



ROKOKAURI NORTH SHA

GEOTECHNICAL ASSESSMENT REPORT

PROJECT NO: HD631
GREEN SEED CONSULTANTS
LIMITED
REFERENCE: PGR/PC
25 OCTOBER 2018

Executive Summary

Green Seed Consultants Limited have engaged HD Geo to conduct a preliminary geotechnical assessment for the Rotokauri North Special Housing Area (SHA) to accompany an application for plan change. The SHA is located at the northwest extent of Hamilton City and is comprised of approximately 133 ha. Green Seed propose to develop the site into a mixture of standard and medium density residential housing, a commercial neighbourhood centre, public parks and potentially a school.

While there are engineering considerations to be further defined by investigation, and designed for during planning of the site, we consider the site to be suitable for the proposed development subject to the considerations and recommendations in this report.

Our scope included

- a summary of testing completed to date
- an overview of the ground conditions at the site
- assessment of the geology and geo-hazards
- recommendations for further work

What we found

- there is a moderate to high risk of liquefaction at the site
- we expect that the liquefaction risk can be mitigated for residential development with strengthened foundations and/or shallow ground improvements

Further work required

- investigation and assessment to further understand the liquefaction hazard at the site and outline mitigation measures where necessary (currently being undertaken by HD Geo)
- assessment of the liquefaction induced lateral spreading risk adjacent to proposed stormwater swales
- earthworks planning
- infrastructure design (ie. stormwater swales and roading)

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Introduction

Green Seed Consultants Limited propose to develop the site known as the Rotokauri North Special Housing Area (SHA) into a mixture of standard and medium density residential housing, a commercial neighbourhood centre, public parks and potentially a school.

We have been engaged to provide a site-wide preliminary geotechnical assessment to accompany an application for plan change.

While there are engineering considerations to be further defined by investigation, and designed for during planning of the development, the site is considered to be suitable for residential development subject to the considerations and recommendations in this report.

Scope

The scope of this report includes:

- a summary of testing completed to date
- an overview of the ground conditions at the site
- assessment of the geology and geo-hazards
- recommendations for further work

Site description

The site is located at the north west extent of Hamilton City and consists of a total area of approximately 133 ha. It is bounded by the Te Kowhai Road (SH39) to the north, greenfields to the east and south and Exelby Road to the west. Burbush Road runs north to south through the eastern portion of the site. A plan showing the extent of the site is included in Appendix A.

The site lies in an area that consists of rolling hill terrain and flat-lying plains. The hill terrain (herein referred to as 'Hill Terrain') is all ground that is elevated above the flat, low-lying plains of the site (herein referred to as 'Plains').

The Hill Terrain is present at the western and eastern edges of the site, rising up to 18 m above the Plains. These hill areas merge south of the site, forming a south to north draining basin in which the majority of the site lies.

The Plains make up the majority of the west and central portions of site, while also surrounding the eastern Hill Terrain to the west, north and east. The Plains are flat with typically less than 1 m of elevation difference across much of the site. Numerous open drains dissect the Plains ranging from less than 0.5 m in depth and width up to 2 m width and depth. A Waikato River paleochannel, known as the Te Kowhai Channel lies in the northeastern corner of the site. The base of the channel lies approximately 1.5 m below the surrounding area. Parts of the low-lying areas of site are located in areas that are expected to be inundated by a 1 in 100 year flood event (Refer to Rotokauri ICMP Plan¹).

The site is predominantly used as pasture for grazing cattle with a dairy farm and associated buildings in the northeast of site. There are eight rural residential dwellings and a number of sheds and barns across the remainder of the site.

¹ Hartland Environment Limited (June, 2017) *Rotokauri – Integrated Catchment Management Plan*.

Previous work

HD Geo undertook a preliminary geotechnical assessment of the site in July 2018 to support master planning and conceptual design for the development². This assessment included an investigation which comprised of:

- 13 hand augers up to 3 m depth
- 8 cone penetrometer tests (CPTs) up to 20 m depth
- 3 dissipation tests
- 5 temporary standpipe piezometers

The key outcomes of this assessment were:

- there was a moderate to high liquefaction hazard identified across the Plains areas of the site
- there were no other significant geotechnical constraints to development at the site

In order to further understand the liquefaction hazard at the site additional testing has been undertaken including:

- installation of 5 permanent piezometers (August 2018)
- 6 shear wave velocity tests by seismic cone CPTs up to 20 m depth (October 2018)

The results of these investigations are to be incorporated into a detailed liquefaction hazard study HD Geo is currently undertaking at the site.

Geological setting

The site is located roughly centrally within the Hamilton Basin which is characterised by low rolling hills (Hamilton Hills) and plains with low terraces and gullies draining into the Waipa and Waikato Rivers (Hamilton Lowlands).

The Hamilton Hills are linear, sinuous and discontinuous hills and ridges that are remnant of an older erosion surface. They consist of alluvial material and non-welded ignimbrites (Walton Subgroup) and are typically overlain by a number of metres of airfall volcanic ash (Kauroa Ash Formation and Hamilton Ash Formation). The Hamilton Lowlands are a broad, low angle alluvial fan created by the Waikato River in the Late Quaternary. The fan materials (Piako Subgroup and Hinuera Formation) are derived from rhyolitic eruptions in the central North Island and generally consist of late Pleistocene primary and secondary volcanoclastic sediments. Deposition of the fan materials ceased when the Waikato River entrenched into its current course approximately 17 ka and thin airfall tephra layers accumulated on the fan surface (Hinuera Surface).

The New Zealand Geological map (QMap) for the Waikato Region shows that Walton Subgroup, Hinuera Formation and Piako Subgroup materials are mapped at the site. The Walton Subgroup is mapped in the Hill Terrain and is described as Early Pleistocene to Middle Pleistocene alluvium dominated by primary and re-worked non-welded ignimbrite. The Hinuera Formation and Piako Subgroup are mapped on the Plains. The Hinuera Formation is mapped in the majority of the flat-lying areas of site with small areas in the south and southeast of the site described as the Piako Subgroup. The Hinuera Formation is described as Late Pleistocene cross-bedded pumice sand, silt

² HD Geo Limited, 2018. *Rotokauri North SHA Preliminary Geotechnical Report*, HD631.

and gravel with interbedded peat and the Piako Subgroup is described as Late Pleistocene locally derived mud, silt, gravel and peat.

