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A Review of the Slope Risk Overlays defined in the Nelson Resource Management Plan

Prepared for Nelson City Council

February 2015

EXECUTIVE SUMMARY

1. Nelson City has a wide variety of different rock types forming large areas of hill country, with slopes ranging from gentle to steep, and is subject to prolonged and high intensity rain storm events from the north as well as having a recognised seismic hazard. The latter includes the active Waimea-Flaxmore Fault System that extends through the city as well as proximity to other major faults in the north of the South Island, such as the Alpine Fault.
2. The above factors contribute to widespread instability, including soil creep, rock falls, small tear drop slips, ill-defined areas of relatively superficial movement, earthflows and large deep-seated rotational landslides.
3. While slope failures are a natural phenomenon their occurrence is commonly exacerbated by human activities, including excavations removing toe support for the slope above, surcharging of the slope below by the placement of fill and poorly designed drainage.
4. Many of the adverse effects of slope instability within the city have arisen due to a failure to recognise existing or potential failures at the time when human modification of the landscape was initiated.
5. The Nelson Resource Management Plan currently recognises two areas within the city where there is a known or potential risk of slope movement.

Tahunanui Slump

6. The Tahunanui Slump is a large active rotational landslide that was recognised early in the European settlement of Nelson. The landslide is currently slowly settling with sporadic bursts of more rapid, but localised, movement resulting from rainstorm events some of which were possibly exacerbated by seismic ground shaking in 1929 and 1962.
7. As defined in the Nelson Resource Management Plan, the Tahunanui Core Slope Risk Overlay is the active part of the Tahunanui Slump whereas the Tahunanui Slump Fringe Slope Risk Overlay includes *in situ* ground comprising the head scarp, the side scarps of the slump and ground marginal to the scarps.
8. It is recommended that the overlays are retained but renamed the Tahunanui Slope Risk Overlay and the Tahunanui Fringe Slope Risk Overlay.
9. It is recommended that the Tahunanui Fringe Slope Risk Overlay be confined to the ground immediately to the north, east and southeast of the Tahunanui Slump where there is a greater likelihood of developments, such as earthworks and drainage, impinging on the Tahunanui Slump as well as a higher risk of regression of the head and side scarps.
10. Developments within the overlays should continue to require geotechnical investigation and supervision.
11. Building consents within the Tahunanui Slope Risk Overlay, other than minor structures and minor alterations, be granted under Section 72 of the Building Act 2004.

Grampians

12. The Grampian Slope Risk Overlay as defined in the Nelson Resource Management Plan extends from the vicinity of Seymour Avenue to Bishopdale and encompasses an area underlain by generally weak rocks of Late Cretaceous and Tertiary age. Although relatively large and well-defined rotational landslides have locally developed in pre-historic times, more commonly slope movement is ill-defined. Rock exposure is generally poor due to a cover, of variable thickness, of scree, slope wash and slope movement deposits derived from further up slope.
13. It is recommended that the Grampian Slope Risk Overlay be either retained or incorporated into a wider hill area where geotechnical investigation is also appropriate (see below).
14. If the overlay is retained then its boundaries be wherever possible realigned to coincide with cadastral boundaries and that minor alterations are made to the permitted earthworks in REr.81.1 a & b of the existing Nelson Resource Management Plan.

Remaining hill areas

15. It is recommended that all developments, other than minor structures and earthworks involving cut and fill faces less than 1 m in height and thickness and/or fill comprising no more than $3m^3$, on sloping ground, that is not within the *Tahunanui Slope Risk Overlay* and the *Tahunanui Fringe Slope Risk Overlay*, be subject to geotechnical input so as to minimise the risk of slope instability. If the *Grampian Slope Risk Overlay* is retained then the area it encompasses would also be excluded.
16. It is recommended that the sloping ground is called *Hill area requiring geotechnical assessment overlay* or if an overlay is not adopted then the area could be referred to in the resource management plan under *Hill area requiring geotechnical assessment* or *Geotechnical assessment requirements for hillsides*.
17. The *Hill area requiring geotechnical assessment* can be defined as an overlay, although its boundaries would rarely coincide with cadastral boundaries, or it can be defined as all ground exclusive of unconsolidated terrestrial and marine sediments underlying slopes of less than 15º (as measured below the horizontal) and be referred to as *Hill area requiring geotechnical assessment* or *Geotechnical assessment requirements for hillsides*.
18. Cognizance should be taken that failures within the *Hill area* may impinge on marginal ground that is in itself not subject to slope failure.

General

19. It is recommended that provision be made in revised Nelson Resource Management Plan so that recommendations arising from subsequent geotechnical investigations, particularly those undertaken as part of geotechnical certification of subdivisions, can be recognised as meeting the intent of the provisions of the resource management plan.

1. INTRODUCTION

1.1 As per a contract dated 16 December 2014, the Grampians Slope Risk Overlay and Tahunanui Slump Core and Fringe slope risk overlays defined in the Nelson Resource Management have been re-evaluated, along with a broad assessment of the hazard of slope instability generally in hill areas of the city (Fig. 1).

