Appendix A2

REPORT

Tonkin+Taylor

Drury Metropolitan Centre

Assessment of Ecological Effects

Prepared for
Kiwi Property Group Limited
Prepared by
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Table of contents

1 Introduction

This report has been prepared to inform the Drury Metropolitan Centre Plan Change on behalf of Kiwi Property Group Limited (Kiwi). Kiwi has engaged Tonkin + Taylor Limited (T+T) to prepare an assessment of ecological effects associated with the Plan Change.

The proposed Plan Change Area (pPCA) is approximately 95 ha and is located to the south of the existing Drury Local Centre and Light Industrial area on Great South Road (Figure 1.1).

The pPCA has frontage to Fitzgerald Road to the east, Brookfield Road to the south, Flanagan Road to west, and Waihoehoe Road to the north. The subject sites are primarily used for farming, with some residential activity. Kiwi currently own 52 ha of land within the pPCA as shown in blue outlined in Figure 1.1. All other properties within the wider pPCA are owned by various parties.

The overall topography of the area is undulating, with several elevated ridgelines. The western extent of the pPCA is traversed by the Hingaia Stream, which forms part of an inter-connected catchment which eventually drains into Drury Creek, an estuary of the Pahurehure Inlet and Manukau Harbour.

The pPCA is currently zoned Future Urban under the Auckland Unitary Plan (Operative in Part) (AUP). Kiwi are seeking to rezone the land to a mix of Metropolitan Centre, Mixed Use, and Open Space – Informal Recreation.

The conceptual layout of the pPCA is shown on Figure 1.1 and Figure 1.2 and includes:

- A rail/bus public transport hub adjacent to Flanagan Road and the main truck railway line at the north end of the Plan Change Area;
- A Metropolitan Centre will extend south from the transit hub. The Metropolitan Centre is likely to feature multi-storey development and a range of retail and commercial activities. Residential development is proposed above ground level in the Metropolitan Centre area;
- An open space reserve is proposed along the western boundary of the pPCA, encompassing the Hingaia Stream;
- A Hilltop Park and Valley Park are proposed to be located in areas of existing vegetation and natural features; and
- The Mixed Use Zone is proposed to occupy the bulk of the remainder of the pPCA to the east, south and northeast of the Metropolitan Centre. A range of commercial and residential activities will occupy this area.

1.1 Purpose and scope

The purpose of this report is to provide an assessment of ecological effects to accompany a private plan change application for the Drury Metropolitan Centre. The assessment includes the following:

- Characterisation of the ecological values within the pPCA;
- An assessment of ecological effects of the proposed plan change on ecological values; and
- Any recommendations to avoid, remedy or mitigate potential adverse effects.

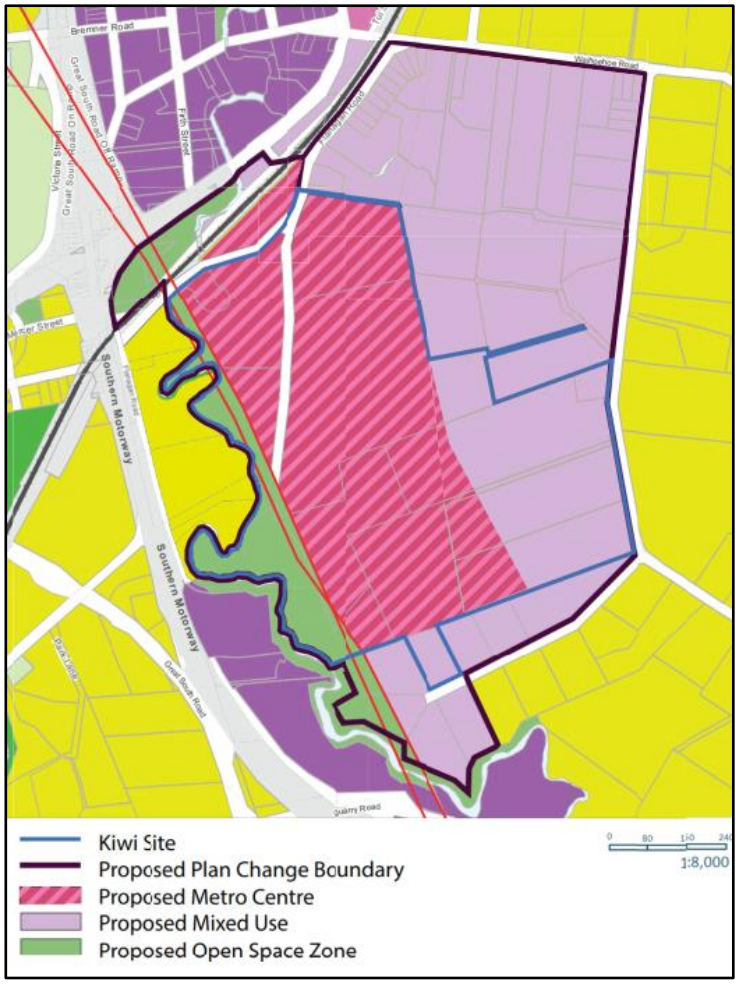

Figure 1.1: Drury Metropolitan Centre – Zoning Plan August 2019.

Figure 1.2: Indicative master plan for Drury Metropolitan Centre, showing areas of 'public realm. Source: Drury Metropolitan Centre Master Plan Report 19 July 2019, prepared by CIVITAS.

2 Methods

A combination of desktop assessments and site visits were used to determine the ecological values of freshwater and terrestrial ecosystems within the pPCA and its surrounding environs, and the significance of those values. The following sections briefly describe the methodology for assessing the ecological values of the pPCA.

2.1 Desktop assessment

A desktop assessment was undertaken to review available information and data relating to the ecological values of the pPCA. This included the following documents and databases.

- The Ecology Assessment Drury Structure Plan[1] (EADSP);
- Auckland Unitary Plan Operative in Part (AUP);
- NIWA New Zealand Freshwater Fish Database (NZFFD);
- Auckland Council Herpetofauna Database; and
- Auckland Council GeoMaps database.

2.2 Site walkover

T+T ecologists visited the site on several occasions in 2018 and early 2019. During these visits, key terrestrial and aquatic habitat features were identified across the site.

The homestead at 120 Flanagan Road was identified as a key area of native vegetation and a species list was composed for this site. Wetlands and streams were classified and their ecological value assessed.

2.2.1 Stream classification

Streams in the Auckland Region are classified as either permanent, intermittent, ephemeral, or artificial in accordance with the criteria outlined in the AUP[2].

Streams within the Kiwi landholdings were identified, mapped and classified according to these criteria in November 2018. Stream extent within the wider extent of the pPCA was estimated based on aerial photography and road side observations.

The weather during the November 2018 site visit was changeable and consisted of intermittent rain showers with overcast and sunny periods. In the 48 hours prior to the November site visit, 70 mm of rainfall was recorded at the Auckland Council Turner Road rain gauge[3].

[1] Auckland Council, 2017. Ecology Assessment Drury Structure Plan. Prepared by Eru Nathan, Auckland Council, dated 30 August 2017.

[2] Permanent river or stream is defined as "The continually flowing reaches of any river or stream".
Intermittent stream is defined as "Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria: a)it has natural pools; b)it has a well-defined channel, such that the bed and banks can be distinguished; c)it contains surface water more than 48 hours after a rain event which results in stream flow; d)rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel; e)organic debris resulting from flood can be seen on the floodplain; or f)there is evidence of substrate sorting process, including scour and deposition.
Ephemeral stream is defined as "Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream"

[3] Auckland Council GeoMaps, 2018. Rainfall data from Drury Rain @ Turner Road (N: 1786464; E: 5886543).

2.2.2 Stream ecological valuation assessment

A Stream Ecological Valuation (SEV) was carried out on a 100 m reach of 'Stream A' following the methodologies outlined in TR2011/009[4] for permanent reaches. The location of Stream A is shown in Appendix A. The Masterplan seeks to retain streams across the site, however, an SEV calculation was undertaken to understand the effects if modifications to Stream A were to occur at some point in the future.

Field data was entered into the Permanent Stream SEV calculator to derive SEV scores for the sampled reach. A macroinvertebrate sample was collected however has not been included within the SEV scores as it isn't required for modelling purposes. Fishing was not undertaken within the SEV reach.

2.3 Assessment of effects

The method applied to this assessment of ecological effects broadly follows the Ecological Impact Assessment Guidelines (EcIAG) (EIANZ, 2018). Using a standard framework and matrix approach such as this provides a consistent and transparent assessment of effects.

The framework for assessment provides structure to quantify the level of ecological effects but needs to incorporate sound ecological judgement to be meaningful. Deviations or adaptions from the methodology are identified within each of the following sections as appropriate.

Outlined in the following sections, the guidelines have been used to ascertain the following:

- The level of ecological value of the environment;
- The magnitude of ecological effect from the proposed activity on the environment; and
- The overall level of effect to determine if mitigation is required.

Further detail regarding these guidelines and the scale used is included in Appendix B.

3 Ecological values

3.1 Catchment description

The Hingaia Stream catchment is approximately 5490 km^2 with its headwater tributaries located within the Hunua Ranges. The main stem of the Hingaia Stream meanders from south to the north, through undulating agricultural and horticultural land before discharging to Drury Creek and the upper Pahurehure Inlet in the Manukau Harbour. The pPCA that this assessment of effects relates to is the lower Hingaia Stream catchment, to the south of Drury (Appendix A).

Historical and current agricultural and horticultural landuse practices have resulted in a range of impacts within the wider catchment. These impacts include stream channel straightening, native vegetation removal, habitat fragmentation and installation of in stream structures (e.g. culverts). Although the Hingaia Stream catchment is heavily modified the upper reaches of the main tributaries maintain some natural habitats, particularly where remnant native vegetation and forest fragments are present at the edge of the Hunua ranges.

The Hingaia Stream remains an important link between the marine environment and an array of freshwater ecosystems located within the upper catchment. These links provide important migration

[4] Storey, R. G., Neale, M. W., Rowe, D. K., Collier, K. J., Hatton, C., Joy, M. K., Maxted, J. R., Moore, S., Parkyn, S. M., Phillips, N. and Quinn, J.M. 2011: Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

pathways for diadromous native fish species and provides for the movement of water, sediment and organics downstream to the marine environment.

3.2 Freshwater ecological values

Across the pPCA, permanent and intermittent stream tributaries of the Hingaia Stream were identified as well as two seepage wetlands (Appendix A). Intermittent and permanent watercourses (including wetlands) are subject to the provisions of Chapter 3 of the AUP.

Historical agricultural and horticultural land use has resulted in the modification and degradation of many of the tributaries of Hingaia Stream. All watercourses within the pPCA showed habitat modifications that are typical of a rural environment.

A description and evaluation of ecological value for each watercourse is provided below and a series of photographs is available in Appendix C.

3.2.1 Hingaia stream

The Hingaia Stream meanders along the entirety of the western boundary of the pPCA (Appendix B: Figure 2), before flowing for approximately 1 km to its confluence with Drury Creek.

Large run and pools sections were dominant along the Hingaia Stream. At the downstream end where the road and rail intersect the stream, a run-riffle sequence was present. Cascade sequences become apparent along the length of the stream when flows are low.

The meandering nature of the stream has resulted in a substrate primarily made up of soft silts, with areas of bedrock forming cascades and providing some instream heterogeneity. Areas of macrophyte growth including oxygen weed (*Lagarosiphon* sp.) and willow weed (*Persicaria* sp.) were observed.

Riparian vegetation on the true left bank comprised primarily exotic weed tree species. The true right bank (within Kiwi landholdings) was fenced along its length and vegetation comprised rank pasture grasses and occasional exotic trees. Outside of the fenced areas, the riparian vegetation was limited to grazed pasture.

The stream banks were typically incised and bank erosion was present throughout the reach. Erosion has likely been exacerbated due to the loss of mature riparian vegetation that would help with binding soils along the margins.

The lower Hingaia Stream (in the vicinity of the pPCA) is typical of soft-bottom lowland river systems that have undergone periods of extensive historic habitat modification. Due to its close proximity to the marine environment, the Hingaia Stream remains an important waterway that contributes to biological processes within the downstream marine environments.

3.2.2 Stream A

Stream A comprises intermittent and permanent stream reaches of approximately 400 m length. It emerges in a paddock, via a series of small intermittent tributaries, before becoming a permanent channel which flows south to north to the Fitzgerald Stream (river 438401[5]) before discharging under Flanagan Road to the Hingaia Stream (Appendix A).

An SEV assessment was undertaken on the middle reaches of Stream A to assist in determining its ecological value. The assessed reach comprised a defined permanently flowing channel with an average width of 1.2 m. The stream reach had unrestricted stock access that has resulted in poor bank stability, slumping, pugging and channel degradation. Riparian vegetation was absent, with

[5] River number derived from Auckland Council GeoMaps (19/02/2019).

grazed grass to the stream edge and only limited shading of the stream channel by a shelterbelt of large non-native trees.

The instream habitat was characterised by a lack of pools and a relatively deep/straight channel with a silt and sand dominated substrate. Patches of leaf litter, woody debris, emergent macrophytes and riparian roots were common. In the lower reaches, emergent macrophytes smothered the channel, likely due to a complete lack of shade and ongoing nutrient inputs from agricultural landuse.

An SEV value of 0.55[6] was recorded at this site, indicating a moderate current ecological function and typical of rural streams[4].

The agricultural land use (both historic and current) has resulted in the modification and degradation of Stream A. The stream was characterised by unrestricted stock access, limited shading and low instream habitat diversity, which is typical of many small tributaries within the wider Hingaia Stream catchment. The SEV value obtained at this site is considered to be representative of other shorter tributaries across the pPCA, such as Stream B and C.

3.2.3 Streams B, C and D

Stream B is approximately 120 m in length and comprises intermittent and permanent stream reaches. Encroachment of weeds into the channel has resulted in a wetland typology in the upper reaches, which is likely exacerbated by the absence of a riparian margin. The entire area is fenced and there is no stock access to stream channel. A culvert is present in the lower 20 m of the reach.

Stream C is an intermittent stream approximately 40 m long, which has been straightened along a fence line. The stream appears to be spring fed. While the stream lacks a riparian margin, it is fenced and some shading is provided in the upper reach.

Stream D is a remnant channel of the Hingaia Stream that is no longer connected to the main channel. As identified within the Heritage Report[7], the course of the Hingaia Stream was modified in approximately 1969. At this time, the meander (that is currently identified as 'Stream C') was cut off and the Hingaia Stream was straightened. Boffa Miskell[8] determined that this watercourse was an isolated depression that was separate from the main Hingaia Stream.

At the time of T+Ts assessment, some water was present within the depression however there was no clear source or outlet for the water. Due to its historic modification and lack of connection to the Hingaia Stream, Stream C is considered to be a remnant channel, and not a 'river or stream' under the definitions of the AUP.

3.2.4 Streams E, F, G

Streams E, F and G are on the Fitzgerald Stream outside of Kiwi landholdings but within the pPCA. These streams were not walked, however they were observed from a distance and their presence assessed from aerial imagery. Photographs of these streams are included in Appendix C.

Stream E (hereafter Fitzgerald Stream) has a substantial catchment to the east, with areas of significant ecological value in the headwaters (as determined by the AUP). The catchment is typical of those in the area, having been subject to modification resulting from agricultural and horticultural landuse. Within the pPCA Fitzgerald Stream has been modified, with evidence of straightening and unnatural meanders. Riparian vegetation is predominantly grass, with isolated pockets of woody

[6] Invertebrate and fish fauna are functions of the SEV method which are excluded from the overall SEV score.
[7] Clough & Associates Ltd (2019), Drury Town Centre: Plan Change for Drury Future Urban Zoned Land (Centre and Surrounds) Heritage Assessment.
[8] Boffa Miskell Limited 2017. Kiwi Drury - Ecology: Master Plan Ecology Values, Constraints & Opportunities. Report prepared by Boffa Miskell Limited for Kiwi Property Trust Limited.

vegetation along the immediate stream edge. A perched culvert at Fitzgerald Road forms a barrier to fish passage.

Streams F and G are tributaries of Fitzgerald Stream and are likely to be intermittent. Both are unfenced and unshaded streams, with excessive macrophyte growth. Unrestricted stock access is likely to have caused damage to the stream banks and exacerbated nutrients entering the stream. Both Stream F and G are expected to have similar ecological values as Stream A.

3.2.5 Wetlands

Two seepage wetlands were identified in depressions on the true right margin of the Hingaia Stream (Appendix A). Wetland 1 encompasses an area of approximately 150 m^2 and is currently unfenced allowing unrestricted stock access to the entire wetland area. Wetland 2 is approximately 1,000 m^2. The upper section is unfenced with riparian vegetation consisting of grazed pasture grasses and sporadic gorse. The lower section of Wetland 2 is located alongside the Hingaia Stream edge and is fenced with Willow sp (*Salix spp.*) present.

Both wetlands are degraded with stock only excluded from a portion of Wetland 2. Weed species such as willow trees (*Salix* sp.) and gorse (*Ulex europaeus*) have colonised the wetland area and stock trampling and pugging has reduced the colonisation of native wetland plants.

As stated within the EADSP, virtually all original wetlands within the wider area have been drained or infilled for other uses. Although the wetland habitats within Kiwi landholdings are degraded, as these are underrepresented in the wider catchment it is considered they are providing some ecological value, albeit at a currently low level. Refer to Appendix C for photographs.

3.2.6 Native fish

A desktop review of the Hingaia Stream catchment was carried out using the NZFFD. There are no NZFFD records within the pPCA, however the records show that a range of native fish are present within the wider Hingaia Stream catchment. In total eight native species have been identified of which one is classified as 'Threatened –Nationally Vulnerable' and three are classified as 'At risk – Declining' by Dunn *et al* (2017)[9] (Table 3.1).

It is likely the species identified in the wider Hingaia Stream catchment will inhabit the lower Hingaia Stream itself and those species tolerant of habitats influenced by agricultural degradation may be present in the tributaries located on the Kiwi landholdings (e.g. Stream A).

Diadromous migration is an important life history trait of many of the species that were identified within the Hingaia Stream catchment. Fish species that undertake diadromous migration must undertake a period of time at sea to complete their life cycle. The occurrence of diadromy within the Hingaia Stream catchment shows that the connection between marine habitats and upstream freshwater habitats is vital for these species. Likewise, it is important to highlight that as fish are highly mobile, migration between freshwater habitats will occur during most of the year and not just at key migration times. The presence of the aforementioned threatened and at-risk species within the Hingaia Stream catchment identifies that maintaining and/ or improving instream habitat health and connectivity to higher quality upstream habitats is an important priority.

A range of farm crossings and structures (e.g. culverts) were identified within the pPCA, including several within Stream A and at Fitzgerald Road. These structures have been designed with the focus primarily on hydraulic conveyance rather than habitat connectivity. Further fish passage issues are likely to have been exacerbated by their lack of maintenance. As such it is likely that these structures

[9] Dunn, N.R., Allibone, R.M., Closs, G.P., Crow, S.K., David, B.O., Goodman, J.M., Griffiths, M., Jack, D.C., Ling, N., Waters, J.M., and Rolfe, J.R. 2017. Conservation status of New Zealand freshwater fishes New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 p

present a partial or complete barrier to fish passage. Existing barriers to fish passage can be removed or remediated to improve passage to stream areas proposed to be enhanced.

Table 3.1: Fish species present within the Hingaia Stream Catchment (source: NZFFD).

Species	Common Name	Threat Status	Diadromous
Anguilla australis	Shortfin eel	Not threatened	Y
Anguilla dieffenbachii	Longfin eel	At risk – Declining	Y
Anguilla spp.	Unidentified eel		Y
Cheimarrichthys fosteri	Torrentfish	At risk – Declining	Y
Galaxias fasciatus	Banded kokopu	Not threatened	Y
Galaxias maculatus	Inanga	At risk – Declining	Y
Geotria australis	Lamprey	Threatened - Nationally vulnerable	Y
Gobiomorphus cotidianus	Common bully	Not threatened	N*
Gobiomorphus huttoni	Redfin bully	Not threatened	Y
Gobiomorphus spp.	Unidentified bully		
Retropinna retropinna	Common smelt	Not threatened	Y
Gambusia affinis	Gambusia	Non-native	N
Ctenopharyngodon idella	Grass carp	Non-native	N
Cyprinus carpio	Koi carp	Non-native	N
Hypophthalmichthys molitrix	Silver carp	Non-native	N
Scardinius erythrophthalmus	Rudd	Non-native	N
Invertebrates present within the Hingaia Stream catchment			
Hyridella menziesi	Freshwater mussel	Declining	
Paranephrops spp.	Koura	Not threatened	
Paratya curvirostris	Freshwater shrimp	Not threatened	

Note: Sea-going populations occur in river and streams near to the coast.

3.3 Terrestrial ecology values

3.3.1 Vegetation

Vegetation within the pPCA is predominantly grazed pasture grasses. Exotic trees have been planted to create shelter belts or to form ornamental and amenity gardens. A non-exhaustive list of species observed is included in Table 3.2 and areas of predominantly native vegetation are shown in Appendix A.

A cluster of mature native and exotic canopy trees with a well-developed understory has been identified within 120 Flanagan Road, Drury ('Homestead Park') (Figure 1.2). Some native trees are also present adjacent to the remnant channel referred to as Stream D.

Historical landuse changes from forest cover to intensive agriculture have severely degraded the landscape. The pPCA is still actively farmed and few remnant native plants are present. Riparian cover along the Hingaia Stream is discontinuous and comprises predominantly weed species.

The site itself is not listed as a Significant Ecological Area (SEA) under the AUP however it is situated between mosaics of SEAs; namely a large marine SEA to the west and a terrestrial SEA to the east.

Table 3.2: Plant species observed within the pPCA (not exhaustive).