Proposed development

The development will comprise a mixture of standard and medium density residential housing, a commercial neighbourhood centre, public parks and potentially a school. The development will contain numerous new local roads and five collector roads linking internal areas with Te Kowhai Road, Exelby Road, Burbush Road and yet to be constructed roads to the south.

The proposed development consists of two stages, Stage 1 in the western portion of site covering an area of approximately 53 ha and Stage 2 in the eastern portion of site which is approximately 80 ha. The proposed development concept and staging plans are included in Appendix B.

Ground conditions

The ground conditions at the site were typically consistent with the mapped geology. The ground conditions have been grouped into areas based on their geomorphology and the conditions encountered in the investigation. All references to soil types from the CPTs are based on the soil behaviour types as interpreted by the CPT results.

Hill terrain

The Hill Terrain is all ground that is elevated above the flat, low-lying plains of the site. CPT investigations predict layered clay, silt and sand deposits to 20 m. Hand auger investigations found that the upper 3 m of the hill terrain consists of stiff to hard clay and silt consistent with the Hamilton Ash Formation.

Plains

The Plains are areas of site that are flat and low-lying. Hand auger and CPT investigations encountered layered deposits of silt, clay and sand to 20 m depth. The deposits are predominantly sand dominated in the upper 8 m to 10 m, becoming more clay dominated with depth. Sand layers reach a maximum thickness of 6.5 m and uniform clay layers reach a maximum thickness of 6 m.

Groundwater

Groundwater is currently being monitored by five piezometers across the site. Since monitoring began in August 2018, the groundwater level has been very high across the site, with a maximum recorded depth of 0.9 m and a minimum recorded depth of 0 m (ie. ground level).

Geotechnical assessment

This assessment is a collection of general information and advice for the site's suitability for the proposed development. It is intended to provide an overview of the geotechnical elements which require consideration at the site.

Liquefaction

The low-lying Plains at the site contain sand and silt soils with a high groundwater table which can be susceptible to liquefaction under earthquake-induced cyclic loading. As a result, a liquefaction

assessment of the CPT data was undertaken in accordance with NZGS guidelines³. The preliminary screening analysis indicated that under ULS (Ultimate limit state) conditions, liquefaction is anticipated to occur across the Plains. The layers that are predicted to liquefy vary throughout the soil profile, however liquefaction is typically predicted to occur within 1 m of the current ground surface. In accordance with NZGS guidelines, the liquefaction risk at the site ranges from L2 (moderate) to L4 (severe).

Preliminary screening of shear wave velocity data indicates that the assessed risk may be reduced in some areas of the site, while the risk in other areas remains unchanged. Further assessment and refinement of this data is currently in progress.

Predicted liquefaction of this magnitude is not uncommon in the Waikato. To allow for residential construction, mitigation in the high to severe risk areas will be achievable through strengthened foundations or shallow ground improvement.

Lateral spreading

Lateral spreading is a phenomenon where liquefied material allows the soil above to move laterally towards a free face, such as a stream bank. The site currently has an isolated lateral spreading risk adjacent to the Te Kowhai Channel in the northeastern corner of site.

Development plans show stormwater swales throughout the site which are likely to be excavated up to 2.0 m below current ground levels. Given the near surface soils have been identified as liquefiable, the formation of these swales is likely to create a lateral spreading hazard.

Specific assessment of the lateral spreading hazard will be required. Potential mitigation options of lateral spreading risks may include:

- dewatering of adjacent ground so liquefaction is unable to occur
- using a buttress of ground improvement along swale edges
- slope stabilisation methods
- specifying foundation types tolerant to lateral spreading in high risk areas

Soft soils and settlement

A screening analysis has been completed on the 13 CPTs that were located on the Plains to determine the susceptibility of the ground to static settlements when loaded. The preliminary analysis indicates that the site generally has a low risk of static settlement as most of the near surface soils are sand-dominated.

While not encountered during this investigation, our experience in the area has shown that organic and soft soils are commonly (but not exclusively) found in paleochannel features and close to the Hill Terrain in 'embayments'. As the risk of consolidation settlements is often greatest in these areas they should be a target area for future investigations.

³ Ministry of Business, Innovation & Employment and New Zealand Geotechnical Society, 2016. *Earthquake geotechnical engineering practice – Module 3: Identification, assessment and mitigation of liquefaction hazards*.

Earthworks

Earthworks at the site are likely to consist of cut and fill operations in order to ease grades on the site, create level building platforms, fill open drains, form stormwater storage and conveyance, and to raise building platforms above flood levels.

The Hamilton Ash Formation was encountered on the Hill Terrain and is typically suitable as an earthworks material. Although not encountered in the investigations to date, our experience has shown that beneath the ash, soils of the Puketoka Formation are typically encountered. These soils are typically highly sensitive and break down on working, making them unsuitable as an earthworks material. Further investigation should define the materials to be used or exposed in earthworks.

Stability

There are no indications of any recent, large scale instability having occurred at the site, or in the immediate surrounding area. Active observed instability in the area tends to be shallow creep on steeper slopes and is often associated with springs, saturated soils or stock movement.

Earthworks on the site are likely to reduce the overall stability risk by reducing both the heights and grades of current slopes. Earthworks on the Hill Terrain may demand grades that will require retaining and specific design is likely to be required.

Pavements

A number of roads are proposed for the development, including local and collector roads. It is likely road pavement subgrades will be based on materials of the Piako Subgroup, Hinuera Formation, Hamilton Ash Formation and, depending on cut depths in the hill terrain, the sensitive materials of the Puketoka Formation.