1.2 Slope instability in the city includes soil creep, rock falls, small tear drop slips, ill-defined areas of relatively superficial movement, earthflows and large deep-seated rotational landslides

1.3 The city has complex geology with a greater variety of rock types than any other urban area in New Zealand. Slope instability is partly governed by rock type, topography and rainfall. In addition, the city is traversed by a number of faults belonging to the active northeast trending Waimea-Flaxmore Fault System[1]. Ground shaking, from events arising both on the fault system, and on other faults adjacent to the city, has the potential to initiate slope instability ranging from minor slips and rock falls to, in an extreme event, major landslides. Instances of slope instability have arisen from inappropriate or poorly designed and/or constructed earthworks and related structures, which have often been compounded by inadequate drainage.

1.4 While slope failures are a natural phenomenon they can be induced, or existing failures re-activated, by human activities, such as removal of toe support for the slope above, surcharging of the slope below by filling, interference with natural runoff or failing to provide adequate drainage during slope modification.

1.5 Inability in the past to recognise and understand the complex geotechnical conditions that prevail in Nelson has resulted in a number of slope failures that could have been avoided. Even minor failures can result in damaging, and in some instances life threatening, events.

1.6 The present report is based on published geological maps[2] supplemented by information known to the writer, including the Nelson City Council database on slope instability. The database, although extremely useful, has to be treated with caution in that it is a record of slope instability that is known or has been reported to council and it is inconsistent in its coverage and its evaluation of that instability.

1.7 The report was forwarded in draft to the Nelson City Council who had it peer reviewed by Mr P. C. Denton of Geo-Logic Limited[3]. The suggestions and recommendations in the review have been taken into consideration in the report.

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[1] Johnston, M. R.; Nicol, A. 2013: Assessment of the Location and Paleoearthquake History of the Waimea-Flaxmore Fault System in the Nelson-Richmond area with recommendations to mitigate the hazard arising from fault rupture of the ground surface. *GNS Science Consultancy Report 2013/186*.

[2] Johnston, M. R. 1979: Geology of the Nelson Urban Area (1:25 000). *New Zealand Geological Survey urban series Map 1.*

Johnston, M. R. 1981: Sheet O27AC – Dun Mountain. *Geological Map of New Zealand 1:50 000*.

Johnston, M. R. 1982: Part sheet N27 – Richmond. *Geological Map of New Zealand 1:50 000*.

Johnston, M. R. 1993: Geology of the Rai Valley Area. *Geological & Nuclear Sciences map 5*.

Rattenbury, M. S.; Cooper, R. A.; Johnston, M. R. 1998: Geology of the Nelson Area. *Institute of Geological & Nuclear Sciences 1:250 000 geological map 9*.

[3] Memo to Sharon Flood dated 2 April 2015: Slope Risk Overlay Re-evaluation Report: Initial Peer Review

2. TAHUNANUI SLUMP CORE RISK OVERLAY and TAHUNANUI SLUMP FRINGE RISK OVERLAY

2.1 The Nelson Resource Management Plan defines the Tahunanui Slump Core Risk Overlay and Tahunanui Slump Fringe Slope Risk Overlay. The core slope risk overlay comprises the Tahunanui Slump, an active landslide, whereas the fringe risk overlay includes the head scarp and side scarps of the landslide along with an area of variable width marginal to the scarps.

2.2 While the intent of the core slope risk overlay is to manage an active landslide that has been extensively built on, the fringe slope risk overlay was defined to minimise activities that might have a detrimental effect on the landslide as well as allowing for imprecision in the location of the boundaries of the slump. It does not include the active landslide. The most obvious detrimental activities within the fringe area is the re-contouring of land that results in increased overland flows onto the active landslide or causes instability within the side scarps and particularly the head scarp.

3. TAHUNANUI SLUMP

3.1 The Tahunanui Slump is a large, complex rotational landslide that has developed in the Port Hills above Tahunanui Beach and the southern end of Rocks Road. The timing of initiation of the landslide is not known but is in the order of several thousand years or more ago.

3.2 Because the rocks in the area dip southeast into the hillside, and are therefore favourably orientated to give maximum stability, the landslide has been interpreted as the result of severe seismic ground shaking, likely arising from rupture along a nearby component of the Waimea-Flaxmore Fault System.

3.3 In the greater Nelson urban area (comprising the city and the adjoining part of the Tasman District stretching south along the Barnicoat Range to the mouth of the Wairoa Gorge) the fault system displays evidence of surface ground rupture on sections of the Waimea, Flaxmore, Eighty-eight, Bishopdale and Whangamoa faults. Movement on any of these faults, or a concealed fault just to the west of the Port Hills, would release sufficient energy to trigger the Tahunanui landslide as well as other known major slope failures at Marybank and near Richmond.

3.4 Erosion by the sea of the toe of the landslide has ensured on going movement although the construction of Rocks Road in the 1890s has eliminated this aggravating factor. Nevertheless, slope movement is continuing and is more evident along the margins of the landslide or between blocks of relatively coherent, but still moving, blocks within it.

3.5 The Tahunanui hillside has long been recognised as being subject to slope movement and the first dwelling on it was damaged beyond repair in the late 1840s. Despite the hazard of slope instability being identified, and against geological advice, the Tahunanui Town Board allowed the slump to be subdivided into residential sections in the late 1920s and 1930. Prior to this the hillside had been used for rough grazing[4].

