REPORT

Tonkin+Taylor

Warkworth Stormwater Management Plan

Stage 1 - Preliminary SMP

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Auckland Council
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Nov 2018	A	Stage 1 – Preliminary SMP	Josh Hodson	Tim Fisher	Tim Fisher
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Table of contents

Executive summary

The Auckland Unitary Plan has identified approximately 15,000 hectares of rural land across Auckland for future urbanisation including approximately 1,000 hectares around Warkworth that is zoned 'Future Urban'. A structure plan is currently being developed for the Future Urban area around Warkworth to determine the future land use zoning of the area. Identifying and integrating stormwater constraints and opportunities and infrastructure needs for the intended land use is an integral part of the structure plan process.

This preliminary stormwater management plan is an information report to inform public consultation on future land use changes and initial discussion with other disciplines in the structure plan process on stormwater management issues and the high level management approaches required. This report will evolve into the Final Stormwater Management Plan over the course of the structure plan process.

The following stormwater constraints and opportunities for the Warkworth Structure Plan Area have been identified:

Managing flood risk	**Constraints**	• Upstream development may increase the flood risk to existing buildings in Warkworth. If this is found to be the case then catchment scale attenuation devices may be required to avoid increasing flooding to habitable floors. • Any new development should occur outside of the 100 year floodplain. • Allow for conveyance of overland flow.
	Opportunities	• Protection of 100 year floodplain also provides an opportunity to enhance riparian corridors. This provides enhanced stormwater management functions, contributes to the ecological values of stream corridors and provides public amenity. Green corridors should be considered to manage the flood hazard, protect ecological values, provide amenity and for walking and cycling tracks.
Minimising and mitigating hydrological change	**Constraints**	• The presence of low permeability ultic clays in the structure plan area may preclude the use of infiltration devices in some areas. • Slope instability risk may preclude the use of infiltration devices in some areas. • The viability of water reuse as a stormwater management tool is contingent on land use activity and will need to be assessed on a site by site basis.
	Opportunities	• The structure plan area is a greenfield area which provides an opportunity to incorporate integrated stormwater management to maintain pre-development hydrology. • Providing opportunity for on-site infiltration to improve aquifer recharge and stream baseflows. • Providing opportunities for water reuse especially for housing and for industrial/commercial activities (depending on water demand).

Opportunities to enhance freshwater systems	**Constraints**	• Permanent and intermittent streams will need to be protected. • Riparian buffer areas around streams needs to be included. In some areas existing riparian vegetation has been classified as a terrestrial SEA and must be protected.
	Opportunities	• Water quality in the water bodies within the structure plan area is currently relatively good for an urban catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality. • Design stormwater management for future urban areas that provides for a high level of water quality to protect the high ecological values and good water quality present in the area. • Use riparian margins as part of the water conveyance system and to provide connections to other freshwater systems and other habitat types. • The change in land use from rural land to urban is an opportunity to revert to natural sedimentation loading in freshwater systems and in the harbour. • Naturalisation of existing modified watercourses to re-develop hydraulic and habitat diversity. • Removal/modification of artificial fish passage barriers to improve the ability of migrant fish species to access upstream habitat. • Restoration of wetlands to help regulate stream flows and enhance ecological functions. • Erosion and sedimentation management during development applying best practice that responses to the sensitive receiving environments and aspirations for freshwater management set out in the SMP and AUP

The following additional site information is required to further inform the production of a detailed stormwater management plan and/or to support plan change hearings:

- Final proposed land use and development type/layout. This is currently being developed during the structure plan process, taking into account this preliminary stormwater management plan. A draft Warkworth Structure Plan has been reviewed with regards to stormwater management and this review has been summarised in Auckland Council (2019).
- Site investigations to confirm soil types and extents, groundwater levels and soil permeability. This will identify which areas are more conducive to infiltration so these characteristics can be preserved and utilised for stormwater management.
- Confirmation of the hydrological parameters (rainfall depths and curve numbers) and potentially the reassessment of the catchment flood flows and flood extents.
- Floor level survey to confirm which existing buildings are at risk of potential flooding. Assessments of how the land use and infrastructure changes might cause flood effects on these buildings. This analysis is currently being undertaken by Healthy Waters at the time of writing.
- Assessment to determine whether minimising or mitigating hydrological changes requires more than hydrological mitigation (i.e. retention and detention outlined in AUP Section E10). This assessment should give consideration to:
  - The extent of development and the likely changes to the hydrological regime.
  - The erosion susceptibility of streams prior to development and their sensitivity to changes in hydrology. This may involve further interpretation of the Watercourse

Assessment data collected to date but may also involve targeted site visits to confirm geomorphic processes.

  - What degree of hydrological mitigation (i.e. detention and retention) can practicably be achieved for the development (e.g. viability of infiltration and water reuse).
  - What opportunities exist to mitigate any changes in hydrology that remain after hydrological mitigation (e.g. in-stream works).
- Groundwater study to determine the effect of increased imperviousness on the Mahurangi Waitematā Aquifer and the interaction with the Mahurangi River.

Based on the regulatory requirements of the Auckland Unitary Plan and the site specific constraints and opportunities identified above, high level guidance on how stormwater will be managed within the Warkworth Structure Plan Area has been developed and is summarised below. This stormwater management framework should be considered as part of an interdisciplinary planning process to allow for implementation of an integrated design approach. More specific guidance to reflect area specific management issues and infrastructure requirements will be given in the final SMP for the structure plan area.

General

- Use an integrated stormwater management approach involving water sensitive design. This will involve the following components:
  - Minimise the generation of stormwater runoff and contaminants with measures such as clustering development, reducing impervious surfaces and using inert building materials.
  - Manage runoff and contaminants as close to source as possible with measures such as capture and reuse, green roofs, permeable pavements and terrestrial revegetation.
  - Use swales for stormwater conveyance where possible as an alternative to pipes and filter strips where practicable as pre-treatment to downstream treatment devices.
  - Utilising downstream treatment devices which mimic natural physical, biological and physical treatment processes.
  - Enhance the receiving environment by preserving and restoring riparian vegetation along banks, natural floodplains and wetland margins, including linking areas of riparian vegetation to create continuous green corridors.
  - Utilise existing natural systems for stormwater management function including the restoration/enhancement of wetlands
- Remove or modify artificial fish passage barriers where possible to improve the ability of migrant fish species to access upstream habitat.

Water quality

- Provide near-source water quality treatment of runoff for all roads and High Contaminant Generated Carparks (>30 carparks). Water quality treatment to target sediment, metals and gross pollutants.
- Use “inert” building materials, or otherwise site-specific treatment is required.
- Minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges.
- Erosion protection in the stormwater systems including discharges to streams. Consider green outfalls for discharges to streams.

Minimising and mitigating hydrological change

- Further assessment that considers the site-specific constraints of the Warkworth Structure Plan Area is required to determine how to minimise or mitigate any changes in hydrology and whether it can practicably be achieved. If there are residual impacts on streams after implementing hydrological mitigation (as per AUP section E10) then other solutions such as in-stream works should be considered to mitigate the effects of changes in hydrology.
- After exploring location specific options in accordance with greenfields policies and where those options are demonstrably not practical to implement, the minimum standard shall be to provide 'hydrological mitigation' in accordance with Table E10.6.3.1.1 of the AUP where the specific effect to be managed is in-stream erosion.
- Utilise stormwater infiltration for retention where it is possible to do so in a safe, and effective manner.
- Utilise rainfall harvesting for retention for residential buildings and industrial/commercial where there is re-use demand.

Flood management

- Use streams and their associated riparian margins to provide storage and conveyance to manage flood waters.
- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be design to be resilient to flood related damage.
- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.
- Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.

1 Introduction

1.1 Background

Tonkin & Taylor Ltd. (T+T) have been engaged by Auckland Council to prepare a Stormwater Management Plan (SMP) for Warkworth to support the development of the Warkworth Structure Plan. Structure planning is a process described in Appendix 1 of the Auckland Unitary Plan (AUP) and will determine the future land use zoning of the area. Identifying and integrating stormwater constraints and opportunities and infrastructure needs for the intended land use is an integral part of the process. To fit within the currently proposed structure plan process the SMP is proposed to be delivered in two stages:

- Preliminary SMP – sets the background and context, identifies stormwater constraints, and provides high level guidance on stormwater management specific to the Future Urban Zone in Warkworth, Auckland.
- Final SMP – adds detail on how stormwater will be managed within the Structure Plan area. The requirements and level of detail are uncertain at this stage and will be borne out through the structure plan process. This document will identify communal/public infrastructure or works that need to be undertaken by Healthy Waters to enable development.

This report is the Preliminary Stormwater Management Plan and will evolve into the Final Stormwater Management Plan over the course of the structure plan process.

1.2 Purpose

The Warkworth Structure Plan SMP is a high level document that provides a framework for stormwater management specific to the planned area in question, rather than design solutions to be implemented on site. Stormwater design layouts are best achieved by the developer based on their development proposals and site specific constraints.

This Preliminary SMP is an information report to inform public consultation on future land use changes and initial discussion with other disciplines in the structure plan process on stormwater management issues and the high level management approaches required in that area.

The Preliminary and Finalised SMPs aim to the requirements of Resource Management Act 1991 (RMA), the National Policy Statement on Freshwater Management 2014 (NPSFM), the New Zealand Coastal Policy Statement (NZCPS), the Hauraki Gulf Marine Park Act 2000 (HGMPA), the Auckland Plan 2050 and the Auckland Unitary Plan (Operative in Part) (AUP) and are tailored to the natural values of the area. The relevant planning principle identified for Warkworth Structure Plan Area for which this SMP seeks to address is (with emphasis added):

The Mahurangi River is the jewel in Warkworth's crown

- Protect the Mahurangi River from the effects of urbanisation as a matter of paramount importance in the development of the Future Urban zone.
- Use the development of the Future Urban zone to improve the health and quality of the Mahurangi River wherever possible.
- Treat all the tributaries in the Future Urban zone as being vital to the health of the Mahurangi River.

Sustainability and natural heritage

- Plan to enable development of the Future Urban zone to be sustainable, including having a compact urban form, providing local employment options, enabling extensive active and public transport routes, and *minimising discharges to air and water bodies.*

- Design the Future Urban zone to be able to adapt to the effects of climate change.
- Protect and enhance existing bush/natural areas and create ecological corridors linking the Future Urban zone to other ecological areas.

1.3 Report scope

The scope of the Preliminary SMP is as follows:

- Currently known information about the catchments.
- Key receiving environments for each catchment.
- Known stormwater infrastructure.
- Knowledge gaps.
- Constraints and opportunities for development.
- Key stormwater management requirements as directed by the AUP.
- Presentation of a draft integrated stormwater management framework for discussion.

2 Development context

Auckland is projected to reach a population of more than 2.4 million people by 2047. Currently it is anticipated that 400,000 new dwellings will be required to enable this growth. The AUP has identified approximately 15,000 hectares of rural land around Auckland for future urbanisation including approximately 1000 hectares around Warkworth that is zoned 'Future Urban' which will be referred to herein as the Warkworth Structure Plan Area (refer Figure 2.1).

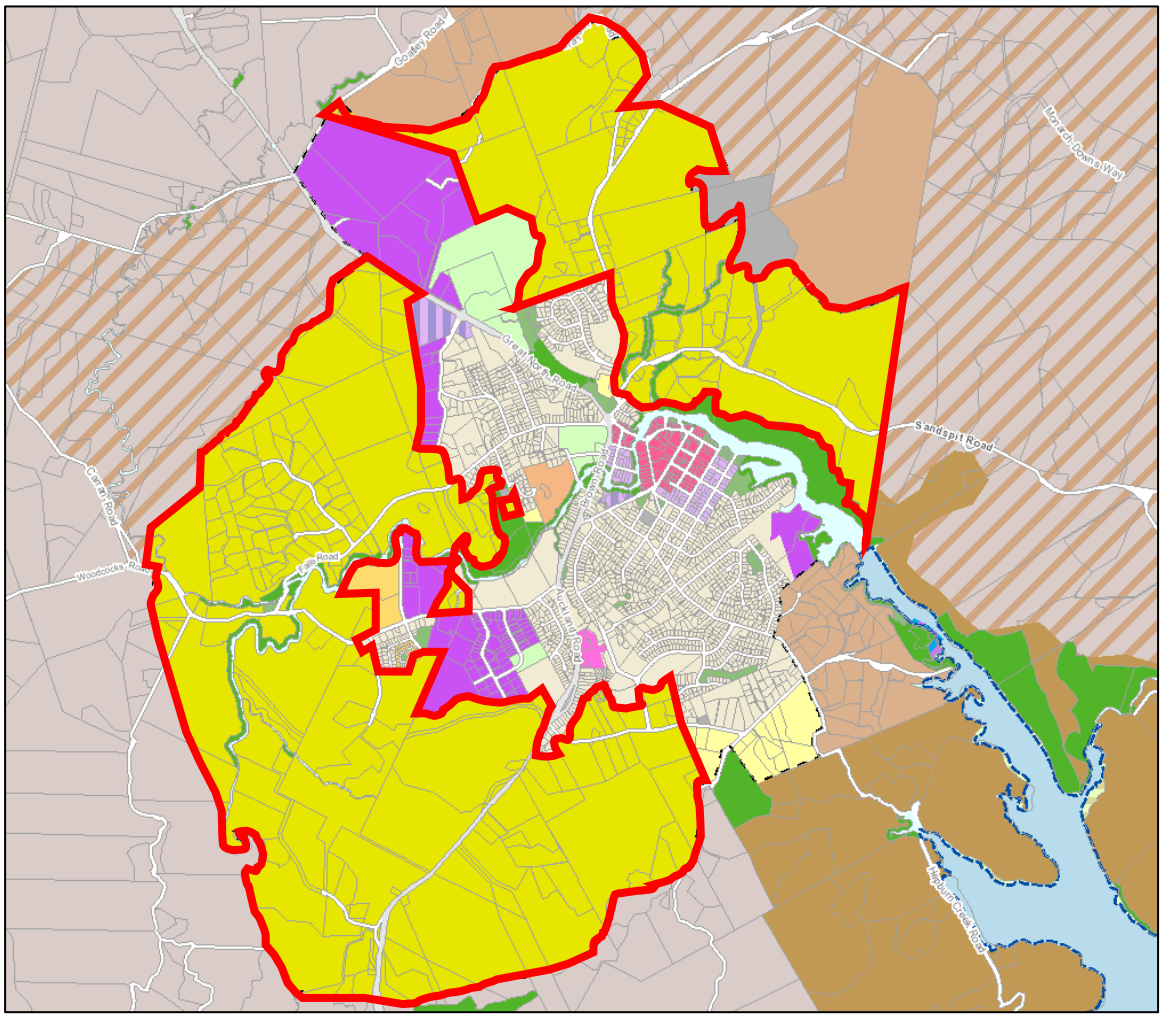


Figure 2.1: Warkworth Structure Plan Area (areas outlined in red)

The Auckland Future Urban Land Supply Strategy (FULSS) (Auckland Council, 2017a) identifies a programme to sequence development of future urban land in Auckland over the next 30 years. The FULSS identifies three stages of development for the Warkworth Future Urban area: Warkworth North, Warkworth South and Warkworth North East (refer Figure 2.2).