Based on these anticipated ground conditions and the testing completed during the investigation, it is likely that natural subgrade CBR will be low. Improvement of the subgrade will likely be required by either compaction or stabilising of the insitu material or by undercutting and replacement with a hardfill subgrade improvement layer. Where organic material is encountered, removal and replacement with suitable backfill will be required. Specific investigation, testing and design will be needed for all pavements.

Recommendations

- the liquefaction hazard at the site should be refined through further investigation and assessment and outline mitigation measures where necessary (currently being undertaken by HD Geo)
- assessment of the liquefaction induced lateral spreading risk adjacent to proposed stormwater swales is completed

Future work

- as the risk of consolidation settlements are often greatest in paleochannels and Hill Terrain embayments, these areas should be targeted by future investigations
- further investigation of the potential cut areas of site should be completed to define the materials to be used or exposed in earthworks

Limitation

This report has been prepared for our client, Green Seed Consultants Limited, for the purpose detailed above and may not be relied on by any other party or for any other purpose. This report contains an assessment based on a site walkover and testing at discrete locations to support plan change for the proposed development.

Further testing and assessment is required prior to finalising the development proposals for the site. Inferences about the conditions at the site have been made based on the testing undertaken and our understanding of the geological environment in which the site lies. The deposits in this area are by nature highly variable both vertically and laterally. We recommend that a geotechnical engineer is engaged to provide input into the design of the development and to undertake further testing, assessment and design. For continuity and to confirm ground conditions, geotechnical observation will also be required during site construction works.

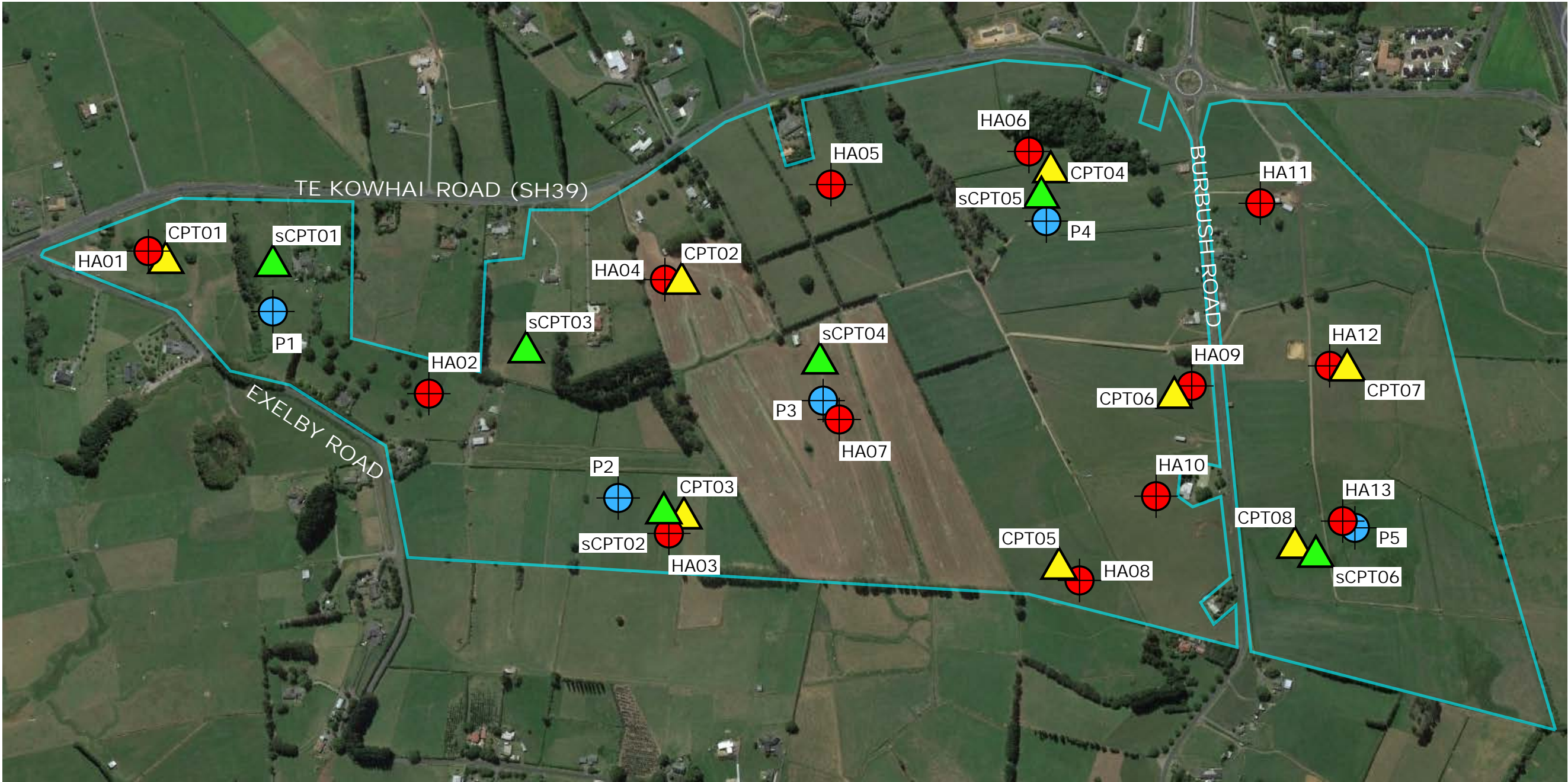
APPENDIX A – SITE PLANS



LEGEND

- Hand auger (HA)
- Cone penetrometer test (CPT)
- Seismic cone penetrometer test (sCPT)
- Piezometer (P)
- Site boundary
- WRC 5m contours

PROJECT:	Rotokauri North SHA
PROJECT NO:	HD631
CLIENT:	Green Seed Consultants Ltd
TITLE:	Geotechnical Investigation Locations
SCALE:	NTS
Drawing No:	HD631/01
Drawing by:	SA
Revision No:	



APPENDIX B – DEVELOPMENT PLANS AND STAGING

ROKOKAURI NORTH SHA AREA (Figure 1)

Map legend

- Site area
- 1 Stage 1 (53.39ha)
- 2 Stage 2 (79.72ha)

Stages 1 and 2 sought as an SHA.
Total of 133.1109ha.