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[4] Denton, P. C.; Johnston, M. R. 1996: *Housing development on a large, active landslide: The Tahunanui Slump Story, Nelson, New Zealand. Geotechnical Issues in Land Development. New Zealand Geomechanics Society Symposium* (and references therein).

3.6 The construction of Moana and Bisley avenues and Grenville Terrace (formerly Edward Street) to service the residential development also interfered with natural drainage and cutting and filling, depending on location, could have had beneficial or detrimental effects on slope stability locally.

3.7 Although the construction of Rocks Road eliminated the ongoing erosion of the toe of the landslide, its building utilised fill quarried from the toe of the landslide, which further removed toe support for already unstable ground immediately upslope.

3.8 A rainstorm event in 1929, perhaps aggravated by moderately severe ground shaking resulting from the Murchison Earthquake of 17 June 1929, caused serious damage to properties on the lower part of the landslide. A similar scenario occurred in 1962[5] and in November 2011, although there were no earthquakes felt in Nelson at the time of the latter.

3.9 While rainfall was the major contributing factor in the 1929, 1962 and 2011 events, severe ground shaking arising from movement on a fault within or close to the city would also cause significant and damaging movement within the landslide, particularly if the ground was fully water saturated.

3.10 Initially there was no reticulated water supply to the residential area, because it was recognised that this would increase the discharge of water to land, but stormwater was disposed of in soak pits. When a reticulated supply was introduced disposal of stormwater remained inadequate.

3.11 Following the 1962 event, major improvements were initiated by the Nelson City Council to the stormwater system, which resulted in a significant reduction of water infiltrating into the landslide.

3.12 Irrespective of the improvements to drainage, the landslide continues to settle as shown by approximately 10 yearly surveys undertaken over the past 50 years of survey standards installed as part of the original subdivisions of the 1920s and 1930s. Rates of settlement, as shown by the survey standards, vary but are up to 25 mm per year. As well as settlement, with movement towards the west, there is in places an upward movement reflecting ground rotation within the landslide.

3.13 Erection of new residential units on the landslide is a non-complying activity although additions, alterations and even replacement of existing buildings may be possible. Unless deemed by council to be of a minor nature[6], building consents are granted under Sec 72 of the Building Act 2004, which basically means that while mitigation measures may have been implemented to ensure that the risk of slope movement is not aggravated, the consent holder acknowledges that there remains a risk that will be higher than on more stable ground.

4. DISCUSSION

4.1 The Tahunanui Slump remains an active landslide and although most movement within it is slow there are areas where more rapid movement can result in significant damage to structures. In this respect it is not so much the intensity of the rain but the duration of it that is the critical factor. A short high intensity rainfall event is unlikely to result in an acceleration of movement of the landslide. On the other hand steady

[5] Falconer, B. H. 1963: Stability of the hillside at Tahunanui, Nelson.
[6] The Building Act does not define what is major or minor.

rain over a longer period, in which the infiltration of water results in saturation of the ground, will likely significantly increase the risk of slope movement, as occurred in the 1929, 1962 and 2011 events.

4.2 The detrimental effects of ground saturation were aggravated in the 1929 and possibly the 1962 events by seismic ground shaking.

4.3 Although there is now an efficient stormwater system in place this has not eliminated the risk of future movement as was demonstrated in 2011. However, it does mean that a lot more rain has to fall than previously for the ground to become fully saturated.

4.4 Council has a duty of care to advise potential purchasers of property within the landslide of the risk of ongoing movement.

4.5 Council also has a role to ensure that existing owners manage their properties in a manner that minimises the risk of movement within their properties and the landslide as a whole.

4.6 Although lightweight flexible construction for buildings on the slump has been generally preferred, in recent years it has been shown that other types of building design, depending on location, are also acceptable. Consequently, the type of building need not be unduly restrictive provided the design is geotechnically appropriate.

4.7 The boundaries of the landslide are not precisely defined. The boundaries delineated on Figure 2 are, at the scale depicted and based on geological data currently available, include the landslide. The most significant alteration to the boundary of the overlay since it was originally defined is in the vicinity of Stansell Avenue. Largely as a result of geotechnical investigations undertaken by the owners of 12 and 16 Stansell Avenue in support of building consent applications it is possible to move the boundary of the landslide further north than the position shown in the Nelson Resource Management Plan.

4.8 If future geotechnical investigations further constrain the boundaries of the landslide then provision needs to be made in the plan change so that areas shown to be on *in situ* ground are excluded from the core slope risk overlay.

4.9 Foundations, earthworks and drainage should be designed and supervised by an appropriately qualified and experienced geotechnical consultant who would also review the overall development.

4.10 If the landslide was undeveloped land today there is a high probability that it would remain largely unsubdivided. However, with the increasing value of land for residential use in the city, coupled with the landslide’s outstanding location adjacent to Tahunanui Beach and overlooking Tasman Bay and the western mountains, it is possible that large scale mitigation works to stabilise the slump or at least reduce the risk to an acceptable level for urban use would have at some stage been implemented.

4.11 While technically feasible, the cost of stabilising the landslide would be high but could have been recovered from more intensive development than is presently the case. An example of this, although on a much smaller scale, was the mitigation measures implemented at the Ridgeways South that has allowed, as part of the Greenmeadows Development, the residential subdivision of an active landslide.

