriate standards (e.g. NZS 3604) without significant risk from instability. The location of the Non-Specific Design Zone shall be identified by the Geotechnical Designer.
Peer Review	A Peer Review is an independent assessment of engineering work, where the peer reviewer needs to have a level of engineering expertise at least equivalent to the engineer (or engineers) responsible for the work being reviewed (Practice Note 2: Peer Review, Engineering New Zealand). It should be a professional opinion based on sound engineering analysis and assumptions, good practice, appropriate regulations and unbiased judgement. For more details please refer to Engineering New Zealand Practice Note 2 and AC2301 – Producer Statement Policy.
Qualitative Risk Assessment	A procedure to describe the risks associated with a site in relative terms (e.g. in terms of its likelihood of its occurrence and consequences to life and property). Qualitative terminology for use in assessing risk may include its likelihood (almost certain, likely, possible, unlikely, rare) and its consequences (major, medium, minor, insignificant).
Quantitative Risk Assessment	A process or methodology for assigning a numeric value to the probability of loss based on known risks and objective data. For example, slope stability analysis determines the Factor of Safety against slope failure.

Term	Definition
Regulatory review	A review of objectives, assumptions, options, engineering rigour, conclusions and recommendations for a complex or unique aspect of a design for compliance with a statutory code, standard or guideline perform by or on behalf of Council. For more details please refer to Engineering New Zealand Practice Note 2: Peer Review.
Resource Consent	A resource consent is a formal approval from Auckland Council for the activities which are not Clearly identified as either permitted or prohibited under the RMA, Auckland Unitary Plan or the legacy plans. For detail definition please refer to the Auckland Unitary Plan and RMA.
Services and maintenance access area (SMAA)	An area of land outside the proposed Building Platform that contains services (e.g. driveways, wastewater pipes, soakage devices, wastewater disposal fields) or will be used to provide access for maintenance to the structure, the services, or any retaining walls. It should be sufficiently wide to allow for whatever plant or equipment is likely to be required for future maintenance activities. For example, adjacent to a house it may need to allow room for scaffolding so that future maintenance on the roof can be undertaken safely.
Significant Slope	A slope that has been identified by a Geo-professional as a very or extremely high Geohazard during the risk assessment. In the Auckland region slopes steeper than 2 (horizontal) to 1 (vertical), i.e. >26 degrees are usually (but not always) considered to be Significant Slopes when greater than 2 m high. Slopes may be hazardous at shallower angles and lower heights, and these can also be defined as Significant Slopes by a Geo-professional.
Specific Design Zone	Land within which development requires specific design by the Geotechnical Designer. All land not designated as a Non-Specific Design Zone by a Geo-professional or Geotechnical Designer shall be treated as Specific Design Zone.
Subdivision consent	A form of Resource Consent needed to divide a parcel of land or a building into one or more further parcels, or to change an existing boundary location. For details definition please refer to RMA Section 87 and the Auckland Unitary Plan.
Temporary works	Temporary works are parts of the works that either enable the construction or protection of the permanent works or support or provide access to the permanent works, and which are not expected to remain in place at the completion of the works.

Appendix A – List of relevant documents

Auckland Council Guideline Documents

Auckland Council Guideline Document 2016/005. *Erosion and sediment control guide for land disturbing activities in the Auckland Region.*

Auckland Council guidance document GD2021/07. *Stormwater soakage and groundwater recharge in the Auckland region.*

Carpenter, N. (2021). *Coastal hazard assessment in the Auckland region*. Auckland Council guideline document, GD2021/010.

Auckland Council Technical Reports

Auckland Council, *Dam safety guidelines*, Technical Publication TP109.

Roberts, R., Carpenter, N. and Klinac, P. (2020). *Predicting Auckland's exposure to coastal instability and erosion*, Auckland Council, technical report, TR2020/021.

Auckland Council Codes of Practice

Auckland Council Code of Practice. (2016). Land Development and Subdivision Chapter 1: *General Requirements.*

Auckland Council Code of Practice. (2022). Land Development and Subdivision, Chapter 3: *Transport*, Auckland Transport.

