Hingaia Stream Catchment Watercourse Assessment Report

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Hingaia Stream Catchment Watercourse Assessment Report

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Executive Summary

Presented below is the Watercourse Assessment Report (WAR) for the Hingaia Stream catchment, a large catchment located in the south of the Auckland Region (Table 1). Watercourse Assessments are designed to provide meaningful baseline information on the existing ecological condition and state of stormwater infrastructure within a waterway. Information collected will inform effective management of:

- Stream ecological health,
- Stormwater infrastructure; and
- Stormwater conveyance.

4Sight Consulting and Urban Solutions, on behalf of Auckland Council, carried out an extensive survey of the Hingaia Stream watercourses between February and May 2018. The survey was conducted in accordance with the Watercourse Assessment Methodology: Infrastructure and Ecology (Version 2.0). Additionally, Stream Ecological Valuations (SEVs) were carried out at five representative sites within the catchment in late May 2018.

Overall 177,056 m of watercourse were surveyed, of which 166,324 m (94%) was classified as permanent or intermittent stream. This largely rural catchment spans from the Bombay Hills in the south to the Drury township in the north. Significant sub-catchments, including the Maketu Stream, also drain the steep hill country associated with the foothills of the Hunua Ranges to the east. Watercourses within the catchment were predominantly soft-bottomed, although hard-bottomed streams were common in steeper areas. At Drury, the Hingaia Stream converges with Slippery Creek and drains into the Manukau Harbour via Drury Creek.

The lower reaches of the catchment have been identified by Auckland Council as a future growth area, designed to help support Auckland City's growing population. Significant development is already underway within Drury South industrial and residential developments, while additional land associated with the Opaheke - Drury Future Urban Zone is likely to be development ready by 2028. This will likely result in rapid changes to the form and functionality of watercourses within the lower Hingaia Stream catchment over the next few decades. The lower catchment is also known to be flood prone and a major challenge will be to balance the needs of development with the requirement for appropriate flood management.

Stream characteristics recorded during the survey were reflective of a predominantly rural catchment used intensively for agricultural purposes. Stream channels typically had steep banks, lacked effective riparian vegetation and were prone to erosion. Poor fencing of stream channels through the agricultural areas, particularly in the east and south of the catchment, has allowed stock to access and further damage many watercourses. The

exception to this was in the many well vegetated gullies found in the eastern hill country. Here stream channels were well shaded, contained mature native vegetation and were often hard-bottomed. However, these vegetated gullies were often fragmented by farmland. More than 300 natural wetlands were recorded through the catchment. These were mostly around smaller streams channels or the margins of larger channels. Many have been degraded as a consequence of stock damage. Artificial wetlands were largely farm ponds and aesthetic ponds, though several wetlands existed due to blocked or flooded culverts.

Scores from Stream Ecological Valuation (SEV) assessments from five sites showed considerable variation through the catchment with a high SEV score recorded in a section of hard-bottomed stream within native bush in the east of the catchment. Low SEV scores were recorded in rural and semi urban areas in the north and south of the catchment and a moderate SEV score recorded from the mid catchment, where a hard-bottomed stream was surrounded by a mixture of native bush and farmland.

Approximately 70% of all assets (inlets / outlets and pipes / culverts) surveyed were privately owned assets in rural areas, so were subjected to abridged and/or limited forms of the assessment methodology. In general, assets were functional in terms of conveying stormwater, but significant erosion issues were identified with inlet/outlets while fish passage issues were common with pipes/culverts. Fish passage issues were also recorded as a result of the many natural waterfalls that were present through the steeper, typically hard-bottomed areas of the catchment. Prioritisation of the remediation of man-made fish passage issues should take into consideration the location of existing significant natural barriers to fish passage. A small number of culverts were recorded as a potential flood risk and require maintenance such as debris removal to restore functionality.

Four key management zones were identified within the catchment based on stream reaches with similar characteristics and facing similar land use pressures. Management Zone 1 is located around developed, developing and future urban land in the lower catchment and floodplain, and is the zone where there is the most potential for stream enhancement to occur. Much of the stream enhancement in this Zone could be achieved through leveraging developer led initiatives for stream restoration, conveyance improvements and amenity enhancements or improving existing public land. Management Zones 2, 3 and 4 are all within rural sections of the catchment and focus on improving stream health and conveyance issues at a local and catchment level. Achieving management goals and objectives in Zones 2, 3 and 4, will likely require a collaborative approach between Council, landowners, businesses and community groups.

Key management goals and objectives identified for the Hingaia Stream catchment include:

- Encouraging and supporting landowners to protect and restore or enhance riparian zones.
- Looking to develop large scale riparian planting projects as a way of helping to control flood management through the catchment by improving source control. Involve multiple stakeholders in these projects where possible.
- Addressing inlet/outlet erosion issues, particularly within the future urban zones where they may be exacerbated as land becomes developed.
- Aiming to remove stock access to watercourses through fencing and the implementation of riparian buffers.
- Providing ecological and amenity focused linkages through the catchment.
- Providing linkages, both ecological and amenity, through the enhancement of existing esplanade reserves and those that will be triggered by development.
- Improving fish passage to sections of stream where natural structures are not already forming highly restrictive fish barriers.
- Determining ownership of stormwater assets with unknown ownership or those that have been recorded as Council owned but are not currently in Council GIS systems.

Table 1: Summary of Survey Area

Est. Length of Permanent and Intermittent Stream (m)	166,324 (estimated from OLFP with catchments >2ha)					
Total Length of Surveyed Watercourse (m)	177,056					
Catchment Area (km^2)	54.9					
Catchment Imperviousness	3.2%					
Receiving Environment	Drury Creek, Pahurehure Inlet, Manukau Harbor					
Dominant Substrate	Silt/Sand					
Vegetation	**0 – 10 %**	**10-30%**	**30-50%**	**50-70%**	**70-90%**	**>90%**
Average Overhead Cover (% of total stream length)	44.0%	14.1%	10.1%	10.5%	13.5%	7.8%
Wetlands	**Natural**			**Artificial**		
Number of Wetlands	303			196		
Erosion	**Excellent**	**Good**	**Fair**	**Poor**		
Overall Stability Index (% of total stream length)	0.1% Scores ≤13	3.5% Scores 14- 23	74.9% Scores 24 -32	21.5% Scores ≥33		
	Percentage of reaches with >60% erosion scarring		**Total No. Erosion hotspots**			
	2		134			
Engineered Assets	**Total No.**	**Poor-Very Poor Condition**	**Incorrect in GIS**	**Accessible Unsafe Drops >1.5m**		
Inlet and Outlet Structures	481	40*	0	15		
Pipes and Culverts	918	25*	0	-		
Bank and Channel Lining (total length (m))	3,300	14	na	88.3		
Fish	**No. of species observed**	**Percentage of fish points with suitable habitat**	**Percentage of reaches with suitable habitat**			
	12	37	17			
Potential Barriers to Fish Passage	**Swimmers**	**Climbers**	**Anguilliforms**			
Natural Structures	469	121	22			
Inlets and Outlet Structures	69	39	15			
Pipes and Culverts	358	237	102			

*Includes abridged assessment assets in poor or very poor condition

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1.0 Introduction

1.1 Scope

Auckland's population is projected to grow by approximately 500,000 – 1,000,000 people by 2043, requiring an additional 400,000 dwellings and 277,000 jobs (Auckland Council, 2017a). The Auckland Unitary Plan identifies the area around the existing Drury Township as a key growth area in helping to accommodate the anticipated population growth as well as the associated increases in infrastructure, housing and employment. Consequently, 2,546 ha of land surrounding the Drury Township was zoned as greenfield (undeveloped) land that would suitable for urbanisation (Auckland Council, 2017a). This was divided into three future urban areas: Drury West, Opaheke - Drury and Drury South, all designed to be development ready at different time periods over the next 15 years.

Bisecting the Drury Township is the Hingaia Stream which contains approximately 173.5 km of watercourse network spanning from Drury Township in the north to the Bombay Hills in the south. To the east the catchment drains the foothills of the Hunua Ranges, while its western edge runs roughly along State Highway 1 (Southern Motorway). The lower catchment contains the Drury South Future Urban area as well as part of the Opaheke - Drury Future Urban Area. Drury South is currently in the early stages of development, while Opaheke - Drury Future Urban area is likely to become development ready between 2028 and 2032. Auckland Council is in the process of developing a draft Structure Plan for the Future Urban Zone around Drury, which will provide a vision for development of the area (Auckland Council, 2017b). A number of technical reports have been developed to support the Drury structure planning process, however Auckland Council saw the benefit of also obtaining baseline information on the watercourses within the catchment, including built and natural features, to expand the understanding of the current state of the watercourses, identify key issues likely to be exacerbated by development, and guide ongoing management and enhancement of the catchment.

4Sight Consulting (4Sight) were commissioned by the Auckland Council Healthy Waters Unit to undertake a Watercourse Assessment and prepare the ensuing Watercourse Assessment Report (WAR), including an associated map series and completed geodatabase, for the section of the Hingaia Stream catchment within the Auckland Regional boundaries.

The scope of this project included:

- An assessment of the entire stream length within the Auckland Region (173.5 km), outlined in the Hingaia Stream Catchment scoping map (dated 8 May 2017) following the Watercourse Assessment Methodology: Infrastructure and Ecology Document (Version 2.0).

- An assessment of all stormwater assets interacting with the watercourse as per the Watercourse Assessment Methodology: Infrastructure and Ecology Document (Version 2.0). This included assets not shown on existing Auckland Council GIS layers, or the scoping map.
- An assessment of all other features associated with the watercourse as per Section Three of the Watercourse Assessment Methodology: Infrastructure and Ecology Document (Version 2.0).
- The identification, and selection, of five Stream Ecological Valuation (SEV) sites following Appendix B Ancillary in the Watercourse Assessment Methodology (Protocols – Stream Ecological Valuation (SEV) protocols for guidance in selecting SEV site locations).
- Completion of five SEV site assessments following AC methodology, including additional variables outlined in Watercourse Assessment Methodology: Infrastructure and Ecology Document (Version 2.0).

A breakdown of all tasks required within the scope of a Watercourse Assessment are displayed in Table 2.

Alterations to Watercourse Assessment Methodology:

- Because only one tributary within the catchment, other than the main Hingaia Stream channel had a known name, the stream numbering conventions set out in the Watercourse Assessment Methodology (Sections 3.1.1.1 and 3.1.1.2) were not followed in this report. As an alternative, streams were coded based on their order (Turner et al. 2017), with additional codes to identify named streams. An example of the coding system can be found in Appendix D.
- The Watercourse Assessment Methodology states that only limited information is to be collected on all rural, private assets (inlets / outlets and culverts / pipes) unless they have a significant issue associated with their structure, erosion or fish passage. For such assets a full assessment is required. It was anticipated that approximately 2,000 rural, private assets could be encountered through the wider catchment (including the Future Urban Zone). Prior experience suggested close to half of these assets would have some sort of issues requiring a full assessment. In consultation with Auckland Council an abridged and limited assessment methodology was developed for assessing rural private assets with and without issues. This was designed to reduce the amount of time spent surveying private assets and instead focused on collecting information on key issues, or lack thereof.
    - Abridged inlet and outlet assessments were applied to all rural, private assets that had moderate to severe erosion, were in poor or very poor condition or were causing fish passage issues.

  - Where no issues existed with a rural, private inlet / outlet asset (i.e. no erosion, condition or fish passage issues) then no data point was captured. In such situations the corresponding pipe/culvert point was considered sufficient to capture the asset.
  - Abridged pipe and culvert assessments applied to all rural, private assets that were in poor or very poor condition or were causing fish passage issues.
  - Limited pipe and culvert assessments were applied to all other rural, private assets that had no condition or fish passage issues.

  Data fields used for each of these assessment types can be found in Appendix E.

- Sections of stream channel that were not surveyed included areas of stream/catchment that could not be accessed due to unsafe drops, thick vegetation or areas where fencing or landowners prohibited entry. In these areas, the field team estimated the ecological data for the reach of stream where possible and made a comment in the notes section about the estimation.

The deliverables were:

- Watercourse Assessment Report,
- Geodatabase,
- Map Series.

The purpose of the work undertaken was to:

- Provide baseline information on the existing condition of watercourses, including both built assets and natural features.
- Provide essential information to many internal Council departments (Healthy Waters, Environmental Services, RIMU, Community Facilities) and to local boards and community groups.
- Contribute to management of built assets within the watercourses, management of the watercourses, and provide baseline surveys and identification of enhancement opportunities.
- Enable the Healthy Waters Unit to facilitate asset management and carry out project planning.

Table 2: Watercourse Assessment scope matrix

Watercourse Management Plan Component Protocol	Urban Environment	Rural/ Future Urban Environment
Pre-survey Desktop Assessment		
Literature Review	Yes	Yes
Field Stream Assessment		
Reach Assessment (Ecoline)	Yes	Yes
Natural Structures	Yes	Yes
Fish Survey	Yes	Yes
Stream Mouths	Yes	Not applicable
Inanga Spawning	Yes	Yes
Wetlands	Yes	Yes
Asset Full Assessment (Inlets / Outlets)	Yes	Yes[1]
Asset Full Assessment (Culverts / Pipes)	Yes	Yes[1]
Asset Abridged Assessment (Inlet / Outlets)	No	Yes[2]
Asset Abridged/Limited Assessment (Culverts / Pipes)	No	Yes[2]
Bank and Channel Lining	Yes	Yes
Erosion Hotspots	Yes	Yes
Enhancement Opportunities	Yes	Yes
Miscellaneous Points	Yes	Yes
Post-survey Desktop Assessment		
Management Zones	Yes	Yes
Stream Ecological Valuations (SEVS)		
SEVs	Yes	Yes
Electrofishing	Yes	Yes
Clarity Measurements	Yes	Yes
Sediment Chemistry and *E. Coli*	Yes	Yes

[1]Full assessment used for rural, public assets

[2]Abridged/Limited used for rural, private assets

1.2 How to use this document

1.2.1 Overview

The Watercourse Assessment Report document summarises comprehensive data collected during the field watercourse assessment, as well as, additional Stream Ecological Valuations (SEVs) conducted at representative reaches throughout the survey area. The document relies on tables and maps to provide concise information to guide selection of management actions.

This document consists of a literature review (Section 2.0), summary of the watercourse assessment findings (Section 3.0), SEV results (Section 4.0), and watercourse management (Section 5.0) including Management Zones, Enhancement Opportunities and Maintenance Activities. These sections are supported by a map series provided in the appendices, which should be referred to whilst reading the body of the Watercourse Assessment Report. The geodatabase provided should be used for further analysis and interrogation.

Refer to the Watercourse Assessment Methodology document (Lowe *et al.* 2014) for information regarding survey methodologies and data collected during the field survey as well as information on the background and objectives of the Watercourse Assessment process and relevant policies and plans. Figure 1 provides a guide to the Watercourse Assessment structure.

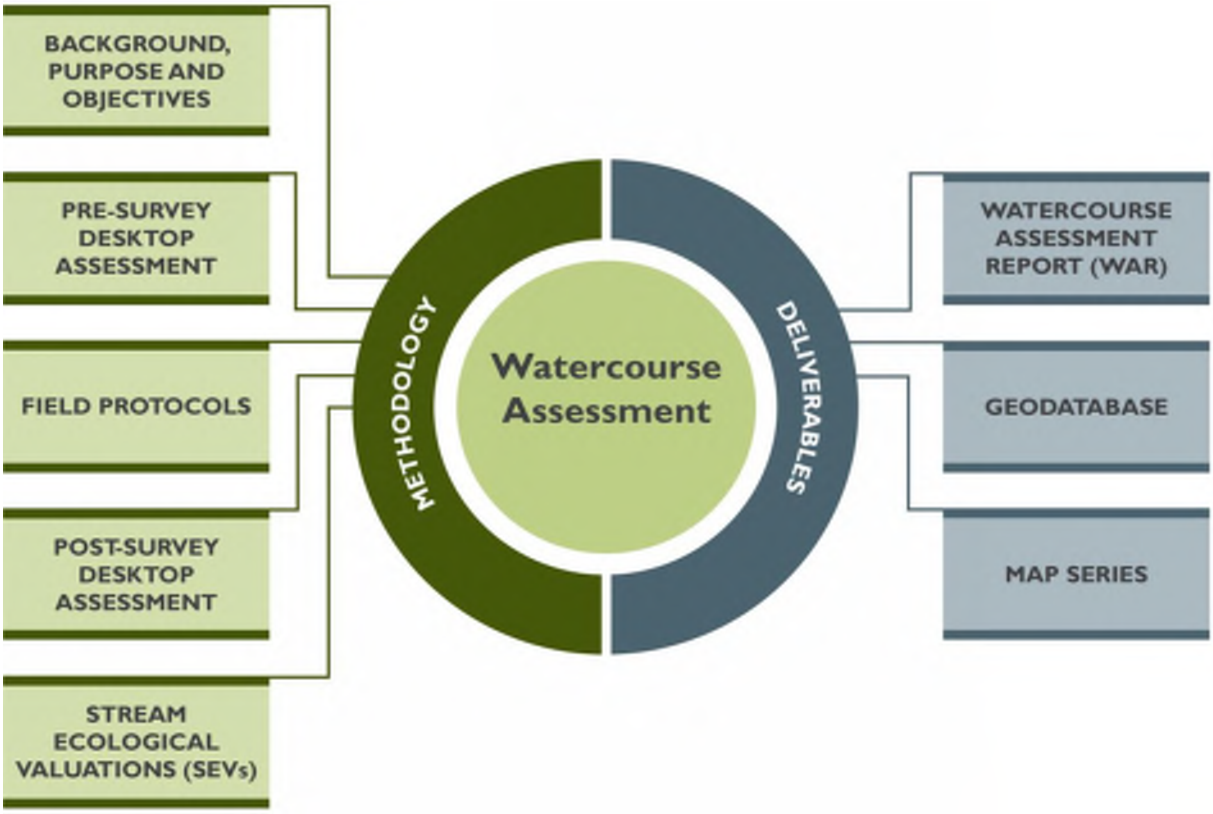


Figure 1: Watercourse Assessment structure

1.2.2 Limitations

1.2.3 Identified Options

Auckland Council is not obligated to undertake any works identified as enhancement or management options in a WAR, nor is Auckland Council bound by preliminary prioritisation of projects undertaken as part of this methodology. Recommendations made will be considered within the context of Auckland Councils obligations, constraints, drivers, project identification, and catchment prioritisation undertaken or identified by Auckland Council.

1.2.4 Stream Classification

The Watercourse Assessment provides an unofficial field estimate of stream classification only and this classification is not specifically intended for Resource Consent purposes. Although specific and detailed assessment is required prior to consent approval for any works within a subject reach, the details contained in this document can be used to guide associated investigations for a resource consent application. Failure to identify a stream reach during this Watercourse Assessment process does not suggest that a stream does not exist or that any such stream is ephemeral.

1.2.5 Temporal limitations

Watercourse Assessment undertaken as per this methodology must be considered within the seasonal context. Variables such as water depth and velocity are dependent on the level of base flow, and stormwater influx prior to the assessment. Time since last rainfall event is recorded which can guide interpretation. Factors that are more variable over diurnal time scales such as temperature are not recorded as part of this assessment as time series data is required for meaningful results.

1.2.6 Rapid Assessment

It is acknowledged that the Watercourse Assessment Methodology is a ‘rapid’ assessment of engineering assets, as well as, biological and geomorphological stream state for the purpose of informing effective management of, stream ecological health; stormwater infrastructure and stormwater conveyance. Therefore, this methodology may lack some parameters of more specific assessments (some of which have informed the development of this methodology).

2.0 Literature Review

2.1 Catchment Overview

The Hingaia Stream is a watercourse network covering an area of 54.9 km^2 within the south-eastern corner of the Auckland region (see Map 1, Appendix A). The southern two-thirds of the catchment is situated within Auckland's Franklin Ward, with the north-western extent situated within the Manurewa-Papakura Ward. The Hingaia Stream headwaters largely arise from the northern slopes of the Bombay Hills at the southern boundary of the Auckland Region, with the main Hingaia Stream channel running close to the catchment's western boundary. Near its midpoint Hingaia Stream is joined by a large tributary, the Maketu Stream, and several smaller unnamed tributaries which drain from the foothills of the Hunua Ranges. Together they collectively flow north towards the township of Drury. To the north of Drury township, the stream is met by Slippery Creek and joins the Drury Creek arm of the Pahurehure Inlet and drains into the upper Manukau Harbour.

The Hingaia Stream catchment is divided into two distinct regions by the Drury fault line. The low elevation and flatly contoured land lies to the west of the Drury fault line and is where the main channel traverses. Snelder (1991) describes the geology of this area as unconsolidated alluvial material, overlying Waitemata Group sandstones and mudstones. The majority (44 km^2 or 77%) of the Hingaia catchment lies to the east of the Drury fault line, which has resulted in upthrust massive greywacke and therefore the steep slopes which comprise the foothills of the Hunua Ranges (Snelder, 1991). The area also has volcanic basalts which intrude into the southern end of the catchment and consist of volcanic ash soils which give rise to high capacity and infiltration rates (Snelder, 1991). There are seven major stratigraphic units in the Hingaia Stream catchment that give rise to a series of aquifers and confining layers (Golder Associates, 2010).

The catchment drains predominantly rural land (79%), which consists of high-producing exotic grassland, or pasture and lifestyle blocks, forested land and cropland, including market gardens to the southwest and in the Drury basin. Commercial land use includes Stevenson's Drury Quarry (7%) and land zoned for industrial use, including the large Drury South Industrial area in the early stages of development (7%). The main urbanised area in the catchment is Drury Township which is located to the north of the catchment and currently comprises 0.3% of the catchment land area (Table 3; Map 2, Appendix A).

Table 3: Catchment Overview

Attribute					
Catchment Area (km²)	54.9				
Geology	Greywacke and alluvium				
% Imperviousness	3.2				
	Public Open Space	**Rural**	**Residential**	**Business**	**New Growth**
Land use (% catchment)	0.9%	79.3%	0.3%	7.4%	7.1%
Receiving Environment	Drury Creek, Pahurehure Inlet, Manukau Harbour				

2.2 Catchment Development History

Historically, the Hingaia Stream catchment was primarily dominated by vegetation characteristic of a kauri, podocarp, broadleaved beech forest. This forest type largely covered the mid-range of the catchment and continued to extend further to the east. The downstream end of the catchment consisted of kahikatea, puriri forest before descending into Mangrove forest and scrub around the stream mouth (Singers et al., 2017).

Kahikatea, pukatea forest was present to the north west of the catchment, bordering on taraire, tawa podocarp forest, which continued largely to the west of the catchment. This kahikatea, pukatea forest also bordered isolated patches of puriri forest in the centre of the catchment, amongst the dominant kauri, podocarp, broadleaf, beech forest (Singers et al., 2017).

As well as being present at the downstream end of the catchment and appearing as isolated patches in the centre of the catchment, kahikatea, puriri forest would have dominated the southern extent of the catchment, where most of the headwaters originate from today. Amongst this, smaller areas of kauri would have occurred, extending south of the catchment, as would have the kahikatea, puriri forest (Singers et al., 2017).

The Hingaia Stream catchment has been extensively modified. Some modification occurred under Maori occupation, for example, earthworks and forest clearance associated with pa construction, tree-felling in the lower catchment for canoe construction and the construction of eel weirs in stream beds (Snelder, 1991). However, the low lying poorly drained soil areas in the west would not have been attractive to Māori for settlement, although they would have been exploited for their wetland resources and birdlife. Selected areas at the base of the foothills where there were arable and swamp soils are likely to have been cultivated (Tatton and Auckland Regional Council, 2001).

Following European settlement in the 1840s, modification intensified with vegetation clearance and drainage of wetlands occurring to enable the development of pastoral farming and timber milling. The Hingaia catchment is located within the Manukau Ecological District, and taraire-broadleaved forest is the main vegetation type remaining (McEwen 1987; Emmett et al., 1999). In the flatlands there is very little original or indigenous vegetation left, and that which is remaining is highly fragmented (Emmett et al., 1999; Julian et al., 2007). Alluvial flats and terraces throughout the district that once supported extensive stands of kahikatea swamp forest, have largely been drained and converted to farmland (Emmett et al., 1999).

Stevenson's Drury Quarry has been operating in the Hingaia catchment since the 1930s. It is one of the largest and most technically advanced quarries in New Zealand. Drury Quarry ranks amongst the biggest producers of aggregate in the Auckland region, supplying over a quarter of its requirements. As such, Drury Quarry is vital to the Auckland region's economy and its expanding infrastructure, providing an estimated economic benefit of around $40–50 million per annum according to independent experts. (Stevenson Resources, 2018).

The quarry has a range of systems in place for the control and treatment of production water and runoff stormwater, which is then recycled and allows the site to be self-sufficient in water (Stevenson Resources, 2018). Water treatment controls the quality of water, which is continually tested, while quality of water re-entering local streams is of a high standard. Open stormwater drains are lined with rock and stormwater retention ponds are maintained to minimise silt entering local streams. The Quarry has a purpose-built facility for washing truck wheels and underbodies with water sprays before departing the quarry, to avoid silt washing onto public roads and entering water tables (Stevenson Resources, 2018).

Further change occurred within the catchment during the 1960s with the construction of the Southern Motorway, and subsequent increases in urbanisation, industrial growth and rural subdivision (Snelder, 1991).

Current urban development and anticipated future urban development is predominately constrained to the north-west of the catchment. The existing Drury township is zoned residential to the east of the Stream mouth, with land to the west and south zoned light industrial.

Auckland's population is anticipated to grow by up to one million people by 2040 (Auckland Council, 2012). It is anticipated that 400,000 new dwellings will be required to meet this growth figure and key strategic documents (Auckland Council, 2012; Auckland Council, 2016) have identified rural land on the city fringes, along with the transition of smaller outlying communities into larger satellite hubs, as a way of partially supplying the accommodation required by Auckland. The Drury area is one of those satellite areas identified for expansion.

To the south and east of Great South Road and the railway line, a large area of rural land has been zoned Future Urban under the Auckland Unitary Plan: Operative in Part (Auckland Council, 2016). This zone is part of the wider Opaheke - Drury area identified by Auckland Council as suitable for future urban growth and Auckland Council is in the early stages of developing a Structure Plan for the Opaheke - Drury area (Auckland Council, 2017b).

Overall the Opaheke - Drury area has been identified as a highly modified landscape, with a town centre surrounded predominantly by pastoral, arable horticultural and rural lifestyle activity. Very little native vegetation remains, and freshwater habitats have been modified and are degraded. There is an estuarine coastal edge in the north-west, and although the marginal vegetation has been highly modified, the marine environment remains in good condition (Nathan, 2017).

South of this Future Urban Zone lies the 'Drury South Business Park' (DSBP), which underwent a recent Plan Change (2014) to re-zone the area for business use, predominantly light and heavy industrial land use. The DSBP is bounded by the Southern Motorway (State Highway 1) to the west and Stevenson's Drury Quarry to the east (Map 2, Appendix A). The DSBP is currently undergoing development and encompasses a land area of approximately 223 ha. Development of the DSBP involves changes to land use and cover, terrain, vegetation cover, stream crossings and alignment, along with the filling of farm drains, intermittent and permanent watercourses and a new stormwater reticulation and treatment network (Boffa Miskell Limited, 2010). The DSBP is expected to provide employment for at least 6,500 people once it is fully developed (around 2025-2030; Beca, 2011).

The Drury South Industrial Precinct is divided into five sub-precincts (A-E); light industry, motorway edge (light industry), commercial services (light industry), open space / stormwater management and heavy industry, located closest to the Stevenson's Quarry. The purpose of the precinct is to provide land for extensive industrial activity and employment opportunities as well as provide for areas of stormwater management, existing and proposed network utility infrastructure, public open space and proposed roads, while recognising the ecological, cultural, landscape and other environmental constraints of the locality (Auckland Council, 2016).

Development of the DSBP has commenced and involves large scale earthworks and direct effects on the lower Hingaia Stream catchment. Works include extensive earthworks, piping and diversion of streams, changes to hydrology and water quality, vegetation removal and revegetation of riparian margins (Boffa Miskell Limited, 2010). The streams that will be piped were found to be highly modified rural streams with relatively low ecological values, minimal native fish recorded and no pollution-sensitive macroinvertebrates (Boffa Miskell Limited, 2010). An Ecological Compensation Ratio evaluation determined that to compensate for the ecological functions lost because of the proposed stream piping, the ecological functionality of streams would need to be enhanced by way of riparian zone revegetation. This would equate to the restoration of the riparian zones (typically 20 m wide on both sides) along the entire length of both the main Hingaia Stream and Maketu Stream reaches located within the Project Area. Stream diversions would also be naturalised and undergo riparian enhancement.

In 2016 a portion of the Drury South Structure Plan area was identified for it’s potential for housing and listed as a Special Housing Area (SHA). The Drury South SHA is located between the Hingaia Stream and the Southern Motorway and encompasses the remaining portion of land within the current Metropolitan Urban Limits. The first stage of residential development within the SHA is currently underway. Works to enable development of this area will include the permanent diversion of a tributary located adjacent to the Southern Motorway and construction of a new stream channel. These works are extensive and are to be off-set to an appropriate level throughout the restoration of native riparian vegetation along the Hingaia Stream and tributaries (Boffa Miskell Limited, 2016).

The Drury South Residential Precinct has underlying zones of mixed housing suburban, mixed housing urban and terrace housing and apartment building. The purpose of the Drury South Residential precinct is to provide land for the comprehensive and integrated development of land in Drury South for residential and ancillary purposes, as well as provide for areas of stormwater management, existing and proposed network utility infrastructure, public open space and proposed roads, while recognising the ecological, cultural, landscape and other environmental constraints of the locality (Auckland Council, 2016).

The urban and commercial expansion anticipated for the lower Hingaia Stream catchment and wider Drury area will result in changes in catchment land use which may cumulatively impact the functionality of the Hingaia Stream (Auckland Council, 2017b). However, this urban expansion is intended to help accommodate Auckland’s growing population. A draft Stormwater Management Plan developed to inform the Opaheke - Drury Structure Planning (AECOM, 2017) recognises that flooding of the lower catchment is an existing issue that will be exacerbated with increased development and will require integrated management and mitigation to avoid adverse impacts on communities, infrastructure and ecological values.

Preliminary assessments have already identified that within the greenfields development area there is an opportunity to enhance and protect the hydrological and ecological values of the freshwater systems of the Drury area, increase the amount of native vegetation in the area, and to maintain, protect and enhance biodiversity (Auckland Council, 2017b;

AECOM, 2017). Opportunities exist for riparian margins to provide increased vegetation cover, connect and buffer existing ecological areas, provide corridors for the movement of native flora and fauna, and to restore ecological function (Nathan, 2017).

2.3 Prior Watercourse Assessment

The most extensive watercourse assessments within the catchment were undertaken by Golder Associates (2009) to inform the Hingaia Stream Integrated Catchment Management Plan (ICMP; Golder Associates, 2010).

Prior to the surveys in 2009, water and sediment quality data for two Hingaia Stream sites (one in an industrial zone and one in a rural zone) were reported in the NIWA Papakura ICMP – Stream Management Component produced by Phillips et al. (2006). In that survey *E. coli* populations were found to be elevated at both sites (1200 and 1700 cfu/100 mL) but sediment concentrations of copper and zinc met the (then) Auckland Regional Council (ARC) Environmental Response Criteria at all sites (Auckland Regional Council, 2004). Phillips et al. (2006) also reported results of Stream Ecological Values (SEV) in the industrial zone, which was classified as stream class 2 – high value, low disturbance in accordance with ARC (2004). The industrial zone also produced 15 benthic invertebrate taxa including three taxa from the more pollution sensitive groups Ephemeroptera, Trichoptera and Plecoptera. Koura (freshwater crayfish) had been found at various locations within the catchment along with banded kokopu, inanga, common smelt, common, Crans and redfin bullies, torrentfish and longfin and shortfin eels. The pest fish *Gambusia affinis* (mosquito fish) was located throughout the catchment (Golder Associates, 2009).

Golder Associates (2009) sampled a total of 45 sites for the Hingaia Stream ICMP study, consisting of 31 sites where both SEV (including macroinvertebrates and fish) and Water and Sediment Quality (WSQ) were sampled, plus 5 additional fish survey sites and 9 additional WSQ sites.

Results from the Hingaia Catchment Environmental Assessment (Golder Associates, 2009) for *E. coli* showed that, at that time, only nine out of the 41 sites surveyed contained sample counts ≤260 cfu/100 mL. This is the ‘Acceptable/Green’ mode stated in the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2003). The highest median (570 cfu/100 mL) and maximum (2,000 cfu/100 mL) for *E. coli* were measured at a forest site.

The Golder Associates (2009) report made the following observations on sediment quality:

- Median concentrations of copper, lead and zinc in sediments were lowest for the forest land use.

- Cropland land use sites had the highest median copper concentration (25 mg/kg in <63 µm fraction sediments) and the highest single copper concentration (41 mg/kg in <2 mm fraction sediments), however, results were well below ANZECC (2000) Interim Sediment Quality Guidelines-Low (ISQG-Low) trigger value of 65 mg/kg.
- Median lead concentrations were slightly higher for urban and pasture land use sites. All lead concentrations were below the ANZECC (2000) ISQG-Low trigger value (50 mg/kg).
- Urban land use sites had the highest median zinc concentrations, but the highest single zinc concentrations were measured in sediments collected from a pasture site (150 mg/kg in both fractions), however results were still below the ANZECC (2000) ISQG-Low trigger value (200 mg/kg).

Golder Associates (2009) conducted SEV assessments at thirty-one sites in the Hingaia Stream catchment. Scores ranged from 0.37 to 0.83, reflecting the widely varied stream and riparian habitat quality throughout the catchment. Results from the study can be summarised as follows:

- Six sites had SEV scores in the ‘poor’ category, fourteen in the ‘moderate’ category, ten in the ‘good’ category and only one site had a score in the ‘excellent’ category.
- The site in the ‘excellent’ category was in indigenous forest, north east of the catchment off Peach Hill Road and had ‘good’ ecological function.
- Sites generally had ‘poor’ habitat and biodiversity scores.
- Hard bottom streams in the elevated portions of the catchment within areas of indigenous forest, generally provided better instream habitat quality compared to soft bottom streams, which were often in the low elevation, grassland, urban or cropping areas of the catchment.
- Fish species recorded were banded kokopu, inanga, common and Crans bully and longfin and shortfin eel, along with koura. Eels were the most abundant and widespread of the species recorded. The pest fish *Gambusia affinis* (mosquito fish) were also widely spread throughout the catchment.
- The large number of benthic invertebrates collected, and the associated biological indices scores reflected the wide range of habitat types and variable habitat quality within the catchment.

Sediment modelling conducted by Green (2008a) over a 100-year future period, predicted that the average sediment runoff into the Pahurehure Inlet from the Hingaia Stream catchment would be 100,079 kg per year. This totalled 10,007,908 kg over the 100-year simulation. Green (2008a) also predicted to see a significant increase (16% to 56%) in sediment runoff from urban sources within the Hingaia Stream catchment. The model also predicts that due to improved and additional stormwater treatment of rural sources from urban development, total zinc runoff and total copper runoff entering the Pahurehure Inlet from the Hingaia Stream catchment would be reduced. The Hingaia Stream catchment showed the largest reduction in total zinc runoff (20%) and second largest reduction in total copper runoff (19%), compared to other catchments in the area (Green 2008b).

Boffa Miskell undertook ecological assessments to inform the Drury South Plan Change (Boffa Miskell, 2010) and Drury South Special Housing Area (Boffa Miskell, 2016). While the freshwater assessments for both surveys largely relied on the work previously undertaken by Golder Associates (2009), field surveys of the estuarine mouth of Drury Creek (below the confluence with Slippery Creek) were undertaken in 2009 (Boffa Miskell, 2010), including sampling of intertidal invertebrates, sediment quality and observations of coastal vegetation cover. The estuarine sampling determined that the habitats of the Hingaia Stream / Drury Creek mouth were typical of those within the wider Manukau Harbour, with substrates dominated by silt and clay fractions. Concentrations of heavy metal contaminants (copper, lead, zinc) and nitrogen in surface sediments were low, while phosphorus was elevated, reflecting the rural nature of most of the contributing catchments. Both surveys identified the general absence and fragmentation of native riparian cover within the survey area and recognised opportunities for significant enhancement.

2.4 Significant and Existing Ecological Values

The Hingaia Stream catchment flows into the Pahurehure Inlet of the Manukau Harbour, via Drury Creek. This is a low energy receiving environment dominated by soft, fine sediments and expansive mangrove forests (Kelly, 2008). Near the Hingaia Stream mouth the coastal marine area (CMA) is classified as Coastal Protection Area (CPA) 1 (No. 29b) in the AUP(OP) (Auckland Council, 2016). The area near the Hingaia Stream Mouth (Upper reaches of Drury Creek) is classified as a marine Significant Ecological Area (SEA; SEA-M1), indicating that it is a high value area that is vulnerable to any adverse effects of inappropriate subdivision, use and development (Auckland Council, 2016). Within the upper tidal reaches of Drury Creek there are a variety of coastal marshes, grading from mangroves through to extensive areas of jointed rush-dominated saltmarsh, to freshwater vegetation in response to salinity changes (Auckland Council, 2016). This same area is a migration pathway between marine and freshwater habitats for a number of different species of native freshwater fish.

The entire Manukau Harbour is identified in the NZ Coastal Policy Statement as an Area of Significant Coastal Value as an internationally important wetland.

Only a small amount of native forest that once dominated this area remains within the Hingaia Stream catchment, with the land now predominantly characterised by pasture or cropland for agriculture purposes. There are 26 terrestrial SEAs identified by the AUP(OP) within the Hingaia Stream catchment, however these are small, and often stand as isolated patches of remnant habitat within an agricultural landscape and collectively cover a minimal area within the catchment (Table 4; n = 26). A terrestrial area is ecologically significant if it meets one or more of the sub-factors outlined in Table 4 (Auckland Council, 2016).

There are no ‘Outstanding Natural Features, Landscapes or Characters’ within the Hingaia Stream catchment (Auckland Council, 2016).

The Hingaia Stream catchment has six ‘Natural Stream Management Areas’, two located in the north-east of the catchment and the remaining four in the middle of the catchment. These are reaches with high natural character and high ecological values. They generally have an unmodified river or stream bed with continuous indigenous riparian vegetation cover on both banks, indicating high ecological values and water quality (Auckland Council, 2016).

There are two ‘Quality-Sensitive Aquifer Management’ areas within the Hingaia Stream catchment. The Drury Sand Aquifer is in the north of the catchment and the Franklin Volcanic Aquifer takes up most of the south and south-western area of the catchment. These aquifers are shallow and unconfined and therefore susceptible to pollution from surface sources such as excess fertiliser application or discharges of contaminants such as stormwater or sewage. The potential for contamination is highest in the volcanic aquifers (Franklin) where discharge to aquifers is most direct. These aquifers are important sources of water for rural and industrial purposes, as well as providing base flow to surface streams (Auckland Council, 2016).

The catchment partially sits atop the Bombay Drury Kaawa Aquifer, Bombay Volcanic Aquifer and the Drury Sand Aquifer which are classified as ‘High-Use Aquifer Management Areas’ and cover the west side of the catchment. Aquifers are an important contributor to the base flow of many streams, particularly in the southern parts of Auckland and provide important inputs into the overall quality and diversity of surface waterbodies (Auckland Council, 2016). High-Use Aquifers are those that are highly allocated, provide water to users, contribute to stream base flows, or will become highly allocated, putting pressure on the resource, particularly in potential growth areas (Auckland Council, 2016). Aquifer recharge is reliant on rainwater infiltration and an increase in impervious surfaces due to urban development, may result in increased surface water runoff and reduced infiltration that would ultimately contribute to aquifer recharge.

Table 4: Significant ecological areas within the Hingaia Stream catchment.

Significant Ecological Area	Location	Representativeness	Threat Status/ Rarity	Diversity	Stepping Stone/ Migration Pathway	Uniqueness or Distinctiveness
SEA_T_1175	226 MacWhinney Drive	✓	✓			
SEA_T_5280	152 - 385 Maketu Road	✓	✓			
SEA_T_5280	152 Maketu Road	✓	✓			
SEA_T_79	1333 Great South Road	✓	✓	✓		
SEA_T_80	1361 Great South Road	✓	✓			
SEA_T_5349	206 Peach Hill Road	✓	✓	✓		
SEA_T_5323	1189 Ponga Road	✓	✓	✓	✓	
SEA_T_1178	222 Peach Hill Road		✓		✓	
SEA_T_5395	394 Peach Hill Road	✓	✓	✓	✓	
SEA_T_5396	442 Peach Hill Road	✓	✓	✓	✓	
SEA_T_1179	232 Peach Hill Road, 58A Otto Road				✓	
SEA_T_5346	49 Pratts Road, 84 Peach Hill Road	✓	✓	✓	✓	
SEA_T_4501	57 Dale Road	✓	✓	✓		
SEA_T_215	233 Maxted Road	✓	✓	✓		
SEA_T_5348	490 Ararimu Road	✓	✓	✓	✓	
SEA_T_4565	28 Fausett Road		✓			
SEA_T_4536	48 Fausett Road				✓	
SEA_T_4537	48 Fausett Road			✓	✓	
SEA_T_5347	192A Chamberlain Road	✓	✓	✓		
SEA_T_5350	192B Chamberlain Road	✓	✓	✓		

Significant Ecological Area	Location	Representativeness	Threat Status/ Rarity	Diversity	Stepping Stone/ Migration Pathway	Uniqueness or Distinctiveness
SEA_T_216	93 Kanuka Road			✓		
SEA_T_4511	242 Maxted Road, 22C Stone Road	✓	✓	✓		
SEA_T_4512	22B Stone Road		✓			
SEA_T_1183	159B Portsmouth Road, 300 Maxted Road				✓	
SEA_T_4513	1799 Great South Road	✓	✓			
SEA_T_4568	92 Totara Road		✓	✓		

2.5 Cultural and Heritage Values

The Hingaia Stream and its catchment, especially areas to the north would have been intensively settled by Māori because of nearby marine food resources and its strategic location at the south-eastern extremity of the Manukau Harbour, and entrance to major inland route ways (Tatton and Auckland Regional Council, 2001). These included routes to Clevedon and Wairoa in the east, and the Waikato in the South (Tatton and Auckland Regional Council, 2001; Mackintosh, 2003).

