Land Use Capability classification assessment

Greenhill Industrial Park site

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Contents

1. Introduction

Landsystems undertook an on-site Land Use Capability (LUC) classification assessment of the Greenhill Industrial Park site (**Site**) to confirm the soils and LUC units at property scale, the presence of Waikato District Plan-Operative in Part defined high class soils, and highly productive land as defined by the National Policy Statement for Highly Productive Land.

Site Description

Greenhill Industrial Park is of irregular shape and approximately 195 hectares. It is situated within the Waikato District, adjacent to the eastern side of the Waikato Expressway.

The Site is accessed from Puketaha Road to the north and Greenhill Road to the south. The Waikato District and Hamilton City jurisdiction boundary is defined by Gordonton Road, which is located approximately 1 kilometre to the west of the Waikato Expressway.

The Project

Greenhill Industrial Park is for a comprehensive new industrial park, with direct access to the Waikato Expressway in both directions via Greenhill Road and Pardoa Boulevard. The project is to create vacant lots that can accommodate a range of industrial and compatible commercial activities and associated buildings. The proposal also includes all required infrastructure, including transport, three waters, and associated site and civil works.

2. LUC background

LUC classification is the common method for assessing land in New Zealand; it uses the Land Use Capability System, which is part of the New Zealand Land Resource Inventory (NZLRI) as produced by the Water and Soil Division of the Ministry of Works, for the National Water and Soil Conservation

Organization during the 1970s. In 2009 the 3rd Edition of the LUC Survey Handbook[1] was published and has been used for this assessment. The LUC uses a systematic arrangement of different kinds of land according to those properties that determine its capacity for permanent sustained production, where the word "capability" is used in the sense of "suitability for productive use" after taking into account the physical limitations the land may have.

The LUC classification is specifically designed to provide an index of versatility. There are eight LUC classes (**Figure 2**) arranged in order of increasing degree of limitation or hazard to use; and a decreasing order of use, from Class 1 to 8.

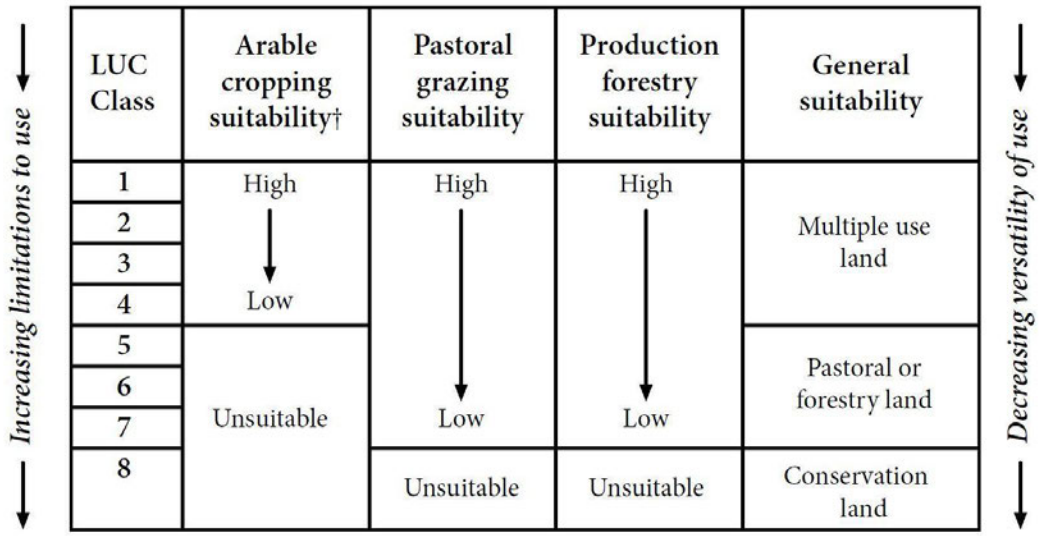

Figure 2: Increasing limitations to use and decreasing versatility of use from LUC Class 1-8.

Within each LUC Class the land is assigned a subclass according to the kind of limitation (e = Erodibility, w = Wetness, s = Soil limitations within the rooting zone, c = Climate). At the most detailed level LUC groups together those inventory units which respond similarly to the same management, and which are suitable for the same kinds of crops, pasture, or forest species with the same potential yield and which require the application of the same conservation measures.

The LUC worksheets were compiled from all relevant databases of land resource documents available at the time, consequently some sheets suffered from a lack of information that only detailed soil and geological surveys could have provided. Therefore, there are **scale limitations**, which need to be considered, especially when interpretation is required at the individual property scale.

The LUC units displayed on the 1970s worksheets remain reasonably robust but are subject to change. For example, the second edition (1993) Northland region worksheets were mapped at the more detailed scale of 1:50 000, replacing the earlier first edition 1:63,360 maps. In the first edition, 69 LUC units were defined compared with 91 LUC units in the second edition - about 60 of the first edition classification units changed.

[1] Lynn IH, Manderson AK, Page MJ, Harmsworth GR, Eyles GO, Douglas GB, Mackay AD, Newsome PJF 2009. Land Use Capability survey handbook – a New Zealand handbook for the classification of land. AgResearch Hamilton; Manaaki Whenua Lincoln; GNS Science Lower Hutt, New Zealand.

The average area for a map unit is 125 ha, however, at the 1:50 000 scale of mapping it is theoretically possible to delineate an unhooked inventory map unit (no vinculum) area of 60 ha (60 ha = 600 m by 1000 m) provided the geology, soil, vegetation, erosion and slope are uniform.

The **purpose of this background information** is to illustrate and emphasise that the NZLRI information provides excellent physical base data for planners (a planning tool) but is not fit for purpose as a plan (map) unless undertaken at the correct scale. The on-site soil LUC assessment fulfils that purpose.

3. Waikato District Plan definition of high class soil

Under the Waikato District Plan-Operative in Part (WDP-OiP) definition, "High class soils" are defined as[2]:

> *those soils in Land Use Capability Classes I and II (excluding peat soils) and soils in Land Use Capability Class IIIe1 and IIIe5, classified as Allophanic Soils, using the New Zealand Soil Classification.*

4. National Policy Statement for Highly Productive Land 2022

The National Policy Statement for Highly Productive Land 2022 (NPS-HPL)[3] came into force on the 17th of October 2022.

"Highly productive land" is defined as:

> *means land that has been mapped in accordance with clause 3.4 and is included in an operative regional policy statement as required by clause 3.5 (but see clause 3.5(7) for what is treated as highly productive land before the maps are included in an operative regional policy statement and clause 3.5(6) for when land is rezoned and therefore ceases to be highly productive land).*

Our understanding is that NPS-HPL clause 3.5(7) applies because maps produced in accordance with clause 3.4 have not yet been included in an operative regional policy statement as required by clause 3.5. Clause 3.5(7) says:

> *(7) Until a regional policy statement containing maps of highly productive land in the region is operative, each relevant territorial authority and consent authority must apply this National Policy Statement as if references to highly productive land were references to land that, at the commencement date:*
>
> *(a) is*
>
> *(i) zoned general rural or rural production; and*
>
> *(ii) LUC 1, 2, or 3 land; but*

[2] https://eplan.waikatodistrict.govt.nz/
[3] https://environment.govt.nz/publications/national-policy-statement-for-highly-productive-land-2022-amended-august-2024/

(b) is not:

(i) identified for future urban development; or

(ii) subject to a Council initiated, or an adopted, notified plan change to rezone it from general rural or rural production to urban or rural lifestyle.

The NPS-HPL includes the following definition of LUC 1, 2, or 3 land:

"LUC 1, 2, or 3 land means land identified as Land Use Capability Class 1, 2, or 3, as mapped by the New Zealand Land Resource Inventory or by any more detailed mapping that uses the Land Use Capability classification".

For the purpose of defining and mapping highly productive land on the Site, the Environment Court decision (Decision No. [2024] NZEnvC 83)[4] determined that only the NZLRI LUC map information at the time the NPS-HPL 2022 became operative (17th October 2022) can be used.

5. Non-productive land and modified areas

For an accurate assessment of LUC classification for a property, the assessment should be based on the current condition of the area (i.e. mapped in current state). This is important because some land management practices (e.g. the placement of tracks, excavation of drains, and general earthworks) result in irreversible changes to the soil (i.e. changes other than those that can be remediated by management practices and return the soil to its intrinsic state). These areas are referred to as non-productive land. Examples of non-productive land include native vegetation, wetlands and riparian areas, tracks, and buildings and curtilage.

Non-productive land can include areas where the soil has been modified by truncation, placement of fill or extensive mixing. Where these areas do not resemble a functioning soil, the areas are not considered to be available for primary production (i.e. they are non-productive land). Where these areas do resemble a functioning soil (such as the reinstatement of a soil profile following gravel extraction) the land can be assigned a LUC classification.

For this assessment the productive area of the Site (to which the LUC classification can be applied) is the Site area excluding non-productive land.

6. Regional scale soil and LUC map information (1:50,000 scale)

An initial desktop LUC assessment was undertaken for the Site. Available map information, soil reports and geospatial data included:

[4] https://www.environmentcourt.govt.nz/assets/Documents/Publications/2024-NZEnvC-083-Blue-Glass-Limited-v-Dunedin-City-Council.pdf

- New Zealand Land Resource Inventory (NZLRI) layers, including the New Zealand Fundamental Soil Layer (NZFSL) and Land Use Capability Layer (providing map units of dominant soil type and LUC unit)[5]
- S-Map Online (providing map units of Soil Siblings)[6]

Of the available map information sources, the S-Map Online soil map information, NZFSL and NZLRI map information are at a regional scale (approximately 1:50,000 scale).

NZLRI (1:50,000 scale) soil and LUC classification

Based on the available NZLRI and NZFSL map information the soils and LUC units the Site are mapped as shown in **Figure 3**. Available NZLRI map information maps the property[7] as predominantly the Te Rapa silt loam and peaty silt loam on flat to gently undulating slopes. The parent material of these soils is a combination of peat and the "Hinuera Formation", namely, rhyolitic alluvial deposits deposited by the Ancestral Waikato River[8]. The subdominant soil within the Site is the Horotiu-Te Kowhai soil complex on flat to gently undulating slopes. These soils and LUC units are mapped to occur in the northwest and northeast of the Site. The parent material of these soils is the Hinuera Formation[9]. There is a small, isolated area of Hamilton clay loam mapped in the centre of the Site on rolling slopes. The parent material of these soils is older, strongly weathered 'Hamilton Ash Formation'.

