Whangarei District Council

Land Development Stabilisation – Technical Design Requirements

April 2018

1. Introduction

1.1 Purpose

The intent of this document is to specify design requirements for stabilisation systems for land development. It is to be read in conjunction with Council's Environmental Engineering Standards (EES) and the *Land Development Stabilisation - Policy*.

The technical content of this standard has been prepared by Tonkin & Taylor Ltd (T+T), in accordance with the Council's Land Development Stabilisation Policy document and with direction from the Council on acceptable levels of risk and future liabilities for Council related to land development. This document has been prepared by T+T for Council with reference to applicable professional standards, guidelines, procedures and practices at the date of issue of this document. Application and interpretation of this document in specific circumstances is outside the control of the Council and T+T and is the user's responsibility.

1.2 Scope

This document applies to private land development projects.

1.3 Glossary of Terms

The definitions provided in the table below relate to the general meaning and not to specifically required design details.

TERM	DEFINITION
AGS	Australian Geomechanics Society
AGS(2007c)	Refers to the "Practice Note guidelines for landslide risk management" published by the **AGS** in 2007 http://australiangeomechanics.org/admin/wp-content/uploads/2010/11/LRM2007-c.pdf
Building	As defined by the New Zealand Building Code.
Council	Whangarei District Council
Counterfort drain	A comparatively deep type of **subsoil drain** constructed by trenching and installing a perforated pipe at the base of the trench surrounded by a filter material to collect groundwater, and sealed at the surface to prevent capture of surface runoff. Counterfort drains are usually constructed parallel to the slope direction. The primary purpose is to reduce the groundwater level and decrease the pore water pressure, which increases the effective shear strength of the soil. Counterfort drains are typically between 2-5 m deep.
CPEng	Chartered Professional Engineer
EES	Environmental Engineering Standards
Extreme (worst credible) groundwater conditions	The groundwater levels assessed for a site under extreme conditions i.e. following significant rainfall events and/or due to failure of subsoil drainage elements and/or blockage of any downstream public stormwater system that the **subsoil drain** discharges into
Factor of Safety (FOS)	The FOS for geotechnical design of slope stabilisation measures is the ratio determined by dividing the resisting forces by the driving forces. A FOS < 1.0 indicates that a slope is unstable and will likely displace until equilibrium is reached (i.e. FOS = 1.0).

TERM	DEFINITION
Geo-professional	A Chartered Professional Engineer (**CPEng**) registered in the Geotechnical practice area with **IPENZ**, or a Professional Engineering Geologist (**PEngGeol**) registered with **IPENZ**.
GIS	Geographic Information System
Hard engineering solution	Means of stabilising sloping ground or landslips by use of cut and fill earthworks, **slope buttresses** and in-ground structures such as **shear keys** or **palisade walls**.
Horizontally bored drain	A drain drilled into a slope to reduce the groundwater level and decrease the pore water pressure. They usually consist of slotted PVC pipe installed at an upwardly sloping angle of inclination to the horizontal (normally 5°) to allow discharge by gravity. Horizontal drains can be installed in a fanned array arrangement or installed in rows parallel to the direction of slope.
IPENZ	Institution of Professional Engineers New Zealand
Land development	Land development refers to altering the landscape in any number of ways such as changing landforms from a natural or semi-natural state for a purpose such as agriculture or housing; subdividing real estate into lots; or changing the purpose of a land parcel.
Land stabilisation system	An engineered system designed to improve land stabilisation to provide an acceptable **FOS**. It may include **hard engineering** and/or **subsurface drainage** elements.
Normal long term groundwater conditions	The groundwater levels assessed for a site that would be expected under normal conditions including normal seasonal variations.
Palisade wall	A line of piles constructed below the ground level and extending into stable ground to improve stability, often designed to intercept a **shear zone**.
PEngGeol	Professional Engineering Geologist
Post-development	After bulk earthworks or final ground shaping (as applicable) has been completed for a particular site.
Proponent	The owner of the subject land proposed for development.
Public stormwater system	Stormwater pipe networks that are owned and maintained by Whangarei District Council.
Shear key	Trench excavated into stable ground often below a shear zone and backfilled with material with high friction angle (generally granular material) to improve the stability of a slope or landslide.
Shear Zone / Shear Surface	A zone of ground (or surface) below ground level which is weaker than the surrounding ground and has either already developed a surface of movement or has the potential to develop a surface/zone of movement.
Slope buttress	A gravity structure or earth fill built at the toe of a slope to improve slope stability.
Subsoil drain	A drain comprising a perforated pipe constructed in a trench and backfilled with granular material, installed to collect subsurface or seepage water and convey it to a point of disposal. Subsoil drains have a variety of uses, including but not limited to; subgrade drainage below road pavements, drainage behind retaining walls, drainage at the base of gullies, drainage of saturated soils for agriculture and horticulture as well as drainage of slopes to improve slope stability.
Subsurface drainage	A drainage system constructed below ground to collect subsurface or seepage water and convey it to a point of disposal.