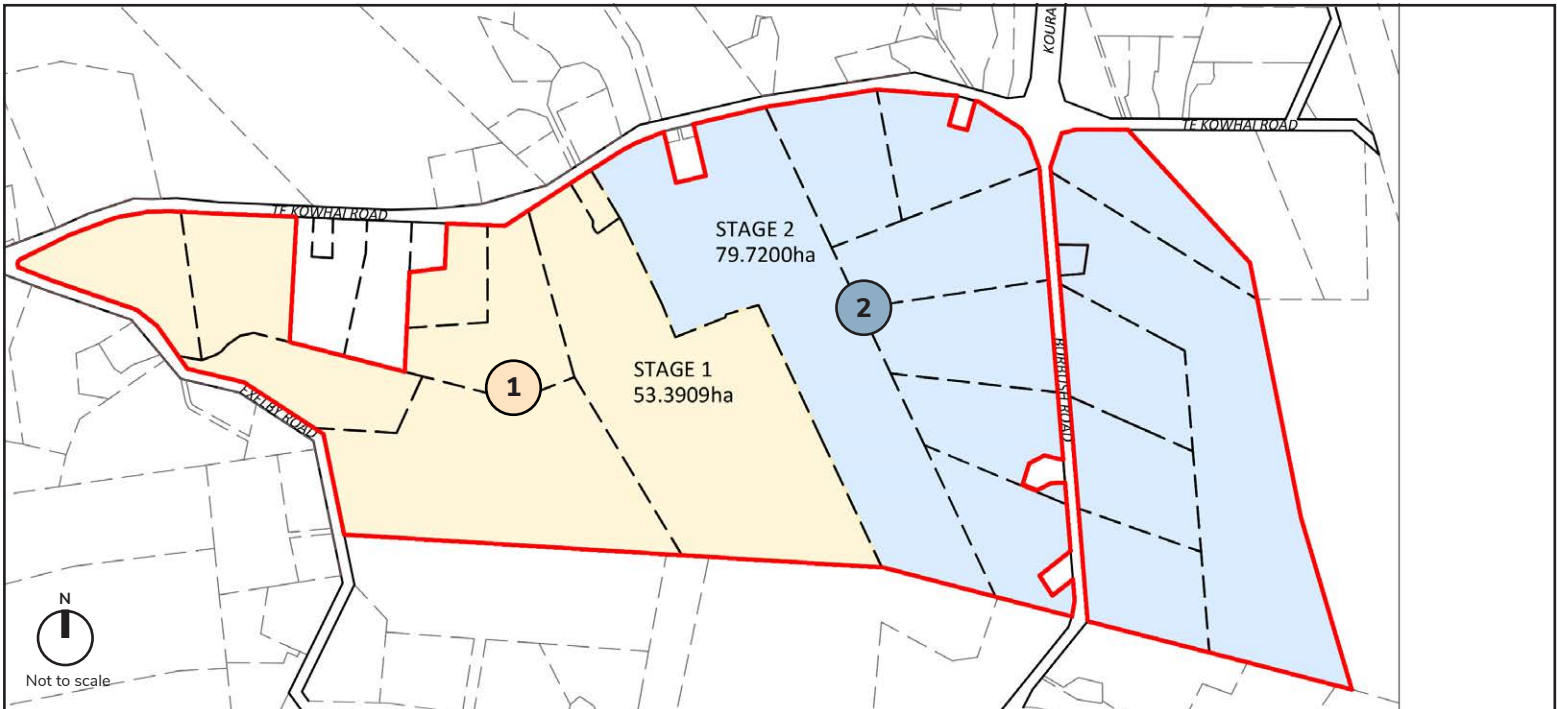


Figure 1: Rotokauri North SHA area

ROKOKAURI NORTH SHA CONCEPT (Figure 2)

Map legend

- Site area
- 1 Optimise connections to east (jobs) as well south.
- 2 Ensure each small centres is focused on its local community.
- 3 Maximise residential catchment around a small centre, and integrate movement network around the centre.
- 4 Provide for necessary stormwater conveyance and storage.
- 5 Provide district-level open space so as to maximise exposure and accessibility to all. Size will be determined by Council acquisition agreement.
- 6 Ensure sensitive slopes can be appreciated as landscape features.