4.12 Although stabilisation of the Tahunanui Slump is still possible, the chances of obtaining the agreement of all property owners to implement and fund the necessary works would probably prove difficult. While it is considered likely that some owners would support the opportunity to redevelop their properties by, for example, building apartment blocks, others may be content to leave the hillside more or less as it is.

4.13 Although the general intent of the Tahunanui Slump Fringe Slope Risk Overlay is worthwhile the name is unfortunate in that there is a perception that it is part of the active landslide.

4.14 Nevertheless, it is important that no activities are undertaken in the fringe zone that could increase the risk of slump movement or result in accelerated regression of the side scarps and, more particularly, the head scarp.

4.15 The head scarp is a prominent feature rising in height from a few metres in the north to an impressive 50 metres in the south. Runoff and slope failures from the head scarp have the potential to increase movement within the landslide itself by adding weight to it and also allowing infiltration of water, particularly into the basal slide plane of the landslide. Also any retreat of the head scarp will impinge onto gentler, residential ground east of its crest.

4.16 Consequently, Council has a duty to ensure that any developments within this gentler ground are not at an elevated risk due to potential retreat of the head scarp. It also has a duty to ensure that the public are aware of this risk. Therefore while the need for a fringe zone encompassing and adjacent to the most prominent sections of the side scarps is less critical, it is essential with respect to the head scarp and prudent to do so for much of the northern side scarp and the southern side scarp in the vicinity of Stansell Avenue. Due to the geotechnical investigations undertaken on 12 and 16 Stansell Avenue the fringe area would increase in extent.

5. RECOMMENDATIONS

It is recommended that:

5.1 The Tahunanui Slump and its fringe areas remain as two separate slope risk overlays and that their boundaries are as depicted on Figure 2.

5.2 The names of the overlays are changed to Tahunanui Slope Risk Overlay and Tahunanui Fringe Slope Risk Overlay.

Explanatory note: The Tahunanui Slope Risk Overlay remains unchanged from the current core slope risk overlay except in the vicinity of Stansell Avenue where the boundary has been moved further north. Except for an increase in its width in the Stansell Aveue area, as a result of the recommended change to the boundary of the Tahunanui Slump, the fringe overlay has been reduced in size, including the deletion of the overlay along the southern side scarp of the Tahunanui Slump. In the head scarp area a minor modification has been made so as to align the southeast corner of the overlay with cadastral boundaries.

5.3 Any developments within the two slope risk overlays are fully investigated by an appropriately qualified and experienced geotechnical consultant and recognised as such by the Nelson City Council.

5.4 Within the Tahunanui Slope Risk Overlay all consents that are granted for new buildings, other than minor structures such garden sheds and alterations to existing buildings that Council deems to be of a minor nature, are granted under Section 72 of the Building Act 2004.

5.5 If ground currently within the Tahunanui Slope Risk Overlay is, as a result of geotechnical investigation shown not to be part of the active landslide, then there should be a mechanism for excluding it from the overlay as this could have implications with respect to the Building Act and other planning requirements.

6. GRAMPIANS SLOPE RISK OVERLAY

6.1 Unlike the relatively distinct Tahunanui Slump, slope instability within the existing Grampian Slope Risk Overlay, defined in the Nelson Resource Management Plan and extending from Seymour Avenue to Bishopdale, ranges from ill-defined slope movement to relatively large rotational landslides that are apparently inactive. It also includes stable ground whose stability could be threatened by inappropriate earthworks or drainage.

6.2 The slope risk overlay requires consent for all earthworks, other than minor garden landscaping involving cuts no greater than 0.6 m in height and fill on any one site does not exceed $3m^3$, and this has helped minimise the risk of inappropriate land use initiating slope instability in an area that was poorly understood geotechnically.

7. DISCUSSION

7.1 Since the Grampians Slope Risk Overlay was introduced more is known about the geotechnical parameters within it and the public generally are now a lot more aware of the need to obtain geotechnical advice before embarking on earthworks. Nevertheless, the overlay encompasses an area where extreme caution should be exercised with earthworks and drainage.

7.2 Stable ground, which forms relatively strong spurs at, for example the head of Collingwood Street and the southern end of Allan Street, are composed of Bishopdale Conglomerate. This rock contains numerous fractures, commonly filled with expansive clays, and can thus readily translate from being stable into slope failures depending on such factors as extent of the cuts, steepness of slope, and moisture levels.

7.3 With the current overlay there commonly arose uncertainty as to whether recommendations with regards to earthworks that resulted from subsequent geotechnical investigation could take precedence over what is permitted in the Nelson Resource Management Plan. In some instances, geotechnical certification, which the Council requires as a condition of resource consent for a subdivision and related earthworks, may after appropriate investigation recommend less onerous earthworks conditions that what are specified in the plan. There are two ways this has been addressed by Council in the past. One was to accept the recommendations that were part of the geotechnical certification as having met the requirements contained within the slope risk overlay. The other was to literally interpret the wording in the plan (REr.81.3) and require any excavations with cut heights not exceeding 0.6 m to be specifically geotechnically investigated. The latter approach led to instances where purchasers of sections in the newly completed Grampians Oak Subdivision had to have further geotechnical investigations undertaken even though the earthworks applied for complied with the geotechnical conditions recognised by Council when it accepted the geotechnical certification for the subdivision. It is therefore desirable that the wording with respect to the overlay should make allowance for situations where there have been recent geotechnical investigations that have resulted in less onerous development conditions.