The Site contains 53% (or 94.5 ha) poorly drained Te Rapa silt loam and peaty silt loam (Gley Soil) on flat to gently undulating slopes (0-3°) with an LUC classification of LUC 2w2. Thirty-one percent (or 28.3 ha) of the Site comprises imperfectly drained Horotiu silt loam-Te Kowhai silt loam complex (Allophanic and Gley Soil) on flat to gently undulating slopes (0-3°) with an LUC classification of LUC 2w3. Sixteen percent (or 28.2 ha) of the Site comprises moderately well drained Hamilton clay loam (Granular Soil) on rolling slopes (8-15°). These map units have an LUC classification of LUC 3e3.

[5] https://lris.scinfo.org.nz/layer/48076-nzlri-land-use-capability-2021/
[6] https://smap.landcareresearch.co.nz/maps-and-tools/app/
[7] https://lris.scinfo.org.nz/layer/48134-nzlri-north-island-edition-2-all-attributes/
[8] McLeod M. 1992. Soils of part northern Matamata County, North Island, New Zealand. DSIR Land Resources Scientific Report No. 18.
[9] McLeod M. 1992. Soils of part northern Matamata County, North Island, New Zealand. DSIR Land Resources Scientific Report No. 18.

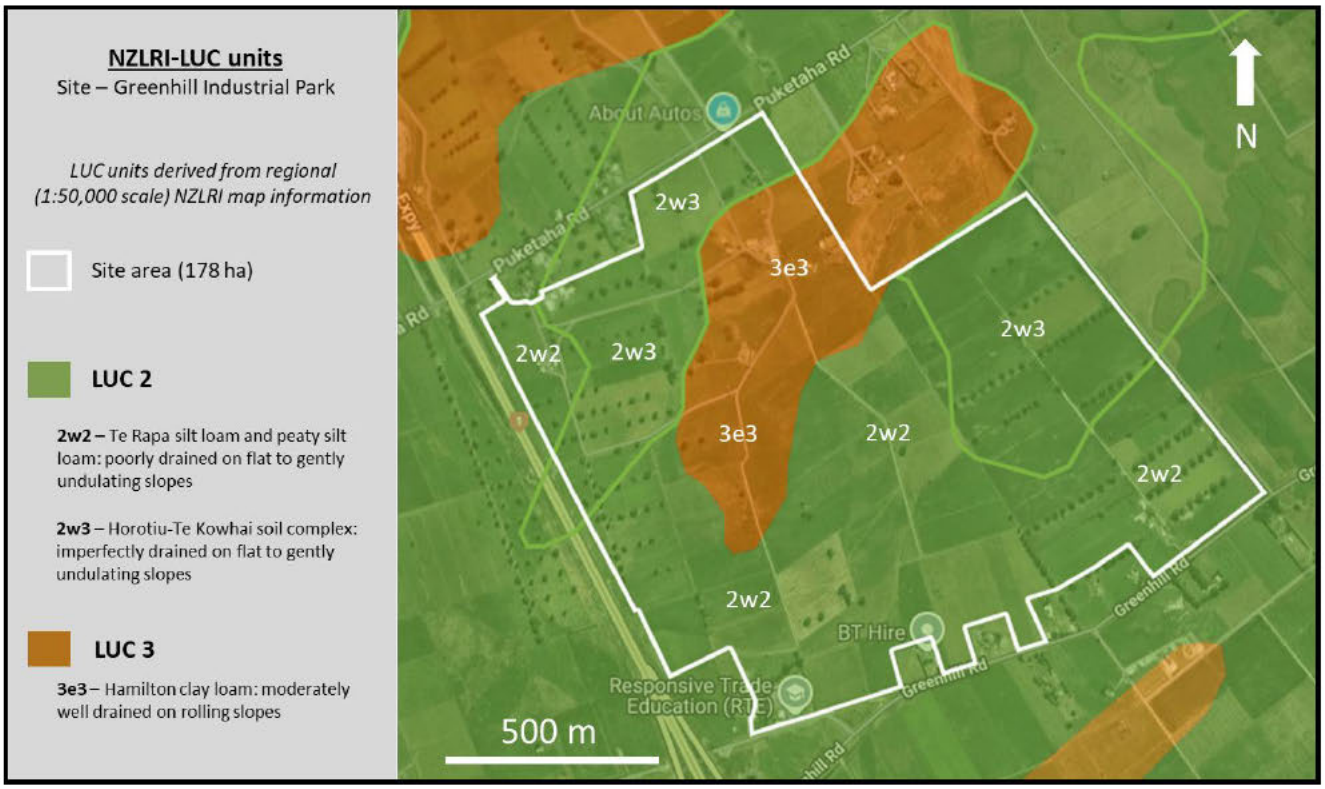

Figure 3: LUC units for the Site, derived from regional scale NZLRI-LUC map information.

Table 1 gives the general characteristics of the soils and LUC units as mapped in **Figure 3**. The approximate % cover of these regional NZLRI derived LUC units were estimated using Google MyMaps.

*Table 1. Summary of the NZLRI soil and LUC map unit characteristics and approximate % cover (estimated from **Figure 3**) of regional NZLRI derived LUC units within the Site.*

Soil type (NZSC Soil Order)	Parent material	Soil drainage	Slope class	LUC unit (limitation)	Area of total assessment area ha (%)*
Te Rapa silt loam and peaty silt loam (Gley Soil)	Hinuera Formation alluvial sediments and peat	Poorly drained	A	2w2 (wetness)	94.5 (53)
Horotiu-Te Kowhai complex (Allophanic +Gley Soil)	Hinuera Formation alluvial sediments	Imperfectly drained	A	2w3 (wetness)	55.3 (31)
Hamilton clay loam (Granular Soil)	Strongly weathered "Hamilton Ash Formation"	Moderately well drained	C	3e3 (erosion)	28.2 (16)

*% areas rounded to whole number.

Based on the available NZLRI and NZFSL map information the majority of the assessment area is a poorly drained Te Rapa silt loam and peaty silt loam on flat to gently undulating slopes and classified as LUC 2w2 (53% of the Site); with a smaller area comprising a mosaic of imperfectly drained Horotiu-Te Kowhai soil complex, on flat to gently undulating slopes and classified as LUC 2w3 (31% of the Site); and a small area of moderately well drained Hamilton clay loam, on rolling slopes classified as LUC 3e3 (16% of the Site) (**Table 1**).

S-Map Online

The S-Map soil map information is sourced from S-Map Online and is mapped at 1:50,000 scale. S-Map soil polygons are only available on the S-Map Online website. The soil names for each map unit are "soil siblings", with a probability of occurrence (%) and certainty rating provided for each soil sibling in a map unit.

S-Map Online identified the majority of the soils in the assessment areas as Allophanic Soils (37%), followed by Gley Soils (32%), Brown Soils (20%), Granular Soils (5.5%), Ultic Soils (5.5%) and Podzol Soils (less than 1%) (**Figure 4** and **Table 2**).

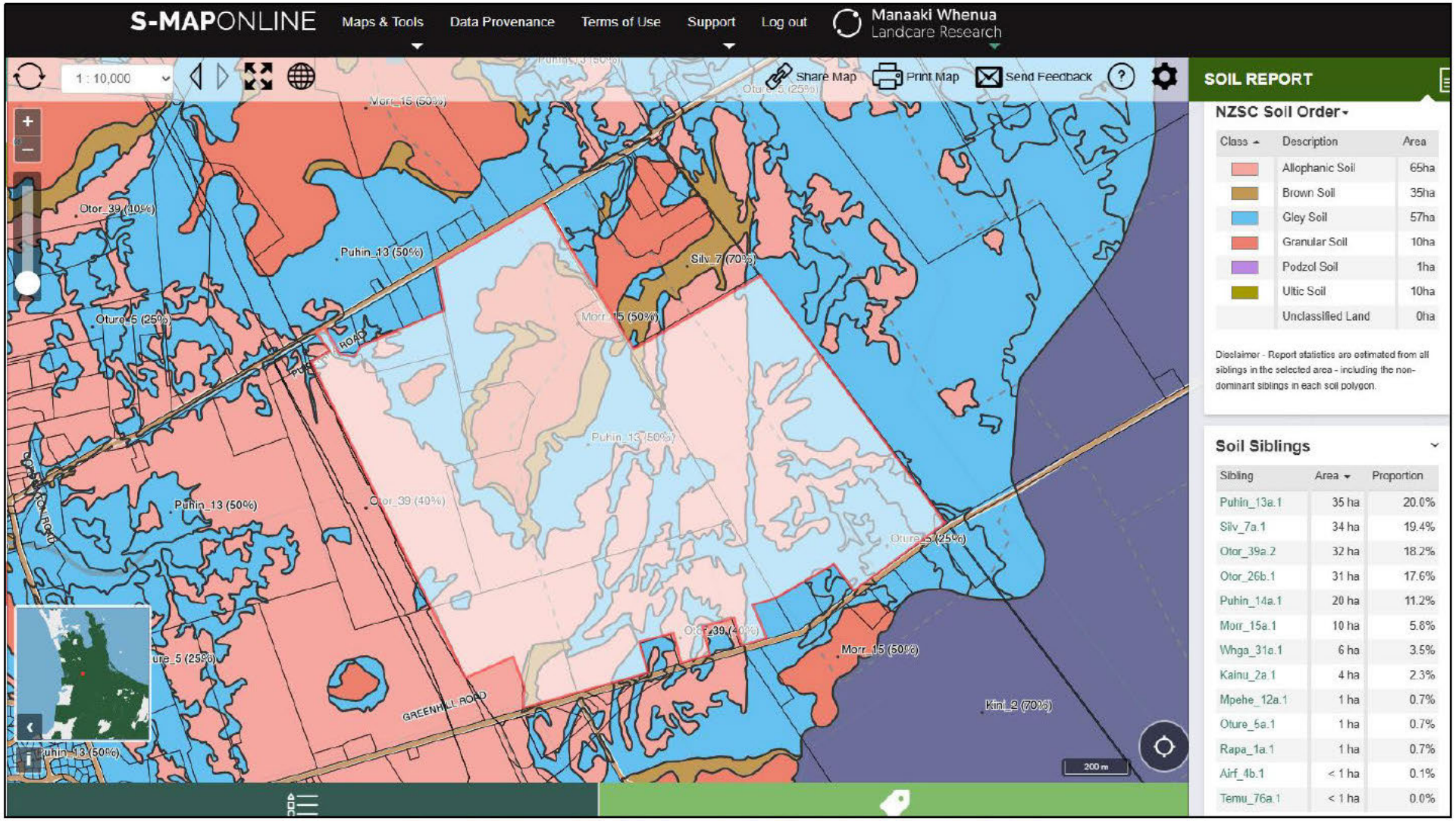

Figure 4: S-Map soil (Soil Order and soil sibling) distributions for the Site.