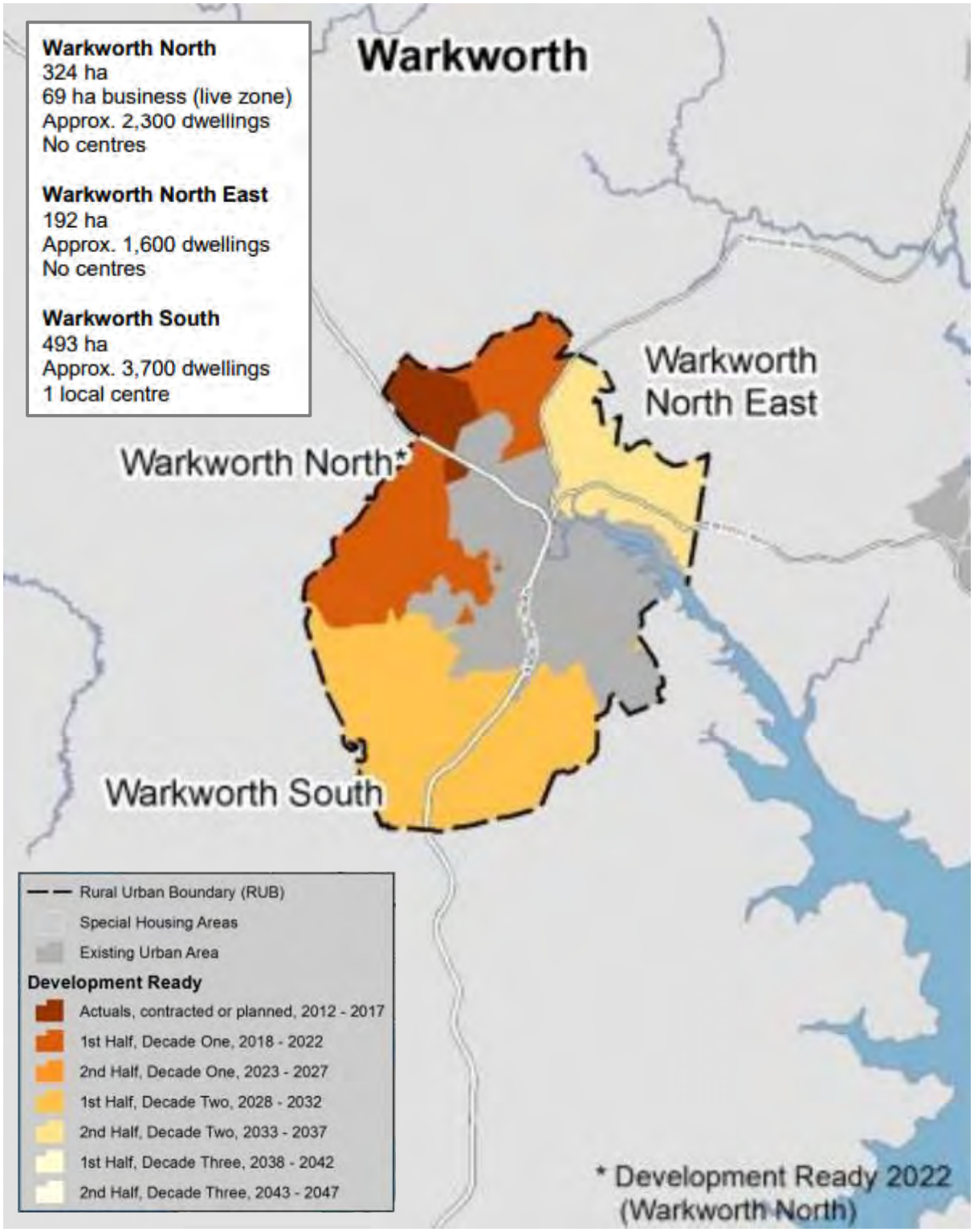


Figure 2.2: Sequencing of future urban land for Warkworth (source: Auckland FULSS Report dated July 2017)

Warkworth North will consist of approximately 2300 dwellings to be developed around the 69 ha business park, which is currently zoned Light Industry under the AUP. The business park is currently being developed while the rest of Warkworth North is sequenced to be development ready by 2022. A new wastewater treatment plant at Snells Beach, along with an associated new pipeline from Warkworth and upgraded outfall, is required to service development in the rest of Warkworth North. This work is currently being consented, and expected to be completed by 2021. The Ara

Tūhona Pūhoi to Warkworth Road (SH1) of National Significance, which borders the north-west side of the structure plan area between Carran Road and existing SH1, is expected to be completed in 2021. This project includes associated upgrades to the local roading network which align with the sequencing of Warkworth North. One such upgrade is the proposed Matakana Link Road which is currently in the detailed design phase and is due for completion by September 2021.

Warkworth South will consist of around 3700 dwellings, including a local centre, and is due to be development ready by 2028-2032. The later sequencing of Warkworth South provides for the efficient staging of wastewater infrastructure.

Warkworth North East consists of approximately 1600 dwellings and is due to be development ready by 2033-2037. Warkworth North East is sequenced later to enable connections to the town centre to be adequately addressed.

3 Planning context

Water supports almost every aspect of life and is an important resource for all New Zealanders. The Resource Management Act 1991 (RMA) is the primary Act for managing natural and physical resources in New Zealand. Section 5 of the RMA identifies its purpose as the sustainable management of natural and physical resources. This means managing the use, development and protection of natural and physical resources in a way that enables people and communities to provide for their social, cultural and economic well-being while sustaining natural and physical resources for future generations, protecting the life supporting capacity of air, water, soil and ecosystems, and avoiding, remedying or mitigating the adverse effects of activities on the environment.

There are also a number of national, regional and local Acts and documents that are required to be considered or had regard to in the preparation of a Stormwater Management Plan. These are identified and relevant sections, objectives and policies are outlined further below.

3.1 National Policy Statement on Freshwater Management 2014 (NPSFM)

Given the vital importance of freshwater resources, and in order to achieve the purpose of the RMA, the NPSFM seeks to set a national direction and manage land use and development activities that affect fresh water so that growth is achieved with a lower environmental footprint. The NPSFM sets out objectives and policies that direct local government to manage water in an integrated and sustainable way, while providing for economic growth within set water quantity and quality limits. The NPSFM is a first step to improve freshwater management at a national level.

The NPSFM states that there are two compulsory values that must be managed. These are ecosystem health and human health. Additionally, it states that national bottom lines outlined are not standards to aim for. Where freshwater management units are below national bottom lines they must be improved to at least the national bottom line, or better, over time. It is up to communities and iwi/hapū, through councils, to determine the pathway and timeframe for ensuring freshwater management units meet the national bottom lines. Where changes in the way communities use fresh water are required, the pace of those changes should take into account impacts on economic well-being.

The NPSFM establishes a range of objectives. The following are relevant to this Stormwater Management Plan:

- Objective A1 - *To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems, of fresh water and the health of people and communities, as affected by contact with freshwater, in sustainably managing the use and development of land, and discharges of contaminants.*
- Objective A4 - *To enable communities to provide for their economic well-being, including productive economic opportunities, in sustainably managing freshwater quality, within limits.*
- Objective C1 - *To improve integrated management of fresh water and the use and development of land in whole catchments, including the interactions between fresh water, land, associated ecosystems and the coastal environment.*

3.2 New Zealand Coastal Policy Statement

The New Zealand Coastal Policy Statement (NZCPS) is a national policy statement under the Resource Management Act 1991. The purpose of the NZCPS is to achieve the sustainable management purpose of the RMA in relation to the coastal environment of New Zealand. The coastal environment has characteristics, qualities and uses that mean there are particular challenges

in promoting sustainable management. With regards to freshwater, the coastal environment is facing the following key issues:

- The ability to manage activities in the coastal environment is hindered by a lack of understanding about some coastal processes and the effects of activities on them.
- Continuing decline in species, habitats and ecosystems in the coastal environment under pressures from subdivision and use, vegetation clearance, loss of intertidal areas, plant and animal pests, poor water quality, and sedimentation in estuaries and the coastal marine area.
- Poor and declining coastal water quality in many areas as a consequence of point and diffuse sources of contamination, including stormwater and wastewater discharges.
- Adverse effects of poor water quality on aquatic life and opportunities for aquaculture, mahinga kai gathering and recreational uses such as swimming and kayaking.

Objectives of the NZCPS relevant to freshwater and this Stormwater Management Plan include:

- Objective 1 - *To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by maintaining coastal water quality, and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.*
- Objective 6 - *To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development, recognising that the potential to protect, use, and develop natural and physical resources in the coastal marine area should not be compromised by activities on land.*

Policies to support these objectives include:

- Policy 4 (Integration) - *Provide for the integrated management of natural and physical resources in the coastal environment, and activities that affect the coastal environment. This requires particular consideration of situations where:*
  - *Subdivision, use, or development and its effects above or below the line of mean high water springs will require, or is likely to result in, associated use or development that crosses the line of mean high water springs* (Policy 4.c.i).
  - *Land use activities affect, or are likely to affect, water quality in the coastal environment and marine ecosystems through increasing sedimentation* (Policy 4.c.iv).
  - *Significant adverse cumulative effects are occurring, or can be anticipated* (Policy 4.c.v).
- Policy 21 (Enhancement of water quality) - *Where the quality of water in the coastal environment has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses, such as aquaculture, shellfish gathering, and cultural activities, give priority to improving that quality by:*
  - *Including provisions in plans to address improving water quality in the areas identified above* (Policy 21.b).
  - *Where practicable, restoring water quality to at least a state that can support such activities and ecosystems and natural habitats* (Policy 21.c).
- Policy 22 (Sedimentation)
  - *Assess and monitor sedimentation levels and impacts on the coastal environment* (Policy 22.1).
  - *Require that subdivision, use, or development will not result in a significant increase in sedimentation in the coastal marine area, or other coastal water* (Policy 22.2).

- *Control the impacts of vegetation removal on sedimentation including the impacts of harvesting plantation forestry* (Policy 22.3).
- *Reduce sediment loadings in runoff and in stormwater systems through controls on land use activities* (Policy 22.4).

- Policy 23 (Discharge of contaminants)
  - *In managing discharges to water in the coastal environment, have particular regard to:*
    - *The sensitivity of the receiving environment* (Policy 23.1.a).
    - *The nature of the contaminants to be discharged, the particular concentration of contaminants needed to achieve the required water quality in the receiving environment, and the risks if that concentration of contaminants is exceeded* (Policy 23.1.b).
    - *The capacity of the receiving environment to assimilate the contaminants* (Policy 23.1.c).
    - *Avoid significant adverse effects on ecosystems and habitats after reasonable mixing* (Policy 23.1.d).
    - *Use the smallest mixing zone necessary to achieve the required water quality in the receiving environment* (Policy 23.1.e).
    - *Minimise adverse effects on the life-supporting capacity of water within a mixing zone* (Policy 23.1.f).
  - *In managing discharges of stormwater take steps to avoid adverse effects of stormwater discharge to water in the coastal environment, on a catchment by catchment basis, by:*
    - *Avoiding where practicable and otherwise remedying cross contamination of sewage and stormwater systems* (Policy 23.4.a).
    - *Reducing contaminant and sediment loadings in stormwater at source, through contaminant treatment and by controls on land use activities* (Policy 23.4.b).
    - *Promoting integrated management of catchments and stormwater networks* (Policy 23.4.c).
    - *Promoting design options that reduce flows to stormwater reticulation systems at source* (Policy 23.4.d).