Hingaia was a chieftainess who is buried at Maketu (near Stevenson Drury Quarry) and the stream, which bears her name, represents her. The Hingaia Stream and surrounding area therefore have special meaning for Māori (Te Roopu Kaitiaki o Papakura, 2010).

Māori protected the resources of the catchment with two fortified pā near the mouth of Slippery Creek. This included one at the head of the Waihoihoi Stream (a Slippery Creek tributary) and another at Pukekiwiriki to the north at Papakura (Snelder, 1991). Other main pā associated with this area were Tuhimata, located west across the southern motorway, and Maketu, on the east (Russell Foster and Associates, 2010). Māori occupied Te Maketu from the 1600's, attracted by its rich natural resources from volcanic soils and warm temperate climate. It was well suited for growing kumara and introduced tropical crops, and the fast-flowing streams provided fresh clean water (ARC, 2003). The eroded 1-million-year-old volcanoes provided high defensible places to live, and offered clear views over surrounding lowlands, resulting in chief Noia a Te Waiohua building a pā at Te

Maketu on one of the old volcanic cones sometime between 1740 and 1780 (ARC, 2003). Later around the mid-1840s, a new pā and large gardens were built below on gently sloping land. Te Maketu pā was traversed by the Ararimu track, one of the three main Māori route ways to the Waikato, which ran through a rugged course of densely forested hills, from the Manukau lowlands across the Drury escarpment to Paparimu and then south to Mangatawhiri Stream and is thought to have been central to Māori occupation of the area (Osbornehay, 2011). Te Maketu also connected to the headwaters of the Mangatawhiri Creek which was one of the main canoe routes both to the Waikato and the Hauraki Gulf in the prehistoric period. The streams (Hingaia and Maketu) were deep and easily navigable in winter, providing access from the Manukau Harbour (Clarke, 1983).

In 1863 the Waikato campaign of the New Zealand Land Wars created a military build-up in the wider Papakura area. The dispute was over European pressure for land and control in Waikato. Māori living between Auckland and Waikato were forced to decide whether to give up their guns and support the Crown or to leave their homes and join the Māori King Potatau Te Whero and his followers in Waikato (ARC, 2003). The land confiscations and subsequent land division that followed the New Zealand Land Wars played a key role in the European settlement of the lowlands of Papakura/Franklin, which were settled by new immigrants from England, Ireland and South Africa who farmed their five to ten-acre plots (Tatton and ARC, 2001; ARC, 2003).

In 1975 the Maketu Pā Historic Reserves were established and are spread over three separate lots of almost 12 ha, Cemetery, Opaheke and Peach Hill Reserves (Mackintosh, 2003). Archaeologists and historians are still uncertain about whether Noia's pā was at Opaheke or Peach Hill Reserve, however, the Cemetery Reserve on Pratt's Road, is thought to be the most recent of the three pā sights. The earthworks of this pā are still in very good condition and are now under regenerating bush. It is open to the public and has an early European cemetery, the pā remains, which was a defended area over 200 metres long (the pit and terrace earthworks, now worn by time are still visible) and a small waterfall and swimming hole (Mackintosh, 2003).

In October 2000, the management of the Maketu Pā Historic Reserves was formally transferred to the Whatāpaka Marae Committee. Today, the Trustees are managing the Reserves at Te Maketu, together with the local community and other heritage agencies. The Management Plan for the Reserves describes Te Maketu as wāhi tapu (sacred) to Te Waiohua descendant's, particularly Ngāti Pou, Ngāti Tai, Ngāti Tamaoho, Te Ākitai, Ngāti Koheriki (Ngāriki) and Ngāoho (ARC, 2003).

Several iwi identify with the land and waters within the Hingaia Stream catchment, including Ngāti Tamaoho, Ngāti Te Ata, Ngāi Tai ki Tāmaki, Te Ahiwaru-Waiohua and Te Ākitai Waiohua from the Waiohua-Tāmaki Tribal Region. Ngāti Maru, Ngāti Tamaterā, Ngāti Whanaunga and Ngāti Pāoa from the Marutūahu Tribal Region, along with Waikato-

Tainui (Auckland Council, 2016). The Manukau Harbour is considered a taonga and is considered a pateka kai (food bowl). The protection and enhancement of environmental linkages associated with the Manukau Harbour is regarded as a fundamental issue for iwi (Waitangi Tribunal, 1985). As such, the tributaries feeding into the Manukau have cultural significance, both for food harvesting and ceremonial purposes.

Russell Foster Associates (2009) describes the European history of the area. The first European settler in the Drury area was Thomas Runciman who settled in the area before or about 1852. The first allotments in the Drury village were sold by the Crown in 1855, when the Great South Road had almost been completed.

By 1862 Drury township had an hotel, a store, a post office (opened in 1857) and eight or nine cottages. By 1863 a railway was planned although it was not built for another 12 years. In this period Drury was the centre for settlers in Pukekoke East and Karaka as it could provide a postal service and provisions could be purchased there.

The general Drury area has a history as an area for commerce and extractive industry. In 1858 the Reverend Angas had discovered coal at Waihoihoi in the Drury Hills, east of the settlement. That same year Hochstetter undertook a survey for the Provincial Council and found good quality clay near Drury. A 3½ mile railway line was laid to a landing at Slippery Creek and in 1863 the first Drury Brick and Fireclay Pottery opened and operated until the mid-20th century. In the 1930's the Stevenson family acquired the Drury Quarry which had been opened some years previously.

During the New Zealand Land Wars Drury was an important centre for the military. It was the furthest south supplies could be brought by water, landing at the "Commissariat Redoubt" on Drury Creek for later overland transport to the Waikato. After the New Zealand Land Wars, the remaining Māori land in the district was confiscated and the government made plans for rapid settlement on the confiscated land (Russell Foster Associates, 2009).

By the start of the 20th century Drury was described as "*The district is agricultural, and dairying is carried on by the settlers with much advantage. Flax milling, too, is successful as a local industry. Game abounds in the district, which has a public school, a post, telegraph and money order office, and a daily mail service.*" (Cyclopaedia of New Zealand, 1902).

The Auckland Council GIS System includes the Cultural Heritage Inventory (CHI) database (Auckland Council, 2016; Auckland Council GeoMaps), which maps items that have heritage and archaeological significance. The Hingaia Stream catchment contains archaeological sites, historic structures and reported historic sites. These include:

- Pā at Ballards Cone and Te Maketu
- Remnants of Flannigan's Mill

- Current buildings deemed to have heritage merit
    - Colonial/Historic houses
    - St John's Church and Cemetery – constructed 1864
    - Drury Post Office
    - Drury Cheese Factory (former)
    - Ramarama Hall
- Shell middens
- Drury rail yards
- Historic stile
- Stone culvert from the construction of the Great South Road
- Military mile posts erected along the Great South Road/outside Drury School
- Military sites from the New Zealand Land Wars
    - General Cameron's Headquarters and military camp
    - Commissariat Redoubt
    - Stockade in Norrie Road

2.6 Community Involvement

Most of the Hingaia Stream catchment is currently devoted to rural land uses within private land and therefore community projects and access to public open spaces is limited. Golder Associates (2009) made the following observations during field surveys:

- Public access to waterways in the catchment is generally poor.
- No parks, reserves or playgrounds were observed adjacent to waterways except for a grassed reserve adjacent to the lower tidal reach of Hingaia Stream where there is a boat ramp.
- There is little riparian planting or enhancement of waterways in either the rural or urban areas of the catchment.
- No people were observed undertaking recreational activities near waterways e.g., walking, cycling, dog walking, horse riding.
- Generally, the waterways were free of litter, however Boffa Miskell (2010) recorded deposited litter in the Drury Creek mouth.
- In the predominantly rural catchment the waterways had low amenity value and were typically channelised, grazed, low gradient, soft-bottomed waterways.

- Areas of the catchment with high amenity value were typically on private land where enhancements such as riparian planting or the creation of ponds had occurred.

The Papakura Greenways Plan (Papakura Local Board, 2016) identifies the Board's long-term plan to develop a network of paths and cycleways to connect communities within the Board area. The Plan includes a pathway within the esplanade reserve along the western (true left) bank of the Hingaia Stream mouth, north of Great South Road with linkages to the coastal edge of Drury Creek and to Slippery Creek.

The Franklin District Local Board recognises that the waterways within the region have significant importance to mana whenua and local residents, and are a resource to be utilised, used and enjoyed. The Local Board is committed to improving water quality within the region, and in general improving the overall state of its watercourses (Franklin Local Board, 2014). As part of its Cherished Natural Environment Outcome the Local Board is keen to support community initiatives such as plantings to enhance rivers, streams and coastlines (Franklin Local Board, 2014). Despite this, the rural nature of the Hingaia Stream catchment and lack of public access to the waterway has, to date, resulted in very little opportunity for community involvement. Future development of the areas designated Urban or Future Urban may increase the opportunity for restoration and improved amenity values for local communities. Significant riparian and amenity enhancement is already anticipated along major stream channels within the Drury South industrial and residential precincts as development progresses.

The Local Board is also part of the Manukau Harbour Forum, a collective of the nine local boards that border the Manukau Harbour. Strategic objectives for the Manukau Harbour Forum include raising the profile of the Manukau Harbour and its importance as a cultural, environmental and economic treasure. They also advocate for integrated management of the Manukau Harbour to be incorporated into all planning frameworks and new Manukau Harbour projects.

WaiCare is a water quality monitoring, education and action programme for community groups, individuals, businesses and schools across the Auckland region. Within Hingaia catchment and nearby area there has been Drury Christian Planting, Drury School planting at Slippery Creek, riparian planting at Slippery Creek and seed propagation workshops (WaiCare, 2018). There is also one WaiCare site identified on the Auckland Council GeoMaps within the Hingaia Stream catchment near the northern tip, that had a clean-up event undertaken by the Department of Corrections.

Trees for Survival, the school based environmental education programme, is active in the lower catchment. Properties on Peach Hill Road have been involved in the programme, which is an environmental education programme aimed at involving young people with the growing and planting of native trees to restore natural habitats (Trees for Survival, 2018).

3.0 Summary of Findings

3.1 Ecoline

The Hingaia Stream catchment watercourse assessment was carried out between February 2018 and May 2018. Rainfall through this period was near normal to above normal, particularly in February where two ex-cyclones resulted in the Auckland Region receiving 2.6 times its normal rainfall (NIWA 2018a, 2018b). Consequently, soil moisture at the end of February was also well above normal. Wetter than usual weather in February and April resulted in surveys being conducted one or two days after a significant rainfall event on several occasions. This was taken into consideration when assessing stream classification (permanent/ intermittent/ ephemeral).

As per the survey protocol, full ecoline assessments were only carried out for stream reaches classified as permanent or intermittent. The below summary of findings for ecolines (Section 3.1) is based on the total length of surveyed permanent and intermittent stream, not the total length of stream assessed. Therefore where 'total length surveyed' or words to that effect are mentioned below, it refers only to the length of permanent or intermittent watercourse.

3.1.1 Physical Attributes

The Hingaia Stream forms to the south, on the northern slopes of the Bombay Hills, from which it flows north towards the Drury Township (Appendix A, Map 1). North of the township it converges with Slippery Creek and enters the estuarine Drury Creek branch of the Pahurehure Inlet and the Manukau Harbour. As it progresses north the Hingaia Stream is joined by several tributaries draining from the east from the foothills of the Hunua Ranges. This includes the large Maketu Stream, whose downstream limit is marked, more or less, by the Maketu Falls. By the time the Hingaia Stream enters the Manukau Harbour it has become a 6th order stream channel, with a catchment encompassing 177,056 m of watercourse, of which 166,324 m was classified as permanent or intermittent stream under the Auckland Unitary Plan definitions (Auckland Council, 2016).

The Hingaia Stream and its tributaries form a predominantly soft-bottomed (sand and silt) watercourse draining through highly-modified agricultural land (Table 5; Figure 2). Agricultural activities include livestock grazing and horticultural productions. As a result, 64% of the total stream length surveyed was found to be bound, at least on one side, by land used for agricultural activities. Stream channels in the eastern sections of the catchment drain through a number of steep, well vegetated gullies. This has resulted in a mosaic of agricultural land, punctuated by stands of vegetation (the other major land use type recorded, Table 5) within these sub-catchments. Stream sections where bush was recorded as the main land use type within 20 metres of both bank were also more likely to be hard bottomed than those surrounded by other land use types (Figure 2). Over 70% of the total stream length that was classified as hard-bottomed (bedrock, boulder, cobble or gravel as the dominate substrate type) occurred within these well vegetated, and often steep, areas. While land use (Table 5) and vegetation (Table 8) were highly modified, the majority of stream channels appeared to follow their natural flow path. Channel straightening was the most commonly observed form of modification, however this only accounted for 11% of the total length of stream surveyed (Table 5). Many modified channels displayed more than one form of modification, with the combination of widening, deepening and straightening commonly observed among modified channels.

Bank angles were steep, averaging 57°, which is a likely reflective of the soft, erosive soils that dominate this catchment (Table 3). This, combined with the general lack of vegetation within the catchment (Table 8) resulted in some form of erosion scarring being observed on almost 97% of the total permanent/intermittent stream length surveyed (Table 5; Appendix A, Map 4). Of particular note was the fact that erosion scarring in excess of 20% (recorded as 20-40% or greater) attributed for almost half of all observed erosion scarring. Additional bank and channel damage, associated with stock access to stream banks and beds, was recorded along 78,843 m (47%) of surveyed stream length. Of the stream length with recorded stock damage, 56% was classified as 'moderate' to 'severe' suggesting medium to high stock densities, multiple stream entry points and signs of bank slumping and pugging. Stock damage was mostly associated with streams bound, at least on one side, by agricultural activities and the incidence of moderate to severe stock damage was higher in the eastern and southern sections of the catchment (see Section 5.1). Through the catchment stock were able to access 80,799 m of stream bank within agricultural areas.

Figure 2: Representative stream photos, A) poorly vegetated soft-bottomed stream channel through agricultural land and B) well vegetated hard-bottomed stream channel through steep gully.

Table 5: Summary of physical variables across the extent of watercourse surveyed. Note Adjacent Land Use is assessed separately for the TRB and TLB therefore the total length will be double the surveyed area. Summary statistics, from reach length onwards, are based off the surveyed permanent and intermittent reaches only.

Attribute			
Total Length of Surveyed Watercourse (m)	177,056 (166,324 fully assessed)		
No. Reaches	1,737 (1,607 fully assessed)		
	Permanent	**Intermittent**	**Ephemeral/OLFP**
Class (% of total stream length) (length of stream (m))	**73.7%** 130,520	**20.2%** 35,804	**6%** 10,732
Summary of Permanent and Intermittent Reaches			
	Mean	**Min**	**Max**
Reach Length (m)	102	3.3	816
Average Width (m)	1.00	0.00	10.0
Depth (m)	0.22	0.0	1.50
Bank Angle (degrees)	57	10	90
Bank Height (m)	0.96	0.03	30
Sediment Deposition (% accumulation)	17%	0%	100%

	Bush	**Park**	**Agricultural**	**Residential**	**Light Industry**	**Industrial**	**Impervious Surface**
Adjacent Land Use (% of total stream length) (length of stream (m))	**30%** 53,359	**0%** 229	**64%** 104,747	**2%** 3,426	**1** 1,091	**2%** 2,022	**1%** 1,450

	Artificial	**Bedrock**	**Boulder**	**Cobble**	**Gravel**	**Silt/Sand**
Dominant Substrate (% of total stream length) (length of stream (m))	**0.3%** 422	**3.0%** 5,019	**2.2%** 3,692	**4.6%** 7,728	**1.0%** 1,656	**88.9%** 147,806

	Widened	**Straightened**	**Deepened**	**Lined**
Channel Modification (% of total stream length) (length of stream (m))	**7%** 12,166	**11%** 17,763	**10%** 16,600	**1.1%** 1,879

	0%	**≤20%**	**20-40%**	**40-60%**	**≥60%**
Erosion Scarring (% of total stream length) (length of stream (m))	**3.1%** 5,126	**55.5%** 184,715	**37.3%** 124,144	**4.2%** 14,026	**1.4%** 4,635
	None	**Minor**	**Moderate**	**Severe**	**NA**
Stock Damage (% of total stream length) (length of stream (m))	**1.2%** 1,956	**21.0%** 34,995	**19.9%** 33,128	**6.5%** 10,720	**51.4%** 85,525

More than 96% of the total stream length was assessed as having either a ‘fair’ (74.9%) or ‘poor’ (21.5%) Pfankuch bank stability score (Table 6; Appendix A, Map 4), which would indicate the potential for ongoing erosion and slumping issues. In general, watercourses scored between ‘fair’ and ‘good’ in mass wasting and debris jams categories but poorly on land slope and bank vegetation.

The combination of erosion scarring, stock damage and low Pfankuch bank stability is reflected in the mean active sediment deposition score observed through the catchment of 17% (Table 5). Of the 77 instances where active sediment depositions of 30% or greater were observed, 59, or 77%, occurred on sections of stream where banks showed >20% erosion scarring. It is acknowledged that active erosion input was a hard metric to judge, particularly in judging the contribution of smaller inputs, in stream reaches that were already soft-bottomed. This difficulty may have resulted in an under-representation of the contribution of active erosion to total stream sediment.

Table 6: Summary of Pfankuch bank stability assessment of the total length of watercourse (m).

	Excellent	**Good**	**Fair**	**Poor**
Land Slope (m)	3,848	4,825	17,468	140,183
Mass Wasting (m)	4,270	125,656	26,043	10,354
Debris Jam (m)	5,210	114,040	38,595	8,479
Bank Vegetation (m)	4,828	29,951	32,899	98,645
Overall Stability Index (% of total stream length) (length of stream (m))	**0.1%** 174 Scores ≤13	**3.5%** 5,810 Scores 14- 23	**74.9%** 124,636 Scores 24 -32	**21.5%** 35,703 Scores ≥33

3.1.2 Water Quality Attributes

Anaerobic conditions, demonstrated by dark, bubbling sediment or a sulphurous odour akin to ‘rotten eggs’, were the single most frequently observed water quality issue observed (Table 7). No areas of sewage fungus or hydrocarbon sheens were observed within the catchment. Anaerobic conditions occur when oxygen levels within the water and sediments fall to low levels, and at which point can be detrimental to aquatic organisms. Oxygen depletion occurs as a consequence of the respiration of aquatic plants (macrophytes and phytoplankton) during the night and as decaying organic matter (from plants and animals) is broken down by bacteria (Collier et al. 2014). This is a natural process, however can be exacerbated by human activities that result in increased nutrients entering a watercourse. Of the 107 recorded instances of anaerobic conditions 98, or 92%, occurred within ecolines bounded, at least on one side, by agricultural land use. Stock had access to 76 of the agricultural ecolines that were identified with anaerobic conditions.

‘Other’ forms of watercourse contamination included iron flocs, bacterial scum associated with stock effluent, and cloudy water resulting from high levels of suspended sediment in the water. Iron oxidising bacteria, forming fluffy orange growths or ‘flocs’ in slow-moving or still sections of stream were commonly observed and represented most of the ‘other’ contaminant attributes recorded in Table 7. These bacteria obtain energy by oxidising iron so are commonly found in iron-rich bodies of water (Landcare Research, 2017a). This can occur naturally where the watercourse interacts with iron-rich soils and seepages or where iron leeches into the water via an external source. On many occasions, the source could be traced to a specific location where rubble or rubbish, containing rusting iron products (often corrugated iron) was located near the watercourse. The observance of bacterial surface scums was indicative of the high level of stock access to the watercourse and the lack of dense riparian vegetation acting as a filter for this type of runoff. Cloudy water, due to high suspended sediment loads, is also likely to be associated with stream erosion, stock damage and a lack of riparian vegetation.

Table 7: Summary of watercourse contamination

Attribute	**Number of observations**		
Sewage Fungus	0		
Petroleum/Hydrocarbons	0		
Anaerobic Conditions	107		
Other	110		
	Mean	**Min**	**Max**
Clarity (m)*	0.36	0.31	0.47

*From SEV results only

One-off water clarity measurements were made at five localities on the 29th and 30th May 2018 as a component of the Stream Ecological Valuation assessments (Section 4.0). Water clarity varied between 0.31 m and 0.47 m, ranging between ‘very turbid’ and ‘extremely turbid’ (Biggs *et al.* 2002). Elevated stream turbidity is a likely indicator of a high suspended sediment load and will also be affected by recent rainfall. High suspended sediment loads can impact instream plant communities by reducing light levels (Ryan 1991), altering native fish behaviour and/or having a lethal effect if prolonged exposure occurs (Kelly, 2010), which is detrimental to most stream life (Biggs *et al.* 2002). It is acknowledged that these were one-off samples and there are inherent issues drawing conclusions from one-off sampling. To make any definitive statements concerning water clarity and its impact on stream health, additional sampling would be required.

3.1.3 Biological Attributes

3.1.3.1 Vegetation

The current state of riparian vegetation within the Hingaia Stream catchment is typical of land that has been heavily modified to suit agricultural purposes. Large scale land clearance and rural conversion has resulted in a limited intactness of the riparian margins within the catchment (Table 8; Appendix A, Map 5). Grasses, mostly in the form of grazed pasture, were the most commonly observed ‘dominant vegetation type’ adjacent to the watercourses, recorded from 53% of the surveyed stream length (Table 8; Appendix A, Map 6). The average riparian width recorded through the catchment was largely less than 5 m, which was to be expected in a highly modified catchment where land is effectively utilised to the stream edge in order to maximise the available space for crop production or livestock grazing. This severely reduces the riparian zone’s ability to slow and spread overland stormwater runoff and filter out pollutants, including sediment laden runoff, before it enters the stream. Canopy and understory vegetation have suffered extensively with almost half of the total stream length surveyed having no canopy vegetation within 20 m of the stream and a third having no form of understory. The degradation to riparian vegetation is also consequential to stream shading and nearly half of the watercourse network had no effective form of shading cover. Degradation to riparian vegetation was the most pronounced in the southern areas of the catchment where agriculture (stock and crop) was the most intensive.

Twenty-six terrestrial Significant Ecological Areas (SEA) were identified within the catchment and largely represent the remnant stands of native vegetation present within the catchment (see Section 2.4). Native riparian vegetation was mostly recorded around steeper section of streams, where other land use types were not practical. Many of the eastern gullies were still vegetated or were in a state of regeneration thanks to the planting and fencing efforts of some landowners. A number of stream planting projects have been carried out in the eastern and southern parts of the catchment, with groups such as Trees for Survival being active in the area. Restoring native riparian vegetation represents the single most beneficial improvement that could be made to the catchment as a whole. Significant gains would most likely be made for stream and ecosystem health, flood management and the amenity of the region if large scale riparian planting projects were to be carried out. Because of this, many identified management goals and enhancement opportunities in Section 5.0 identify riparian planting as a key component.

A lack of stream shade, in conjunction with nutrient laden runoff, can result in waterways developing excessive growth of macrophytes (aquatic plants) and/or periphyton (Table 9; Figure 3). Emergent macrophytes were commonly observed during the stream survey, with 60,289 m of stream, 37% of the total surveyed length, having emergent macrophyte growth in excess of 20% of the water surface area. Submerged macrophyte beds, while not as prevalent were still frequently encountered (Table 9). Macrophytes have the potential to choke waterways, trap sediment and impede water movement, which can cause flooding issues during rainfall events (James, 2013). Given the high abundance of macrophyte growth recorded, this is potentially an issue in some areas within the Hingaia Stream catchment.

Figure 3: Excessive macrophyte growth along poorly shaded section of stream.

Table 8: Summary of riparian vegetation across the extent of watercourse surveyed. Note that Average Riparian Width, Vegetation Height Categories, and Dominant Vegetation Type are assessed for each bank separately, so the sum total length will be twice the total length of surveyed watercourse.

Attribute	
Total Length of Surveyed Permanent and Intermittent Watercourse (m)	166,324
No. Permanent and Intermittent reaches (Ecolines)	1,607

	Mean	**Min**	**Max**
Percentage of intact vegetation within reach.	17%	0%	100%

	≤10 %	**≤30%**	**≤50%**	**≤70%**	**≤90%**	**>90%**
Average Overhead Cover (% of total stream length) (length of stream (m))	**44%** 73,208	**14%** 23,460	**10%** 16,748	**11%** 17,474	**13%** 22,418	**8%** 13,016
	0m	**≤5m**	**≤10m**	**≤15m**	**≤20m**	**>20m**
Average Riparian Width (% of total stream length) (length of stream (m))	**38%** 125,602	**31%** 102,581	**11%** 35,981	**6%** 19,813	**6%** 18,459	**9%** 30,211

	None	**Exotic**	**Mixed**	**Native**
Canopy (% of total stream length) (length of stream (m))	**44%** 145,505	**18%** 60,856	**13%** 43,547	**25%** 82,740
Understorey (% of total stream length) (length of stream (m))	**35%** 115,641	**16%** 52,179	**34%** 113,129	**15%** 51,699
Groundcover (% of total stream length) (length of stream (m))	**10%** 32,631	**83%** 277,491	**4%** 13,937	**3%** 8,589

	Grassed	**Planted**	**Low Growing**	**Scrub**	**Regenerating**	**Mature**
Dominant Vegetation Type (% of total stream length) (length of stream (m))	**53%** 177,694	**3%** 9,624	**3%** 9,753	**10%** 34,014	**16%** 54,370	**14%** 47,193

Table 9: Summary of instream vegetation across the extent of watercourse surveyed.

	≤20%	20-50%	>50%
Submerged Macrophyte Cover (% of total stream length) (length of stream (m))	**56%** 933,331	**3%** 4,804	**0%** 629
Emergent Macrophyte Cover (% of total stream length) (length of stream (m))	**49%** 81,486	**21%** 34,405	**16%** 25,884
Periphyton Cover (% of total stream length) (length of stream (m))	**18%** 29,744	**2%** 3,128	**1%** 2,175

3.1.3.2 Habitat

The soft-sediment nature of the Hingaia Stream catchment has resulted in watercourses containing a low diversity of instream habitat and a limited amount of stable bank undercutting or suitable fish spawning habitat (Table 10). Stream modifications (straightening, widening and deepening) throughout portions of the catchment have also contributed to low instream habitat diversity, by making stream channels more uniform, through the removal of natural sinuosity or features such as pools or riffles. Through much of the catchment, continuous runs were the only habitat type observed. Stream habitat diversity was the highest in the steeper sections of stream, mostly in the west, where undeveloped hard-bottomed stream ran through incised, vegetated gullies. Here it was not uncommon to find riffle, run, pool sequences with cascades and/or rapids also present.

Table 10: Summary of watercourse habitat diversity. Note that for bank undercutting the categories are defined by a percentage of the total reach length with undercutting present i.e. if there are 500m of reach with 'Good' undercutting then <50% of this total length is undercut. Refer to the methodology document for further details.

Attribute	**Mean**	**Min**	**Max**
Number of Habitat Types within reach	1	0	5
	In stream	**Bank**	**In stream & Bank**
Percentage of Reaches with Fish Spawning Habitat present	14.5%	3.7%	4.6%

	None	**Some**	**Moderate**	**Good**	**Extensive**
Stable Bank Undercutting (% of total stream length)	**56.6%**	**39.9%**	**3.2%**	**0.3%**	**0%**
(length of stream (m))	94,066	66,445	5,361	452	0

The general paucity of stable substrates such as boulders, cobble, gravel or bedrock throughout the catchment (Table 5) and the lack of stable woody debris or bank undercutting meant that macrophytes likely provided the most important form of three-dimensional habitat for organisms living within much of the watercourse network. Macrophytes and submerged root mats were considered when assessing the potential for fish spawning. While these plant materials can provide spawning habitat, they may also have negative impacts on fish health and reduce their ability to successfully spawn. Excessive macrophyte growth and decay can negatively impact fish by lowering in stream oxygen levels (Caraco and Cole, 2002), while sediment accumulation within macrophyte beds or root mats may inhibit the ability of fish to successfully attach eggs to plant material (Ryan, 1991). Both the density and apparent sediment accumulation within instream plant material was taken into account when assessing its suitability for fish spawning habitat. Overall, most macrophyte beds were not considered likely to provide suitable spawning habitat and most good quality spawning habitat was located within areas of hard-bottomed stream, with well vegetated stream margins. Much of this habitat was however not available for fish, such as bullies, to utilise due to numerous fish passage barriers, particularly in the form of natural structures, being recorded through the catchment (see Sections 3.2 and 3.3).

3.2 Natural Structures

Waterfalls and cascades were very common throughout the catchment, with a total of 506 of these natural structures recorded (Table 11). The highest concentration of these were found in the steeper eastern sections of the catchment, where hard bottomed streams wound down through steep gullies (Appendix A; Map 6). Fifteen waterfalls were recorded as having a total height of 7 m or more, with the largest a tiered 30 m waterfall on a tributary of the Maketu Stream. These larger waterfalls were all within the eastern tributaries. A significant number of smaller waterfalls and cascades were also recorded on the main Hingaia Stream channel and these were concentrated in areas where hard-bottomed streams dominated, particularly in the upper mid-section.

More than 200 of these natural structures were classified as 'not safe' (an unprotected drop of 1 – 1.5 m), or 'not safe with a drop height of >1.5 m'. Two 'not safe' natural structures (Object ID 226 and 262) were located on public land, however both were difficult to access due to vegetation and steep topography which somewhat negated their overall risk to public safety. All other 'not safe' natural structures were on private property and had moderate to difficult access.

Waterfalls and cascades have the potential to cause issues for upstream fish passage due to drop height, water depth, water velocity or turbulence. Natural structures represent a major barrier to fish passage through the catchment with 469 of the 506 recorded natural structures presenting a barrier to at least one form of fish (swimmers, climbers, anguilliforms). Further details of this are described in Section 0 of this report.

Table 11: Natural structure safety risk matrix for structures recorded as ‘Not safe’ and ‘Not safe, Drop >1.5m’.

Attribute				
Total number of natural structures		506		
		Access		
Not safe		Easy	Moderate	Difficult
Land Ownership	Public	0	0	2
	Private	0	5	59
Not safe, Drop >1.5m		Easy	Moderate	Difficult
Land Ownership	Public	0	0	1
	Private	0	18	133


Figure 4: Maketu Waterfall, one of several large waterfalls in the eastern catchment.

3.3 Fish Survey

During the watercourse assessment and SEV surveys 2,513 fish were observed (Figure 5). In total, five species of fish were recorded (four native and one exotic). Longfin eel (*Anguilla dieffenbachii*), shortfin eel (*Anguilla australis*), banded kokopu (*Galaxias fasciatus*), inanga (*Galaxias maculatus*) and *Gambusia* (formerly mosquitofish, *Gambusia affinis*) were all positively identified during the field survey components. In addition, unidentified eels, unidentified bullies, unidentified galaxiids and fish that could not be identified to any level were recorded. Kahawai (*Arripis trutta*), recorded as 'other', were also observed near the stream mouth.

Most fish were recorded in the lower / mid catchment, north of Dale Road South. Despite significant natural and manmade fish barriers in the southern and eastern areas of the catchment eels, *Gambusia* and a solitary banded kokopu were recorded in these difficult to access areas. Koura (*Paranephrops planifrons*; freshwater crayfish), while not a fish species, were also recorded in the southern and eastern parts of the catchment.

Of all fish recorded during the survey, 95% were *Gambusia*, an exotic species classified as an 'unwanted organism' under the Biosecurity Act (1993). *Gambusia* are highly competitive, tolerate a wide range of environmental conditions and can produce 3-4 broods per year, all of which create the potential for this species to impact our native fish species (Baker et al. 2004). Loose schools of a few hundred *Gambusia* were often observed in the shallow, unshaded margins of a stream or darting in and out of clumps of macrophytes.

No single species of native fish was commonly observed and in general native fish sightings were rare. Two small schools of inanga, totalling approximately 12 individuals, represented the highest number of individuals observed for a positively identified native fish species during the watercourse assessment. Inanga have been identified as 'At Risk – declining' in the most recent threat classification list (Goodman et al., 2014), because of threats including fishing pressures (whitebaiting), pressure from pest fish (including *Gambusia*), habitat modifications and manmade fish passage barriers all likely to be contributing to population declines (Department of Conservation, 2018a). Longfin eel are also classified as 'At Risk – declining' (Goodman et al., 2014), Longfin eels are less tolerant of environmental changes than shortfin eels, and ongoing anthropogenic impacts such as habitat loss, pollution loading, and a lack of riparian vegetation are resulting in population declines (Department of Conservation, 2018b).

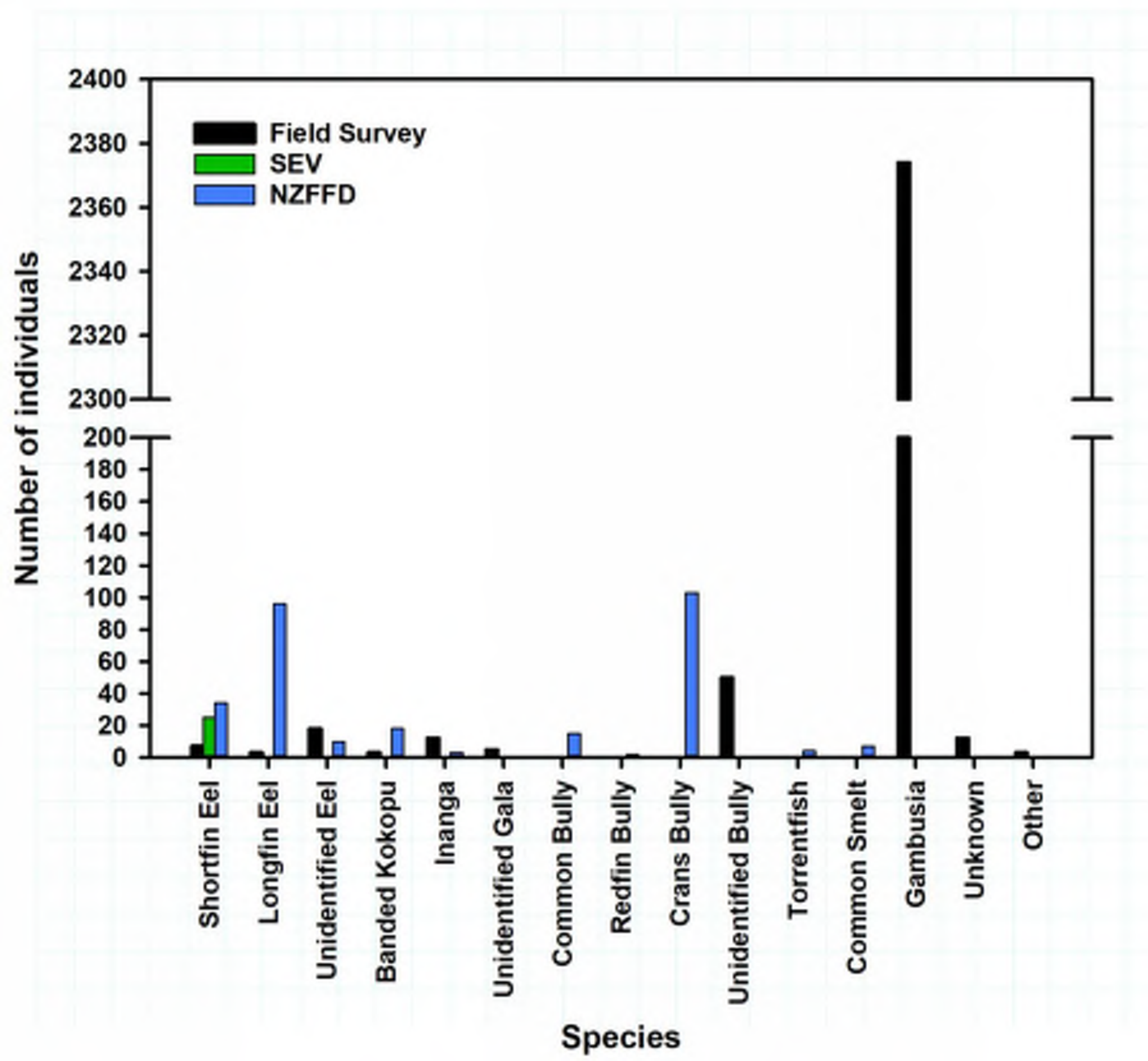


Figure 5: Fish species identified during the field survey and historically within the catchment from the New Zealand Freshwater Fish Database

Shortfin eels were the most commonly observed fish caught electrofishing during the SEV surveys and the most common eel observed during the general watercourse assessment. Shortfin eels and banded kokopu are both classified as 'Not Threatened' (Goodman et al., 2014).

The New Zealand Freshwater Fish Database (NZFFD) has no recent (within the past five years) fish records for the Hingaia catchment, however 33 records do exist from information collected between 1988 and 2008. Twenty of these records were associated with the small tributaries directly to the north and south of the Drury Quarry. Shortfin eel, longfin eel, banded kokopu and inanga were all identified in these records in addition to common bully (*Gobiomorphus cotidianus*), redfin bully (*Gobiomorphus huttoni*), Crans bully (*Gobiomorphus basalis*), torrentfish (*Cheimarrichthys fosteri*) and common smelt (*Retropinna retropinna*). Both longfin eel and Crans bully were recorded in good numbers through this period, however the majority of individuals recorded (70 of 103 Crans Bully and 55 of 93 longfin eels) came from a single site assessed in 1988 (NZFFD card 7382).

All historical records of torrentfish and inanga were also from this site, as were three of seven recorded smelt. This site was at the lower end of the Maketu Stream, downstream from the Maketu waterfall. At the time of survey this was an unvegetated section of stream with a mixture of hard-bottomed substrate types and mud. This appear to be very similar to current conditions based on that description. During the watercourse assessment inanga were observed from the lower Maketu Stream, in a very similar location to the Card 7382 site.

Fish passage barriers are an issue through much of the catchment with natural structures and culverts presenting the major challenges for fish dispersal (Table 12; Appendix A, Map 6;

Figure 6). Over 90% of natural structures surveyed (469 of 506) presented a barrier to fish passage, however the majority only presented a barrier to swimmers. More restrictive barriers, partial or complete barriers to climbers and/or anguilliforms, were recorded on 121 natural structures (26% of natural structures with a fish passage issue). Because fish species within the swimmer locomotory class do not typically penetrate far inland these waterfalls and cascades which limit climbers and/or anguilliforms are likely to have the greatest overall impact on the degree of fish dispersal through the catchment.

Fish barriers associated with culverts that were perched above the watercourse and/or experienced low flow impedances not characteristic of the surrounding reaches were present on 39% (358 of 918) of all culverts surveyed. The majority of these issues were associated with perched culverts where erosion at the outfall has resulted in a vertical drop from the culvert to the downstream channel. In many cases the culvert is also overhanging, making entrance impossible for fish. Culvert related fish passage issues were much more of an issue through the rural areas of the catchment, where privately installed culverts and pipes were often undersized or poorly placed. There were 326 fish passage issues recorded on rural, private assets, representing 91% of the total number of assets assessed as having some form of fish passages issues.

Prioritising the removal of fish barriers on engineering assets should be carefully considered, as the removal of such barriers may have little benefit in areas upstream of where waterfalls and/or cascades naturally restrict passage, for all but those species with excellent climbing ability. For example, perched culverts were commonly observed through the upper reaches of the eastern tributaries, however natural barriers to fish dispersal are present on almost all of these watercourses making the removal of manmade barriers less of a priority. Those locations where the removal of fish passage barriers would be of greatest benefit to fish dispersal have been included in the Enhancement Opportunities listed below in Section 5.2.

Table 12: Fish passage and habitat features within the catchment.

Fish Barriers	Natural Structures	Engineering Assets (inlets and outlets)	Engineering Assets (culverts and pipes)
Fish Passage devices present	na	0	0
Barrier to Swimmers	469	69	358
Barrier to Climbers	121	39	237
Barrier to Anguilliforms	22	15	102

Figure 6: Representative photos of fish passage issues. A) a natural barrier to fish passage (large waterfall) and B) artificial barrier to fish passage (perched culvert).

3.4 Stream Mouths

The Hingaia Stream mouth was 1.1 km in length and extended from its confluence with Slippery Creek to as far upstream as Cross Street within the Drury township. The upper stream mouth boundary was marked by the disappearance of obvious crab holes and the appearance of freshwater macrophytes on the channel edge. The stream mouth itself was dominated by saltmarsh. The lower (northern) sections of the stream mouth were lined by large rows of gabion baskets. These ‘flood training’ gabions have been installed to mitigate the impacts of flooding within the lower Hingaia Stream (AECOM, 2017), and are reflective of the significant flow volumes that occur during heavy rainfall events. These sections of bank lining were considered ‘unsafe’ as they were easily accessible and unfenced. More detail is provided in Section 3.9.

The Hingaia Stream drains into the Pahurehure Inlet (the south-eastern arm of the Manukau Harbour) via Drury Creek. This is a low energy receiving environment dominated by soft, fine sediments and expansive mangrove forests (Kelly, 2008). Near the Hingaia Stream mouth the coastal marine area (CMA) is classified as Coastal Protection Area (CPA) 1 (No. 29b) in the AUP(OP) (Auckland Council, 2016). The area near the Hingaia Stream Mouth (upper reaches of Drury Creek) is classified as a marine Significant Ecological Area (SEA-M1), a high value area that will be the most vulnerable to any adverse effects of inappropriate subdivision, use and development (Auckland Council, 2016). Within the upper tidal reaches of Drury Creek there are a variety of coastal marshes, grading from mangroves through to extensive areas of jointed rush-dominated saltmarsh to freshwater vegetation, in response to salinity changes (Auckland Council, 2016). This same area is a migration pathway between marine and freshwater habitats for numerous species of native freshwater fish.