Exotic		Native	
Common name	**Scientific name**	**Common name**	**Scientific name**
		Titoki	*Alectryon excelsus*
Yucca	*Yucca* sp.	nīkau	*Rhopalostylis sapida*
Bromeliads		Puka	*Meryta sinclairii*
Elms	*Ulmus* sp.	Pōhutukawa	*Metrosideros excelsa*
Fan palm		Karaka	*Corynocarpus laevigatus*
Gingko		Puriri	*Vitex lucens*
Cypress	*Cupressus* sp.	Muehlenbeckia	*Muehlenbeckia* sp.
Camelia		Kowhai	*Sophora* sp.
Phoenix palm	*Phoenix canariensis*	Karo	*Pittosporum crassifolium*
Bottle brush tree	*Callistemon* sp.	Red mapou	*Myrsine australis*
African love grass	*Eragrostis curvula*		
Grapefruit tree			
Woolly nightshade	*Solanum mauritianum*		
Willow	*Salix* sp.		
Norfolk pine	*Araucaria heterophylla*		

3.3.2 Terrestrial fauna

At a local and/or landscape-level shelter belts and remnant trees present across the site have the potential to provide habitat, refugia, food source, flight path connectivity for native avifauna, bat, and lizard populations. The pPCA also supports a large array of common non-native bird species.

A known population of threatened long-tailed bats (*Chalinolobus tuberculatus*) is located in the Hunua Ranges. Shelter belts are likely to support bat foraging and movement pathways across site. Mature specimen trees (exotic and native) observed within Homestead Park and distributed throughout the site can also act as roost trees (i.e. mature puriri trees with abundant crevices).

Lizard habitat is likely to be restricted to areas outside of heavily grazed pastures and any low lying areas that are regularly inundated by during rain events. Lizard habitat is expected to include rank pasture grasses and any refuge habitat that may exist in tree fell areas and farming debris.

3.4 Marine ecology values

The streams within the site discharge to the Pahurehure Inlet of the Drury Creek approximately 1 km downstream. The intertidal marine areas of the Drury Creek are recognised as significant ecological areas.

The upper tidal reaches of Drury Creek are identified as an SEA (M1-29b) due to the value of the habitat present, comprising a variety of marshes, grading from mangroves through to extensive areas of jointed rush-dominated saltmarsh, to freshwater vegetation in response to salinity changes. This area is identified as a valuable migration pathway for a number of different species of native freshwater fish.

The more intertidal and estuarine reaches (M2-29a) are comprised of a variety of intertidal habitats ranging from sandy mud intertidal flats, to tidally-exposed rocky reefs and a variety of saline

vegetation. Areas of mangroves grow in the Whangamaire Stream, and Drury and Whangapouri Creeks. Notable eel grass (*Zostera*) beds are present in the southern half of the Whangapouri Creek.

Drury Creek is comprised of a variety of intertidal habitats ranging from sandy mud intertidal flats to current-exposed rocky reefs and a variety of saline vegetation. Wading bird roosting habitats are present, including an important area for pied stilt.

Due to the depositional nature of this area, it is sensitive to sedimentation and contaminants transported from the wider catchment.

3.5 Summary of ecological values

In summary, the ecological values of the pPCA are of low to moderate overall value, consistent with typical agricultural landuse.

The intermittent and permanent watercourses and wetlands present have moderate to low current ecological value, but have the potential to be enhanced, particularly the small tributaries. The Hingaia Stream adjacent to the site provides connectivity to the wider catchment and is an important migratory pathway for native fish, including threatened and at risk species.

Terrestrial vegetation of low to moderate value is located within isolated pockets across the site, with the area of highest value located in the future Homestead Park. The marine environment downstream of the pPCA is an SEA and sensitive to changes in upstream landuse.

4 Assessment of ecological effects

A change from rural to urban land use poses a range of potential effects to the ecological values that have been identified within the pPCA. This section provides an assessment of the ecological effects of the proposed plan change and future development of the site. The assessment is based on the indicative master plan shown in Figure 1.2 which will be further refined. A summary of the activities and the relative affects according to the EcIAG is provided in Section 4.5.

4.1 Earthworks and sediment discharges

Earthworks activities associated with the land use change, including any works in watercourses, have the potential to result in an uncontrolled discharge of sediment laden water. Increased sediment in the receiving environment can impact water quality within the freshwater and marine environment and result in sediment deposition, changing habitat features. Further, modifications to landforms through earthworks can result in changes to contributing catchments.

A cut to fill balance is proposed to be achieved on site and will be managed through minimal modification to the natural topography. It is the intention that the landforms remain much the same, with no changes to contributing catchments proposed.

The Hingaia Stream and the Drury Creek are both sensitive to sediment deposition, particularly the marine environment which is an SEA. Implementation of an erosion and sediment control plan that is designed and maintained in accordance with Auckland Council GD05 - Guidance for Erosion and Sediment Control[10] will reduce the potential for an uncontrolled discharge of sediment laden water to the environment and this can be addressed as part of a future resource consent process in accordance with the Unitary Plan earthworks provisions.

[10] Leersnyder, H., Bunting, K., Parsonson, M., and Stewart, C. (2016). Erosion and sediment control guide for land disturbing activities in the Auckland region. Auckland Council Guideline Document GD2016/005. Incorporating amendment 1. Prepared by Beca Ltd and SouthernSkies Environmental for Auckland Council.

4.2 Water quality and quantity

Under the current landuse, the hydrological cycle occurs in a relatively unmodified state and water is filtered through the soil or grassed paddocks prior to entering streams. The proposed change to urban landuse will result in an increase in impervious surfaces across the site and will change the quality and quantity of water entering the receiving environment.

The streams within the pPCA including the Hingaia Stream are subject to degraded water quality resulting from agricultural landuse and a lack of riparian buffers and unrestricted stock access. The streams exhibit abundant macrohpyte growth which is an indicator of nutrient enrichment.

The proposed urban landuse will change the type of contaminants entering the stream environment, with an expected reduction in nutrients and increase in heavy metals and hydrocarbons associated with impervious surfaces. These contaminants can impact aquatic flora and fauna and the way that streams function as a whole.

Auckland Council GD01 provides guidance on applying a water sensitive urban design (WSUD) approach to treating urban stormwater runoff[11]. This includes using devices such as swales, rain garden, tree pits and permeable paving to treat stormwater prior to it entering the receiving environment[12]. This approach is proposed to be applied across the pPCA to minimise the potential for contaminants to enter the environment. Contaminant specific treatment is proposed for high contaminant generating areas such as roads and car parking.

An additional potential impact from the proposed landuse change, specifically increased impervious surfaces, is increased temperatures[13]. Elevated temperatures within the receiving environment can have acute effects on fauna. Streams across the site are currently subject to elevated temperatures due to lack of shading. The proposed riparian planting adjacent to streams across the site will work to reduce potential temperature increases in stream. Stormwater treatment in ponds can further increase water temperature, so WSUD approaches are proposed to minimise this potential effect.

Increased impervious surfaces also have the potential to change the volume of and rate at which stormwater enters the receiving environment. High velocity flows can cause stream erosion and scour, which contributes to bank instability and sediment deposition. Use of detention and retention of stormwater across the site is the best practice approach to stormwater management and reduces the potential for these effects to occur.

4.3 Stream and wetland habitat loss

Auckland Council has identified that intermittent and permanent streams and wetlands are important and subsequently they are protected under the AUP (Chapter E3). Changes in landuse often results in the loss of streams to enable efficient use of land and maximum yield.

There are several streams and wetlands across the pPCA including some within the centre of the site. Kiwi recognises the importance of these ecosystems within the pPCA and as such, impacts to stream and wetland ecosystems will be avoided and minimised wherever possible.

Hingaia Stream and the stream tributaries along the true right bank will be retained and enhanced. Retained streams and wetlands across the site will be planted to have riparian margins of no less

[11] Cunningham, A., Colibaba, A., Hellberg, B., Silyn Roberts, G., Simcock, R., S. Speed, Vigar, N and Woortman, W (2017) Stormwater management devices in the Auckland region. Auckland Council guideline document, GD2017/001.
[12] Tonkin & Taylor Ltd (2019). Drury Metropoltican Centre Stormwater Management Plan. Prepared for Kiwi Property Trust Ltd.
[13] Young D, Afoa E, Meijer K, Wagenhoff A, Utech C (2013). Temperature as a contaminant in streams in the Auckland region, stormwater issues and management options. Prepared by Morphum Environmental Ltd for Auckland Council. Auckland Council technical report, TR2013/044.

than 10 m on smaller streams and 20 m on the main channels of the Hingaia Stream and Fitzgerald Stream.

An Enhancement Plan will be developed prior to landuse consents being sought which incorporates ecological enhancement with amenity and recreational use. This approach will see the landuse change associated with the pPCA is aligned with policies of the AUP and EADSP.

The historically diverted section of the lower Hingaia Stream (i.e. Stream D) is expected to be reclaimed. The remnant channel does not appear to have connectivity to the Hingaia Stream and the effects of its isolation from the main channel will have been addressed in the 1960's when the diversion occurred. The channel is not a 'river or stream' as defined under the AUP and as such, the provisions of E3 do not apply and any further assessment of effects is not considered to be necessary.

While the intention is to retain and enhance aquatic habitats within the pPCA, it may be necessary to modify some stream or wetland to enable land development. Impacts to stream or wetland habitat may require resource consents and further consideration of effects at the time of consenting. The following provides some guidance as to the potential options to address effects.

Where practicable, bridges will be constructed for stream crossings. Culverts of less than 30 m in length and that meet other criteria are a permitted activity in the AUP. In the event that the permitted activity criteria cannot be met and to address potential future stream loss requirements, an assessment of the potential effects of stream loss, which would be subject to resource consent has been provided. An assessment of stream culverting and stream reclamation has been undertaken.

Any culverts required will be designed and constructed in accordance with best practice guidelines, for instance, the New Zealand Fish Passage Guidelines[14]. Existing culverts which are barriers to passage will be removed or remediated.

It is not possible to remediate or mitigate stream reclamation at the point of impact. To 'mitigate' means to alleviate, or moderate the severity of something[15] which is not possible in relation to stream reclamation as there is a complete and permanent loss of habitat.

While stream and wetland reclamation cannot be mitigated, it can be offset. Offsetting is 'a measurable conservation outcome resulting from actions designed to compensate for residual adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied'[15]. To be considered an offset, the conservation outcomes resulting should be consistent with a set of offsetting principles, including the goal of 'no net loss'.

At this stage, the final extent of stream or wetland impact is unknown and will not be known until the master plan design is finalised.

Wetland offset, if required, should be determined based on enhancement measures proposed and will be based around infill and riparian margin planting on site.

In terms of any stream offset required, riparian planting or creation of new stream habitat, through diversion for example, could also contribute to an offset package.

While the potential effects and offset requirements have not been quantified in this assessment, we consider that the identified activities should be considered at the time of consenting as part of an offset package and not part of the plan change requirements. That is, the enhancement should be

[14] Franklin, P, Gee, E, Baker, C, and Bowie S. (2018). New Zealand Fish Passage Guidelines for structures up to 4 metres. Prepared by NIWA. Client Report 2018019HN.
[15] Maseyk, F, Ussher, G, Kessels, G, Christensen, M, and Brown, M (2018). Biodiversity offsetting under the Resource Management Act – A guidance document September 2018.

considered to benefit the stream and wetland habitat to address those potential effects, and not to address effects of the plan change itself.

In respect of the wider principles of offsetting (outlined in AUP Policy E3.3(4)), the offset works within the site would be on aquatic habitats streams that are like for like and proximate to the impact.

A resource consent for streamworks would be required to be sought, however the effects of the potential habitat loss could be addressed by the enhancement activities outlined within this proposal. Any impacts beyond those anticipated by this assessment would need to be considered separately and may require additional offset works to be undertaken outside of the pPCA.

4.4 Impacts on terrestrial flora and fauna

Current landuse across the pPCA has resulted in an almost complete removal of native vegetation and there are no areas of ecological significance. Current vegetation consists of grazed and rank pasture grasses and exotic trees which form shelter belts or planted ornamental/amenity gardens.

The proposed plan change and site works will result in some additional loss of vegetation particularly through the removal of shelter belt vegetation (predominantly mature exotics) to facilitate land development. Vegetation loss will be kept to a minimum and will be avoided where possible. Of note, planted native vegetation adjacent to the homestead is intended to be retained where practicable.

Removal of vegetation has the potential to adversely affect terrestrial fauna. Potential direct effects to both avifauna and herpetofauna have been identified as damage to nests, associated eggs, fledglings, and loss of individuals killed during vegetation removal, construction, and earthworks.

The implementation of a Fauna Management Plan is recommended at the time of resource consenting for future works to manage potential impacts on terrestrial fauna. Where practicable remnant native vegetation or large exotic trees within the pPCA will be retained, to minimise effects on terrestrial fauna.

Potential indirect effects of vegetation removal include loss of habitat and food resources (particularly from mature trees), and general disturbance during construction and development. It is considered the effects will be mitigated through enhancement planting across the pPCA particularly along the Hingaia Stream which will create high quality habitat, migratory corridors and see an overall increase in native food resources for terrestrial fauna. An Enhancement Plan will be developed prior to landuse consents being sought which incorporates ecological enhancement with amenity and recreational use.

Overall it is considered that the effects of the landuse change on terrestrial flora and fauna is low.

4.5 Summary of effects

Table 4.1 provides a summary of each of the above activities in general accordance with the EcIA guidelines, drawing on the information presented in the above sections. For each activity, the relevant ecological values, magnitude of effect after mitigation and the overall level of effect are provided. Refer to Appendix B for interpretation of this assessment.

The overall level of effect has not been translated into statutory language (i.e. more than or less than minor), however the guidance in Appendix B can assist with this interpretation.

Table 4.1: Overall level of ecological effect after mitigation measures are implemented.

Activity	Ecological value of affected environment	Magnitude of effect – with mitigation measures	Overall level of effect
Earthworks and sediment	Freshwater environment – **moderate** in tributaries, **high** in Hingaia due to presence of threatened fish, its value for migration, sensitivity of banded kokopu to sediment and SEV values within tributary streams. Marine environment – **high**, due to status as SEA and depositional nature of catchment	**Low** If erosion and sediment control measures are implemented in accordance with GD05.	**Low**
Water quality and quantity	Freshwater environment – **moderate** in tributaries, **high** in Hingaia (as above). Marine environment – **high**, (as above)	**Low** If water sensitive urban design approach applied across site in keeping with recommendations of the Stormwater Management Plan and GD01.	**Low**
Stream habitat loss	Freshwater environment – **moderate** in tributaries.	**Low** if bridges or culverts consistent with permitted activity standards and fish passage guidance implemented. **Very High** if reclamation, but expect effects can be offset onsite (positive effect).	**Low** to **High** Offset contributes a positive effect, but does not reduce the overall effect if the activity is reclamation.
Terrestrial vegetation and fauna	**Low** to **moderate**	**Low** Enhancement of wider site with vegetation and habitat corridors along Hingaia Stream and Fitzgerald Stream.	**Low**

5 AUP: OP objectives and policies

This section summarises the key chapters of the AUP which provide direction for stormwater management, streams and wetlands and vegetation. Chapter B also provides higher level regional policy level direction.

Chapters E1, E8 and E9 of the AUP outline the policies and objectives in respect to the management of stormwater, including specific provisions regarding high contaminant generating areas and macroinvertebrate indices.

Chapter E3 of the AUP outlines the policies and objectives in regards to lakes, rivers, streams and wetlands. The AUP directs that permanent loss of rivers or streams is minimised and that significant modification or diversion of streams and rivers is avoided. The AUP also recognises that a balance must be struck between the need to provide for infrastructure and the protection of rivers and streams.

Chapter E15 provides direction to the objectives and policies regarding vegetation management in the Auckland region. The AUP identifies that vegetation contributes to a range of ecosystem services such as erosion and sediment control, reducing stormwater flows, protecting or enhancing water quality, amenity and natural character values, and mitigating natural hazards. In areas such as this, where ecological values are degraded, indigenous biodiversity should be restored and enhanced, while also providing for appropriate development.

6 Conclusion

The Drury Metropolitan Centre pPCA will result in rural land being rezoned to enable the development of a town centre and associated residential properties.

The ecological values of the site are consistent with those anticipated within rural landuse. Vegetation across the area is limited to exotic shelterbelts or planted ornamental gardens, where some native trees are present. Streams within the pPCA area are degraded resulting from unrestricted stock access, lack of riparian margins and degraded water quality associated with agricultural landuse. The Hingaia Stream is located on the western boundary of the pPCA and lacks riparian margins of any significance, however, it is an important watercourse with connectivity to significant ecological areas in its headwaters. The ultimate receiving environment is the Drury Creek which is a marine SEA, important for its intertidal bird habitat.

The proposed landuse change has the potential to impact the remaining ecological values of the site through sedimentation, increased impervious surface resulting in changes to water quality and quantity, stream habitat loss and vegetation removal.

Through the implementation of appropriate sediment and erosion controls across the site, the potential for sedimentation effects is reduced and measures will be in accordance with best practice methods.

Water sensitive urban design principles will be applied for all stormwater management which will result in potential effects of stormwater on the receiving being minimised. A level of water quality treatment will be applied which will result in a reduction in nutrients under the current scenario and a change to high level treatment of urban contaminants.

Stream and wetland habitat loss will be minimised across the site. A remnant channel (Stream D) of currently low ecological value will be reclaimed It is considered that Stream D is not a ‘river or stream’ and is therefore not subject to the provisions of the AUP. Where stream modification may be required in the future for road crossings or to enable development, enhancement of aquatic habitat within the site could contribute to an offset package to achieve no net loss of ecological function onsite.

Vegetation removal will be limited to shelterbelts, small areas of native vegetation and some planted trees within the homestead. These areas of vegetation may provide limited habitat value to fauna and a fauna management plan should be prepared at time of consenting to address potential effects.

An Enhancement Plan will be developed prior to landuse consents being sought which incorporates ecological enhancement with amenity and recreational use. Fauna Management Plans will also be prepared prior to works commencing to address potential effects on fauna.

The AUP includes a comprehensive set of rules relating to identified features (for example E1 for stormwater, E3 for streams and E15 for vegetation). These are considered to be appropriate to address the potential for adverse effects in the same way they already apply to the area's Future Urban Zone. From an ecological perspective, these rules are appropriate to address relevant effects that may be generated at the time of resource consent.

Overall, it is considered that the potential effects of the change in landuse and the development of the Drury Metropolitan Centre can be avoided, minimised, mitigated or offset and as such, the overall level of effects is low.

7 Applicability

This report has been prepared for the exclusive use of our client Kiwi Property Group Limited, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Report prepared by:	Authorised for Tonkin & Taylor Ltd by:
	
.....	.....
Justine Quinn	Tim Fisher
Senior Freshwater Scientist	Project Director

Technical review: Josh Markham, Senior Ecologist.

JQU
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Appendix A: Site Map

Path: T:\Tauranga\Projects\1003297\1003297.1000\WorkingMaterial\GIS\MapDocuments\1003297.1000_FIG001.mxd Date: 28/03/2019 Time: 11:06:39 AM

LEGEND

Streams

- Permanent
- Intermittent
- Indicative
- Potential Watercourse
- Suspected Pipe
- Catchment Overland Flowpath
- Wetland
- RiparianBufferAroundStreams20m
- Ornamental and Native Trees
- Kiwi Site
- Proposed Plan Change Boundary

Northern KPL Development Area
Stream E
(Fitzgerald Stream)
Stream A
Stream F
Stream G
State Highway 22
Stream D
Wetland 2
Wetland 1
Hingaia Stream
Auckland-Hamilton Motorway State Highway 1
Stream C
Southern KPL Development Area
Fitzgerald Road
Stream B
Brookfield Road
Location Plan

Notes: Aerial photograph sourced from Auckland Council and licensed for re-use under the Creative Commons Attribution 3.0 New Zealand licence.

A3 SCALE 1:5,000

0 60 120 180 240 300 (m)

N

Tonkin+Taylor
105 Carlton Gore Rd, Newmarket, Auckland
www.tonkintaylor.co.nz

DRAWN	DXLR	Mar.19
CHECKED		
APPROVED		
ARCFILE	1003297.1000_FIG001.mxd	
SCALE (AT A3 SIZE)	1:5,000	
PROJECT No.	1003297.1000	

KIWI PROPERTY LIMITED
DRURY METROPOLITAN CENTRE
Ecological Considerations
Stream extent and ecological features

FIGURE No. Figure 1.
Rev. 0

Appendix B: Ecological Impact Assessment Guidelines

Appendix B Table 1: Factors to consider in scoring sites values in relation to species representativeness, rarity, diversity and pattern, and ecological context (adapted from EIANZ, 2018).

Value	Species Values	Vegetation/Habitat Values
Very High	Nationally Threatened - Endangered, Critical or Vulnerable.	Supporting more than one national priority type. Nationally Threatened species found or likely to occur there, either permanently or occasionally.
High	Nationally At Risk - Declining,	Supporting one national priority type or naturally uncommon ecosystem and/or a designated significant ecological area in a regional or district Plan. At Risk - Declining species found or likely to occur there, either permanently or occasionally.
Moderate-high	Nationally At Risk - Recovering, Relict or Naturally Uncommon.	A site that meets ecological significance criteria as set out the relevant regional or district policies and plans.
Moderate	Not Nationally Threatened or At Risk, but locally uncommon or rare	A site that does not meet ecological significance criteria but that contributes to local ecosystem services (e.g. water quality or erosion control).
Low	Not Threatened Nationally, common locally	Nationally or locally common with a low or negligible contribution to local ecosystem services.

Appendix B Table 2: Summary of the criteria for describing the magnitude of effect (adapted from EIANZ, 2018).

Magnitude	Description
Very High	Total loss or very major alteration to key elements or features of the existing baseline conditions; Loss of high proportion of the known population or range of the element/feature.
High	Major loss or alteration to one or more key elements of existing baseline conditions; Loss of high proportion of the known population or range of the element/feature.
Moderate	Loss or alteration to one or more key elements of existing baseline conditions; Loss of a moderate proportion of the known population or range of the element/feature.
Low	Minor shift away from existing baseline conditions; Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development; Having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from the existing baseline physical or chemical conditions; change barely distinguishable from the 'no change' scenario; Having negligible effect on the known population or range of the element/feature.