3.3 Hauraki Gulf Marine Park Act 2000 (HGMPA)

The Hauraki Gulf Marine Park Act 2000 (HGMPA) is relevant to this Stormwater Management Plan as the Mahurangi River widens to become the Mahurangi Harbour which then opens to the Hauraki Gulf. The purpose of the HGMPA is to integrate the management of natural, historic, and physical resources of the Hauraki Gulf, its islands, and catchments and establish objectives for its management. The interrelationship between the Hauraki Gulf, its islands, and catchments and the ability of that interrelationship to sustain the life-supporting capacity of the environment of the Hauraki Gulf and its islands are matters of national significance under Section 7 of the HGMPA.

The objectives (under Section 8 of the HGMPA) for the management of the Hauraki Gulf, its islands and catchments include:

- The protection and, where appropriate, the enhancement of the life-supporting capacity and the natural, historic, and physical resources of the environment of the Hauraki Gulf, its islands, and catchments.
- The maintenance and, where appropriate, the enhancement of the contribution of the natural, historic, and physical resources of the Hauraki Gulf, its islands, and catchments to the

social and economic well-being, recreation and enjoyment of the people and communities of the Hauraki Gulf and New Zealand.

Sections 7 and 8 of the HGMPA must be treated as a New Zealand Coastal Policy Statement.

3.4 Auckland Plan 2050

The Auckland Plan is Auckland's long-term spatial plan and its sets directions for Auckland's future development. It identifies that Auckland's environment is important and should be preserved and protected for its intrinsic value and the benefit of present and future generations. The Auckland Plan also identifies that stormwater, wastewater, litter, sediment and heavy metals all eventually end up in the harbours, and impact on ecology. Additionally, sediment runoff from the land has a significant impact on streams and on the marine environment by blanketing ecosystems, affecting plant growth and water clarity. Impervious surfaces in the urban environment, such as roads and carparks, collect heavy metals such as lead, nickel and zinc, which are quickly washed into streams and stormwater systems and then into the marine environment when it rains. Heavy metals are toxic to both people and animals, even at relatively low concentrations.

The Auckland Plan directions identify that Auckland's growth and development should be used to protect and enhance the natural environment and upgrade degraded ecosystems by embedding sustainable environmental practices into development in order to improve water quality and stormwater treatment. It recognises that stormwater infrastructure, including green infrastructure, plays an important role in improving the quality of the environment and that environmentally sensitive approaches such as water sensitive design, quality urban design and future-proofed infrastructure should be embedded in developments from the start, rather than retrofitting later or doing expensive restoration projects.

3.5 Auckland Unitary Plan (AUP)

The Auckland Unitary Plan (AUP) is the planning document for Auckland that replaces the former Regional Policy Statement and the 13 regional and district plans. The AUP became 'operative in part' on 15 November 2016.

3.5.1 Regional Policy Statement (RPS)

The purpose of the Regional Policy Statement (RPS) is to provide an overview of the resource management issues of the Auckland region and outline objectives, policies and methods for achieving integrated management of natural and physical resources as required by the RMA.

Chapter B7.3 and B7.4 of the AUP establishes the RPS objectives and policies for freshwater systems and coastal water. For freshwater systems, the RPS objectives seek that degraded freshwater systems are enhanced, the loss of freshwater systems is minimised and the adverse effects of changes in land use on freshwater are avoided, remedied or mitigated.

For coastal water and freshwater the RPS objectives seek to maintain the quality of freshwater and coastal water where it is excellent or good and progressively improve water quality over time where it is degraded; and avoid, remedy or mitigate adverse effects from changes in intensification or land use on coastal water and freshwater. Additionally, the adverse effects on freshwater and coastal water from point and non-point discharges from stormwater runoff and wastewater discharges are required to be minimised and adverse effects progressively reduced.

The policies to achieve the objectives seek to integrate the management of subdivision, use and development and freshwater systems and coastal water by:

- Ensuring infrastructure such as stormwater, wastewater and water is adequately provided for in areas of new growth or intensification.

- Ensuring catchment management plans form part of the structure planning process.
- Controlling the use of land and discharges to minimise the adverse effects of runoff on freshwater systems and water to progressively reduce adverse effects where system or water are degraded.
- Avoiding development where it will significantly increase adverse effects on freshwater systems and water, unless those adverse effects can be adequately mitigated.

Additionally, for freshwater, the RPS policies require the identification of degraded freshwater systems and the promotion of the enhancement of these systems to progressively reduce adverse effects. Policies to manage freshwater also include the need to avoid the permanent loss and significant modification or diversion of lakes, rivers, streams and wetlands and their margins unless it is necessary to provide for the following (and no practicable alternative exists):

- The health and safety of communities.
- The enhancement and restoration of freshwater systems or values.
- The sustainable use of land and resources to provide for growth and development.
- Infrastructure.

Furthermore, mitigation is to be provided to address adverse effects from any loss in freshwater system function of value and where adverse effects cannot be adequately mitigated then environmental benefits, including on-site or off-site works, are required to be provided.

Policies also seek to manage subdivision, use and development, including discharges and activities in the beds of lakes, rivers, streams and wetlands in order to protect identified areas and minimise erosion and modification of the beds and banks of lakes, rivers, streams and wetlands. Additionally, policies seek to limit the establishment of structures within the beds of lakes, rivers, streams and wetlands to those that have a functional or operational need to be there.

Furthermore, the RPS policies require the restoration and enhancement of freshwater systems when development, change of use or subdivision occurs; and the maintenance and enhancement of:

- Freshwater systems not otherwise protected.
- Navigation and public access.
- Existing riparian vegetation located on the margins of lakes, rivers, streams and wetlands.
- Areas of significant indigenous biodiversity.

The RPS also includes polices which give effect to the NPSFM (outlined above). These include policies regarding water quality which seek to:

- Identify coastal water and freshwater bodies that have been degraded by human activities.
- Progressively improve water quality in identified degraded areas through managing subdivision, use, development and discharges.
- Manage the discharge of contaminants (including nutrients generated on or applied to land) into water from subdivision, use and development (including point and non-point sources) to avoid where practicable, and otherwise minimise bacterial contamination and adverse effects on the quality of freshwater, coastal water, catchments and aquifers; and on mana whenua values.

Specific to sediment runoff and the management of the discharge of sediment into freshwater and coastal water, the RPS policies seek to minimise the loss of sediment from subdivision, use and development and promote the use of soil conservation and management measures, including industry best practice and standards, to retain soil and sediment on land.

In addition, specific to stormwater management, the RPS policies seek to manage stormwater by requiring subdivision use and development to minimise the generation and discharge of contaminants and minimise the adverse effects on freshwater, coastal water and the capacity of the stormwater network. The adoption of the best practicable option (BPO) for every stormwater diversion and discharge and controlling the diversion and discharge of stormwater outside areas serviced by a public stormwater network is also required.

3.5.2 Freshwater management

The National Policy Statement for Freshwater Management, the New Zealand Coastal Policy Statement and the Auckland Unitary Plan emphasise the importance of managing and improving the condition of Auckland's freshwater and coastal systems. To support this, at the Regional Plan and District Plan level, Auckland Council's three strategic objectives for the management of freshwater (found in section E1.2 of the AUP) are:

- *Freshwater and sediment quality is maintained where it is excellent or good and progressively improved over time in degraded areas.*
- *The mauri of freshwater is maintained or progressively improved over time enable traditional and cultural use of this resource by mana whenua.*
- *Stormwater and wastewater networks are managed to protect public health and safety and to prevent or minimise adverse effects of contaminants on freshwater and coastal water quality.*

These objectives recognise that stormwater is an integral part of the hydrological cycle and that the quality of stormwater impacts on the mauri of water in the receiving environments.

The policies to achieve the objectives require that freshwater systems be enhanced unless irreversibly modified by existing intensive use or development so that enhancement is practicably excluded. Policies also require the management of discharges, subdivision, use and development to maintain or enhance water quality, flows, stream channels and their margins and other freshwater values; and when considering discharges, the extent to which:

- The discharge would avoid contamination that has an adverse effect on the life-supporting capacity of freshwater and associated ecosystems and the health of people and communities as affected by their secondary contact with fresh water.
- It is feasible and dependable that any more than minor adverse effect from a discharge on freshwater and associated ecosystems and the health of people and communities as affected by their secondary contact with fresh water would be avoided.

3.5.3 Integrated stormwater management

Policy E1.3(8) of the AUP requires the avoidance, as far as practicable, or otherwise, the minimising or mitigation of adverse effects of stormwater runoff from greenfield developments. This is to be achieved by taking an Integrated Stormwater Management approach for greenfield development. Policy E1.3(10) outlines that an integrated stormwater management approach involves collaboration with a range of disciplinary fields in the design process to identify project risks and opportunities at an early stage to deliver multiple and complementary environmental, economic and social benefits from stormwater management. Policy E1.3(10) also identifies the following considerations for an integrated stormwater management approach:

- The nature and scale of the development and practical and cost considerations.
- The location and design, capacity, intensity and integration of the site/development and infrastructure to protect significant site features and hydrology and minimise effects on receiving environments.

- The nature and sensitivity of receiving environments, including fragmentation and loss of connectivity of rivers and streams, hydrological effects and contaminant discharges and how these can be minimised and mitigated, including opportunities to enhance degraded environments.
- Reducing stormwater flows and contaminants at source.
- The use and enhancement of natural hydrological features and green infrastructure where practicable.

3.5.4 Water Sensitive Design

Water sensitive design (WSD) is a design process to achieve integrated stormwater management. WSD is defined as:

"An approach to freshwater management, it is applied to land use planning and development at complementary scales including region, catchment, development and site. Water sensitive design seeks to protect and enhance natural freshwater systems, sustainably manage water resources, and mimic natural processes to achieve enhanced outcomes for ecosystems and our communities."

Water Sensitive Design for Stormwater, GD04 (Auckland Council, 2015) is a guideline document produced by Auckland Council to introduce practitioners to the principles and objectives for WSD in Auckland. The WSD principles identified for Auckland are summarised below:

- Promote inter-disciplinary planning and design.
- Protect and enhance the values and functions of natural ecosystems.
- Address stormwater effects as close to the source as possible.
- Mimic natural systems and processes for stormwater management.

Figure 3.1 provides an example of how the "end product" of an integrated stormwater management and WSD approach might look.

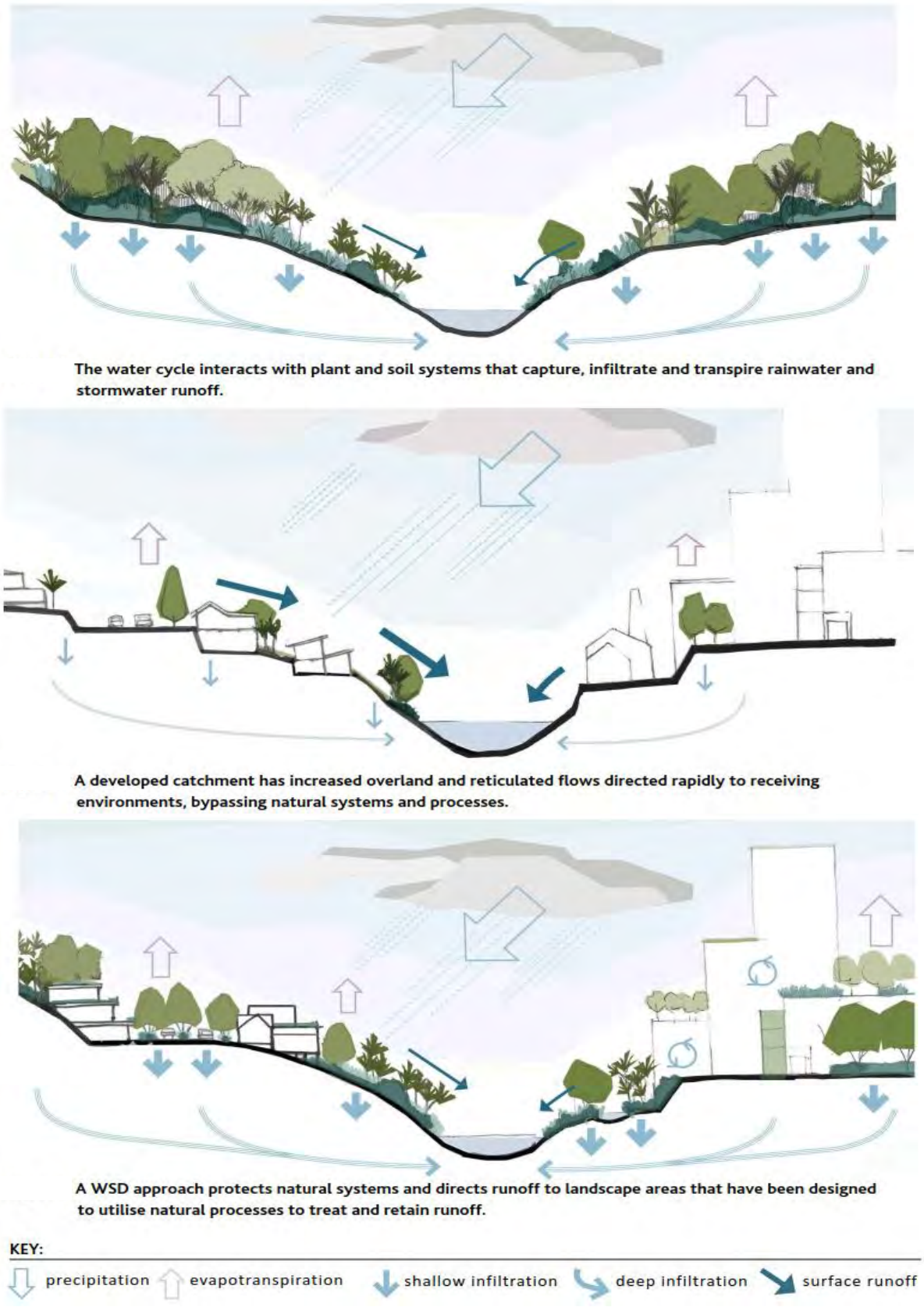


Figure 3.1: Effect of a WSD urban design on the hydrological cycle (source: GD04 (Auckland Council, 2015))

3.5.5 General stormwater management

Other relevant AUP objectives and policies for the management of stormwater and flooding are provided in the following sections of the AUP:

- E1 – Water quality and integrated management.
- E10 – Stormwater management area – Flow 1 and Flow 2.
- E36 - Natural hazards and flooding.