3.5 Inanga Spawning

No specific areas of inanga spawning were identified during the survey. The Hingaia Stream, around and immediately upstream from the stream mouth, had steep, poorly vegetated banks with little overhead cover making it largely unsuitable for inanga spawning. An area of more general galaxiid spawning habitat with the potential for enhancement has been incorporated into Enhancement Opportunity 3. This was located on the northernmost tributary, maintained good connectivity to the main Hingaia Stream channel and was still very close to the stream mouth. See Section 5.2.2 for more details.

3.6 Wetlands

A total of 499 wetlands were recorded within the Hingaia Stream catchment. This included natural wetlands (303) and artificial wetlands (196) (Figure 7).

All the natural wetlands surveyed were classified as palustrine or riverine wetlands. Natural wetlands were found on the margins of main stream channels or through the low gradient channels and headwaters of smaller intermittent and ephemeral stream channels. Most natural wetlands occurred in agricultural land and were unfenced. Consequently, many have been significantly damaged by stock (Figure 8). Vegetation in these wetlands was degraded and typically consisted of occasional native sedges, rushes and pastoral grasses and weeds.

Artificial wetlands fell largely into two categories: Wetlands designed for aesthetic purposes (26%), or those used for farming purposes (35%). Aesthetic ponds were largely designed to serve as a visual feature, however many were poorly maintained, and vegetation was dominated by exotic species. Many appeared to be utilised for duck shooting, evident through the placement of maimai.

Farm ponds, 51 in total, were features created to provide water for stock or other farming requirements. Most farm ponds contained perimeter vegetation, including 14 where native vegetation was the dominant vegetation type. Sediment detention wetlands were common in the earthworks area associated with Drury South and within or adjacent to the Drury Quarry. Twenty-five wetlands had been formed as a consequence of blocked culverts. Two were associated with the culvert under Fielding Road. The presence of these wetlands suggests the potential for road flooding as water was unable to dissipate through the designated culvert under the road.

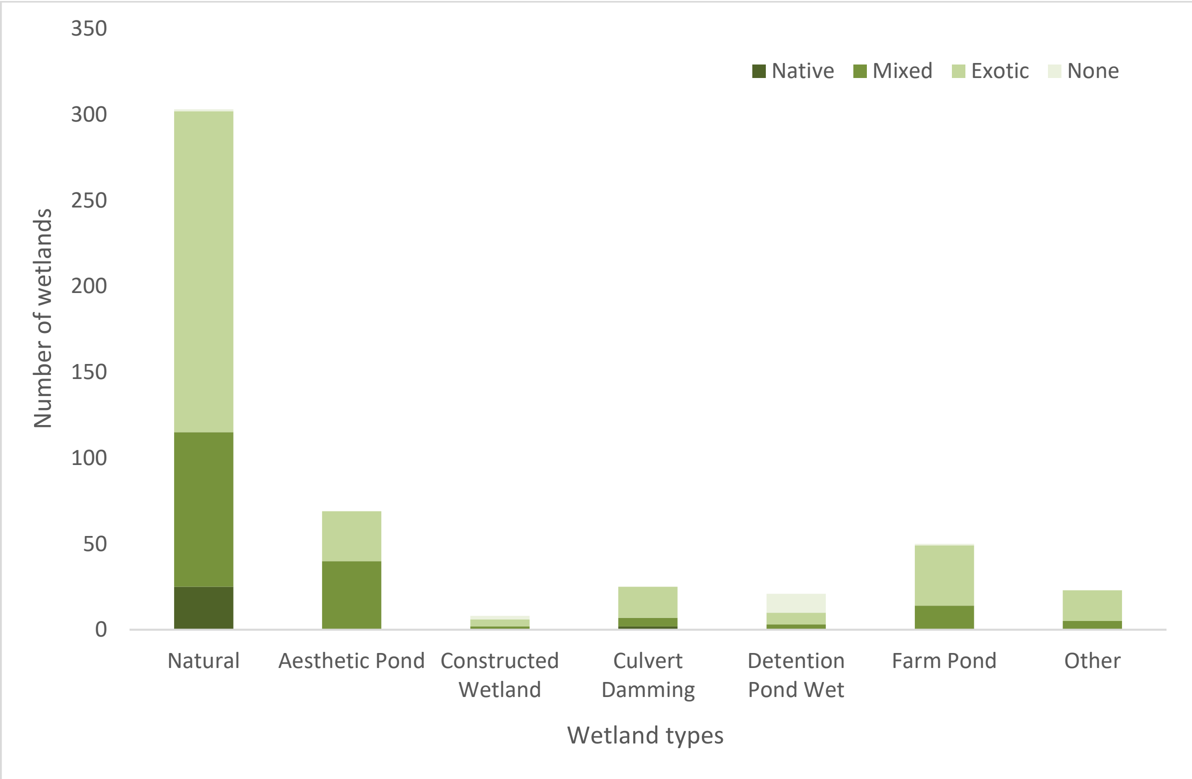


Figure 7: Summary of wetlands in the catchment area.

Figure 8: Wetlands within the catchment. A) stock damaged natural wetland and B) farm pond

The enhancement of wetlands and streams within the headwater regions of the southern catchment has been suggested within Management Zone 4 and Enhancement Opportunity 10. These headwater wetlands play an important role in dictating the ecological and conveyance values of the wider catchment and should be protected from stock. Further details can be found within Section 5.1and 5.2.7.

3.7 Engineering Assets (inlets, outlets)

A total of 481 inlets and outlets were surveyed within the Hingaia Stream catchment, 262 (54%) of which were fully assessed using standard WAR methodology (Table 13). This included 13 Council owned inlets and outlets that were located from existing Auckland Council GIS and an additional 138 assets on public or mixed ownership land, but not recorded within existing Council GIS layers. These assets were classified as having 'unknown' ownership. Other fully assessed assets were located on private land within urban areas and had private, or unknown ownership. Five Council owned assets could not be located, these were not considered as surveyed assets so are not included in Table 13: Summary of inlets and outlets assessed over the surveyed extent.. The remaining 219 (46% of total) surveyed assets were rural, private assets assessed using the abridged methodology, due to an issue associated with erosion and/or condition and/or fish passage.

The overall condition of inlets/outlets assets was assessed using specified WAR methodology whereby each asset was assigned a condition grade along a spectrum from 'very poor' to 'very good'. This rating system was not applied to inlet or outlet points that did not have headwall, wingwall or apron structures and subsequently 44% of fully assessed assets within the catchment could not be rated (the pipe and culvert associated with these 'non rateable' inlet or outlet points was rated separately as detailed in Section 3.8). The remaining 56% of fully assessed assets are defined as 'rateable' throughout this report.

A 'poor' or 'very poor' condition rating was one of the issues that would trigger an abridged assessment on a private, rural asset. Subsequently 14% of abridged assessments were triggered, in part, due to the poor condition of the asset (Table 13; Appendix A, Map 4). All remaining abridged assessments were either in acceptable condition structurally, or did not have headwall, wingwall or apron structures so condition could not be assessed. 'Rateable' abridged assets are reported separately to fully assessed 'rateable' assets in this report.

Of the 114 fully assessed rateable inlets/outlets within the catchment, 64% were recorded as being in 'good' or 'very good' condition, which suggests an asset is essentially brand new or is in an acceptable physical condition, has only minor deterioration evident and has a minimal short-term risk of failure. Eight rateable inlets/outlets (7% of rateable inlets/outlets) were in 'poor' condition, which suggest they were functioning poorly due to damage or deterioration, requiring repair or replacement. A single privately-owned outlet (UKNA134) was recorded as being in 'very poor' condition. This outlet had a timber headwall which had completely collapsed over the culvert. The headwall was no longer providing any functionality and was causing moderate erosion issues. Assets with a condition grade of 'very poor' are no longer functional and require urgent attention.

No Council owned assets were identified as in 'poor' or 'very poor' condition.

Table 13: Summary of inlets and outlets assessed over the surveyed extent.

<table>
<tr><th></th><th>Assets Surveyed</th><th>Assets Correct in GIS</th><th>Assets Incorrect in GIS</th><th>Assets Not in GIS</th></tr>
<tr><td>Number of assets (inlets/outlets)</td><td>481</td><td>13</td><td>0</td><td>468</td></tr>
<tr><th></th><th colspan="2">Full assessment</th><th colspan="2">Abridged Assessment</th></tr>
<tr><td>Number of assets (inlets/outlets)</td><td colspan="2">262</td><td colspan="2">219</td></tr>
<tr><th>Condition Assessment</th><th>Very Good</th><th>Good</th><th>Average</th><th>Poor</th><th>Very Poor</th></tr>
<tr><td>Condition of structure (Full assessment)</td><td>2</td><td>71</td><td>32</td><td>8</td><td>1</td></tr>
<tr><td>Condition of structure (Abridged assessment)</td><td>na</td><td>na</td><td>na</td><td>28</td><td>3</td></tr>
<tr><th></th><th>None</th><th>Slight</th><th>Moderate</th><th>Severe</th></tr>
<tr><td>Extent of erosion associated with structures</td><td>29</td><td>233</td><td>144</td><td>75</td></tr>
<tr><th></th><th>Replacement</th><th>Structural</th><th>Patching</th><th>Debris Removal</th><th>Vegetation Clearance</th><th>Erosion Protection</th></tr>
<tr><td>Maintenance required (Full assessment only)</td><td>0</td><td>28</td><td>0</td><td>3</td><td>9</td><td>4</td></tr>
</table>

Twenty-eight abridged assessment (private) inlets and outlets were recorded as in 'poor' condition, with a further three in 'very poor' condition (. 'Assets in 'very poor' condition were associated with completely collapsed structures where material was now blocking the culvert leading to erosion, flooding and fish passage issues.

Forty-four of 114 (39%) fully assessed, rateable assets (representing 18% of the total number of inlets/outlets fully assessed) required some form of maintenance. Two of forty-four were Council owned (1115669; 1174015) Maintenance requirements consisted of routine maintenance such as debris removal, vegetation clearance, asset repair or erosion protection. Structural repairs were the most common form of maintenance required with 28 (60%) of inlets and outlets requiring maintenance needing structural repairs. Private assets assessed using the abridged methodology were not prescribed a maintenance type so are not mentioned in the maintenance section below.

Routine maintenance requirements typically applied to fully assessed assets with a ‘good’ or ‘average’ condition grade. While the requirement for repair or erosion protection typically applied to assets with a ‘average’ to ‘very poor’ condition grade. Seven fully assessed assets with a ‘poor’ condition grade (and the assets in ‘very poor’ condition) required structural repairs while one required erosion protection and the remaining eight (and the asset in ‘very poor’ condition) required repairs.

Figure 9: Significant erosion, and a fish barrier, associated with a rural, private asset.

All inlets and outlets, including those assessed using abridged methodology and regardless of whether they were considered as ‘rateable’ or not were assessed for the level of erosion surrounding the asset. Asset erosion was defined as erosion within 2 - 5 m of the outfall structure which had the potential to cause ongoing erosion. Of the 481 inlets and outlet assets assessed, 8% of assets had no erosion, 48% had slight erosion and 45% had more significant erosion issues. Erosion issues can be detrimental to stream health and bank stability or result in the damage or failure of stormwater assets. Thirty-five inlets and outlets with moderate to severe erosion were fully assessed assets, of which 10 were assets with structures and required maintenance (erosion protection or structural repairs). This included one council owned outlet point (1115624) with moderate erosion issues and 23 other inlets or outlets on public land with unknown ownership that had moderate to severe erosion issues. All remaining inlets or outlets assessed as having moderate to severe erosion issues (184 of 219) were private, rural assets surveyed using the abridged methodology. Overall 84% of abridged assessment inlets and outlets had moderate to severe erosion issues. This highlights a significant issue in the rural areas of the catchment, where poorly installed or undersized culverts are erosion prone. Rural Management Zone objectives and a number of Enhancement Opportunities aim to address this issue (see Section 5.0 for more information).

Outlets and occasionally inlets have the potential to create fish barriers, which impede the passage of native fish between sections of watercourse. Barriers to fish may be a consequence of poor asset construction and can be caused by;

- Incorrect placement of dissipating structures, resulting in a vertical drop.
- Insufficient water depth at the outlet to allow passage for swimming fish.
- Blockages by debris or sediment.

Sixty-nine inlets or outlets, were recorded as having a barrier which would impede at least one form of fish locomotory type (swimmers, climbers, or anguilliforms). This included 15 inlets or outlets in urban areas and 44 in rural areas. Forty-one of these inlets and outlets presented barriers to climbers (in addition to swimmers), while 18 of those 41 also presented a barrier to anguilliforms. These 41 represent the most ‘restrictive’ inlets and outlets for fish passage. Of the highly restrictive inlets and outlets, 31 (76%) had a partial or complete barrier, such as a vertical drop, which would be expected to restrict fish passage at all times of the year. Three of these were assets with unknown ownership on public or mixed ownership land (UNKA172; UNKA174; UKNA195). The remaining eight of the highly restrictive inlets and outlets had temporary barriers associated with a low flow impedance over a dissipating structure. These types of barriers are not likely to exist during wetter months when stream levels are higher.

In total, there were 13 Council owned assets (inlets and outlets recorded in existing Auckland Council GIS layers) that were surveyed during this assessment. An additional five were marked in existing GIS layers, but could not be located, so were not surveyed. Overall Council owned assets were found to be in ‘good’ to ‘average’ condition with very few maintenance related issues recorded.

A list of recorded maintenance issues on Council assets is outlined below:

- Two Council owned assets in average condition required structural repairs (1115669; 1174015).
- One Council owned outlet point had moderate erosion (1115624).

Additionally;

- Four assets on public or mixed ownership land, but with unknown asset ownership were in 'poor' condition (UKNA002; UKNA030; UKNA150; UKNA240).
- Fifteen assets with unknown asset ownership required engineering maintenance (UKNA002; UKNA016; UKNA030; UKNA065; UKNA104; UKNA147; UKNA150; UKNA161; UKNA168; UKNA171; UKNA181; UKNA195; UKNA208; UKNA229; UKNA240).
- Twenty-seven assets with unknown asset ownership had moderate to severe erosion (UKNA004; UKNA065; UKNA104; UKNA105; UKNA167; UKNA176; UKNA178; UKNA181; UKNA185; UKNA187; UKNA189; UKNA191; UKNA192; UKNA201; UKNA203; UKNA205; UKNA206; UKNA208: UKNA210; UKNA218; UKNA219; UKNA228 UKNA229; UKNA240; UKNA244; UKNA245).
- Three assets with unknown ownership had presented a highly restrictive barrier to fish passage (UKNA172; UKNA174; UKNA195).

It is recommended that ownership of these assets be established so that maintenance can be carried out by the appropriate parties where necessary.

Structure safety was only assessed on fully assessed 'rateable' assets. Twenty fully assessed, rateable inlets / outlets were classified as 'not safe' and a further 58 as 'not safe, drop > 1.5 m' (Table 14). Safety was assessed with regards to the extent of the risk the hazard presented to public safety and the location of the hazard. A risk rating of 'not safe' was given to potential hazards with an unprotected drop of between 1 m and 1.5 m or where fencing was deteriorating. A risk rating of 'not safe, drop > 1.5 m' was given to assets with an unprotected drop greater than 1.5 m in height.

Three 'not safe' inlets and/or outlets were easily accessible via public land, however all three had unknown ownership (UKNA029; UKNA182; UKNA201). Five additional 'not safe' assets with unknown ownership were located on mixed ownership or public land, however these were all surveyed in areas with moderate to difficult access, reducing the likelihood of public access. All other 'not safe' assets were on private property and had moderate to difficult access (Table 14).

Fifteen easily accessible assets with unprotected drops of >1.5 m were located on public land, however all 15 had unknown ownership (UKNA014; UKNA017; UKNA018; UKNA019; UKNA100; UKNA101; UKNA109; UKNA110; UKNA116; UKNA170; UKNA171; UKNA181; UKNA186; UKNA197; UKNA198). Twenty-seven additional 'not safe - drop

>1.5 m' assets with unknown ownership were located on mixed ownership or public land, however these were all surveyed in areas with moderate to difficult access, reducing the likelihood of public access. All other 'not safe - drop >1.5 m' assets were on private property and had moderate to difficult access.

It is recommended that ownership of those assets with unknown ownership be established so that any safety improvements can be carried out by the appropriate parties where necessary.

Table 14: Engineering structure safety risk matrix for fully assessed structures recorded as 'Not safe' and 'Not safe, Drop >1.5m'.

Not safe		**Access**		
		Easy	**Moderate**	**Difficult**
Land Ownership	Public	3	3	0
	Council	0	0	0
	Private	0	1	11
	Unsure	0	0	2
Not safe, Drop >1.5m		**Easy**	**Moderate**	**Difficult**
Land Ownership	Public	15	16	7
	Council	0	0	0
	Private	0	9	7
	Unsure	0	3	1

3.8 Engineering Assets (culverts, pipes)

A total of 918 pipes and culverts were surveyed within the Hingaia Stream catchment, 151 (16% of total) of which were fully assessed using standard WAR methodology (Table 15; Appendix A, Map 4). This included five Council owned pipes and culverts that were located from existing Auckland Council GIS and an additional 87 assets on council, public or mixed ownership land, that were not recorded within existing Council GIS layers. These assets were classified as having 'unknown' ownership. Other fully assessed assets were located on private land within urban areas and had private, or unknown ownership. Three Council owned assets could not be located; these were not considered as surveyed assets, so are not included in Table 15. The remaining 767 (84% of total) surveyed assets were rural, private assets assessed using the abridged and limited methodologies (Table 15). The abridged assessment methodology was applied to rural, private asset with condition or fish passage issues while the limited assessment methodology was applied to all remaining rural, private assets with no significant issues.

The overall condition of pipes and culverts was assessed using specified WAR methodology whereby each asset was assigned a condition grade along a spectrum from ‘very poor’ to ‘very good’. All fully assessed pipes and culverts (assets within urban areas) were assessed for condition and are defined as ‘rateable’ throughout the report.

A ‘poor’ or ‘very poor’ condition rating was one of the issues that would trigger an abridged assessment on a private, rural asset and subsequently 4% of abridged assessments were triggered, in part, due to the poor condition of the asset (Table 15). All remaining abridged assessment assets were structurally in acceptable condition. Abridged assessment assets are reported separately to fully assessed ‘rateable’ assets in this report. Assets assessed with the limited methodology were considered to be in ‘average’ condition or better and the condition field for such assets was not filled out.

The majority of fully assessed rateable pipes and culverts (71%) were in ‘good’ or very ‘good condition meaning they were either near new or in good working condition with only minor deterioration present. Eight fully assessed rateable culverts were in ‘poor condition, suggesting these culverts possessed elements approaching the end of their service life and currently had a high risk of failure. Three of these were on Council or public owned land but had unknown ownership (UKNP017; UKNP123; UKNP126). Three fully assessed pipes and culverts were identified as being in ‘very poor’ condition, all three were privately owned assets. An additional 15 culverts were identified as being in ‘poor’ or ‘very poor condition during abridged assessments of rural, private assets.

The highest priority maintenance type was prescribed to all fully assessed rateable assets. Maintenance types included general maintenance such as vegetation clearance or debris removal, erosion protection, structural repairs and patching or full replacement. Overall 32% (48 of 151) fully assessed pipes and culverts required maintenance. Routine maintenance was the most common form of maintenance required with 21 pipes and culverts requiring vegetation clearance or debris removal. Culverts in ‘poor’ or ‘very poor’ condition typically required replacement or structural repairs to address a loss of functionality.

Culverts and pipes have the potential to create fish barriers, which impede the passage of native fish between sections of watercourse. Barriers to fish passage may be a consequence of:

- Poor asset placement, including culverts and pipes that are perched above the watercourse resulting in vertical separation between the two sections of watercourse;
- Culverts/pipes that have insufficient water flow during baseflow periods or undersized culverts with high water velocity.
- Debris or fine sediment blocking passage through the culvert.

A barrier to at least one form of fish locomotory type was recorded on 32 culverts, including eight identified on Council, public or mixed ownership land, but with unknown ownership (UKNP004; UKNP007; UKNP013; UKNP014; UKNP018; UKNP099; UKNP104; UKNP137). Fish passage issues represent a major reason for abridged assessments being applied to rural, private assets and 326 of the 344 (95%) of pipes and culverts assessed using the abridged methodology presented some form of fish passage issue. Overall 358 fish barriers were recorded in association with culverts and pipes.

Most fish passage issues associated with culverts and pipes were associated with poor culvert placement, resulting in erosion and the subsequent perching of the culvert above the stream (at the downstream end). Culvert perching was causing an issue for 69% of fully assessed culverts and pipes with fish passage issues and 78% abridged assessment culverts and pipes with fish passage issues. Because perching creates a vertical, or near vertical, drop and perched culverts are often overhanging the watercourse below these can become highly restrictive to fish, even those with a good ability to climb (fish in the climber and anguilliform classes). Highly restrictive barriers, partial or complete barriers to swimmers and climbers were present on 13 fully assessed pipes and culverts, six of which were also a barrier to anguilliforms. Highly restrictive barriers were present on 186 abridged assessment culverts and pipes, 91 of which were also a barrier to anguilliforms.

Table 15: Summary of culverts and pipes assessed over the surveyed extent

<table>
<tr><th></th><th colspan="15">Assets Surveyed</th><th colspan="15">Assets Correct in GIS</th><th colspan="15">Assets Incorrect in GIS</th><th colspan="15">Assets Not in GIS</th></tr>
<tr><td>Number of Assets (pipes/culverts)</td><td colspan="15">918</td><td colspan="15">5</td><td colspan="15">0</td><td colspan="15">913</td></tr>
<tr><th></th><th colspan="20">Full Assessment</th><th colspan="20">Abridged Assessment</th><th colspan="20">Limited Assessment</th></tr>
<tr><td>Number of assets (inlets/outlets)</td><td colspan="20">151</td><td colspan="20">344</td><td colspan="20">423</td></tr>
<tr><th>Condition Assessment</th><th colspan="12">Very Good</th><th colspan="12">Good</th><th colspan="12">Average</th><th colspan="12">Poor</th><th colspan="12">Very Poor</th></tr>
<tr><td>Condition of assets (full assessment)</td><td colspan="12">2</td><td colspan="12">105</td><td colspan="12">33</td><td colspan="12">8</td><td colspan="12">3</td></tr>
<tr><td>Condition of assets (abridged assessment)</td><td colspan="12">na</td><td colspan="12">na</td><td colspan="12">na</td><td colspan="12">12</td><td colspan="12">2</td></tr>
<tr><th></th><th colspan="10">Replacement</th><th colspan="10">Structural</th><th colspan="10">Patching</th><th colspan="10">Debris Removal</th><th colspan="10">Vegetation Clearance</th><th colspan="10">Erosion Protection</th></tr>
<tr><td>Maintenance required (full assessment)</td><td colspan="10">7</td><td colspan="10">13</td><td colspan="10">2</td><td colspan="10">7</td><td colspan="10">14</td><td colspan="10">5</td></tr>
</table>

While the large number of highly restrictive fish passage barriers associated with pipes and culverts identified within the catchment is a concern, many of these fish passage issues were recorded on smaller stream channels and tributaries that were upstream of natural structures also restricting fish passage. The removal of manmade fish passage barriers, particularly highly restrictive ones, should be prioritised to areas where natural structures downstream are not already creating fish passage issues. Areas where this is likely to improve fish dispersal through the catchment are outlined within some of the Enhancement Opportunities listed below in Section 5.2.

In total, five Council owned assets were assessed, two of which required vegetation clearance (SWM6323 and UKNP002). No other issues were recorded on Council owned assets in existing GIS records.

Nine culverts were deemed to be creating a potential flood risk. These were either due to being blocked, or the culvert being undersized and no longer being able to cope with stormwater flows. Four culverts (UKNP017; UKNP019; UKNP023: UKNP124) were on Council, public or mixed ownership land, but with unknown ownership. This included a culvert under Fielding Road, which was completely blocked, with a large area of water pooling upstream of the road. It is recommended that ownership of assets comprising a potential flood risk be determined so the appropriate flood management actions can be taken.

An additional 11 pipes and culverts on Council, public or mixed ownership land, but with unknown ownership required vegetation clearance or debris removal (UKNP004; UKNP007; UKNP017; UKNP019; UKNP023; UKNP024; UKNP062; UKNP094; UKNP105; UKNP123; UKNP133). Two of these assets were in 'poor' condition (UKNP017; UKNP123). A further 16 required erosion protection, patching or structural repairs (UKNP003; UKNP008; UKNP010; UKNP012; UKNP014; UKNP020; UKNP022; UKNP026; UKNP075; UKNP076; UKNP091; UKNP092; UKNP109; UKNP120; UKNP126; UKNP127). One of these assets was in 'poor' condition (UKNP127). It is recommended that the ownership of these culverts be established so that maintenance can be carried out by the appropriate parties.

3.9 Bank and Channel Lining

Stream bank and channel lining are typically installed to help manage erosion occurring under high velocity stream flow conditions, often near existing structures which need to be protected, or where major stream channels converge. Extensive lining, however, can exacerbate downstream flooding by constraining higher flood peaks and leading to more frequent flood events.

A total of 2,467 m of stream bank was lined within the Hingaia Stream catchment, with a further 832 m of bed (channel) lining recorded (Table 16). Channel base lining was only found on sections of stream also containing bank lining. The overall condition of most of the lining was good, with 70% of bank and 73% of channel lining recorded as being in 'good' condition (Table 16). Four short sections of bank lining, three of which included channel lining, were recorded as being in 'poor' condition. These were all non-functioning sections of rock or timber lining. The overall impact of channel lining on stormwater flows was not significant, suggesting that the presence of lining was not restricting flows in a manner that would lead to flooding or erosion issues during heavy rainfall events. The single exception to this was a 19 m section of bank lining on the stream channel east of Dale Road. Here large concrete blocks that were lining the banks were extending into the middle of the channel, potentially blocking flow and causing flooding or damage to lining itself.

Table 16: Summary of bank lining assessed over the surveyed extent. Note that the condition assessment is based on the overall condition of the lining, where both banks or channels are lined these are not assessed separately.

Physical Factors					
Total Length of Surveyed Watercourse (m)	177,056				
No. Reaches	1,737				
Total Length of Bank Lining (m)	2,467				
Total Length of Channel Lining (m)	832				
	Mean		**Min**		**Max**
Bank Height (m)	1.2		0.25		3.5
Length of bank lining (m)	32.5		3.0		127.7
Length of channel lining (m)	36		3.5		127.7
Condition Assessment	**Very Good**	**Good**	**Average**	**Poor**	**Very Poor**
Condition of bank lining (% of total bank lining length) (length of lining (m))	**0%** 0	**70%** 1,736	**29%** 711	**1%** 19	**0%** 0
Condition of channel lining (% of total channel lining length) (length of lining (m))	**0%** 0	**73%** 862	**38%** 316	**1%** 7	**0%** 0
	Not Significant		**Significant**		**Critical**
Impact on Stormwater Flows (% of total bank and channel lining) (length of lining (m))	**98.6%** 1,353		**1.4%** 19		**0%** 0

The majority of the lining assessed as having safety issues were on private land with moderate or difficult access (Table 17). Three lengths of lining were on Public land, all of which were assessed as being not safe with an unprotected drop of >1.5 m. Two of these areas of linings were in localities of moderate to difficult access, while the last was easily accessible. This was the series of gabion baskets lining the Hingaia Stream mouth. Public reserve allowed easy access to the edge of these gabion baskets and there were no protective barriers in place. The safety of these structures should be reviewed, and protective measures erected if deemed necessary. The enhancement of the Hingaia Stream mouth is part of Enhancement Opportunity 1 and improved safety of these structures, while not listed as an enhancement in Table 31, is something that could be considered as a part of potential enhancement works.

Table 17: Bank lining safety risk matrix for structures recorded as 'Not safe' and 'Not safe, Drop >1.5m'.

Not safe		**Access**		
		Easy	**Moderate**	**Difficult**
Land Ownership	Public	*0*	*0*	*1*
	Private	*0*	*1*	*8*
Not safe, Drop >1.5 m		**Easy**	**Moderate**	**Difficult**
Land Ownership	Public	*1*	*1*	*1*
	Private	*0*	*0*	*9*

3.10 Erosion Hotspots

Erosion hotspots are described in the WAR methodology as areas of the stream channel or bank greater than 2 metres in length where severe erosion has caused slumping, or exposed areas of soil that are greater than 5 m^2. Such areas must also show evidence of active erosion and pose a potential risk to stream health or safety to be considered a hotspot. Areas where severe stock damage had compromised bank structure and stability, to a point where active erosion by flood events would be highly likely, were also considered as erosion hotspots in this report. Surveyed stream lengths were assessed for erosion hotspots according to these criteria and areas located 10 metres immediately upstream of any erosion hotspots were assessed for bank and channel stability using the standard Pfankuch Bank Stability assessment method.

In total 134 erosion hotspots were recorded within the catchment (Table 18; Appendix A, Map 4; Figure 10). The majority of hotspots (122) had formed as a direct response to increased water flow during flood events while the remaining 16 were in areas where severe stock damage was likely to create ongoing bank erosion issues during high flow periods. The average size of an erosion hotspot was 13 m in length and 37 m^2 in area (Table 18). The four largest erosion hotspots were all approximately 200 m^2 in area and were scattered through the catchment. These were large scale eroded areas contributing significant amounts of sediment to the stream, however the majority of hotspots were smaller, isolated patches of active erosion that was considerably more severe than observed on the surrounding banks.

Figure 10: Erosion hotspot alongside a stream channel edge.

Four hotspots were recorded with a moderate to high safety risk, though all of these were in areas of difficult access on private property (Table 18). These were located in close proximity to farm tracks and/or buildings on a single property near the airstrip on Peach Hill Road. Two hotspots, including one that had a moderate safety risk, were recorded as presenting a moderate risk to building safety. Both hotspots were within 15 m of the nearest structure (a storage container and pump shed). Overall only five separate hotspots presented a moderate or high risk to human or building safety. The majority of hotspots were therefore recorded due to their potential detrimental effect on stream health, as opposed to any obvious safety risk.

Erosion hotspots were characteristically found on steep, unvegetated bank slopes with evidence of mass wasting on the banks immediately upstream or downstream (Table 19). Consequently, they scored poorly in the Pfankuch bank stability assessment (Table 19) and were likely to suffer from ongoing erosion issues, detrimental to the watercourse.

Table 18: Summary of erosion hotspots.

Attribute				
Total Length of Surveyed Watercourse (m)		177,056 (166,324 fully assessed)		
No. Reaches		1,737 (1,607 fully assessed)		
Total Length of Erosion Hotspots (m)		1,766		
Total Area of Erosion Hotspots (m^2)		4,898		
Total Number of Erosion Hotspots		134		
		Mean	**Min**	**Max**
Length (m)		13	1.6	127
Bank Height (m)		1.9	0.2	6
Area (m^2)		37	2	200
Safety Risk		**Access**		
		Easy	**Moderate**	**Difficult**
Land Ownership	Public	0	0	0
	Private	0	0	4

Table 19: Summary of Pfankuch bank stability assessment of the 10m upstream of erosion hotspots.

	Excellent	Good	Fair	Poor
Land Slope	0	0	33	1,733
Mass Wasting	0	193	798	776
Debris Jam	162	969	434	201
Bank Vegetation	24	91	349	1,303
Overall Stability Index (% of total stream length) (length of stream (m))	**0%** 0 Scores ≤13	**0%** 0 Scores 14- 23	**19.3%** 340 Scores 24 -32	**80.7%** 1,426 Scores ≥33

3.11 Miscellaneous Points

3.11.1 Discharges

Most discharge type miscellaneous points recorded were for tributaries that were not present on the stream lines to survey provided by Auckland Council. This consisted of permanent, intermittent and ephemeral channels. A single spring was observed adjacent to the stream channel. This spring had resulted in a small wetland area near ecoline MAK_1_195_F. No discharge points were considered to have a significant or critical impact on stormwater flows.

3.11.2 Engineering

Engineering type miscellaneous points were the most commonly recorded miscellaneous point and the majority of these were debris jams within the watercourse network. Most debris jams were not causing issues that would be considered significant or critical for the stormwater network, as per the watercourse methodology. In total, 5 of 249 recorded debris jams were having an impact on stormwater flows, one significantly and four critically. These debris jams represented large scale build-ups that were restricting and altering water flow, resulting in severe stream bank erosion. Four of these were on the Maketu Stream near ecolines MAK_3_037_I; MAK_3_039_A; MAK_3_071_B and MAK_2_082_A, while the other was along the Hingaia Stream near ecoline HIN_3_104_A.

Dams were the most numerous engineering type miscellaneous point to be recorded as having an impact on stormwater flows by restricting the flow of water downstream, potentially altering stream dynamics. Sixteen dams were recorded as having a significant or critical impact on stormwater flows, though few of these were likely to be impacting fish passage. These were low lying structures on private property largely associated with the creation of farm or aesthetic ponds.

3.11.3 Other

Other data points collected included bridges, landslides / slips, small scale litter dumping on private property and manmade fords. Bridges, including bridges crossing large roads, were the most common form of ‘other’ data point collected. While most bridges were having no impact on stormwater flows there were several that had degraded to the point that they were effectively blocking stream channels or creating debris jams, with the potential to impact stormwater flows. Three large slips, or debris that had been pushed into the channel were also impacting stream flows.

4.0 SEVs and Additional Variables

4.1 In-Stream and Riparian Habitat

More detailed ecological sampling following the Stream Ecological Valuation (SEV) methodology was undertaken at five sites within the Hingaia Stream Catchment between 29 - 30 May 2018.

SEV locations were selected based on relevant criteria which included:

- Representative of the wider catchment – Considering major land use or catchment vegetation cover changes, major changes in stream geomorphology, or other significant differences in pressures affecting the watercourses within the region.
- High priority enhancement opportunity sites.
- Future development – Future urban and/or special housing areas designated under the Auckland Unitary Plan (Operative in Part), to improve understanding of watercourses within these areas to inform planning for future development.

The five sites selected for SEVs are described below:

SEV1

- Located upstream from Flanagan Road (soft-bottomed stream).
- Located on the margins of an Urban and Future Urban Zone.
- Currently has a mixed/rural land use including light industry, horticulture, agriculture and residential (representative of lower catchment).
- Current site under investigation by Healthy Waters Unit (Auckland Council) for stormwater management opportunities and has been identified in this report as an Enhancement Opportunity site (See Section 5.2).

SEV2

- Located north of Peach Hill Road (hard-bottomed stream).
- Located within native bush remnant within farmland (representative of similar stony streams within remnant bush stands).
- Readily accessible, moderate sized section of stream.

SEV3

- Located along Hillview Road (hard-bottomed stream).
- Surrounded by lifestyle blocks (representative of low-lying mid catchment).
- Moderate sized stony stream similar to SEV2, however with limited riparian cover.

SEV4

- Located along Pinnacle Hill Road (soft-bottomed stream).
- Rural headwater stream in upper catchment (representative of small rural streams in upper catchment).

SEV5

- Located along Wykita Lane (soft-bottomed stream).
- Located within a Future Urban Zone.
- Flood prone area, representative of small, modified rural streams in lower catchment.
- Within identified Enhancement Opportunity site (see Section 5.2).

Detailed instream surveys at each site encompassed SEV assessments (Section 4.0), macroinvertebrate and fish community sampling (Section 4.3), as well as sediment chemistry (Section 4.4) and water quality/public health (Section 4.5).

For SEV site locations refer to Appendix A – Map 1. Representative photos of each SEV site surveyed in the Hingaia Stream catchment are shown in Figure 11.

	
SEV Site 1	

SEV Site 2

SEV Site 3

SEV Site 4

SEV Site 5

Figure 11: Representative SEV site photos.

4.2 Stream Ecological Valuation Assessment

Transect and habitat data, in conjunction with the macroinvertebrate and fish community data, was used to calculate a SEV (SEV Spreadsheet Version 2.2) score using the methodology specified in the Auckland Council Technical Publication 2011/009 (Storey et al., 2011a). A 100-metre reach was assessed at each of the five SEV sites within the catchment. The overall SEV score consists of 14 functions, including hydraulic, biogeochemical, habitat and biodiversity functions, and provides a basis for comparison with other aquatic systems. Results of the function summaries are presented within Table 20.

A full summary of SEV scores is provided in Appendix B.

Table 20: Summary of mean SEV scores across sites.

Site Code	Hydraulic	Bio-geochemical	Habitat Provision	Biodiversity	Total SEV Score
SEV1*	0.54	0.24	0.46	0.19	0.35
SEV2	0.99	0.85	0.66	0.70	0.83
SEV3	0.84	0.49	0.54	0.42	0.58
SEV4*	0.57	0.19	0.16	0.31	0.32
SEV5*	0.59	0.30	0.15	0.17	0.32

*soft-bottomed streams

The SEV scores calculated for the sites ranged from 0.32 to 0.83, out of a possible total of 1.0 (Table 20), reflecting the high degree of contrast within the Hingaia Stream catchment, from highly modified (SEV1, SEV4 and SEV5) to high value (SEV2). There were also clear differences between stream bottom type (soft versus hard-bottomed streams) as well as land use type (urban, rural and forest). Hard-bottomed sites (SEV2 and SEV3) scored higher than soft-bottomed sites (SEV1, SEV4 and SEV5), while forested sites (SEV2) scored significantly higher than urban and rural sites (SEV1, 4 and 5). SEV3 was an intermediary for land use type with forest and rural land use within its immediate area, consequently this site scored between the highly rural and highly forested sites.

The rural SEV sites (SEV 3, SEV4 and SEV5) were below the Auckland Council average for rural streams (0.63, based off 30 SoE monitoring sites; Holland and Hussain, 2016). Site SEV1, which was located within a Future Urban Zone and positioned along the edges of an urban/industrial area, was also below the Auckland Council average for rural and urban streams (0.51, based off 45 SoE monitoring sites; Holland and Hussain, 2016). The native forest SEV Site (SEV2) scored 0.83, which was just above the Auckland Council average for native forest streams (0.82, based off 22 reference sites; Holland and Hussain, 2016).

Hydraulic function was the highest scoring SEV category for all five sites. All streams surveyed provided good connectivity for fish migrations and were well connected to their groundwater sources. A natural flow regime still existed at SEV2 and SEV3, however channel modifications within the smaller agricultural/semi urban streams has resulted in a reduction of this stream characteristic. SEV2 was the only site with a truly effective floodplain, all other sites suffered due to channel modifications that restricted the flow of water onto the floodplain and/or degradation to the surrounding riparian vegetation.

The three highly modified SEV sites (SEV1, SEV4 and SEV5) scored ‘poorly’ (<0.3) for biogeochemical function. Poor levels of stream shading limited these watercourses ability to control water temperature and restricted the natural organic inputs to the stream. Instream particle retention was also hampered at these sites. SEV3 also suffered from poor water temperature control and organic inputs due to limited riparian cover. SEV2, the only site with good riparian stream shading scored ‘moderately’ (0.62) for temperature control and very well for organic ‘inputs’. Instream particle retention was excellent, as was dissolved oxygen maintenance. SEV2 was also the site most capable of dealing with decontaminating pollutants before they entered the stream and within the stream, however SEV5 also scored ‘moderately’ for this, due to dense macrophyte growth and rank grass on the stream margins.

Habitat provision mean scores were relatively similar for SEV1, SEV2 and SEV3 (0.46 – 0.66) and also for SEV4 and 5 (0.15 – 0.16). SEV1 was considered to have the most suitable habitat available for fish spawning overall, followed by SEV2 and SEV3. This was largely due to the presence of suitable habitat for galaxiid spawning at SEV1, which was absent at SEV2 and SEV3. In contrast, the rocky beds of SEV2 and SEV3 provided good quality habitat for bully spawning. SEV2 scored very well for overall habitats for aquatic fauna as a result of the range and variability of instream habitats and riparian cover. SEV4 and 5 scored ‘poorly’ for both available spawning habitat and habitat for aquatic fauna.

Biodiversity values, which are derived from intactness of fish, invertebrate and vegetation communities, were in the ‘poor’ to ‘moderate’ range for all sites. Consistent with overall SEV scores SEV1, SEV4 and SEV5 had the lowest biodiversity scores. This was a result of lower MCI and fish IBI scores along with a limited intactness of riparian vegetation. SEV2 had a mean biodiversity score of 0.70, as a result of a high MCI score and the relatively intact riparian vegetation at this site. This site and SEV3 also had higher IBI scores than SEV1, 4 and 5, resulting in a higher score for intact fish fauna.

SEVs were conducted through the Hingaia Stream catchment as part of the Papakura ICMP and the Hingaia Stream ICMP (Phillips et al., 2006; Golder Associates, 2009). As both were carried out prior to 2011, when changes in SEV methodology occurred (Storey et al., 2011a), they cannot be used to directly compares sites, however they still provide a useful reference for the state of those streams at the times of survey.

Phillips et al. (2006) recorded an SEV score of 0.43 at Norrie Road Bridge, located in an industrial zone in the very lower reaches of the Hingaia Stream. This site was highly modified by urban land use, which was reflected in the SEV score. The loss of riparian vegetation and stream heterogeneity meant that aquatic habitats were compromised. The limited riparian vegetation, in addition to the stream being wide also meant there was poor instream water temperature control, a lack of shading and minimal organic input. While downstream and on the main stream, as opposed to a tributary, the overall state of this site was similar to that found at SEV1 (0.35), the only peri-urban stream surveyed in the report. Both the Norrie Road Bridge site and SEV1 are likely to be reflective of modified urban streams within the Hingaia Stream catchment.