7.4 If provision is made for recommendations, as part of a geotechnical certification of a subdivision, that are less onerous that the current plan then Council will need to ensure that they are still valid. As a general rule Council has an unwritten policy that after approximately two years after it has received geotechnical documentation relating to recommended development conditions it may require, as part of any application for resource or building consent, confirmation from the geotechnical provider that these are still appropriate. Geotechnical certifications of building sites generally have a longer, but unspecified, “shelf life”.

8. RECOMMENDATIONS

It is recommended that:

8.1 Controls on earthworks and drainage are continued within the lower western slopes of the Grampians. There are two potential ways this can be achieved:

Option A

8.2 The Grampians Slope Risk Overlay remains in the Nelson Resource Management Plan but that its boundaries are amended, as far as it is possible and practical to do so, with cadastral boundaries (Figure 3).

8.3 As part of the permitted earthworks (REr.81.1 a & b), that in addition to excavations not exceeding 0.6m in height and fill, limited to $3m^3$, should also not exceed 0.6 m in thickness.

8.4 Provision is made in the plan so that recommendations arising from subsequent geotechnical investigations, particularly those undertaken as part of geotechnical certification of subdivisions, can be adopted.

8.5 If recommendation 8.4 is implemented then, depending on the amount of time that has elapsed since the consultant’s investigation was completed, Council may require confirmation from the consultant, or from another geotechnical consultant, that the conditions pertaining to the certification remain relevant.

Option B

8.6 That because more is known of the underlying geology than when the Grampians Slope Risk Overlay was introduced, coupled with a greater awareness generally of the need for geotechnical input, that the slope risk overlay be abolished and that it be incorporated within a requirement for geotechnical input into all developments within the hill areas of Nelson City (see 9 below), other than for the areas within the Tahunanui Slope Risk Overlay and Tahunanui Fringe Slope Risk Overlay as referred to above.

9. SLOPE STABITY CONSIDERATIONS ELSEWHERE IN THE CITY

9.1 Within the hill areas of Nelson City, and possibly elsewhere depending on the ground conditions, the Nelson City Council generally requires earthworks to be supervised and, if appropriate to do so, certified by a geotechnical consultant recognised as such by the Council. Similarly Council requires that all new building sites in hill areas, and locally elsewhere, are certified as suitable for that purpose by a geotechnical consultant.

10. DISCUSSION

10.1 Due to the wide variability of factors, such as topography, groundwater levels and rock types, Council has required for many years geotechnical input into all developments in hill areas other than for some minor works. In some areas of flat or gently sloping land geotechnical input has also be required and this may include alluvial land abutting hillsides that may have an elevated slope instability risk.

10.2 Arising from 10.1 development conditions are held by Council in a register or “Conditions Book”. These conditions provide a guide as to how Council would expect development works to proceed, such as to who should design and supervise earthworks. As the conditions have limited legal standing, Council now requires the more critical ones to be entered as consent notices on the relevant certificate titles at the time of 224 Certification in the resource consent process for subdivisions. To ensure this can be achieved, this requirement needs to be a condition of the resource consent.

10.3 Most conditions and all consent notices are specific to a subdivision but other more general conditions, such as the prevention of detrimental overland flows, vegetation cover etc, have wider applicability. It may be worthwhile to incorporate these more general conditions in guidelines for development and management of hill and other areas. Alternatively it may be possible to incorporate them in explanatory notes within the resource management plan.

10.4 One specific geotechnical condition is C418 that applies to the abandoned sea cliff that extends along the former waterfront from Annesbrook to Tahunanui, Magazine Point to Anzac Park and from The Wood northwards through parts of Atawhai. These cliffs are cut in relatively weak rock whose stability is decreasing as weathering progresses. In many places, excavations into the toe of the cliffs for roads and buildings have further over-steepened the ground, particularly along Wakefield Quay and Haven Road. The areas referred to in C418 could be, subject to a revision of its boundaries, incorporated into a slope risk overlay but if it is formally recognised in an amended Nelson Resource Management Plan that geotechnical input is required on all developments on hillsides then a new overlay is not warranted. Similarly, the Grampians Slope Risk Overlay could be incorporated into a broader requirement for geotechnical input into developments in hill areas that are not within the Tahunanui overlays, as recommended in this report.

10.5 There are two methods for defining the hill area. It can be defined as a boundary on an overlay but because of its nature it would be, except locally, impossible to align with cadastral boundaries. Although the latter is of advantage in planning documents it would be hard to justify geotechnically. An alternative to an overlay is to define hill country as being over a certain slope. This geologically is not necessarily straight forward as very gentle slopes may be subject to movement or indeed could be the toe of an active failure, whereas a steep slope underlain by competent rock may be at low risk of instability. However, if the latter approach is adopted then a slope that excludes most unconsolidated rocks, such as alluvial and marine deposits, will be required. In Nelson, hill country can be defined as all ground exclusive of unconsolidated terrestrial and marine sediments underlying slopes of less than 15º. This figure would exclude all flat land and gently sloping alluvium, such as the major fan deposits. However, gently sloping ground within the hill areas, such as ridge crests, that are less than 15º, should be included.