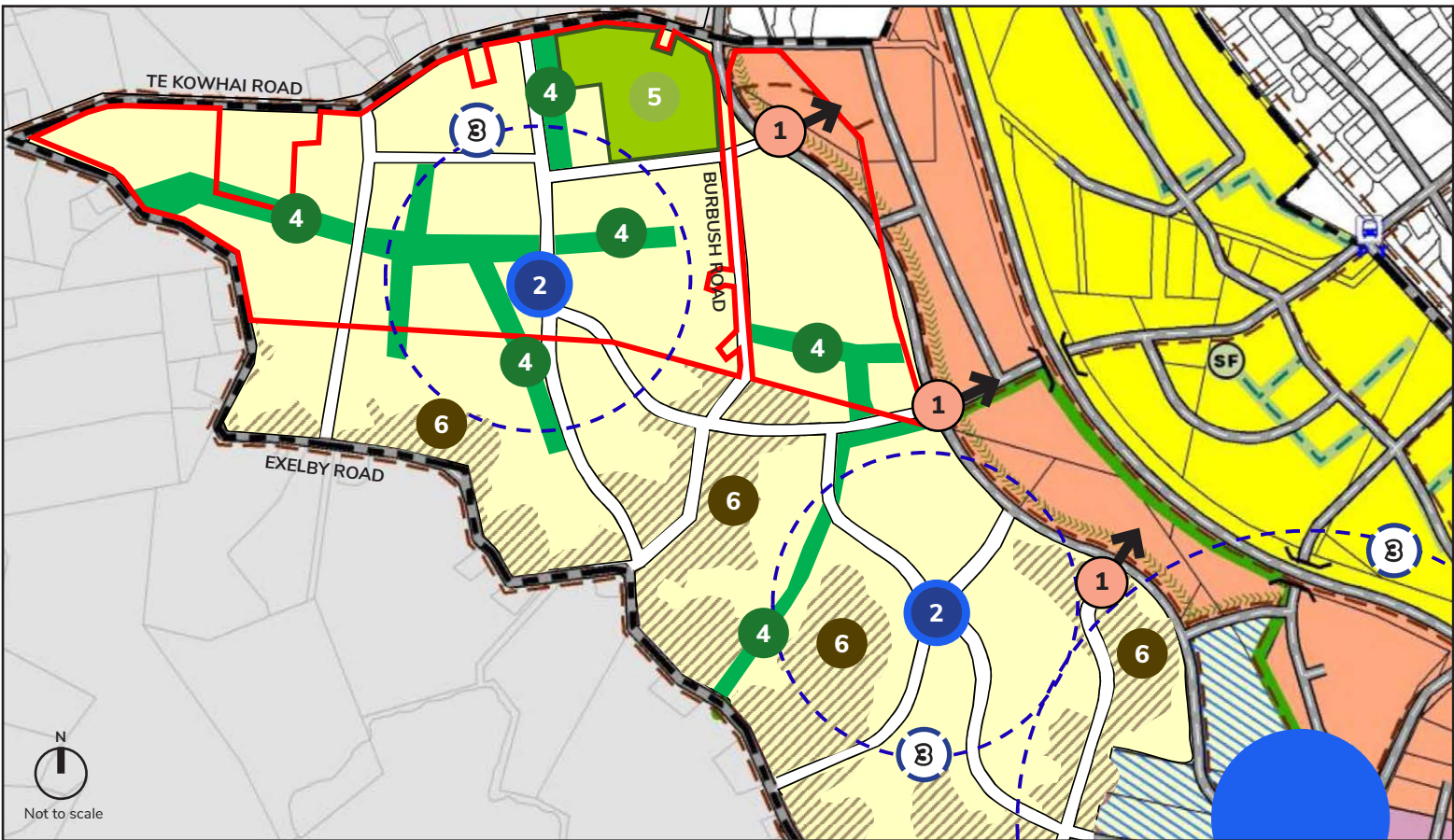


Figure 1: Key structuring elements of Rotokauri North SHA concept

ROKOKAURI NORTH SHA OPTIONS FOR STORMWATER (Figure 3)

Map legend

- Site area
- Floodway basin (conveyance and flood storage)
- Swale (conveyance only)
- Treatment wetlands
- Discharge locations

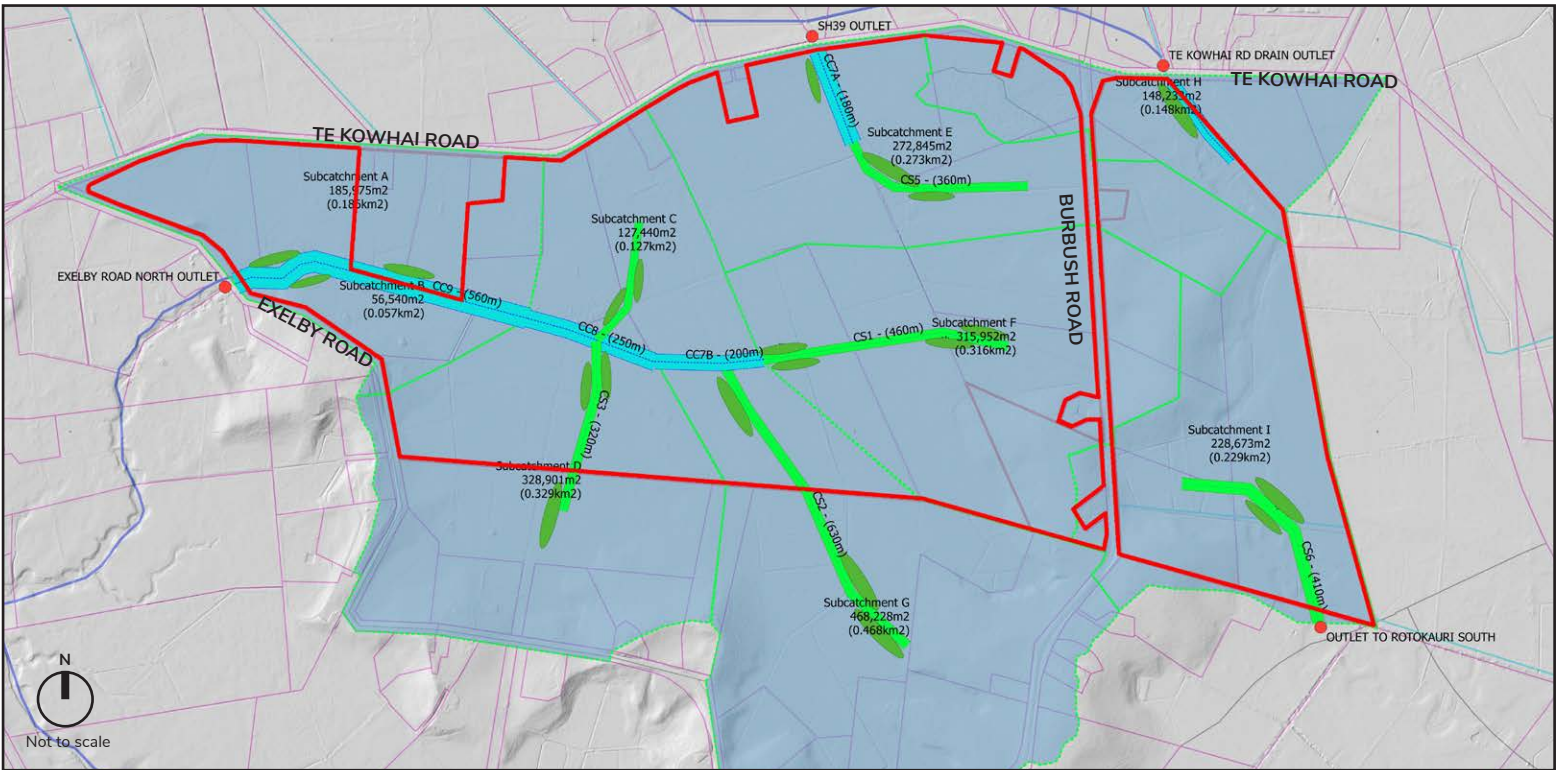


Figure 3: Rotokauri North SHA options for stormwater
Source: CKL Stormwater Solutions