TERM	DEFINITION
Underfill drains	Drainage measures typically constructed at the base of bulk earthworks fill and are typically located at depth below the final ground surface e.g. drains that follow cleaned out gullies or areas of seepage prior to starting bulk earthworks for subdivision developments.
Vested asset	An asset whose ownership is transferred to Council upon development completion.

1.4 Background

Subsurface drainage is a common method used by Geo-professionals to improve the FOS of a slope. NZS 4404:2010 and NZS 4431:1989 include some subsurface drain design requirements[1] for subdivisions and residential developments which are, in general, applicable to the design of subsurface drains for slope stabilisation. The relevant sections are summarised below.

Section 4.3.9.9 "Subsoil drains" of NZS 4404:2010 states:

> *"Subsoil drains are installed to control groundwater levels. Perforated or slotted pipe used under all areas subject to vehicular traffic loads shall comply with NZTA specification F/2 and NZTA F/2 notes. It is good practice to provide regular inspection points.*
>
> *Bedding and backfill material around a subsoil drain pipe shall be more free-draining than the in situ soil. If filter fabrics are used their susceptibility to clogging, thereby reducing the through flow, should be considered."*

Section 6.2.4 "Subsoil drainage" of NZS 4431:1989 states:

> *"6.2.4.1*
>
> *Before fill is constructed over natural ground, pervious drains or similar subsoil seepage control systems should be installed to lead seepage away from all springs or potential areas of seepage emission from natural ground into fill, in order to:*
>
> *(a) Prevent saturation of the fill before construction of the fill is complete (prior saturation can delay settlement of the fill);*
>
> *(b) Prevent internal erosion ("piping"); and*
>
> *(c) Prevent internal seepage pressures which reduce shear strength.*
>
> *6.2.4.2*
>
> *Subsoil drains shall discharge via flexible jointed pipes to a destination approved by the local authority, preferably to stable watercourses or to piped stormwater systems.*
>
> *6.2.4.3*
>
> *A record shall be kept of the position, type and sizes of all subsoil drains, and in particular, the position of their outlets.*
>
> *6.2.4.4*
>
> *Where seepage is encountered from a sloping natural ground abutting a fill, a bench shall be cut just below the line of seepage and drains installed to collect the seepage and discharge it clear of the fill to a destination approved by the local authority, preferably to a stable watercourse or a piped stormwater system."*

There is risk associated with relying solely on subsurface drainage as the only means of slope stabilisation. Subsoil drains can over time become less effective, or in extreme cases become blocked. This depends on a number of factors, some of which may be able to be controlled during the design stage (e.g. use of filters, good specification, type of drain suited to the ground conditions/permeability) and other factors where there is less

[1] NZS 4404 and NZS 4431 use the phrase "subsoil drain". For the purposes of section 1.4 the terms "subsoil drain" and "subsurface drain" are used relatively interchangeably; elsewhere in this technical standard a *subsoil* drain is defined as a type or subset of *subsurface* drain.

control post-construction (e.g. algae growth, reliance on maintenance, protection from future development etc.). Some of the design and construction considerations are referred to in the NZTA F2 Specification. However, neither NZS 4404:2010, NZS 4431:1989 or NZTA F2 cover all the issues (particularly post-construction) for design of subsurface drainage for slope stabilisation purposes.

The Geo-professional should consider the limitations of particular systems when undertaking stabilisation design. For example, horizontally bored drains are limited in their capacity to reduce groundwater levels, due to their reduced cross sectional area. They are also at greater risk of blockage compared to counterfort drains and would not normally be installed as a standalone measure to stabilise land.

2. Design Requirements

2.1 General

The design of land stabilisation systems shall be performed and certified by a competent Geo-professional, and shall include a site-specific geotechnical risk assessment for both the existing and developed conditions.

In addition to the requirements of this document any stabilisation systems for land development shall also comply with the EES.

Land stabilisation systems shall be designed for at least 100 years' life.