10.6 Land marginal, but excluded from, the hill area may be affected by run out from failures originating within steeper ground. Without specific investigation it is not possible to define this marginal area but if possible cognizance of this risk should be recognized.

11. RECOMMENDATION

It is recommended that:

11.1 Developments in sloping ground that is potentially at risk from slope instability, and lying outside of the Tahunanui overlays as recommended in this report, are subject to geotechnical assessment. Also some areas of flat to gently sloping alluvial land at the toe of hillsides may also require geotechnical assessment.

Explanatory notes:

1) The level of geotechnical input will be dependent on the scale of the works proposed and the nature of the underlying ground. Thus geotechnical input could simply involve a review by a geotechnical consultant or it could require investigation, design and construction under the supervision of an appropriately qualified and experienced geotechnical consultant and recognised as such by the Nelson City Council.
2) The area within the *Grampian Slope Risk Overlay* could become part of the new area requiring geotechnical input.
3) If, on the other hand, the *Grampian Slope Risk Overlay* is retained, subject to recommendations contained in Section 8 above, then the area involved would be excluded from Recommendation 11.1

11.2 If the area covered by 11.1 is an overlay then this be named *Hill area requiring geotechnical assessment overlay*.

Explanatory note:

1) If an overlay is defined then it can include marginal areas that may be at risk from slope instability in sloping ground.

11.3 If the area referred to in 11.1 is not an overlay then it be defined as all ground exclusive of unconsolidated terrestrial and marine sediments underlying slopes of less than 15º (as measured below the horizontal) and be referred to as *Hill area requiring geotechnical assessment* or *Geotechnical assessment requirements for hillsides*.

Explanatory note:

1) Any definition of the hill area should recognise that slope instability may also impinge on gentler sloping marginal ground.

11.4 The criteria be the same as for Grampian Slope Risk Overlay except that REr.81.1 a & b), be amended to excavations not exceeding 1.0 m in height and fill, limited to $3m^3$, not exceed 1.0 m in thickness.

ACKNOWLEGEMENTS

The writer thanks Mr Paul Denton of Geo-Logic Limited for his helpful review and Dr Steve Read, Nelson City Council, for preparing digital versions of the figures.

LIMITATIONS

This report has been prepared solely for the Nelson City Council and is based on existing published geological maps and a limited amount of unpublished data. No site specific investigations have been undertaken.

Figure Captions

Fig. 1 – Nelson City showing *Tahunanui Slump Core Slope Risk Overlay*, *Tahunanui Slump Fringe Risk Overlay* and *Grampians Slope Risk Overlay* as currently defined in Nelson Resource Management Plan and also the extent of hill country in city.

Fig. 2 – Recommended boundaries of *Tahunanui Slope Risk Overlay* and *Tahunanui Fringe Slope Risk Overlay*.

Fig. 3 – Recommended boundaries of the *Grampians Slope Risk Overlay* should it be retained.