Golder Associates (2009) surveyed 31 SEV sites throughout the Hingaia Stream catchment, including a range of soft-bottomed and hard-bottomed sites. The authors found that hard-bottomed sites, in general, provided better habitat quality than soft-bottomed sites. The mean SEV score for the soft-bottomed streams surveyed was 0.47, while the mean SEV score for hard-bottomed sites was 0.66. The report also recorded a large difference in overall SEV score between sites within indigenous forest and other major land-use types (urban, agricultural and horticultural). Indigenous forest sites scored on average 0.73, compared to urban, agricultural and horticultural sites, which on average scored between 0.47 and 0.51. This is consistent with the findings in this report where SEV2, the indigenous forest site, scored significantly higher than SEV1, SEV4 and SEV5 (sites within urban, agricultural and horticultural areas). SEV3 was an intermediary as it was a hard-bottomed site surrounded by some indigenous forest, as well as agricultural and horticultural activities.

4.3 Biodiversity

To assess overall stream biodiversity various components of the aquatic biota, including the fish community and macroinvertebrates (snails, insect larvae etc.), which are established indicators of habitat quality and are easily sampled, were sampled.

Macroinvertebrate sampling was carried out in accordance with the Ministry for the Environment's "Protocols for Sampling Macroinvertebrates in Wadeable Streams" (Stark et al., 2001). Protocol C2: soft-bottomed, semi-quantitative was utilised at SEV1, SEV4 and SEV5. Protocol C1: hard-bottomed, semi-quantitative was utilised at SEV2 and SEV3. All samples were preserved in 70% isopropyl alcohol, returned to the laboratory and sorted by a specialist taxonomist using protocol 'P3: full count with sub-sampling option' (Stark et al., 2001). Macroinvertebrates were identified to the lowest practicable taxonomic level and counted to enable biotic indices to be calculated.

A range of biotic indices were calculated, namely the number of taxa (taxa richness), the number of Ephemeroptera (mayflies); Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa recorded in a sample (EPT) and the Macroinvertebrate Community Index (MCI). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment but excludes *Oxyethira* and *Paroxyethira* as these taxa are not sensitive and can proliferate in degraded habitats.

Pollution tolerance is highly variable between macroinvertebrate taxa. To calculate a MCI score, each taxon is assigned a pollution sensitivity score between 0 and 10, with a higher score indicating a taxon less tolerant of, or more sensitive to organic pollution or habitat changes (Stark and Maxted, 2007). Typically, taxa from the EPT (mayflies, damselflies and caddisflies) group of insects are more pollution sensitive than other groups and consequently EPT taxa are generally the highest scoring. A higher proportion of EPT taxa in a macroinvertebrate community is typically indicative of good water and habitat quality.

To identify the range of fish species, on-site electric fishing was undertaken at the SEV1, SEV2, SEV4 and SEV5 sites, where water depth allowed. Single pass electric fishing was carried out at each site using an EFM 300 backpack electric fishing machine. This machine temporarily stuns fish, allowing them to be captured. Stream levels at SEV3 made the use of the EFM300 impractical and unsafe. At this site, rather than return a record of no fish, previous fish records were obtained from the New Zealand Freshwater Fish Database (NZFFD). All fish captured during the survey were identified, counted and their size estimated before being returned to their habitats. An Index of Biotic Integrity (IBI) was calculated for the site based on fish species present (or those present from NZFFD in the case of SEV3), stream altitude and distance inland (Joy and Henderson, 2004).

A full list of macroinvertebrate taxa and fish species identified from each SEV survey site is provided in Appendix B.

4.3.1 Macroinvertebrate Community Index Scores

The number of macroinvertebrate taxa recorded from the five survey sites ranged from 9 to 20 (Table 21), with fewer EPT taxa recorded at the more degraded sites (SEV1, SEV4 and SEV5) than at the less degraded sites (SEV2 and SEV3). Overall SEV2 was the only site where EPT taxa formed the majority of taxa recorded (Table 21).

A single EPT taxon was recorded at peri-urban SEV1. This was a *Zelandobius* stonefly nymph which can be found in streams of moderate to good water quality throughout the country. *Zelandobius* has a sensitivity score of 7.4 (soft-bottomed). Four EPT taxa were recorded from the rural SEV4, however one of these was *Oxyethira,* which is a taxa of caddisfly larvae not considered to be a sensitive EPT taxa. *Oxyethira* have a soft-bottomed MCI score of 1.2 indicating they are pollution tolerant. *Oxyethira* are most common in streams with abundant stream bed algae, most likely from nutrient enrichment, limited shade and a lack of recent high flow (algae scouring) events (Landcare Research, 2017b). The other three taxa recorded were also caddisfly larvae (*Plectrocnemia, Polyplectropus, Psilochorema*) and had soft-bottomed MCI scores ranging from 6.6 to 8.1. These species are typically indicative of good water quality when found with mayfly and stonefly larvae, however in this case they were not. No EPT taxa were recorded from the rural SEV5.

Table 21: Summary of biodiversity index values across sites.

Site Code	MCI-sb or hb	No. Taxa	EPT Taxa	Fish IBI Scores
SEV1	68.15 (sb)	13	1	14
SEV2	128.75 (hb)	16	11	30
SEV3	93.33 (hb)	15	7*	34
SEV4	68.70 (sb)	20	4*	22
SEV5	67.11 (sb)	9	0	14

* Includes *Oxyethira*, a pollution tolerant EPT taxon.

In the less degraded sites the number of EPT taxa recorded from samples was higher. Seven of the fifteen taxa recorded at the stony bottomed SEV3 were EPT taxa, however this did include *Oxyethira*. Other taxa recorded ranged from taxa indicative of moderate water quality, such as *Aoteapsyche* caddisfly larvae (hard-bottomed MCI score of 4), to taxa indicative of good instream conditions, such as *Olinga* caddisfly larvae (hard-bottomed MCI score of 9). Eleven of sixteen taxa recorded at the bush site (SEV2) were EPT. The majority of these were mayfly larvae which had hard-bottomed MCI scores of between 7 and 9. *Olinga* caddisfly larvae were also recorded, as were *Helicopsyche* caddisfly larvae, which are highly pollution intolerant and has a hard-bottomed MCI score of 10.

Overall MCI scores ranged from poor to excellent (Table 21 and Table 22) and were consistent with the number of EPT taxa versus non-EPT taxa recorded. The MCI scores calculated for sites SEV1, SEV4 and SEV5, were all less than 80, indicative of ‘poor’ instream habitat and water quality with severe enrichment (Stark & Maxted, 2007). The MCI score at SEV3 (93) suggested ‘fair’ habitat and water quality with moderate pollution. SEV2 provided high quality habitat, with suitable substrate, high shading and clean water. This was reflected in the overall MCI score of 129 which puts it in the ‘excellent’ habitat quality range (Table 22).

Macroinvertebrates were sampled at the Norrie Road Bridge site by Phillips et al. (2006). They reported 15 taxa from that site, of which three were EPT. An MCI score was not calculated for this site, as an Invertebrate Community Loss Index (ICLI) was utilised instead. This is a measure of the loss of macroinvertebrates species from a stream site, compared to what would be expected from an undisturbed or ‘reference’ stream. The Norrie Road Bridge site scored within the ‘poor to fair’ ICLI category and had a community composition relatively dissimilar to what would be expected in an undisturbed stream (Phillips et al., 2006). While this site is downstream from SEV1, and on the main Hingaia Stream, as opposed to the tributary SEV1 was on, it indicates that macroinvertebrate communities in 2006 were already fairly compromised in the lower catchment.

Macroinvertebrate communities were sampled at 31 sites to inform the Hingaia Stream ICMP (Golder Associates, 2009). Four of the sites assessed were within close proximity to macroinvertebrate sites sampled for SEVs in this report. The patterns in macroinvertebrate metrics, including MCI scores, through the catchment were relatively similar in Golder Associates (2009) to the findings in this report. Native forest sites (including E18, located close to SEV2) scored in the ‘excellent’ MCI range, while urban and grassland sites (including E3, close to SEV1 and E31, close to SEV4) scored in the ‘poor’ to ‘moderate/fair’ range. Individual MCI scores were not presented in the report. The similarities in trends suggest there has been no significant decline in MCI scores, as indicators of instream habitat quality, over the past nearly ten years.

Table 22: Quality thresholds for interpretation of MCI (Stark et al. 2004).

Quality	Description	MCI score
Excellent	High quality, well shaded, clean water.	>120
Good	Mild pollution	100-120
Fair	Moderate pollution	80-100
Poor	Severe enrichment	<80

4.3.2 Fish IBI Score

The Fish IBI model (Joy and Henderson, 2004) considers the range of fish species caught at a site, the distance the site is from the coast and the site's elevation, in comparison to the range of native fish that could be expected in an unmodified system. Electrofishing was conducted at SEV1, SEV2, SEV4 and SEV5, but was not possible at SEV3 so existing fish records from NZFFD were utilised for this site. Native eels were the only identified fish species at all sites (including SEV3 based on NZFFD records).

Shortfin eels (*Anguilla australis*) were caught at SEV1, SEV4 and SEV5 and were previously recorded at SEV3. Shortfin eels are the most tolerant of New Zealand's native fish species with regard to high instream temperatures and low concentrations of dissolved oxygen. These eels are exceptional climbers, enabling them to pass many fish barriers (natural or man-made) that may present migratory issues for other native fish species. Shortfin eels are listed as 'Not Threatened' in the Department of Conservation Threat Classification lists (Goodman et al., 2014).

A single large longfin eel (*Anguilla dieffenbachii*) was captured at SEV2 and records also show longfin eel previously being recorded at SEV3. Longfin eel have an 'At Risk: Declining' conservation status (Goodman et al., 2014) and are less tolerant of environmental changes than shortfin eels (Department of Conservation, 2018). Ongoing anthropogenic impacts such as habitat loss, pollution loading, and a lack of riparian vegetation are leading to ongoing population declines. Longfin eel, like shortfins, are exceptional climbers so finding one at SEV2, despite this site's location upstream from the approximately 10m high Maketu waterfall, is not unexpected.

IBI scores at SEV1 and SEV5 were both within the 'very poor' integrity class, while SEV4 was within the 'poor' integrity class (Table 21 and Table 23). This suggests that species richness within these areas has been significantly reduced due to habitat degradation and/or migratory access. Despite SEV1, SEV4 and SEV5 all having shortfin eels present, the lower IBI scores at SEV1 and SEV5 are reflective of these sites being closer to the coast and at a lower elevation than SEV4. This would suggest that access and/or habitat is more impacted at these sites.

SEV2 and SEV3 had similar scores, both of which were within the 'fair' integrity class, suggesting there is some impairment to biotic integrity, likely through habitat degradation or access (Table 23). SEV2 was within native bush and had excellent habitat, however was located upstream of a series of natural barriers including cascades, small waterfalls and the large Maketu waterfall, which is likely to impact access for many fish species. SEV3 on the other hand was a low-lying site along the main stream. No major fish passage barriers existed between this site and the coast, suggesting impaired biotic integrity may more likely to be due to habitat degradation.

Table 23: Attributes and suggested integrity classes for the Index of Biotic Integrity: Fish

Total IBI score	Integrity class	Description
42 – 60	Very Good	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present.
36 – 41	Good	Species richness and habitat or migratory access reduced, site shows some signs of stress.
28 – 35	Fair	Some stressors present, biotic integrity impaired.
18 – 27	Poor	Species richness is drastically reduced biotic integrity harmed. Habitat and or access is impacted.
1 – 17	Very Poor	Impacted or migratory access almost non-existent.
0	No native fish	Site is grossly impacted or access non-existent.

4.4 Sediment Chemistry

Laboratory results confirmed the presence of zinc, copper, lead and polycyclic aromatic hydrocarbons (PAH) in the sediments at all SEV Sites (Table 24).

At SEV2, SEV4 and SEV5 heavy metal and PAH concentrations fell within the Auckland Council Environmental Response Criteria (ERC) Green Zone (ARC, 2004) and below ANZECC 2000 Guideline ISQG Low trigger values (Table 24 and Table 25). This suggests that heavy metal and PAHs are at levels unlikely to result in adverse biological effects within these sections of watercourse.

Both zinc and lead were within the ERC Green Zone at SEV3, however copper concentrations fell within the ERC Amber Zone (Table 24). No values were above ANZECC 2000 ISQG Low trigger values. Concentrations within the ERC Amber Zone suggest contaminant levels are elevated above background levels and indicates the potential for adverse biological impacts to occur. ERC values are intentionally set low and are considered to be more conservative than ANZECC 2000 ISQG trigger values, with the purpose of this being to prompt further investigation of a site before it becomes seriously degraded (ARC, 2004). Copper is a common compound in many agricultural fungicides used in New Zealand and copper runoff from such fungicides is a recognised source of sediment contamination in streams (Wightwick et al., 2010). SEV3 was immediately downstream from a number of market garden sites, which may explain the elevated copper concentrations at this site.

Table 24: Summary of laboratory results for sediment contaminants. Colour shades are based on ERC guidelines

SEV Sites	Heavy Metal Concentrations (mg/kg dry wt)			Total PAH* (µg/kg dry wt)
	Zn	Cu	Pb	
SEV1	186	21	19.2	141
SEV2	54	11.4	13.3	35
SEV3	78	22	24	83
SEV4	28	9.6	10.9	94
SEV5	82	17.3	21	220

*Where individual PAH were below detection limit half of the detection limit value was used to calculate total PAH

Copper was also within the ERC Amber Zone at SEV1, while zinc was within the ERC Red Zone (Table 24). No sediment contaminants were above ANZECC 2000 ISQG Low trigger values (Table 24). Concentrations falling within the ERC Red Zone suggest contaminant levels are high compared to background levels and warn of the increased potential that the site's biology will be impacted (ARC, 2004). SEV1 was located downstream from, and immediately adjacent to a number of horticultural glasshouses and cropland which may provide an explanation for elevated copper levels at this site. Runoff from vehicle activity, paints and unpainted metal roofing material are key contributors of zinc to aquatic sediments (Kennedy and Sutherland, 2008). This site was on the urban fringe, and the rural fringe upstream contained a number of road crossings as well as significant horticultural, rural, residential infrastructure, all of which may contribute to the elevated zinc concentrations observed.

Table 25: Summary of sediment contaminants in relation to ANZECC guidelines.

	Zn	Cu	Pb	Total PAH
ANZECC >ISQG-Low values	>200 mg/kg dry wt	>65 mg/kg dry wt	>50 mg/kg dry wt	>4000 µg/kg/ dry wt
No. sites ANZECC >ISQG-Low	0	0	0	0
ANZECC >ISQG-High Values	>410 mg/kg dry wt	>270 mg/kg dry wt	> 220 mg/kg dry wt	>45,000 µg/kg/ dry wt
No. sites ANZECC >ISQG-High	0	0	0	0

Four sites surveyed by Golder Associates (2009) were located near to the sediment sampling sites in this report. Sampling in the Golder Associates (2009) report focussed specifically on the <500 µm and <63 µm fractions, whereas analyses undertaken for this report focused on the <2 mm sediment fraction. However, comparisons are useful for providing an indication of the change, or lack thereof, in the heavy metal concentration patterns of over the past nine years.

In general, heavy metal concentration patterns were found to be similar between the sampling done in 2009 and the results recorded from this report (Table 24 and Table 26). Concentrations of zinc, copper and lead were all higher at sites E3 and W12 (equivalent to SEV1 and SEV3) than E18 and E31 (equivalent to SEV2 and SEV4), which is consistent with current findings. Zinc was also the metal found at the highest concentrations at each of the 2009 sites, another consistency with the current findings.

There are indicators of potential change in the overall concentrations of heavy metals within the catchment, in particular zinc at SEV1. Total recoverable zinc (<500 µm) at Site E3 was 100 mg/kg dry wt, while at SEV1, sampled approximately nine years later, total recoverable zinc (<2 mm) was 186 mg/kg dry wt), a value that is now above the ERC Red Zone. As mentioned these results are not truly comparable but may provide an indication of the trend through time in zinc concentrations.

Table 26: Heavy metal concentrations at comparable sampling sites from the Golder Associates (2009) Hingaia catchment environmental assessment.

Sediment contaminant	Zn (<500 µm)	Zn (<63 µm)	Cu (<500 µm)	Cu (<63 µm)	Pb (<500 µm)	Pb (<63 µm)
E3 (SEV1)	100	88	18	15	23	19
E18 (SEV2)	53	63	7	8.4	11	13
W12 (SEV3)	100	110	18	16	19	19
E31 (SEV4)	21	41	2.5	7.7	4.7	15

The Hingaia Stream discharges into the Pahurehure Inlet (south-eastern arm of the Manukau Harbour), via the Drury Creek. The wider Drury Creek is considered to be a marine SEA (SEA_M2_29a) and contains a number of important intertidal habitats, whilst also providing roosting habitat for native wading birds (Auckland Council, 2016). The upper reaches of the Drury Creek, including the immediate receiving environment for the Hingaia Stream, are classified as a separate marine SEA (SEA_M1_29b) with higher sensitivities to adverse impacts. This area is acknowledged for its transitional vegetation characteristics, from mangroves through to saltmarsh to freshwater vegetation. It also offers a significant migratory pathway between freshwater and marine environments for native fish (Auckland Council, 2016).

Heavy metals accumulating in the receiving environments of freshwater systems can have a detrimental impact on marine organisms through contact or ingestion, and on human health as a consequence of consumption of organisms with accumulated levels of heavy metals (EOS Ecology, 2012). Heavy metal accumulation within the immediate receiving environment for the Hingaia Stream does not appear to be a significant issue based on previous sampling of the marine sediments within the Drury Creek (Boffa Miskell, 2010; Golder Associates, 2009). Copper, zinc and lead at all estuarine sites surveyed in those studies were below ANZECC (2000) and ERC threshold values.

4.5 Public Health

Results from the SEV sampling are shown in Table 27 below. These results are compared to the 'Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas' published by the Ministry for the Environment (MfE) (2003), and the 2014 National Policy Statement for Freshwater Management (NPSFM) Attribute State limits for *E. coli* (Ministry for the Environment, 2014, amended in 2017; Table 28). The Freshwater Bathing Guidelines are based on an estimate that approximately 5% of *Campylobacter* infections could be attributable to freshwater contact recreation. NPSFM Attribute State limits are based on the overall level of infection risk from contact with water.

Table 27: Summary of *E. coli* results across sites, compared to the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2003).

						Surveillance, alert and action levels for freshwater		
SEV Site	1	2	3	4	5	Acceptable/ Green Mode	Alert/Amber Mode	Action/Red Mode
E. coli (*E. coli/*100 mL)	2000	220	230	1000	>2400	*≤260 E. coli/ 100 mL*	*>260 E. coli/ 100 mL*	*>550 E. coli/ 100 mL*

E. coli levels from water collected during the SEV survey ranged from 220 to >2400 *E. coli/*100 mL. Water collected from SEV2 and SEV3, the less degraded sites, had the lowest overall levels of *E. coli* and both fell within the MfE Acceptable/Green Mode, as well as the *E. coli* Attribute State A (the best overall state) based on the NPSFM 2014.

E. coli levels at three sites (SEV1, SEV4 and SEV5) were above the MfE Action/Red Mode threshold for freshwater recreational area while SEV1 and SEV5 were also above the 95th percentile limits for the worst freshwater attribute states based on *E. coli* concentrations set out in the NPSFM (Table 28). This would suggest the risk of infection from contact with the water is >5% at least 20% of the time and the average risk of infection is >3% (Ministry for the Environment, 2014). It is acknowledged that the values in this report are based on a one-off sample whereas the values provided in the NPSFM are based on a minimum of 60 samples over a five-year period. Despite this, these values indicate that all sites are likely to suffer from elevated *E. coli* levels at time, that have the potential to cause issues for human health.

Due to the potential implications of these results to public health and to address the limitations associated with one-off sampling, further sampling and investigation may be required at SEV1, SEV4 and SEV5. Recommended MfE actions in response to *E. coli* levels being detected above the Action/Red Mode at sites used for contact recreation are to:

- Increase sampling effort
- Identify possible location of sources of contamination
- Conduct a sanitary survey, and report on sources of contamination
- Erect warning signs
- Inform the public through the media that a public health problem exists

Table 28: Summary of *E. coli* levels for each Attribute State outlined in the National Policy Statement for Freshwater Management (Ministry for the Environment, 2014; amended 2017).

	NPSFM 2014 (amended 2017) *E. coli* Attribute State			
	A (Blue)	B (Green)	C (Yellow)	D (Orange)/ E (Red)
E. coli limits for each attribute state (sample 95th percentile)	*≤540 cells/ 100 mL*	*≤1000 cells /100 mL*	*≤1200 cells /100 mL*	*>1200 cells /100 mL*
No sites within each *E. coli* attribute state	***2***	***1***	***0***	***2***

Previous water quality assessments undertaken by Phillips et al. (2006) show similarly high levels of *E. coli* in agricultural (1700 *E. coli*/100 mL) and urban sites (1200 *E. coli*/100 mL*)*. However, sampling undertaken by Golder Associates (2009) is less conclusive of any general pattern, with median *E. coli* levels at urban, cropland, pasture and forest sites all being very similar (490 – 570 *E. coli*/100 mL). The lowest *E. coli* value was recorded within a pastural site, while the highest was within forest. These results may further highlight the issues associated with one-off sampling and should be taken cautiously as there was much greater sampling effort in pastural areas than either urban/cropland or forested areas.

4.6 Summary

The SEV scores recorded from the five survey sites ranged from 0.32 to 0.83. Overall SEV scores reflected differences in stream bottom type (hard versus soft-bottomed) and land use type (rural, urban and forest).

Highly modified sites, which tended to also be soft-bottomed (with silt or sand substrates dominant), in both the upper and lower catchment tended to score poorly whereas the relatively undisturbed hard-bottomed site within native forest in the east of the catchment scored highly for most SEV functions. SEV3, was an intermediary (hard-bottomed, but surrounded by rural land use types as well as some forest) and consequently scored between the modified and unmodified sites.

MCI scores were higher within hard-bottomed sites and SEV2 scored in the 'excellent' range, indicating good quality habitat and excellent water quality. Most taxa recorded at this site were EPT. MCI scores at the more disturbed soft-bottomed sites were all below 80, indicative of 'poor' instream habitat or water quality with high levels of organic enrichment. Very few EPT taxa were recorded at these sites.

Only a single species of fish was recorded at four of the five sites surveyed, while two species were reported at SEV3 utilising the NZFFD records, as this site could not be fished. SEV2 and SEV3 both scored within the 'fair' Fish IBI category. This would suggest that the biotic integrity of these sites is compromised due to stressors such as pollution and/or barriers to migration. IBI scores at all other sites were within the 'low' or 'very low' integrity classes. This is likely due to a lack of species diversity and/or the presence of fish barriers restricting access through the catchment.

Sediment chemistry (heavy metals and PAH) was recorded at levels below ANZECC 2000 Guideline ISQG Low trigger values at all sites, however copper concentrations were within the ERC Amber Zone at SEV1 and SEV3, indicating they were marginally elevated above typical background levels. This may be a consequence of these sites being downstream of croplands where fungicides or other chemicals containing copper are potentially used during crop production. Zinc was also within the ERC Red Zone at SEV1. As the most urbanised site surveyed, SEV1 may receive zinc through sources such as roads and buildings which are less common in rural areas.

E. coli levels exceeded the MfE Action/Red Mode threshold at three sites (SEV1, SEV4 and SEV5), indicating an increased risk of water-borne infection during the time of sampling. *E. coli* concentrations at SEV1 and SEV5 were also within the worst *E.* coli attribute states (D and E) according to the NPSFM 2014.

Results from the SEV surveys, sediment chemistry and microbial concentration analyses suggest that a number of actions are required to improve stream habitat and the overall SEV scores, particularly in areas where urban or rural land use dominated. Options include undertaking riparian planting, reducing stock access and re-establishing natural connection to the floodplains and riparian margins.

5.0 Watercourse Management

5.1 Management Zones

Four management zones (MZ) have been identified within the Hingaia Stream Catchment (Appendix A, Map 7; Table 29). Overall the watercourses through much of this catchment have been heavily modified, and pressures such as flooding, and a lack of established riparian vegetation are ubiquitous. Management of such issues involves a catchment wide approach and consequently management objectives related to these issues are suggested throughout all management zones.

There are however distinct differences in current and future land use, catchment topography and overall enhancement potential through the catchment. Management zones have been designed to reflect areas where:

- Land in the lower catchment is already developed and/or undergoing current development and/or designated for future urban growth (MZ1).
- Rural land in the mid catchment where market gardens are a major land use type (MZ2).
- Rural land in steep eastern hill country regions where notable stands of native bush are present but are fragmented by agriculture (MZ3).
- Rural land in the southern headwater regions (MZ4).

Table 29: Management Zone Summary.

Management Zone (MZ)	Location/Stream Reaches	Enhancement Opportunities
MZ1: Lower Catchment Urban/Future Urban Zones	Lower reaches of the stream channel as far south as Ararimu Road	EO1, EO2, EO3, EO4
MZ2: Mid Catchment Cropland	All low-lying stream channels between Ararimu Road and Fahey/ Main Road	EO8
MZ3: Eastern Hill Country	Stream channels in the eastern foothills of the Hunua Ranges. Includes the Maketu Stream.	EO5, EO6, EO7
MZ4: Southern Headwaters	Headwater streams in the south section of the catchment. South and east of Fahey/ Main Road	EO9, EO10

It is acknowledged that the majority of land in MZ2, MZ3 and MZ4 is currently in private ownership and that addressing general maintenance issues, management objectives or enhancement opportunities within these areas will likely require cooperation from land owners.

5.1.1 Management Zone 1 – Lower Catchment – Urban/Future Urban Catchment

MZ1 focuses on the main Hingaia Stream from the stream mouth to Ararimu Road, incorporating the watercourses through the Drury township and Drury South urban zones. Also included within this management zone are stream channels along the two northernmost tributaries, which are surrounded by land zoned for future urban development. Therefore, MZ1 focuses on the watercourse within the existing urban, developing urban, developing industrial, and future urban areas of the catchment.

During a 1% AEP rainfall event the Hingaia Stream catchment produces 10,500,000 m^3 of runoff (AECOM, 2017). MZ1, at the lower end of the catchment ultimately bears the brunt of this runoff and is considered to be a highly flood prone area (AECOM, 2017). Approximately 14% of the future urban land within the Hingaia Stream catchment is currently within the 1% AEP floodplain (AECOM, 2017), while considerable land within the Drury Township and Drury South precincts are also within 1% AEP floodplains (Beca, 2016). There are existing flooding issues within the Drury township as a result of its location within the Hingaia Stream floodplain, and some remedial works (including channel vegetation clearance and flood training gabions) have been undertaken to mitigate flooding impacts (AECOM, 2017). A preliminary Stormwater Management Plan (draft) recently developed for the Opaheke - Drury structure plan area (AECOM, 2017) recognises that that major challenge of future development in this area will be to address existing flooding issues within the developed the Drury Township, and to effectively manage existing and expected flooding issues within the future development areas. The draft Opaheke - Drury, and Drury South stormwater management plans and guidelines recognise that an integrated Water Sensitive Design (WSD) approach, including the retention, protection and enhancement of existing floodplains, permanent and intermittent streams and natural wetlands, will be vital to achieve successful stormwater management.

Due to the ongoing and potential development within MZ1, and future stormwater management requirements, this is the management zone where the greatest potential for large scale stream protection and enhancement lies. Consequently, the four highest priority Enhancement Opportunities were identified within this management zone. Enhancement within all four identified areas (main Hingaia Stream channel and both northern tributaries) is likely to result in moderate to high levels of improvement in amenity, ecological and conveyance values for these watercourses.

An opportunity exists to fast track some management goals, objectives and enhancement opportunities within Management Zone 1 and address current management issues in conjunction with land rezoning and development. This would alleviate issues, particularly those concerning stormwater conveyance and erosion, that might become more pronounced as development occurs. As most of this land is in private ownership it is acknowledged that addressing current issues will require the cooperation of existing property owners or developers who have already purchased land. However, during the stream assessments, numerous landowners within this area identified flooding, both small and large scale, as a common, and often frustrating occurrence, so community buy-in for improvements that alleviate flood issues may be relatively easy to obtain.

General Maintenance Issues within this Management Zone:

- Two Council owned inlet/outlets require structural repairs (1115669, 1174015).
- Two Council owned culverts require vegetation clearance (SWM6323, UKNP002).
- One Council owned culvert require erosion protection (SWM6253).
- Three Council owned inlet/outlets and one culvert/pipe were not located.
- Eleven inlet/outlets with unknown ownership require maintenance:
    - Three (UKNA005, UKNA023, UKNA162) require vegetation clearance;
    - One (UKNA029) require debris removal; and
    - Seven (UKNA002, UKNA016, UKNA030, UKNA065, UKNA147, UKNA150, UKNA161) require structural repair with three of these classed in poor condition (UKNA002, UKNA030, UKNA150).
- Twenty unknown ownership pipe/culverts require maintenance:
    - Four (UKNP004, UKNP019, UKNP023, UKNP094) require vegetation clearance;
    - Ten (UKNP008, UKNP010, UKNP012, UKNP014, UKNP022, UKNP075, UKNP076, UKNP091, UKNP092, UKNP093) require structural repair;
    - Two (UKNP003, UKNP020) require erosion protection;
    - One (UKNP026) require patching; and
    - Three (UKNP007, UKNP017, UKNP024) require debris removal with one of these classed in poor condition (UKNP017).
- One culvert in unknown ownership was identified as a flood risk (UKNP017) and nine were a partial or complete barrier to climbers.
- Two inlet/outlets in unknown ownership had moderate to severe erosion and two were identified as a partial or complete barrier to climbers.
- Six inlet/outlets with unknown ownership had moderate-high public safety risk as they were all on public land, with easy access and identified as either ‘not safe’ or ‘not safe with a drop greater than 1.5 metres’ (UKNA014, UKNA017, UKNA018, UKNA019, UKNA029, UKNA116).

- Five privately owned inlet/outlets were in poor condition, 28 had moderate to severe erosion issues and seven were a partial or complete barrier to climbers.
- One privately owned pipe/culvert was in poor condition and one in very poor condition.
- One privately owned pipe/culvert was a potential flood risk (UKNP053).
- Thirty-two privately owned pipe/culverts were identified as a partial or complete barrier to climbers.

Providing linkages in amenity improvements, ecological enhancement and stormwater management between existing, developing and future urban areas is the key focus for this management zone.

Suggested goals and objectives for the Management Zones are to:

- Establish ownership of assets with unknown ownership. If they are council owned, then incorporate them into Council GIS.
- Investigate and remedy all assets with flooding issues on public and private land.
- Address erosions issues, both erosion hotspots and culvert erosion before and/or as urban development occurs.
- Futureproof stormwater conveyance capacity in areas that may be put under pressure by further development. Remove unnecessary culverts and replace undersized culverts before land development occurs.
- Investigate potential point sources of faecal bacteria to urban/peri-urban streams and identify any necessary maintenance requirements.
- Encourage landowners and/or developers to restore, enhance and/or protect riparian zones.
- Improve aquatic habitat in the northern tributaries by naturalising modified streams and removing potential fish barriers.
- Ensure ecological, amenity and stormwater management linkages are established between existing, developing and future urban zones.
- Look to create a continuous riparian corridor from the Hingaia Stream mouth to Ararimu Road, integrating with proposed riparian improvements within the Drury South developments.
- Create better public access to the existing esplanade reserves within the Drury Township.
- Improve the amenity value of the stream network by incorporating walkways/cycleways into the design of new public open spaces, particularly within

Esplanade Reserves. Aim to have a continuous walkway/cycleway from the Hingaia Stream mouth to Ararimu Road.

- Involve iwi, community groups, schools and local residents in riparian restoration or habitat improvement projects on public land.
- Take advantage of greenfield development to leverage stream enhancement outcomes (improving ecological, amenity and stormwater functions).

5.1.2 Management Zone 2 – Mid Catchment Cropland

MZ2 focuses on the low lying mid catchment streams. Streams within this management zone are surrounded by rural land use and represent the main area of catchment that is within or immediately downstream from significant areas of horticultural activity. Instream sediment chemistry results from SEV3, within MZ2, showed elevated copper levels (within ERC Amber Zone), a possible consequence of the horticultural activity within the area. Anecdotal evidence from residents in the south of the zone also suggest that significant sediment-laden runoff from these horticultural areas occurs during heavy rainfall events, particularly in the Paparata/Mile, Fahey/Portsmouth Road area. Similar issues in these areas were identified in earlier reports (Golder Associates, 2010). The watercourse assessments found that, in general, fencing was good through farmland, with moderate or severe stock damage only occurring along 15% of permanent/intermittent streams. Riparian vegetation through this area has been compromised by rural land use activities.

A single enhancement opportunity was identified within MZ2. This involved enhancement of the main Hingaia Stream. The overall SEV score at SEV3, within the enhancement opportunity area, suggest that there is good potential for stream function and health to be improved through riparian enhancement works. Here three sections of SEA could be linked through riparian planting, while a number of reserves within these SEAs could be improved by infill planting and weeding, both of which could involve community input. Riparian planting would also have benefits beyond ecological linkages and could help control runoff, flooding and erosion issues.

General Maintenance Issues within this Management Zone:

- One Council inlet/outlet could not be located.
- No Council owned assets with maintenance issues were identified within this zone.
- Four inlet/outlets in unknown ownership require maintenance:
    - One (UKNA103) requires vegetation clearance; and
    - Three (UKNA104, UKNA180, UKNA195) require structural repair.
- Five pipe/culverts with unknown ownership require maintenance:
    - Two (UKNP120, UKNP126) require structural repair;
    - One (UKNP109) requires erosion protection; and

  - Two (UKNP105, UKNP123) require vegetation clearance, with one of these classed in poor condition (UKNP123).
- One culvert with unknown ownership was identified as a flood risk (UKNP124) and six were a complete barrier to climbers.
- Thirteen inlet/outlets with unknown ownership had moderate to severe erosion and five were a partial or complete barrier to climbers.
- Four inlet/outlets with unknown ownership had moderate-high public safety risk as they were all located on public land, with easy access and were either 'not safe' or 'not safe with a drop greater than 1.5 metres' (UKNA100, UKNA101, UKNA197, UKNA201).
- Thirty-five privately owned inlet/outlets had moderate to severe erosion issues and thirteen were a partial or complete barrier to climbers.
- Fifty-seven privately owned pipe/culverts were a partial or complete barrier to climbers.

Management goals within this area should focus on opportunities to improve stream health, ensuring sediment runoff from agricultural land is controlled and reduced. Sediment inputs to watercourses from rural land, and during urbanisation, has been identified as a significant risk to the ecological values of the Hingaia Stream and the sensitive Drury Creek receiving environment (AECOM, 2017). Options to manage stream erosion and downstream flooding issues through non-structural stormwater management techniques, such as stream and wetland protection and riparian enhancement, as recommended in the Hingaia Stream ICMP (Golder Associates, 2010), should also be investigated and encouraged in this area.

Suggested goals and objectives for the Mid-Catchment Management Zone are to:

- Encourage landowners to restore, enhance or protect riparian zones, including fencing and maintaining appropriate riparian buffer widths to minimise sediment and agricultural chemical runoff into stream systems. Riparian vegetation can also be used as a non-structural stormwater management option.
- Link existing Significant Ecological Areas via the development of riparian corridors.
- Ensure that owners of properties in horticultural/cropping land use are keeping sediment management systems up to date and well maintained so that sediment inputs to the surrounding watercourse are minimised, following Auckland Unitary Plan requirements and industry best practise guidelines (i.e. Barber, 2014).
- Educate landowners and/or community groups on funding opportunities available to undertake stream restoration or enhancement projects.
- Establish ownership of assets with unknown ownership. If they are Council owned, then incorporate them into Council GIS.

- Identify opportunities to involve community groups, schools and residents in restoration / enhancement projects on public land.

5.1.3 Management Zone 3 – Eastern Hill Country

In the east of the catchment the Maketu Stream and several other smaller tributaries wind down through steep hillslopes of the Hunua Range foothills. These streams typically follow steep, and often well vegetated gullies, emerging periodically into more open farmland. This has created a mosaic of stream networks with and without good quality riparian vegetation. Many of the streams through this eastern section are hard-bottomed and contain numerous waterfalls and cascades that are likely to naturally restrict upstream passage for fish with poor climbing ability. Water quality within vegetated sections is generally good and the highest SEV score was recorded from a stream in this zone (SEV2). Through the farmland sections of stream, fencing is generally poor, and stock has caused moderate to severe damage along 28% of the stream network. Poorly installed or undersized private culverts have resulted in numerous erosion issues related to culvert inlets and outlets (80% of private inlet/outlets had moderate to severe erosion), while erosion hotspots (47) were also common, though these were found in both well vegetated and unvegetated areas.

Three Enhancement Opportunities have been identified within MZ3, one within public land through the MacWhinney Reserve and two on the Maketu Stream and its tributaries. Enhancement within these areas focusses on restoring riparian vegetation, fencing to remove stock from waterways and connecting important ecological areas. Except for MacWhinney Reserve, any enhancement will largely occur on private land, so Council should look to work with landowners and look to involve schools and community groups with restorative works where possible. A number of private landowners are already undertaking fencing and riparian enhancement works within this zone.

General Maintenance Issues within this Management Zone:

- One Council inlet/outlet and two pipe/culverts were not located.
- No Council owned assets with maintenance issues were identified within this zone.
- Three unknown ownership inlet/outlets require maintenance:
    - Two (UKNA168, UKNA171) require structural repair; and
    - One (UKNA240) requires erosion protection and was also classed as in poor condition.
- One pipe/culvert in unknown ownership requires vegetation clearance (UKNP062).
- Two culverts in unknown ownership were a partial or complete barrier to climbers.
- Four inlet/outlets with unknown ownership had moderate to severe erosion and two were a partial or complete barrier to climbers.

- Four inlet/outlets with unknown ownership had moderate-high public safety risk as they were all on public land, with easy access and identified as ‘not safe with a drop greater than 1.5 metres’ (UKNA109, UKNA110, UKNA170, UKNA171).
- Forty privately owned inlet/outlets had moderate to severe erosion issues and thirteen were a partial or complete barrier to climbers.
- Four privately owned pipe/culverts were in poor condition and two were in very poor condition.
- Four privately owned pipe/culverts were a potential flood risk (UKNP106; UKNP107; UKNP113; UKNP114).
- Sixty-nine privately owned pipe/culverts were a partial or complete barrier to climbers.

Management of the Eastern Hill Country Management Zone should focus on removing stock access to watercourses and linking fragmented sections of native vegetation via riparian corridors. Landowners should also be encouraged to address erosion issues associated with poorly placed or undersized culverts.

Suggested goals and objectives for the Management Zone are to:

- Engage rural landowners to install or repair fencing around watercourses that have free stock access, thus minimising further damage, erosion/ sediment loading and pollution issues, including bacterial and sediment contamination. Prioritise watercourses that have been moderately or severely damaged as a result of stock access.
- Encourage and work with landowners to restore, enhance and/or protect riparian zones, including maintaining appropriate riparian buffer widths to minimise sediment and agricultural runoff into stream systems.
- Educate landowners on the importance of riparian planting and stock exclusion from waterways and highlight funding opportunities available to undertake stream restoration or enhancement projects.
- Involve community and school groups with restoration projects where possible.
- Aim to establish a continual riparian corridor along the main Maketu Stream channel and main tributaries and link fragmented Significant Ecological Areas.

5.1.4 Management Zone 4 – Southern Headwaters

MZ4 focuses on the southern headwaters of the catchment draining the elevated hillslopes of the Bombay Hills and Hunua Range. These southern headwaters are almost exclusively within agricultural land use and suffer from moderate or severe stock damage (45%), stream erosion (61% of streams had >20% erosion on at least one bank) and outfall erosion (85% of inlet/outlets had moderate to severe erosion). Riparian vegetation has been removed from the majority of this management zone in order to maximise the amount of land available for rural land use. SEV4, located within MZ4, was one of the lowest scoring sites and also suffered from elevated *E. coli* concentrations.

Headwater streams and wetlands are a highly important component of a watercourse network and the health of larger receiving streams in the lower catchment relies on an intact headwater system (Ohio EPA, 2015). Headwater streams can provide important benefits for biodiversity, sediment control, nutrient control and flood control for the wider catchment so an intact headwater system can reduce downstream flooding and prevent excessive erosion (Alexander et al., 2007; Ohio EPA, 2015; Storey et al., 2011b). Considerable effort could be put into protecting and enhancing these headwater streams. There is opportunity to develop this area as a large-scale flagship project where Auckland Council works closely with residents, businesses, schools and community groups in the area to improve the overall health and conveyance properties of the entire watercourse by improving the condition of the headwater streams. The area could also provide localities for offset stream enhancement contributions that may be required for unavoidable stream loss that will occur as a result of development of the lower catchment.

There are two specific Enhancement Opportunities within MZ4. EO9 captures the stream network running through the Simunovich Olive Estate, while EO10 is a large-scale enhancement opportunity aiming to improve the health of first and second order headwater streams in the southern section of the catchment.

General Maintenance Issues within this Management Zone:

- There are no maintenance issues identified with Council owned assets that interact with the Hingaia Stream.
- Six inlet/outlets in unknown ownership require maintenance:
  - Two (UKNA213, UKNA214) require vegetation clearance;
  - One (UKNA212) requires debris removal;
  - Two (UKNA181, (UKNA229) require erosion protection; and
  - One (UKNA208) requires structural repair.
- Two pipe/culverts in unknown ownership require maintenance:
  - One (UKNP133) requires debris removal; and

    - One (UKNP127) requires structural repair and was also classed as in poor condition.
- Three unknown ownership pipe/culverts were a partial or complete barrier to climbers.
- Nine unknown ownership inlet/outlets had moderate to severe erosion and one was a partial or complete barrier to climbers.
- Eighty-seven privately owned inlet/outlets had moderate to severe erosion issues and thirteen were a partial or complete barrier to climbers.
- 105 privately owned pipe/culverts were a partial or complete barrier to climbers.