2.2 Geotechnical Risk Assessment

Broad-scale geotechnical hazard maps are published on Council's online Geographic Information System (GIS) and identify areas prone to landslide hazards for planning purposes[2]. When land is proposed to be developed, the Geo-professional shall undertake a site-specific qualitative geotechnical risk assessment to characterise the slope stability hazard and the consequence of slope failure, and assign a risk classification in accordance with Appendix C of (AGS(2007c), 2007). This will refine the broad-scale three-category hazard classification into a site-specific five-category risk classification.

2.3 Design solution

Following the geotechnical risk classification described in section 2.2 above, the Geo-professional shall prepare a design solution incorporating the requirements of Table 2-1,

Figure *2-1* and Table 2-2.

The risk assessment shall continue through the slope stabilisation design process and consider the consequence of partial or complete failure of subsurface drainage and the effect on the proposed development. The outcomes of the risk assessment shall be included in the geotechnical design report and presented to Council in support of any request for engineering approval.

For sites assessed to have a High to Very High Risk level, subsurface drains will not be accepted as a standalone measure for slope stabilisation due to their potential to reduce in effectiveness over time. Acceptable design solutions are further discussed below (refer to

Figure *2-1* and Table 2-2). The minimum FOS to use in the design of land stabilisation systems is stated in Table 2-1.

Table 2-1: Minimum FOS for land stabilisation design

Design Condition	Minimum FOS
Normal long term groundwater conditions	1.5

[2] Hazard maps and accompanying reports are available on Council's website www.wdc.govt.nz

Extreme groundwater conditions	1.3
Seismic condition in 500 year return period event	1.1

2.3.1 Case 1

When the post-development FOS is less than 1.3 for normal groundwater conditions, hard engineering solutions (with or without subsurface drainage) are required to improve the FOS to ≥ 1.5. If subsurface drainage is used, the design will also need to confirm that a sufficient margin of safety is retained under extreme groundwater conditions, assuming drainage failure.

2.3.2 Case 2

When the post-development FOS is greater than 1.3 for normal groundwater conditions, subsurface drainage may be used to improve the FOS to ≥ 1.5. The design will also need to confirm that a sufficient margin of safety is retained under extreme groundwater conditions, assuming drainage failure.