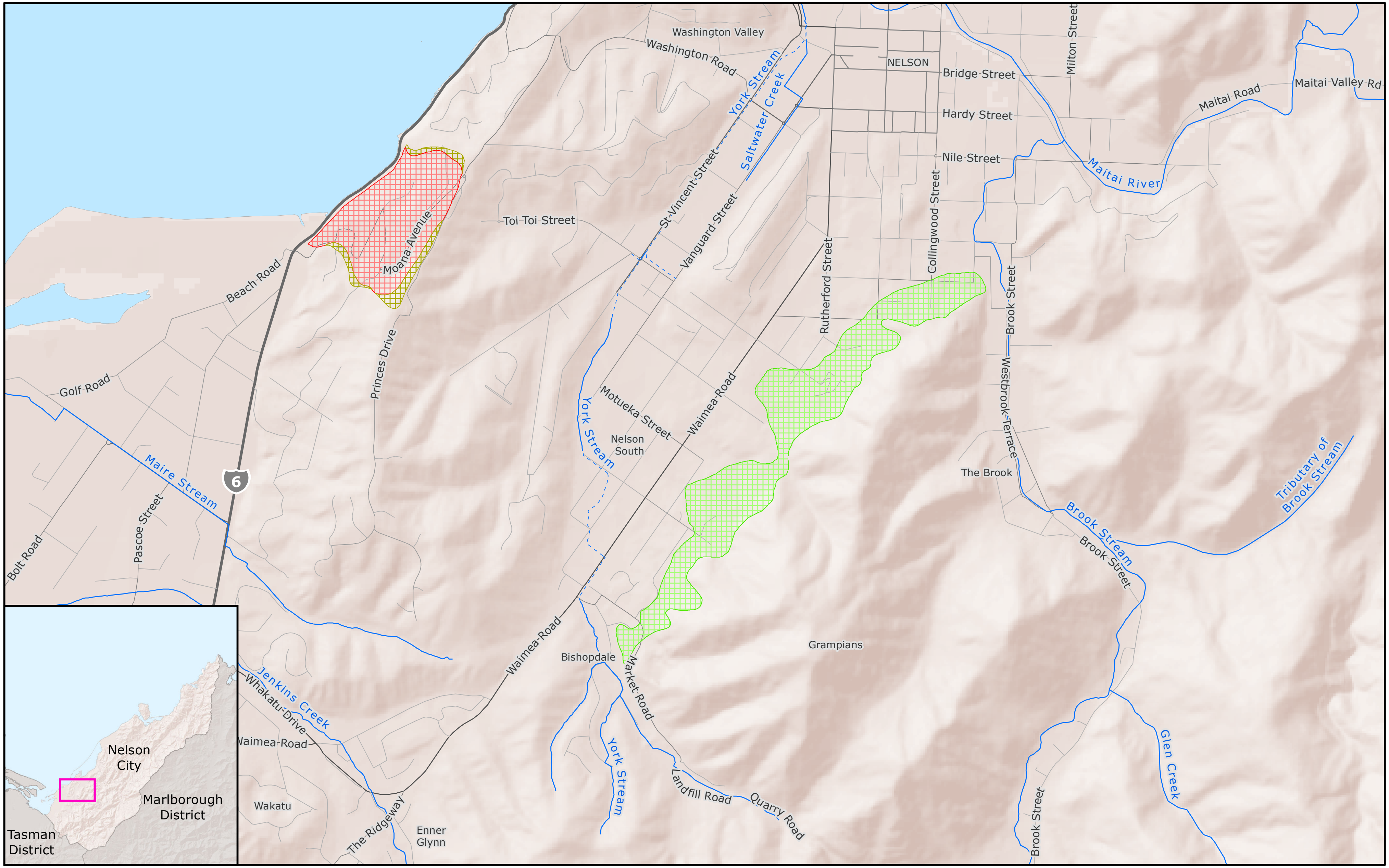

Fig. 1 - Nelson City showing current Slope Risk Overlay

Slope Risk Overlay Review 2015

Nelson City Council
te kaunihera o whakatū

NRMP Slope Risk Overlay

- Grampians
- Tahunanui Slump Core
- Tahunanui Slump Fringe

0 250 500 750 1,000 m

Scale 1:25,000

N

June 2015

PO Box 645 Nelson 7040 New Zealand PH 03 5460200 www.nelson.govt.nz

File Ref: A1328178
SER. Original map size A4.