Appendix B Table 3: Criteria for describing overall levels of ecological effects (adapted from EIANZ, 2018).

Level of effect	Ecological Value				
	Very high	**High**	**Moderate**	**Low**	**Negligible**
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

Appendix B Table 4: Interpretation of assessed ecological effects against standard RMA terms.

Level of Ecological Effect (refer Table E3)	RMA Interpretation	Description
Very high	Unacceptable adverse effects	Extensive adverse effects that cannot be avoided, remedied or mitigated.
High	Significant adverse effects that could be remedied or mitigated	Adverse effects that are noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.
Moderate	More than minor adverse effects	Adverse effects that are noticeable and may cause an adverse impact on the environment, but could be potentially mitigated or remedied.
Low	Minor adverse effects	Adverse effects that are noticeable but that will not cause any significant adverse impacts.
Very low	Less than minor adverse effects	Adverse effects that are discernible day to day effects but which are too small to adversely affect the environment.
Nil	Nil effects	No effects at all.

Appendix C: Site photographs

Photograph Appendix C.1: Stream B, with some wetland characteristics

Photograph Appendix C.2: Stream C.

Photograph Appendix C.3: River 438401 immediately upstream of Flanagan Road, downstream of confluence with Stream A.

Photograph Appendix C.4: Wetland seep 1

Photograph Appendix C.5: Wetland seep 2

Photograph Appendix C.6: Hingaia Stream

Photograph Appendix C.7: Stream A, western headwater tributary, view upstream, perched culvert in background.

Photograph Appendix C.8: Stream A, central headwater tributary (looking downstream)

Photograph Appendix C.9: Stream A, eastern headwater tributary (looking downstream).

Photograph Appendix C.10: Stream A main channel (looking downstream

Photograph Appendix C.11: Stream A, main channel under deciduous shelter belt (looking downstream).

Photograph Appendix C.12: Remnant stream channel (Stream E).

Photograph Appendix C.13: Remnant stream channel (Stream E).

Photograph Appendix C.14: Stream F overgrown with macrophyte growth at 113 Fitzgerald Road.

Photograph Appendix C.15: Stream G within 111 Fitzgerald Road.

www.tonkintaylor.co.nz

19 February 2019

Kiwi Property Group Ltd
Level 7
Vero Centre
48 Shortland Street
Auckland 1010

Attention: Emma McDonald

RE: Percolation Testing to Support Stormwater Assessment for Drury Development Project, Drury, Auckland

(Our Reference: 13451.000.000_18)

1 Introduction

ENGEO Limited (ENGEO) was requested by Tonkin and Taylor Limited (T&T), on behalf of Kiwi Property Group Limited (KPGL), to undertake percolation testing across the sites at 133 Fitzgerald Road / 120 Flanagan Road to inform a stormwater modelling exercise to support the larger Drury Development Project.

The purpose of this assessment is to broadly characterise representative percolation rates at the site to support a stormwater assessment. A total of ten percolation tests were completed, with test locations and depths selected by T&T and provided to ENGEO via email on 4 and 6 December 2018. The test methodology and results are summarised in the following sections, and full analysis sheets are appended in Appendix C.

A summary of the ground conditions and strengths encountered are also provided with the field logs included within Appendix B.

2 Percolation Test Methodology

Ten tests were conducted across the site in accordance with Auckland Council's guidance document 'Stormwater Disposal via Soakage in the Auckland Region' (Technical Report 2013/040, dated October 2013).

T&T have requested that the tests be undertaken at the locations specified in Appendix A: T&T Percolation Testing Location Plan.

The guidance from T&T states “Constant head test or falling head permeability test (the degree of permeability encountered on site will determine which method is more suitable). These should be conducted in a borehole hand augered to a depth of 3 m below existing ground, depth of practical refusal or groundwater depth (whichever is encountered first). The boreholes should be logged and the depth to groundwater level recorded (this may require an additional borehole if groundwater is deeper than 3 m). This test should be undertaken as per Appendix A of Auckland Council’s TR2013/040.”

All boreholes were progressed using a 100 mm diameter auger, logged, and scarified prior to filling with water for the pre-soak period. The boreholes were then pre-soaked for at least 17 hours and falling head tests conducted at each location in accordance with the methodology presented in the guidance document.

3 Percolation Test Results

All percolation rates were less than the minimum infiltration rate of 0.5 litres/m^2/min prescribed Council’s guidance document, and accordingly it will be difficult to obtain a building consent for soakage systems.

Test results are summarised in Percolation Test Results Summary Table 1, and full analysis results are attached.

Table 1: Percolation Test Results Summary

Test ID	Borehole Depth (m)	Pre-soak Duration (hh:mm)	Test Duration (hh:mm)	Percolation Rate (L/m^2/min)
PT01	3.0	17:00	4:00	0.0152
PT02	3.0	17:15	4:00	0.0054
PT03	3.0	17:00	4:00	0.0617
PT04	3.0	17:15	4:00	0.0287
PT05	3.0	17:15	4:00	0.0093
PT06	3.0	17:15	4:00	0.0086
PT07	3.0	18:00	2:30	0.0201
PT08	3.0	18:00	4:00	0.0059
PT09	3.0	17:00	4:00	0.0055
PT010	3.0	17:15	4:00	0.0085

5 Geotechnical Comment

As part of the scope of works ENGEO undertook geotechnical logging and strength testing in each of the prescribed hand auger borehole locations.

Borehole logs and measured shear strengths were consistent with the subsurface conditions encountered at the other nearby investigation locations. These logs can be used for further verification of the ground model for the overall development.

The full set of field logs are included within Appendix B.

6 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Kiwi Property Group Limited, their professional advisers and Auckland Council in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. This report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.

iii. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

iv. This report is not to be reproduced either wholly or in part without our prior written permission.

We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on (09) 972 2205 if you require any further information.

Report prepared by

David Brodie

Associate Geotechnical Engineer

Report reviewed by

Paul Fletcher, CMEngNZ (CPEng)

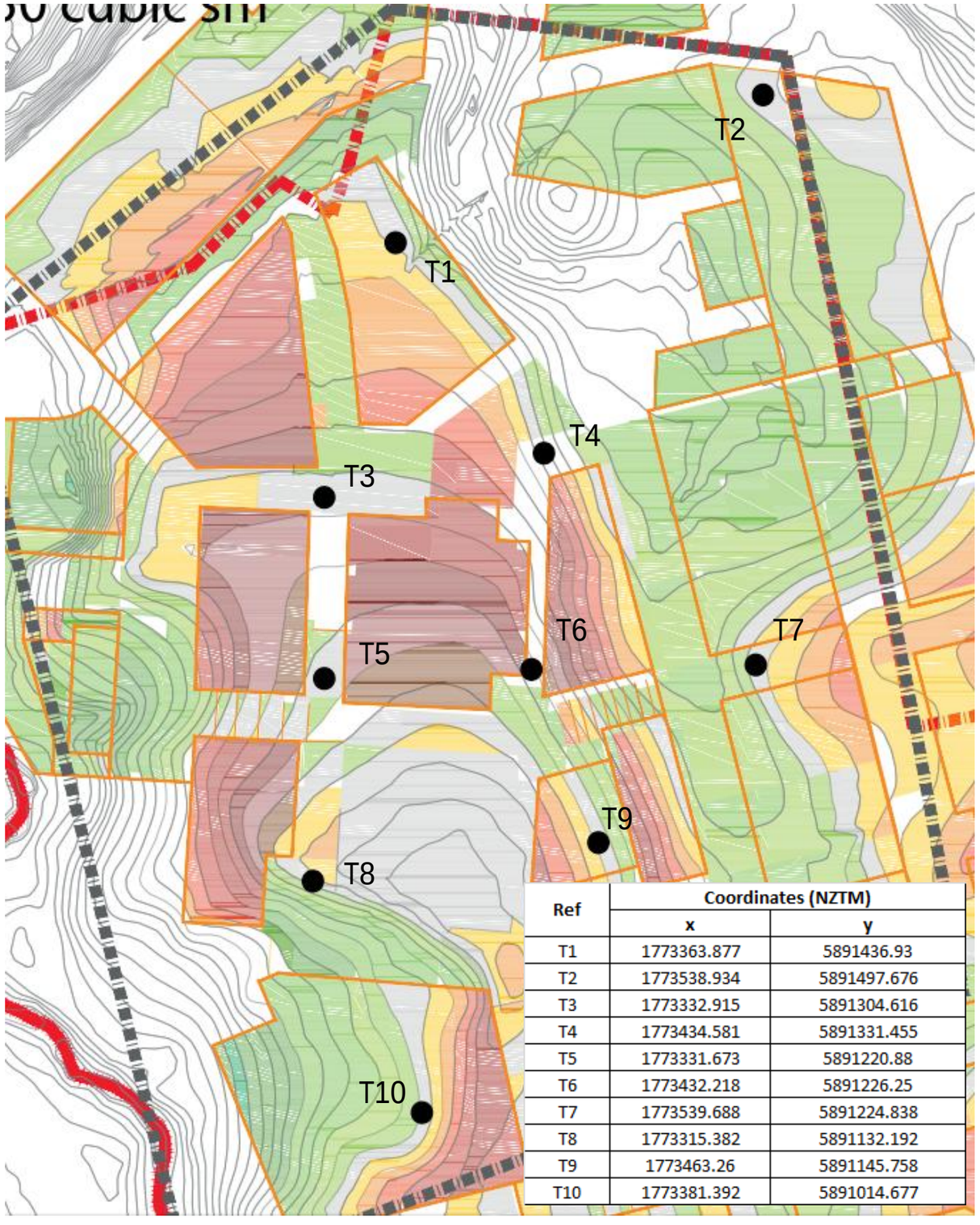
Associate Geotechnical Engineer

Attachments:

Percolation Test Location Plan
Hand Auger Borehole Records
Percolation Test Results

APPENDIX 1

Percolation Test Location Plan



Ref	Coordinates (NZTM)	
	x	y
T1	1773363.877	5891436.93
T2	1773538.934	5891497.676
T3	1773332.915	5891304.616
T4	1773434.581	5891331.455
T5	1773331.673	5891220.88
T6	1773432.218	5891226.25
T7	1773539.688	5891224.838
T8	1773315.382	5891132.192
T9	1773463.26	5891145.758
T10	1773381.392	5891014.677

Percolation Test Location Plan provided by Tonkin and Taylor Limited via email dated 4 December 2018

APPENDIX 2

Hand Auger Borehole Records

LOG OF AUGER T1

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/19
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1413
Logged By : JM
Reviewed By : NB
Latitude : -37.107316
Longitude : 174.95112

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].				NA		
0.5	Auckland Volcanic Soils	CH	Silty CLAY; light brown. High plasticity.			D	H	UTP	
			Encountered trace lapilli and becomes light brown with red mottles at 0.7 m depth. Becomes moist at 0.8 m depth.					UTP	
1.0			Becomes light brown with light streaks and reddish orange mottles at 0.9 m depth.					200+	
			Silty CLAY with trace lapilli; light grey with light brown streaks and reddish orange mottles. High plasticity.				H	200+	
			Becomes light brown at 1.2 m depth.						
1.5			Becomes light grey with orange streaks at 1.4 m depth.				VSt	187/103	
			Becomes light grey with orange and pink streaks at 1.8 m depth.			M		152/114	
2.0		CH						144/101	
2.5							VSt-St	93/59	
								114/76	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					76/44	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

LOG OF AUGER T2

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/2019
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1858
Logged By : AK
Reviewed By : NB
Latitude : -37.10846
Longitude : 174.950727

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	ML	Clayey SILT; light brown. Low plasticity. Becomes light brown with light greyish brown mottles at 0.7 m depth.				H	200+ UTP	
1.0		CH	Silty CLAY; light greyish brown with light orange brown streaks. High plasticity.			M	VSt-H	166/104 200+	
1.5		ML	Clayey SILT; pinkish brown with orange brown streaks. Low plasticity.			W	VSt-H	200+ 190/83 200+ 131/76 145/62	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					123/39	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

LOG OF AUGER T3

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/19
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1413
Logged By : JM
Reviewed By : NB
Latitude : -37.108249
Longitude : 174.951898

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	CH	Silty CLAY; light brown. High plasticity.				H	200+	
								200+	
1.0			Becomes dark brownish grey with reddish orange mottles at 1.0 m depth.					200+	
			Becomes brown at 1.2 m depth.					UTP	
1.5		ML	Clayey SILT with trace lapilli; dark brown with reddish mottles. Low plasticity.			M	H	UTP	
								UTP	
2.0								UTP	
2.5								UTP	
								UTP	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					UTP	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T4

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/19
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1413
Logged By : JM
Reviewed By : NB
Latitude : -37.109333
Longitude : 174.95074

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm
0	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	ML	Clayey SILT with trace rootlets; dark greenish brown with orange mottles. Low plasticity.				H	UTP UTP	
1.0		ML	Clayey SILT with trace lapilli; bluish grey with orange mottles. Low plasticity.			M	H	UTP 200+	
1.5			Becomes with reddish mottles at 1.7 m depth.					200+ 200+	
2.0		ML	Clayey SILT with minor lapilli; light yellowish grey with orange mottles. Low plasticity.		▼	S	VSt	155/38 127/36	
2.5								160/41	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					158/36	

Hand auger met target depth at 3 m.
TS = Topsoil
Dip test showed standing water at 2.2 m depth.
UTP = Unable to penetrate

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T5

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/2019
Hole Depth : 3 m
Hole Diameter : 50 mm

Shear Vane No : 1858
Logged By : AK
Reviewed By : NB
Latitude : -37.109279
Longitude : 174.951836

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm
	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			M	NA		
0.5	Auckland Volcanic Soils	ML	Clayey SILT; brown with orange brown streaks. Low plasticity.				VSt	180/71 156/76	
1.0		CH	Silty CLAY; brown with orange brown streaks. High plasticity.				VSt	125/39 156/40	
1.5		ML	Clayey SILT; brown. Low plasticity.			W	H H	200+ 200+	
2.0		CH	Silty CLAY; brown with orange brown streaks. High plasticity.				H	UTP UTP	
2.5		ML	Clayey SILT; brown with reddish brown and orange brown streaks. Low plasticity. Silt concretions encountered from 2.80 m to 2.85 m depth.				H	UTP	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					UTP	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T6

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/19
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1413
Logged By : JM
Reviewed By : NB
Latitude : -37.109188
Longitude : 174.953081

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	CH	Silty CLAY; dark greenish brown. High plasticity. Becomes dark grey with orange mottles at 0.7 m depth.				H	UTP 200+	
1.0		CH	Silty CLAY; dark bluish grey with white and reddish orange mottles. High plasticity.				VSt	192/111	
1.5		ML	Clayey SILT; reddish orange. Low plasticity. Becomes intermixed with red, orange, light grey and brown at 1.7 m depth.			M	H	200+ UTP 200+	
2.0			Becomes dark brown at 2.1 m depth.				VSt	136/46 106/52	
2.5							H	200+	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					200+	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

LOG OF AUGER T7

ENGEO Expect Excellence

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 29/1/19
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1413
Logged By : JM
Reviewed By : NB
Latitude : -37.110118
Longitude : 174.950593

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
0	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	CH	Silty CLAY; light brown. Low plasticity. Becomes reddish orange at 0.7 m depth.				H	UTP UTP	
1.0		ML	Clayey SILT; light brown with reddish orange mottles. Low plasticity. Becomes light brown with light grey streaks and red mottles from 1.3 m depth.			M	St	200+ 98/63 92/67	
2.0		CH	Silty CLAY; light grey with red streaks. High plasticity.				St	92/63	
2.5		ML	Clayey SILT; white with red and pink streaks. Low plasticity. Becomes saturated at 2.8 m depth.		▼	S	St VSt	136/41 76/38 68/35	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					63/30	

Hand auger met target depth at 3 m.
TS = Topsoil
Dip test showed standing water at 2.8 m depth.
UTP = Unable to penetrate

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T8

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 31/1/2019
Hole Depth : 3 m
Hole Diameter : 50 mm
Shear Vane No : 1858
Logged By : AK
Reviewed By : NB
Latitude : -37.109992
Longitude : 174.9522

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm
0	TS	ML	Clayey SILT with trace rootlets and shells; dark brown. Low plasticity [TOPSOIL].			D	NA		
0.5	Auckland Volcanic Soils	ML	Clayey SILT; brown with dark brown mottles. Low plasticity.				UTP	UTP UTP	
1.0		CH	Silty CLAY; light grey with light brown and pinkish red streaks. High plasticity.			M	VSt-H	199/67	
			Becomes wet at 1.2 m depth.					200+	
1.5		ML	Clayey SILT; pinkish red with light grey and occasional orange streaks. Low plasticity.				VSt	183/101	
2.0			Becomes orange at 2.0 m depth.			W		186/86	
			Becomes purplish grey with red and orange streaks at 2.2 m depth.					125/39	
2.5		CH	CLAY; purple. High plasticity.				VSt	151/101 144/107	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					183/116	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T9

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 31/1/2019
Hole Depth : 3 m
Hole Diameter : 50 mm

Shear Vane No : 1858
Logged By : AK
Reviewed By : NB
Latitude : -37.111158
Longitude : 174.951285

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
0.0	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].			D	NA	UTP	
0.5	Auckland Volcanic Soils	CH	Silty CLAY; brown. High plasticity.				H	UTP	
1.0		ML	Clayey SILT; reddish brown. Low plasticity.			M	H	UTP	
1.5							VSt	166/77	
2.0		CH	Silty CLAY; light pinkish brown with light brown streaks. High plasticity.				VSt	177/117 160/77	
2.5		ML	Clayey SILT; light pinkish brown with light brownish grey streaks. Low plasticity.			W	VSt	171/79 157/80	
3.0			Limonite nodules encountered from 2.90 m to 2.95 m depth. End of Hole Depth: 3 m Termination Condition: Target depth					138/88	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

LOG OF AUGER T10

Geotechnical Investigation
Drury Development Project
Drury, Auckland
13451.000.000

Client : Kiwi Propoerty Holdings Ltd
Client Ref. : 13451.000.000
Date : 31/1/2019
Hole Depth : 3 m
Hole Diameter : 50 mm

Shear Vane No : 1858
Logged By : AK
Reviewed By : NB
Latitude : -37.106781
Longitude : 174.953017

Depth (m)	Material	USCS Symbol	DESCRIPTION	Graphic Symbol	Water Level	Moisture Cond.	Consistency/ Density Index	Shear Vane Undrained Shear Strength (kPa) Peak/Remolded	Scala Penetrometer Blows per 100mm (2 4 6 8 10 12)
0	TS	ML	Clayey SILT with trace rootlets; dark brown. Low plasticity [TOPSOIL].				NA		
	Auckland Volcanic Soils		Clayey SILT; brown. Low plasticity.			D		UTP	
			Becomes moist at 0.4 m depth.					UTP	
0.5						M		UTP	
1.0			Becomes wet at 1.0 m depth.				H	200+	
		ML	Becomes dark brown with orange streaks at 1.4 m depth.					200+	
1.5								UTP	
			Becomes dark purplish brown with light brown and orange streaks at 1.8 m depth.			W		200+	
2.0							VSt	128/31	
2.5							H	UTP	
3.0			End of Hole Depth: 3 m Termination Condition: Target depth					200+	

Hand auger met target depth at 3 m.
TS = Topsoil
UTP = Unable to penetrate
Standing groundwater was not encountered.