Management goal and objectives through MZ4 should be focused on improving the overall health and protection of streams in the southern catchment to help maintain and improve stream health and conveyance properties throughout the wider catchment.

Suggested goals and objectives for the Management Zones are to:

- Engage rural landowners to install or repair fencing around watercourses that have free stock access, thus minimising further damage, erosion / sediment loading and pollution issues, including bacterial and sediment contamination. Prioritise watercourses that have been moderately or severely damaged by stock.

- Encourage and work with landowners to restore, enhance or protect riparian zones, including maintaining appropriate riparian buffer widths to minimise sediment and agricultural runoff into stream systems.

- Educate landowners on the importance of riparian planting and stock exclusion from waterways and highlight funding opportunities available to undertake stream restoration or enhancement projects.

- Set a target of revegetation all first and second order streams within the southern section of the catchment. This will help improve stream health and will improve the catchments ability to cope with heavy rainfall events.

- Identify opportunities to develop relationships with local businesses and empower them to assist with restorative works through the southern catchment.

- Involve community and school groups with restoration/enhancement projects where possible.

5.2 Enhancement Opportunities

Ten Enhancement Opportunities (EOs) have been identified throughout the catchment. These range from small scale riparian plantings to large scale projects aimed at addressing amenity, ecological and conveyance issues. Table 30 provides a summary of the prioritisation of each enhancement opportunities, while more detailed information, including a summary card for each EO is provided in the sections below. EO locations are provided in Appendix A, Map 7

Table 30: Summary of prioritisation of enhancement opportunities.

Enhancement Opportunity	Management Zone	Description	Amenity	Ecology	Conveyance	Overall Score	Prioritisation Score
EO1	MZ1	Main Hingaia Stream. Existing esplanade reserve. Poor riparian vegetation and potential for improved amenity.	High	Moderate	Moderate	10	2
EO2	MZ1	Main Hingaia Stream. Future Urban Zone. Stream width may trigger esplanade reserve if development occurs.	High	Moderate	Moderate	10	2
EO3	MZ1	First tributary off Hingaia Stream. Has conveyance issues and is a site being investigated by AC Healthy waters. Future Urban Zone	Low	High	High	10	2
EO4	MZ1	Second tributary off Hingaia Stream. Conveyance issues and modified stream. Future Urban Zone. Stream width may trigger esplanade reserve if development occurs.	Moderate	High	High	11	1

Enhancement Opportunity	Management Zone	Description	Amenity	Ecology	Conveyance	Overall Score	Prioritisation Score
EO5	MZ3	Public land on Mcwhinney Drive. Limited public access and poorly vegetated.	High	Moderate	Low	9	3
EO6	MZ3	Section of farmland between areas of significant native bush	Low	High	Low	8	4
EO7	MZ3	Multiple sections of unfenced farmland on Maketu Stream. Linkage opportunities for fragmented native bush	Low	High	Moderate	9	3
EO8	MZ2	Main Hingaia Stream. Unplanted and unfenced stream sections between significant vegetation. Some public land.	Moderate	High	Low	9	3
EO9	MZ4	Stream network through Simunovich Olive Estate. Poor riparian vegetation and litter issues.	Low	High	Low	8	4
EO10	MZ4	First and second order streams in the southern headwaters	Moderate	High	High	11	1

5.2.1 Hingaia Stream Channel – Lower Reaches (EO2 and EO3)

The lower reaches of the Hingaia Stream, including the section through the Drury township, have the potential to be enhanced to improve the amenity, ecological and conveyance values of these lower stream reaches. Two key enhancement opportunities have been identified along the lower reaches of the main stream; one through existing esplanade reserve land within the Drury township (EO1) and the other within land zoned for future urban development (EO2). Both have a prioritisation score of two, with potential enhancement likely to have a moderate to high impact on amenity, ecology and conveyance values.

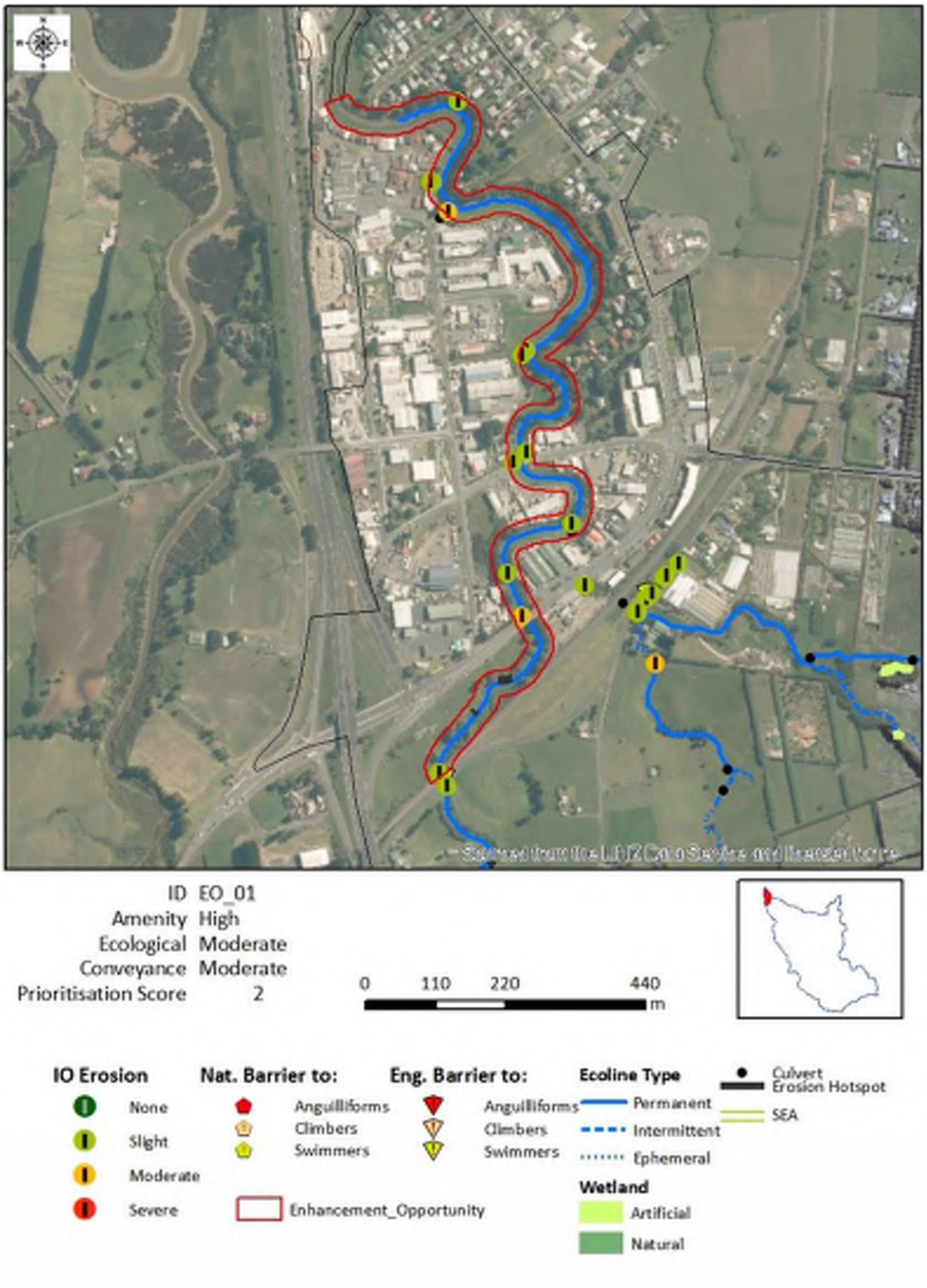
EO1, within the Drury township, focuses on enhancing the existing esplanade reserves that run along the Hingaia Stream from the stream mouth back to the Flanagan Rd Bridge (Table 31). In their current state these reserves consist largely of a wide grass strip backing directly on to the stream. Native riparian vegetation is largely absent or is compromised by encroachment from exotic plants and/or weedy species and there is limited access for public use of this space. The most obvious, and likely beneficial enhancements to this area is the reinstatement of a continual, vegetated riparian buffer along the stream margins and the establishment of a walkway/cycleway with linkage options to other EOs and reserves within the catchment. The Papakura Greenways Plan (Papakura Local Board, 2016) identifies a proposed pathway route within the esplanade reserve with linkages to the coastal edge of Drury Creek and to Slippery Creek.

Riparian vegetation provides a range of ecosystem services which improve the ecological values of a stream and its terrestrial margins. An established vegetation zone along the stream edge can help control stream temperature and light levels, provide additional habitat, both terrestrial and aquatic, increase organic inputs into the stream and reduce contaminant loads reaching the watercourse, all of which can be beneficial to water quality and biodiversity (Collier et al., 1995; Vigiak et al., 2016). Even relatively small increases in the amount of riparian cover can have a significant impact on stream health (Chase et al., 2016). Riparian vegetation can also play an important role in stream hydrodynamics, flood management, sediment retention and erosion control (Collier et al., 1995; Vigiak et al., 2016). Riparian planting should also be considered for its potential impact on reducing conveyance related issues. Improving the state of riparian planting throughout the catchment was a non-structural flood management option presented in the 2010 Hingaia Stream ICMP (Golders, 2010) and the AUP(OP) states that riparian vegetation within the Auckland region should progressively restored or enhanced. Proper assessment should be made as to the appropriate riparian width, given stream width, and appropriate plant combinations to improve amenity, ecological and conveyance values.

Table 31: EO1 information card.

EO1	**Lower Hingaia Stream (Drury Township)**	**Priority Score: 2**	**Area: 72,233 m^2**
Enhancement	Amenity	**Stakeholders**	AC Parks
	Weed Control and Planting		AC SW
	Erosion Protection		Local School
	Conveyance		Iwi
Site Map			

EO1	Lower Hingaia Stream (Drury Township)	Priority Score: 2	Area: 72,233 m^2



<table>
<tr><th>EO1</th><th>Lower Hingaia Stream
(Drury Township)</th><th>Priority Score:
2</th><th>Area:
72,233 m^2</th></tr>
<tr><td colspan="2">
Poorly vegetated esplanade reserves.</td><td colspan="2">
Lack of riparian vegetation around Norrie Rd bridge.</td></tr>
<tr><th colspan="2">Notes</th><th colspan="2">Benefits to Council</th></tr>
<tr><td colspan="2">Exisitng esplanade reserves through Drury township are poorly vegetated and have limited public access.
Flooding is a major issue through the township.
Improving riparian planting offers an opportunity to improve amenity, ecological and conveyance values of the lower Hingaia Stream.
Walkway/cycleway could be incorperated into any plans for enhancement, in line with the Local Board plans.
Ecological and amenity linkages with other enhancement opportunities and development areas (Drury South).</td><td colspan="2">Land immediately available (exisiting esplanade reserves).
Contributes to erosion protection, flood filtration measures within Drury township.
Good opportunity for school, Iwi and community involvement.
Contributes to Local Board Greenways Plan.</td></tr>
</table>

While riparian planting is likely to improve ecological and conveyance values the addition of a walkway would provide significant amenity enhancements to these esplanade reserves. In many areas the esplanade reserve is wide enough to support a walkway/cycle way. This would improve public access to the area and provide better linkages between people and the natural environment. The provisions of a walkway/cycleway would also contribute to Auckland's Greenways networks, including the Papakura Greenways Plan

(Papakura Local Board, 2016), and could be linked with potential public accessways through EO3 and EO4 as development occurs, along with pedestrian accessways planned within the Drury South development, which is currently underway (Beca, 2016). Amenity and cultural values of these esplanade reserves could also be improved by involving local schools or iwi groups in restorative works, thus providing more public awareness of these spaces and improving education around the importance of riparian zones, stream health and stream ecosystems.

Any enhancement works undertaken within EO1 have significant potential to link into potential enhancement projects within EO2, which is located on the main Hingaia Stream channel immediately upstream of the Drury township, south of Great South Road (Table 32). EO2 is currently surrounded by agricultural land but is zoned for future urban development as part of the Opaheke - Drury Future Urban Zone. This land is anticipated to be development ready between 2028 and 2032 (Auckland Council, 2017). Within this EO the stream width, at bank-full, will be wide enough to trigger the requirement for the establishment of esplanade reserves as development occurs, and to maintain the floodplain for stormwater management requirements (AECOM, 2017). Riparian planting of the Stream margins within EO3 could therefore leverage off developer contributions.

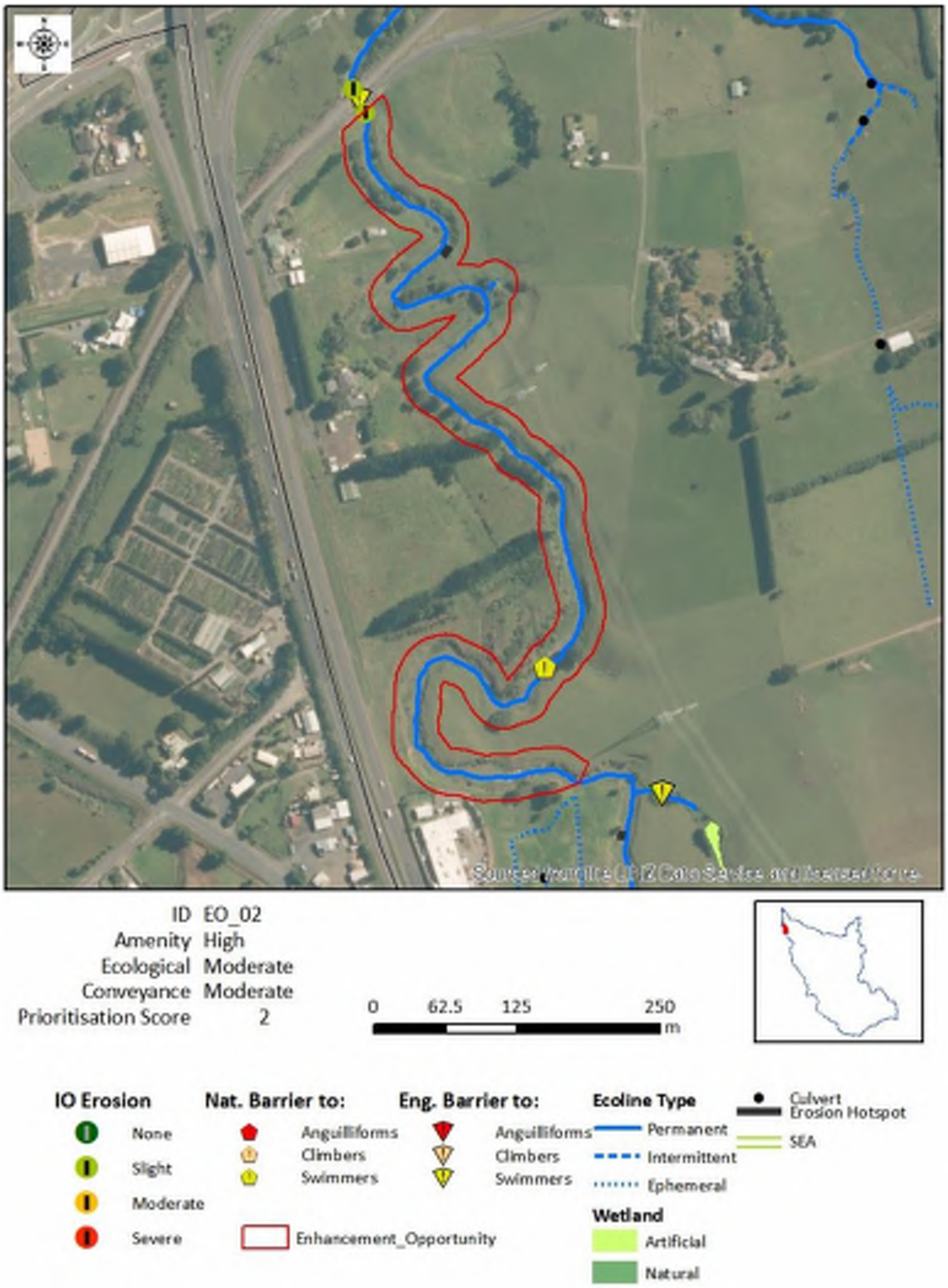
EO2 provides an important link between existing urban areas upstream (Drury township) and developing urban areas downstream (Drury South) and enhancement should focus on providing both ecological and amenity linkages between these areas. The most substantial improvements to the stream through this EO would be improving riparian vegetation through weed control and riparian planting of native vegetation. If the riparian margins within this section of stream were restored, along with riparian improvements through the Drury township and that which will be undertaken as a result of the Drury South developments, it would result in a continuous 10 km riparian corridor along the Hingaia Stream from the stream mouth to Ararimu Road. Riparian planting would also contribute to both the AUP objective of improving riparian vegetation throughout the region and the key non-structural flood management option suggested in the Hingaia ICMP (Golder Associates, 2010) and the preliminary Opaheke - Drury Stormwater Management Plan (AECOM, 2017). On a more local scale, riparian vegetation could help to stabilise a number of erosion hotspots that were noted through this section of stream.

To achieve an integrated design and development of the esplanade reserve, the area should form part of a Greenways Plan that extends through the future urban and Drury South development areas and informs the Opaheke - Drury Structure Plan. Having a high-level plan in place will assist in design and integrated development of the esplanade reserve and stormwater management reserves alongside the Hingaia Stream as this area is progressively developed. Development is anticipated to occur in 2028.

Plans for the EO2 esplanade reserve should include cycle/walkways. This, like the potential of a 10 km riparian corridor, could enable a continual pedestrian greenway along the lower Hingaia Stream from the Drury Township, through the Opaheke - Drury Future Urban Zone to the southern extent of the Drury South development area. This would significantly increase amenity values of the area, providing greater public access to the watercourse and connections to the wider region.

Table 32: EO2 information card.

EO2	Lower Hingaia Stream (Future Urban Zone)	Priority Score: 2	Area: 43651 m^2
Enhancement	Amenity	**Stakeholders**	AC Parks
	Conveyance Improvements		AC SW
	Weed Control and Planting		Community Groups
	Erosion Protection		Residents
Site Map			



<table>
<tr><th>EO2</th><th>Lower Hingaia Stream
(Future Urban Zone)</th><th>Priority Score:
2</th><th>Area:
43651 m²</th></tr>
<tr><td colspan="2">
Poorly vegetated riparian margins, with erosion evident in the background.</td><td colspan="2">
Further evidence of degradation to riparian margins.</td></tr>
<tr><th colspan="2">Notes</th><th colspan="2">Benefits to Council</th></tr>
<tr><td colspan="2">
Stream through EO2 is within land zoned for future urban development.
Currently farmland, but anticipated for development from 2028 onwards, with stream size large enough to trigger esplanade reserve requirements.
Riparian margins are degraded.
Improving riparian planting offers an opportunity to improve amenity, ecological and conveyance values of the lower Hingaia Stream.
Walkway/cycleway could be incorporated into any plans for enhancement.
Provides important link between existing esplanade reserves in urban areas upstream (Drury Township) and downstream (Drury South).
Potential for establishment of 10 km riparian corridor along Hingaia Stream, if this section is planted and linked with enhancement upstream/downstream.
</td><td colspan="2">
Leverage off developer lead initiatives for restoration.
Helps to address flooding issues within Hingaia Stream catchment .
Good opportunity, once development occurs, for and community involvement.
Contributes to and extends the Local Board Greenways Plan.
</td></tr>
</table>

5.2.2 Lower Catchment Tributaries: EO3 and EO4

EO3 and EO4 are smaller scale enhancement opportunities on the most northern tributaries of the Hingaia Stream. Both are within sections of stream that are zoned for future urban development as part of the Opaheke - Drury Future Urban Zone. Land around these EOs is likely to be developed from 2028 onwards (Auckland Council, 2017) and is currently subject to a structure planning process. Both EOs are high priority, with ranking scores of 2 and 1 respectively.

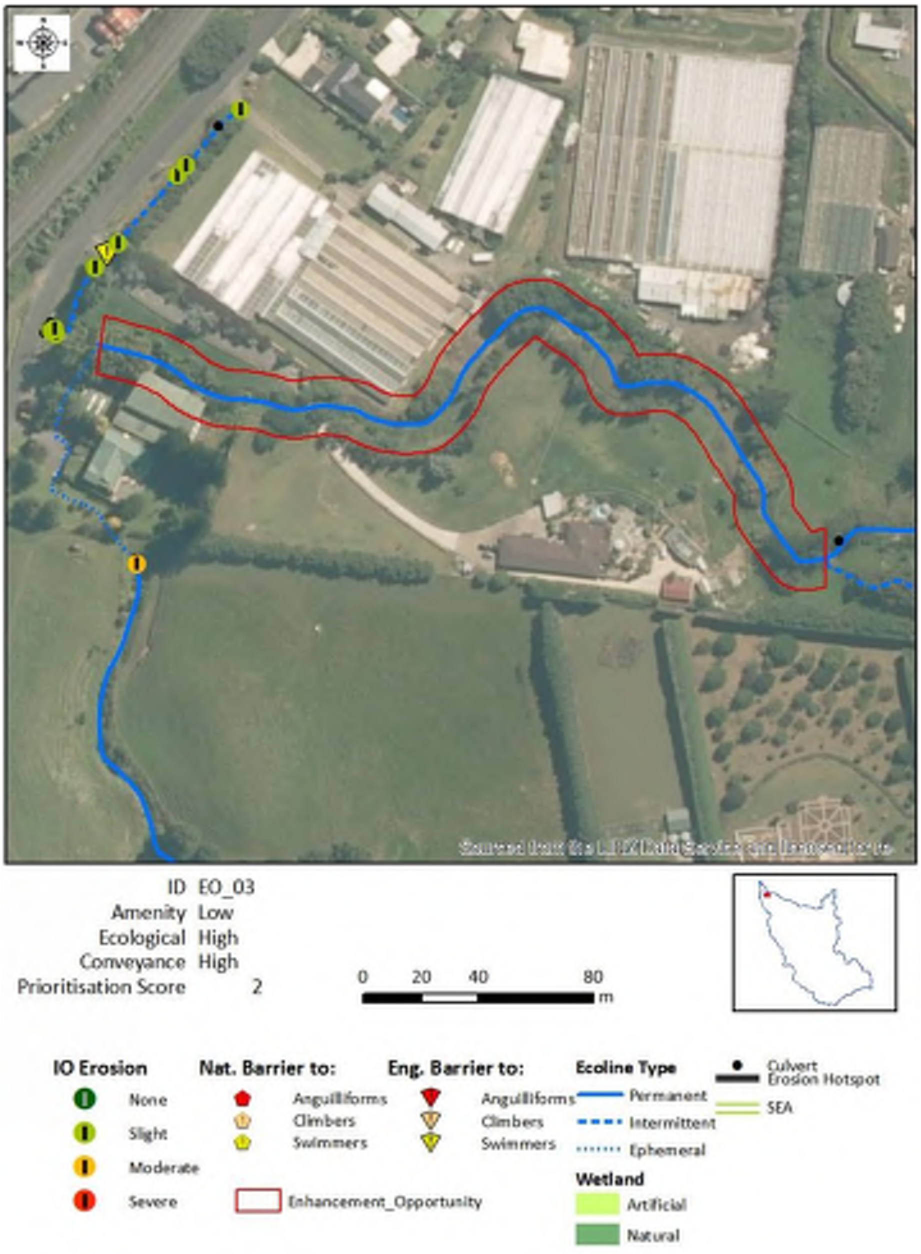
EO3 lies south of Flanagan Road, on the first tributary feeding into the lower Hingaia Stream (Table 33). This site currently suffers from flooding issues and is a site that is being investigated by Auckland Council, in order to improve conveyance issues. This site is on the southern fringe of Drury township and is surrounded by agricultural, horticultural, industrial and residential properties. An SEV was carried out within this EO and it revealed a relatively poor-quality stream where biogeochemical and biodiversity functions were significantly compromised, along with its connection to the wider floodplain. This loss of functionality was highlighted further in sediment and water quality results which found high levels of *E. coli* within the stream (above MfE Red/Action Mode thresholds) and elevated levels of zinc and copper (above ERC Red and Amber alert levels respectively).

Despite this, no obvious fish barriers were identified between the Hingaia Stream and this tributary, the site is close to the Hingaia Stream mouth and it provided some good quality habitat, particularly for galaxiids (whitebait species). Naturalisation of this section of stream should be considered to enhance the habitat available for fish and macroinvertebrates. Naturalisation could include instream improvements, as well as improvements to the current state of riparian vegetation. At present riparian vegetation is limited, and dominated by exotic species, so making improvements to this could significantly improve stream health, not only through increasing shade, organic input and habitat, but also through its ability to trap and diffuse contaminants before they enter the watercourse. Riparian vegetation, in addition to other features such as wetlands, or re-establishing connection to the wider floodplain may also help to alleviate some of the flooding issues associated with this area.

EO4 is situated along the second major tributary feeding into the lower Hingaia Stream, and comprises a sub-catchment comprising lifestyle block, horticulture and grazing. Similar to EO3 this area is flood prone and conversations with local residents revealed that they are frequently cut off from accessing or leaving their properties by flood waters extending over local roads. As a result of this flooding residents are routinely digging out the stream channels to remove sediment build-ups caused during heavy rainfall events. There are several erosion issues associated with SW assets within the catchment and, in addition, blocked culverts around nearby Fielding Road have resulted in artificial wetlands being formed on both sides of the road.

Table 33: EO3 information card.

EO3	First (Flanagan Rd) Tributary (Future Urban Zone)	Priority Score: 2	Area: 6,476 m^2
Enhancement	Naturalising (habitat enhancement)	Stakeholders	AC SW
	Weed Control and Planting		
	Conveyance Improvements		Residents
Site Map			



<table>
<tr><th>EO3</th><th>First (Flanagan Rd) Tributary (Future Urban Zone)</th><th>Priority Score: 2</th><th>Area: 6,476 m²</th></tr>
<tr><td colspan="2">
Limited riparian vegetation, low TLB providing some potential fish spawning habitat</td><td colspan="2">
Bank lining designed to protect property against elevevated stream levels</td></tr>
<tr><th colspan="2">Notes</th><th colspan="2">Benefits to Council</th></tr>
<tr><td colspan="2">Stream through EO3 is within land zoned for future urban development.
Current mixed land use including urban and rural activities.
Flood prone area under investigation by AC.
Riparian margins are degraded.
Elevetated E.coli and heavy metals.
Good connectivity to lower Hingaia Stream mainstem and has some value for potential fish (galaxiid) spawning habitat.
Stream naturalisation (bank recontouring) and riparian improvements could address ecological and some conveyance issues
Structures such as wetlands may also alleviate some flooding issues.</td><td colspan="2">Leverage off developer lead initiatives for stream enhancement.
Helps to address flooding issues within Hingaia Stream catchment.</td></tr>
</table>

A SEV assessment was conducted within EO4 and the overall SEV score was reflective of the highly modified nature of the stream channel here and lack of established riparian vegetation. The stream suffered in terms of its biogeochemical, habitat provisioning and biodiversity functions. Despite these issues the tributary is well connected to the main

Hingaia Stream and native fish were observed upstream, suggesting no significant fish barriers exist up to this point.

Enhancement of this area should consider naturalising the stream channels (including reintroducing natural meanders) to improve habitat for aquatic fauna and also to improve the natural flow regime. Additionally, fencing and reinstatement of riparian vegetation should be prioritised as a key initiative in helping to restore stream health. Shading riparian cover will help reduce excessive growth of aquatic plants and reduce sediment inputs to the stream.

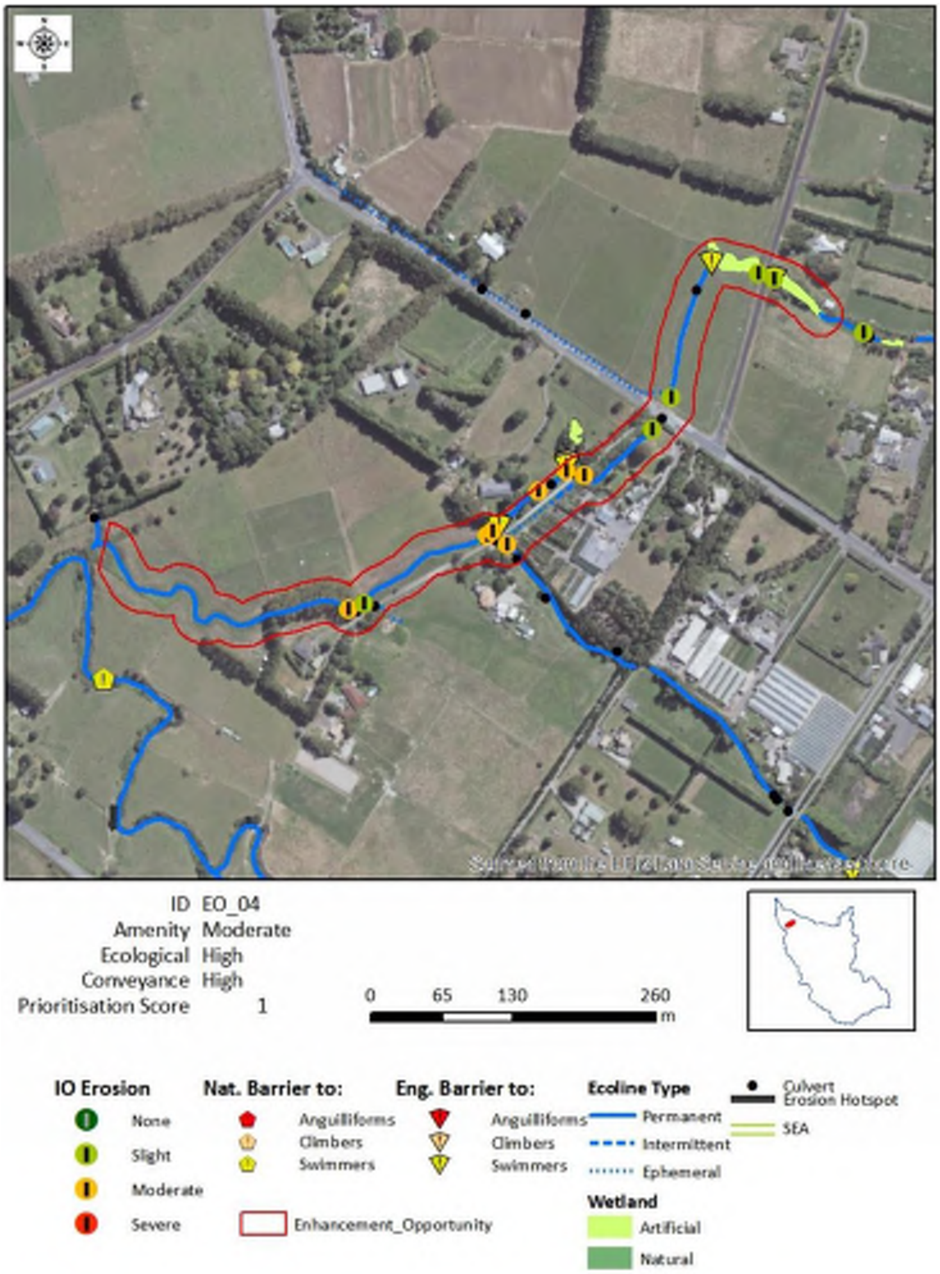
The stream width, at bank full, through much of this EO may be wide enough to trigger the creation of an esplanade reserve as development occurs. Where not of sufficient width it would still trigger a 10m riparian yard requirement. Therefore, much of the restorative stream works could be incorporated into the development process.

Additional issues identified, such as culvert erosion will likely also be addressed through development of the area. Culverts that have created potential flood issues, such as those around Fielding Road should be addressed immediately, with longer term improvements to flood management, being planned for as part of the development process.

EO4 ranks highly in its prioritisation because there is the likelihood that significant improvements to the ecological and conveyance values of this tributary can be made through addressing issues within the EO. In addition to this the potential creation of esplanade reserves, as a result of development, would open this area up to the public and allow for further connectivity through the catchment.

Table 34: EO4 information card.

EO4	Second (Wykita Lane) Tributary (Future Urban Zone)	Priority Score: 1	Area: 36,600 m^2
Enhancement	Conveyance Improvements	Stakeholders	AC SW
	Outfall Erosion		AC Parks
	Naturalising (habitat enhancement)		Residents
	Weed Control and Planting		AT
Site Map			



EO4	Second (Wykita Lane) Tributary (Future Urban Zone)	Priority Score: 1	Area: 36,600 m^2

Modified stream channel within EO. Degraded riparian vegetation

Failing structure with erosion issues.

Notes	Benefits to Council
• Stream through EO4 is within land zoned for future urban development. • Current mixed land use including large lot urban and rural activities. • Flood prone area. • Riparian margins are degraded. • Good connectivity to lower Hingaia Stream and has some value for fish galaxiid habitat. • Stream naturalisation and riparian improvements could address ecological and some conveyance issues	• Leverage off developer lead initiatives for stream enhancement. • Helps to address flooding issues within Hingaia Stream catchment. • Enhancements could be staged, including short-term (coveyance) and longer term (riparian) enhancement opportunities.

5.2.3 MacWhinney Reserve: EO5

MacWhinney Reserve is a small reserve situated around the watercourse that flows through the MacWhinney Drive area in the northeast of the catchment (Table 35). This reserve is currently listed as Open Space – Conservation Zone, a designation that applies to open spaces with natural, ecological, landscape and cultural/historical values (Auckland Council, 2016). However, the vegetation within the reserve is not listed as a SEA nor contains any identified historic/mana whenua points of interest (Auckland Council, 2016). At present the native vegetation within this reserve is being encroached on by exotic plants and is also suffering from weed infestations. A small section of the eastern reserve (to the east of MacWhinney Drive) is used as an informal dog recreation area. There also appears to be a number of properties whose land use activities have extended past their own boundaries and into the reserve footprint.

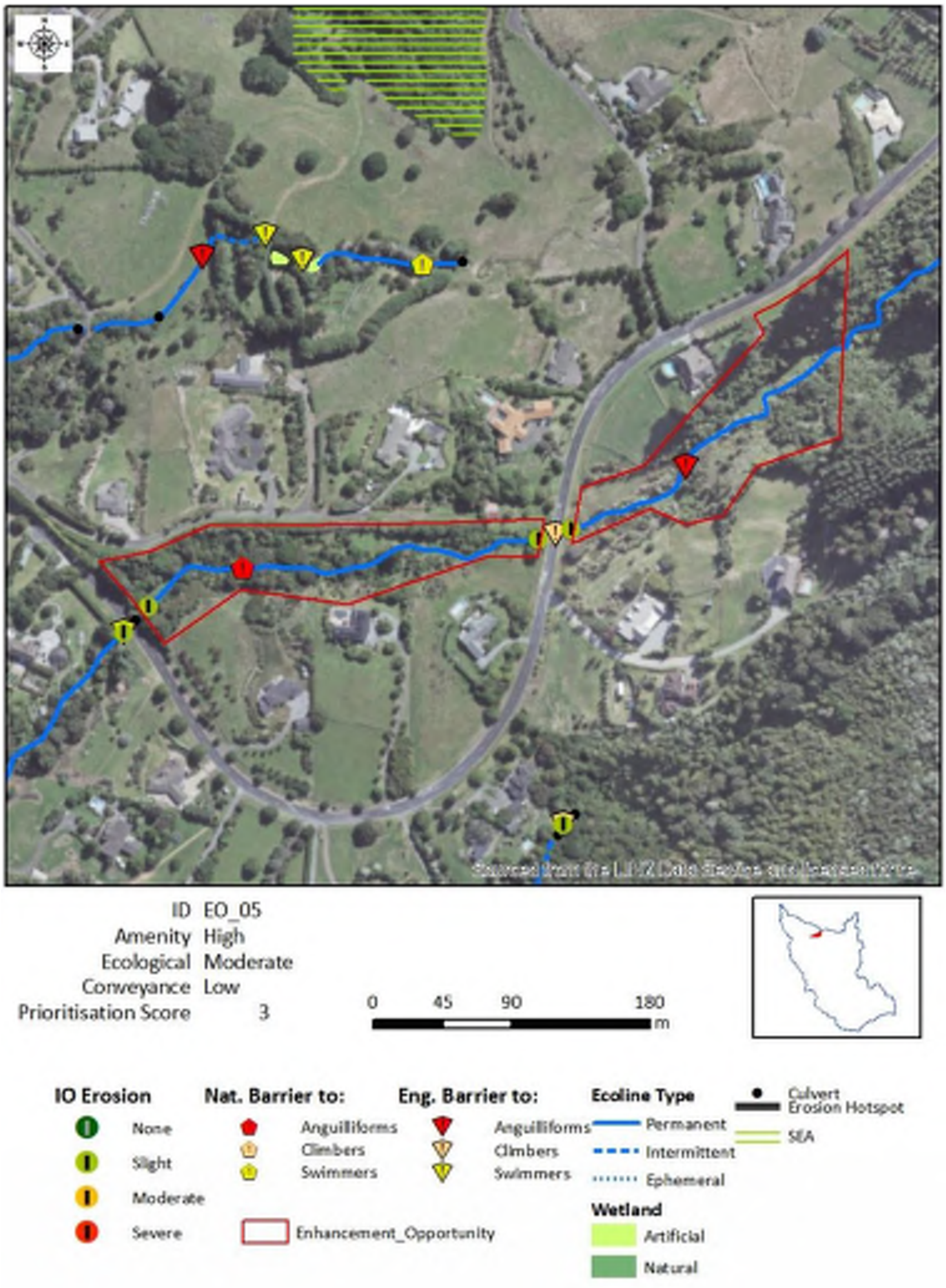
A key objective of a conservation zone is that the natural, ecological, landscape, Mana Whenua and historic heritage values of the zone are enhanced and protected from adverse effects of use and development (Auckland Council, 2016). In the MacWhinney Reserve this could be achieved primarily through planting and weed control. As long as use and development compliment and protects the conservation values and natural qualities of the zone there should be no reason the existing dog recreation area could not be maintained, or a walkway be developed to improve public access to this space.

The MacWhinney Reserve watercourse will link to south with the proposed Drury South Business Park Northern Stream Diversion. This diversion will comprise a naturalised stream channel that connects several existing watercourses while diverting stormwater flows away from the industrial development area. The diversion channel is to undergo significant riparian replanting. Enhancement of the MacWhinney Reserve will extend the riparian connections through this area, with weed removal also improving the long-term resilience of the riparian margins.

Any restoration projects should look to involve local residents, schools and community groups. This could be done as an educational exercise on enhancing natural habitats and would also help improve the amenity value of this reserve.

Table 35: EO5 information card.

EO5	Hingaia Tributary (stream around MacWhinney Drive)	Priority Score: 3	Area: 24,126 m^2
Enhancement	Weed control and Planting	Stakeholders	AC Parks
			Residents
	Amenity		Local Schools
			Community Groups
Site Map			



EO5	Hingaia Tributary (stream around MacWhinney Drive)	Priority Score: 3	Area: 24,126 m^2

Degradation of riparian zone within MacWhinney Reserve

Weed infestations within MacWhinney Reserve..

Notes	Benefits to Council
• Stream through MacWhinney Reserve. • Listed as Public Space – Conservation Zone. • Riparian vegetation compromised by weeds and exotic species. • Community involvement in weeding and planting projects would improve amenity values. • Options for formal walkway or improved dog recreation area should be considered. • Good linkage with downstream DSBP 'Northern Diversion' channel and enhancements.	• Immediately actionable as it is on public land • Good opportunity to involve the community in a restoration project.

5.2.4 Maketu Stream and Tributaries: EO6 and EO7:

The Maketu Stream, and its tributaries form a major sub-catchment within the larger Hingaia Stream Catchment. This stream network drains the east of the catchment and comprises a number of steep, well vegetated gullies or hillsides, the majority of which are identified as SEAs, interspersed by farmland. Large sections of the streams are hard-bottomed, and the watercourse flows over a number of notable waterfalls and cascades. Two EOs have been identified along the Maketu Stream and its tributaries; EO6, to the north of Peach Hill Road (Table 36), and EO7, along the main Maketu Stream Channel to the south of Peach Hill Road (Table 37).

EO6, the smaller of the two EOs, would link SEA_T_1178 with SEA_T_5323. This could be achieved through the replanting of approximately 350 m of watercourse between the SEAs which is currently open farmland. This small addition would result in approximately 6 km of stream network being bounded by a continuous buffer of native vegetation and would incorporate SEA_T_1178 into SEA_T_5323, which currently covers much of the hillside to the east of Drury and Papakura. Additional infill planting through areas of SEA_T_1178 and the installation of fencing to prevent stock from entering the streams throughout the EO would further help to enhance the ecological values this watercourse.