Policy E1.3(8) sets out the following policies for management of stormwater runoff from greenfield development:

Avoid as far as practicable, or otherwise minimise or mitigate, adverse effects of stormwater runoff from greenfield development on freshwater systems, freshwater and coastal water by:

- *taking an integrated stormwater management approach (refer to Policy E1.3(10));*
- *minimising the generation and discharge of contaminants, particularly from high contaminant generating car parks and high use roads and into sensitive receiving environments;*
- *minimising or mitigating changes in hydrology, including loss of infiltration, to:*
  - *minimise erosion and associated effects on stream health and values;*
  - *maintain stream baseflows; and*
  - *support groundwater recharge;*
- *where practicable, minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges; and*
- *providing for the management of gross stormwater pollutants, such as litter, in areas where the generation of these may be an issue.*

The other relevant policies for addressing stormwater management from Section E1 are summarised briefly below:

- Maintain or enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is above the relevant thresholds OR enhance water quality, flows, stream channels and their margins and other freshwater values where the current condition is below the relevant thresholds (Policies E1.3(2)(a), (2)(b) and (3)).
- Discharges must avoid contamination that will have an adverse effect on the life supporting capacity of freshwater (Policy E1.3(4)).
- Discharges must avoid contamination that will have an adverse effect on health of people and communities (Policy E1.3(5)).
- Avoid, minimise or mitigate adverse effects of stormwater diversions and discharges (Policy E1.3(11)).
- Manage contaminants in stormwater runoff from High Contaminant Generating Carparks (> 30 cars) and High Use Roads (>5000 vehicles per day) to minimise adverse effects on water and sediment quality (Policy E1.3(12)).
- Require stormwater quality or flow management to be achieved on-site unless there is a downstream communal device (Policy E1.3(13)).
- Adopt the best practicable option to minimise the adverse effects of stormwater discharges (Policy E1.3(14)).
- Utilise stormwater discharge to ground soakage where it is possible to do so in a safe, and effective manner (Policy E1.3(15)).

Section E36 - Natural hazards and flooding sets out the objectives and policies relating to management of natural hazards and flooding. The relevant policies are summarised briefly below:

- Avoid locating buildings in the 100 year ARI floodplain (Policy E36.3(17)).
- Earthworks within the 100 year ARI floodplain should not permanently reduce floodplain conveyance or exacerbate flooding experienced by other sites upstream or downstream (Policy E36.3(20)).
- Ensure all development in the 100 year floodplain does not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site (Policy E36.3(21)).
- Maintain the function and capacity of overland flowpaths to convey stormwater runoff safely and without damage to the receiving environment (Policies E36.3(29) and (30)).

3.5.6 Changes in hydrology

The Warkworth Structure Plan Area is within the Future Urban Zone so is not identified in the AUP as urban land. Management of hydrological changes for greenfield development such as the Warkworth Structure Plan Area needs to be assessed against the objectives and policies of the AUP, specifically the need to minimise or mitigate changes in hydrology (Policy E1.3(8)). For greenfield development the hydrological mitigation approach may not be sufficient to fully mitigate the development effects from changes to hydrology on receiving streams and this is reflected in the need to apply policy E1.3(8). Further site-specific assessment of greenfield areas should be undertaken to determine what degree of mitigation of hydrological changes may be required. Such assessment should give consideration to:

- The extent of development and the likely changes to the hydrological regime. This should not only consider changes to peak flows but also duration of bank full flows and effects on stream base flows.
- The current baseline of stream values and the sensitivity of streams to changes in hydrology.
- What degree of hydrological mitigation (i.e. detention and retention) can practicably be achieved for the development (e.g. viability of infiltration and water reuse).
- What opportunities exist to mitigate any changes in hydrology that remain after hydrological mitigation are implemented (e.g. in-stream works).

Section E10 of the AUP sets out additional controls for areas identified as been within a Stormwater management area control – Flow 1 and Flow 2 (SMAF) overlay for streams in existing urban areas. These additional controls are referred to as 'hydrological mitigation' as they seek to minimise the change in hydrology, namely runoff volumes and flow rate, as a result of development. Hydrological mitigation is aimed at protecting rivers and streams in urban areas that are particularly susceptible to the effects of development and have relatively high values. The SMAF 1 hydrological mitigation requirements are given in Table E10.6.3.1.1 in the AUP and are as follows:

- Retention (volume reduction) of at least 5 mm of runoff depth from impervious surfaces.
- Detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from impervious surfaces in the 95th percentile, 24 hour rainfall event minus the achieved retention volume.

Note that Table E10.6.3.1.1 allows for transfer of the retention volume when there are constraints to infiltration and/or water reuse opportunities.

Site-specific assessment may identify that more stringent controls than the hydrological mitigation requirements outlined above are required for the Warkworth Structure Plan Area in order to minimise changes in hydrology; or that other solutions such as in-stream works are required to

mitigate the effects of changes in hydrology that remain after hydrological mitigation measures are implemented.

3.5.7 Streams and wetlands

The objectives and policies for streams and wetlands are covered in Section E3 of the AUP – Lakes, Rivers, Streams and Wetlands. The relevant objectives for the management of stormwater are as follows:

- *Auckland's lakes, rivers, streams and wetlands with high natural values are protected from degradation and permanent loss* (Objective E3.2(1)).
- *Auckland's lakes, rivers, streams and wetlands are restored, maintained or enhanced* (Objective E3.2(2)).
- *Reclamation and drainage of the bed of a lake, river, stream and wetland is avoided, unless there is no practicable alternative* (Objective E3.2(6)).

The relevant policies for lakes, rivers, streams and wetlands with regards to the management of stormwater include:

- Managing the effects of activities in, on under or over beds of lakes, rivers, stream or wetlands outside identified areas by avoiding where practicable or otherwise mitigating any adverse effects on lakes, rivers, streams or wetlands and where appropriate restoring and enhancing them (Policy E3.3(2)).
- Enable the enhancement, maintenance and restoration of lakes, rivers, streams or wetlands, noting that there is policy guidance on how restoration and enhancement actions should occur (Policy E3.3(3) and Policy E3.3(4)).
- Structures in rivers, streams and wetlands and the associated diversion of water, as well as the disturbance and depositing of any substance, are provided for where there is no practicable alternative method or location; and the structure is the minimum size necessary and designed to avoid creating or increasing a hazard. Additionally, structures and associated diversions, as well as disturbance and depositing of any substance, are provided for where the structure or activity is necessary in order to restore or enhance natural values or indigenous vegetation or habitat; and to maintain or enhance public access; and for infrastructure, flood protection or reasonable use of production land. However, the structure must avoid significant adverse effects and avoid, remedy or mitigate other adverse effects (Policy E3.3(7) and Policy E3.3(9)).
- Avoidance of the reclamation and drainage of the beds of lakes, rivers, streams and wetland is required unless there is no practicable alternative and if the activity required is in order to restore or enhance the natural values of a lake, river, stream, wetland or any adjacent area of indigenous vegetation or fauna. Avoidance of reclamation or drainage is also required unless it is for infrastructure purposes; and provided significant adverse effects are avoided and other adverse effects are avoided, remedied or mitigated (Policy E3.3(13)).
- Protect the riparian margins of lakes, rivers, streams, and wetlands from inappropriate use and development and promote their enhancement to:
  - Safeguard habitats for fish, plant and other aquatic species, particularly in rivers and streams with high ecological values.
  - Safeguard their aesthetic, landscape and natural character values.
  - Safeguard the contribution of natural freshwater systems to the biodiversity, resilience and integrity of ecosystems.
  - Avoid or mitigate the effects of flooding, surface erosion, stormwater contamination, bank erosion and increased surface water temperature (Policy E3.3(15)).

- Protect land alongside streams for public access through the use of esplanade reserves and esplanade strips, marginal strips, drainage reserves, easements or covenants where appropriate and for water quality, ecological and landscape protection purposes (Policy E3.3(16)).

3.5.8 Coastal Marine Zone

The objectives and policies for the Coastal Marine Zone are outlined in Section F2 of the AUP – General Coastal Marine Zone. The relevant objectives for management of stormwater are listed below:

- *Water and sediment quality in the coastal marine area is maintained where it is excellent or good and progressively improved over time in degraded areas* (Objective F2.11.2(1)).
- *The life-supporting capacity and resources of the Hauraki Gulf, are protected and, where appropriate, enhanced* (Objective F2.11.2(2)).
- *Stormwater and wastewater networks protect public health and safety by preventing or minimising the adverse effects of contaminants on the coastal water quality* (Objective F2.11.2(3)).

The policies that give effect to the objectives outlined above encourage the source control of contaminants through the management of land use and discharges , including source contaminant control devices and methods where these can be practicably installed and maintained, to prevent or minimise contaminant generation and discharge to coastal receiving environments (Policy F2.11.3(5)).

The design and maintenance of discharge structures is required to help minimise the amount of litter entering coastal waters (Policy F2.11.3(6)). Additionally, discharges associated with new infrastructure are enabled provided the integrated management approach outlined in Section 3.5.3, as well as the cost of infrastructure, public health, the nature of the receiving environment and discharge, priorities for flooding and inundation, and the operational need for the infrastructure to be located in the coastal marine area, are accounted for (Policy F2.11.3(7)).

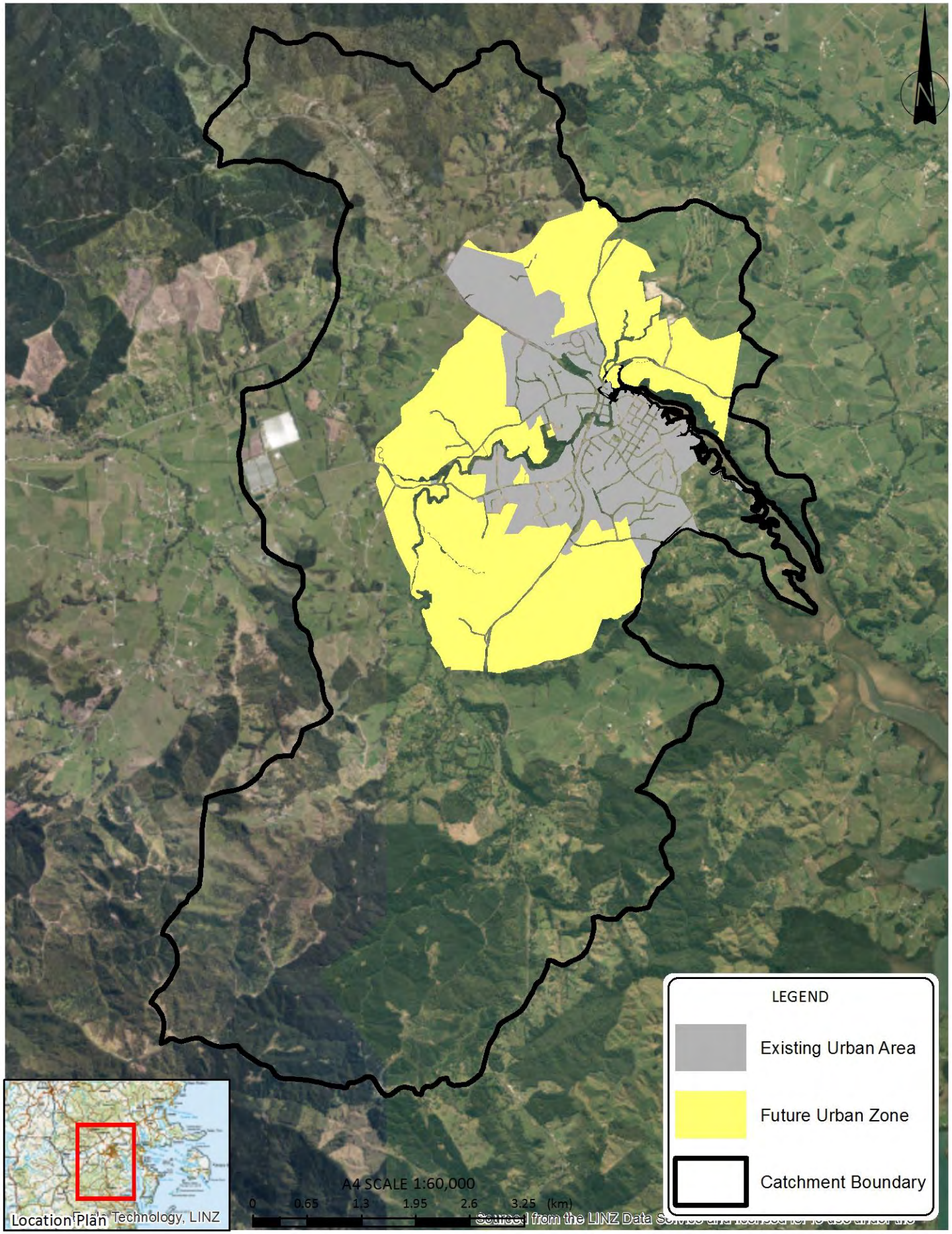
4 Site characteristics

The following subsections address specific site characteristics of the Warkworth Structure Plan Area so far as they relate to management of stormwater. Mapping of catchment features are included in this section. A3 copies of these maps are included as Appendix A.