NA = Not assessed

GEOTECH HAND AUGER DRAFT_GINT_JM.GPJ NZ DATA TEMPLATE 2.GDT 11/2/19

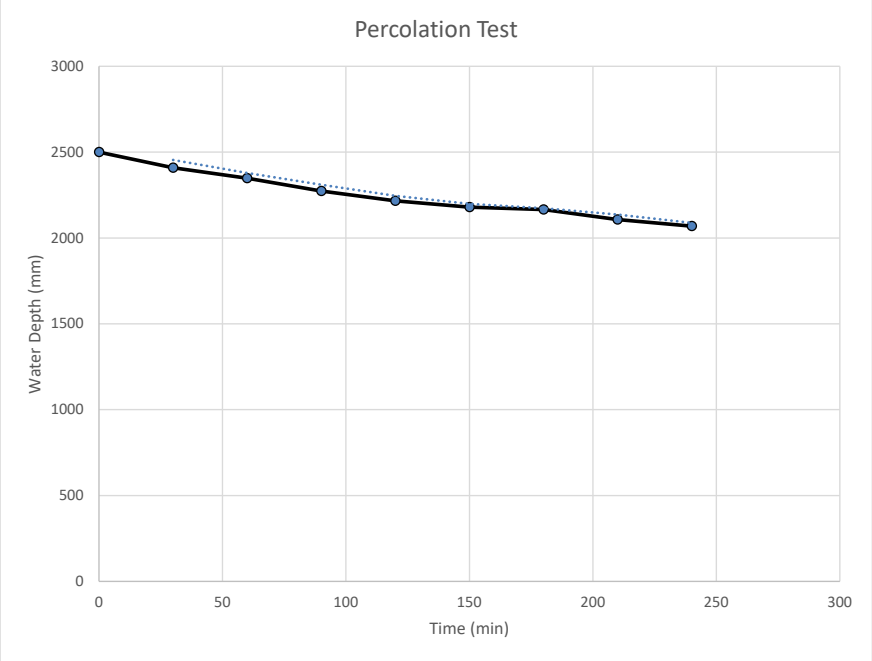
APPENDIX 3

Percolation Test Results

1. Test Details

PT01 — Depth (m): 3
Groundwater at 5.0m — Diameter (mm): 100
30/01/2019 — Presoak Time: 17h

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
591	2409	30	30
652	2348	30	60
727	2273	30	90
783	2217	30	120
820	2180	30	150
834	2166	30	180
893	2107	30	210
931	2069	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	38	30

1.27 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,x\,d}$$

D (m)	Gradient	d (mm)	d (m)
0.1	1.27	2088	2.088

	mm	m
Numerator	126.6666667	0.126666667
Denominator	8352	8.352

P1 (taken from middle) 0.015166028 L/m2/min

	d (mm)	d (m)
	2088	2.088

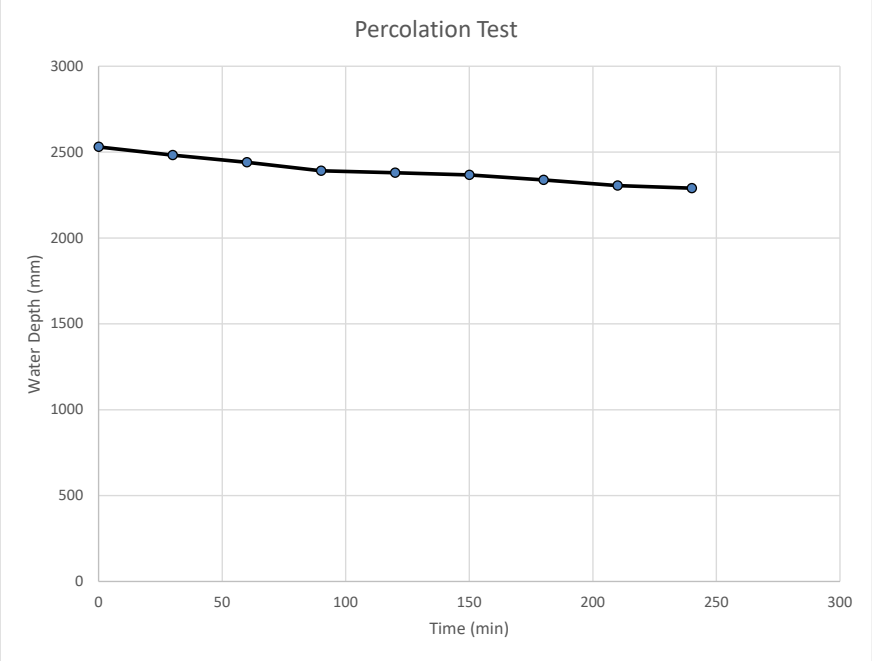
	mm	m
Numerator	126.6666667	0.126666667
Denominator	8352	8.352

P_1 = 0.0152 L/m2/min

1. Test Details

PT02 — Depth (m): 3
Groundwater not encountered — Diameter (mm): 100
30/01/2019 — Presoak Time: 17h 15m

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
470	2530	0	0
518	2482	30	30
560	2440	30	60
609	2391	30	90
620	2380	30	120
633	2367	30	150
662	2338	30	180
695	2305	30	210
710	2290	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	15	30

0.50 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,x\,d}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.50	2297.5	2.2975

	mm	m
Numerator	50	0.05
Denominator	9190	9.19

P1 (taken from middle) 0.005440696 L/m2/min

	d (mm)	d (m)
	2297.5	2.2975

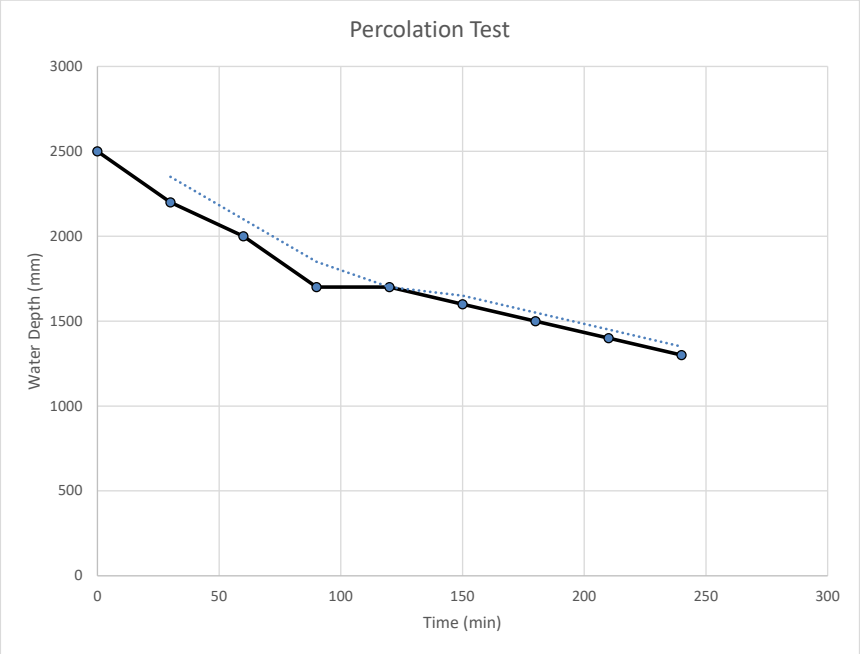
	mm	m
Numerator	50	0.05
Denominator	9190	9.19

P_1 = 0.0054 L/m2/min

1. Test Details

PT03 — Depth (m): 3
Groundwater at 4.4m — Diameter (mm): 100
30/01/2019 — Presoak Time: 17h

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
800	2200	30	30
1000	2000	30	60
1300	1700	30	90
1300	1700	30	120
1400	1600	30	150
1500	1500	30	180
1600	1400	30	210
1700	1300	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	100	30

3.33 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,xd}$$

D (m)	Gradient	d (mm)	d (m)
0.1	3.33	1350	1.35

	mm	m
Numerator	333.3333333	0.333333333
Denominator	5400	5.4

P1 (taken from middle) 0.061728395 L/m2/min

	d (mm)	d (m)
	1350	1.35

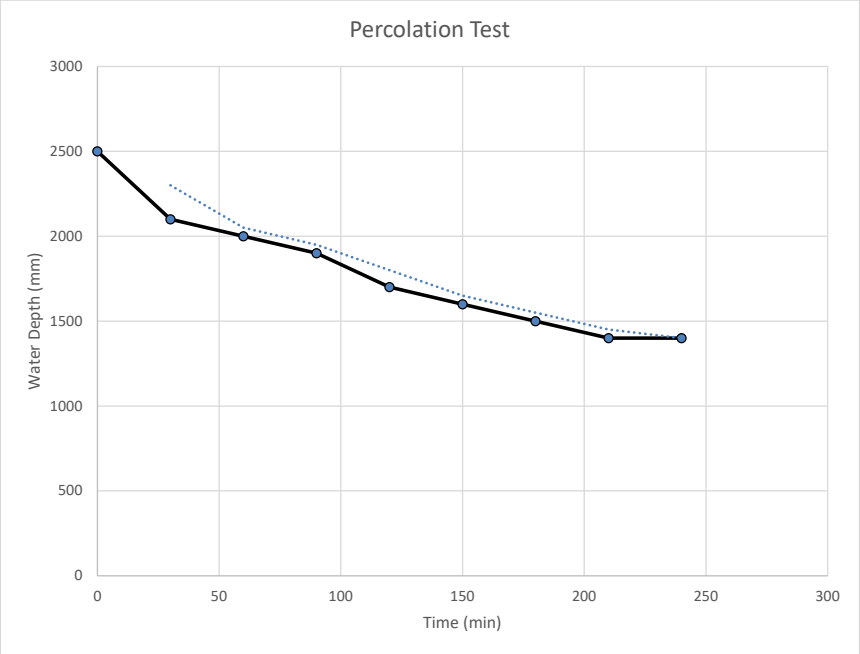
	mm	m
Numerator	333.3333333	0.333333333
Denominator	5400	5.4

P_1 = 0.0617 L/m2/min

1. Test Details

PT04 — Depth (m): 3
Groundwater at 2.2m — Diameter (mm): 100
1/02/2019 — Presoak Time: 17h 15m

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
900	2100	30	30
1000	2000	30	60
1100	1900	30	90
1300	1700	30	120
1400	1600	30	150
1500	1500	30	180
1600	1400	30	210
1600	1400	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	100	30

3.33 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,xd}$$

D (m)	Gradient	d (mm)	d (m)
0.05	3.33	1450	1.45

	mm	m
Numerator	166.6666667	0.166666667
Denominator	5800	5.8

P1 (taken from middle) 0.028735632 L/m2/min

	d (mm)	d (m)
	1450	1.45

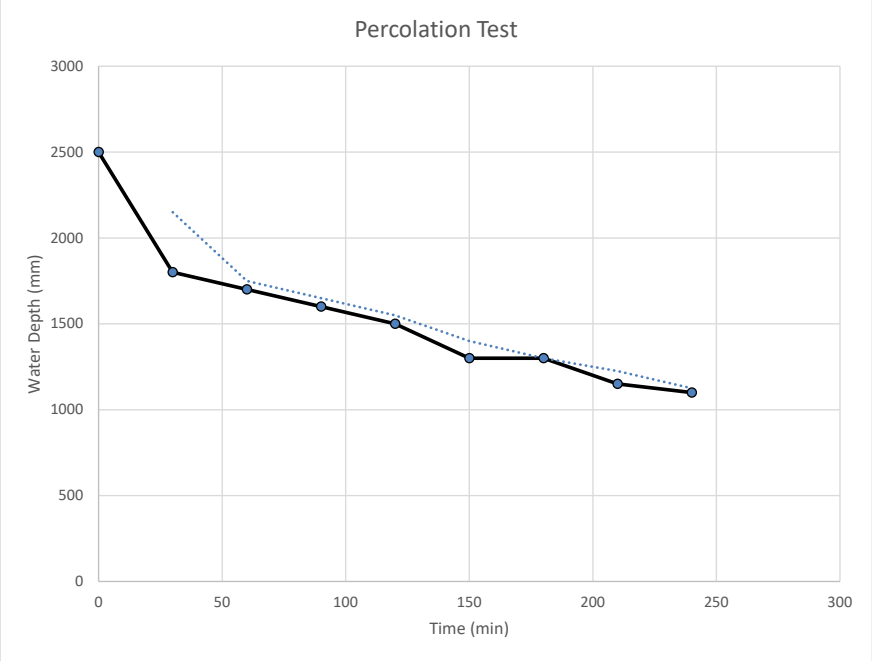
	mm	m
Numerator	166.6666667	0.166666667
Denominator	5800	5.8

P_1 = 0.0287 L/m2/min

1. Test Details

PT05 — Depth (m): 3
Groundwater was not encountered — Diameter (mm): 100
30/01/2019 — Presoak Time: 17h 15m

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
1200	1800	30	30
1300	1700	30	60
1400	1600	30	90
1500	1500	30	120
1700	1300	30	150
1700	1300	30	180
1850	1150	30	210
1900	1100	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	10	24

0.42 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,xd}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.42	1125	1.125

	mm	m
Numerator	41.66666667	0.041666667
Denominator	4500	4.5

P1 (taken from middle) 0.009259259 L/m2/min

	d (mm)	d (m)
	1125	1.125

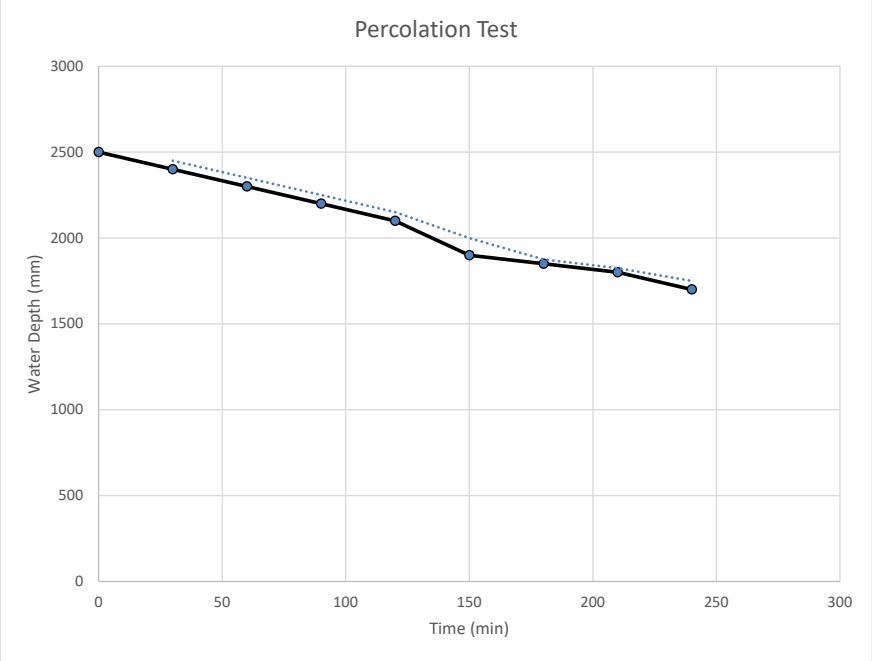
	mm	m
Numerator	41.66666667	0.041666667
Denominator	4500	4.5

P_1 = 0.0093 L/m2/min

1. Test Details

PT06 — Depth (m): 3
Groundwater not encountered — Diameter (mm): 100
1/02/2019 — Presoak Time: 17h 15m

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
600	2400	30	30
700	2300	30	60
800	2200	30	90
900	2100	30	120
1100	1900	30	150
1150	1850	30	180
1200	1800	30	210
1300	1700	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	37	59

0.63 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,xd}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.63	1825	1.825

	mm	m
Numerator	62.71186441	0.062711864
Denominator	7300	7.3

P1 (taken from middle) 0.008590666 L/m2/min

	d (mm)	d (m)
	1825	1.825

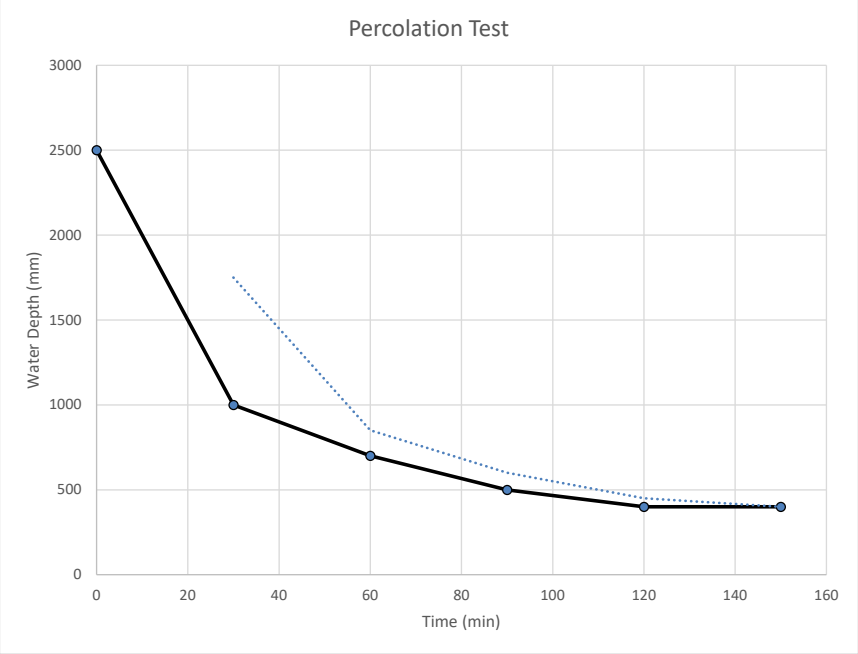
	mm	
Numerator	62.71186441	0.062711864
Denominator	7300	7.3

P_1 = 0.0086 L/m2/min

1. Test Details

PT07 — Depth (m): 3
Groundwater at 2.8 — Diameter (mm): 100
1/02/2019 — Presoak Time: 18h

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
2000	1000	30	30
2300	700	30	60
2500	500	30	90
2600	400	30	120
2600	400	30	150



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	14	29

0.48 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.\, gradient \quad .1000}{4 \; x \, d}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.48	600	0.6

	mm	m
Numerator	48.27586207	0.048275862
Denominator	2400	2.4

P1 (taken from middle) 0.020114943 L/m2/min

	d (mm)	d (m)
	600	0.6

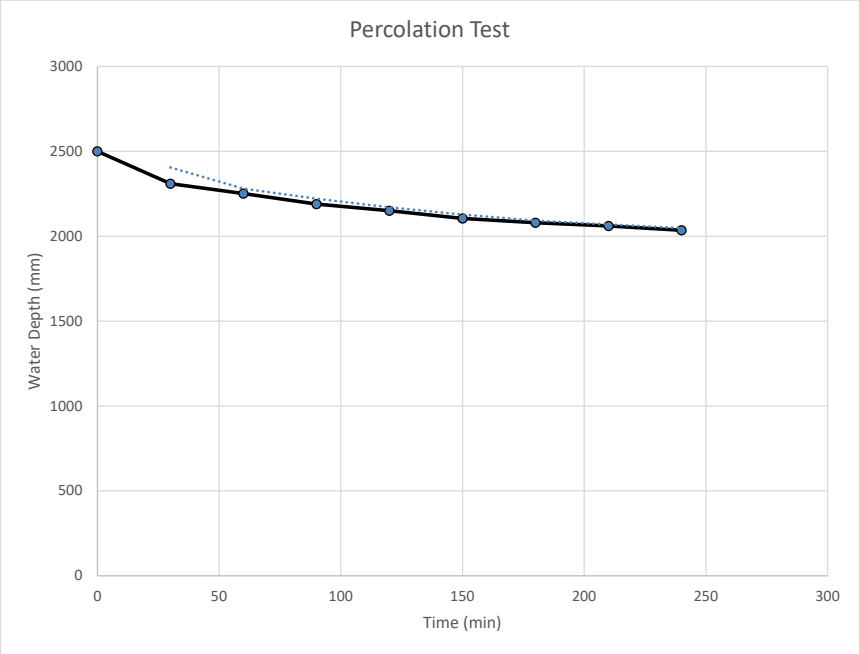
	mm	m
Numerator	48.27586207	0.048275862
Denominator	2400	2.4

P_1 = 0.0201 L/m2/min

1. Test Details

PT08 — Depth (m): 3
Groundwater not encountered — Diameter (mm): 100
1/02/2019 — Presoak Time: 18h

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
690	2310	30	30
748	2252	30	60
810	2190	30	90
850	2150	30	120
895	2105	30	150
920	2080	30	180
940	2060	30	210
965	2035	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	14	29

0.48 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.gradient \quad .1000}{4\,xd}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.48	2047.5	2.0475

	mm	m
Numerator	48.27586207	0.048275862
Denominator	8190	8.19

P1 (taken from middle) 0.005894489 L/m2/min

	d (mm)	d (m)
	2047.5	2.0475

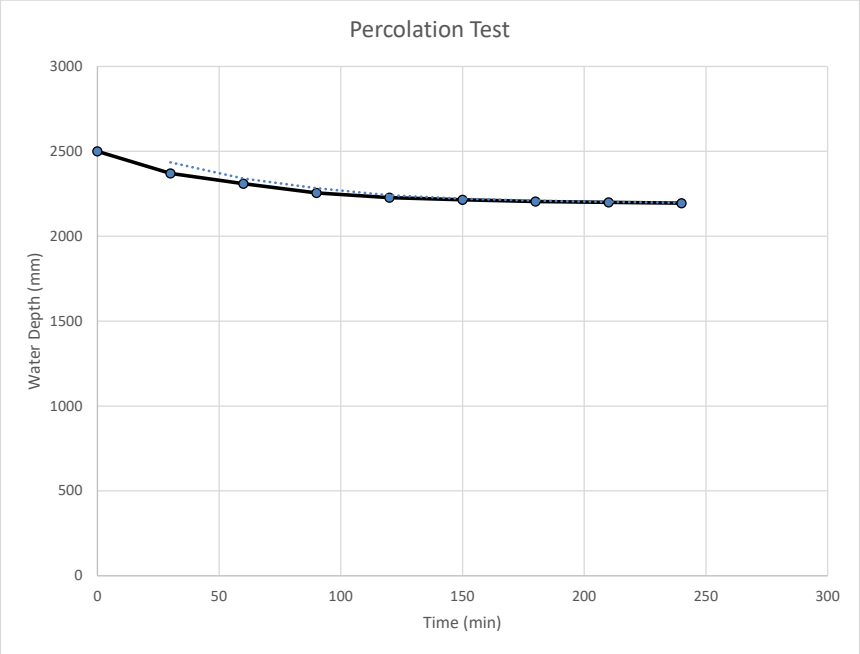
	mm	m
Numerator	48.27586207	0.048275862
Denominator	8190	8.19

P_1 = 0.0059 L/m2/min

1. Test Details

PT09 — Depth (m): 3
Groundwater not encountered — Diameter (mm): 100
1/02/2019 — Presoak Time: 17h

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
630	2370	30	30
690	2310	30	60
745	2255	30	90
773	2227	30	120
785	2215	30	150
795	2205	30	180
800	2200	30	210
805	2195	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	14	29

0.48 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.\, gradient \quad .1000}{4\ x d}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.48	2197.5	2.1975

	mm	m
Numerator	48.27586207	0.048275862
Denominator	8790	8.79

P1 (taken from middle) 0.005492134 L/m2/min

	d (mm)	d (m)
	2197.5	2.1975

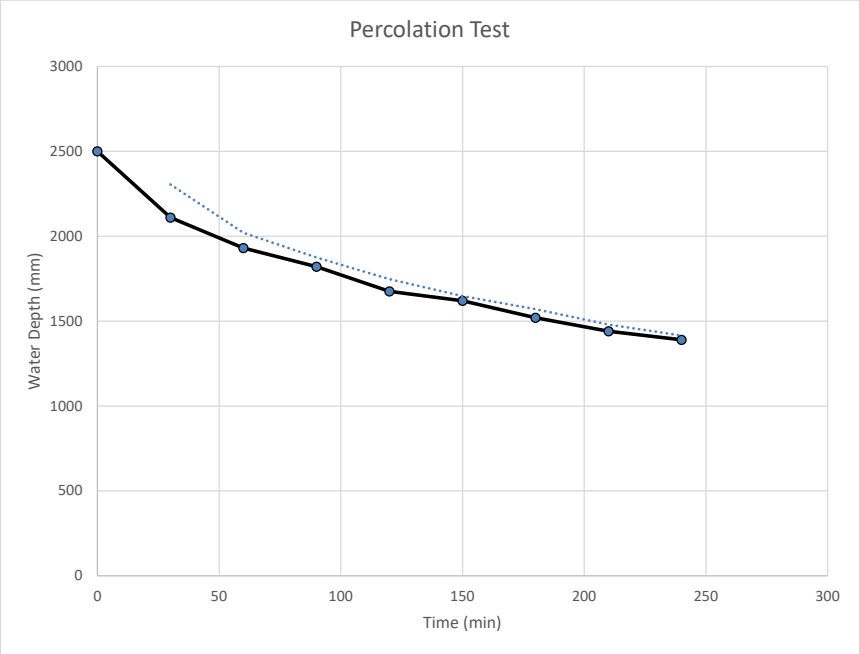
	mm	m
Numerator	48.27586207	0.048275862
Denominator	8790	8.79

P_1 = 0.0055 L/m2/min

1. Test Details

PT10 — Depth (m): 3
Groundwater not encountered — Diameter (mm): 100
1/02/2019 — Presoak Time: 17h 15m

Water Depth (mm)	Change in Water Depth Cumulative	Elapsed Time	Time (min)
500	2500	0	0
890	2110	30	30
1070	1930	30	60
1180	1820	30	90
1325	1675	30	120
1380	1620	30	150
1480	1520	30	180
1560	1440	30	210
1610	1390	30	240



2. Calculate mimimum gradient

	y	x
(a) Minimum gradient = y/x	14	29

0.48 mm/min

3. Calculate Percolation Rate

$$P_1 = \frac{D \,.\, gradient \quad .1000}{4\ x\ d}$$

D (m)	Gradient	d (mm)	d (m)
0.1	0.48	1415	1.415

	mm	m
Numerator	48.27586207	0.048275862
Denominator	5660	5.66

P1 (taken from middle) 0.008529304 L/m2/min

	d (mm)	d (m)
	1415	1.415

	mm	m
Numerator	48.27586207	0.048275862
Denominator	5660	5.66

P_1 = 0.0085 L/m2/min

Ecological values within the area affected by the proposed Drury East Plan Change

PREPARED FOR:

Fulton Hogan Land Development

August 2019

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Fulton Hogan Land Development (FHLD) requests a Plan Change affecting approximately 187 hectares of land at Drury East (north and east of Drury township). The Plan Change extent is mostly bound by Fitzgerald Road, Drury Hills Road and Waihoehoe Road, but includes a small area north of Waihoehoe Road. Currently, the land is predominantly used for farming, with some rural lifestyle blocks. The Plan Change area is within the Hingaia Creek catchment and the overall topography of the area is gently undulating with several low ridgelines. The Ecology Company was retained to undertake a high level assessment of the ecological context and existing ecological values of the Plan Change area, in order to inform the Plan Change application to Auckland Council to rezone the area to enable urban development.