Auckland Council Code of Practice. (2022). Land Development and Subdivision, Chapter 4: *Stormwater.*

Watercare Services (2017). Water and Wastewater Code of Practice for Land Development and Subdivision *Chapter 5: Wastewater* (Part of Auckland Code of Practice for Land Development and Subdivision)

NZ Legislation

Building Act, 2004

Health and Safety at Work Act 2015

Health and Safety at Work (Asbestos) Regulations 2016

New Zealand Building Code

Resource Management Act, 1991

Standards New Zealand

- AS/NZS 1170.0:2002 - Structural design actions, Part 0: General principles
- AS/NZS ISO 31000:2009 (ISO 31000) – Risk management – Principles and guidelines
- AS 2870:2011 - Residential slabs and footings
- NZS 1170.5:2004 - Structural design actions, Part 5: Earthquake actions
- NZS 3604:2011 - Timber-framed buildings

- NZS 4402:1986 - Methods of testing soils for civil engineering purposes
- NZS 4404:2010 - Land Development and subdivision infrastructure
- NZS 4407:2015- Method of sampling and testing road aggregates
- NZS 4431:2022 - Engineered fill construction for lightweight structures

Standards Australia

- AS 1289.7.1.1:2003 – Soil reactivity tests - Determination of the shrinkage index of a soil - Shrink-swell index
- AS 2159 Piling – Design and installation
- AS 2870:2011 Residential slab and footings classification

Other Standards

- BS 1377 (Part 1-9) Method of Tests for Soils for Civil Engineering Purposes
- BS 5930:2015 - Code of Practice for Ground Investigation

Publications

AC2301 2015. *Producer Statement Policy*, Auckland Council

Auckland Unitary Plan Operative in part (updated 23 June 2022)

Australian Geomechanics Society. 2007. *Practice Note Guidelines for Landslide Risk Management.*

Australian Landslide Risk Management Guidelines 2007

BRANZ, 1987, BRANZ Study Report 004, *Assessment of slope stability at building sites*. BRANZ and Worley Consultants Ltd.

BRANZ, 2008, *Soil expansivity in the Auckland region*. Study Report 120A. BRANZ and Fraser Thomas Ltd.

Cook, D., Pickens, G.A., and MacDonald, G., 1995, *The role of peer review.* Report by Crawford, S.A. NZ Geomechanics News Dec 1995.

Crawford, S.A., and Millar, P.J., 1998. *The design of permanent slopes for residential building development.* EQC research project 95/183. NZ Geomechanics News June 1998.

Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M., 2014. Queensland Acid Sulfate Soil Technical Manual: *Soil Management Guidelines.* Brisbane: Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Engineering New Zealand Practice Note 2: Peer Review.

Engineering New Zealand Practice Note 28 (2015). *Screw Piles: Guidelines for Designs, Construction & Installation.*

International Association for Engineering Geology and The Environment (IAEG) (2022). Guidelines for the development and application of engineering geological models on projects. IAEG Commission 25 Publication No. 1. Retrieved March 2023 from https://www.iaeg.info/wp-content/uploads/2022/12/IAEG-C25-EGM-Guidelines-v1.0-14-December-2022.pdf

Ministry for Business, Innovation and Employment (MBIE), (2017). *Planning and engineering guidance for potentially liquefaction-prone land.*

Ministry for Business, Innovation and Employment (MBIE) and New Zealand Geotechnical Society (NZGS). *Rockfall: Design considerations for passive protection structures.*

Ministry for Business, Innovation and Employment (MBIE) and New Zealand Geotechnical Society (NZGS). *Earthquake geotechnical engineering practice modules.*

Ministry for the Environment. Contaminated land management guidelines No. 1*: Reporting on contaminated sites in New Zealand.* (Revised 2021)

Ministry for the Environment. Contaminated land management guidelines No. 5: *Site investigation and analysis of soils.* (Revised 2021)

New Zealand Geotechnical Society (NZGS). (2001). *Guide for Hand-Held Shear Vane Test.*

New Zealand Geotechnical Society (NZGS). (2005). *Field description of soil and rock.*

New Zealand Geotechnical Society (NZGS), *New Zealand Ground Investigation Specificatio*n, Volumes 0 to 3.

NZSOLD. (2015). *The New Zealand Dam Safety Guidelines*.

NZ Transport Agency. (2018). *Bridge Manual* SP/M/022. Third Edition, Amendment 3.