4.1 Topography and catchment

The Warkworth Structure Plan Area is located within the lower Mahurangi River Catchment in the far north of the Auckland Region (refer Figure 4.1). The Mahurangi River Catchment is approximately 5892 ha in area and drains to the Mahurangi Harbour within the Hauraki Gulf. The Warkworth Structure Plan Area comprises approximately 17% of the wider Mahurangi Catchment.

Within the Warkworth Structure Plan Area the topography is generally characterised as rolling to moderately sloping with elevations ranging from approximately 100 m RL at its northern, western and southern extents to sea level around the existing urban area alongside the Mahurangi River. To the north of the existing urban area the Warkworth Structure Plan Area generally grades in a south westerly direction while to the south of the existing urban area it generally grades in a north easterly direction. The topography of the Future Urban Zone is shown on Figure 4.2.



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Stormwater Management Plan

Catchment Setting

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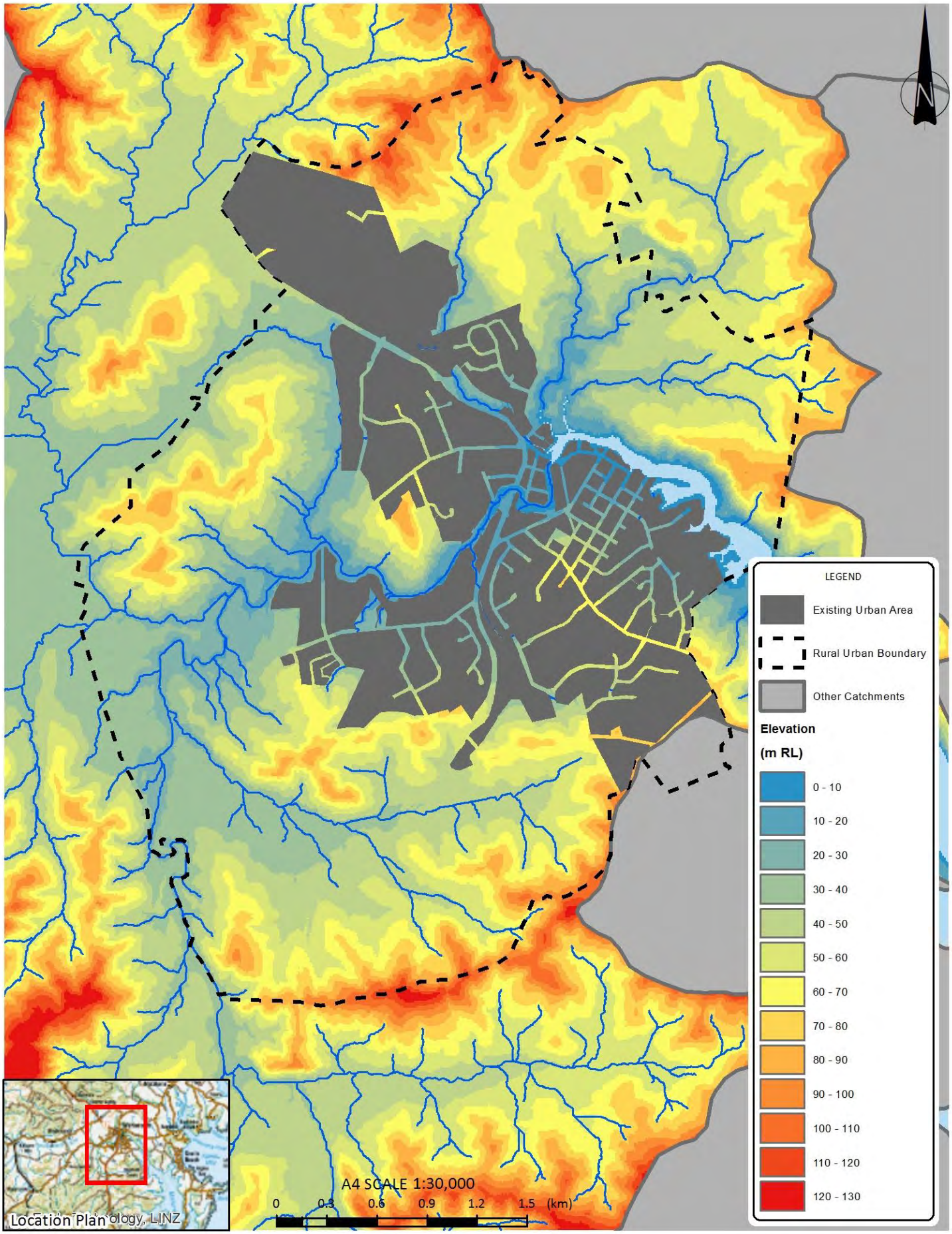

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Warkworth Structure Plan Area

Stormwater Management Plan

Existing Topography

FIGURE No.: Figure 4.2
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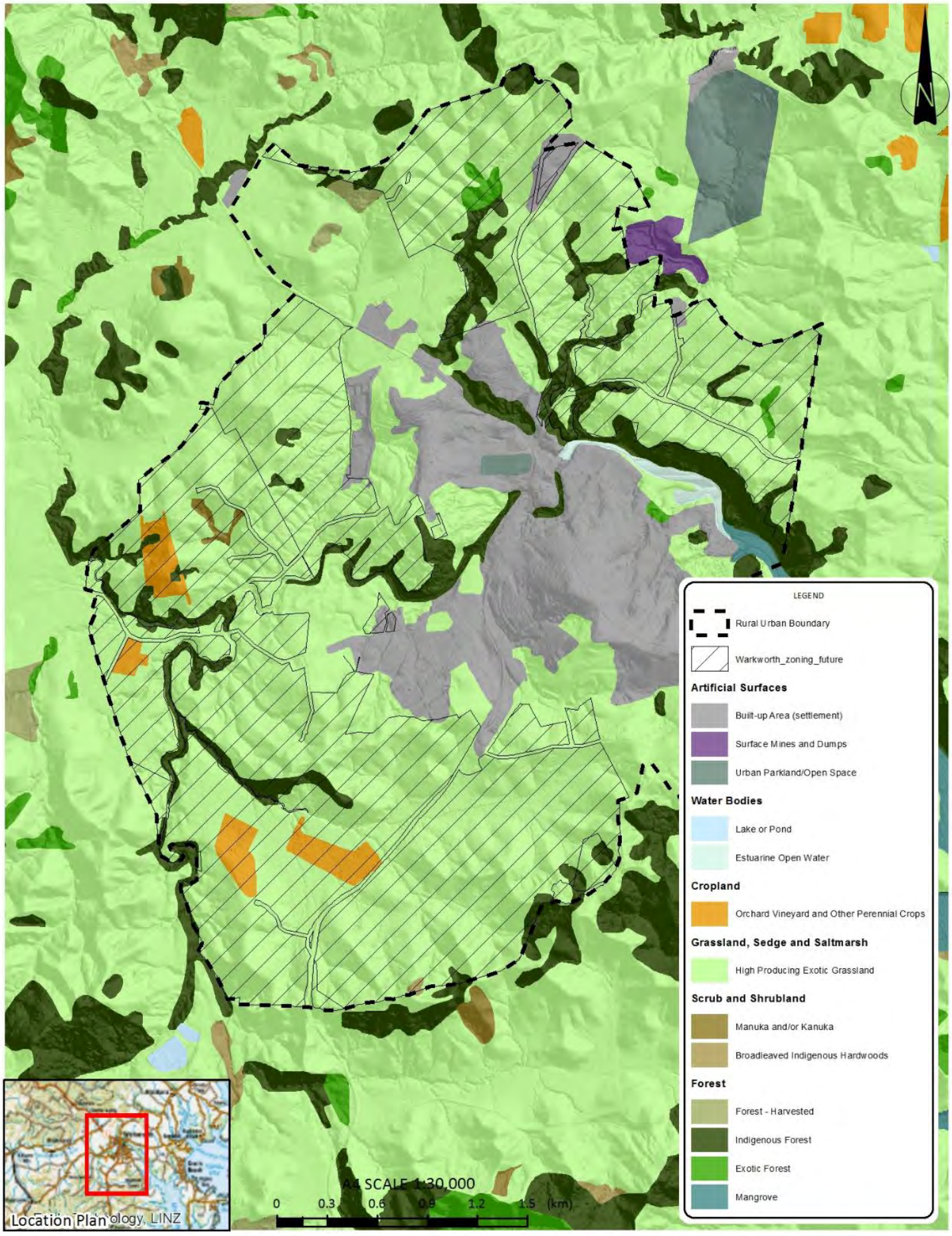
4.2 Existing land use

The Warkworth Structure Plan Area, which surrounds the existing Warkworth urban area, is currently predominantly pastoral land used for agriculture, horticulture and lifestyle properties. Based on Landcare Research's Land Cover Database version 4 (LCDB4), pasture comprises almost 90% of the area (refer Table 4.1). There are also clusters of regenerating indigenous vegetation over the slopes together with exotic trees, sporadic low hedgerows and a scattering of scrub throughout the area. The spatial distribution of the different land uses is shown in Figure 4.3.

Although in recent years development in the form of lifestyle properties has increased in the Warkworth Structure Plan Area, it is still predominantly pervious and considered a "greenfield" site. Development and the associated increase in impervious area will result in hydrological changes in the form of increased runoff volumes and runoff rates that will need to be mitigated.

Table 4.1: Warkworth Structure Plan Area existing land use (source: Landcare Research)

Land use (P - pervious, I - impervious)	Area (ha)	Percentage of area (%)
High producing exotic grassland (P)	892.8	88.5
Indigenous forest (P)	69.7	6.9
Orchard, vineyard or other perennial crop (P)	29.0	2.9
Built-up area (I)	8.0	0.8
Exotic forest (P)	6.2	0.6
Manuka and/or kanuka (P)	2.7	0.3
Broadleaved indigenous hardwoods (P)	0.6	0.1



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Warkworth Structure Plan Area

Stormwater Management Plan

Existing Land Use

FIGURE No. Figure 4.3

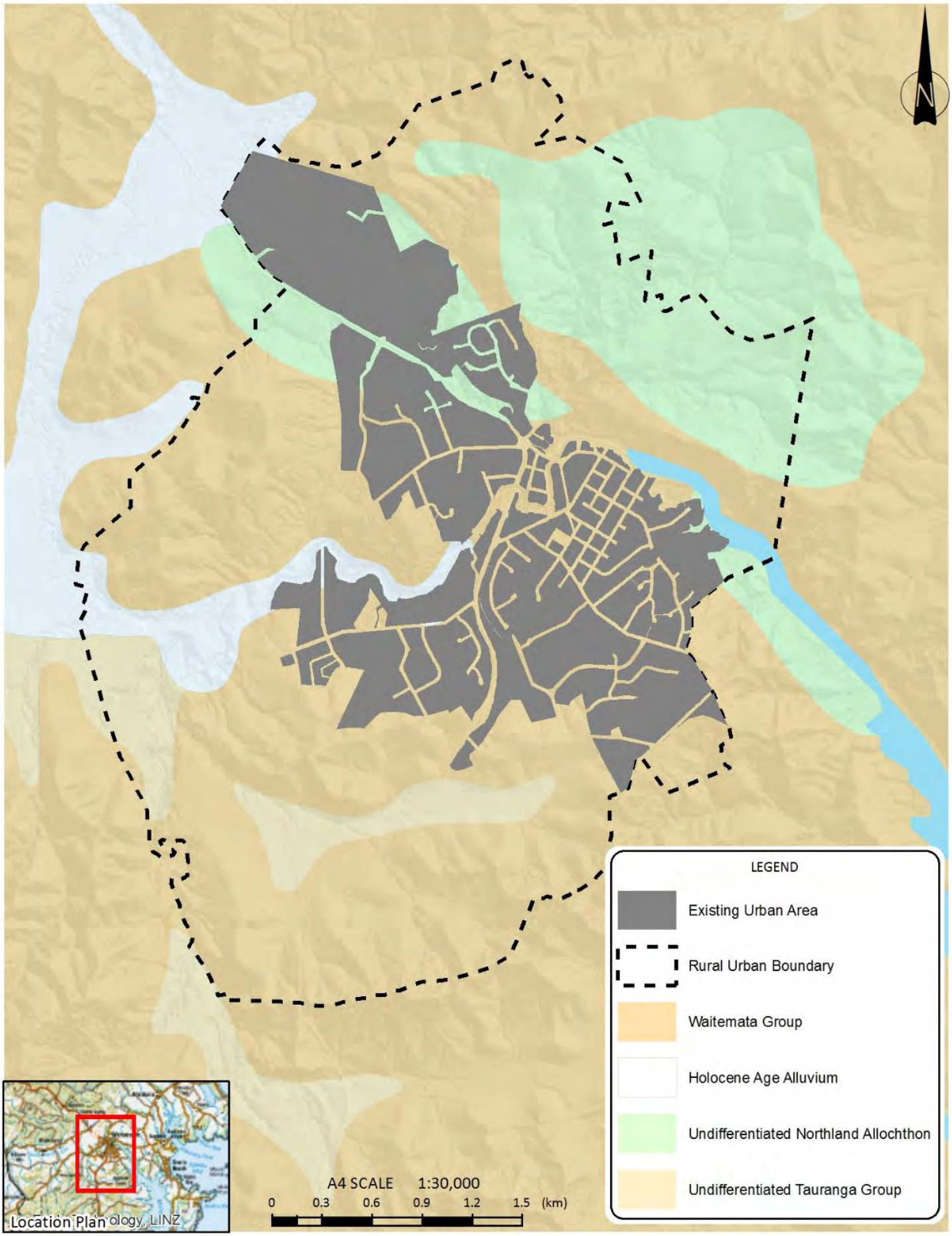
Rev. 0

4.3 Geology and soils

Published geological maps show that the underlying geology of the Warkworth area comprises primarily of residual Waitemata Group Ultic soils overlying Pakiri Formation Rock (refer Figure 4.4). Waitemata Group is overlain in major stream channel systems by variable thicknesses of Holocene or Pleistocene Tauranga Group Alluvium. Areas of Undifferentiated Northland Allochthon (including Mahurangi Limestone) are also present (refer Figure 4.4).