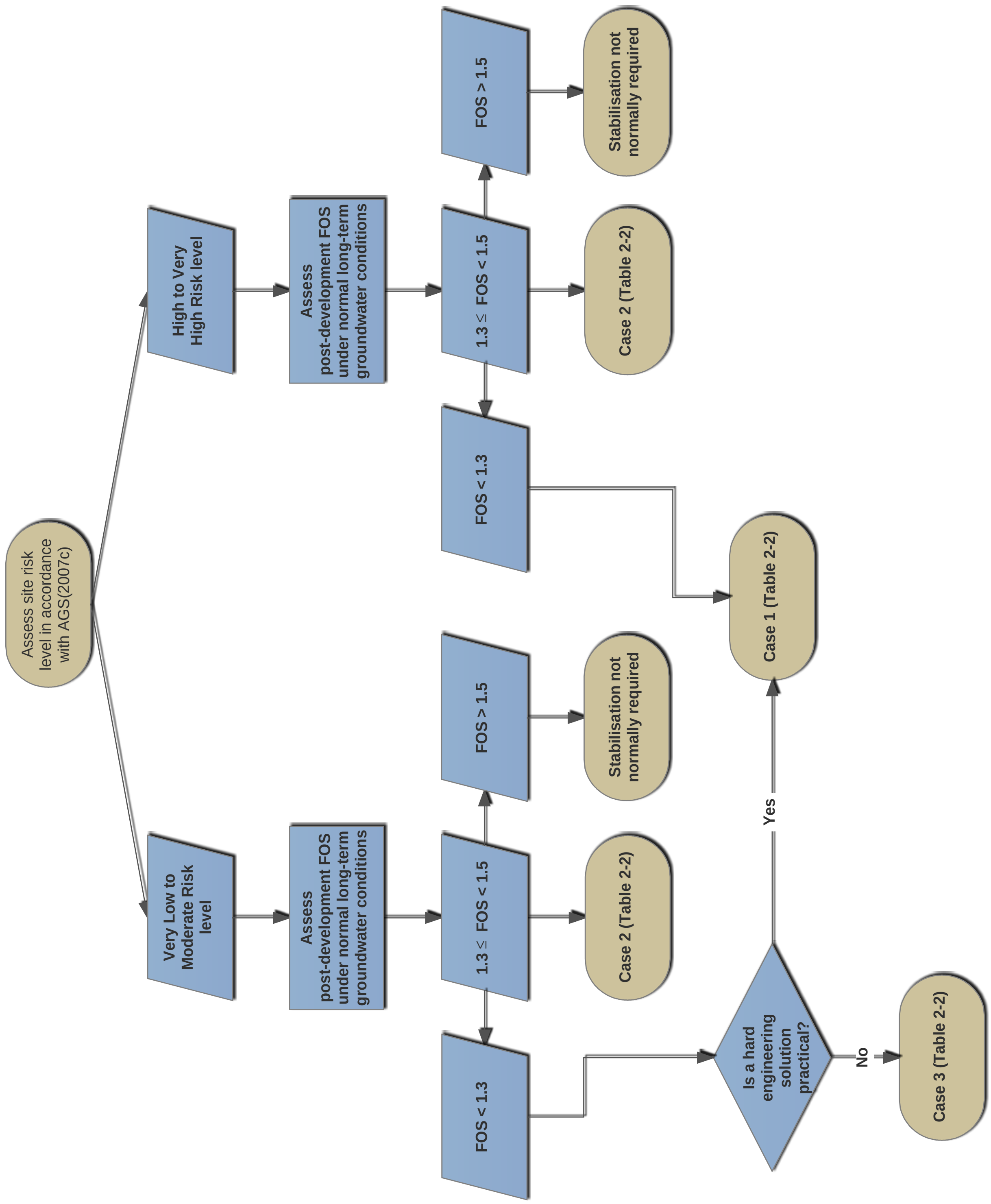
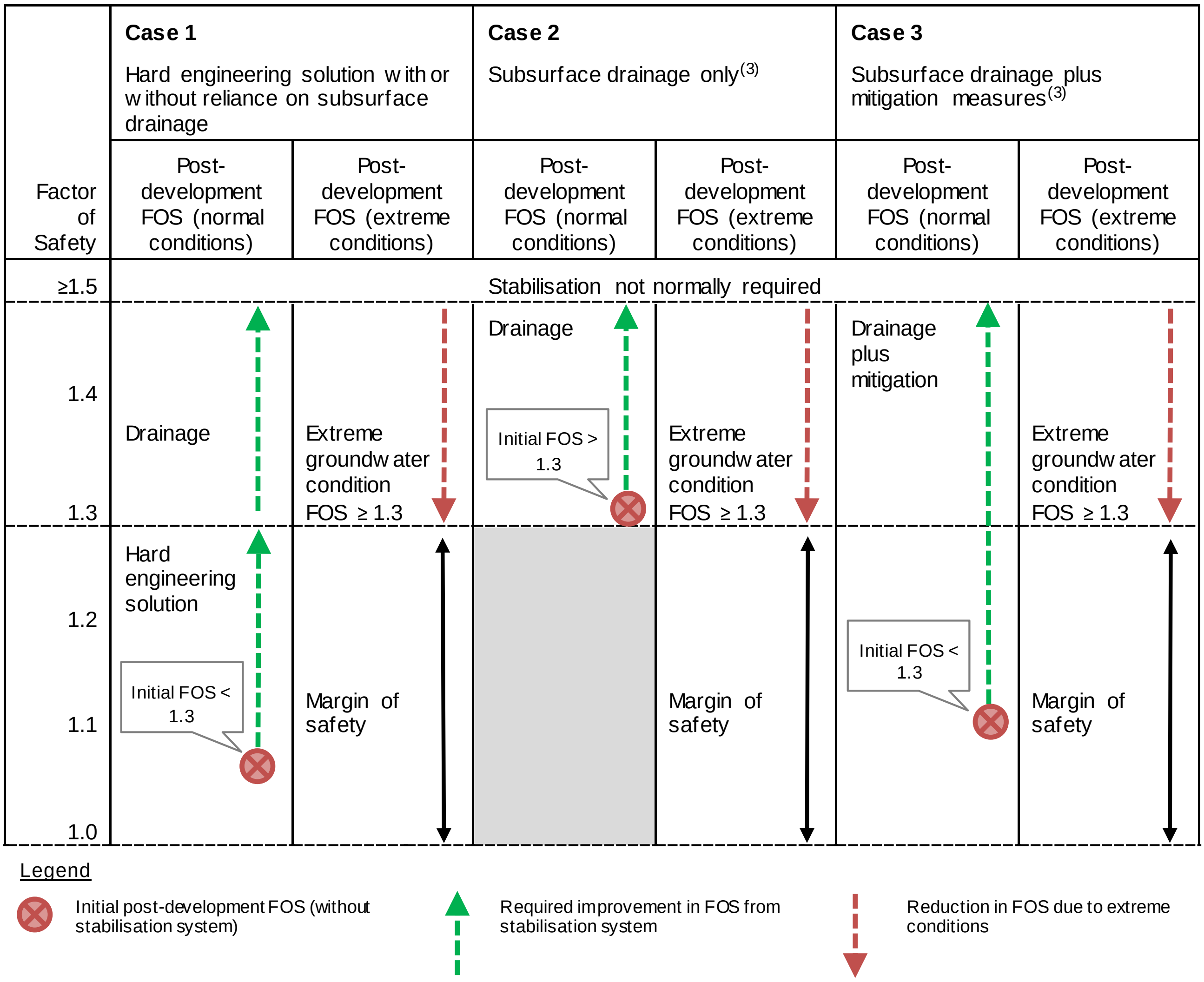