Table 2 provides a summary of the S-Map soil sibling map unit characteristics, including S-Map Family, S-Map Sibling, correlating Soil Series name, NZSC Soil Order, soil drainage, and their approximate proportions, for the Site. All soils are deep (> 100 cm), have either silt loam or clay loam textures, with variable drainage. This information is derived from S-Map Online factsheets and can be sourced from the S-Map Online website[10].

Table 2. S-Map soil sibling map unit characteristics for the Site.

S-Map Family	S-Map Sibling	Soil Series name	NZSC (Soil Order)	Soil drainage	Proportion (%)
Pukehina	Puhin_13a.1	Te Kowhai	Gley (GOT)	Poorly drained	20.0
Silverdale	Silv_7a.1	Bruntwood	Brown (BOM)	Imperfectly drained	19.4
Otorohanga	Otor_39a.2	Horotiu	Allophanic (LOT)	Well drained	18.2
Otorohanga	Otor_26b.1	Horotiu	Allophanic (LOT)	Moderately well drained	17.6
Pukehina	Puhin_14a.1	Te Kowhai	Gley (GOT)	Poorly drained	11.6
Morrinsville	Morr_15a.1	Hamilton	Granular (NOT)	Moderately well drained	5.8
Whangaripo	Whga_31a.1	Whangaripo	Ultic (UYM)	Imperfectly drained	3.5
Kainui	Kainu_2a.1	Kainui	Ultic (UYBG)	Imperfectly drained	2.3
Matapehe	Mpehe_12a.1	Te Rapa	Podzol (ZOT)	Imperfectly drained	0.7
Oturere	Oture_5a.1	Te Rapa	Gley (GOO)	Poorly drained	0.7
Te Rapa	Rapa_1a.1	Te Rapa	Allophanic (LGO)	Moderately well drained	0.7
Airfield	Airf_4b.1	Horsham	Brown (BOM)	Imperfectly drained	0.1
Temuka	Temu_76a.1	Rotokauri	Gley (GOT)	Poorly drained	0.1

The S-Map soil map information provides a more spatially detailed representation of the soils on the Site than the NZLRI 1:50,000 soil map information. However, because of the absence of land characteristics information (e.g. slope) for the soil map units, there is currently no direct correlation with LUC units. Some, but not all, of the S-Map soil map units correlate to the soil series identified by the NZLRI map information. In this report, we have retained the DSIR's soil nomenclature (e.g. soil type and series names) in preference to the S-Map soil sibling nomenclature to allow for direct correlation of the soils with the LUC units provided by the NZLRI map information and associated NZLRI Extended Legends.

[10] https://smap.landcareresearch.co.nz/maps-and-tools/app/

7. NPS-HPL assessment based on regional map information

Based on the available 1:50,000 scale NZLRI information and applying the NPS-HPL, LUC 2w2, 2w3 and 3e3 land is considered highly productive land (**Figure 5**).

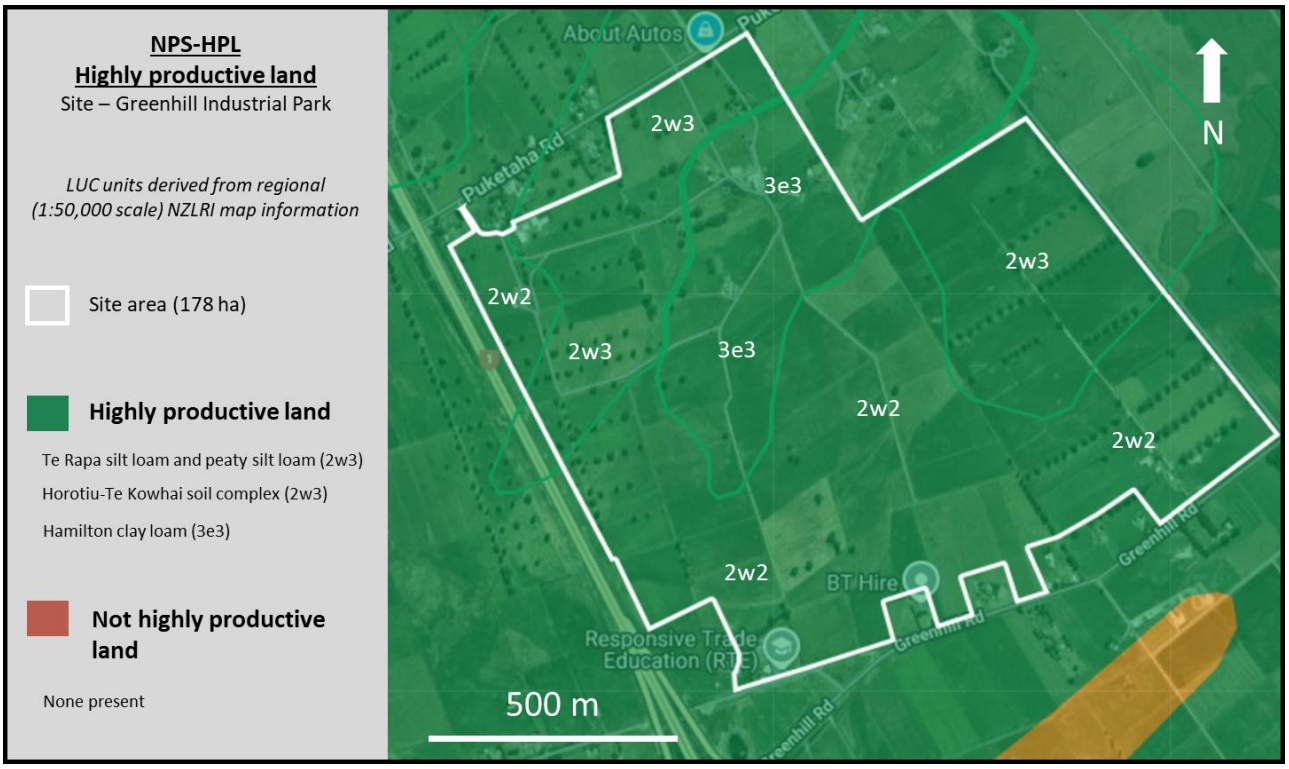

Figure 5. The distribution of NPS-HPL highly productive land for the Site, based on the NZLRI (1:50,000 scale) map information.

8. Regional scale map information limitations

The LUC classification can be applied (mapped) at any scale and regional scale LUC map units can differ from those identified at property scale. Property scale mapping is typically mapped at a scale between 1:5,000 and 1:15,000, while catchment and regional maps are generally mapped at 1:50,000 scale. The LUC Handbook sets out recommended mapping scales for inventory surveys and LUC mapping (p100).

Mapping LUC at a property scale can identify different LUC units (and map units) than depicted by regional scale LUC mapping. This is because property scale mapping includes more observations compared with regional scale mapping.

Soil and LUC maps are usually drawn at a specific scale depending on the smallest area of interest for a particular use and the density of field observations. For example, a 1:5,000 scale map requires on average four observations/ha while a 1:50,000 scale map requires 0.04 observations/ha (or four observations per 100 ha). With GIS tools and geospatial databases, it has become easy to manipulate maps, creating the temptation to rescale a map beyond its original scale of collection. Enlarging maps from their original scale will not provide the same accuracy or contain more detail than a coarse scale map. This is because they are not based on sufficient field observations to delineate soil map units at the finer scales portrayed. For the regional scale LUC map information, map unit boundaries may not align with the topography (slope) and other geographic features (such as rivers or terraces). Therefore, to correctly identify and map the LUC

units at property scale, assessment using the LUC classification criteria described in the LUC Handbook is required.

The 1:50,000 scale NZLRI data provides good foundational physical information for regional planning. However, its use as a definitive map requires an appropriate scale. For the objective of assessing soil resources, land use capability, and informing land productivity, the on-site assessment is the most accurate and fit-for-purpose method for providing the necessary soil and LUC information.

9. On-site LUC classification assessment

Method

Landsystems undertook an on-site property scale LUC assessment of the 178 ha Site according to standard methods (Milne et al., 1993[11] and Lynn et al., 2009[9]). The on-site assessment was undertaken on Thursday 4th, Tuesday 9th, Tuesday 16th and Wednesday 17th of September 2025.

The on-site mapping does not constitute a detailed soil survey rather the focus is on characterisation of soil and land properties to apply the LUC classification, in turn used to determine the extent of NPS-HPL highly productive land on the Site. However, recorded soil properties are used to identify limitations that may affect the productivity of the Site.

The on-site assessment included soil observations by hand auger across the Site using a free survey approach. Approximately 330 soil auger observations (excluding additional observations for checking boundaries) were used to determine the LUC map units. A higher proportion of observations were undertaken on the Site area with potential high class soils.

Observations of slope angle, topography and soil parent material were made over the relevant area. Soil augering up to 100 cm depth was used to assess soil properties such as soil horizons, drainage, plant root depths, depth to gravels, soil texture, structure, and colour.

All soils were assessed in current condition and areas with modified soils and areas considered to be non-productive land were identified and mapped. Soil series and types have been used for this report (as opposed to S-Map Soil Siblings) to provided clearer correlation with LUC units provided by the regional NZLRI LUC map information. LUC classification was assigned based on the criteria provided in Lynn et al. (2009). LUC units were assigned based on the closest fitting LUC unit provided by the regional NZLRI LUC map information.

Mapping scale

The number of soil auger observations across the 178 ha Site equated to an observation density of 1.9 observations per hectare (or one observation per 0.54 ha). Considering the Site area as a whole, this density of observations (using conventional mapping techniques) is sufficient to support an approximate map scale of 1:10,000[12].

[11] Milne JDG, Clayden B, Singleton P.L, Wilson AD. 1995. Soil Description Handbook. Lincoln, New Zealand, Manaaki Whenua Press. 157p.
[12] Page 12 - Grealish G. 2017. New Zealand soil mapping protocols and guidelines. Envirolink Grant: C09X1606. Manaaki Whenua –Landcare Research.