Rotokauri North Special Housing Area

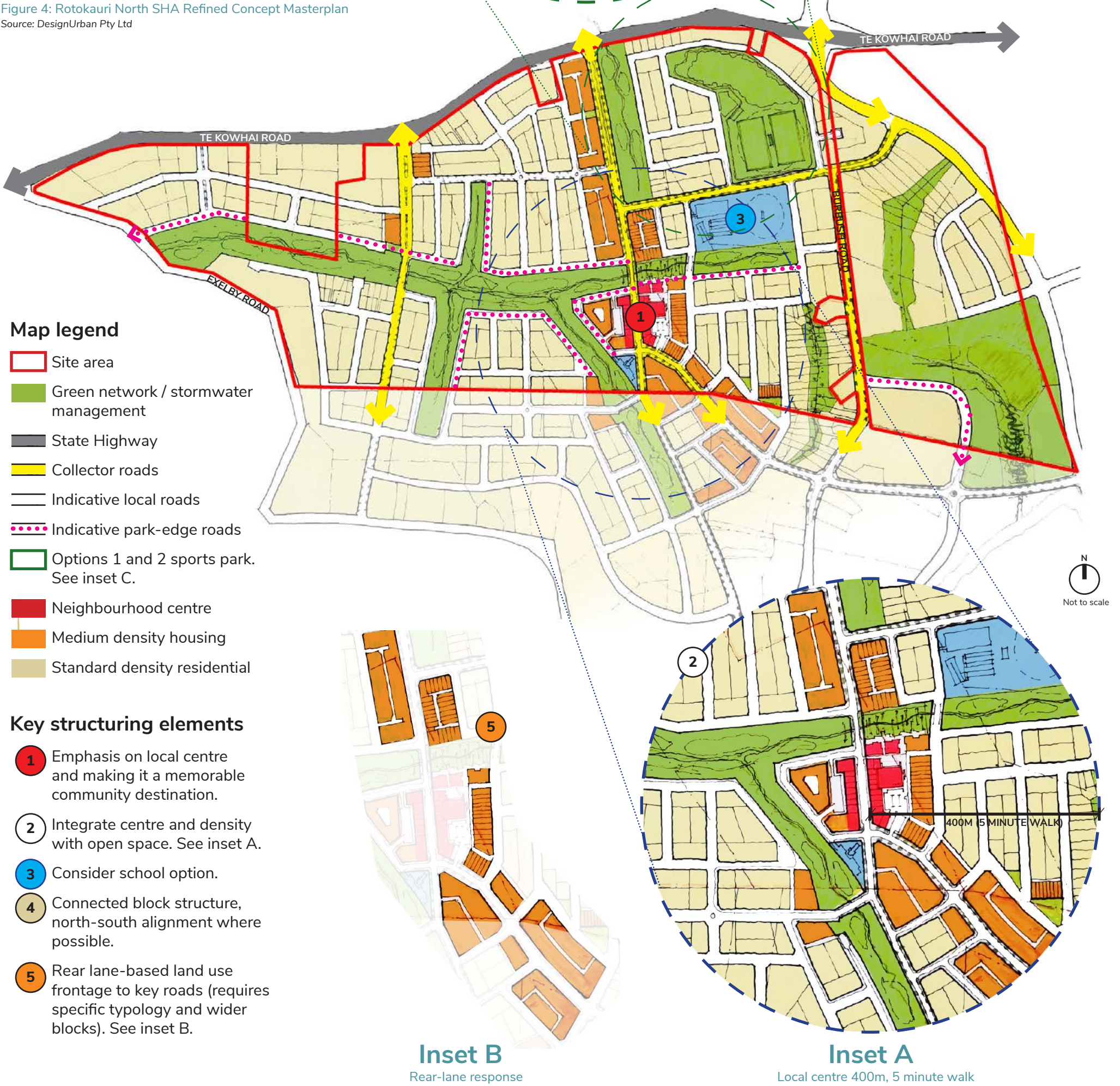
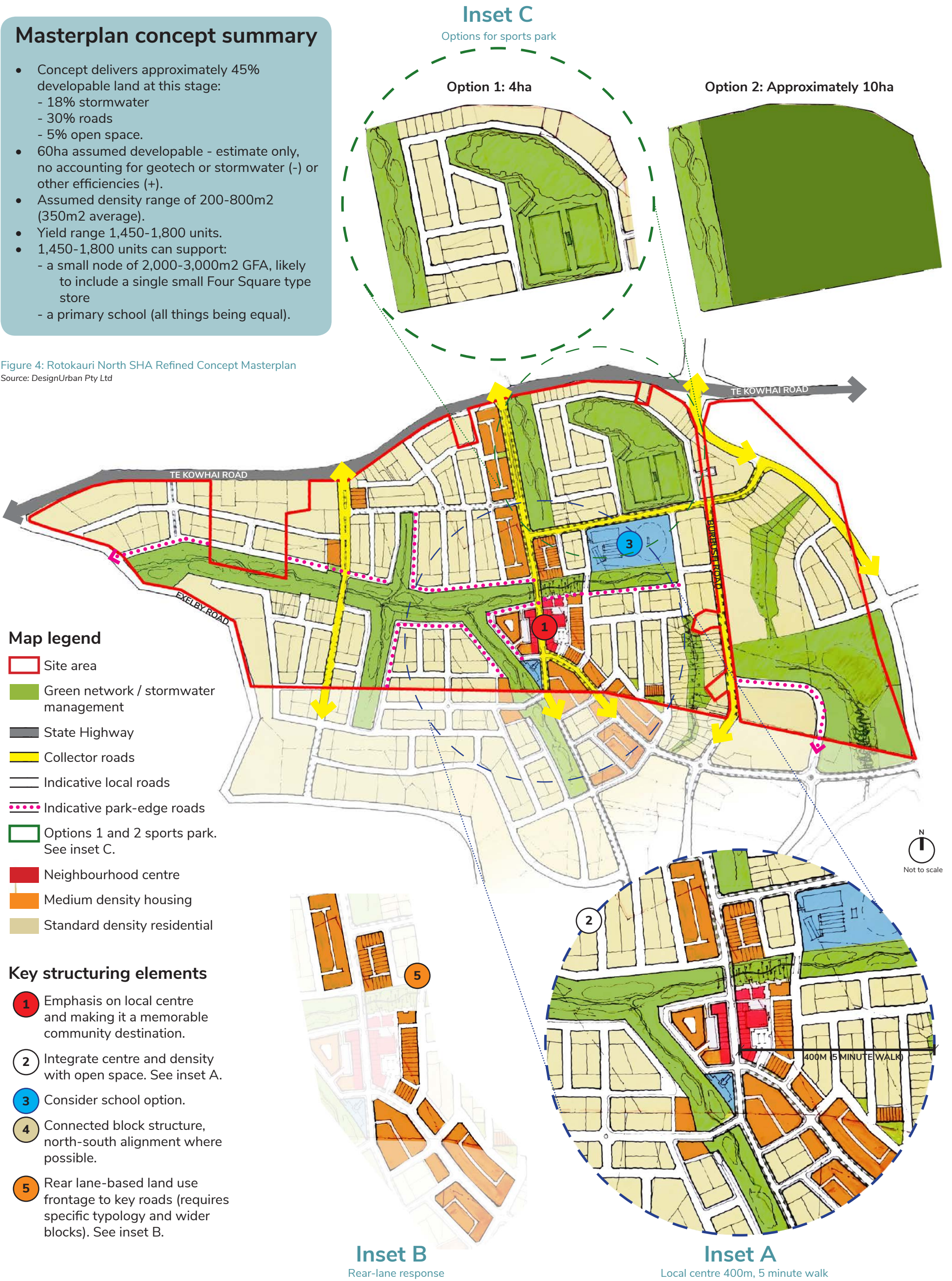
February 2018
Green Seed Consultants Ltd