Figure 2-1: Process for selecting a land stabilisation system

Table 2-2: Stabilisation solutions



Notes

1. Refer to Figure 2-1 for applicability of various cases.
2. Refer to Table 2-1 for minimum FOS.
3. Doesn't preclude the use of hard engineering solutions.

2.3.3 Case 3 (Very Low to Moderate Risk only)

This case will only be considered for sites assessed as very low to moderate risk in accordance with section 2.2.

If it can be demonstrated to Council's satisfaction that a hard engineering solution is impractical, Council may at its sole discretion consider a subsurface drainage solution only, provided a whole-of-life strategy is developed including the following mitigation measures:

a) All constraints to the use of hard engineering solutions should be re-examined by the proponent and Council before implementing a subsurface drainage-only solution. Where consent conditions are constraining or precluding the use of a hard engineering solution then consideration should be given to relaxing those conditions;

b) The Geo-professional shall demonstrate that an appropriate margin of safety is retained if the subsurface drains fail under extreme groundwater conditions;

c) Adequate redundancy is built into the drainage design i.e. more drainage than required, different types of drainage, multiple outlets etc.;

d) The design allows for regular cleaning/flushing and that regular maintenance is enforced and carried out e.g. via a covenant on the title (and the liability for failing to maintain is explicitly defined);

e) The design provides suitable access for maintenance, as described in d) above;

f) Specification for the drainage is set high to reduce the risk of blockage e.g. conservatively sized pipe, concrete outlets, high specification drainage metal etc.;

g) Design certification by a suitably qualified and experienced Geo-professional in accordance with the EES;

h) Contingency measures are identified in the case that the drains become blocked e.g. designing so they can be replaced or flushed if required;

i) Ongoing monitoring of groundwater levels and pore water pressures by means of in-ground piezometers. Monitoring is enforced similar to item d) above; and

j) A Management Plan is prepared to capture items d) and i).

2.4 Location of Land Stabilisation Systems

Land stabilisation systems shall be located in accordance with the *Land Development Stabilisation - Policy.*

3. Design Submissions

3.1 General

The required content of geotechnical assessments is defined in the EES.

3.2 As-Constructed Drawings

As-built drawings shall record the position, depth, type and dimensions of all land stabilisation system components, and in particular the position and depth of subsurface drain pipes and outlets. Submissions shall additionally comply with EES requirements.

4. References

AGS(2007c) Practice Note guidelines for landslide risk management [Journal]. - [s.l.] : Australian Geomechnics, 2007. - 1 : Vol. 42.

New Zealand Transport Agency Specification for Pipe Subsoil Drain Construction. - 2013. - NZTA F2:2013.

Standards New Zealand Code of practice for earth fill for residential development. - 1989. - NZS 4431:1989.

Standards New Zealand Land development and subdivision infrastructure. - 2010. - NZS 4404:2010.

Tonkin & Taylor Ltd Coastal Structure Plan - Slope instability hazard potential and effluent disposal potential Oakura to Langs Beach [Report]. - 2005.

Tonkin & Taylor Ltd Land Zonation Mapping - Geotechnical assessment level / stability hazard mapping for East and West Kensington, Morningside and the Port [Report]. - 2007.

Tonkin & Taylor Ltd Land Zonation Mapping - Geotechnical assessment level / stability hazard mapping for Hikurangi, Mid Kensington, Whangarei City Centre, East Kamo & Portland [Report]. - 2008.

Tonkin and Taylor Ltd Land Zonation Mapping - Stability hazard mapping / geotechnical assessment level and effluent disposal potential for Kamo, Maunu, Onerahi, Otaika and Tikipunga [Report]. - 2006.

Whangarei District Council Environmental Engineering Standards. - 2010.

Whangarei District Council Stabilisation Systems for Land Development Policy (Superceded). - 2016.

5. Adoption

This Technical Standard has been authorised by the Waste and Drainage Manager and the General Manager Infrastructure.

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Waste and Drainage Manager

Date

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