The Plan Change area is located in the Manukau Ecological District, which is characterised by very little remnant indigenous vegetation which is generally located in small, highly fragmented patches in the southern half of the district. The Plan Change area has been substantially modified for farming and other land uses and currently contains only a small (0.4ha) area of indigenous vegetation and some isolated mature trees near the corner of Waihoehoe Road and Drury Hills Road. The Plan Change area is located near several terrestrial Significant Ecological Areas (SEA_T) identified in the Auckland Unitary Plan, but does not include any SEA_T within its boundary. The majority of the vegetation within the Plan Change area comprises exotic pasture, crops and exotic and native trees associated with gardens and shelterbelts. There are no records of native geckos within the Plan Change area, but native copper skink (*Oligosoma aeneum*) have been recorded nearby. Similarly there are no records of native bats within the Plan Change area, but long-tailed bats (*Chalinolobus tuberculatus*) have been detected in low numbers within a few kilometres of the Plan Change area. Birds recorded nearby are generally those common native and exotic species typical of farmed areas and suburban gardens.

Three unnamed tributaries of Hingaia Stream traverse the Plan Change area and drain ultimately to the Manukau Harbour via Otuwairoa (Slippery Creek). There are no natural wetlands remaining within the Plan Change area, but several ponds have been created to provide water for livestock. The aquatic habitats are highly degraded and at the time of the site visits most of the stream beds were dry or nearly so. There are no records of native fish from within the site, but historic records show Hingaia Stream has good fish diversity, including eight species of native fish.

The Drury – Opāheke area generally lacks indigenous habitats and poses a barrier to ecological connectivity and function at the broader landscape scale. There is considerable potential to restore habitats within the Plan Change area as part of the Plan Change. Habitats which could be restored or created include wetlands, streams, forest and shrubland, as well as ecotones between habitats. We recommend retention and enhancement of the forest remnant, along with stream restoration and aquatic habitat enhancement (via instream works), weed and pest control, riparian planting and wetland creation in order to maximise the ecological benefits of the proposal and assist in restoring ecological function and connectivity at both the site and broader landscape scale.

1. INTRODUCTION

1.1 BACKGROUND

This report has been prepared to inform the Drury East Plan Change (**'the Plan Change'**) on behalf of Fulton Hogan Land Development (**'FHLD'**). The approximate boundary of the Plan Change area is shown in Figure 1 below.

The Plan Change area is located within Drury East (north and east of Drury township) and has a land area of approximately 187 hectares. Drury East is contained by the Papakura urban area to the north, the Hunua foothills to the east, the Drury South Business zone to the south, and State Highway 1 to the west. FHLD has large landholdings within the Plan Change extent, which is mostly bound by Fitzgerald Road, Drury Hills Road and Waihoehoe Road, with a small area north of Waihoehoe Road. Currently, the sites are predominantly used for farming, with some rural lifestyle blocks.

Drury East has an extensive stream and flood plain network which connects headwater streams to Te Mānukanuka o Hoturoa (Manukau Harbour). The Plan Change area is within the Hingaia Creek catchment and is traversed by three main watercourses. The overall topography of the area is gently undulating with several low ridgelines.

The Plan Change area is currently zoned Future Urban under the Auckland Unitary Plan. FHLD are seeking to rezone the land for residential development, with a range of densities proposed across three zones (Town Housing and Apartment Buildings, Mixed Housing Urban and Mixed Housing Suburban). The proposed Plan Change provides for a small mixed use centre within the Plan Change area. New roading and servicing infrastructure is proposed to service the development. Once developed, it is anticipated that the Plan Change area could accommodate approximately 2800 dwellings.

1.2 PURPOSE AND SCOPE

FHLD engaged The Ecology Company in January 2019 to undertake an assessment of the ecological values of the Plan Change area to inform their Plan Change request to Auckland Council to allow the Plan Change area to be rezoned in order to enable urban development. FHLD requested a high level assessment of the existing ecology within the area to inform the Plan Change, specifically the scope of work included:

- Describe current ecological values of the Plan Change area including streams, vegetation and native fauna (noting limited access to some parts of the Plan Change area);
- Describe the ecological context of the wider Drury East area;
- Categorise the existing streams as permanent or intermittent in accordance with Auckland Council criteria. This task was limited by the very dry conditions at the time of the site visits;
- Identify priority areas for retention or protection within the affected area;
- Identify potential opportunities for enhancement or improvement of ecological linkages which could be included in the Plan Change.

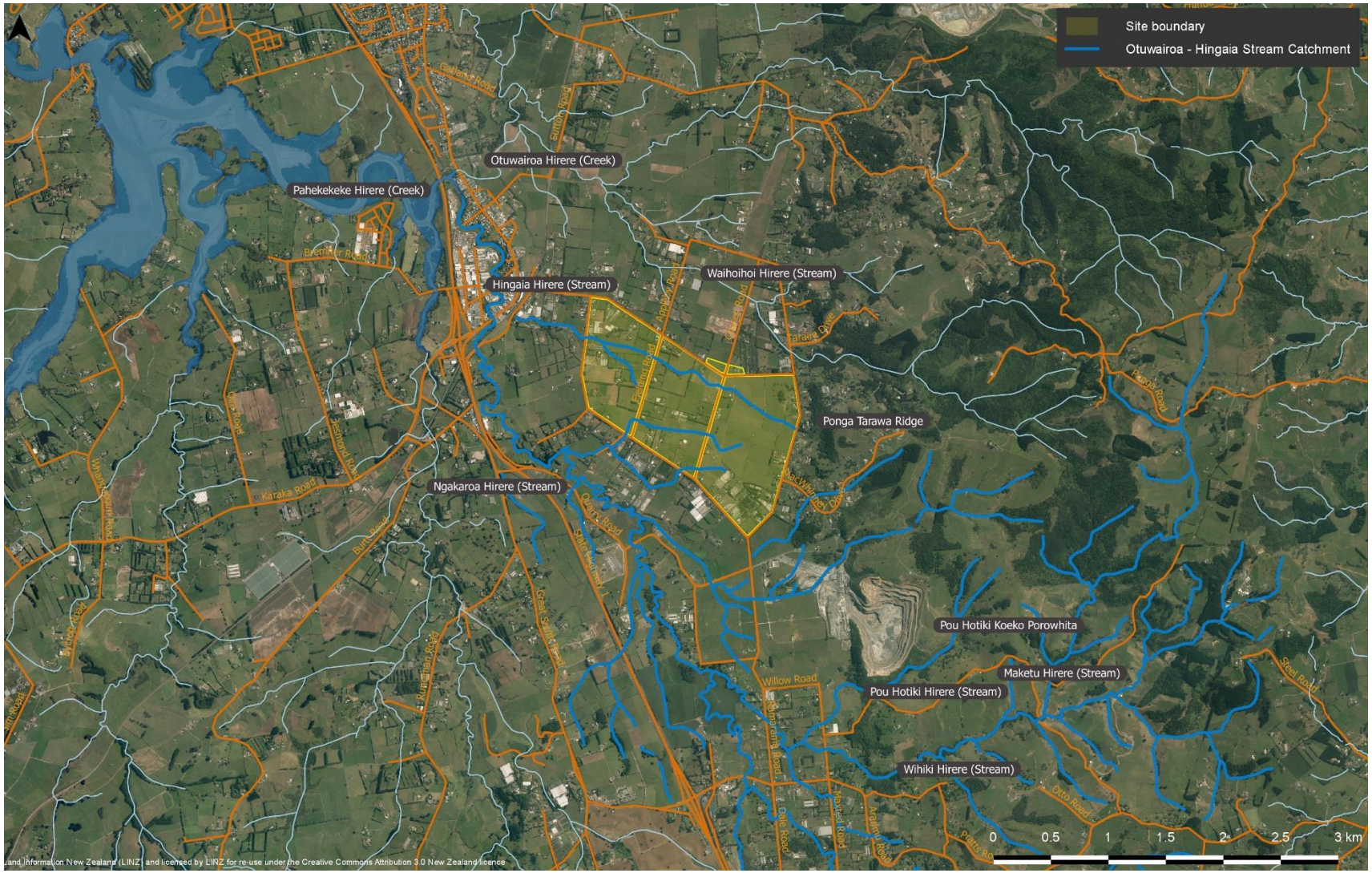


Figure 1: Approximate Location of the Proposed Drury East Plan Change Area

These matters are addressed in this report, which comprises seven sections as follows:

- **Section 1** (Introduction) describes the background of the proposal and the agreed scope of work.
- **Section 2** (Methods) describes the background literature used and the field work undertaken to inform this report.
- **Section 3** (Results) describes the findings of the literature search and field surveys in relation to terrestrial and aquatic ecological values.
- **Section 4** (Development Proposal) describes the proposed development and the anticipated effects.
- **Section 5** (Recommendations) provides recommended actions to maximise the positive ecological effects of the Plan Change and avoid, remedy or mitigate anticipated adverse effects on ecological values.
- **Section 6** (Conclusions) outlines our conclusions in relation to the proposal.
- **Section 7** (References) provides the references used in compiling this report.
- **The Appendices** provide reference material or summaries of data relevant to the findings and conclusions outlined in this report.

2. METHODS

2.1 DESKTOP METHODS

As part of gathering information about the Plan Change area, the following documents and databases were reviewed to assist in identifying the ecological values which were known or might be present at the Plan Change area:

- Herpetofauna Database for records of amphibians and lizards within 10km of the Plan Change area. The output from the Herpetofauna Database is discussed in Section 3.2.1.
- Auckland Council Bat records (B. Paris pers. comm. (2019)). The records from this Plan Change area are discussed in Section 3.2.1.
- eBird records within 10km of the Plan Change area. These records are also discussed in Section 3.2.1.
- Kane-Sanderson, P., Spyksma, A., Bennett, K., Lindgreen, M., Pertziger, F., Allen, J., Gasson, S and Canal, L (2018) Hingaia Stream Watercourse Assessment Report. 4Sight Consulting and Urban Solutions for Auckland Council.
- New Zealand Freshwater Fish Database for fish capture records in the Waihoihoi, Symonds and Hingaia Streams. The records from this database discussed in Section 3.2.2.
- Draft Drury – Opāheke Structure Plan Report (April 2019)
- Nathan, E. 2017. Ecology Assessment - Drury Structure Plan. Auckland Council.
- Auckland Unitary Plan (including the online maps).
- National Policy Statement for Freshwater Management (2014).
- National Policy Statement for Indigenous Biodiversity (proposed).
- Cultural Values Assessments from and consultation with Mana Whenua with respect to this proposal.

2.2 FIELD ASSESSMENT

The site walkovers which informed our description of the existing terrestrial and freshwater values took place on 14 February 2019 and 3 April 2019. The weather had been seasonally dry during autumn 2018 and summer and autumn 2018-2019 and ground water levels were generally low – very low.

Access was only available to parts of the Plan Change area and terrestrial plant, bird and mammal species encountered were recorded and where possible communities described.

Watercourses were classified in accordance with Auckland Unitary Plan criteria as provided in Appendix 1, following a review of existing information and in particular Kane-Sanderson *et al*. (2018) and the site visits carried out in February and April 2019. Aquatic habitats and aquatic flora were photographed and briefly described.

3. RESULTS

3.1 ECOLOGICAL CONTEXT

3.1.1 Terrestrial Ecology

The Plan Change area is located within the Manukau Ecological District which together with the Āwhitu and Hunua ecological districts forms the southernmost portion of the Auckland Ecological Region (McEwen 1987).

The Manukau Ecological District was characterised on the basis of geology and topography and encompasses Te Mānukanuka o Hoturoa (Manukau Harbour) as well as the low altitude flat to rolling land between the southern shores of the harbour and the north bank of the Waikato River. The Manukau Ecological District excludes the Āwhitu Peninsula (which comprises the Āwhitu Ecological District to the west) and is bordered to the east by the Hunua Ecological District and to the north by the Tāmaki and Waitākere ecological districts (McEwen 1987). In the south the ecological district boundary departs from the Waikato River near Tuakau, extending to the southeastern corner of the district, which is located west of Pokeno. From the southeastern corner the boundary extends north along the ridgeline which includes Opāheke, and Pukekiwiriki Pā and then travels east to include the Wairoa River mouth at Clevedon, before curving back to Brookby and north to approximately East Tāmaki before extending across to meet the northern shore of the harbour at Manurewa (McEwen 1987).

The Manukau Ecological District comprises around 62 500ha which experiences warm humid summers and mild winters with an annual rainfall of approximately 1100 – 1300 mm (McEwen 1987). Soils are generally well drained loam from old, strongly weathered volcanic ashes and vegetation has been highly modified by human activity particularly for farming and urbanisation (McEwen 1987).

Historically, lowland conifer-broadleaved forest was the most common vegetation type in the Manukau Ecological District, followed by podocarp-broadleaved rainforest, mixed kauri (*Agathis australis*) forest and kauri-hard beech (*Fuscospora truncata*) forest (Emmett *et al*. 2000). Modelling suggests that three forest types dominated across the Drury-Opāheke landscape including pūriri (*Vitex lucens*) forest, kahikatea (*Dacrydium dacrydioides*), pukatea (*Laurelia novae-zelandiae*) forest and taraire (*Beilschmiedia tarairi*), tawa (*B*. *tawa*), podocarp forest (Singers *et a*l. 2017). Pūriri forest would have been located on the flattest and most fertile volcanic or alluvial soils. Kahikatea – pukatea forest would have formed corridors associated with the major streams and wettest lowland areas, with taraire, tawa podocarp forest occurring on slightly more elevated or otherwise more moderately fertile areas (Nathan 2017). All three types would likely have occurred within the Plan Change area, although most of the Plan Change area would have been occupied by pūriri forest, referred to by Singers *et al*. (2017) as forest type WF7.

In 2000 only c. 947ha (1.5%) of the Manukau Ecological District retained any indigenous vegetation cover. The remaining indigenous vegetation was sparse and highly fragmented with 296 fragments of forest, scrub or wetland, with the majority of sites (85%) less than 5ha in size (Emmett *et al*. 2000). The present isolation and scarcity of remnant vegetation patches within the district means that all areas of indigenous vegetation, no matter how small or modified, are important for contributing to the maintenance of biodiversity (Auckland Regional Council 2004). Nathan (2017) also identified a current lack of native vegetation within the wider Drury area of which the Plan Change area is a part, considering that the Drury – Opāheke area generally constitutes a ‘gap’ in ecological connectivity and a barrier to the movement of flora and fauna at the broader landscape scale.

Most fragments of indigenous vegetation remaining within the Manukau Ecological District are located south of Paerata and only 9% of the remaining indigenous vegetation lies within protected natural areas (Auckland Regional Council 2004). More than half of the protected vegetation comprises conservation covenants on private land (Auckland Regional Council 2004).

The Plan Change area is located near (<200m) several terrestrial Significant Ecological Areas (SEA_T) identified in the Auckland Unitary Plan located east of Drury Hills Road and approximately 1.8 – 2.5km south of two small SEA_Ts (SEA_ T 77 at Ponga Road and SEA_T 545 at Sutton Road) as shown in Figure 2. These are both remnant fragments of kahikatea forest (Nathan 2017). These areas qualify

as SEA because they are representative and rare (i.e. they fulfil factors 1 and 2 of the Auckland Unitary Plan's ecological significance factors). Kahikatea forest is regarded as a "critically endangered" ecosystem type in the Auckland region (Singers *et al*. 2017).

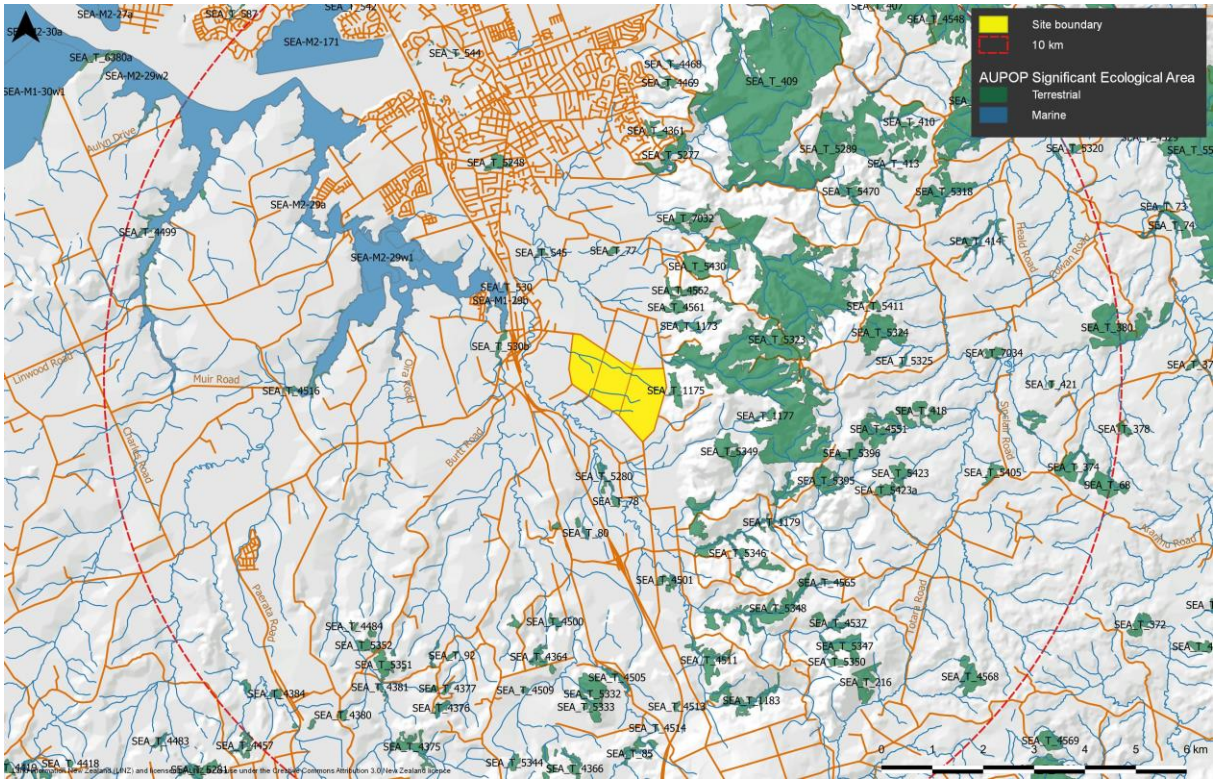


Figure 2: Significant Ecological Areas identified in the Auckland Unitary Plan in the vicinity of the proposed Drury East Plan Change Area

Restoration and protection of indigenous vegetation using a variety of mechanisms and restoring ecological linkages between natural areas were seen as priorities for the Manukau Ecological District by former Auckland Regional Council natural heritage staff in 2004 (Auckland Regional Council 2004). Nathan (2017) also identified that restoration of ecological values in the Drury – Opāheke structure plan area would bridge the gap he identified in ecological connectivity and is thus expected to yield ecological benefits of a larger scale and across a much larger area of the Auckland region.

Existing land use within the Plan Change area comprises mostly farming and lifestyle blocks. Three watercourses and at least six artificial ponds were identified within the site, along with one small remnant which appears to be indigenous forest and several isolated pūriri, totara and kahikatea trees nearby.

3.1.2 Aquatic Ecology

Because of the topography and elevation of the Plan Change area, original freshwater habitats in the area were characterised by low order, low energy watercourses connected to large wetland swamps and fens (Nathan 2017). These wetland areas functioned to attenuate water flows and acted as slow release water storage areas preventing downstream channel scouring, reducing sediment load and minimising flooding. Wetland areas would have harboured a variety of native terrestrial and aquatic flora and fauna, including a high diversity of native macroinvertebrates and fish species (Nathan 2017). They would also have been important food sources for nearby residents. Currently the freshwater habitats within the wider Drury – Opāheke structure plan area are highly modified with degraded habitat and compromised fauna values (Nathan 2017). Stream modifications include channelization and straightening, removal of riparian vegetation, installation of structures such as culverts and dams which affect fish passage and water quality, construction of ponds and pollution. These changes have resulted in low aquatic habitat diversity, low aquatic biodiversity and poor water quality.