10. On-site LUC assessment

A generalised physiographic distribution of soils within the assessment area is shown below in **Figure 6**[13]. The Waikato Plains consist of volcanogenic alluvium deposited by the Waikato River during its fan building stage which ended about 12,000 years ago. The volcanogenic alluvium, known as the Hinuera Formation, consists of rhyolitic sands, silts and gravels, which infilled the existing hilly ash covered landscape and in the present day only low rolling ridge crests protrude through the alluvium. The emplacement of alluvium altered the original drainage patterns and caused formation of lakes. Peat subsequently formed in many of the lakes, back swamp areas, and adjacent low-lying land. As a result, the Waikato Plains comprise two district sub-patterns: a mineral soil pattern based on the volcanogenic alluvium deposited by the Waikato River and an organic soil pattern, with intergrades between the two[14].

The main landform units and soils of the assessment area include mineral soils formed on the plains (Horotiu-Te Kowhai soil complex), peaty gley soils formed on the margins of peat (Te Rapa Series); low hills and fans in in the Hamilton Basin (Hamilton and Kainui Series), and modified soil areas (not shown in **Figure 6**).

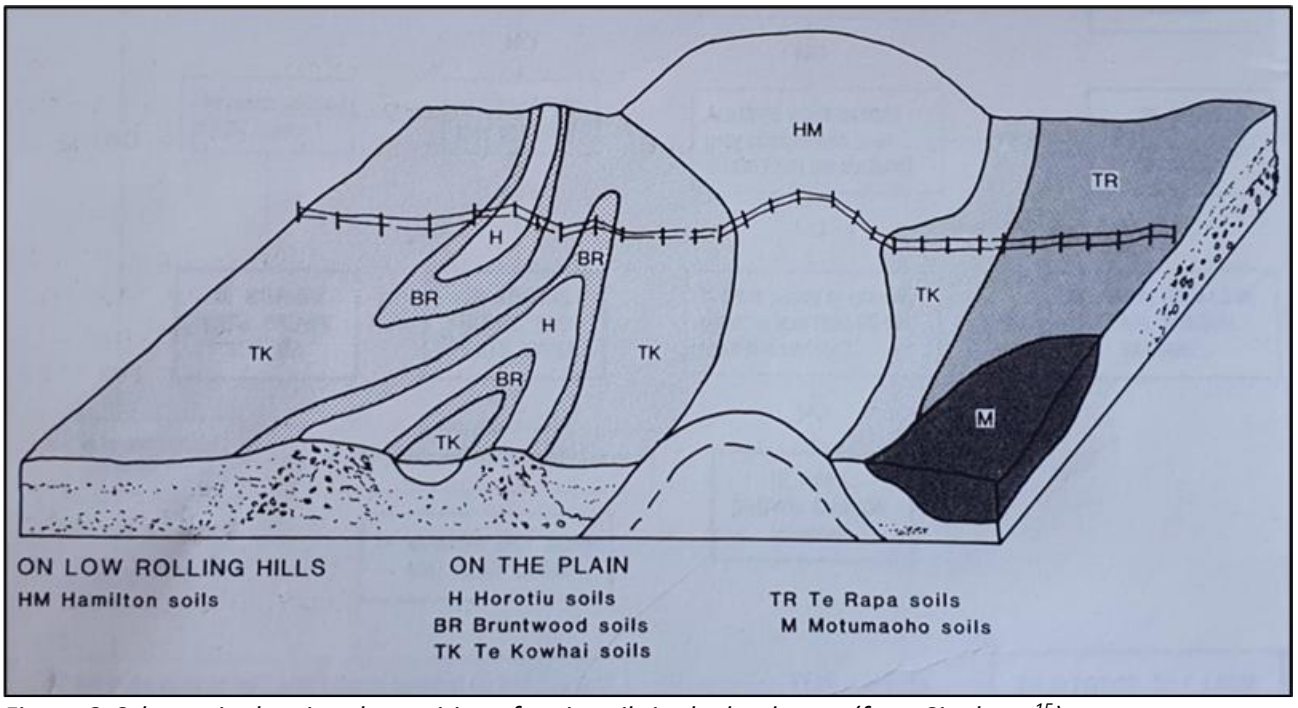

Figure 6: Schematic showing the position of main soils in the landscape (from Singleton[15])

A summary of the soils and LUC units identified in the assessment area are provided in **Table 3**. The main soils observed and examples of poorly to very poorly drained and non-productive land in the assessment area are shown in **Figures 7** to **9**. The soil profiles should be considered example soil

[13] Singleton, P. 1991. Soils of Ruakura – a window on the Waikato. DSIR Land Resources, Scientific Report No. 5. Image from pg. 30.
[14] Singleton, P. 1991. Soils of Ruakura – a window on the Waikato. DSIR Land Resources, Scientific Report No. 5.
[15] Singleton, P. 1991. Soils of Ruakura – a window on the Waikato. DSIR Land Resources, Scientific Report No. 5. Image from pg. 30.

profiles for each soil as the profile for actual soil observed in the field at any given point may differ slightly from the example shown.

Table 3. Soils and dominant LUC units identified for the Site (in order of increasing limitations).

Soil type (NZSC Soil Order)	Parent material	Texture profile	Slope class	Soil depth	Soil drainage	Dominant LUC unit (limitation)
Horotiu-Te Kowhai complex, *Bruntwood silt loam dominant* (Allophanic Soil)	Rhyolitic alluvial deposits of the 'Hinuera Formation'	Silt loam over silt or sand	A+B (0 -5°)	Deep (100+ cm)	Imperfectly to well drained	2s1 (soil)
Hamilton clay loam (Granular Soil)	Strongly weathered tephra on 'Hamilton Ash Formation'	Silty clay loam on clay loam on clay	B (2-5°)	Deep (100+ cm)	Moderately well drained	2e2 (slope)
Kainui silt loam (Ultic Soil)	Tephra on 'Hamilton Ash Formation'	Silt loam on clay loam	B (2-5°)	Deep (100+ cm)	Imperfectly drained	2e5# (slope)
Te Rapa peaty silt loam (Gley Soil, drained)	Decomposed peat on rhyolitic alluvial deposits of the 'Hinuera Formation'	Peaty silt loam over silt loam or sandy loam over silty clay loam or sand	A (0 -3°)	Deep (100+ cm)	Imperfectly to moderately well drained	2w2 (wetness)
Horotiu-Te Kowhai complex, *Te Kowhai silt loam dominant* (Gley Soil + Allophanic Soil)	Rhyolitic alluvial deposits of the 'Hinuera Formation'	Silt loam over silt or sand	A (0 -3°)	Deep (100+ cm)	Poorly to imperfectly drained	2w3 (wetness)
Hamilton clay loam (Granular Soil)	Strongly weathered tephra on 'Hamilton Ash Formation'	Silty clay loam on clay loam on clay	C+B (7 -14°)	Deep (100+ cm)	Moderately well drained	3e3 (slope)
Te Kowhai silt loam (Gley Soil)	Rhyolitic alluvial deposits of the 'Hinuera Formation'	Silt loam over silt or sand	A (0 -3°)	Deep (100+ cm)	Poorly to very poorly drained	3w1 (wetness)
Rotokauri clay loam (Gley Soil)	Colluvium from 'Hamilton Ash Formation'	Clay loam over clay	A (0 -3°)	Deep (100+ cm)	Poorly to very poorly drained	3w1 (wetness)
Hamilton clay loam (Granular Soil)	Strongly weathered tephra on 'Hamilton Ash Formation'	Silty clay loam on clay loam on clay	D+E (16-28°)	Deep (100+ cm)	Moderately well drained	4e2 (slope)
Kainui silt loam (Ultic Soil)	Tephra on 'Hamilton Ash Formation'	Silt loam on clay loam	D+C (10-21°)	Deep (100+ cm)	Imperfectly drained	4e3 (slope)
Rotokauri clay loam (Gley Soil)	Colluvium from 'Hamilton Ash Formation'	Clay loam over clay	A (0 -3°)	Deep (100+ cm)	Very poorly drained	4w* (wetness)
Puketaha peaty loam (Gley Soil)	Rhyolitic alluvial deposits of the 'Hinuera Formation' with an iron pan	Peaty silt loam over concretionary sandy loam over gravelly iron pan	A (0 -3°)	Shallow (20-45 cm)	Poorly drained	4s* (soil)
Modified soil (Fill + Truncated Anthropic Soil)	Deposited fill on soils derived from 'Hinuera Formation' sediments or 'Hamilton Ash Formation' sediments	Areas of fill >30 cm, areas of no topsoil, gravel at surface or at very shallow	A (0 -3°)	Very shallow (cannot auger) to deep	Imperfectly to very poorly drained	4s* (soil)

	OR truncated material derived from those parent materials mentioned above	depths, unable to auger				
Modified soil / non-productive land	Existing houses and curtilage, farm races, drains, gravelled storage areas, ponds, deposited fill areas, earthworks, farm infrastructure and sheds					-

[#]Jessen, MR. 1992. Waikato LUC units correlated. Unpublished file note, Land Resources Division, Department of Scientific and Industrial Research; *LUC class and limitation only as no corresponding LUC unit in NZLRI Extended Legend.