Once weathered, the Waitemata Formation forms silty clays and clayey silt soils that are of high plasticity. Such soils are characterised by high shrinkage and low permeability. As a consequence the Waitemata Group soils tend to have poor soakage abilities with relatively high runoff volumes. This may preclude use in some areas of stormwater devices that rely on infiltration to meet the policies of the AUP. Site specific geotechnical investigations should be undertaken to identify areas which may be conducive to infiltration and soil disturbance of these areas should be minimised during development.

For further discussion on the implications of the site geology on the development potential of different parts of the study area the reader is referred to the Geotechnical and Coastal Hazards Topic Report prepared for the Warkworth Structure Plan Area (Auckland Council, 2018a).



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Warkworth Structure Plan Area

Stormwater Management Plan

Geology

FIGURE No. Figure 4.4

Rev. 0

4.4 Existing stormwater infrastructure

Stormwater infrastructure within the existing Warkworth urban area consists of a stormwater pipe network with pipes ranging in size from 225 mm to 1800 mm in diameter. The few stormwater assets that currently exist within the Warkworth Structure Plan Area consist mainly of bridges and culverts where roads cross streams.

Auckland Council have recently developed a 1D/2D hydrological and hydraulic model of the Mahurangi Catchment and existing stormwater network. The model was built using Integrated Catchment Modelling Version 6.5 modelling software and includes 1030 stormwater pipes, 19 bridges and 49 culverts. The location of the modelled stormwater assets are shown in Figure 4.5. It should be noted that there is also a large amount of privately owned stormwater infrastructure in the Warkworth Structure Plan Area that is not shown in Figure 4.5. These are predominantly culverts for farm tracks and their locations and condition have been assessed as part of the Warkworth Watercourse Assessment (Morphum, 2018b).

The Model Build and System Performance Report (Auckland Council, 2017b) provides more detail on the Mahurangi Catchment model build. Along with assessing flood risk in the catchment, the model has been used to assess system performance of the stormwater pipe network in the existing Warkworth urban area and the bridges and culverts in the wider catchment. System performance modelling shows that over 34 of the 44 bridges and culverts within the greater Mahurangi River catchment do not meet Auckland Council level of service, and are too small to pass the 10 year event without surcharging. Healthy Waters have assigned priority levels for upgrades to the bridges and culverts to indicate in which order they should be upgraded to enable development within the Warkworth Structure Plan Area. The upgrade priority levels are summarised in Table 4.2 below. Those bridges and culverts not listed either do not require upgrading or require further investigation. The Ara Tūhona Pūhoi to Warkworth Road (SH1) Road has new culverts and bridges, which are being designed for a 100 year ARI level of service.

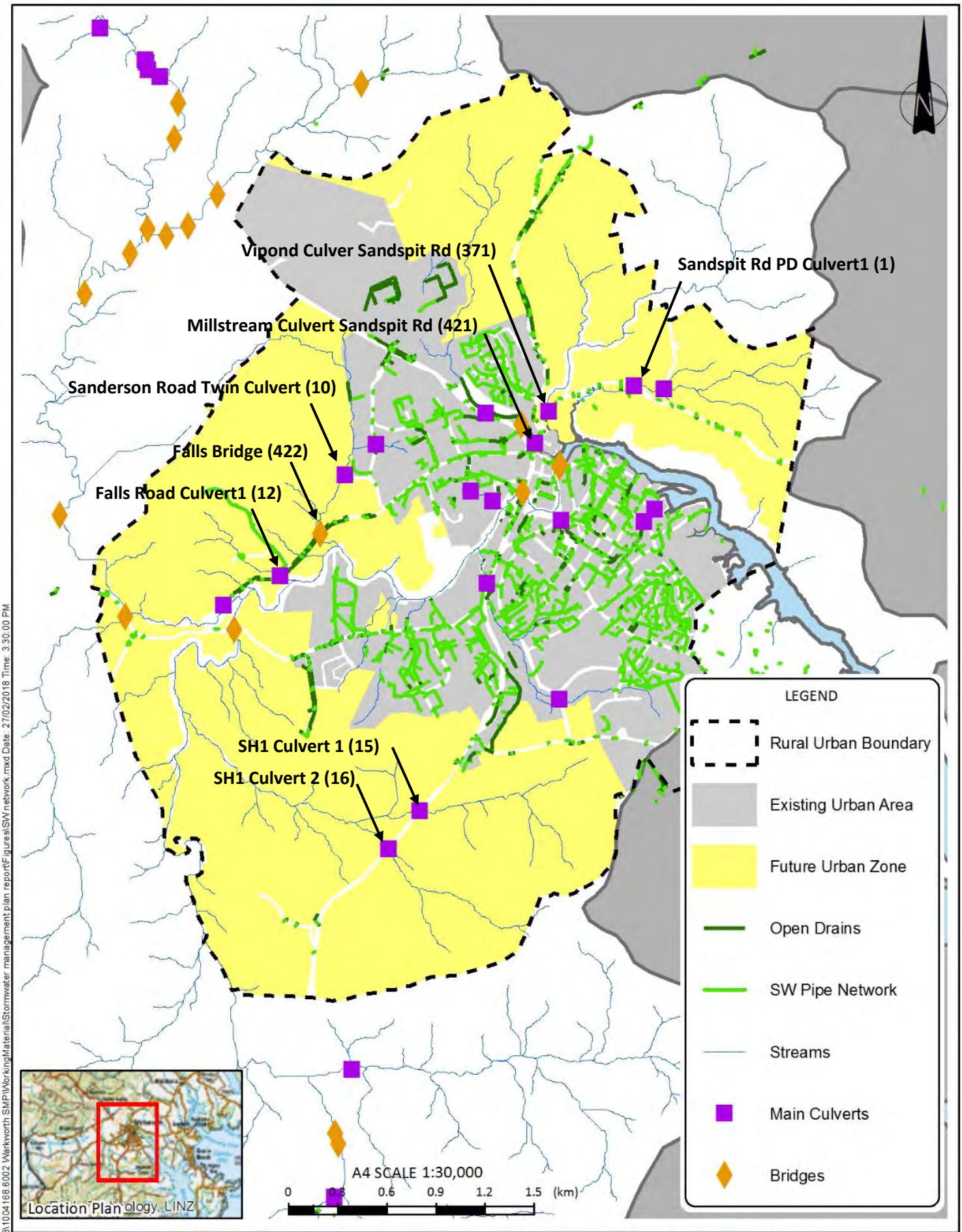
Table 4.2: Upgrade priority level for stormwater infrastructure

Reference ID	Structure name	Structure type	Healthy Waters priority level
421	Millstream Culvert Sandspit Rd	Culvert	1
1	Sandspit Rd PD Culvert1	Culvert	2
10	Sanderson Road Twin Culvert	Twin Culvert	2
371	Vipond Culvert Sandspit Rd	Culvert	2
422	Falls Bridge	Bridge	2
12	Falls Road Culvert1	Culvert	3
15	SH1 Culvert 1	Culvert	3
16	SH1 Culvert 2	Culvert	3

Morphum (2018b) concluded that the majority of Council owned stormwater assets assessed as part of the watercourse assessment were in good condition and many of the private assets that were in poor to very poor condition (10 inlet/outlets, 13 pipes/culverts) may be removed through development processes. The most significant public stormwater assets issues identified for remediation as part of the Watercourse assessment included:

- The Armco corrugated steel arch culvert at Sandspit Rd (Item 1 in Table 4.2).
- Maintenance actions are recommended for culverts under the existing SH1 to address moderate erosion issues, tailwater effects and blockages that may contribute to flood risk.

Cherry's bridge has erosion on the outer bend and protection works are recommended.



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Warkworth Structure Plan Area
Stormwater Management Plan
Existing Stormwater Infrastructure

4.5 Flooding and other hazards

4.5.1 Flooding

In Auckland the floodplain is defined by the 100 year average recurrence interval (ARI) event, including allowance for climate change and maximum probable development (MPD). Auckland Council's Mahurangi Catchment model (refer Section 4.4) has been used to determine the extent of the 100 year floodplain and it identifies building footprints where flood depth exceeds 100 mm. The model follows the Auckland Council Stormwater Flood Modelling Specifications 2011 which complies with the Ministry for the Environment guidelines for climate change. The specifications for climate change allowance include a 2.1°C temperature increase, rainfall depth adjustment of 16.8% for a 100 year ARI event and an increase in Mean High Water Springs of 0.5 m to account for sea level rise.

The Mahurangi Catchment model uses TP108 design rainfall depths and which are generally 20% higher than those from NIWA HIRDS V3. A calibrated model has also been developed for the Ara Tūhona Pūhoi to Warkworth Road (SH1) Road by NZTA/NX2 that estimates lower flood flows than those reported by the Mahurangi Catchment model. Healthy Waters are currently reviewing regional rain gauge data to determine whether the hydrological parameters used in the model (and therefore the floodplain extent) need to be revised. However in the meantime, the Mahurangi model results can be relied upon for the purposes of the Warkworth Structure Plan. Should more up to date model results be available when the Future Urban Zone is developed then these should be utilised for individual development.

Figure 4.6 below shows the extent of the floodplain for the Warkworth Structure Plan Area. The floodplain extent from the Mahurangi Catchment model is similar, but differs slightly from the 100 year floodplain on Auckland Council Geomaps.

Generally the floodplain is confined to the streams and adjacent areas. Of particular note is the interaction of the floodplain in the valley to the north east of Carran Road. This is a tributary of the north branch of the Mahurangi River which during large flood events can reverse its flow direction and convey flows past Hudson Road and back into the Mahurangi River near the intersection of Falls Road and Mansel Drive.

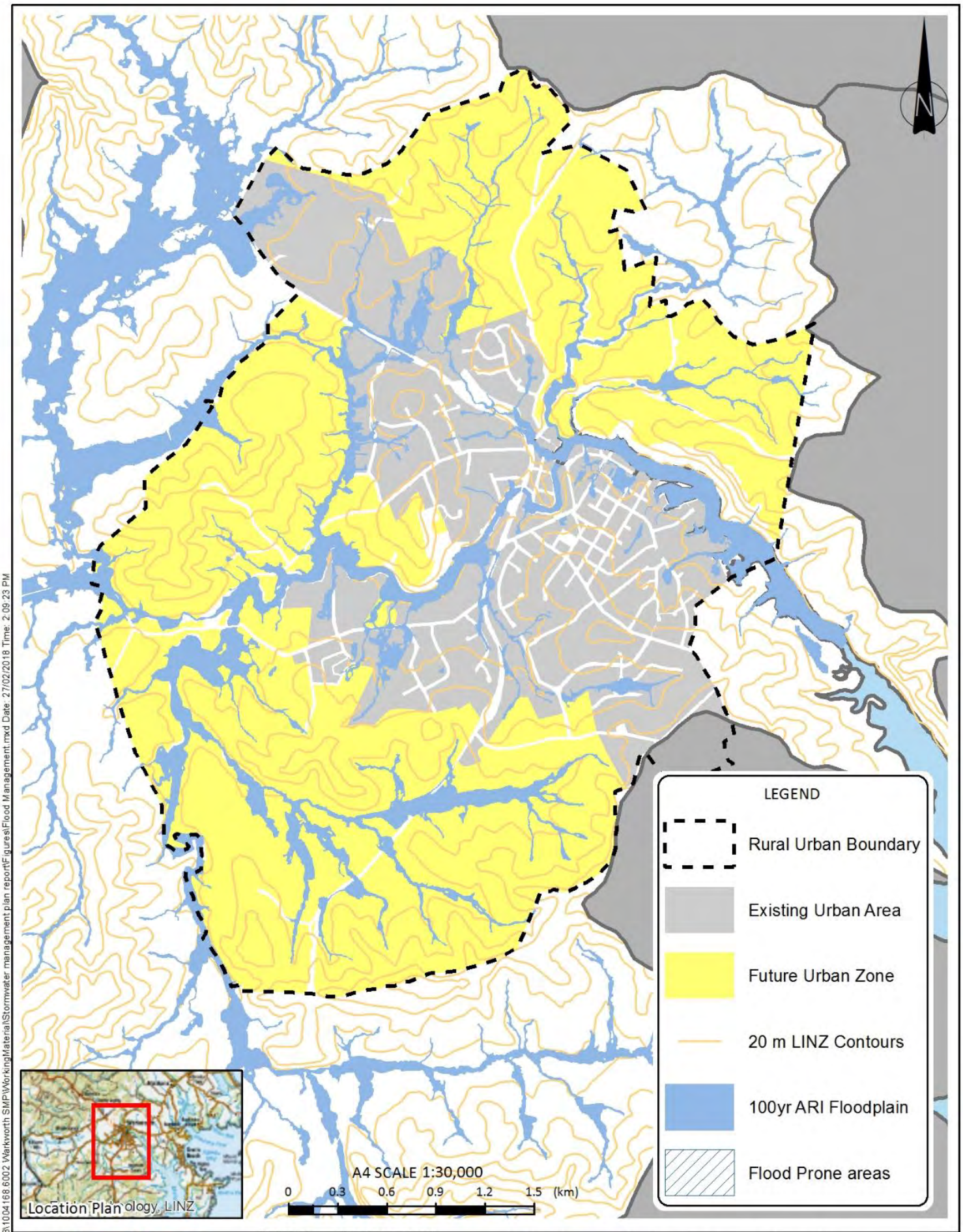
Within the existing Warkworth urban area there are several pockets of buildings where flood depth exceeds 100 mm. These include the industrial area around Morrison Drive, the residential areas around Coquette Street and State Highway 1 and the commercial area around Queen Street. The full set of flood hazard maps from Auckland Council (2017b) are included as Appendix B. However it should be noted that the buildings highlighted on these maps are not necessarily going to be flooded as some will have floor levels that are higher than surrounding flood levels. A floor level survey is currently being undertaken to determine the number of buildings that would be potentially flooded but the results of this analysis was not available at the time of writing.