ROKOKAURI NORTH SHA REFINED MASTERPLAN (Figure 4)

Masterplan concept summary

- Concept delivers approximately 45% developable land at this stage:
 - 18% stormwater
 - 30% roads
 - 5% open space.
- 60ha assumed developable - estimate only, no accounting for geotech or stormwater (-) or other efficiencies (+).
- Assumed density range of 200-800m2 (350m2 average).
- Yield range 1,450-1,800 units.
- 1,450-1,800 units can support:
 - a small node of 2,000-3,000m2 GFA, likely to include a single small Four Square type store
 - a primary school (all things being equal).

Figure 4: Rotokauri North SHA Refined Concept Masterplan
Source: DesignUrban Pty Ltd



27 February 2019



Rotokauri North SHA

c/- Renee Fraser-Smith

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HD631 – Rotokauri North SHA – Response to HCC Peer Review

Dear Renee,

I understand that Council's peer reviewer has further questions regarding the liquefaction hazard at the Rotokauri North SHA. My understanding is that at plan change stage, we shouldn't need to provide detailed information on how we are to mitigate the risk (that will be done at later stages of the development design and consenting). The test is whether there is anything there that should preclude the site being zoned for development. To my mind, an appropriate test of this (in relation to liquefaction) is whether there are similar local areas that have recently been developed. There are several such examples locally that have been developed under the current guidance (noting that liquefaction assessment practice has changed significantly in the last 10 years). In our report we have highlighted that there is a liquefaction hazard that needs consideration and, at the subdivision suitability stage, we are aware that we will have to provide detailed information on our mitigation approach to meet the requirements of s106.

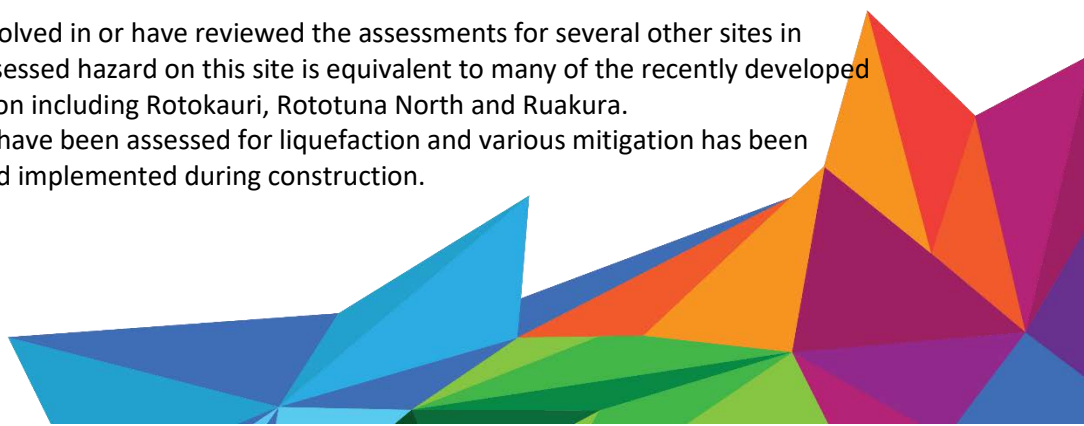
To answer the specific questions provided to us:

Further information is required from the applicant to substantiate the conclusion that mitigation of the moderate to severe liquefaction risk is achievable. The further information should demonstrate that the liquefaction risk can be managed at subdivision/land use stage.

The terminology 'moderate to severe' is based on the LSN categories. Based on the MBIE planning guidance, the category for the susceptible areas of the site is generally 'Medium' liquefaction vulnerability with some areas that may be categorised as 'High'.