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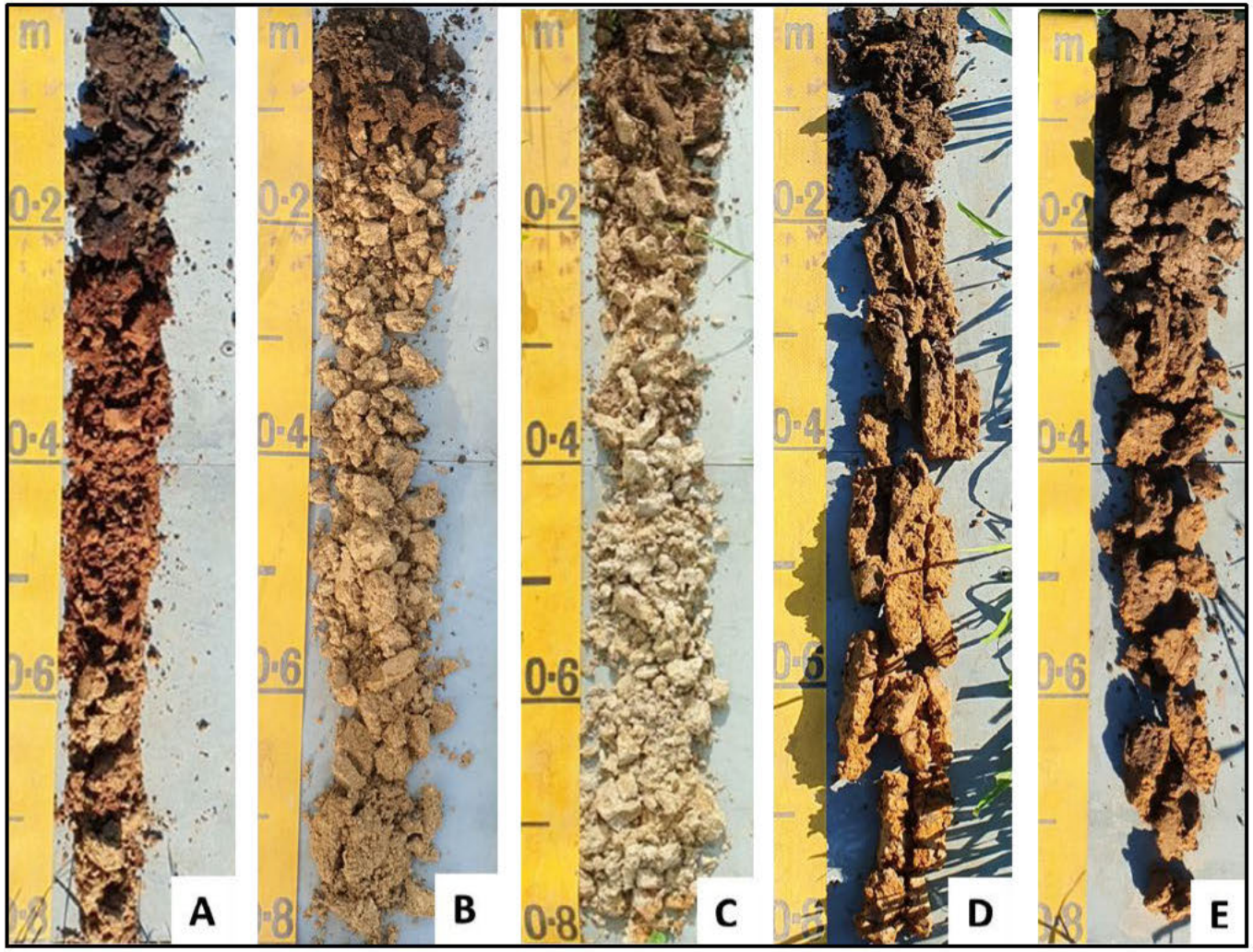

Figure 7: Example soil profiles of the dominant soils identified in the Site. A) Te Rapa peaty silt loam, LUC 2w2 on A slopes; B) Bruntwood silt loam, LUC 2s1 on A+B slopes; C) Te Kowhai silt loam, LUC 2w3 on A slopes; D) Hamilton clay loam, LUC 4e2 on D+E slopes; E) Kainui silt loam, LUC 4e3 on D+C slopes.

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Figure 8: Example non-productive land and modified soils identified at the Site. A) Area of earthworks, Fill Anthropic Soil (modified soil), mounds of fill and drain in NE of Site; B) Area of Fill Anthropic Soil (modified soil) and buried rubbish in south of Site; C) Ponds, effluent pond, felled trees and drains in north of Site; D) Farm infrastructure and races; E) Active slip between base of existing property and tennis court, northcentral location, on strongly rolling to moderately steep slopes (Hamilton clay loam, LUC 4e2); F) Non-productive land in NW of Site.

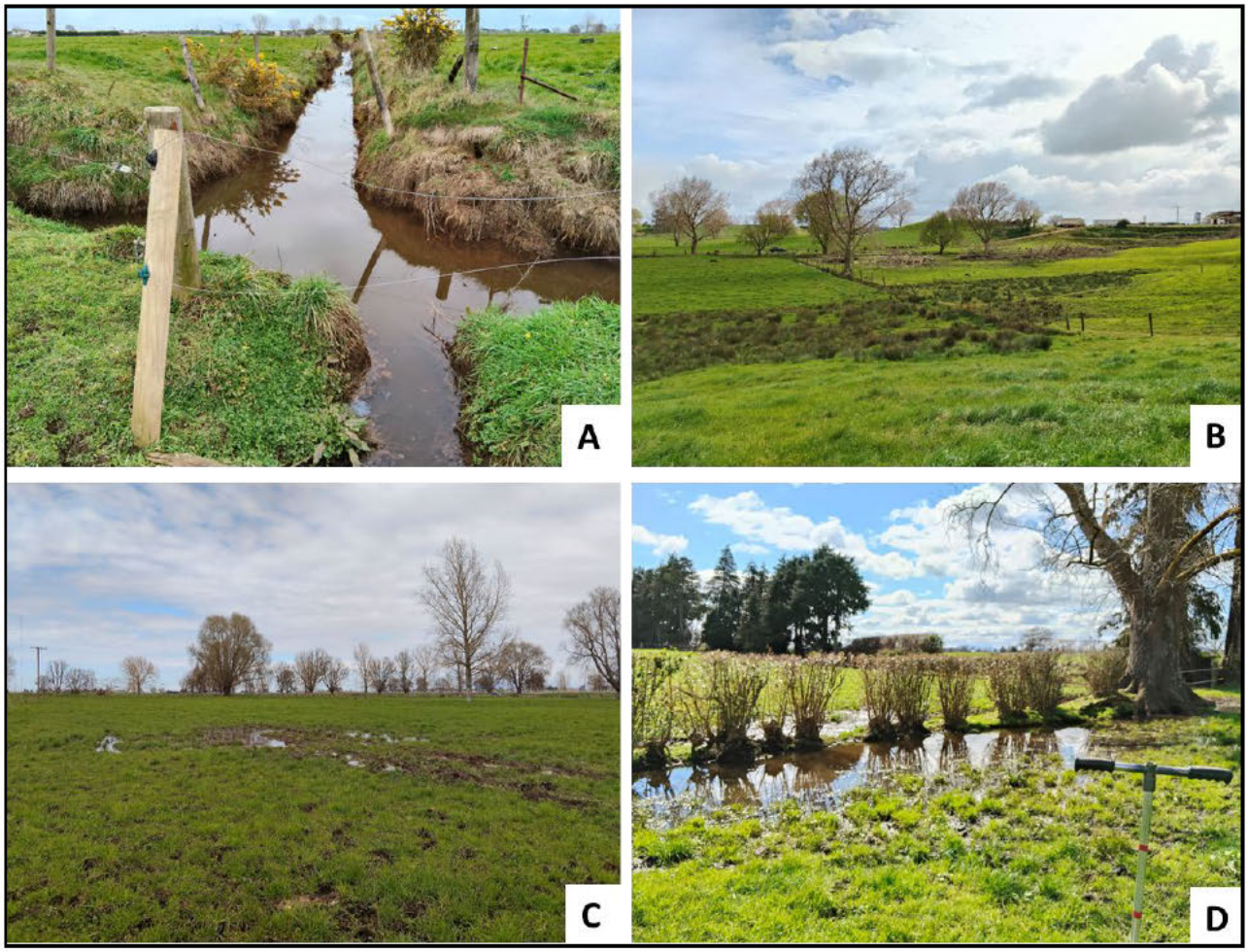


Figure 9: Examples of drains and poor to very poor drainage identified at the Site. A) Full drains around peaty gley soil areas (Te Rapa peaty loam, LUC 2w2); B) Wetland area with free-standing (LUC 4w1) in north of Site; C) Area of free-standing/ponded water in NW of Site (Te Kowhai silt loam, LUC 3w1); D) Area of free-standing/ponded water in E of Site.

The detailed on-site assessment confirmed the Site comprises areas that are the alluvial surface of the Hinuera Formation, left by the ancestral Waikato River, which although relatively flat, contains ridges and swales of old levees and channels; large expanses of peaty gley soils; a series of undulating to moderately steep low hills; and modified soil areas.

Much on the flat to gently undulating eastern, western and southern boundaries of the Site was dominated by drained peaty Gley Soils (Te Rapa Series) (**Figure 10**). The Te Rapa Series forms in backswamp areas on plains (see **Figure 6**) and the dominant variant found on the Site, the Te Rapa peaty silt loam, has a completely decomposed peaty top that is less than 40 cm thick, with a dark reddish brown humic layer occurring immediately below the topsoil (**Figure 7A**) [16]. A thin layer of coarse pumice sand is common at about 20 cm depth. In its natural state the Te Rapa peaty silt loam is poorly drained, but with artificial drainage, these soils are imperfectly to moderately well drained

[16] Singleton P. 1991. Soils of Ruakura – a window on the Waikato. DSIR Land Resources Scientific Report No. 5.

with a LUC classification of 2w2 (**Table 3**, **Figure 11**). Due to artificial drainage of the Te Rapa Series, some soil boundaries were dictated by paddock drains. On the eastern boundary of the Site, a very small unmappable pocket of very poorly drained Kaipaki peaty loam (Organic Soil) was observed among the LUC 2w2 area (**Figure 9D**).

On either side of the low hills in the central part of the Site the Horotiu-Te Kowhai soil complex (Allophanic Soil and Gley Soil) was observed. These soils are formed on the Hinuera Formation within the Waikato and are a complex of poorly drained Te Kowhai soil series to imperfectly drained Bruntwood soil series to well drained Horotiu soil series, often found in close proximity to one another[17]. To the north of the central low hills a mosaic of imperfectly to well drained ridges and imperfectly to poorly drained swales was found, and the imperfectly drained, deep, Bruntwood silt loam soil dominated the Horotiu-Te Kowhai soil complex (**Figure 7B** and **10**). These were assigned LUC 2s1 and occurred on flat to undulating slopes. To the south of the central low hills the Horotiu-Te Kowhai soil complex is dominated by the deep, poorly drained Te Kowhai silt loam soils. These were assigned a LUC classification of 2w3 and were on flat to gently undulating slopes (**Table 3**, **Figures 7C** and **Figure 10**). In the southcentral part of the Site there was a small area of poorly drained, shallow, Puketaha peaty loam (Gley Soil). This soil is formed from Hinuera Formation volcanogenic material, however had an iron fan at 35 cm depth and therefore assigned an LUC classification of 4s (**Table 3, Figure 10**).