In the Warkworth Structure Plan Area the 100 year floodplain will act as a constraint for development as generally buildings and infrastructure should not be located within the floodplain. However, the floodplain as a development constraint may overlap with the requirement for protecting permanent and intermittent streams as well as protecting areas of existing riparian vegetation which is prominent along the Mahurangi River.

Also shown on Figure 4.6 are flood prone areas within the structure plan area as determined by the Mahurangi Catchment model. Flood prone areas are defined as topographical depressions that may fill with runoff rapidly during a storm event due to a lack of capacity or blockage of the primary network. They can be natural low points or man-made areas where water can pool (e.g. due to an embankment such as a road). It appears most flood prone areas within the Mahurangi Catchment have been created by road embankments and culverts. If development creates additional flood prone areas these should consider resilience to blockage with consideration of additional/secondary

inlets and overland flow paths. In general bridges are preferred over culverting streams and road crossings of existing streams should be minimised.

Overland flowpaths have also been mapped for the structure plan area but are too detailed to be shown at the scale of Figure 4.6. Overland flowpaths are topographical low points which become the routes by which stormwater runoff is conveyed. Overland flowpaths exclude classified permanent and intermittent streams and have a catchment area over 4000 m^2. Overland flowpaths need to be identified in the design process to ensure that they remain unobstructed and able to safely convey runoff through the development.



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Warkworth Structure Plan Area

Stormwater Management Plan

Flooding

FIGURE No.: Figure 4.6
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4.5.2 Slope instability and liquefaction

Slope instability and liquefaction risk is a key constraint for the use of stormwater management devices that involve infiltration of stormwater runoff to ground (such as raingardens). For further discussion slope instability and liquefaction risk the reader is referred to the Geotechnical and Coastal Hazards Topic Report prepared for the Warkworth Structure Plan Area (Auckland Council, 2018a) which is summarised here where relevant to the SMP.

Most of the natural slopes in the Warkworth Structure Plan Area are generally moderately steep (25-40°) and underlain by deeply weathered materials of the Pakiri Formation. Shallower slopes are formed where underlain by Northland Allochthon materials. There is widespread evidence of shallow soil creep and shallow translational landslides across much of the Warkworth Structure Plan Area and numerous examples of historical and current instability exist along the present road network, including the current SH1 alignment. Shallow landslides can be triggered by the build-up of groundwater at the interface of the soil mantle and underlying weathered bedrock causing a destabilising effect in both Northland Allochthon and Pakiri Formation. This may preclude the use in some areas of stormwater devices that rely on infiltration to meet the policies of the AUP. The Auckland Council Slope Instability Hazard Map (Williams A. L., 1996) shows that a significant portion of the study area is considered a High hazard for general slope instability (refer Figure 4.7).

Figure 4.7: Mapped distribution of high (orange) and medium (yellow) risk areas for slope instability

Liquefaction hazards primarily exist in areas of saturated unconsolidated finer grained soils, although coarse-grained soils may be susceptible to liquefaction under certain seismic conditions. The primary areas of liquefaction hazard in the study area are considered to be alluvial and estuarine sediments in the river valleys.

A study undertaken in 1996 for the Auckland Engineering Lifelines Group identified the areas shown in Figure 4.8 as potentially liquefiable. Because of the low probability of a large earthquake, the likelihood of liquefaction occurring even in these susceptible zones is considered to be low to medium. Currently there is another study by University of Auckland underway that takes into account the latest research and lessons learnt from the 2011 Canterbury Earthquake. While the full findings are not yet available this newer, more reliable research suggests that the liquefaction susceptibility extent from the 1996 study may be overly conservative. It is anticipated that future revisions will show a significantly smaller area that may be susceptible to liquefaction than currently indicated.

Where liquefiable soils are present within approximately 200 m of a watercourse or other free face it should be assumed that they area also susceptible to lateral spreading, which may severely compromise foundations.

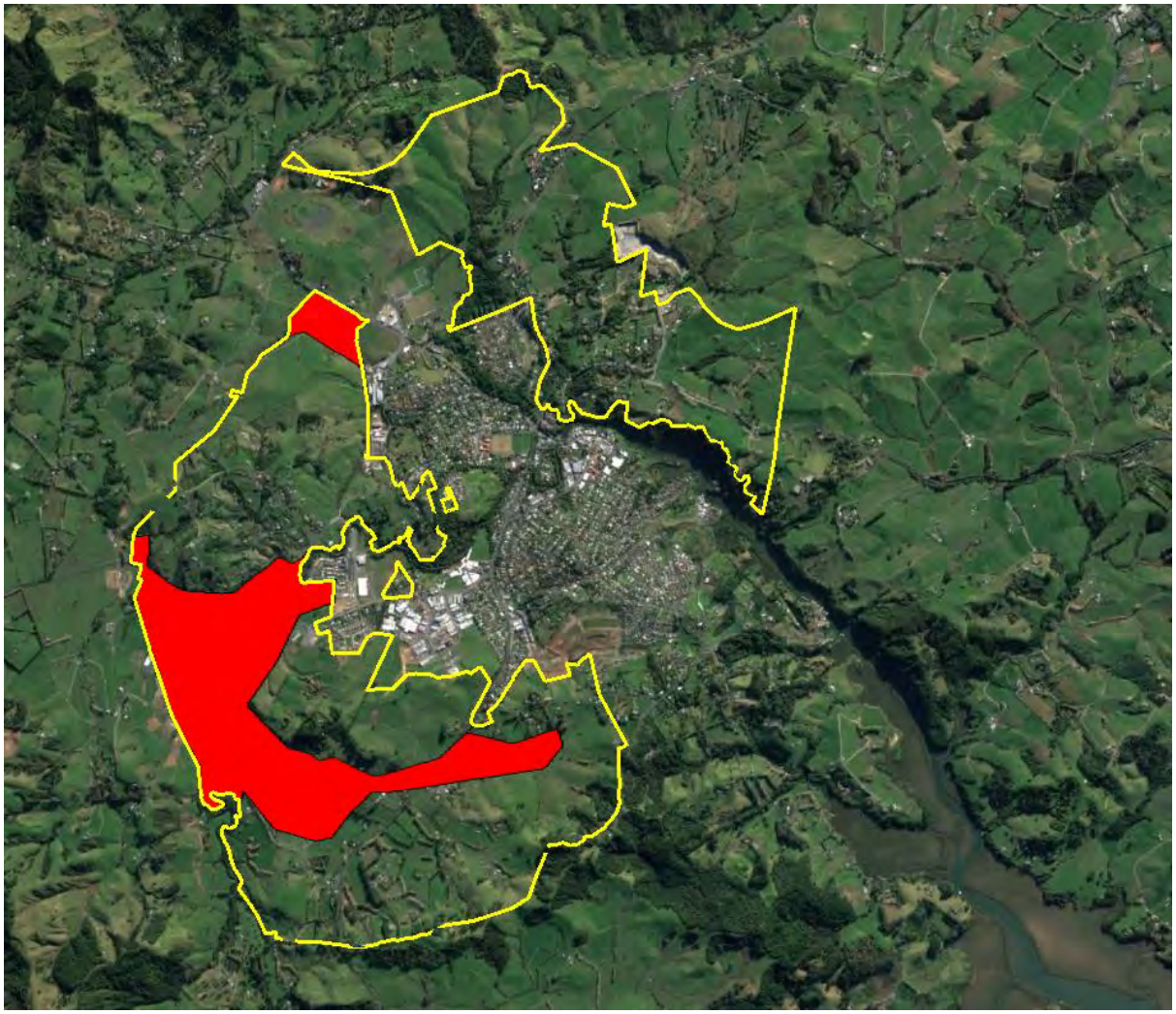


Figure 4.8: Potential liquefaction susceptibility extent

4.6 Receiving environments

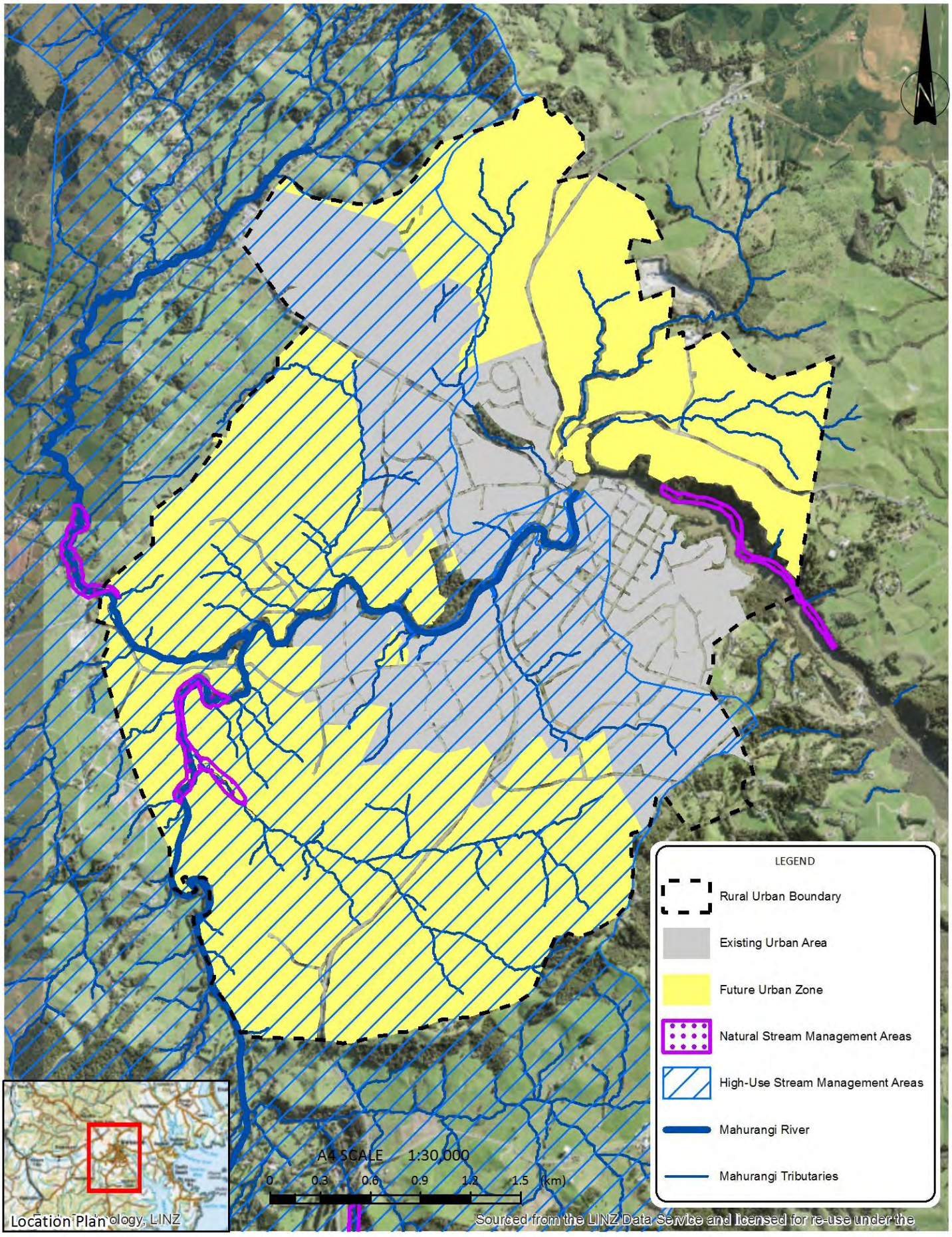
4.6.1 Streams

Streams with the Warkworth Structure Plan Area are all a part of the Mahurangi River system. These streams vary from natural streams with good indigenous riparian vegetation to farm drains. In total approximately 59.3 km of waterways within the Warkworth Structure Plan Area have been identified as 'permanent' or 'intermittent' as per the definitions and criteria within the AUP.