Any original wetlands have been drained, filled or otherwise reclaimed, largely for agricultural purposes. These modifications have resulted in a near complete loss of wetland ecosystem types from the area along with the biota dependent on them. The ecosystem services provided by wetland systems including flow attenuation and water quality improvement have also been lost (Nathan 2017).

3.1.3 Coastal Ecology

The Plan Change area is not located immediately adjacent to the coast, however Te Mānukanuka o Hoturoa is the ultimate receiving environment for the streams which drain the site. The Manukau Harbour, together with the Firth of Thames, forms the most important wintering grounds for wading birds in the Southwest Pacific and is considered to be of international significance for wading birds (McEwen 1987). Accordingly parts of Pāhurehure Inlet and the adjoining estuary are mapped as Significant Ecological Areas (Marine) in the Auckland Unitary Plan. An important consideration of upstream developments surrounding the harbour should be the management of sediment and contaminant runoff so as to minimise effects on migratory and other wading birds feeding in the estuary. Coastal ecology is not considered further in this report.

3.2 ECOLOGICAL VALUES

3.2.1 Terrestrial Ecological Values

Indigenous Vegetation

The majority of the vegetation within the Plan Change area is exotic pasture, crops (maize at the time of the first site visit) and exotic trees and shrubs planted for shelter, amenity or as part of gardens. The only example of predominantly indigenous vegetation is a small area of forest located near the corner of Waihoehoe Road and Drury Hills Road as shown in Figure 3. This area is approximately 4,300m^2 (0.43ha) in extent and is surrounded to the north and west by a number of isolated mature pūriri, totara and kahikatea trees in the adjoining paddock. If all the nearby trees are included the area occupied by this vegetation is approximately 2.2ha (22 000m^2).

This small remnant of vegetation is the only indigenous vegetation within the Plan Change area that is likely to have potential value as habitat for native species. These mature trees and the small forest remnant are not identified either as SEA or notable trees on the Auckland Council Unitary Plan maps. The nearest SEA is located approximately 220m east across Drury Hills Road (SEA_T 1175). The small size and isolation of this patch of vegetation from other areas of natural habitat in the wider area limits its ecological value, but there is the potential for enlarging the area and connecting it to other habitats via riparian or other plantings. Pūriri in particular is a reliable source of nectar and fruit for native species because it has flowers and ripe fruit throughout the year. In addition these are mature trees and have potential as habitats for other species of native fauna such as bats and lizards.

Figure 3: Remnant indigenous vegetation within the proposed Drury East Plan Change area

Herpetofauna (Frogs and Lizards)

The Amphibian and Reptile Database administered by the Department of Conservation was searched for records within a 10km radius of the approximate centre of the Plan Change area. There are no records from the Plan Change area itself, but several records from within the search area (shown in Figure 4). No native frogs have been recorded in the search area, although Australian frogs *(Litoria* spp.) do occur there. Similarly, there have been no records of native gecko, probably because of a lack of suitable habitat. Two species of skink have been recorded – the native copper skink (*Oligosoma aeneum*) and the exotic rainbow (or plague) skink (*Lampropholis delicata*). Copper skink occur throughout the North Island and on some offshore islands and are found in forest, shrublands, coastal areas, gardens and rough pasture. They live amongst leaf litter, under rocks, logs or other debris and in dense herbage (e.g. ungrazed grass). Copper skinks are regarded as "not threatened" (Hitchmough *et al.* 2015).

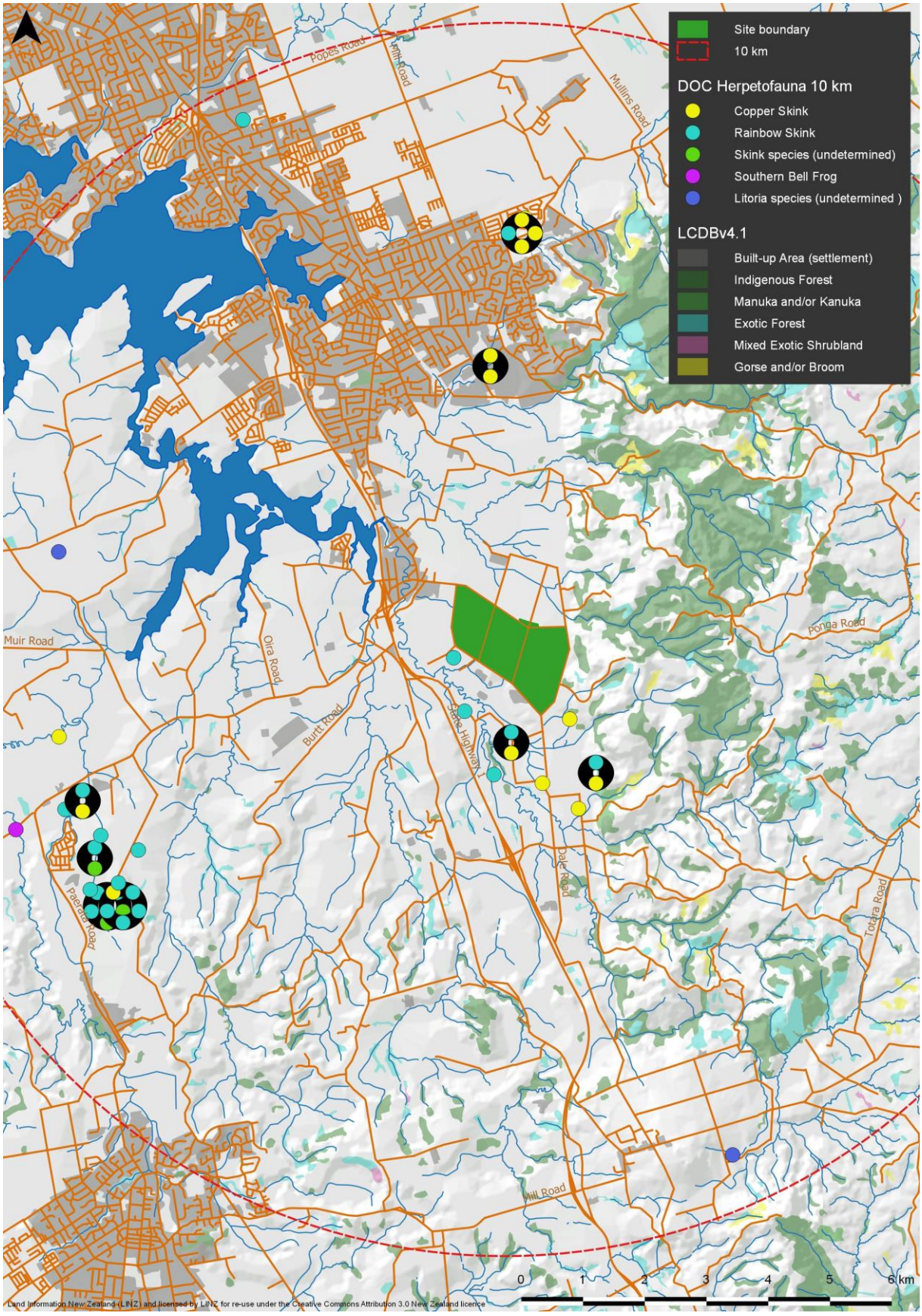


Figure 4: Database Records of frogs and lizards within approximately 10km of the Plan Change area

Pekapeka (Bats)

Pekapeka roost in cavities in mature trees and in the absence of suitable native trees will use exotic tree species or occasionally man-made structures such as bridges and buildings (O'Donnell 2005). Bats forage on the wing for flying invertebrates and often feed near streams and forest edges where invertebrate life is more abundant. Bat home ranges are large and bats can travel tens of kilometres in a night between their roosting and foraging sites. Home ranges include multiple roost sites and bats change roosts often.

Auckland Council bat records indicate the presence of long-tailed bats (*Chalinolobus tuberculatus*) at Ponga Road (approximately 3km north of the Plan Change area) in 2014. However, monitoring completed at Redhill along Hays Stream (approximately 4.7km north of the Plan Change area) in 2013 did not detect bats.

Other surveys by Auckland Council further east in the Hunua Ranges, Waharau and Tapapakanga Regional Parks, south at Mangatangi, north at Totara Park and Clevedon and west at Mauku, Puni and Patumahoe have detected bats, usually in low numbers except at forested sites to the east where numbers were higher. No surveys have been carried out within the structure plan area. Long-tailed bats are regarded as "Threatened (nationally critical)" (O'Donnell *et al*. 2017).

It is possible that long-tailed bats make use of some of the older trees or other habitat within the Plan Change area. The presence of bats in the vicinity indicates that more specific survey for bats is warranted prior to lodgement of any specific resource consent applications pertaining to the Plan Change area.

Birds

A search of the eBird database records within approximately 10km of the Plan Change area revealed records of 78 bird species (or unidentified types of birds), including 31 species of land bird, of which 15 species were introduced and 16 native. The native species of land bird recorded are shown in Table 1 and all birds recorded are provided in Appendix 2. Only three of the species of land birds recorded are of conservation interest (kārearea New Zealand falcon, kākā North Island kaka and mātātā North Island fernbird). Both kākā and kārearea populations are considered to be "recovering" whilst mātātā are "declining" (Robertson *et al*. 2017).

In total, the eBird database has 24,665 records of birds within the radius selected. Of those, one record is of mātātā, four of kārearea and seven of kākā. Thus the number of records for all three species represents a very tiny proportion (0.03% or less) of all bird records for the area. This rarity of records probably reflects the lack of suitable habitat in the wider area for mātātā and kākā, although kākā may visit the gardens and large trees within the Plan Change area seasonally, looking for nectar or other food. Kārearea range over large areas eating mostly small birds (including introduced birds). Kārearea are likely to be fly over the Plan Change area or visit on occasion, but the habitats within the Plan Change area are more likely to form part of a larger home range than core habitat.

As well as land based birds, other native species of water birds (shags, ducks, grebes and the like) and coastal birds (oystercatchers, dotterels, gulls and the like) were also recorded in the area. Nathan (2017) noted that the only records of nationally or regionally threatened bird species occurring in the wider Drury – Opāheke structure plan area were associated with the coastal end of Ngakoroa Stream (all records from SEA_T_530b). Water birds and coastal birds have been excluded here because the Plan Change area does not provide sufficient suitable habitat to support them continuously, even seasonally. As noted by Nathan (2017), some of these species are likely to visit the Plan Change area on occasion, including poaka (pied stilt, *Himantopus leucocephalus*), tarāpunga (red-billed gull, *Larus novaehollandiae scopulinus*) and karoro (Southern black-backed gulls *L*. *dominicanus*) and some are of conservation concern. These species would make temporary use of damp or disturbed pasture for feeding at certain times of the year. This type of habitat is present within the Plan Change area seasonally (e.g prior to crops being sown) and would be used at those times. Creation of wetland habitat within the Plan Change area would benefit water birds, and improvements to water quality downstream would benefit coastal birds in the longer term.

Table 1: Indigenous land-based birds known from within approximately 10km of the site

Scientific name	Common Name	Conservation Status
Bowdleria punctata vealeae	mātātā, North Island fernbird	At risk (declining)
Chrysococcyx lucidus	pīpīwharauroa, shining cuckoo	Not threatened
Circus approximans	kāhu, Australasian harrier	Not threatened
Egretta novaehollandiae	matuku, white-faced heron	Not threatened
Falco novaeseelandiae	kārearea, New Zealand falcon	At risk (recovering)
Gerygone igata	riroriro, grey warbler	Not threatened
Hemiphaga novaeseelandiae	kererū, kukupa, New Zealand pigeon	Not threatened
Hirundo neoxena	warou, welcome swallow	Not threatened
Nestor meridionalis meridionalis	kākā, North Island kaka	At risk (recovering)
Ninox novaeseelandiae	ruru, morepork	Not threatened
Porphyrio melanotus	pūkeko	Not threatened
Prosthemadera novaeseelandiae	tūī	Not threatened
Rhipidura fuliginosa	pīwakawaka, tīrairaka, fantail	Not threatened
Tadorna variegata	pūtangitangi, paradise shelduck	Not threatened
Todiramphus sanctus	kōtare, sacred kingfisher	Not threatened
Zosterops lateralis	tauhou, silvereye, waxeye	Not threatened

3.2.2 Aquatic Ecological Values

Water Courses

The Plan Change area includes three streams which are all first order tributaries of Hingaia Stream. The Hingaia Stream is named for the chieftaness Hingaia and located mostly east of State Highway One, Drury as shown in Figure 1.

Approached from the south, the Hingaia Stream catchment begins just north of Bombay and extends east to Ararimu then north to Opāheke before turning west to the ridgeline known traditionally as Ponga Tarawa (near Drury Hills Road) and following the approximate line of Waihoehoe Road northwest to Drury township and the confluence with Otuwairoa (Slippery Creek). The western boundary approximately follows State Highway One until Ararimu Road, north of which three tributaries located between Great South Road and State Highway One flow northeast crossing under the highway to join the main stem of Hingaia Stream just east of the existing substation.

Hingaia Stream and its tributaries drain the southern and southwestern slopes of the peak known as Opāheke as well as the slopes of Pou Hotiki, Koeko Porowhita (Ballard's Cone), Te Maketu Pā and the area surrounding Pukekura Puna (spring) near Ramarama. The headwater streams which supply Hingaia Stream include Pou Hotiki Hīrere, Maketu Hīrere and Wihikī Hīrere as well as the three unnamed streams which drain the Plan Change area and one other unnamed tributary. Together these streams unite to form Hingaia Stream which flows north to enter Otuwairoa (Slippery Creek) near the State

Highway One Bridge over Otuwairoa. From there the Hingaia Stream discharges to Pāhekeheke Hīrere (Drury Stream) and the Pāhurehure Inlet of Te Mānukanuka o Hoturoa (Manukau Harbour).

The unnamed tributaries of Hingaia Stream within the Plan Change area have been inspected (where possible) and categorised according to the Auckland Council definitions. The stream classifications are shown in Figure 5, but it should be noted that this assessment was undertaken during unusually dry weather and not all sites could be accessed, thus there are some differences between this classification and Auckland Council's assessment of the streams. The stream classifications in Figure 5 have been used as the basis for other interrelated technical assessments and maps to support the plan change.

Figure 5: Stream categorisation of the tributaries of Hingaia Stream within the Plan Change area

As described in Section 3.1.2 above, the watercourses within the Plan Change area have been substantially altered by previous land uses. By way of example, typical current habitats along Stream 2 are shown in Plates 1 – 5 below. These plates show locations along the watercourse from upstream of Cossey Road to downstream of Fielding Road and clearly illustrate the lack of indigenous riparian cover, channelizing, the presence of aquatic weeds such as parrots feather (*Myriophyllum aquaticum*), access to the channel by livestock at some locations and the lack of flow at the time of the site visit.

Plate 1: Stream 2 upstream of Cossey Road

Plate 2: Stream 2, downstream of Cossey Road

Plate 3: Stream 2 upstream of Fielding Road

Plate 4: Stream 2 immediately upstream of Fielding Road

Plate 5: Stream 2 downstream of Fielding Road

Freshwater Fish

The search of the New Zealand Freshwater Fish Database revealed no fish have been recorded within the streams within the Plan Change area, but eight species of native fish (and no exotic species) have been recorded elsewhere in the headwaters of Hingaia Stream. These include:

- Longfin eel (*Anguilla dieffenbachii*)
- Shortfin eel (*Anguilla australis*)
- Common smelt (*Retropinna retropinna*)
- Torrentfish (*Cheimarrichthys fosteri*)
- Banded kokopu (*Galaxias fasciatus*)
- Redfin bully (*Gobiomorphus huttoni*)
- Cran's bully (*Gobiomorphus basalis*)
- Common bully (*Gobiomorphus cotidianus*).

None of these records has been obtained within the last five years. Kane-Sanderson *et al*. (2018) also noted the presence of the exotic pest fish gambusia (*Gambusia affinis*) within the catchment from surveys undertaken by Golder Associates in 2009. The location of records in the Freshwater Fish database is shown in Figure 6. Of these species recorded, longfin eel and common smelt are regarded as "At Risk (Declining)" and the other six species are regarded as "not threatened" (Dunn *et al*. 2018). The streams within the Plan Change area do not provide good habitat for any of these species at

present, although eels are likely to tolerate the present conditions. The permanent streams have the potential for restoration, which would improve aquatic habitat quality in the medium – long term.

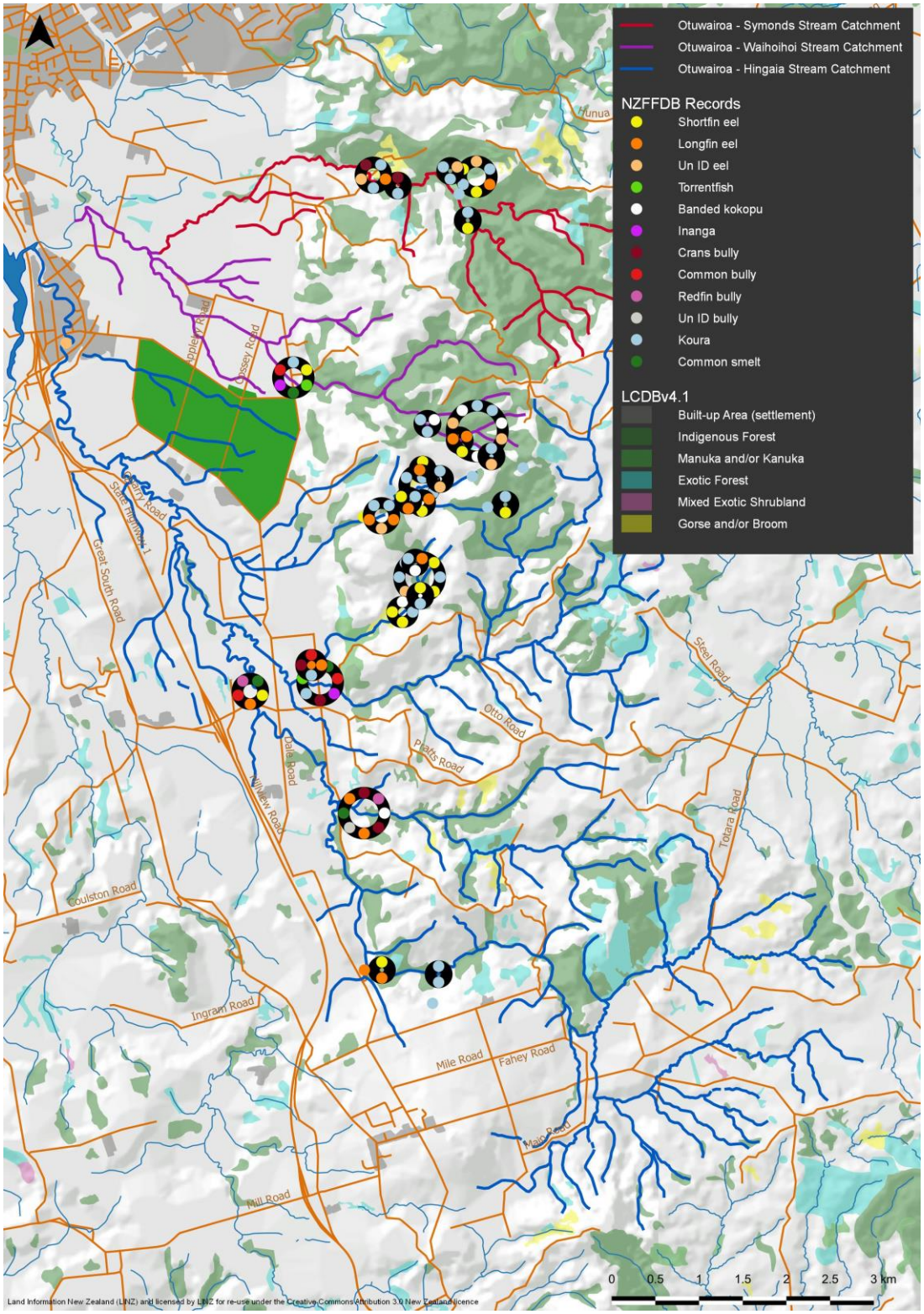


Figure 6: New Zealand Freshwater Fish Database Records for the Hingaia, Waihoihoi and Symonds Streams sub catchments of the Otuwairoa catchment

4. DEVELOPMENT PROPOSAL

4.1 STREAM REMOVAL

The proposed master plan for the Plan Change area is shown in Figure 7. The proposal as shown in Figure 7 would involve the removal of approximately 655m of stream as follows:

- Approximately 188m of intermittent stream;
- Approximately 467m of permanent stream.

Roads, culverts and bridges also affect stream habitats by affecting the hydrology of the surrounding catchment and modifying the magnitude and direction of water movements as well as affecting sediment, nutrient and toxin inputs (Jones *et al*. 2000, Trombulak & Frissell, 2000), which in turn can affect aquatic biota.

Where adverse effects on waterways and/or loss of reaches of intermittent or permanent streams cannot be avoided, then that adverse effect needs to be mitigated or compensated for. The extent of such mitigation is normally calculated using the Environmental Compensation Ratio (ECR) as per the methodology outlined in Auckland Council Technical Report TR2011/009 (Storey *et al*. 2011).

The precise effects of the residential development on aquatic ecological values remain unknown and would be determined using the Environmental Compensation Ratio method (Storey *et al*. 2011) at the resource consents stage of the project when detailed design is available. Calculation of the ECR is based on Stream Ecological Valuations (SEV). The SEV uses a set of fourteen qualitative and quantitative variables to assess the integrity of stream ecological functions. The SEV assessment results in a comprehensive measure of the in-stream and riparian environment. This data is analysed using a series of formulae to derive an SEV score which ranges from 0 (no ecological value) to 1 (a pristine stream with maximum ecological value). The detailed SEV calculations would be undertaken as part of a future resource consent process in accordance with the provisions in E3 of the Auckland Unitary Plan.