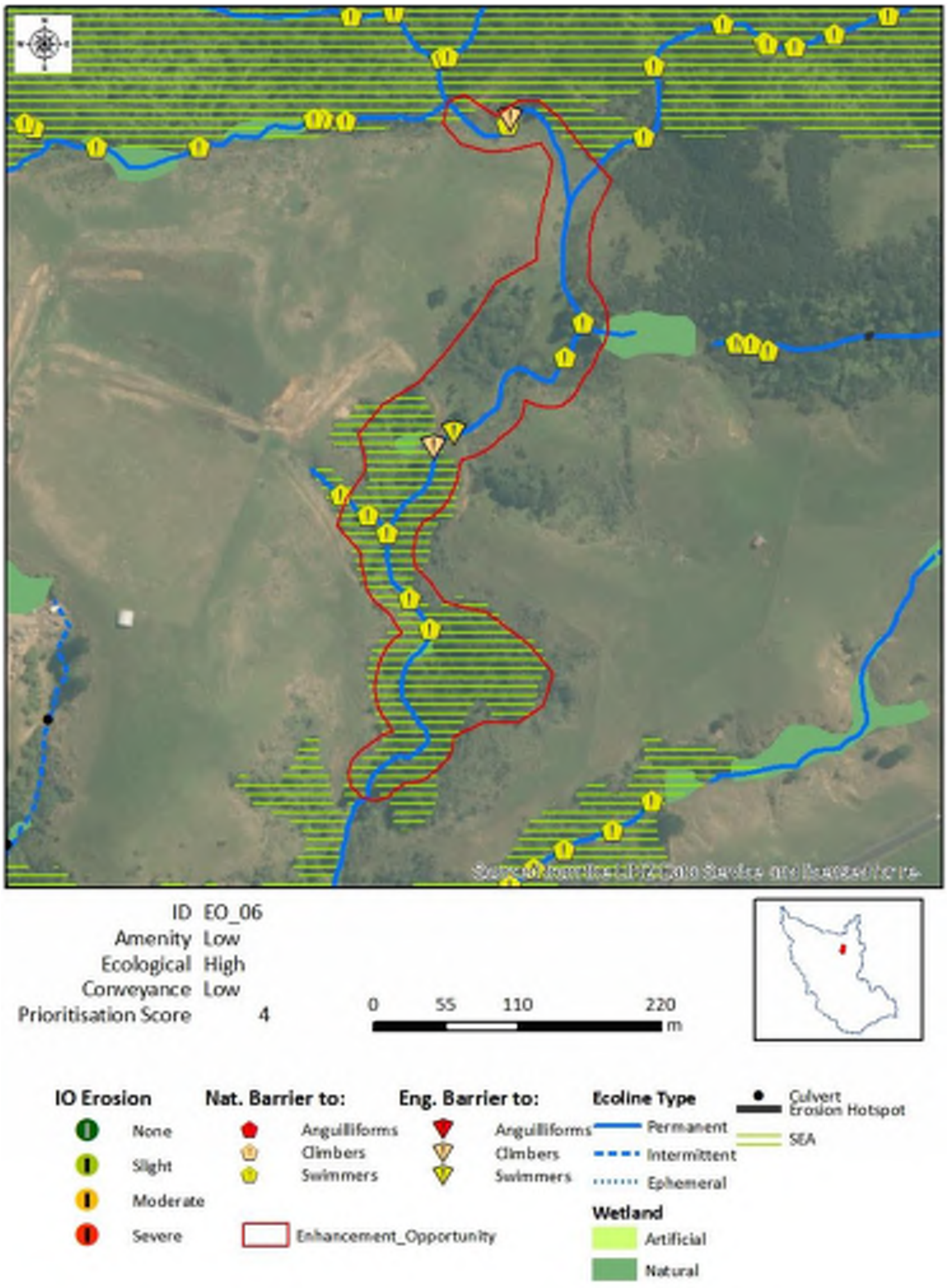
EO6 is located on private land and would need the co-operation of landowners in order to carry out any restorative work. Auckland Council should work with the landowners of this property to achieve planting and stock exclusion goals. The Maketu Stream and its tributaries are potentially going to be used for a number restoration compensation sites associated with farming and landfill activities within the Bombay/Drury area (Scott Lowery [Director of Envoco], pers. comms.). This EO, with the approval of existing landowners, could be suggested as one of the potential compensation sites in order to reduce the associated costs to Council and/or landowners.

EO7, at approximately ten times the size of EO6, would look to address conveyance issues along the Maketu Stream in addition to improving ecological values. This EO comprises of a number of significant stands of native bush, including three SEAs. These are currently fragmented by farmland. There are a number of erosion hotspots recorded within this EO, mostly along unvegetated, unfenced sections of stream, while poorly installed culverts with moderate to severe erosion issues were also common. Riparian planting and fencing would provide the significant improvements to the ecological values of this stream and would also help to control erosion issues. As this is such a large area riparian planting would also potentially have a positive impact on downstream flood management. Working with landowners on the repair and replacement of stormwater assets with moderate or severe erosion issues should also be a priority for this EO.

Table 36: EO6 information card.

EO6	Maketu Stream (north of Peach Hill Road)	Priority Score: 4	Area: 42, 391 m^2
Enhancement	Weed control and Planting	**Stakeholders**	AC ESU
	Fencing/ Stock exclusion		Residents

Site Map



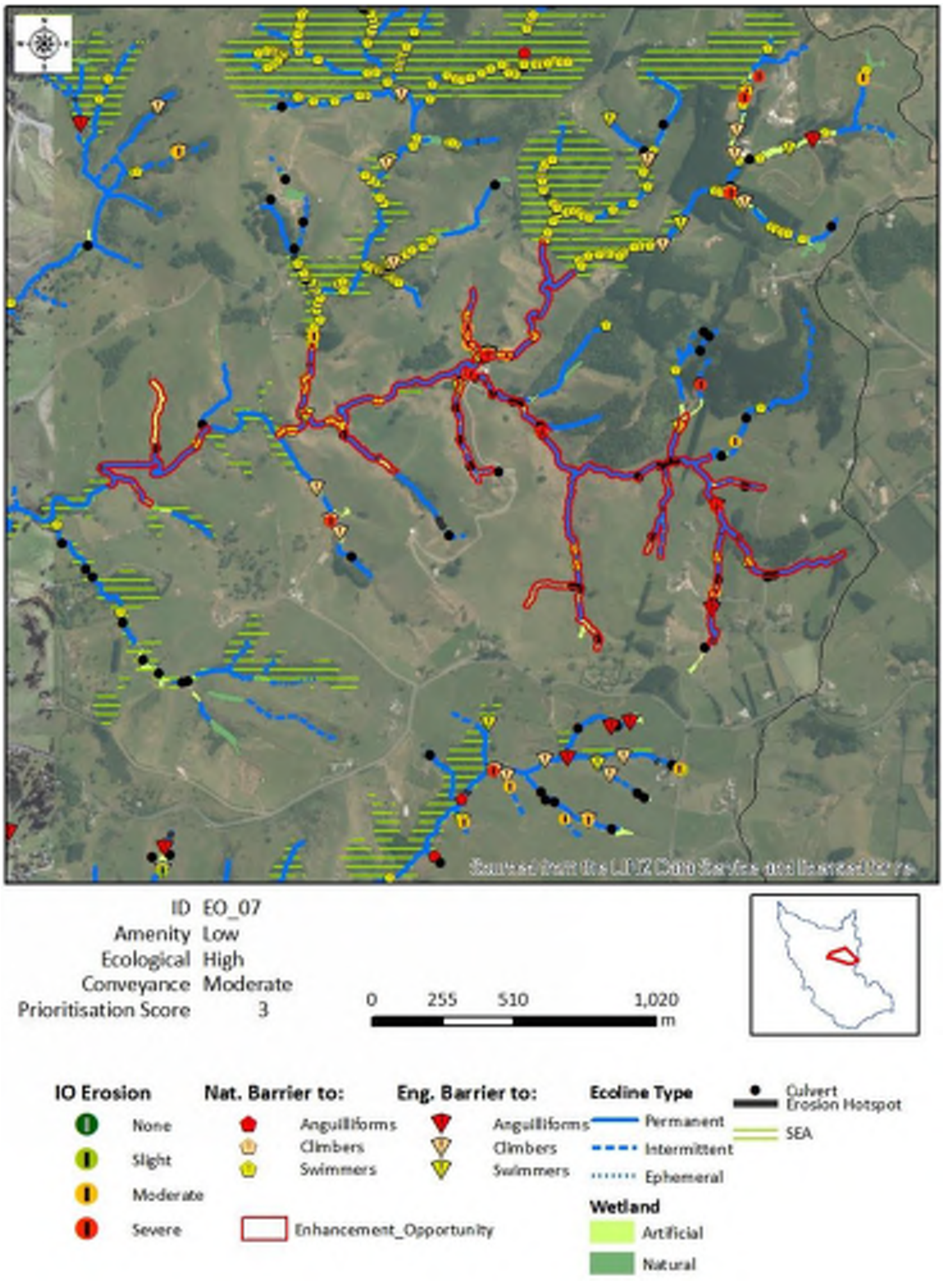
<table>
<tr><th>EO6</th><th>Maketu Stream
(north of Peach Hill Road)</th><th>Priority Score:
4</th><th>Area:
42, 391 m²</th></tr>
<tr><td colspan="2">
Natural stream channel through well vegetated SEA.</td><td colspan="2">
Poorly vegetated stream channel between SEAs.</td></tr>
<tr><td colspan="2">Notes</td><td colspan="2">Benefits to Council</td></tr>
<tr><td colspan="2">Maketu Stream tributary north of Peach Hill Road.
Link existing SEAs via approximately 350 m of riparian planting.
Additional planting through SEA_T_1178 and stock exclusion would further benefit ecological values.</td><td colspan="2">Relatively small amount of stream planting required to link a significant amount of watercourse and high value vegetation.
Potential stream effects offset compensation site, with agreement from landowners.</td></tr>
</table>

Land ownership throughout EO7 is exclusively private and any restorative actions led by Auckland Council would require cooperation from landowners. This may not present a major issue as during the course of the assessment tributaries within this area were noted to have been recently planted and fenced by landowners, while other landowners expressed a desire to plant the riparian margins of the watercourses on their properties. Properties on Peach Hill Road have been involved in the Trees for Survival programme, which is an environmental education programme aimed at involving young people with the growing and planting of native trees to restore natural habitats (Trees for Survival, 2018). Involving school and community groups with restorative works or suggesting some of the poorly vegetated site be used as environmental compensation/offset enhancement area would reduce costs to the Council or landowners. If restorative plantings are to be done within this EO then they should look to link with native bush to the north of Peach Hill Road, further increasing the ecological connectivity within the Maketu Stream catchment.

Table 37: EO7 information card

EO7	Maketu Stream (south of Peach Hill Road)	Priority Score: 3	Area: 170, 341 m^2
Enhancement	Fencing/Stock Exclusion	**Stakeholders**	AC ESU
	Weed Control and Planting		AC SW
	Outfall Erosion		Residents
	Erosion Protection		Community Groups

Site Map



<table>
<tr><th>EO7</th><th>Maketu Stream
(south of Peach Hill Road)</th><th>Priority Score:
3</th><th>Area:
170, 341 m^2</th></tr>
<tr><td colspan="2">
Poorly placed and possibly undersized culvert with significant erosion issues.</td><td colspan="2">
Unfenced and poorly vegetated stream channel positioned between SEAs.</td></tr>
<tr><td colspan="2">Notes</td><td colspan="2">Benefits to Council</td></tr>
<tr><td colspan="2">• Maketu Stream and tributaries south of Peach Hill Road.
• Link significant stands of native bush, including three SEAs with riparian planting.
• Riparain planting can be used to address erosion issues and provide flood management benefits for lower catchment.
• Poorly constructed and undersized stormwater assets should be replaced to address erosion issues.
• A number of tributaries have been replanted by residents, while other residents have expressed interest in replanting the riparian margins of streams on their properties.
• Linkage with EO6 is possible.</td><td colspan="2">• Reduction in erosion/sediment generating potential within catchment.
• Good opportunity to engage with landowners in a positive manner.
• Large enough area to provide tangible benefits for downstream flood management.
• Potential environmental compensation offset sites.</td></tr>
</table>

5.2.5 Main Hingaia Stream Channel – Mid Reaches: EO8

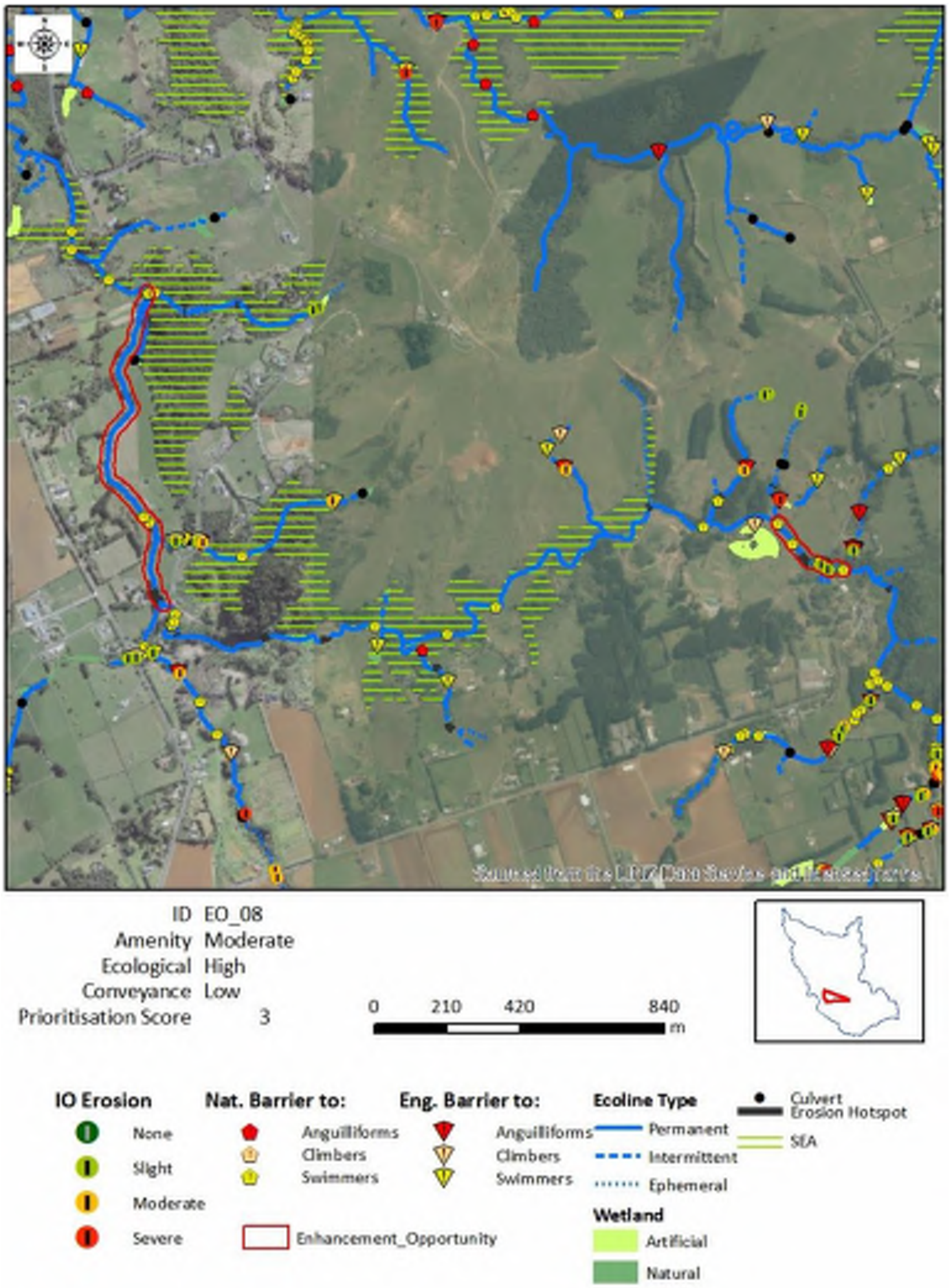
An opportunity to enhance the main Hingaia Stream channel presents itself in the mid reaches of the catchment. Here the stream channel, which is predominantly hard-bottomed at this point, flows to the east and north of Hillview Road and Portsmouth Road respectively, hugging the edge of the hills (Table 38). Three separate SEAs (SEA_T_4511, SEA_T_4512, SEA_T_1183) are located to the east of the stream channel here, however all are fragmented bush blocks in an otherwise agricultural landscape. There are two identified areas (northern and southern) where the addition of riparian planting would help to link these SEAs. Together, the two enhancement areas constitute a total length of stream nearly 1.2 km in length, most of which is in the northern section.

An SEV carried out in the northern section of this EO (SEV3, north of Stone Road) returned a relatively good overall SEV score, however the lack of riparian vegetation was impacting the streams biogeochemical functions. The SEV score of 0.58 is within the range where stream enhancement is likely to have the largest positive effect on improving the functional values of the stream (Storey et al., 2011a). The stream here was found to have elevated levels of copper in its sediments, which may be a consequence of being downstream from the largest contiguous area of cropland in the catchment. Improvements to the riparian vegetation is likely to be the most effective remedial action to improve the SEV score. The stream in this area receives high velocity storm flows from the steep contributing catchment, with subsequent high erosive potential. Riparian vegetation therefore offers a non-structural way of protecting the stream channel and controlling erosion, which was identified as an issue within both sections of stream where vegetation cover was limited.

While the stream sections that that require the most attention are surrounded by privately owned land three sections of public land do exist in the wider area. This includes the Stone Road and Cascades Road esplanade reserves and the Stone Road Forest and Quarry Reserve. All of this land is classified as Open Space – Conservation Zone, suggesting it has high natural, ecological, landscape and/or cultural/historical values. These are areas that may provide good opportunities for community involvement in projects such as weeding and/or infill planting. This would further enhance the value of these conservation zones. Auckland Council purchase of the riparian margins as esplanade reserve could potentially turn the 1.2 km network of reserves around Stone Road into a 2.2 km reserve network that would ultimately offer the greater protection to the stream and enable greater community involvement in restorative works.

Table 38: EO8 information card

EO8	Hingaia Stream – mid reaches	Priority Score: 3	Area: 53,920 m^2
Enhancement	Weed Control and Planting	**Stakeholders**	AC Parks
	Erosion Protection		Local School
	Amenity		Community Groups
			Residents
Site Map			



EO8	Hingaia Stream – mid reaches	Priority Score: 3	Area: 53,920 m^2

Hard-bottomed stream with poor riparian vegetation cover and stock access.

Well vegetated hard-bottomed stream through SEA.

Notes	Benefits to Council
• Mid reaches of main Hingaia Stream. • Poorly vegetated sections of stream between SEAs. • Within proximity to significant area of cropland, potential source of elevated instream copper concentrations. • Improvements to 1.2 km of riparian vegetation would link large SEAs. • Potential for community engagement.	• Areas of enhancement back on to public spaces. • Large enough area to provide tangible benefits for downstream flood management. • Riparian enhance would protect stream banks from erosion. • Good opportunity for community engagment.

5.2.6 Simunovich Olive Estate: EO9

The Simunovich Olive Estate occupies a large block of land in the upper catchment (approximately 68 ha), used for olive production, cropping and associated commercial ventures. The headwater streams through this estate are highly modified and largely lack riparian vegetation. A number of online ponds are present. There are litter issues associated with duck/clay bird shooting issues and erosion issues associated with some of the unvegetated online ponds within the property.

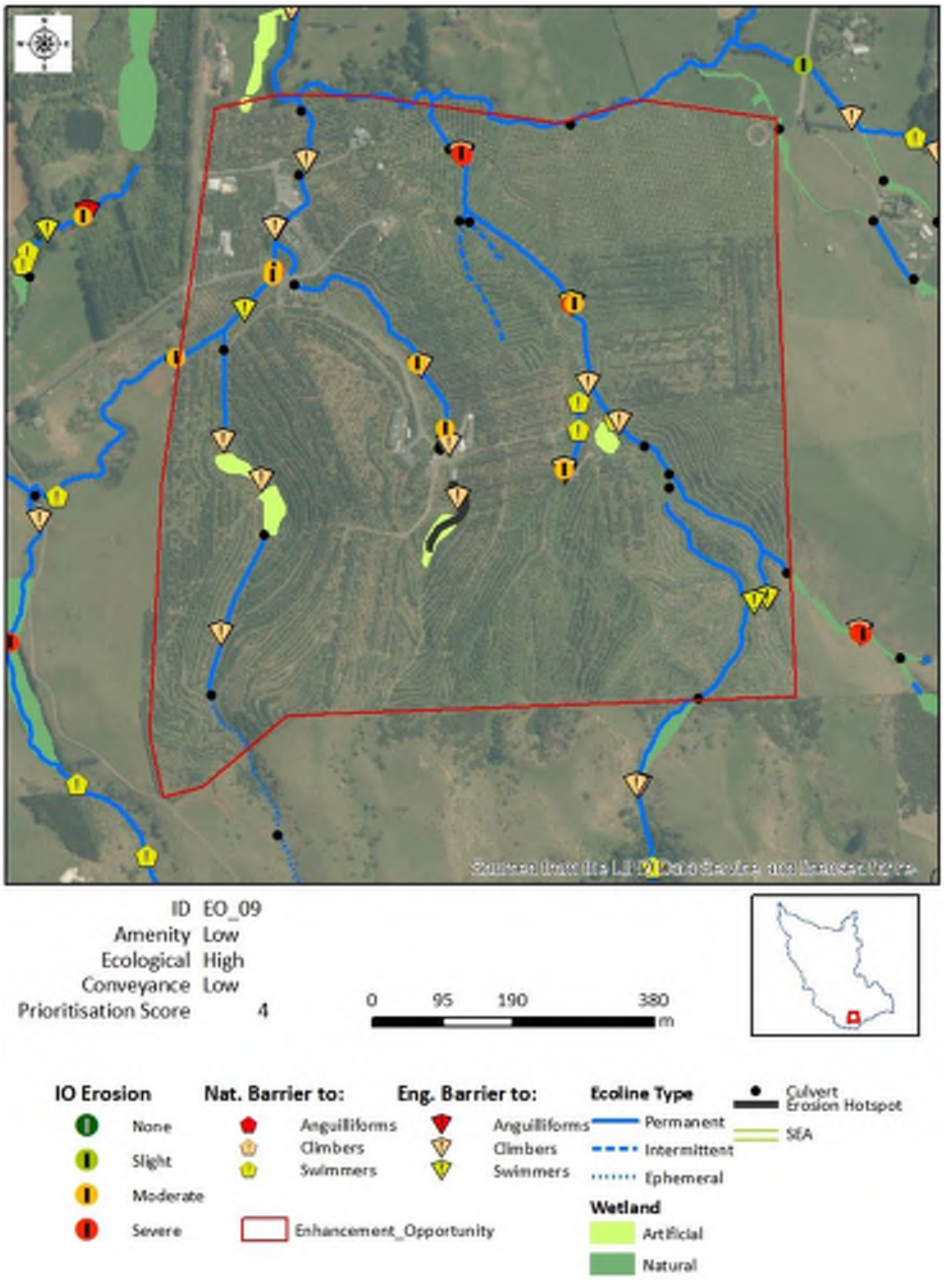
The main Hingaia Stream, up to the point where the tributaries from the Simunovich Olive Estate join it, is relatively free of fish barriers that would prevent climbers or anguilliforms (eels) from reaching these upper reaches. Therefore, improving the stream habitat and removing fish barriers through this single property could potentially provide a significant amount of 'good' and accessible habitat for fish in the upper catchment. Stream naturalisation and riparian planting could improve instream condition, while also providing other benefits such as stabilising banks and preventing any agrichemical runoff associated with olive cultivation.

During the course of the survey through this property it was noted that downstream of ponds used for duck/clay bird shooting there were considerable build-ups of used shotgun shell casings. This littering issue should be addressed, and a system put in place to stop these used cartridges being carried downstream during heavy rainfall events.

It is acknowledged that this EO is located on a large private block of land and that Auckland Council would have to work with the Simunovich Olive Estate as corporate landowners to achieve any enhancements within this area. Nevertheless, this site, as a large single ownership site presents a good opportunity to improve a significant length of stream without the need to engage with multiple private stakeholders. Trees for Survival, the school based environmental education programme, is active in the lower catchment so could be suggested as a potential partner to help restore streams through this area.

Table 39: EO9 information card.

EO9	Simunovich Olive Estate	Priority Score: 4	Area: 681,189 m^2
Enhancement	Weed Control and Planting	Stakeholders	Landowners
	Naturalising (habitat enhancement)		AC ESU
	Erosion Protection		Local School
	Fish Barrier		
Site Map			



EO9	Simunovich Olive Estate	Priority Score: 4	Area: 681,189 m^2

Used shotgun cartridges accumulating downstream of duck shooting pond.

Modified intermittent stream channel through olive estate.

Notes	Benefits to Council
• Head water streams through olive estate. • Limited riparian vegetation. • Litter issues associated with shotgun cartridges associated with clay bird and duck shooting. • Erosion issues around unplanted ponds. • Few artificial downstream fish barriers so fixing fish barrier issues within this area would open upper catchment to climbers and anguilliforms	• Good opportunity to work with commercial landowner to meet their corporate social responsibilities. • Riparian enhance would protect stream/pond banks from erosion. • Riparian enhance would limit potential agrichemical runoff.

5.2.7 Southern Headwater Streams: EO10

Headwater streams, typically small first order streams are an extremely important part of stream network and add significant length to the total length of watercourse within a catchment. It is estimated that permanent streams too small to be included on a 1:50,000 topographic map represent 44% (or 7,200 km) of all permanent streams within the Auckland Region (Storey and Wadhwa, 2009). Intermittent streams contribute a further 4,500 km.

Headwaters stream typically differ from reaches in lower parts of a catchment because they are more closely linked to hillslope processes and have more temporal and spatial variation (Gomi et al., 2002). These connections ultimately mean headwater streams have a strong influence on hydrological, geomorphic, biogeochemical and biological processes and functions in larger order streams and rivers further down the catchment (Gomi et al., 2002; Alexander et al., 2007; Dodds and Oakes, 2008; Storey et al., 2011b). This includes influences on flow rates and volumes, biodiversity, water chemistry and nutrient and sediment loads (Wilding and Parkyn, 2006; McKergow et al., 2006; Sukias et al., 2006; Parkyn et al., 2006). Headwater streams therefore should be considered important at both a local and landscape level.

Headwater streams, particularly intermittent and ephemeral streams that are periodically or predominantly dry, are often subjected to greater levels of modification and consequently degradations than larger streams. This has largely been a consequence of limited legal protection of smaller watercourse and it is only within the past decade that intermittent streams have been granted the same level of protection as permanent streams within the Auckland Region. Because these smaller streams have such an important influence on the overall state of the watercourse management, protection and enhancement of such areas should be considered a priority and seen as a landscape level control on issues that are prominent throughout a watercourse.

In the southern section there are 124 first order stream channels that eventually feed into the Hingaia Stream. The majority of these (85%) are surrounding by agriculture and have been significantly degraded due to a complete loss of riparian shading and ongoing stock access. As a consequence, erosion and stock damage are major issues (54, 718 m of stream damage with >20% erosion scarring, 36 identified erosion hotspots and 20, 292 m of moderately or severely stock damaged watercourse), instream *E. coli* levels are high (as recorded at SEV4) and biogeochemical, habitat provisioning and biodiversity functions are low.

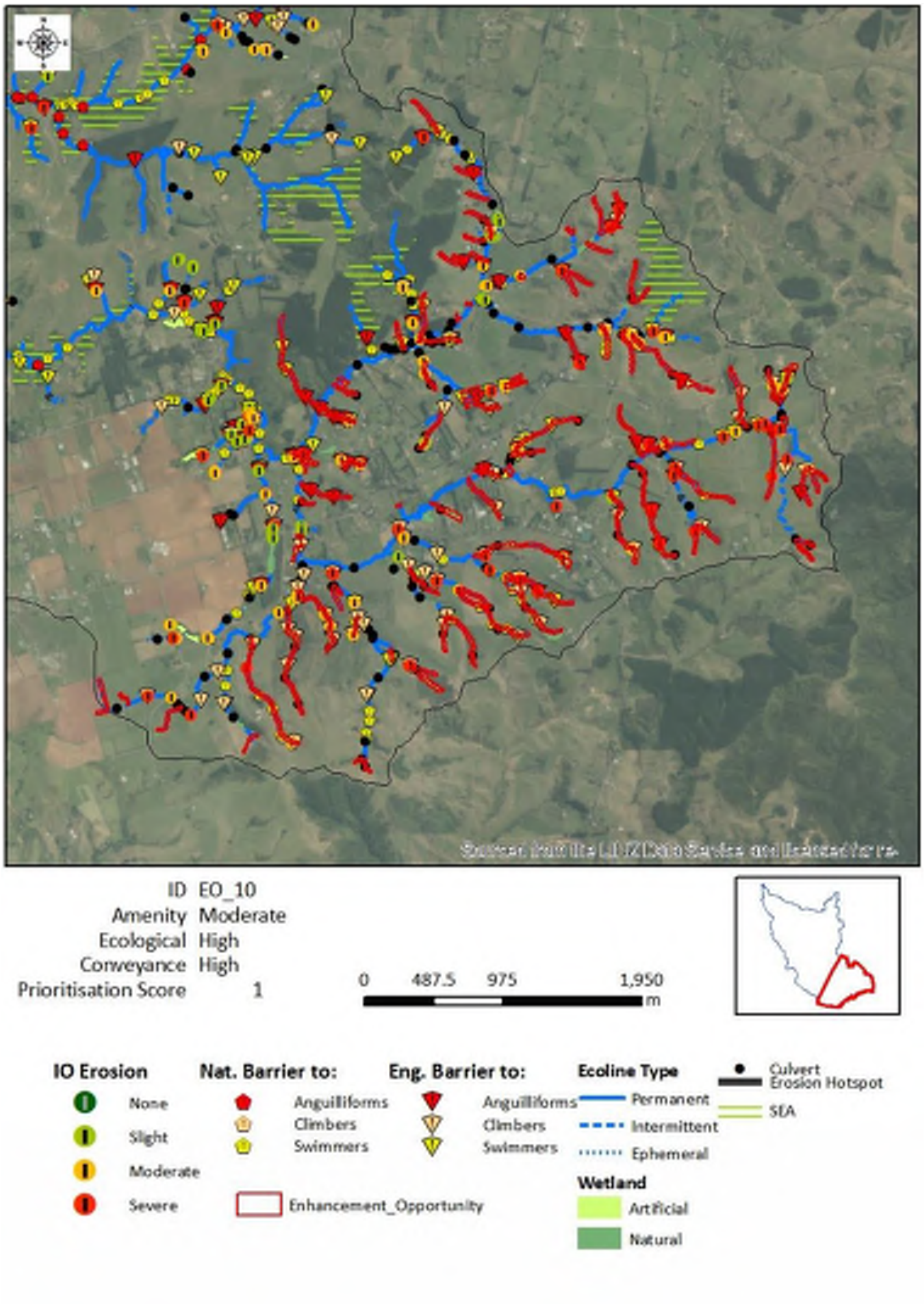
Significant improvements to these headwaters would likely have local and landscape level benefits to the Hingaia Stream. In the first instances riparian planting and stock exclusion from watercourse could help to reduce localised erosion and sediment laden runoff, improve instream habitat quality for aquatic fauna and generally boost stream health.

Overtime these enhancements would likely have flow on effects to the wider catchment including helping with sediment control and flood prevention, reducing stream faecal contamination and boosting aquatic and terrestrial biodiversity.

It is acknowledged that EO10 is a major, and probably long-term, project and that much of the improvements would need to be done on private land. The approach to this should be for the Council to work closely with residents and involve community groups, schools and local businesses. There may be opportunity (i.e. through Local Board contributions) to develop a widescale enhancement plan for the EO area, that provides landowners and community groups with the range of information they need to get enhancement works underway and to identify where and how they can get help. Empowering the local community to be involved and take pride in the upper Hingaia Stream catchment will boost the amenity and landscape values of EO10 and likely improve overall interest in the project. A project of this scale, if managed well, may help to kickstart a community lead catchment wide approach to improving stream health and function.

EO10	Southern Headwaters	Priority Score: 1	Area: 545, 752m^2
Enhancement	Weed Control and Planting	**Stakeholders**	AC SW
	Conveyance		AC ESU
	Erosion Protection		Residents
	Fish Barriers		Community Groups

Site Map



EO10	Southern Headwaters	Priority Score: 1	Area: 545, 752m^2

 Degraded headwater stream.	 Degraded headwater stream.
Notes	**Benefits to Council**
• Collection of numerous headwater streams in southern catchment • Minimal riparian vegetation. • Moderate to severe stock damage is common and fencing of waterways is rare. • Poorly placed and/or undersized culverts have resulted in multiple erosion issues. • Large scale project aiming to improve local and wider catchment issues.	• Input from multiple Council units. • Could become a flagship project for stream restoration within the Auckland Region. • Good opportunity to work with multiple community stakeholders.

5.3 Auckland Council Maintenance Contract

Intergroup is responsible for implementing the ‘southern area stormwater maintenance contract’ for Auckland Council. This contract includes the Hingaia Stream catchment area. The contract works to be carried out under this contract include, but are not limited to, the regular maintenance of the Auckland Council’s Stormwater assets in the Southern Area. This includes maintenance of pipeline, open channel and watercourses, culverts, ponds, treatment devices, network and related works within urban areas, including isolated urban settlements. The contract includes regular inspections for both lined and unlined channels specifically scheduled within the contract. Vegetation control is to be undertaken as required. The purpose of vegetation control of watercourses is to maintain the low flow and ensure the stormwater capacity of the drainage system remains in an efficient state. It is also to ensure watercourses are acceptable from an aesthetic and environmental viewpoint. Tasks to be carried out include grass cutting, weeding, and spraying. All spraying is to be carried out by licensed applicators, which shall use the appropriate herbicide spray and additive agents to achieve a successful result. Particular care shall be taken to ensure that bank stabilisation is maintained by restricting spray only to the required areas.

The contractor shall complete an inspection and clearing of the features as detailed in the contract. Inlets and outlet locations are specifically listed in the contract within the Hingaia Stream catchment. The assets are listed as requiring either 2 weekly or 4 weekly inspections and clearing of obstructions. The inlet or outlet includes the adjacent area 2 m wide and 5 m long on either side along the direction of flow. Critical hotspots are also identified which include known areas of flooding, surcharging, and/or overflowing that are known to cause flooding in private property. These also need to be inspected prior to heavy rain at the request of the engineer to the contract. The contractor shall also conduct inspections of all stormwater inlet and outfall structures as part of the watercourse inspection. Each outfall shall be maintained to ensure that water flows freely from the outfall into and along the watercourse, or receiving environment, that it discharges to.

Ponds and wetlands listed in the contract, filters (sand and storm filters) and other mechanical devices such as litter traps are also listed for regular inspection.

Additional maintenance contracts such as those relating to parks and open spaces were not provided, and therefore are not discussed here.

6.0 Conclusions

The Hingaia Stream catchment encompasses 54.9 km^2 of land in the south of the Auckland Region. The catchment contains approximately 166 km of permanent and intermittent watercourse and drains from the Bombay Hills in the south to the Drury Township in the north. It collects stream flows from a number of sub-catchments draining the foothills of the Hunua Ranges to the east. The lower catchment contains significant amounts of land zone for future urban development, and residential and industrial zoned land which is currently being developed as part of the Drury South developments. Consequently, the catchment is likely to experience a rapid change in land-use over the next 30 years.

In its present state, the Hingaia Stream and its tributaries, including the Maketu Stream, can be considered a moderately degraded soft-bottomed watercourse network. Extensive land development to accommodate agricultural land use activities has resulted in a loss of riparian vegetation, poor diversity of instream habitat for native fish and invertebrates, significant erosion and stock damage issues as well as erosion and fish passage issues associated with assets. SEV scores in agricultural areas were reflective of this degradation and were below the Auckland Council mean SEV reference score for rural sites. The main exception to this was a number of well vegetated gullies in the steep hill country to the east of the catchment. Through these areas streams were well shaded, hard-bottomed and were highly functionally, as reflected by the SEV score within one of these gully streams. While most of these gully areas were fragmented by farmland they provide an excellent reference for the overall state the stream could be in and should be enhanced towards.

The catchment is known to be flood prone, especially within the lower catchment. A major challenge going forward will be balancing the demands of new development with the need to manage stormwater discharges and provide appropriate flood management. Developments currently underway within Drury South are set to help improve stormwater management within the lower catchment, and flood management for future development should tie in with this. There is significant scope for a catchment level approach to flood management to be applied. This would largely focus on protecting and restoring riparian vegetation, including first order headwater streams in the upper catchment, as a non-structural form of flood management. A project such as this could have significant benefits for flood management, as well as stream and ecosystem health. Riparian planting is a common theme through the Management Zones and Enhancement Opportunities identified.

Four Management Zones (MZ) and ten Enhancement Opportunities (EO) were identified through the catchment. These include one MZ incorporating the developed, developing and future urban zones (MZ1) and three MZs through the rural areas of the catchment (MZ2, MZ3 and MZ4). MZ1 has the most potential for stream enhancement to improve amenity, ecological and conveyance values and consequently has four of the highest priority EOs with it. Within this zone enhancement can be achieved by leveraging developer lead initiatives as development progresses and by taking advantage of existing public space surrounding the streams. Rural MZs are focused on improving stream health and conveyance at a local and landscape level. EOs in these areas are aimed at linking significant stands of bush through riparian corridors, removing stock from waterways and implementing collaborative restoration projects that would involve Council, landowners, businesses and community groups. Those projects are aimed to improve stream health, stream function and erosion issues locally while providing wider reaching benefits to ecology, amenity and conveyance. The EO proposed for the Southern Headwater Streams is recognised as an ambitious project which would require a long term strategic plan and community buy-in to achieve but would have significant positive benefits both locally and for the wider catchment values.

Key management goals and objectives identified for the Hingaia Stream catchment include:

- Encouraging and supporting landowners to protect and restore or enhance riparian zones.
- Looking to develop large scale riparian planting projects as a way of helping to control flood management through the catchment. Involve multiple stakeholders in these projects where possible.
- Addressing inlet/outlet erosion issues, particularly within the future urban zones where they may be exacerbated as land becomes developed.
- Aiming to remove stock access from watercourses through fencing and riparian buffers.
- Providing improved ecological and amenity linkages through the catchment.
- In the lower catchment, providing linkages, both ecological and amenity, through the enhancement of existing esplanade reserves and those that will be triggered by development.
- Prioritise the improvement of fish passage to sections of stream where natural structures are not forming highly restrictive fish barriers.
- Determining ownership of stormwater assets with unknown ownership or those that have been recorded as Council owned but are not currently in Council GIS systems.