On the central portion and southwestern boundary of the Site older low hills protrude through the younger volcanogenic alluvium of the Hinuera Surface and the Hamilton Series and Kainui Series soils were observed. The Hamilton clay loam (Granular Soil), found in the central portion of the Site, is a moderately well drained, deep, heavy clay soil, assigned an LUC classification of 2e2 on undulating slopes, LUC 3e3 (**Figure 7D**) on undulating to rolling slopes, and LUC 4e2 on strongly rolling to moderately steep slopes (**Table 3**). The Kainui silt loam (Ultic Soil) is imperfectly drained, deep, and found on the low hills in the northwest and southwest of the Site. Where it occurred on undulating slopes it had an LUC classification of 2e5 and on strongly rolling slopes, an LUC classification of 4e3 (**Table 3**, **Figure 7E**).

Areas of Gley Soils were common at the base of low hills within the Site and soils formed in the material eroded from the surrounding hills (colluvium) and adjacent alluvium from the plains. These soils were poorly to very poorly drained, can have silt loam or clay loam topsoil textures, with mottled silt loam or clay loam to clay subsoils. At the base of the central low hills, poorly to very poorly drained Rotokauri clay loam was common and had an LUC classification of 3w1. Where drainage was very poor at the base of strongly rolling to moderately steep (LUC 4e2) slopes, active slips and ponded surface water (after drainage) were observed and these areas were assigned an LUC classification of 4w1 (**Figures 8E** and **9B**). In low-lying areas within the Hinuera Surface areas of poorly to very poorly drained the Te Kowhai silt loam were observed and was assigned an LUC classification of 3w1 (**Figure 9C** and **Figure 10**).

[17] Singleton P. 1991. Soils of Ruakura – a window on the Waikato. DSIR Land Resources Scientific Report No. 5.

There were isolated pockets of modified soil areas, usually associated with farming operations, particularly in the northcentral and northwest of the Site. In the northwest there were areas of Fill Anthropic Soils (modified soils), including high mounds of subsoil and topsoil material (**Figures 8A, 8F**), and earthwork areas. In the northcentral portion of the Site there were modified soil areas associated with farm infrastructure, areas of Fill Anthropic Soil and gravel at the surface (**Figure 8D**), and an active slip area between an existing property and tennis court (**Figure 8E**).

There were also areas of non-productive land within the Site (**Figure 10**), including farm infrastructure, existing houses and curtilage, gravelled storage areas, drains, ponds, and gravelled farm races (see **Figure 8**).

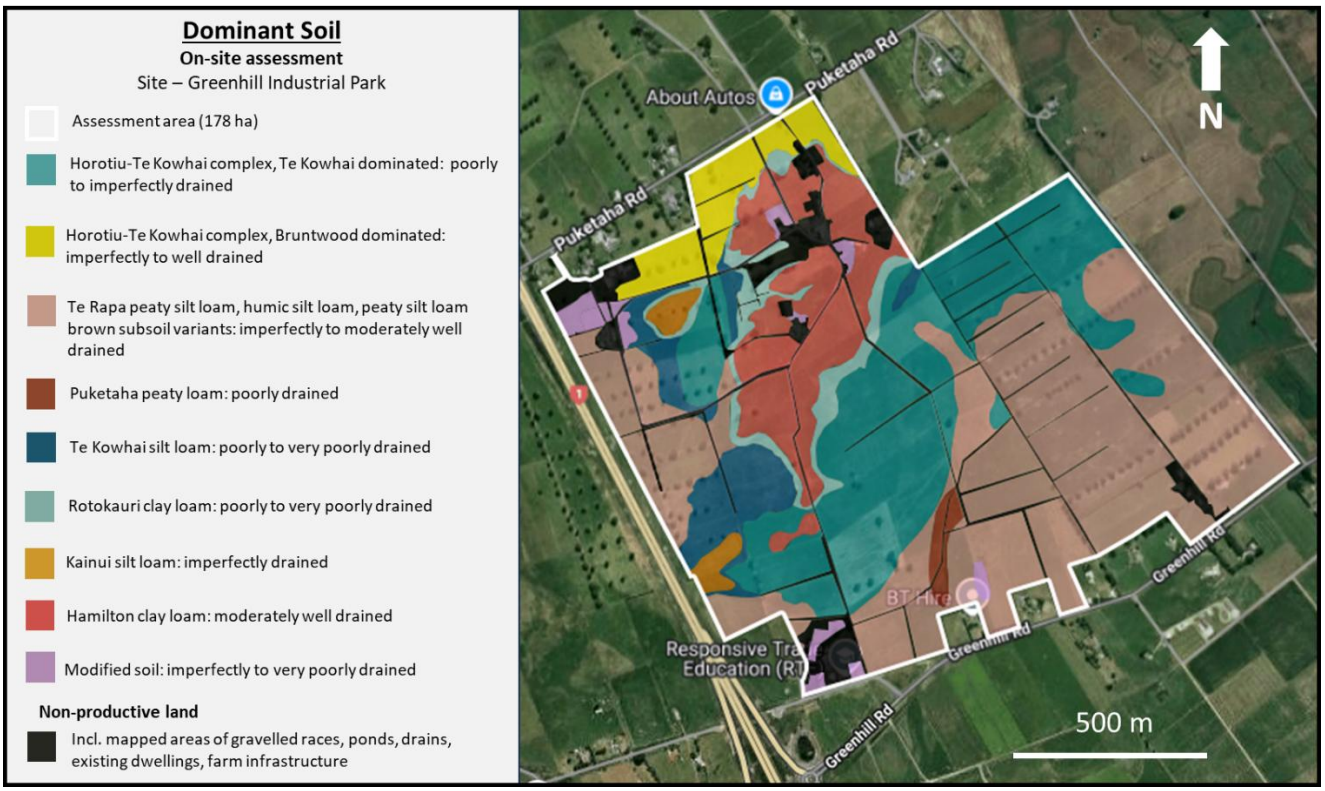


Figure 10: The on-site mapped distribution of the dominant soils for the Site.

The estimated distribution of dominant soils, LUC classes and LUC units are given in **Figure 11** (larger maps are provided at the end of the report).

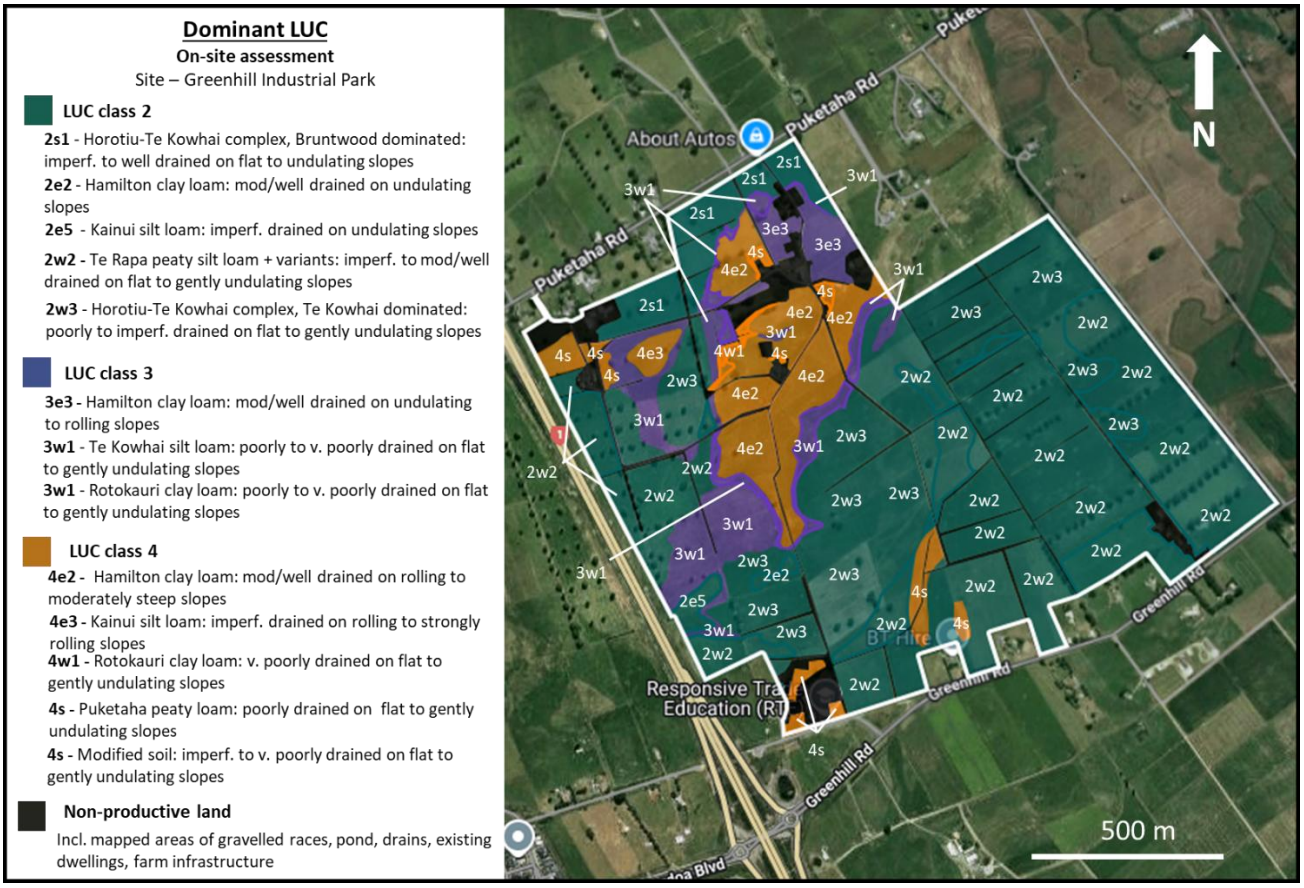


Figure 11: The on-site mapped distribution of dominant LUC units for the Site.

11. Revised LUC classification

Based on the on-site assessment, aerial photographs of the assessment area and surrounding areas and soil auger observations, the original NZLRI delineated LUC map units differ from the LUC map units identified and mapped in the on-site assessment.