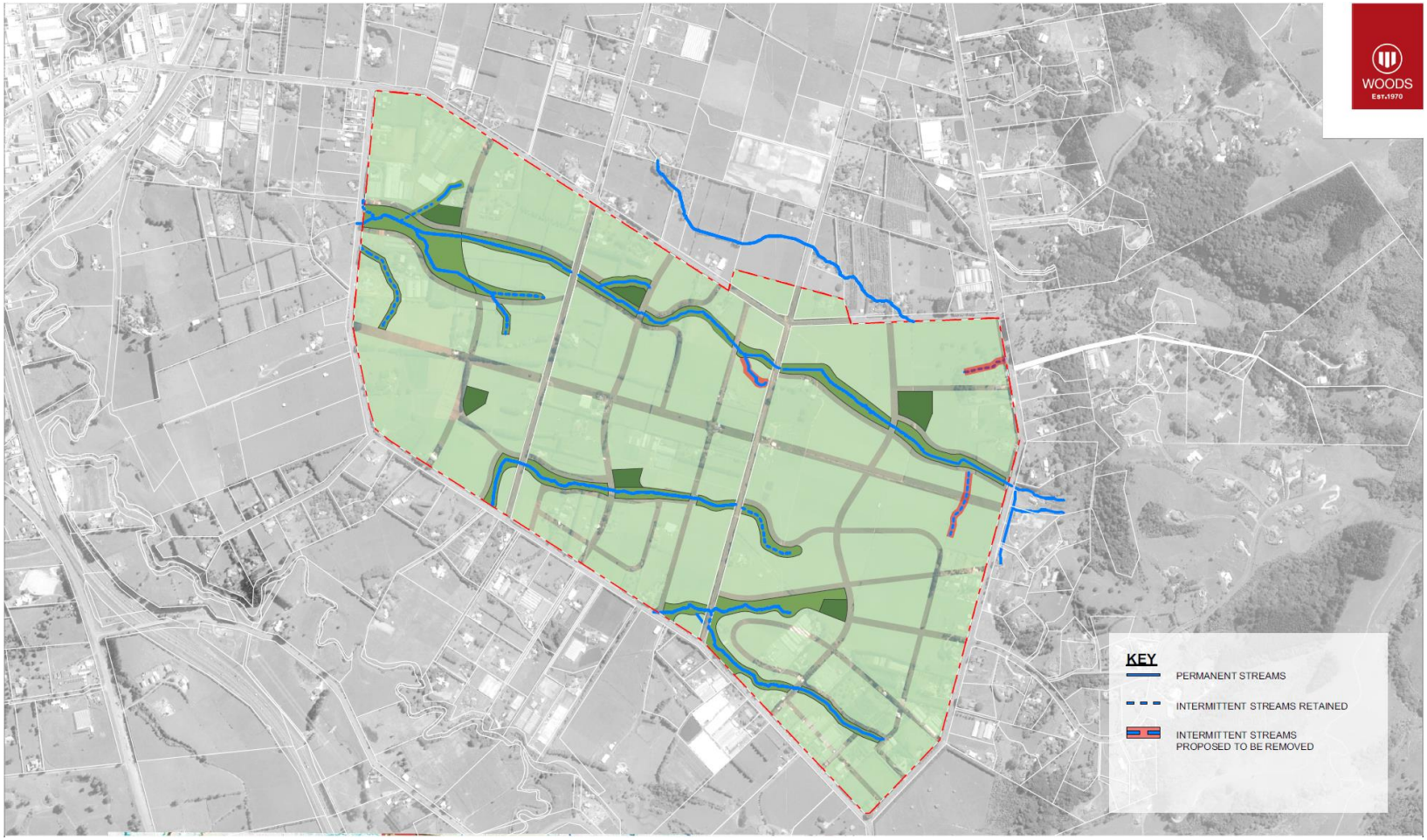


Figure 7: Proposed waterway network at Drury East

4.2 RIPARIAN PLANTING

We have recommended riparian planting of at least 10m each side of intermittent and permanent streams. Planted riparian margins must exclude walkways.

Riparian buffers of 10m either side of retained permanent and intermittent streams would require approximately 10.8ha of riparian planting across the site.

4.3 RESERVE AREAS

Figure 7 includes approximately 2.8ha of proposed parks, but does not include the proposed 2.2ha area which includes the existing forest remnant and surrounding mature trees in the northeast. The exact layout, location, purpose and desirability of reserve areas will need to be agreed with Auckland Council once more detailed design is to hand.

5. RECOMMENDATIONS

The ecological values of the Plan Change area are currently very limited, however there is considerable potential for the ecological values to be restored and enhanced across the Plan Change area as it is developed and for ecological connections to be restored across the wider area via the use of riparian and other plantings.

Section 3.7 of the Drury – Opāheke Structure Plan proposes a "blue – green network" to holistically address the rivers, floodplains, and coastal environments of the area (the "blue" aspects) and the areas of indigenous biodiversity, areas of ecological significance and the parks and reserves (the "green" aspects of the environment) and that proposal has been considered when formulating these recommendations. Ecological restoration of the site should involve:

- Retention of the existing area of indigenous vegetation near the intersection of Waihoehoe Road and Drury Hills Road (which is protected by a consent notice) and if practicable the isolated mature trees nearby. The isolated trees could form part of an open space reserve, but ideally planting would be used to connect the currently isolated trees to the existing stand and create a larger forest fragment which is geographically close to the existing SEA_T areas across Drury Hills Road and would be physically connected (via planting) to riparian areas downstream. As indicated above, the area affected including all the isolated trees and the small remnant covers approximately 2.2ha. Protection of these mature trees has a number of ecological benefits including maintaining a food source and nesting sites for local birds (particularly kererū and tūī), maintaining potential roost sites for long-tailed bats and providing a seed source for natural dispersal of locally adapted individuals elsewhere across the site. This area also includes a watercourse which would benefit from the proposal to establish forest around it and riparian planting would ecologically connect the remnant and stream with downstream vegetation and habitats improving ecological connectivity. The planting should be guided by a planting plan with the aim of restoring pūriri forest to the Plan Change area and make use of plants sourced from the Manukau Ecological District. Unfortunately, both the proposed corridors for the new Mill Road arterial route affect this area and utilisation of Corridor A in particular could result in the complete removal of the remaining forest remnant. Corridor B would bisect the area and would also likely result in vegetation removal. This matter will need to be addressed before the ecological potential of the forest remnant can be realised.

- Planting trees and other vegetation in riparian areas with the aim of increasing the current extent of forest and shrubland, protecting and buffering sensitive sites such as wetlands and forest, connecting habitats and creating a diversity of natural habitat types across the Plan Change area including kahikatea – pukatea forest and taraire – tawa – podocarp forest where appropriate. Creation of wetlands in low or poorly drained sites would also be of direct ecological benefit to local flora and fauna, including birdlife.

- Stream restoration with the aim of maintaining base flows, reducing flooding, improving water quality, reducing stream bank erosion, creating aquatic habitat, reducing water temperature fluctuations and improving fish passage and food sources for aquatic life. Actions to support this outcome would include removal of the existing ponds across the Plan Change area, creation of more natural wetlands at suitable locations (such as the reserve area near the confluence of Stream 1 and Stream 1B), reconfiguring the stream channel to create a variety of channel widths, depths and profiles and restore sinuosity, addition of wood and variably sized inorganic substrates to add to channel complexity and create refuges for fish and invertebrates, installation of fish passages where culverts and other stream crossings are created (if required), riparian planting of at least 10m each side of retained intermittent and permanent streams excluding walkways. The width of any plantings at particular locations could be varied to assist in providing habitat variation, including the creation of ecotones where appropriate.

Given the presence of native fish species elsewhere within the catchment, stream restoration of the type recommended would likely result in the recolonization of the headwater streams where habitats become suitable over the medium – long term. The presence of common native birds means these are also likely to expand across the Plan Change area as habitats improve and become suitable for them, particularly if pest control is maintained throughout the Plan Change area.

If implemented, these recommendations would result in an increase in the extent of native vegetation in the proposed plan change area and improve ecological connectivity and function. They would also buffer and connect habitats and improve water quality and aquatic habitat.

6. CONCLUSIONS

The ecological values at the Plan Change area have been adversely affected by previous land uses which have resulted in the removal of all the previously existing wetlands, almost all of the indigenous vegetation and the degradation of aquatic habitats in streams which have been dammed, diverted and channelized. There are no recognised sites of ecological significance within the affected area. The presence of a tiny (0.4ha) remnant of pūriri forest and three headwater tributaries of Hingaia Stream provide a basis upon which ecological restoration can be built.

Ecological restoration within the Plan Change area should include retention and augmentation of the remaining forest fragment (subject to the location of the proposed Mill Road arterial route), effective weed and pest control, creation of new wetlands at appropriate locations in order to attenuate flows and provide habitat as well as restoration of the streams via reconfiguring of the channels and addition of substrates to increase habitat complexity and provide refuges for fish and invertebrates. Fish passages should also be provided where required. It is most likely that there is sufficient stream habitat within the Plan Change area to be restored to compensate for the areas of stream to be lost. Riparian planting in accordance with a suitable planting plan would improve aquatic habitats, increase habitat diversity and provide ecological connection across the site for mobile species.

The Manukau Ecological District is characterised by a lack of indigenous habitats and the small to very small size and highly fragmented nature of what remains. There is good potential to increase the ecological value of the Drury East site in the medium to long term and contribute to improved local ecological diversity and connectivity by creating and restoring habitats in association with the existing forest remnant and the three headwater streams. These actions would also contribute to ecological connectivity in the wider area between the Hunua Ranges and Te Mānukanuka o Hoturoa in the medium – longer term.

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APPENDIX 1
Auckland Unitary Plan Stream Status Definitions

River or stream

A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).

Permanent river or stream

The continually flowing reaches of any river or stream.

Intermittent stream

Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:

(a) it has natural pools;

(b) it has a well-defined channel, such that the bed and banks can be distinguished;

(c) it contains surface water more than 48 hours after a rain event which results in stream flow;

(d) rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;

(e) organic debris resulting from flood can be seen on the floodplain; or

(f) there is evidence of substrate sorting process, including scour and deposition.

Ephemeral stream

Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.

Overland flow path

Low point in terrain, excluding a permanent watercourse or intermittent river or stream, where surface runoff will flow, with an upstream contributing catchment exceeding 4,000m².

Excludes the following areas:

- constructed depressions and pits within Special Purpose - Quarry Zone.

Artificial watercourse

Constructed watercourses that contain no natural portions from their confluence with a river or stream to their headwaters. Includes:

• canals that supply water to electricity power generation plants;

• farm drainage canals;

• irrigation canals; and

• water supply races.

Excludes:

• naturally occurring watercourses.

APPENDIX 2
EBird records within approximately 10km of the site

Ebird name	Scientific Name	Status	Number of Observations	Rank
African Collared-Dove	*Streptopelia roseogrisea*		1	69=
Australasian Swamphen	*Porphyrio melanotus*		287	23
Australian Magpie	*Gymnorhina tibicen*		705	18
Australian Shoveler	*Spatula rhynchotis*		4	54=
Bar-tailed Godwit	*Limosa lapponica*		21	37
Black Swan	*Cygnus atratus*		7	48=
Black-billed Gull	*Chroicocephalus bulleri*		10	44=
Brown Teal	*Anas chlorotis*		2	63=
Buff-banded Rail	*Gallirallus philippensis*		6	51=
California Quail	*Callipepla californica*		139	26
Canada Goose	*Branta canadensis*		2	63=
Caspian Tern	*Hydroprogne caspia*		6	51=
Common Chaffinch	*Fringilla coelebs*		1298	8
Common Myna	*Acridotheres tristis*		1322	7
Common Redpoll	*Acanthis flammea*		1	69=
Cormorant sp.	*Phalacrocoracidae* sp.		1	69=
Domestic goose sp. (Domestic type)	*Anser* sp. (Domestic type)		2	63=
Dunnock	*Prunella modularis*		2	63=
Eastern Rosella	*Platycercus eximius*		1327	6
Eurasian Blackbird	*Turdus merula*		1569	1
Eurasian Skylark	*Alauda arvensis*		972	13
European Goldfinch	*Carduelis carduelis*		932	14
European Greenfinch	*Chloris chloris*		877	15
European Starling	*Sturnus vulgaris*		1294	9

Fernbird	*Megalurus punctatus*	1	69=
Franklin's Gull	*Leucophaeus pipixcan*	7	48=
Gray Gerygone	*Gerygone igata*	1338	5
Graylag Goose	*Anser anser*	15	42=
Great Cormorant	*Phalacrocorax carbo*	23	35
Great Egret	*Ardea alba*	3	62
House Sparrow	*Passer domesticus*	826	16
Hudsonian Godwit	*Limosa haemastica*	4	54=
Indian Peafowl	*Pavo cristatus*	2	63=
Kelp Gull	*Larus dominicanus*	47	31
Little Black Cormorant	*Phalacrocorax sulcirostris*	20	38
Little Egret	*Egretta garzetta*	1	69=
Little Pied Cormorant	*Microcarbo melanoleucos*	10	44=
Long-tailed Koel	*Urodynamis taitensis*	4	54=
Mallard	*Anas platyrhynchos*	76	28
Mallard (Domestic type)	*Anas platyrhynchos* (Domestic type)	4	54=
Mallard x Pacific Black Duck (hybrid)	*Anas platyrhynchos* x *superciliosa*	16	41
Masked Lapwing	*Vanellus miles*	623	20
New Zealand Falcon	*Falco novaeseelandiae*	4	54=
New Zealand Fantail	*Rhipidura fuliginosa*	1341	4
New Zealand Grebe	*Poliocephalus rufopectus*	26	33=
New Zealand Kaka	*Nestor meridionalis*	7	48=

New Zealand Pigeon	*Hemiphaga novaeseelandiae*	1083	11
Pacific Black Duck	*Anas superciliosa*	5	53
Paradise Shelduck	*Tadorna variegata*	57	29
passerine sp.	*Passeriformes* sp.	4	54=
Pied Cormorant	*Phalacrocorax varius*	15	42=
Pied Stilt	*Himantopus leucocephalus*	43	32
Pied x Black Stilt (hybrid)	*Himantopus leucocephalus* x *novaezelandiae*	1	69=
Red Junglefowl (Domestic type)	*Gallus gallus (Domestic type)*	4	54=
Red Knot	*Calidris canutus*	8	46=
Red-billed Gull	*Chroicocephalus scopulinus*	26	33=
Red-breasted Dotterel	*Charadrius obscurus*	1	69=
Ring-necked Pheasant	*Phasianus colchicus*	663	19
Rock Pigeon	*Columba livia*	17	39=
Royal Spoonbill	*Platalea regia*	17	39=
Sacred Kingfisher	*Todiramphus sanctus*	1208	10
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	247	24
Silver-eye	*Zosterops lateralis*	1030	12
Song Thrush	*Turdus philomelos*	1391	3
South Island Oystercatcher	*Haematopus finschi*	22	36
Southern Boobook	*Ninox novaeseelandiae*	182	25
Spotless Crake	*Zapornia tabuensis*	1	69=
Spotted Dove	*Streptopelia chinensis*	453	22

Sulphur-crested Cockatoo	*Cacatua galerita*		4	54=
Swamp Harrier	*Circus approximans*		777	17
Tui	*Prosthemadera novaeseelandiae*	1439		2
Variable Oystercatcher	*Haematopus unicolor*	8		46=
Welcome Swallow	*Hirundo neoxena*	597		21
White-faced Heron	*Egretta novaehollandiae*	48		30
White-fronted Tern	*Sterna striata*	2		63=
Wild Turkey	*Meleagris gallopavo*	1		69=
Wrybill	*Anarhynchus frontalis*	1		69=
Yellowhammer	*Emberiza citrinella*	125		27
Total observations	78 species or types	**24665**		

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AUTHOR:

Dr Gary Bramley – Ecologist

Gary holds a PhD (Biology, 1999) and an MSc (Hons) in Ecology and has worked as an ecologist since 2000. Prior to that he lectured at the University of Waikato and tutored at Waikato Polytechnic. A Northland local, Gary has a strong knowledge of New Zealand flora and fauna and has produced ten peer reviewed papers and more than 250 technical reports for clients throughout New Zealand from Houhora in the north to Te Anau in the south. His work includes ecological survey and monitoring, producing Assessments of Ecological Significance, Assessments of Environmental Effects, restoration plans, iwi/hapu management plans, weed and pest management plans, drafting resource consent conditions and contributing to policies and plan changes. He has completed the "Making Good Decisions" course for Resource Management Act decision makers and is a member of the Environment Institute of Australia and New Zealand Incorporated. In 2003 Gary received the RFBPS "Old Blue" award for contribution to Conservation in Northland and in 2007 received an award for Contribution in Conservation of Northland's Biodiversity from the Northland Biodiversity Enhancement Group.

DISCLAIMER:

This report was prepared in accordance with the scope of work and for the purpose outlined in Section 1.2 above. This report was prepared between 19 January 2019 and 26 August 2019 and is based on the information obtained and conditions encountered at that time. The Ecology Company disclaims responsibility for any changes that may have occurred after this time. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice.


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COMPANY

09 August 2019

Drury Plan Change

GEOTECHNICAL ASSESSMENT REPORT

Fulton Hogan Land Development Limited

AKL2018-0233AB Rev 3

AKL2018-0233AB		
Date	**Revision**	**Comments**
10 May 2019	A	Initial draft for internal review
10 June 2019	0	Final issue to client
24 June 2019	1	Revised Final issue to client
15 July 2019	2	Revised Zoning, Final Issue to Client
09 August 2019	3	Updated Plan Change area

	Name	**Signature**	**Position**
Prepared by	Andrew Linton		Principal Geotechnical Engineer
Reviewed & Authorised by	Richard Knowles		Principal Geotechnical Engineer, CPEng

Table of Contents

Appendix A: Drawings

1 INTRODUCTION

1.1 Project Brief

CMW Geosciences (CMW) was engaged by Fulton Hogan Land Development Limited (FHLD) to carry out a geotechnical assessment of the Plan Change area which is located within Drury East and bound by Waihoehoe Road, Fitzgerald Road and Drury Hills Road. The Plan Change proposes to rezone this piece of land from Future Urban Zone to a mixture of residential zones.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter AKL2019-0233AA, Rev 0 dated 18 December 2014.

1.2 Scope of Work

The purpose of this report is to describe the assessment undertaken, identify any particular geotechnical risks or limitations to development, and provide geotechnical recommendations for future development of the Plan Change area.

1.3 Background

This report has been prepared to inform the Drury East Residential Plan Change on behalf of FHLD. The boundary of the Plan Change area is shown in Figure 1 in Section 2 below and on Drawing 01 in Appendix A.

The area subject to this Plan Change is located within Drury East and has a land area of approximately 200.2088 hectares. Drury East is contained by the Papakura urban area to the north, the Hunua foothills to the east, the Drury South Business zone to the south, and State Highway 1 to the west. FHLD has large landholdings within the Plan Change extent, which is bound by Fitzgerald Road, Drury Hills Road and Waihoehoe Road. A small area of land north of Waihoehoe Road would also be included in the Plan Change extents due to overall catchments. Currently, the Plan Change area are predominantly used for farming, with some rural lifestyle blocks.

Drury East has an extensive stream and flood plain network which connects headwaters to the Manukau Harbour. The Plan Change area is within the Hingaia Creek catchment and is traversed by several watercourses. The overall topography of the area is relatively undulating, with several low ridgelines.

The Plan Change area is currently zoned Future Urban under the Auckland Unitary Plan. FHLD are seeking to rezone the land for residential development Mixed Housing Urban and Mixed Housing Suburban. The Plan Change provides for a small mixed-use centre within the Plan Change area, as well as a range of public open spaces. New roading and servicing infrastructure is proposed to service the development. Once developed, it is anticipated that the Plan Change area could accommodate approximately 2800 dwellings.

2 SITE DESCRIPTION

2.1 Site Location

The Plan Change area comprises multiple properties to the east of the Drury township, with an area of approximately 200.2088 hectares, and is bound by Waihoehoe Road to the north, Fitzgerald Road to the west and south and Drury Hills Road to the east, as shown on Figure 1 below and Drawing 01 in Appendix A. A small area to the north of Waihoehoe Road will also be included due to catchment gradients.