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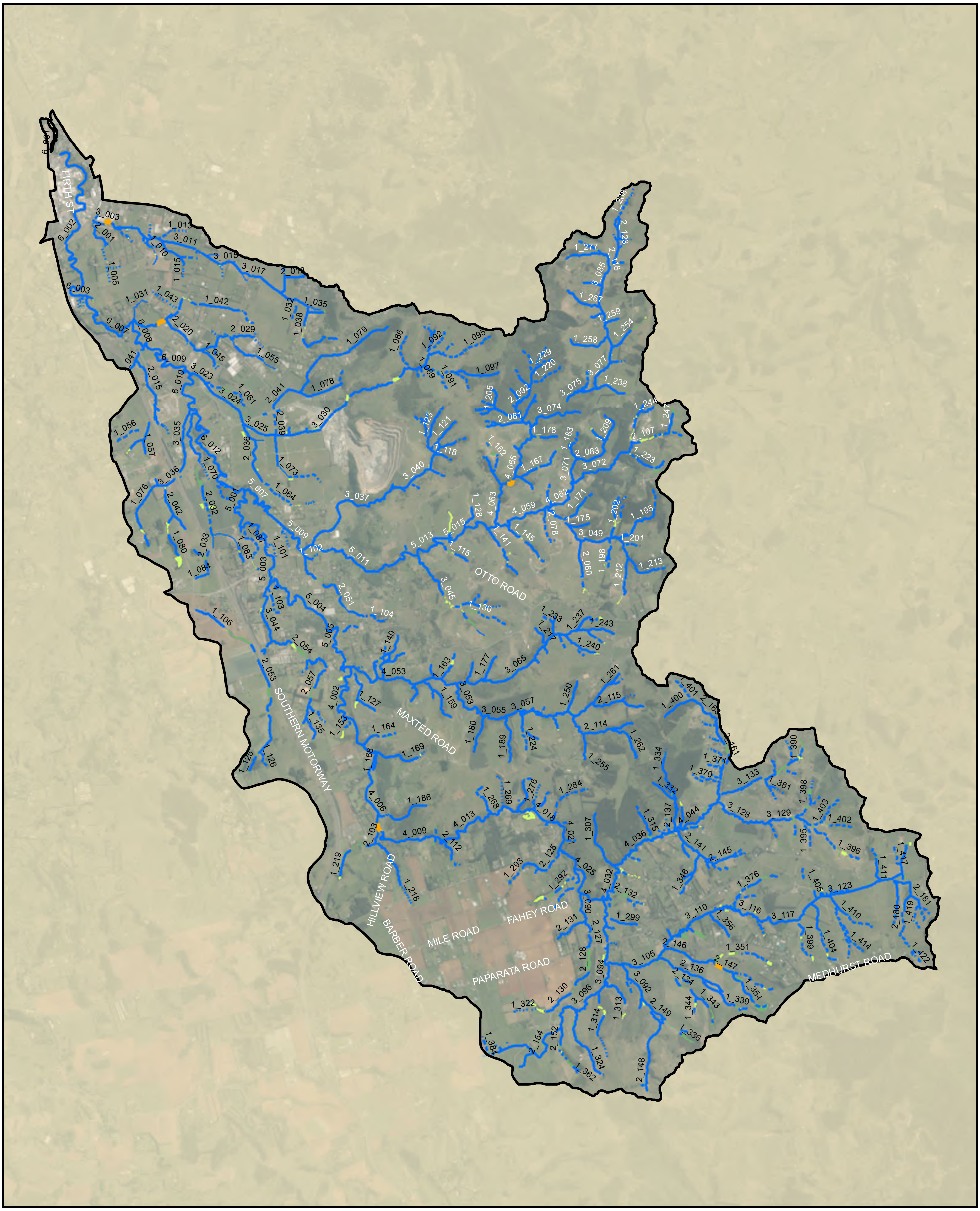
Appendix A Maps

Map 1: Overview Map



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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class
- Permanent
- Intermittent
- Ephemeral
- OLFP

Wetland
- Artificial
- Natural

SEV Lines

0 0.25 0.5 1 km

1	2	3	4	N
5	6	7	8	
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	14	15	16	17

Page 1 out of 18

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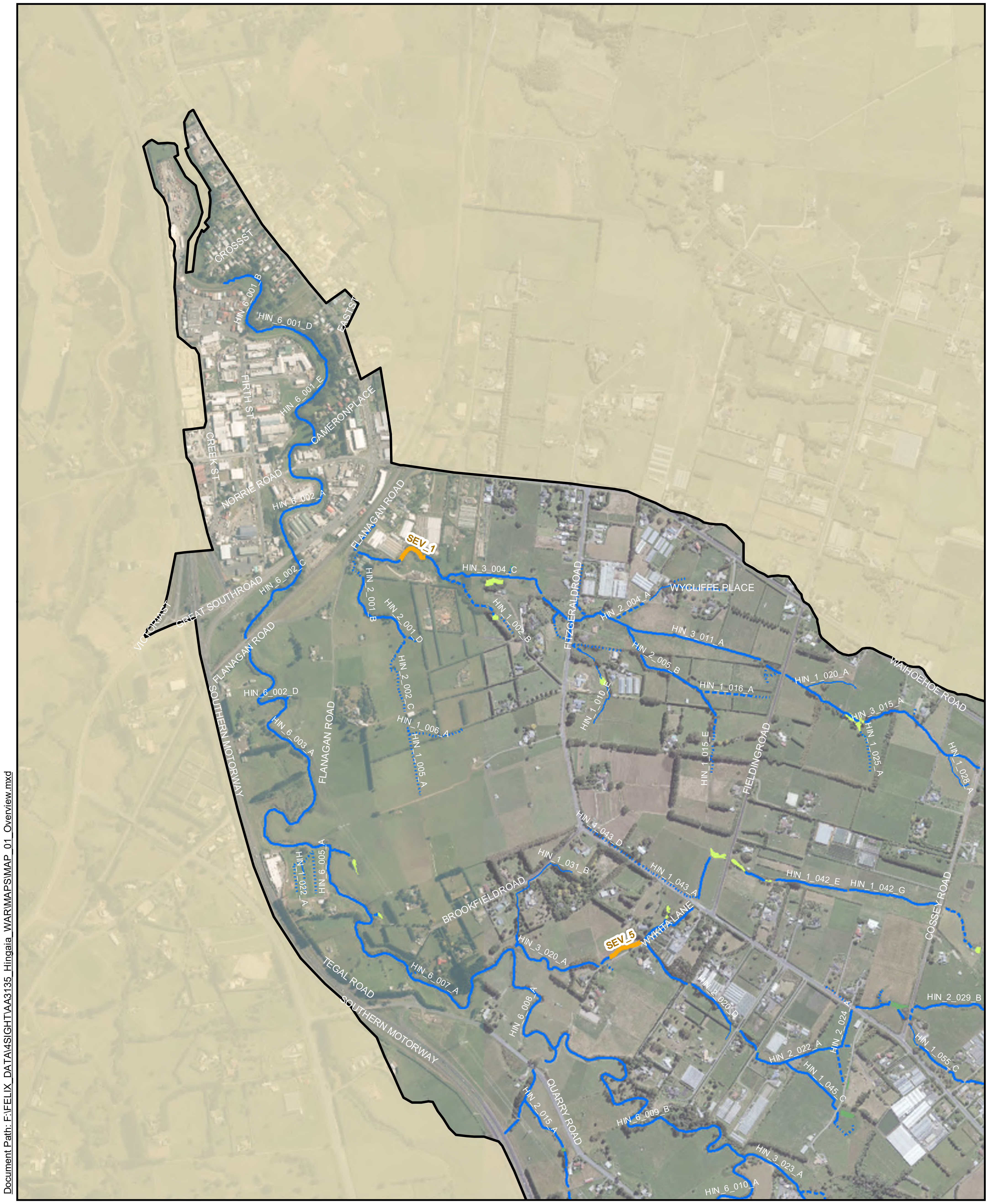
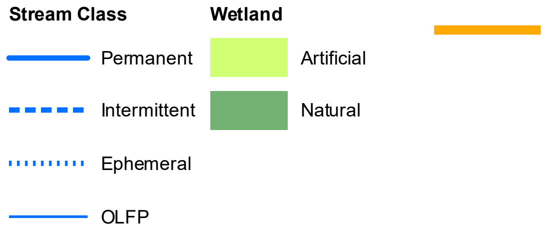
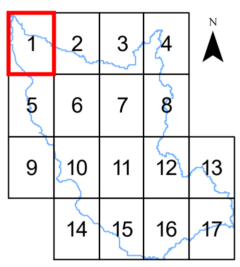




HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland	
Permanent	Artificial	SEV Lines
Intermittent	Natural	
Ephemeral		
OLFP		

0 0.25 0.5 1 km



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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class
- Permanent
- Intermittent
- Ephemeral
- OLFP

Wetland
- Artificial
- Natural

0 | 0.25 | 0.5 | 1 km

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class		Wetland	
(solid line)	Permanent		Artificial
(dashed line)	Intermittent		Natural

0 0.25 0.5 1 km

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland
Permanent	Artificial
Intermittent	Natural
Ephemeral	

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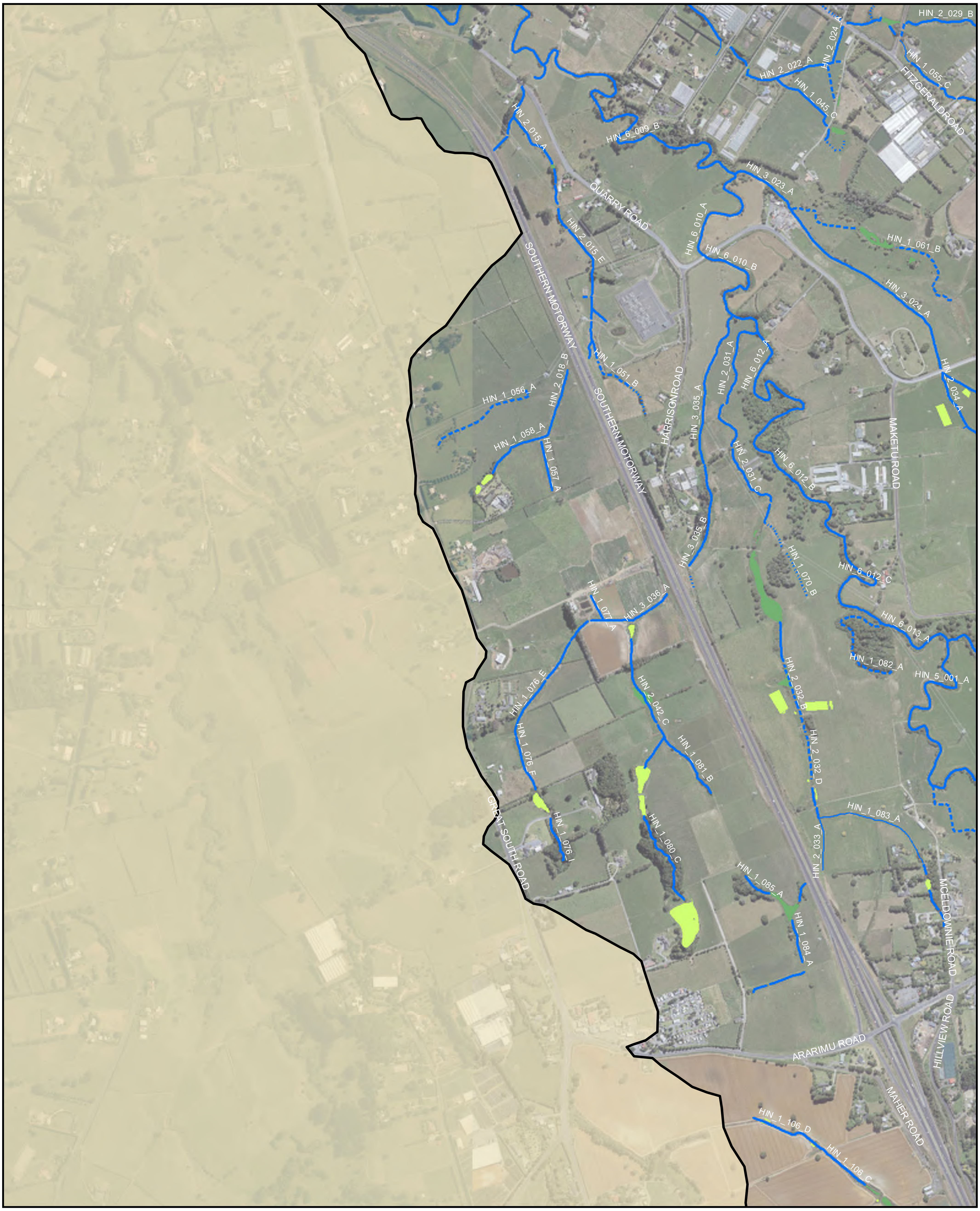

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland
Permanent	Artificial
Intermittent	Natural
Ephemeral	
OLFP	

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland	
Permanent	Artificial	
Intermittent	Natural	
Ephemeral		
OLFP		

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland	
Permanent	Artificial	SEV Lines
Intermittent	Natural	
Ephemeral		
OLFP		

0 0.25 0.5 1 km

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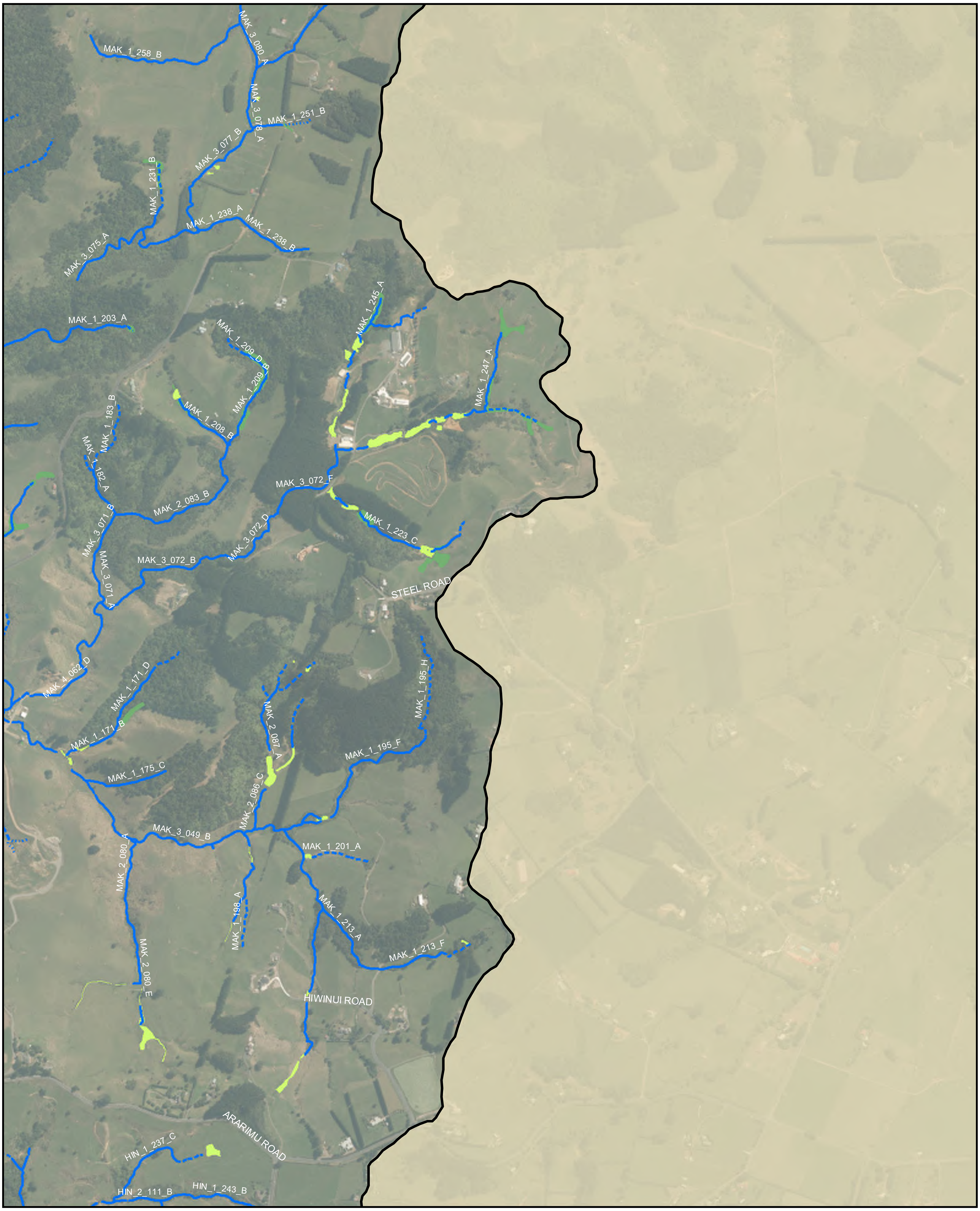

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland
Permanent	Artificial
Intermittent	Natural
Ephemeral	
OLFP	

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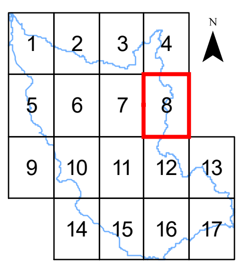

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class		Wetland	
	Permanent		Artificial
			Natural

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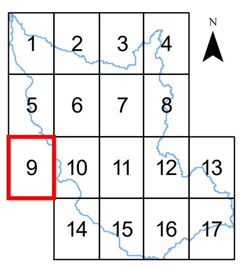

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class
- Permanent
- Intermittent
- Ephemeral
- OLFP

Wetland
- Artificial
- Natural

SEV Lines

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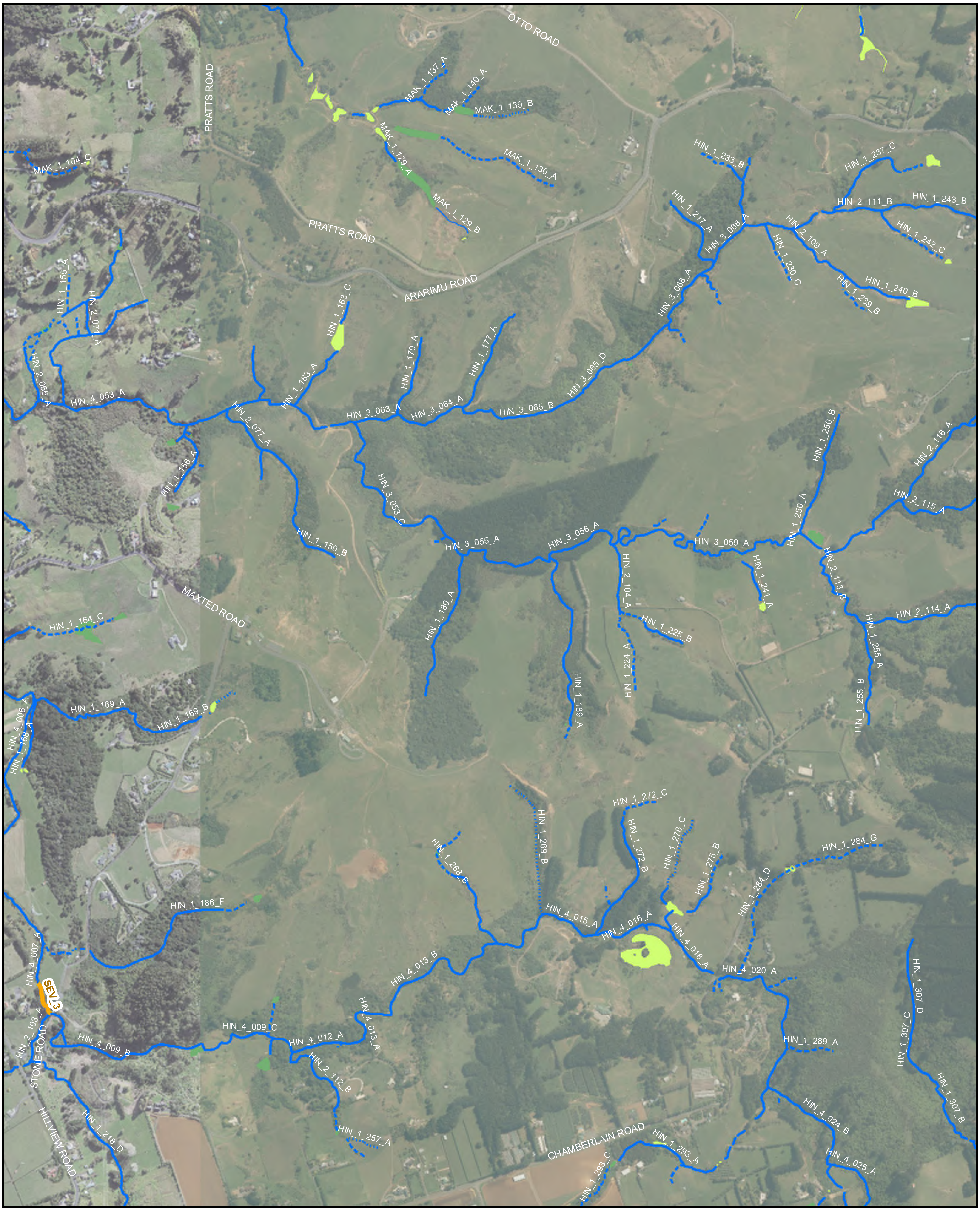

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class
- Permanent
- Intermittent
- Ephemeral
- OLFP

Wetland
- Artificial
- Natural

SEV Lines

0 0.25 0.5 1 km

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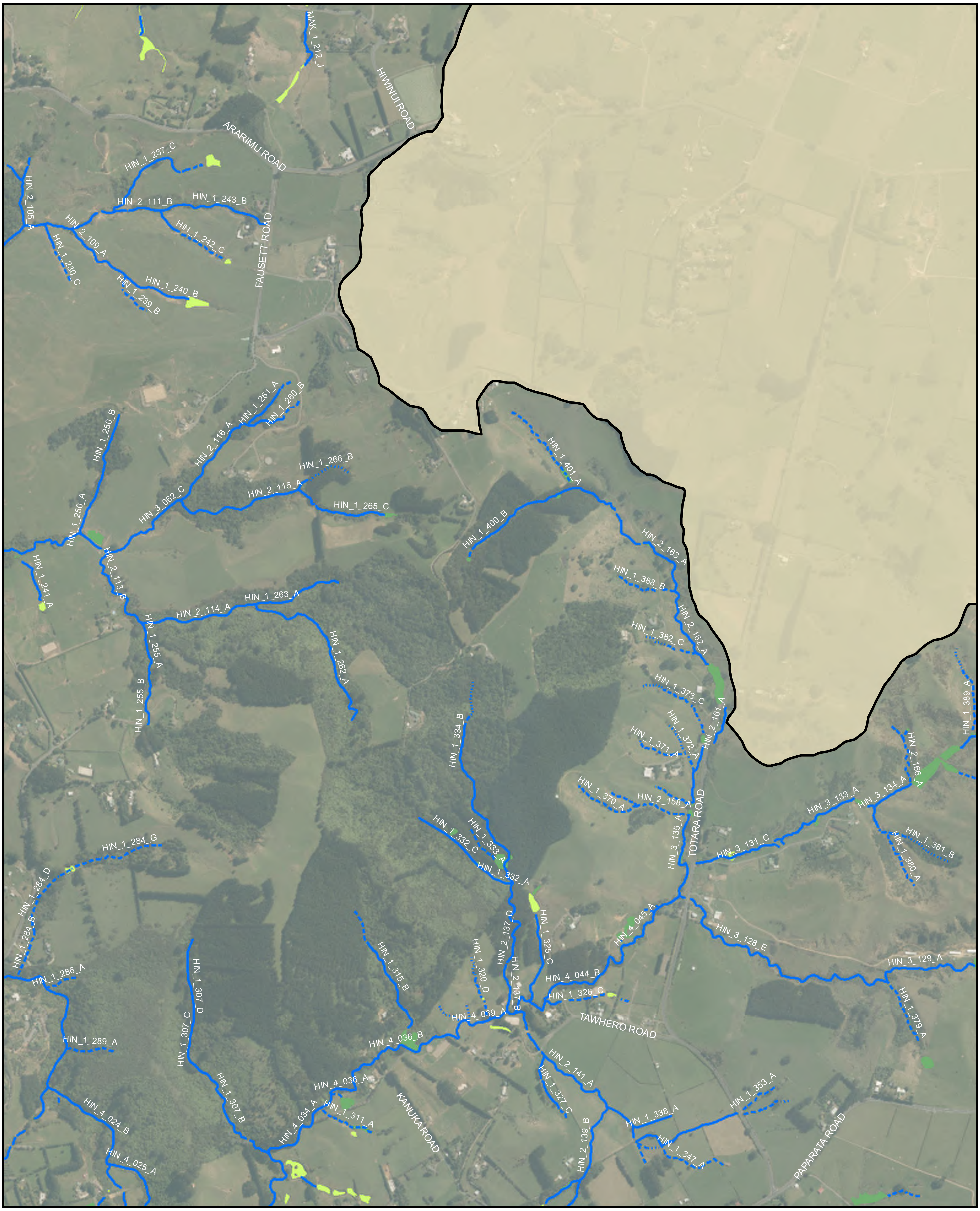

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Stream Class	Wetland
Permanent	Artificial
Intermittent	Natural
Ephemeral	

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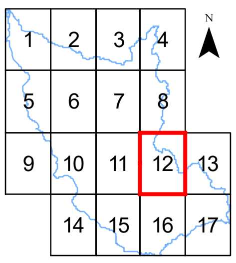

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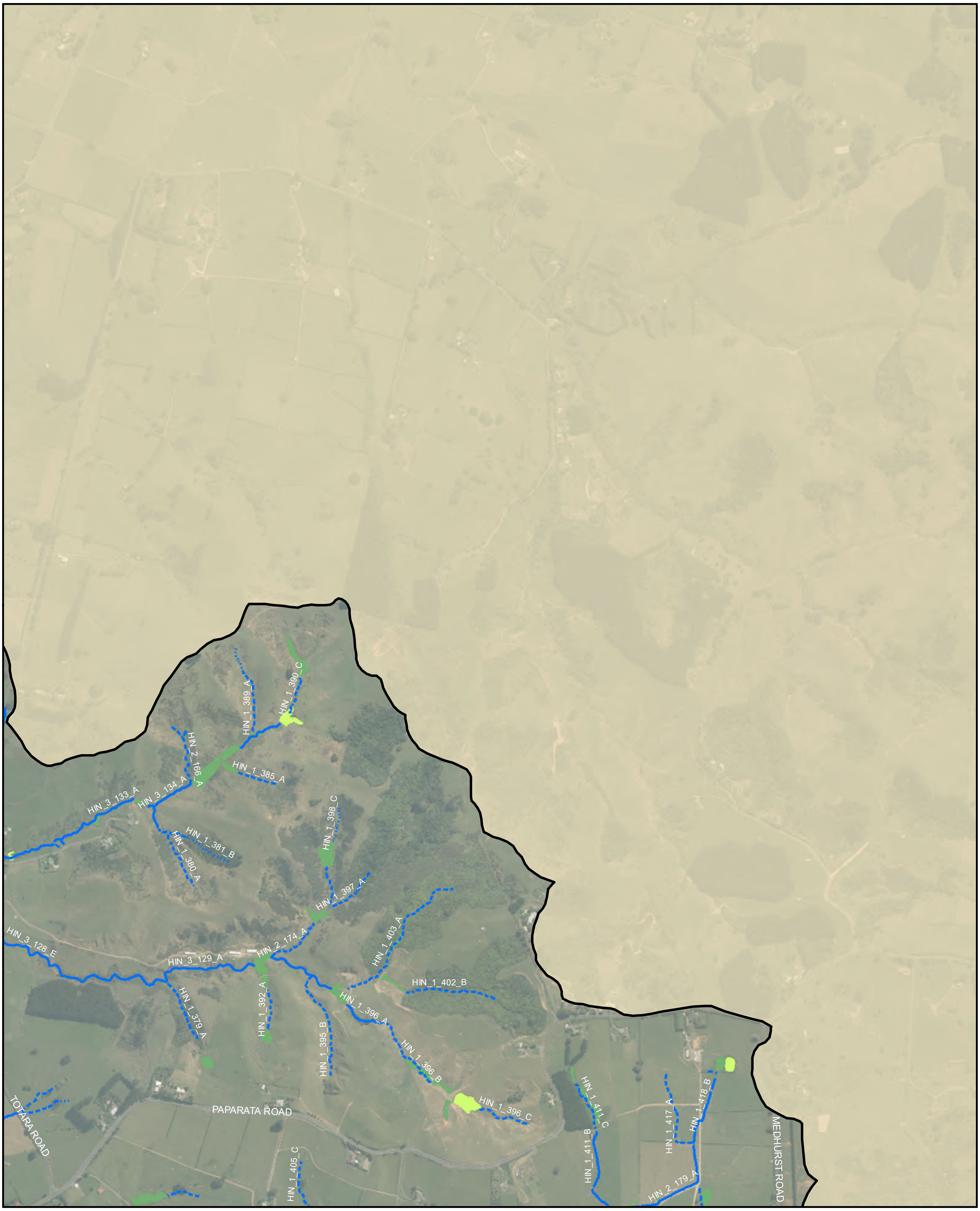
Map 1: Overview Map



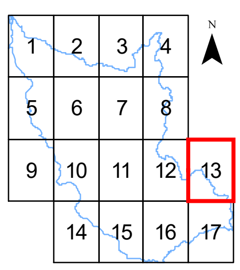
Document Path: F:\FELIX_DATA\4SIGHT\AA3135_Hingaia_WAR\MAPS\MAP_01_Overview.mxd

Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland
Permanent	Artificial
Intermittent	Natural
Ephemeral	

0 0.25 0.5 1 km



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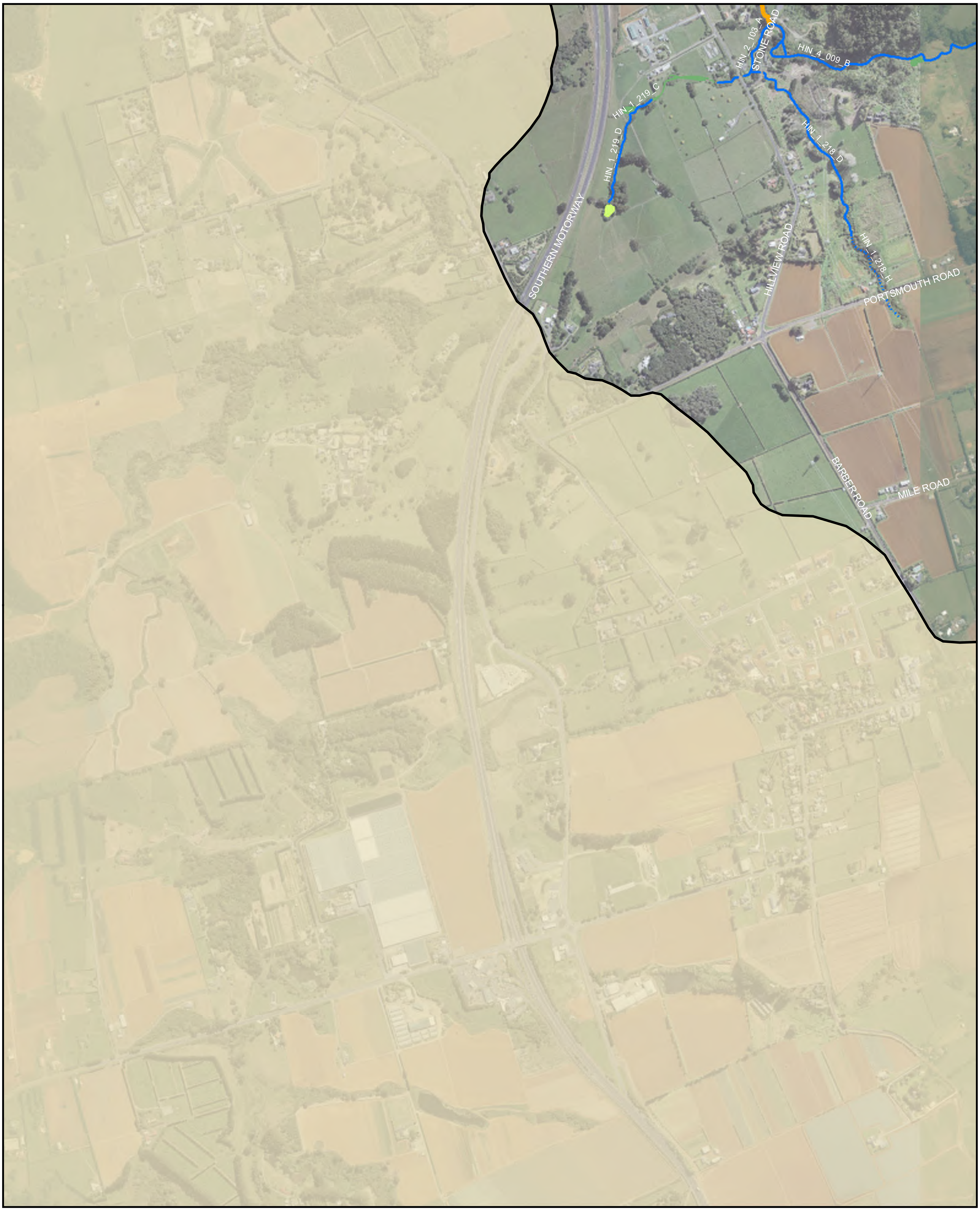
Author:	FP
Checked:	AS
Approved:	KB

Map 1: Overview Map



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Auckland Council

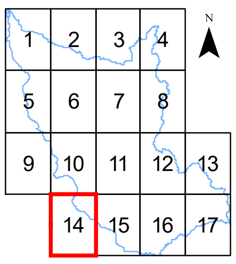
HINGAIAI CATCHMENT STREAM SURVEY

Stream Class
- Permanent
- Ephemeral

Wetland
- Artificial
- Natural

SEV Lines

0 — 0.25 — 0.5 — 1 km



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Approved:	KB

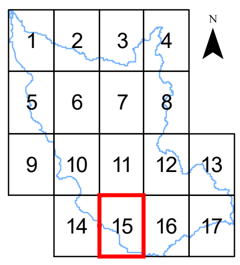
Map 1: Overview Map

Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland	
Permanent	Artificial	SEV Lines
Intermittent	Natural	
Ephemeral		

0 0.25 0.5 1 km



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Map 1: Overview Map

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Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class	Wetland	
Permanent	Artificial	SEV Lines
Intermittent	Natural	
Ephemeral		
OLFP		

0 0.25 0.5 1 km

1	2	3	4
5	6	7	8
9	10	11	12	13
	14	15	16	17

N

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Map 1: Overview Map

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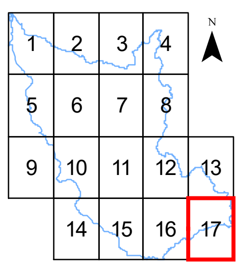
Auckland Council

HINGAIAI CATCHMENT STREAM SURVEY

Stream Class		Wetland	
	Permanent		Artificial
	Intermittent		Natural
	Ephemeral		
	OLFP		

0 0.25 0.5 1 km



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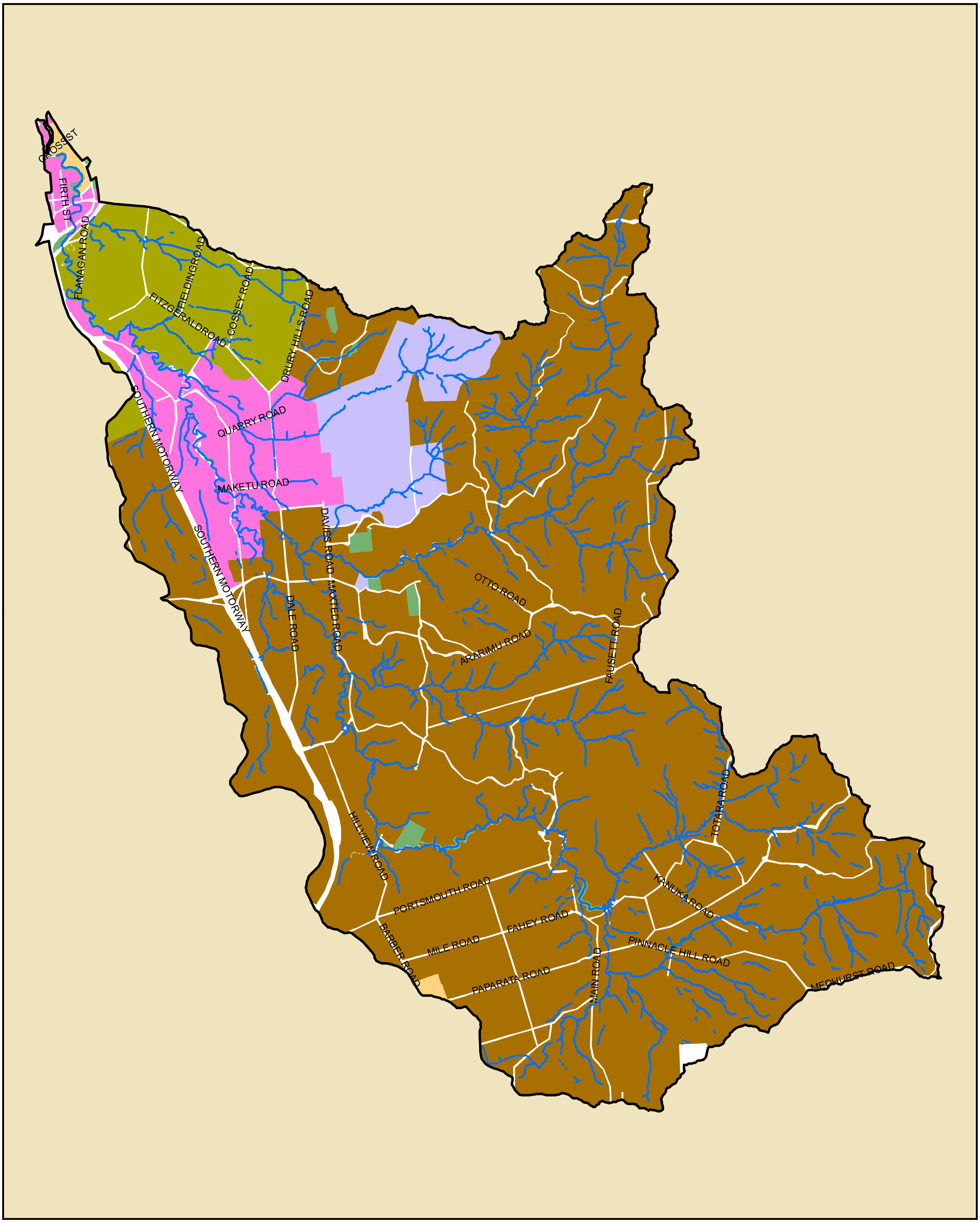
Map 2: Catchment Land Use



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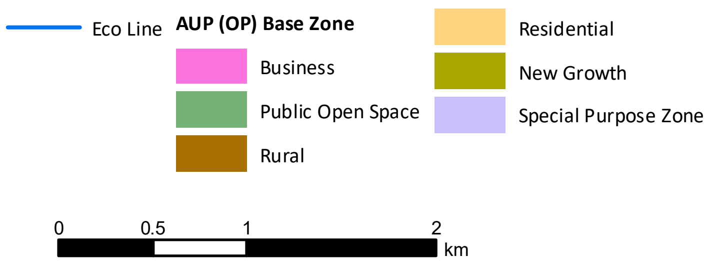
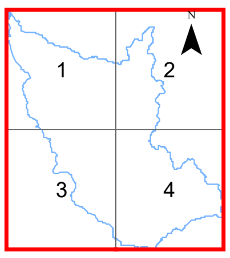
HINGAIA CATCHMENT STREAM SURVEY





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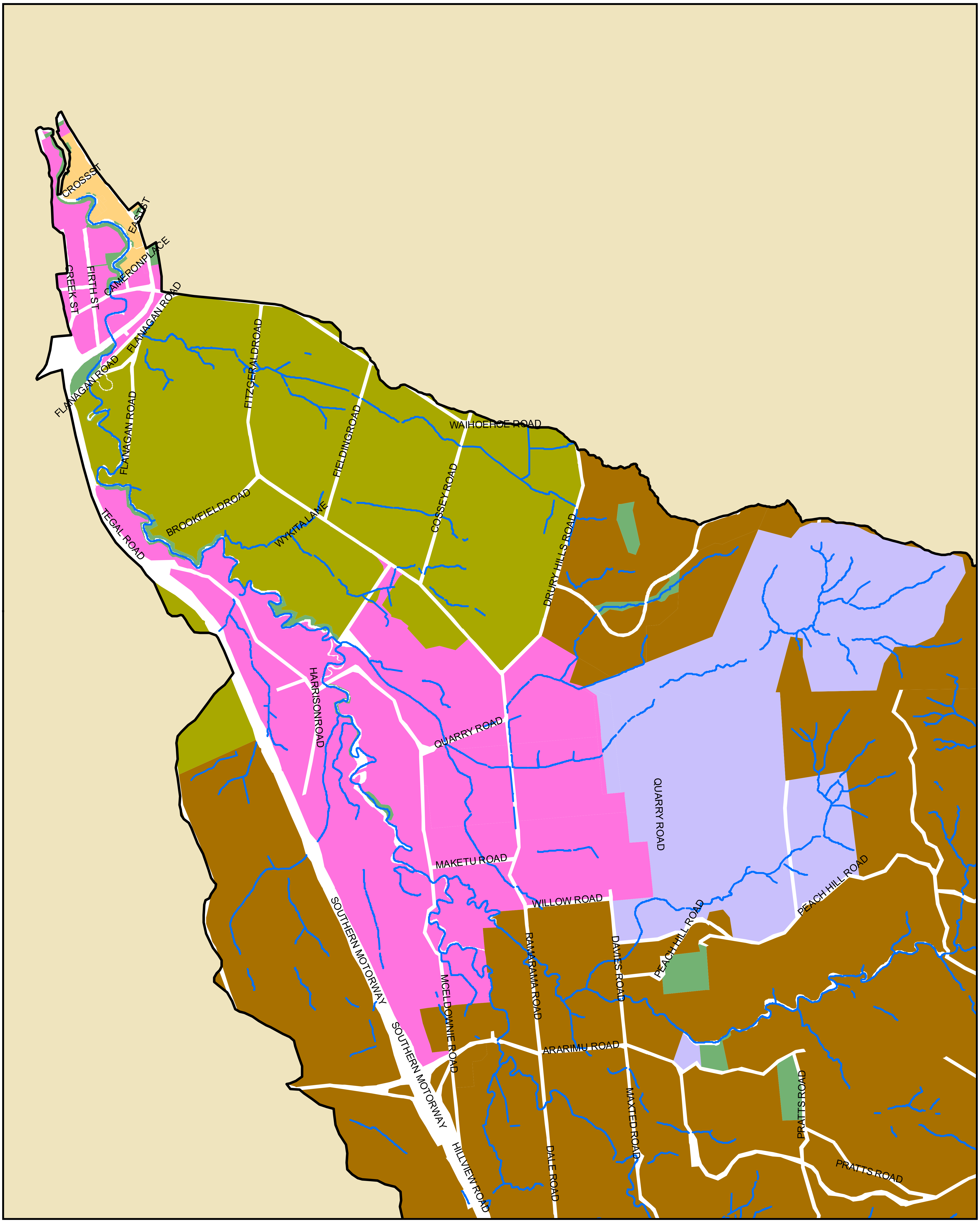
Map 2: Catchment Land Use



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Auckland Council

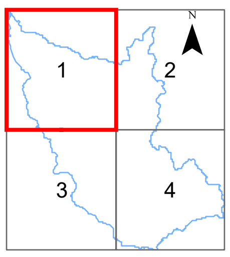
HINGAIA CATCHMENT STREAM SURVEY

Eco Line

AUP (OP) Base Zone

- Business
- Public Open Space
- Rural
- Residential
- New Growth
- Special Purpose Zone

0 0.5 1 2 km



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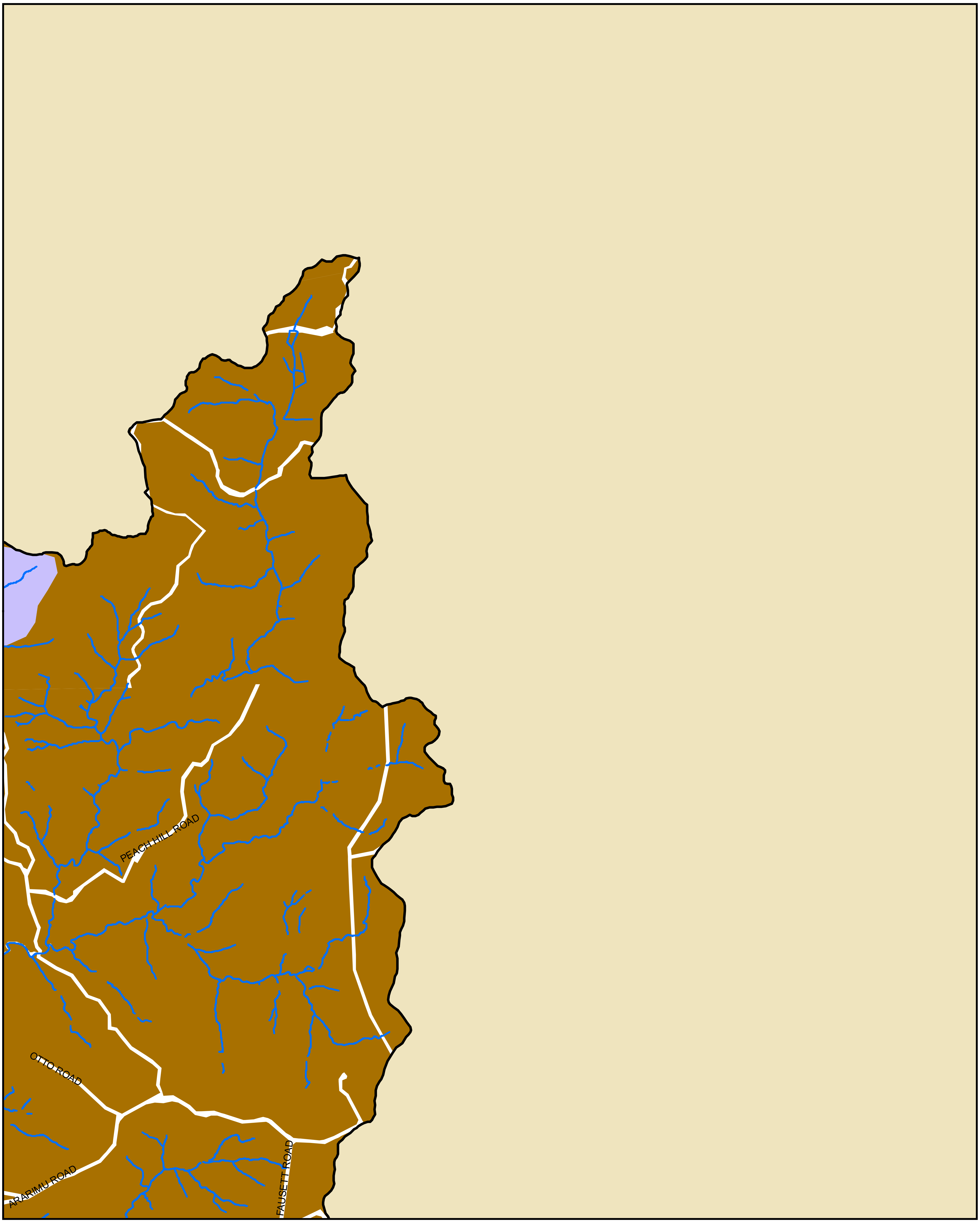
Map 2: Catchment Land Use