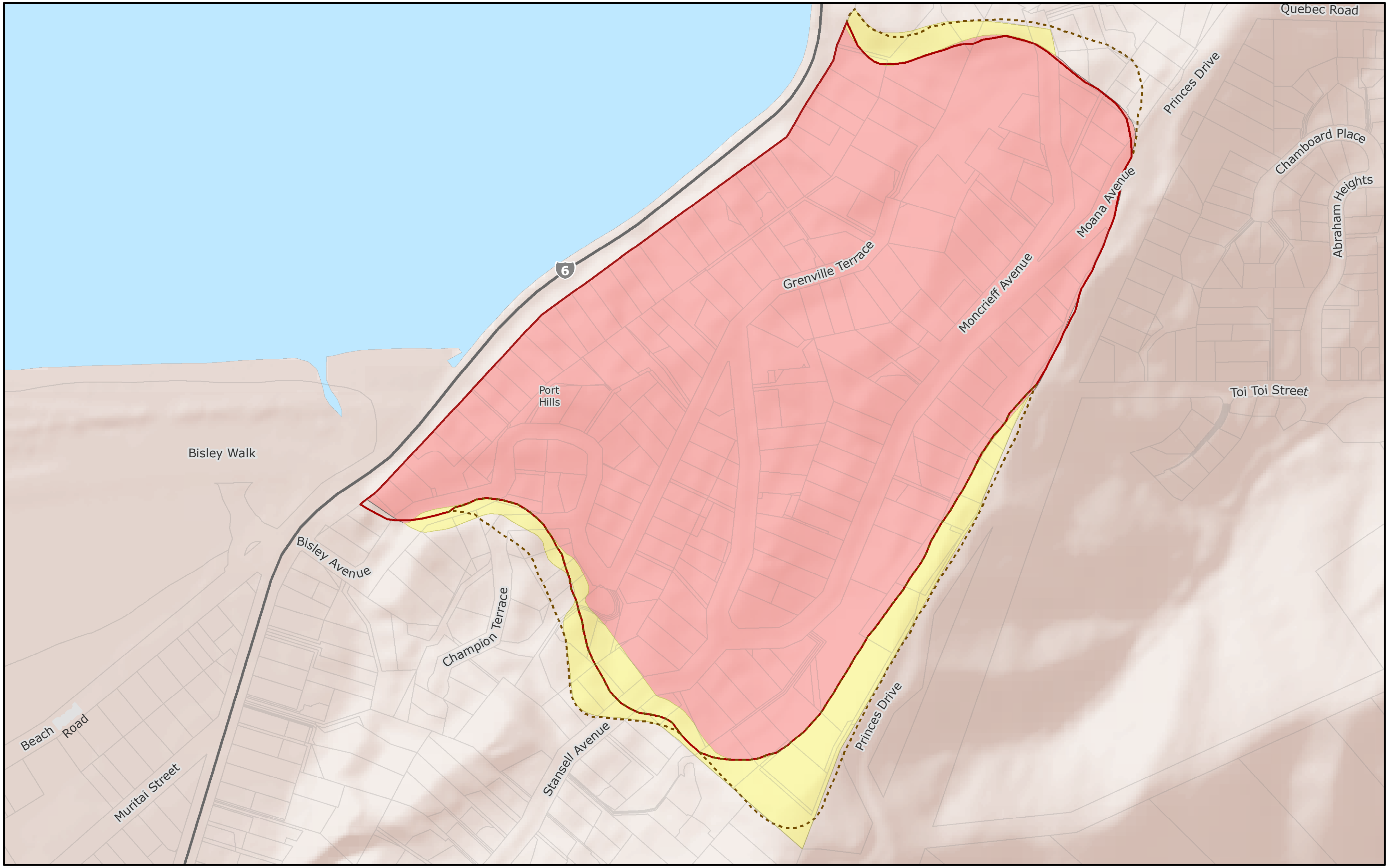

Fig. 2 - Recommended boundaries of the Tahunanui Slope Risk Overlay

Slope Risk Overlay Review

Nelson City Council
te kaunihera o whakatū

Slope Risk Overlays

- Existing Tahunanui Slump Core
- Existing Tahunanui Slump Fringe
- Recommended Tahunanui Slope Risk Overlay
- Recommended Tahunanui Fringe Slope Risk Overlay

0 50 100 150 200 m

Scale 1:5,000

N

June 2015

File Ref: A1331478
SER. Original map size A4.

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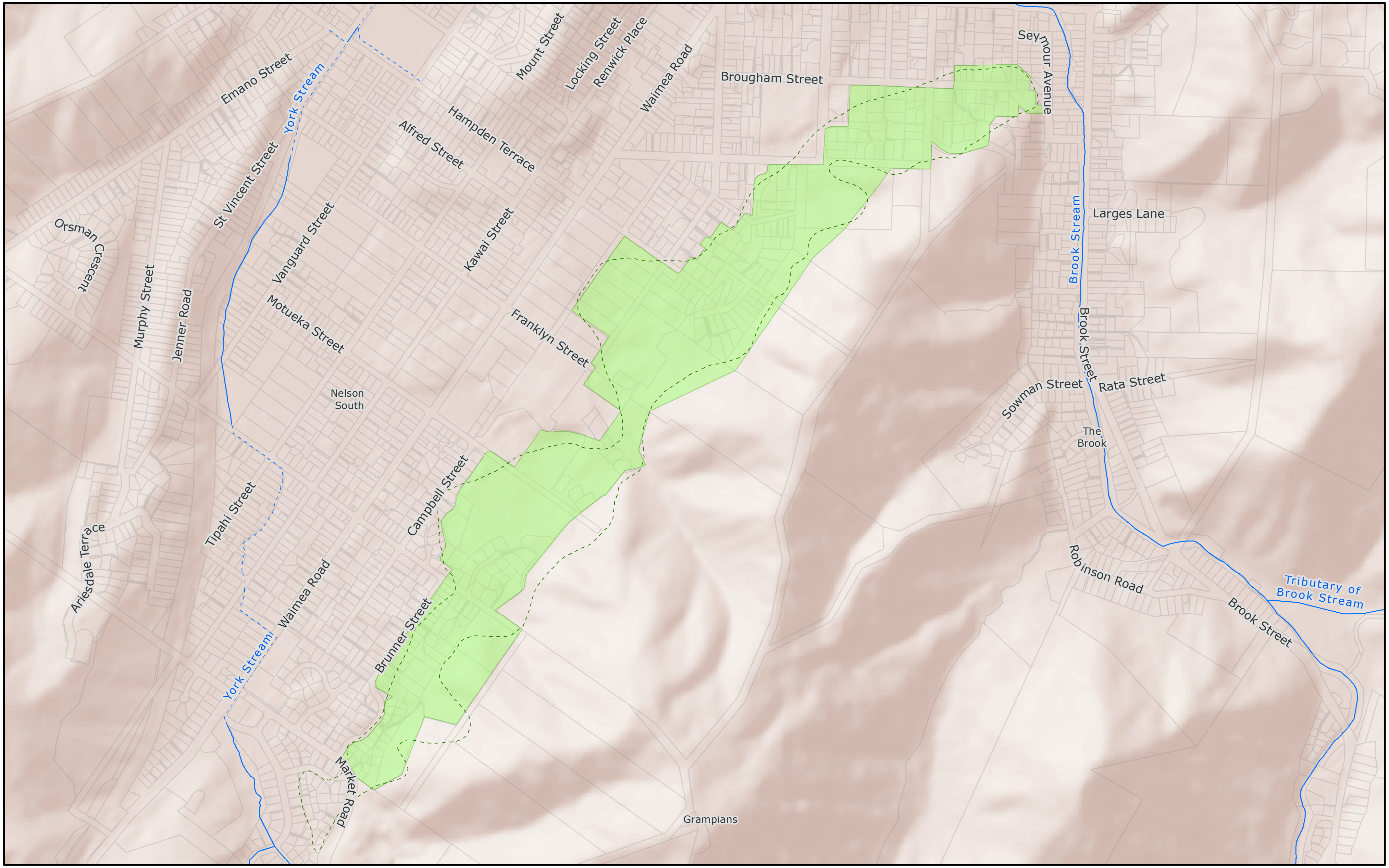

Fig. 3 - Recommended boundaries of the Grampians Slope Risk Overlay

Slope Risk Overlay Review 2015

Nelson City Council
te kaunihera o whakatū

Slope Risk Overlays

- Existing Grampians Slope Risk Overlay
- Recommended Grampians Slope Risk Overlay

0 100 200 300 400 m

Scale 1:12,500

N

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