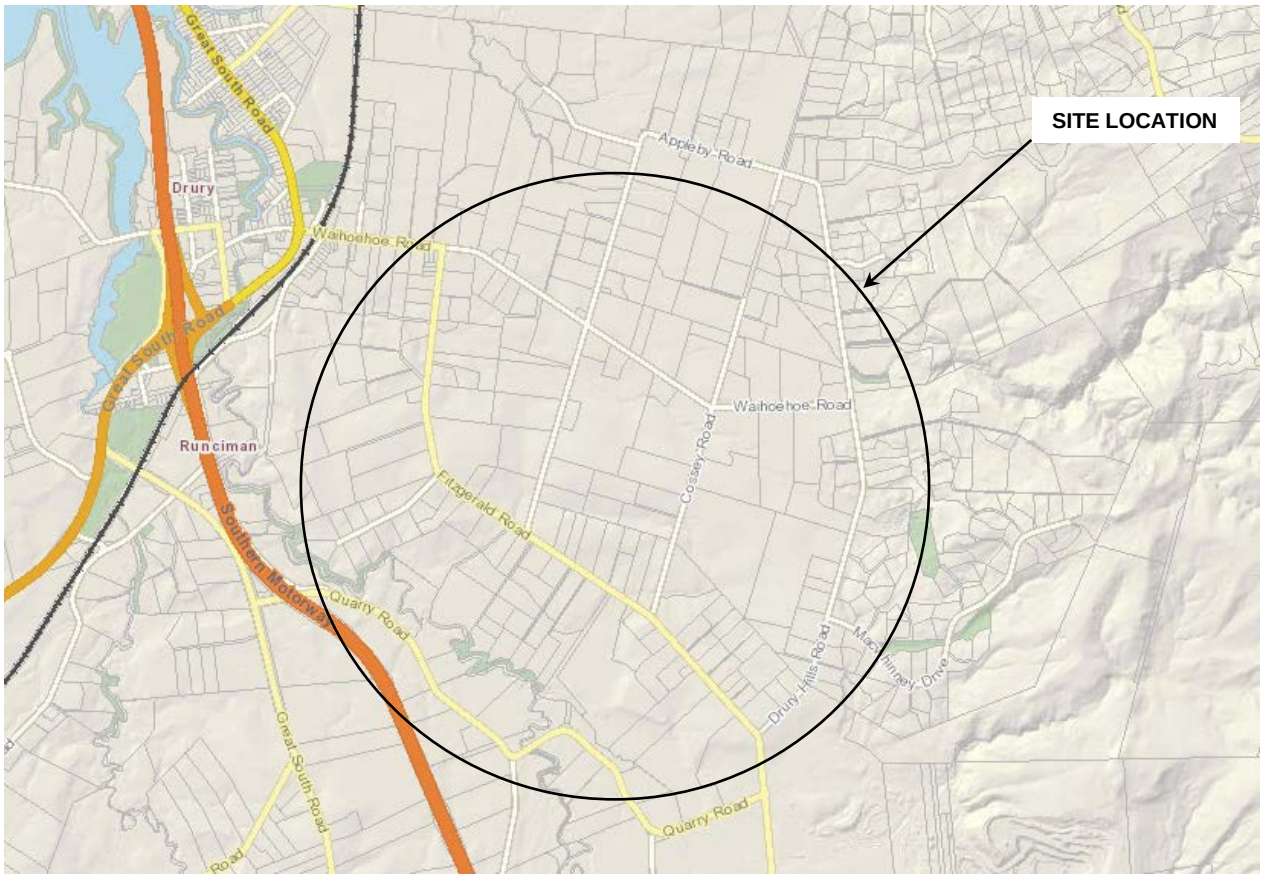

Figure 1: Site Location Plan (Reference: AC GIS)

2.2 Landform

The current general landform, together with associated features located within and adjacent to the Plan Change area is presented on the attached Existing Contours Plan (Drawing 01*)* in Appendix A*.*

The Plan Change area comprises a number of gently graded terraces falling towards the west with broad, shallow gullies bisecting the terraces. A local highpoint is located in the north-eastern corner of the Plan Change area, demarcated by a relatively sharp change in contour compared to the overall topography of the area. Drury Hills Road forms the eastern boundary of the site and essentially runs along the base of the Hunua foothills.

Ground levels grade from a highpoint of RL48m in the north-eastern corner to RL13m on the western boundary, over a distance of approximately 1.8km.

Several small watercourses run through the site, generally falling to the west and eventually discharge into the Hingaia Stream.

Development around the Plan Change area typically comprises either rural residential properties and farm and/or market garden type operations, with numerous residential and farm related dwellings and structures. There are several locations around the overall Plan Change area comprising commercial green-house operations.

3 DESKTOP STUDY

A desktop study of relevant available information has been undertaken as part of our site assessment, and included the following:

1. Aerial photograph review of the Retrolens and Auckland Council GIS database:
    a. 1942, Photoset SN192, Run Number 274;
    b. 1960, Photoset SN583, Run Number 1929B;
    c. 1961, Photoset SN1397, Run Number 3244;
    d. 1969, Photoset SN1875, Run Number 5048;
    e. 1975, Photoset SN3800, Run Number P;
    f. 1981, Photoset SN5783B, Run V,
    g. 1988, Photoset SN8772, Run V.
    h. AC GIS 1996,
    i. AC GIS 2003/2004,
    j. AC GIS 2006
    k. AC GIS 2008
    l. AC GIS 2010 / 2011
    m. AC HIS 2015/2016
    n. AC GIS 2017
2. IGNS, Geology of the Auckland Area, 1:250,000 Geological Map 3
3. Beca Carter Hollings & Ferner Ltd, Drury Fault Investigation, Ref 2012030, Dated August 2005
4. Beca Infrastructure Limited, Drury Project – Geotechnical Factual Report, Ref 3910474 // NZ1-1762748-10, Dated 1 July 2009
5. Beca Infrastructure Limited, Drury South Business Project Geotechnical Appraisal, Ref 3910474 // NZ1-2300665-23, Dated 10 February 2010
6. Beca Infrastructure Limited, Drury South Project – Geotechnical Addendum Report, Ref 3910474//NZ1-7132642-5, Dated 30 April 2013
7. Geoscience, Due Diligence Geotechnical Review, Project KEA, Drury, Auckland, Job Ref. 11294.0, Dated 08-09-2014
8. Gaia Engineers, Ararimu Development, Geotechnical Factual Report, Ref. 2053/04, Dated 20 April 2015
9. Ministry for the Environment Guidelines, “Planning for Development of Land on or Close to Active Faults.”, July 2003

4 HISTORICAL DEVELOPMENT

The aerial photograph review indicates historic development across the Plan Change area has been as follows:

- In 1942 the majority of the Plan Change area had been cleared and was being used as pasture. There were isolated small areas of bush and a larger bush area was located at the western end of the Plan Change area. Residential dwellings and farm buildings were located across the site. Fielding Road and Cossey Road had yet to be formed
- By 1960 the larger bush area had been felled and the remaining areas of bush had also decreased in number and scale. Pasture remained the predominant land-use. Cossey Road had been formed.
- The 1961 photos show Fielding Road had been formed.
- By 1981 development in the area had increased. There were more dwellings and structures across the overall Plan Change area. Green-houses and market gardens / orchards had started to appear in the north-west and south-east portions of the Plan Change area. There was evidence of the Vector Transmission line to the west of Fielding Road. Shelter belts were growing along numerous fence lines across the Plan Change area, particularly around the orchard/garden areas.
- By 1988 more green-houses and market gardens / orchards were present across the Plan Change area. Additional houses had also been built.
- Development across the site in 1996 is broadly similar to 1988, although it appeared that some orchard/garden areas had reverted to pasture. A pond of some description had been developed in Lot 56 DP 119.
- By 2003/2004 pasture in the centre of the Plan Change area appeared to be being converted to garden areas. A second pond had been formed in Lot 56 DP 119. More houses across the Plan Change area.
- In 2006 there was little change. A greenhouse at 319 Waihoehoe Road had been demolished.
- In 2010/2011, minimal change.
- In 2015/2016, market gardens were being developed in the south-west corner of the Plan Change area. Green-houses at 86 Fitzgerald Road and 37 Cossey Road had been removed. An additional green-house at 112 Cossey Road had been built. Significant areas across Lots 53, 56 and 57, DP 119 Lot 5 DP 185120 and Lot 2 DP487007 had been developed into market gardens.
- By 2017, the ponds in Lot 5 DP119 had been filled. Minimal other changes.

5 PUBLISHED GEOLOGY

Published geological maps[1] for the area (see Figure 2) depict the regional geology as comprising:

- Predominantly volcanic deposits from the South Auckland Volcanic Field (Qvs), consisting of basalt and scoria with areas of ash, lapilli and lithic tuff;
- Some of the western margin is mapped as being underlain by the Pleistocene aged Puketoka Formation (Pup), comprising alluvial deposits of pumiceous mud, sand and gravel with muddy black peat and lignite; rhyolite pumice, including non-welded ignimbrite, tephra and alluvial pumice deposits.
- Isolated areas of more recent Holocene aged Tauranga Group materials (Q1a), comprising alluvial/colluvial deposits.

[1] Edbrooke, S.W. (compiler) 2001. Geology of the Auckland area. Institute of Geological and Nuclear Sciences 1:250,000 geological map 3. 1 sheet + 74p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited.

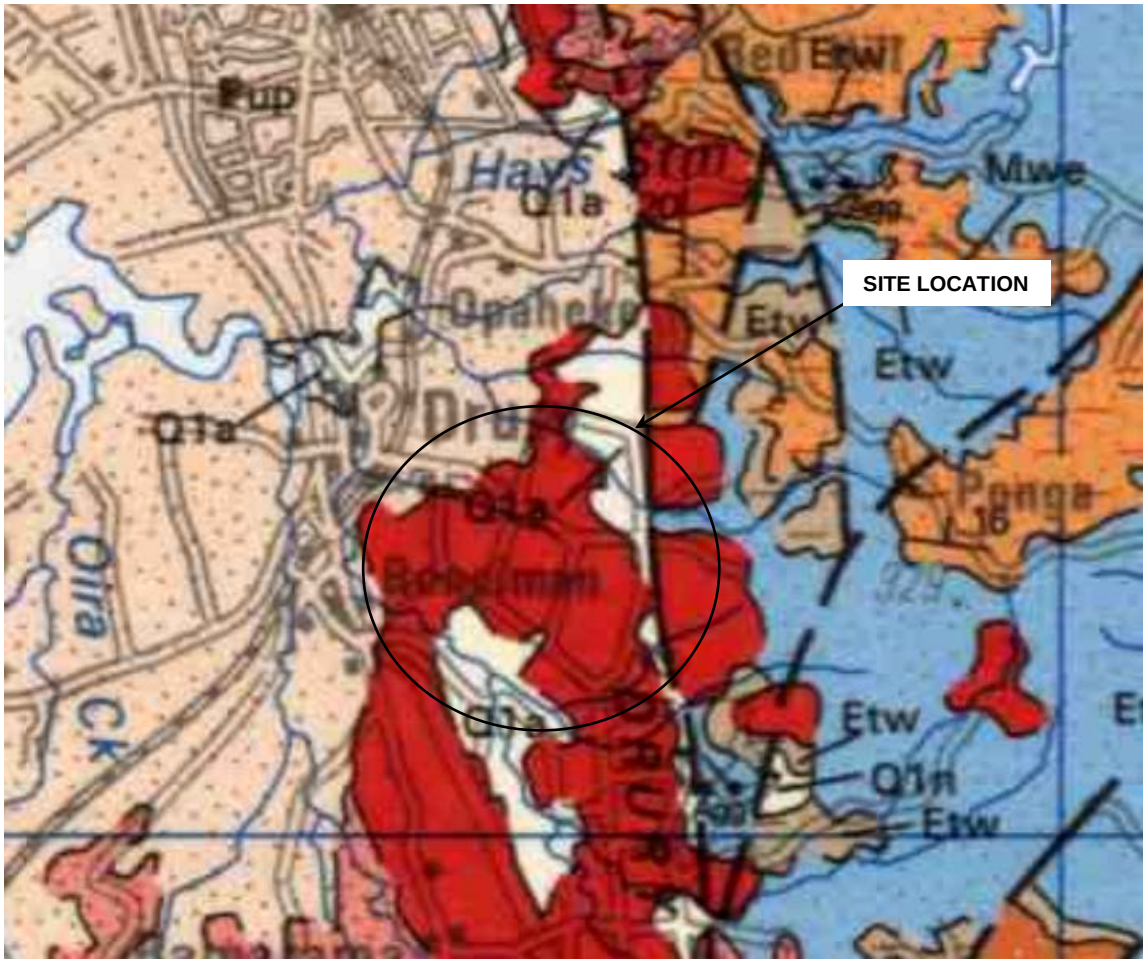

Figure 2: Regional Geology (GNS)

Based on the known history of the Plan Change area and surrounding land uses, some superficial depths of fill would also be anticipated as a result of landscaping and/or minor earthworks during prior development and infilling of ponds.

6 GEOHAZARDS ASSESSMENT

6.1 Context

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. Although subdivision is not currently proposed, it will be an expected result of the Plan Change process. Accordingly, we have undertaken a natural hazard assessment of the overall Plan Change area in accordance with the Act. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

The following sections of this report provide an assessment of the geohazards relevant to this Plan Change area.

6.2 Faulting and Seismicity

6.2.1 Drury Fault

The Plan Change area is located in close proximity to the mapped alignment of the Drury Fault, which trends in a NNW direction along the base of the Hunua foothills. The alignment of the fault is included on the Geological Map prepared by Edbrooke (2001) as shown in Figure 2 and at its nearest is indicated to run along the eastern edge of Drury Hills Road in the north-east corner of the site.

The fault is not included in the Geologic and Nuclear Sciences (GNS) database of Active New Zealand Faults. Beca undertook specific investigation of the Drury Fault in 2005 to assess whether this fault could be considered active (known movement within the past 125,000 years).

The Beca report determined that the most recent fault movement (or rupture) likely occurred some 45,000 years ago, with slip rates estimated in the range of 0.01mm to 0.03mm per year. On this basis, the Drury Fault could be considered active.

The site investigation information and topographic data obtained by Beca (2005) indicates that the mapped alignment of the fault as presented by Edbrooke (2001) is relatively accurate to within +/- 5m.

6.2.2 Wairoa North Fault

A second fault, the Wairoa North Fault is located some 12km to the east of the Plan Change area and is included in the GNS Active Fault database. Although the recurrence interval for movement along this fault has yet to be determined, a low vertical slip rate of between 0.1mm and 0.3mm per year has been reported by Edbrooke (2201) and Wise (1999) respectively.

6.2.3 Fault Rupture Risk

The MfE Guidelines define a “Fault Avoidance Zone” as “an area created by establishing a buffer zone either side of the known fault trace (or the identified likely fault rupture zone that appears on the land surface)”. They recommend a minimum buffer zone of 20m either side of the know fault trace or likely fault rupture zone.

As noted above, the nearest location of the Drury Fault alignment is indicated to run along the eastern edge of Drury Hills Road. Given the width of this road is 20m, it is unlikely that the fault rupture zone would have an impact on future development of the site. However, this should be considered in more detail as part of any future development proposals.

The Wairoa North Fault is not considered capable of causing a ground rupture risk due to the distance to this fault.

6.3 Liquefaction

6.3.1 General

Soil liquefaction is a process where typically saturated, granular soils develop excess pore water pressures during cyclic (earthquake) loading that exceed the effective stress of the soil. In loose soils, some dilation can occur during this process, which can lead to individual soil grains moving into suspension. Following the onset of liquefaction, the shear strength and stiffness of the liquefied soil is effectively lost causing excessive differential settlement of the ground surface, bearing capacity failure and collapse of structures and low-angle lateral spreading of slopes in liquefiable soils.

In accordance with NZGS guidance[2] the liquefaction susceptibility of the soils within the Plan Change area has been considered with respect to geological age, soil fabric and soil consistency / density.

6.3.2 Geological Age

The vast majority of case history data compiled in empirical charts for liquefaction evaluation come from Holocene deposits or man-made fills (Seed and Idriss, 1971). Youd and Perkins, 1978 also state that young Holocene age (15,000 years) sediments and man-made fills are susceptible to liquefaction. Table 1 of Idriss and Boulanger (extracted from Youd and Perkins (1978)), presents the susceptibility of soil deposits to liquefaction based on geological age, which states that Pleistocene aged alluvium (>12,000 years), as indicated to be present along the western margins of the site, has a very low to low risk of liquefaction.

The recent alluvium, units Q1a, if present within the Plan Change area, are of Holocene geological age and therefore, in terms of geological age, are considered potentially susceptible to liquefaction. Specific site investigations would be required to confirm the presence, or otherwise, of these materials and the potential liquefaction risk associated with them on future development.

Across the elevated terraces, volcanic deposits are indicated to be present and are considered to be at low risk of liquefaction.

6.3.3 Soil Fabric

Soils are also classified with respect to their grain size and plasticity to assess liquefaction susceptibility. Based on more recent case histories, there is general agreement that sands, non-plastic silts, gravels and their mixtures form soils that are susceptible to liquefaction. Clays, although they may significantly soften under cyclic loading, do not exhibit liquefaction features, and therefore are not considered liquefiable. NZGS guidance sets out the plasticity index (PI) criteria for liquefaction susceptibility as follows:

PI < 7: Susceptible to Liquefaction

7 ≤ PI ≥ 12: Potentially Susceptible to Liquefaction

PI ≥ 12: Not Susceptible to Liquefaction

The fines content of any sands beneath the Plan Change area also has a significant impact on their liquefaction susceptibility.

Specific soil grading / plasticity index laboratory test results are not available for the site soils. However based on our experience in the area and with similar soils, and laboratory data associated with the adjacent Drury South development, the site soils are expected to generally have a PI greater than 12 and are therefore not considered liquefiable.

[2] Earthquake Geotechnical Engineering Practice, Module 3: Identification, assessment and mitigation of liquefaction hazards", (May 2016)

6.4 Lateral Spread

Following the onset of liquefaction, the liquefied soils behave as a very weak undrained material, which can give rise to lateral spreading where a free face is present within the vicinity of the site or where proposed cut and fill batters are proposed over or within liquefied soils.

Although likely to be a low risk, the potential for localised lateral spread may be higher adjacent to the existing watercourses and should be assessed as part of future development proposals.

6.5 Slope Stability

Overall the Plan Change area is gently graded and we expect development proposals are unlikely to require significant batter slopes. Existing cut batters within the site, generally associated with road formation, appear to be generally stable at relatively steep gradients. Nonetheless, slope stability will need to be assessed as part of any future development proposals.

6.6 Settlement

Fill embankments and / or future building loads could induce settlements within soft underlying subsoils. In general, this hazard is considered to be relatively low, but will require site specific investigation and assessment to confirm, once development proposals are available.

6.7 Expansive Soils

NZS 3604:2011 excludes from the definition of 'good ground', soils with a liquid limit of more than 50% and a linear shrinkage of more than 15% due to their potential to shrink and swell as a result of seasonal fluctuations in water content.

This shrinking and swelling results in vertical surface ground movement which can cause significant cracking of floor slabs and walls. There have been instances of concrete floors and/ or foundations that have been poured on dry, desiccated subgrades in summer months on expansive soils and have undergone heaving and cracking requiring extensive repairs or re-building once the soil moisture contents have returned to higher levels.

Based on our experience in the area and in similar soils, we consider that expansive soil deposits are likely to occur across the site.

Mitigation of the expansive soil hazard is undertaken by a combination of appropriate foundation design selection at Building Consent stage and appropriate moisture control within subgrade soils during construction. Foundation contractors must be made aware of this issue and the need to maintain appropriate moisture contents in the footings and building platform subgrade between the time of excavation and pouring concrete.

Remedial actions that may be appropriate include platform protection with a hard fill layer, pouring of a blinding layer of concrete in footing bases and soaking of the building platform with sprinklers for an extended period.

Home owners must also be made aware that the planting of high water demand plants where their roots may extend close to footings can also cause settlement damage.

6.8 Earthworks

Site soils are considered to be generally suitable for bulk earthworks operations. Conditioning of some areas may be required to ensure appropriate moisture contents are achieved prior to compaction.

All earthwork activities must be carried out in general accordance with the requirements of NZS 4431 and the requirements of the Auckland Council Infrastructure Development Code under the guidance of a Chartered Professional Geotechnical Engineer.

Specific requirements will need to be evaluated during site specific investigations and design as part of future development proposals.

6.9 Foundation Bearing Capacity

Once bulk earthworks are completed, a preliminary geotechnical ultimate bearing pressure of 300kPa should be available for shallow strip and pad foundations constructed within both the natural cut ground and engineered fill areas, subject to site specific investigations and recommendations developed as part of future development assessment.

There may be areas where localised variations in shear strength within the natural cut ground occur, particularly where the depth of cut varies across the building platforms. Further confirmation of available bearing pressures will be addressed at the time of post earthworks soil testing and preparation of the Geotechnical Completion Report (GCR) for the development.

6.10 Erosion

Overall erosion is considered to be a relatively low risk across the Plan Change area. However, some volcanic and alluvial deposits, including pumiceous silt beds, can be more susceptible to erosion action. Accordingly, any proposed cut and/or fill batters should be specifically assessed in relation to this hazard as part of site specific investigations and design.

6.11 Stormwater

Site specific testing has not been undertaken to assess suitability of Plan Change area soils for stormwater soakage design.

However, based on our experience in similar soils, we consider that the site soils are likely to provide moderate soakage capability. This should be confirmed with specific testing as part of detailed stormwater design.

7 CONCLUSION

Based on the desk-top study undertaken, in conjunction with our general understanding of ground conditions across the Plan Change area, we expect the Plan Change area can be satisfactorily developed from a geotechnical perspective using normal engineering techniques.

Appendix A: Drawings

AKL2018-0233 Drawing 01 - Existing Contours Plan
AKL2018-0233 Drawing 02 - Geological Plan

LEGEND:

SITE BOUNDARY

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS MAP

1:10 000 0 100 200 300 400 500 m

CMW Geosciences

CLIENT: FULTON HOGAN LAND DEVELOPMENT		DRAWN: FMS	PROJECT No: AKL2018-0233
PROJECT: DRURY DEVELOPMENT PLAN CHANGE		CHECKED: AL	DRAWING: 01
		REVISION: 0	SCALE: 1:10000
TITLE: EXISTING CONTOUR PLAN		DATE: 30/05/2019	SHEET: A3

X:\01 PROJECTS\AKL\AKL2018\AKL2018-0201-0250\AKL2018-0233 - DRURY PLAN CHANGE\07 DRAWINGS\CAD\AKL2018-0233-FIG 01 SITE PLAN REV 0.DWG

LEGEND:

- SITE BOUNDARY
- INFERRED ALLUVIAL DEPOSITS
- INFERRED BASALT

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS MAP

1:10 000 — 0 100 200 300 400 500 m

CMW Geosciences

CLIENT: FULTON HOGAN LAND DEVELOPMENT		DRAWN: FMS	PROJECT No: AKL2018-0233
PROJECT: DRURY DEVELOPMENT PLAN CHANGE		CHECKED: AL	DRAWING: 02
		REVISION: 0	SCALE: 1:10000
TITLE: INFERRED GEOLOGY PLAN		DATE: 30/05/2019	SHEET: A3

X:\01 PROJECTS\AKL\AKL2018\AKL2018-0201-0250\AKL2018-0233 - DRURY PLAN CHANGE\07 DRAWINGS\CAD\AKL2018-0233-FIG 01 SITE PLAN REV 0.DWG