Based on the available NZLRI and NZFSL map information (**Figure 3**) the majority of the assessment area was mapped as poorly drained Te Rapa silt loam and peaty silt loam (Gley Soil) on flat to gently undulating slopes with an LUC classification of LUC 2w2 (53% of the Site). A smaller area of the Site was mapped as imperfectly drained Horotiu silt loam-Te Kowhai silt loam complex (Allophanic and Gley Soil) on flat to gently undulating slopes with an LUC classification of LUC 2w3 (31% of the Site). The remainder was mapped as moderately well drained Hamilton clay loam (Granular Soil) on rolling slopes with an LUC classification of LUC 3e3 (16% of the Site).

However, detailed on-site mapping showed discrepancies in the extent of LUC class 2 and 3 land, and the slope and drainage characteristics across the Site (refer **Table 4** below and **Figures 10** and **11**).

Specific comments are as follows:

- Fifty-three percent of the Site was mapped at LUC 2w2 at a regional scale. Detailed LUC mapping showed this to be an overestimation of LUC 2w2 land, with 40% of the Site LUC 2w2.
- Thirty-one percent of the Site was mapped as LUC 2w3 at a regional scale. Detailed mapping showed this was also an overestimation of LUC 2w3 land, with 24% of the Site LUC 2w3.
- Regional mapping gave 84% of the Site as LUC class 2 land, however, on-site mapping showed 69% of the land as LUC class 2.

- Despite artificial drainage on Site there was a greater proportion land with poorer soil drainage, including 12% mapped as poorly to very poorly drained LUC 3w1, 4w1, 4s land (**Table 4**). These poorly to very poorly drainage classes were missing from regional scale maps.
- Regional scale mapping underestimated the slope classes onsite (NZLRI maximum slope of LUC 3e3, rolling). On-site mapping showed a mix of slope classes from low undulating hills to moderate steep land, and LUC 2e2, LUC 2e5, LUC 3e3, LUC 4e2 and LUC 4e3 land with some slopes up to 28 degrees.
- Within the Site an area of 3.3 ha (~2% of the Site) was mapped as modified soil, dominated by either Fill Anthropic Soil or Truncated Anthropic Soil (LUC 4s).
- Nine percent of the Site was mapped as non-productive land, including mapped areas of gravelled races, ponds, extensive drains, existing dwellings, concrete areas, and farm infrastructure (**Table 4**, **Figures 8, 10-11**).

Table 4. LUC classes, LUC units and dominant soil type within the Site, based on the LUC map units identified by the on-site assessment.

LUC class	Dominant LUC unit	Dominant soil type	LUC unit area (ha)	LUC class area, ha, (%)[$]
2	2s1	Horotiu-Te Kowhai complex, Bruntwood dominant	8.13	122.65 (69)
	2e2	Hamilton clay loam	0.56	
	2e5	Kainui silt loam	1.23	
	2w2	Te Rapa peaty silt loam	70.34	
	2w3	Horotiu-Te Kowhai complex, Te Kowhai dominant	42.39	
3	3e3	Hamilton clay loam	3.22	18.38 (10)
	3w1	Te Kowhai silt loam	9.40	
	3w1	Rotokauri clay loam	5.76	
4	4e2	Hamilton clay loam	14.56	21.08 (12)
	4e3	Kainui silt loam	1.06	
	4w1	Rotokauri clay loam	0.73	
	4s	Puketaha peaty loam	1.43	
	4s	Modified soil	3.30	
Non-productive land/modified soil			15.89 (9)	

[$] % areas rounded to whole number.

12. On-site WDP-OiP high class soil classification

Detailed on-site assessment showed 69% of the assessment area as high class soil (LUC 2s1, 2e2, 2e5, 2w2 and 2w3) under the WDP-OiP definition for high class soil (**Table 5, Figure 12**).

The balance, 31% of the Site, was LUC 3e3, LUC 3w1, LUC 4e2, LUC 4e3, LUC 4w1, and LUC 4s, which is not high class soil. Non-productive areas (9% of the Site) including mapped areas of gravelled races, ponds, extensive drains, existing dwellings, concrete areas, and farm infrastructure, are not high class soil (**Table 5, Figure 12**).

Table 5. WDP-OiP high class soil for the Site based on the on-site mapped LUC map units.

LUC unit (dominant)	High class soil	Area ha, (%)[$]
2s1	High class soil	8.13
2e2	High class soil	0.56
2e5	High class soil	1.23
2w2	High class soil	70.34
2w3	High class soil	42.39
High class soil total		High class soil = 122.65 (69)
3e3	Not high class soil	3.22
3w1 (Te Kowhai)	Not high class soil	9.40
3w1 (Rotokauri)	Not high class soil	5.76
4e2	Not high class soil	14.56
4e3	Not high class soil	1.06
4w1	Not high class soil	0.73
4s (Fill +Truncated Anthropic)	Not high class soil	1.43
4s (Puketaha)	Not high class soil	3.30
NPL[#]	Not high class soil	15.89
Not high class soil total		Not high class soil = 55.35 (31)

[$]% areas rounded to whole number; [#]NPL = Non-productive land.

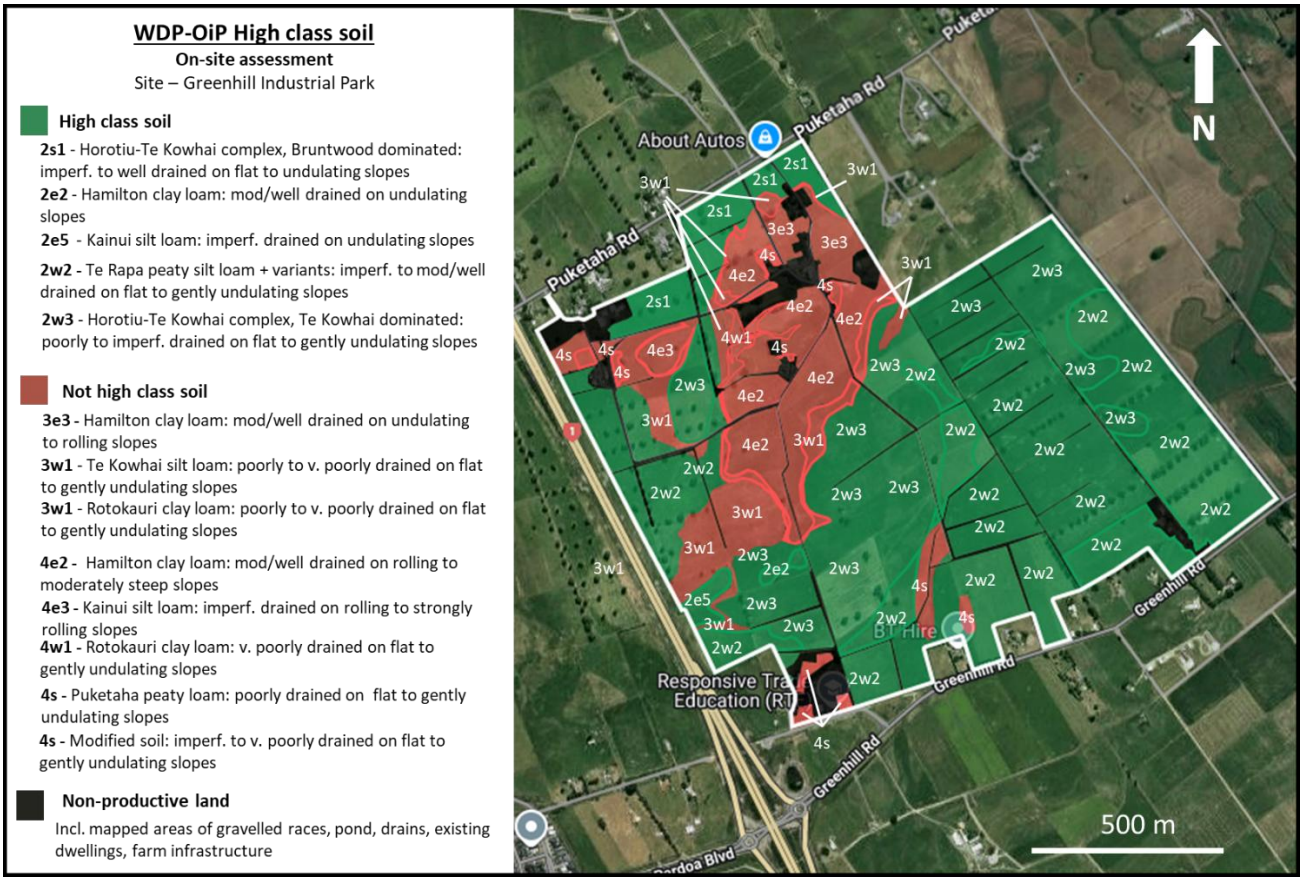


Figure 11: On-site mapped distribution of WDP-OiP defined high class soil for the Site.

13. LUC classification, slope and drainage considerations

The main land use limitations at the Site are the susceptibility of land to erosion (a function of slope and substrate type) and soil wetness (high water table, slow internal drainage, susceptibility to flooding)[18].

Drainage: Detailed on-site mapping showed soils to have a mix of drainage classes, with 24% of land imperfectly to poorly drained (LUC 2w3), and 12% poorly to very poorly drained (LUC 3w1, LUC 4w1, and LUC 4s). The soil wetness limitations of LUC 2w3 and 3w1 land will restrict year-round cropping (summer months only) and horticultural use. Seasonally high water tables, and days in which soil is inundated by water on LUC 2w3 and 3w1 land is likely to affect the yield and/or survival of water sensitive crops[19]. Therefore, these LUC 2w3 and 3w1 areas are most suited to pastoral land uses, with no or lighter stocking in wetter months. LUC 4w1 land (<1% of the Site), is prone to frequent

[18] Lynn IH, Manderson AK, Page MJ, Harmsworth GR, Eyles GO, Douglas GB, Mackay AD, Newsome PJF 2009. Land Use Capability survey handbook – a New Zealand handbook for the classification of land. AgResearch Hamilton; Manaaki Whenua Lincoln; GNS Science Lower Hutt, New Zealand.

[19] Lynn IH, Manderson AK, Page MJ, Harmsworth GR, Eyles GO, Douglas GB, Mackay AD, Newsome PJF 2009. Land Use Capability survey handbook – a New Zealand handbook for the classification of land. AgResearch Hamilton; Manaaki Whenua Lincoln; GNS Science Lower Hutt, New Zealand

flooding and is excessively wet after drainage and is best suited to low intensity seasonal pastoral use in drier months or retirement from productive use.