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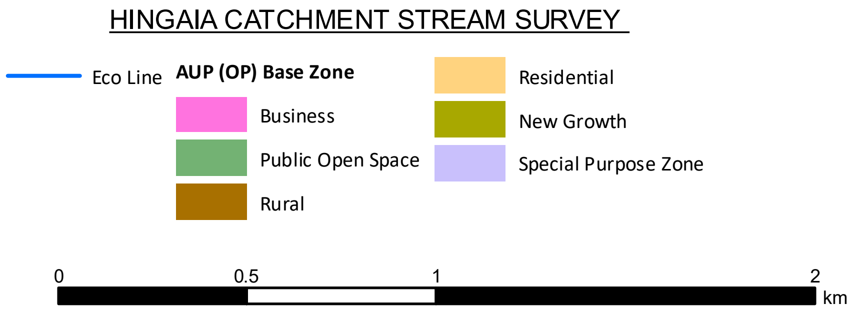

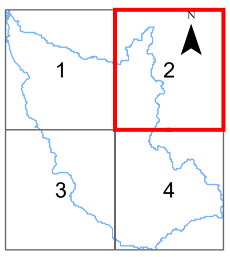

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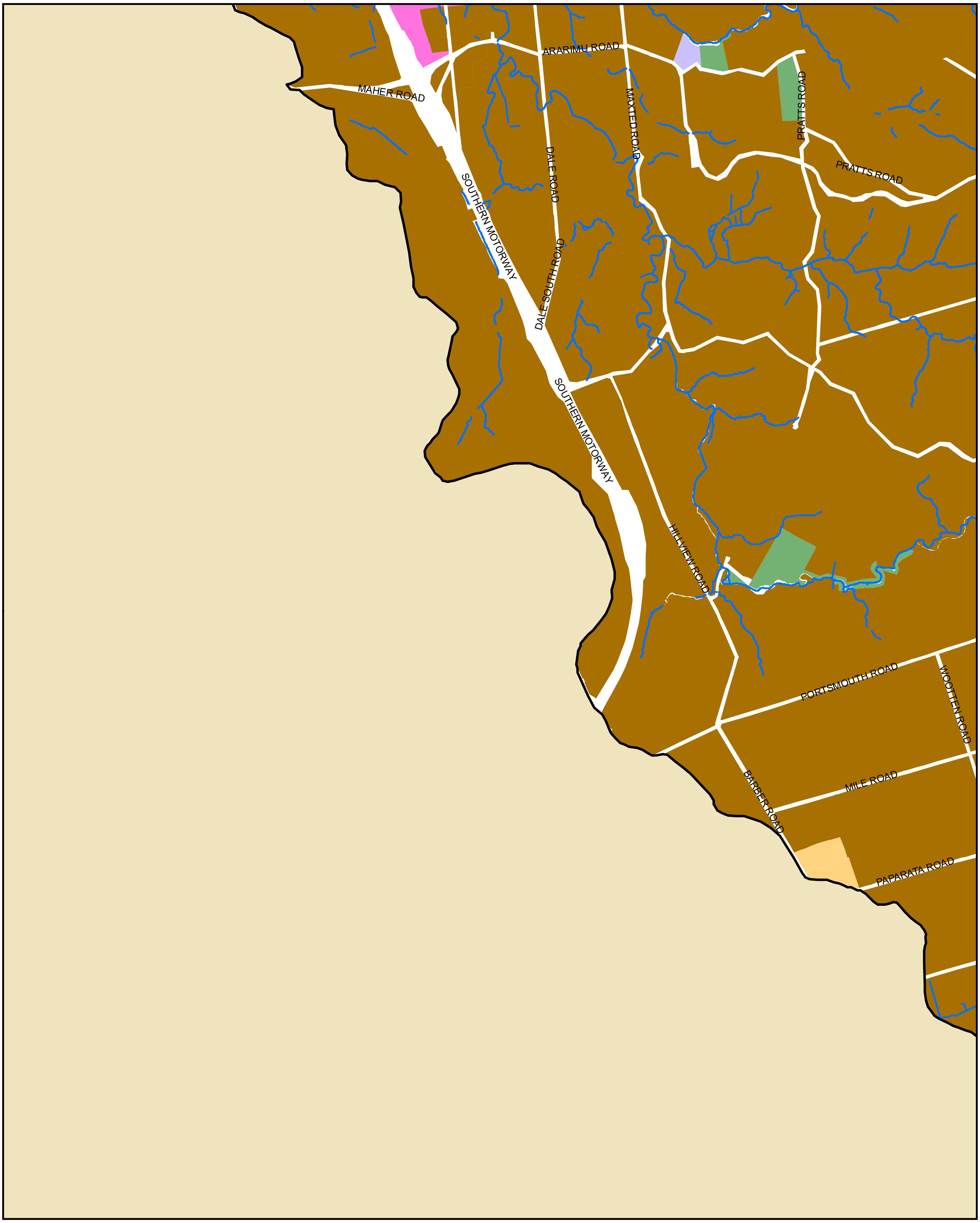
Map 2: Catchment Land Use



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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line

AUP (OP) Base Zone

- Business
- Public Open Space
- Rural
- Residential
- New Growth
- Special Purpose Zone

0 0.5 1 2 km

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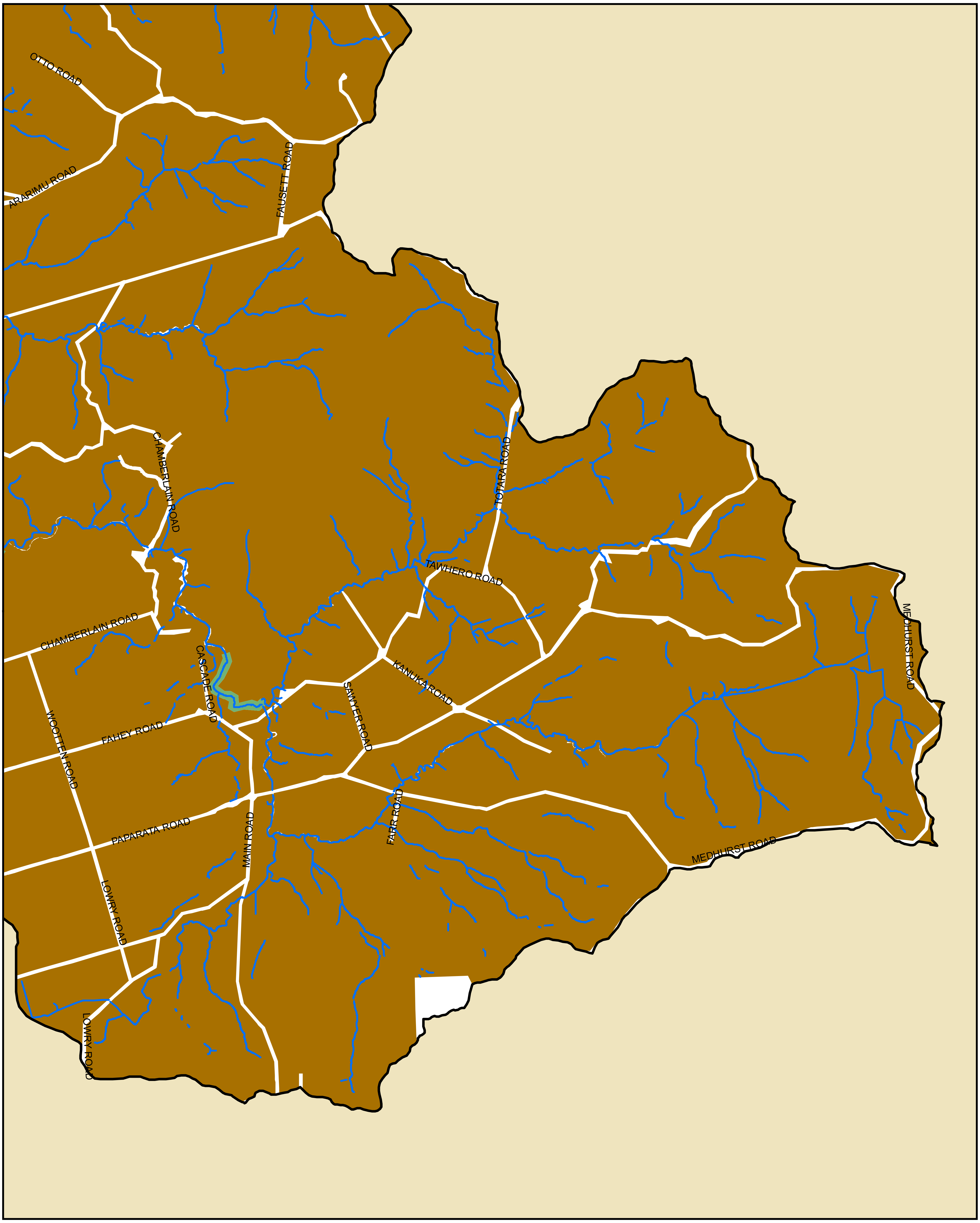
Map 2: Catchment Land Use



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Auckland Council

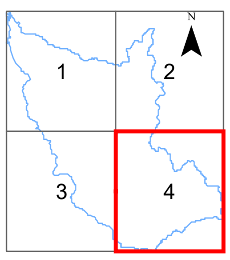
HINGAIA CATCHMENT STREAM SURVEY

Eco Line

AUP (OP) Base Zone

- Business
- Public Open Space
- Rural
- Residential
- New Growth
- Special Purpose Zone

0 0.5 1 2 km



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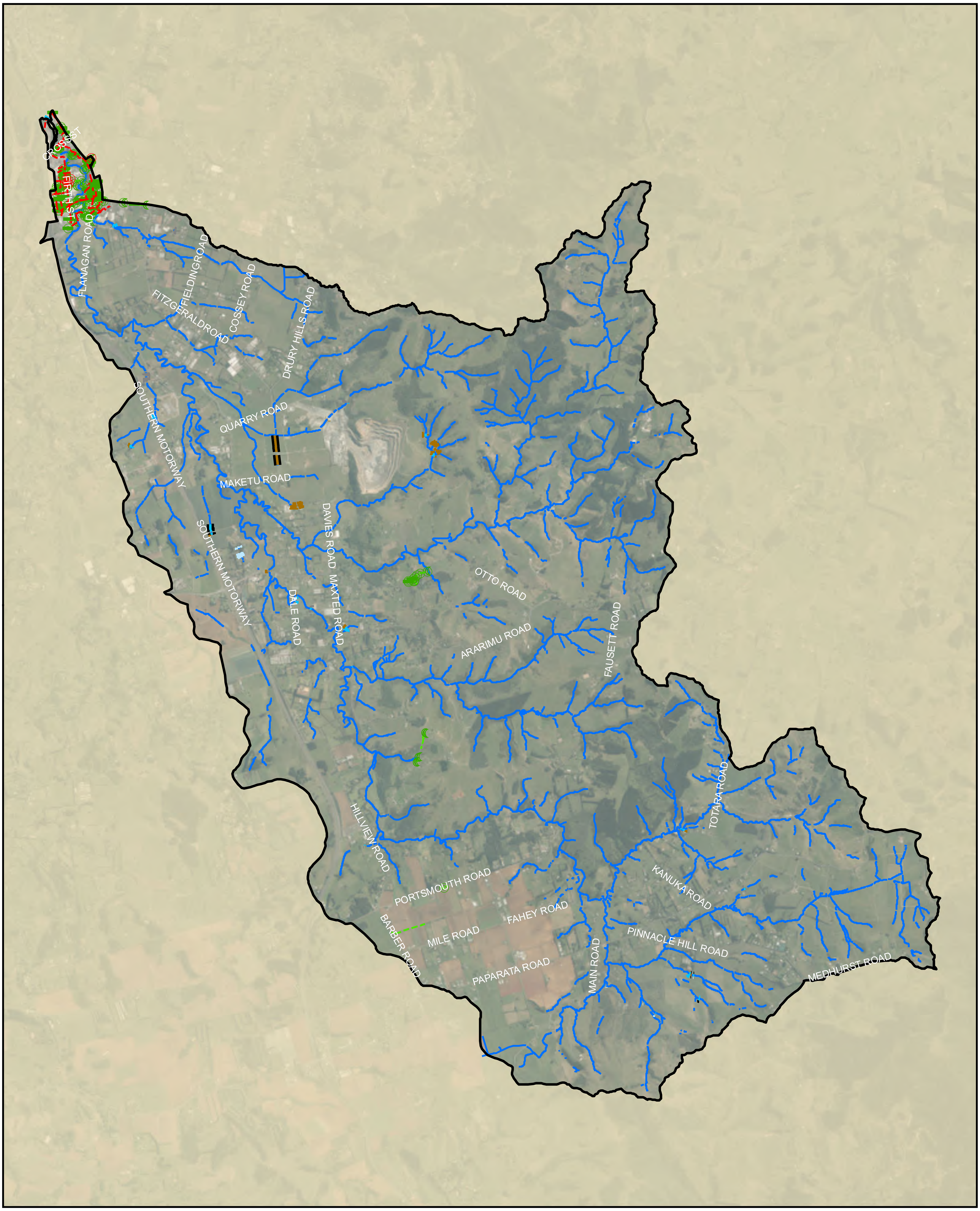
Map 3: Bank and Channel Modification Type & Extent (%)



Document Path: F:\FELIX_DATA\4SIGHT\AA3135_Hingaia_WAR\MAPS\MAP_03_Bank_Channel_Modification.mxd

Auckland Council

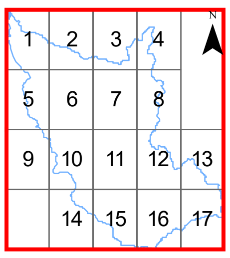
HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

- Stormwater Drain
- Catchpit
- Inlet or outlet
- Manhole
- Wastewater Pipe
- Wastewater Manhole

0 0.25 0.5 1 km



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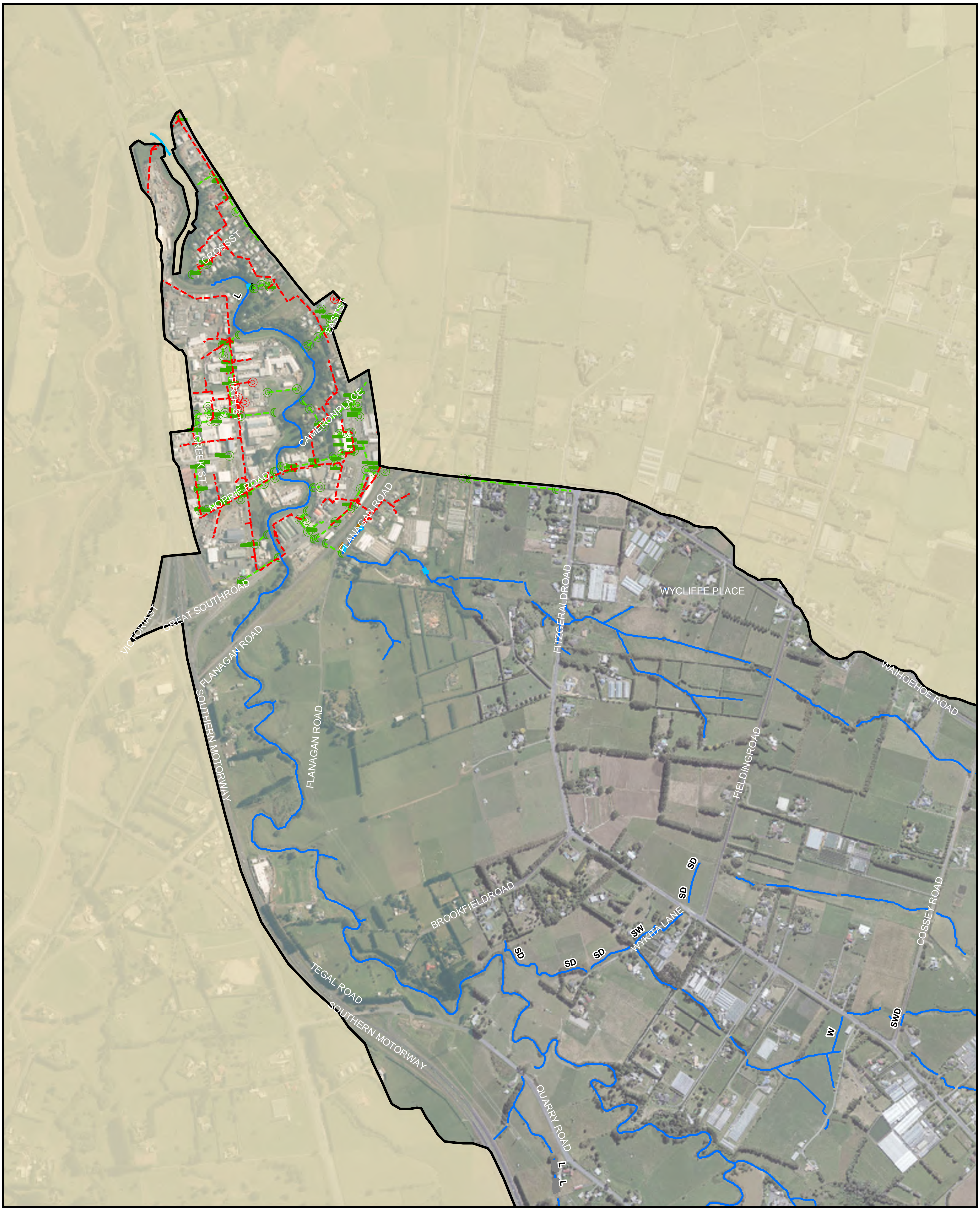
Map 3: Bank and Channel Modification Type & Extent (%)



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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

- Stormwater Drain
- Catchpit
- Inlet or outlet
- Manhole
- Wastewater Pipe
- Wastewater Manhole

0 0.25 0.5 1 km

1 2 3 4
5 6 7 8
9 10 11 12 13
14 15 16 17

N

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HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
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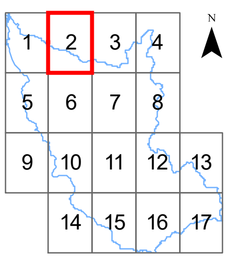
- Rock
- Timber

0 0.25 0.5 1 km



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Map 3: Bank and Channel Modification Type & Extent (%)

HINGAIA CATCHMENT STREAM SURVEY

Auckland Council

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
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0 0.25 0.5 1 km

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HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
- Masonry Block
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- Other
- Rock
- Timber

0 0.25 0.5 1 km

Auckland Council

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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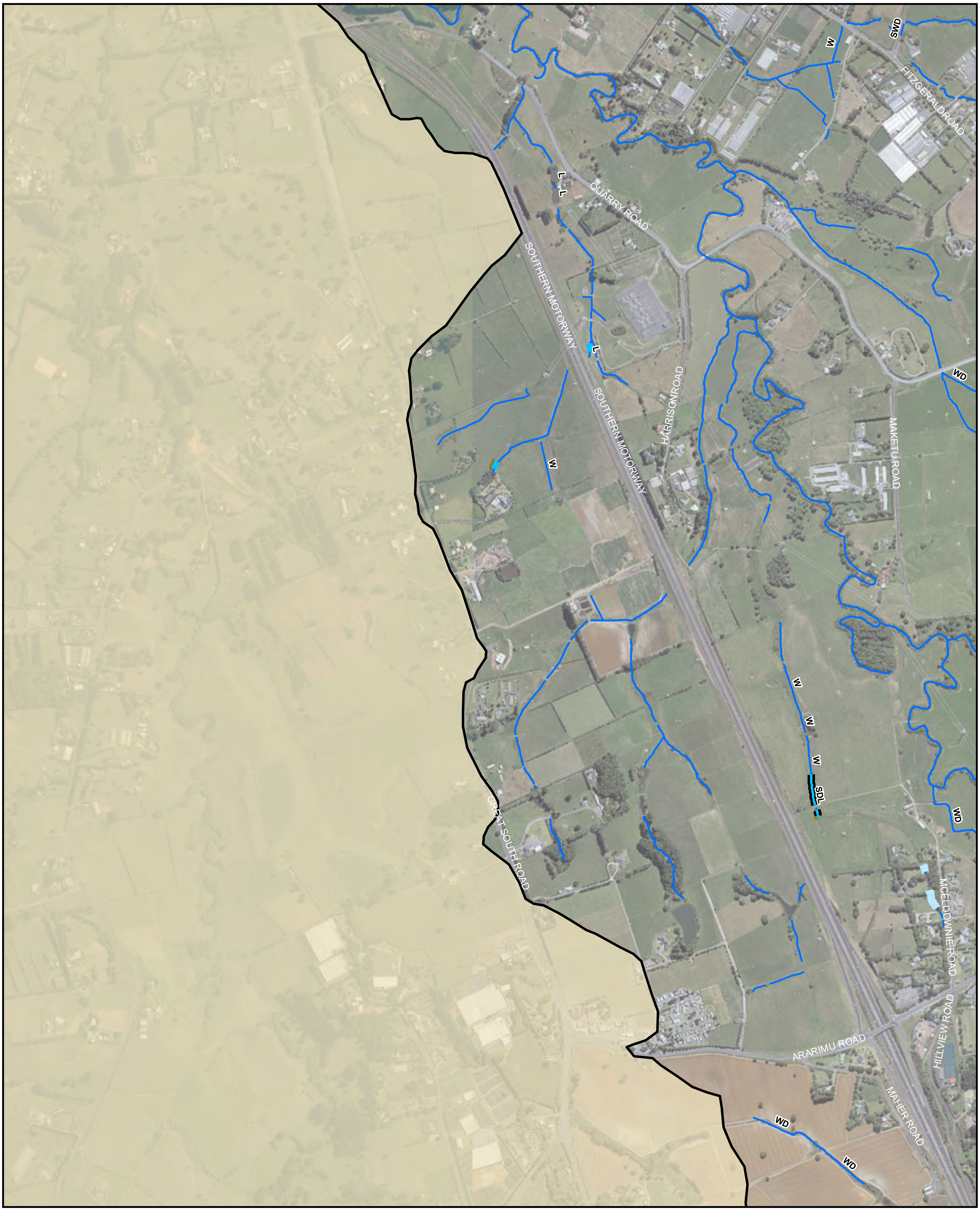

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HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

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- Timber

0 0.25 0.5 1 km

Auckland Council

1	2	3	4	
5	6	7	8	
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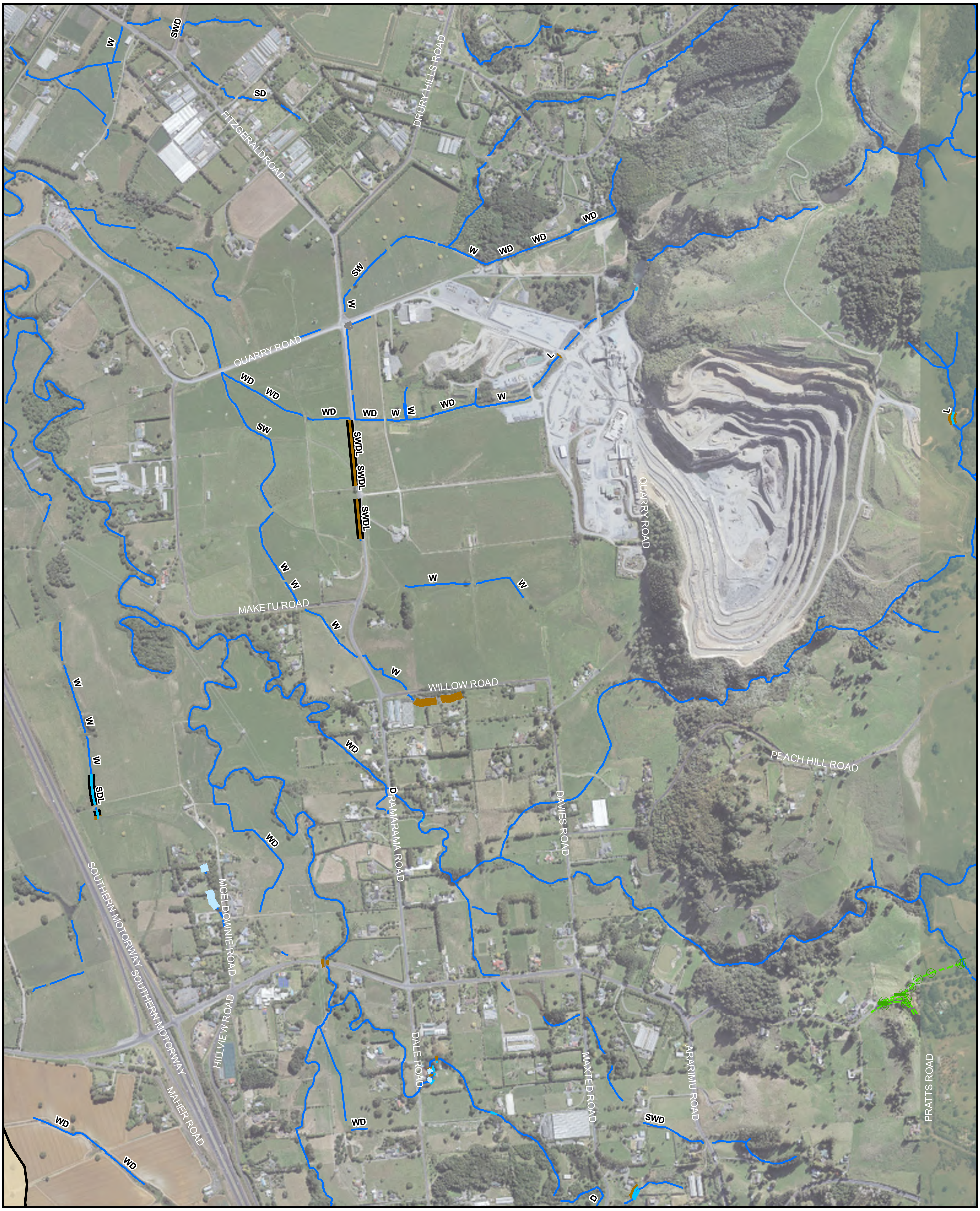

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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

- Stormwater Drain
- Catchpit
- Inlet or outlet
- Manhole

0 0.25 0.5 1 km

1	2	3	4	
5	6	7	8	
9	10	11	12	13
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N

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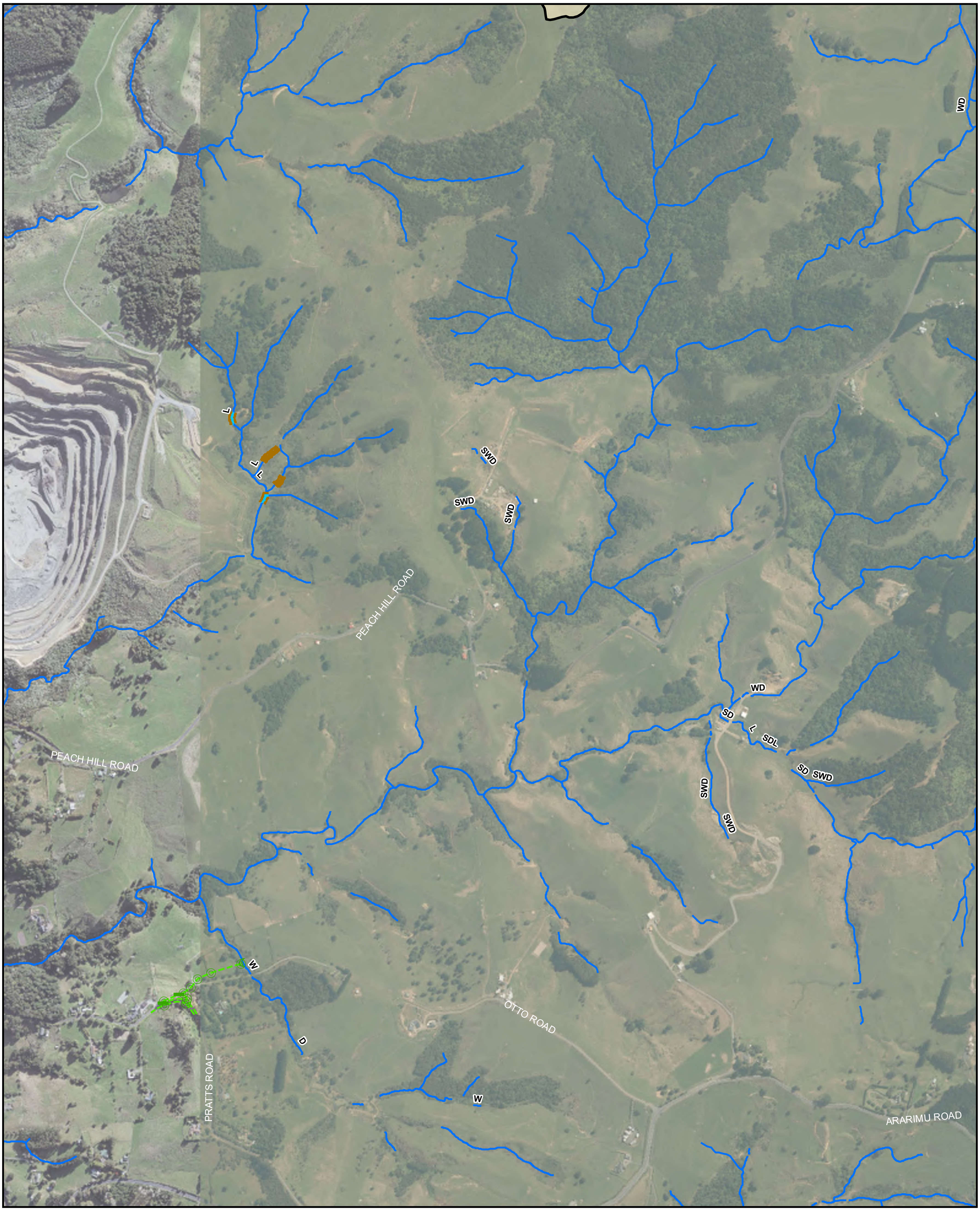

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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

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- Masonry Block
- None
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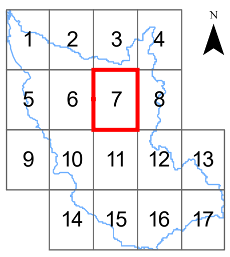
0 0.25 0.5 1 km



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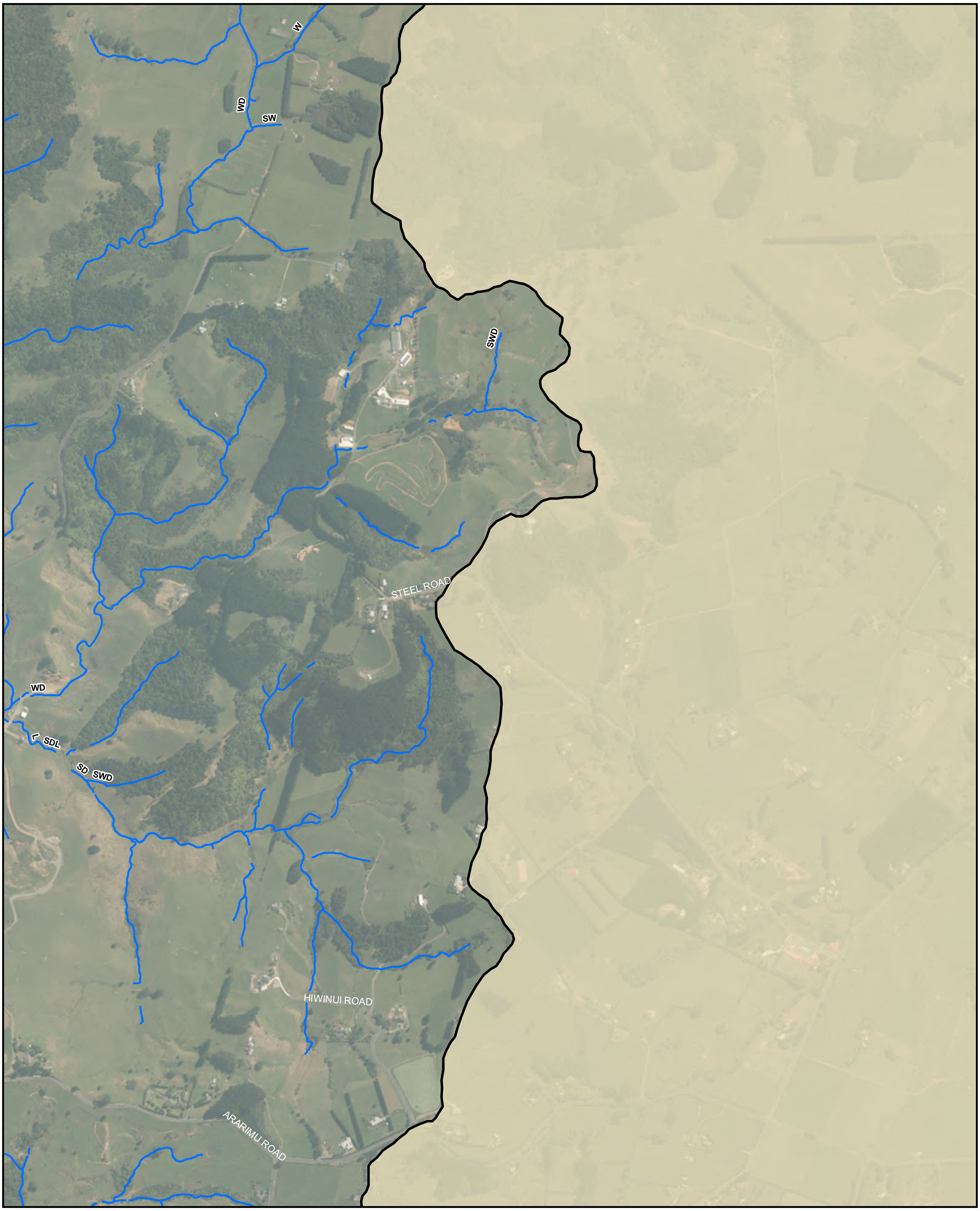
Map 3: Bank and Channel Modification Type & Extent (%)



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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
- Masonry Block
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- Other
- Rock
- Timber

0 0.25 0.5 1 km

1 2 3 4
5 6 7 8
9 10 11 12 13
14 15 16 17

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Map 3: Bank and Channel Modification Type & Extent (%)

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HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining

- Cast In Situ Concrete
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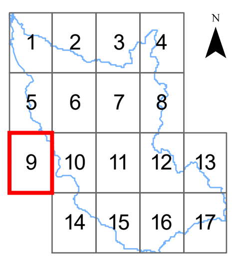

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Map 3: Bank and Channel Modification Type & Extent (%)

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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

- Stormwater Drain
- Catchpit
- Inlet or outlet
- Manhole

0 0.25 0.5 1 km

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Map 3: Bank and Channel Modification Type & Extent (%)

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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

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Channel Modification

Bank Lining

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- Stormwater Drain
- Catchpit
- Inlet or outlet
- Manhole

0 0.25 0.5 1 km

1 2 3 4
5 6 7 8
9 10 11 12 13
14 15 16 17

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Map 3: Bank and Channel Modification Type & Extent (%)

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HINGAIA CATCHMENT STREAM SURVEY

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Channel Modification

Bank Lining
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- Masonry Block
- None
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- Rock
- Timber

0 0.25 0.5 1 km

Auckland Council

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Map 3: Bank and Channel Modification Type & Extent (%)

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HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

0 0.25 0.5 1 km

Auckland Council

1	2	3	4
5	6	7	8
9	10	11	12	13
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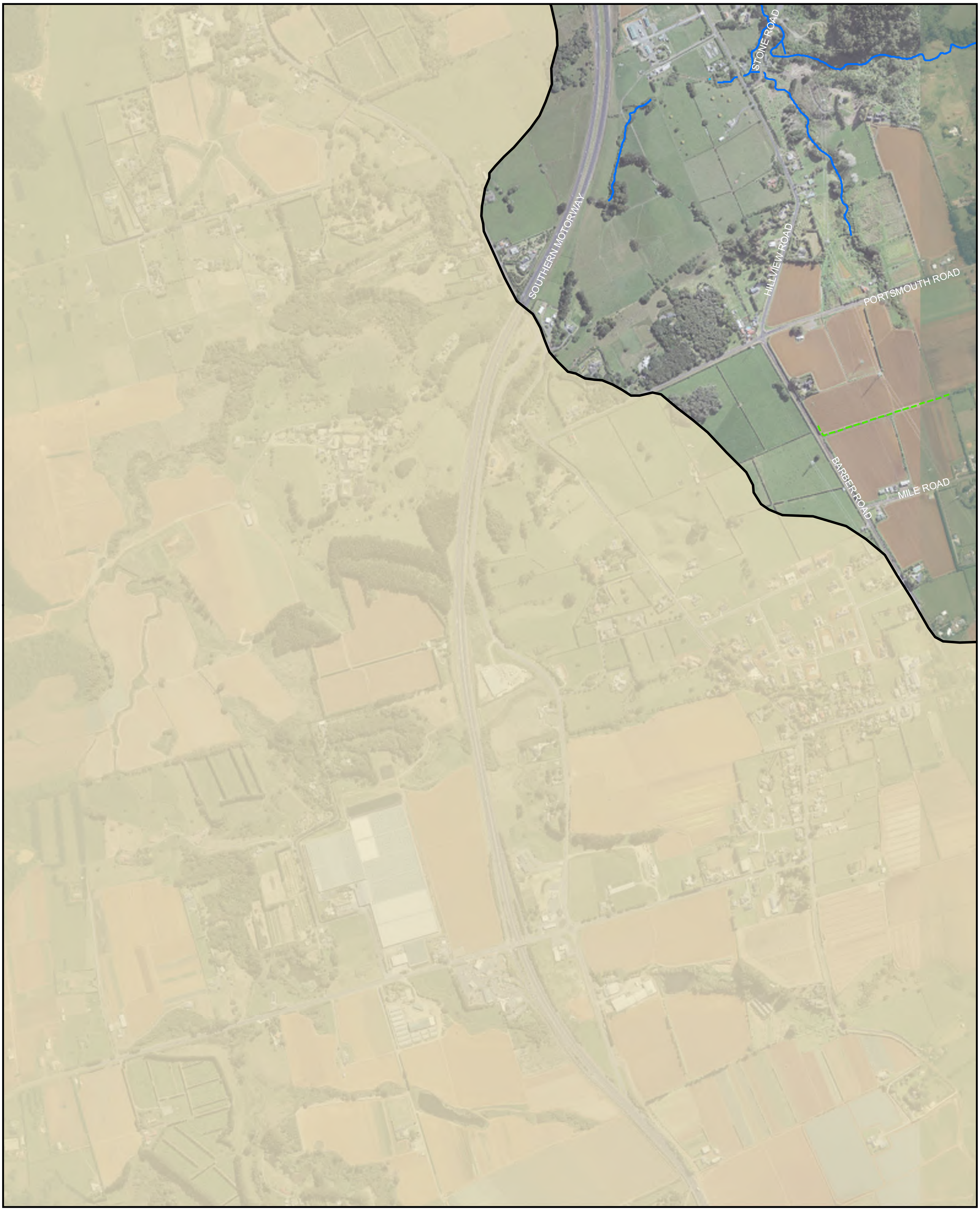
Map 3: Bank and Channel Modification Type & Extent (%)



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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

Stormwater Drain

0 0.25 0.5 1 km

1	2	3	4
5	6	7	8
9	10	11	12	13
	14	15	16	17

N

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Map 3: Bank and Channel Modification Type & Extent (%)

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Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

Stormwater Drain
Manhole

0 0.25 0.5 1 km

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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Approved:	KB

Map 3: Bank and Channel Modification Type & Extent (%)

Document Path: F:\FELIX_DATA\4SIGHT\AA3135_Hingaia_WAR\MAPS\MAP_03_Bank_Channel_Modification.mxd

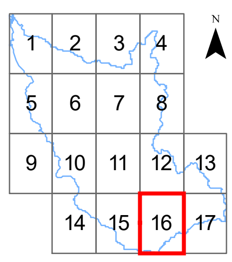
Auckland Council

HINGAIA CATCHMENT STREAM SURVEY

Eco Line
Channel Modification

Bank Lining
- Cast In Situ Concrete
- Masonry Block
- None
- Other
- Rock
- Timber

0 | 0.25 | 0.5 | 1 km



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Author: FP
Checked: AS
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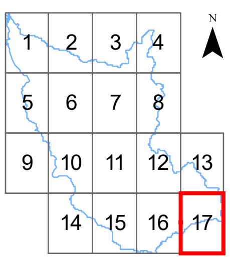

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