We based our conclusion that the site is appropriate for development on:

- We have been involved in or have reviewed the assessments for several other sites in Hamilton. The assessed hazard on this site is equivalent to many of the recently developed suburbs in Hamilton including Rotokauri, Rototuna North and Ruakura.
- All of these areas have been assessed for liquefaction and various mitigation has been recommended and implemented during construction.



- The site is assessed as roughly the equivalent of TC2 land in Christchurch. Such land has been, and is, regularly developed.

We note that there is no regional or district policy that sets a framework for accepting/rejecting development based on liquefaction risk and so current practice is a good measure of suitability.

The extent of the liquefaction hazard should be discussed.

The area of the site with geology/geomorphology that indicates it may be subject to a liquefaction risk is the Plains, which covers most of the site. The site geomorphology plan in our preliminary report (attached) identified these areas. While there is variation in the assessed hazard, our study identifies that liquefaction damage is likely across the Plains area and the likely hazard ranges from **Medium** to **High** liquefaction vulnerability. Liquefaction is not a hazard in the Hills areas of the site.

Feasible measures that might be employed to mitigate the risk should be identified and discussed.

Mitigation in the recently developed parts of Hamilton that have a liquefaction hazard included measures such as

- shallow ground improvement (to separate structures from liquefiable layers)
- reinforced raft foundations (varying from simple ribraft to reinforced, resilient raft foundations)
- piles to non-liquefying layers
- de-watering to reduce the hazard (usually locally to a lateral spreading hazard)
- setbacks or barrier piles in some locations where lateral spreading was considered to be a risk

The MBIE planning and engineering guidance for potentially liquefaction prone land asks for a Level B assessment at plan change – we have exceeded this with a Level C Area-wide study.

Please let me know if you have any further questions.

Kind regards,

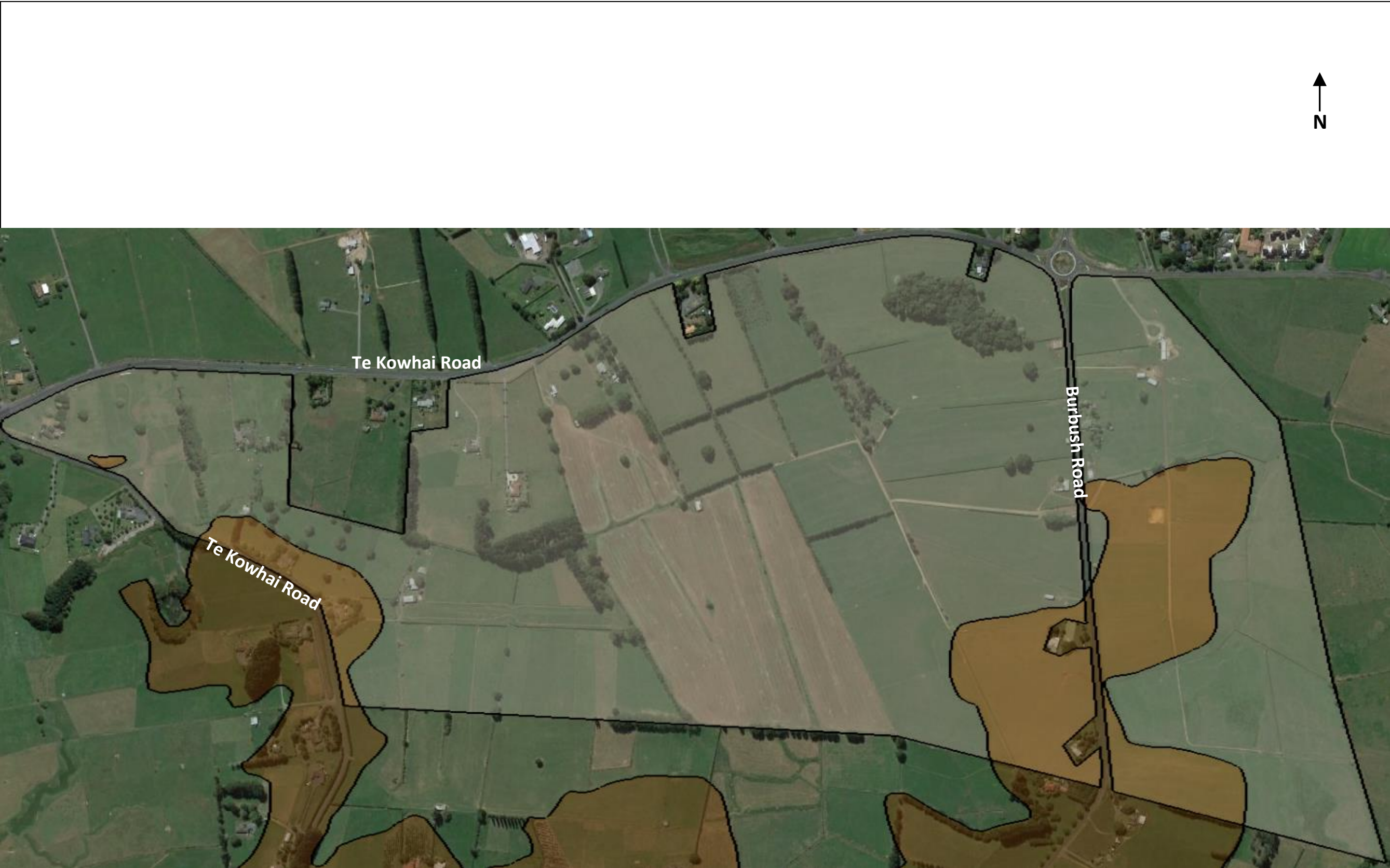


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- Plains
- Hill Terrain

PROJECT: Rotokauri North SHA	
PROJECT NO: HD631	
CLIENT: Green Seed Consultants Limited	
TITLE: Site Geomorphology	
SCALE: NTS	
Drawing No: HD631/2	
Drawing by: MM	
Rev Number	
0	Initial