The LUC 2w2 land within the assessment area (covering 40%) is mapped as Te Rapa peaty silt loam (peaty Gley Soils) which have been artificially drained to increase their versatility. Although these soils are now moderately well to imperfectly drained, if surrounding drains are not well maintained the drainage status can deteriorate. These soils have low bulk density and high porosity in the organic part of their profile, with limitations to trafficability in wetter months due to low bearing strength[20]. This land is best suited to low intensity pastoral systems.

Slope class: Eleven percent of the Site was classified as LUC 3e3, LUC 4e2 and LUC 4e3, rolling to moderately steep land, with slopes of up to 28 degrees. This land has moderate to high susceptibility to erosion under cultivation and is best suited for pastoral use, production forestry, or conservation planting.

14.Comment on productive capacity

The detailed on-site soil and Land Use Capability (LUC) assessment confirmed the presence of different LUC units and distribution across the Site compared to the regional scale mapping, which had indicated 100% of the area was LUC Class 2 or 3 land. The property-scale assessment verified that the actual extent of high class soils (LUC 2s1, 2e2, 2e5, 2w2, and 2w3), as defined by the Waikato District Plan-Operative in Part (WDP-OiP), collectively comprises 69% of the Site. Conversely, 31% of the Site is designated as either not high class soil (22%) or non-productive land (9%).

The location and prevalence of this lower class land, combined with the non-productive areas (spanning from the near centre of the Site through into the north-western portion), restricts continuous land-based primary production under a single land use. Importantly, the contiguous area of LUC Class 4 land and non-productive land isolates and fragments the surrounding high class soils (LUC Class 2 land).

This pattern of fragmentation within the Site directly limits the size and cohesion of areas that can be utilised for more intensive land uses, such as intensive cropping and horticultural activities, thereby reducing the Site's overall productive capacity for land-based primary production over the long term.

15.Summary

Based on NZLRI LUC map information, 100% of the land on the Site is classified as highly productive land when applying NPS-HPL clause 3.5(7).

The detailed on-site assessment showed soils across the Site predominantly consisted of Te Rapa peaty silt loam on flat to gently undulating slopes, Horotiu-Te Kowhai soil complex (Te Kowhai silt loam dominated) on flat to gently undulating slopes, an isolated area of Horotiu-Te Kowhai soil complex (Bruntwood silt loam dominated) on flat to undulating slopes, pockets of Te Kowhai silt loam in low-lying swales, areas of undulating to moderately steep Hamilton clay loam and Kainui silt loam

[20] McLeod M. 1992. Soils of part northern Matamata County, North Island, New Zealand. DSIR Land Resources Scientific Report No. 18

on low hills, with some areas of Rotokauri clay loam on wetter toe slopes, a small pocket of shallow Puketaha peaty loam, and some areas of modified soils and non-productive land.

Imperfectly to moderately well drained Te Rapa peaty silt loam on flat to gently undulating slopes are classified as LUC 2w2. The poorly to imperfectly drained Horotiu-Te Kowhai complex on flat to gently undulating slopes is classified as LUC 2w3, and the isolated areas of imperfectly to well drained Horotiu-Te Kowhai complex on flat to undulating slopes is classified as 2s1. Small areas of poorly to very poorly drained soils on flat slopes: Te Kowhai silt loam is classified as LUC 3w1. The low hills of variable slope comprised the moderately well drained Hamilton clay loam on undulating slopes (LUC 2e2), undulating to rolling slopes (LUC 3e3) and rolling to moderately steep slopes (LUC 4e2), and imperfectly drained Kainui silt loam on undulating slopes (LUC 2e5) and rolling to strongly rolling slopes (LUC 4e3). The poorly to very poorly drained toe slopes of these central low hills contain areas of Rotokauri clay loam (LUC 3w1 and 4w1). The isolated pocket of poorly drained, shallow, Puketaha peaty loam has an LUC classification of 4s. Finally, small areas of Fill and Truncated Anthropic Soil (modified soil) were observed and classified as LUC 4s.

The non-productive land areas (e.g. mapped areas of gravelled races, ponds, extensive drains, existing dwellings, and farm infrastructure) are excluded from productive land (i.e. they are non-productive land).

Regional scale NZLRI and NZFSL map information showed 53% of the total assessment area was mapped as LUC 2w2 (poorly drained Te Rapa silt loam and peaty silt loam (Gley Soil) on flat to gently undulating slopes), 31% of the assessment area imperfectly drained Horotiu silt loam-Te Kowhai silt loam complex (Allophanic and Gley Soil) on flat to gently undulating slopes with an LUC classification of LUC 2w3, and 16% of the Site as Hamilton clay loam (Granular Soil) on rolling slopes.

Detailed on-site mapping showed discrepancies in the extent of LUC class 2, class 3 and class 4 land, drainage characteristics and slope classes across the Site.

Regional scale map information showed 84% of the Site as LUC class 2 land, however, on-site mapping showed 69% of the land as LUC class 2. Despite artificial drainage on Site there was a greater proportion land with poorer soil drainage, including 12% mapped as poorly to very poorly drained LUC 3w1, 4w1 and 4s land. These poorly to very poorly drainage class soils, often associated with low-lying areas or wet toe slope areas beneath low, but short hills, were not shown on the regional scale NZLRI map information.

Discrepancies between regional scale NZLRI delineated LUC maps and detailed field mapping within the Site were as follows (% of LUC class in each assessment area in descending order for comparative purposes):

Site – Greenhill Industrial Park:

Regional scale NZLRI-LUC: LUC class 2 - 84%
LUC class 3 – 16%

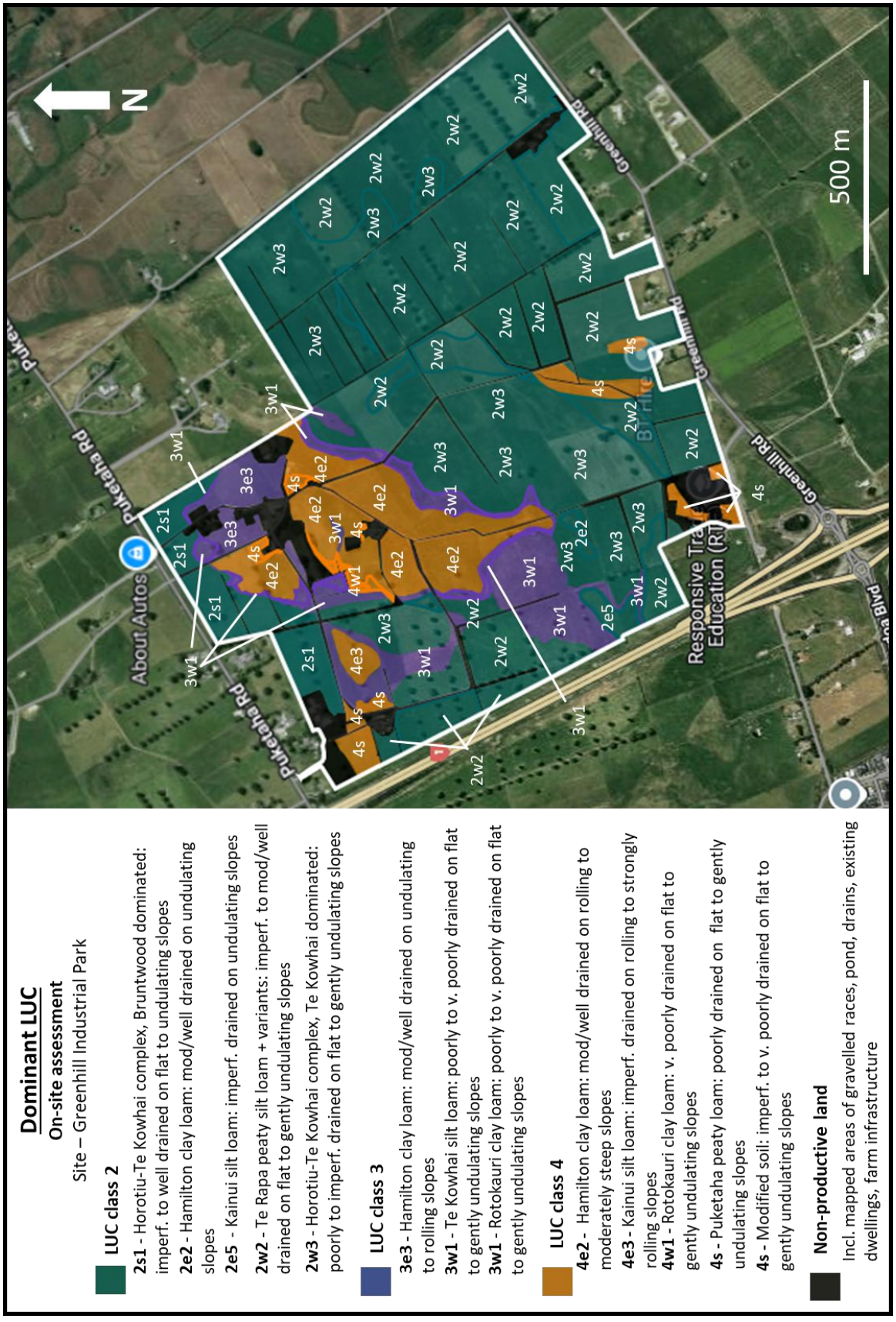
On-site LUC: LUC class 2 - 69%
LUC class 3 - 10%
LUC class 4 - 12%
NPL - 9%

Detailed on-site assessment showed 69% of the assessment area as high class soil (LUC 2s1, 2e2, 2e5, 2w2 and 2w3) under the WDP-OiP definition for high class soil. Of the balance, 22% of the Site was LUC 3e3, LUC 3w1, LUC 4e2, LUC 4e3, LUC 4w1, and LUC 4s (Puketaha), LUC 4s (modified soil), which are not high class soil. Non-productive areas (9% of the Site) including mapped areas of gravelled races, a pond, extensive drains and shelterbelts, existing dwellings, farm infrastructure, are not high class soil.

The on-site assessment identified that the central, contiguous area of lower-class and non-productive land causes fragmentation of the surrounding high class soils, reducing the Site's overall productive capacity for continuous, intensive land-based primary production over the long term.

Appendix 1: Enlarged map image from Figure 10.

Appendix 2: Enlarged map image from Figure 11.



Appendix 3: Enlarged map image from Figure 12.