The north and south branches of the Mahurangi River join at the intersection of Falls Road and Woodcocks Road on to the west of the structure plan area and the river then travels west to east, bisecting the study area (refer Figure 4.9). The stream beds of the tributaries of the Mahurangi River generally consist of silt/mud with bedrock and gravels in some reaches while the Mahurangi River itself has a bedrock base. The Mahurangi River catchment is designated as a High-Use Stream Management Area overlay in the AUP due to its use for local water supply. Background, objectives and policies relating to High-Use Stream Management Areas are contained in Chapter D3 of the AUP. Appendix 2 of the AUP states that water use of the Mahurangi River must be managed so that a minimum flow of 35 l/s is maintained. Increases in imperviousness associated with development can increase peak flows during storm events but decrease long term stream baseflows due to a reduction in infiltration. Minimising reductions in infiltration as a result of development is an important consideration for maintaining stream baseflows.

There are also a couple of small pockets of Natural Stream Management Area Overlay designated in the AUP to the west of the Warkworth Structure Plan Area. Background, objectives and policies relating to Natural Stream Management Areas are contained in Chapter D4 of the AUP. The Natural Stream Management Areas overlay identifies river and stream reaches with high natural character and high ecological values. They generally have an unmodified river or stream bed with existing indigenous riparian vegetation on both sides. The presence of indigenous riparian vegetation indicates that the river or stream has high ecological values and water quality. These stream reaches are protected under the AUP. In general all natural systems such as watercourses and their riparian margins should be protected and enhanced regardless, in adherence to WSD principles for development.

More discussion on existing ecological values, erosion and water quality for streams in the Warkworth Structure Plan Area is given in Section 4.7.



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Warkworth Structure Plan Area

Stormwater Management Plan

Stream Overlays

FIGURE No. Figure 4.9

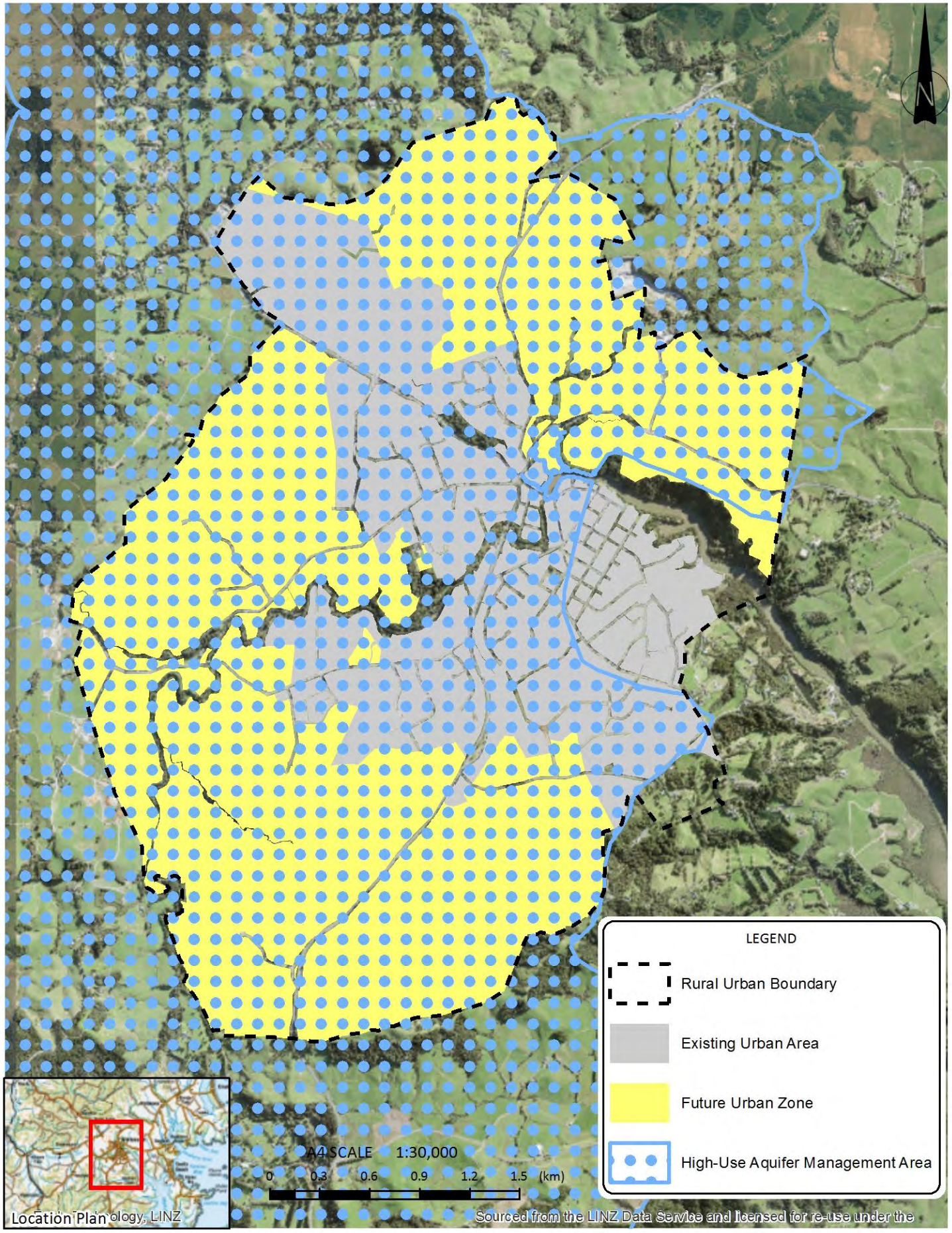
Rev. 0

4.6.2 Aquifers

The Warkworth Structure Plan Area is underlain by the Mahurangi Waitematā aquifer. The aquifer is designated as a High-Use Aquifer Management Area in the AUP (refer Figure 4.10). Background, objectives and policies relating to High-Use Aquifer Management Areas are contained in Chapter D1 of the AUP. Appendix 3 of the AUP identifies the Mahurangi Waitematā aquifer as having an annual water availability of 1,605,500 m^3.

Currently Watercare extract and treat surface water from the Mahurangi River for use as potable water in Warkworth but Watercare are now in the process of changing to a local groundwater bore as the main potable water source. Construction of a new water treatment plant to treat the extracted groundwater began in May 2017 and is due to be completed by mid-2018.

In general, high use aquifers are sensitive to increasing imperviousness which can result in a reduction in infiltration and aquifer recharge. Minimising reductions in infiltration as a result of development is an important consideration for the continuing viability of aquifer resources. Further work needs to be undertaken to determine the sensitivity of the Mahurangi Waitematā aquifer to changes in catchment imperviousness.



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Warkworth Structure Plan Area

Stormwater Management Plan

Aquifer Overlays

FIGURE No. Figure 4.10

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4.6.3 Coastal marine area

The Warkworth Structure Plan Area drains to the Mahurangi Harbour which is a valuable fishing, aquaculture and general recreational resource. The Mahurangi Harbour is a drowned river valley. It contains many small bays and upper estuaries, with large intertidal areas that are exposed during the tidal cycle and are comprised of soft muddy sediments. The remainder of the harbour has large areas of permanent water and less soft sediments.

Sediment generation and deposition has been identified as a key issue in the Mahurangi Harbour and a number of studies and initiatives have been undertaken in recent years to address the issue. In 2004 the Mahurangi Action Plan was initiated by the Auckland Regional Council and Rodney District Council in response to indications that the water quality of the Mahurangi Harbour was in decline due to increased sedimentation. The plan details how the rates of sediment entering the harbour had significantly increased as a result of human activities including deforestation, development, and intensive landuse. The vision of the plan is to restore and maintain a healthy Mahurangi River and Harbour with the key to this being good water quality. In order to achieve a healthy harbour and river, sound land management practices aimed at reducing sedimentation are required. The most recent version of the plan prepared in 2010 sets out a number of objectives and priority actions for 2010-2030 of which Council is the lead party for many of them.

In July 1994 a long-term ecological monitoring programme of Mahurangi Estuary's intertidal and subtidal benthic communities was commissioned by the then Auckland Regional Council. The most recent results of the ecological monitoring are presented in Auckland Council's Marine Water Quality Annual Report 2015 (Auckland Council, 2017d). The two monitoring sites in the Mahurangi Harbour, Dawson's Creek and Mahurangi Heads, were given a marine water quality index of 'Good' and 'Excellent', respectively. A more detailed summary of the historical monitoring data for the Mahurangi Harbour is presented in Auckland Council's Technical Report 2013/038 (NIWA, 2013).

Under the AUP the upper Mahurangi Harbour is classified as a 'Degraded 1' area while the lower harbour is classified as 'Degraded 2' (refer Figure 4.13). The downstream estuarine and harbour environs of the Mahurangi River are also identified in the AUP as significant ecological areas (SEAs). The location of these are shown on Figure 4.11 and they are classified as follows:

- SEA-M2-76a – Intertidal flats Mahurangi Harbour.
- SEA-M1-76b, 76c, 76d – Mangroves Mahurangi Harbour.

Background, objectives and policies relating to SEAs are contained in Chapter D9 of the AUP.

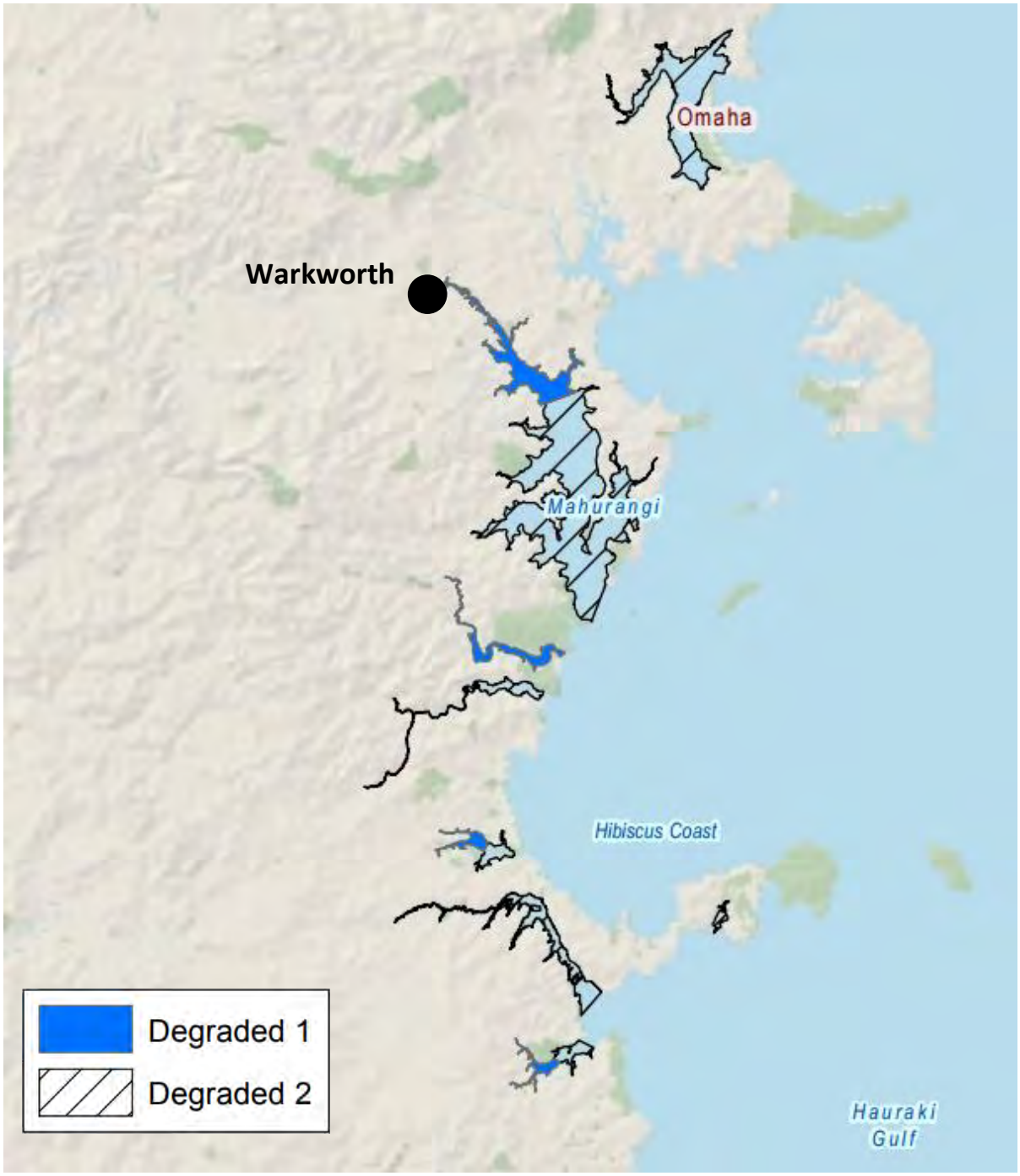


Figure 4.11: Degraded marine areas (source: AUP Chapter B7 Toitū te whenua, toitū te taiao – Natural resources)

4.7 Stream ecology, erosion and water quality

There are a number of streams within the Warkworth Structure Plan Area which play a critical role in conveyance of runoff as well as providing ecological, cultural (mauri of water) and amenity value within the catchment. Stormwater runoff from impervious surfaces can adversely affect stream health due to increased contaminant and sediment concentrations which can negatively impact stream ecology and water quality. Impervious surfaces can also result in changes in hydrology namely increased velocity, peak flows and duration of bank-full flows which can lead to stream bank erosion.

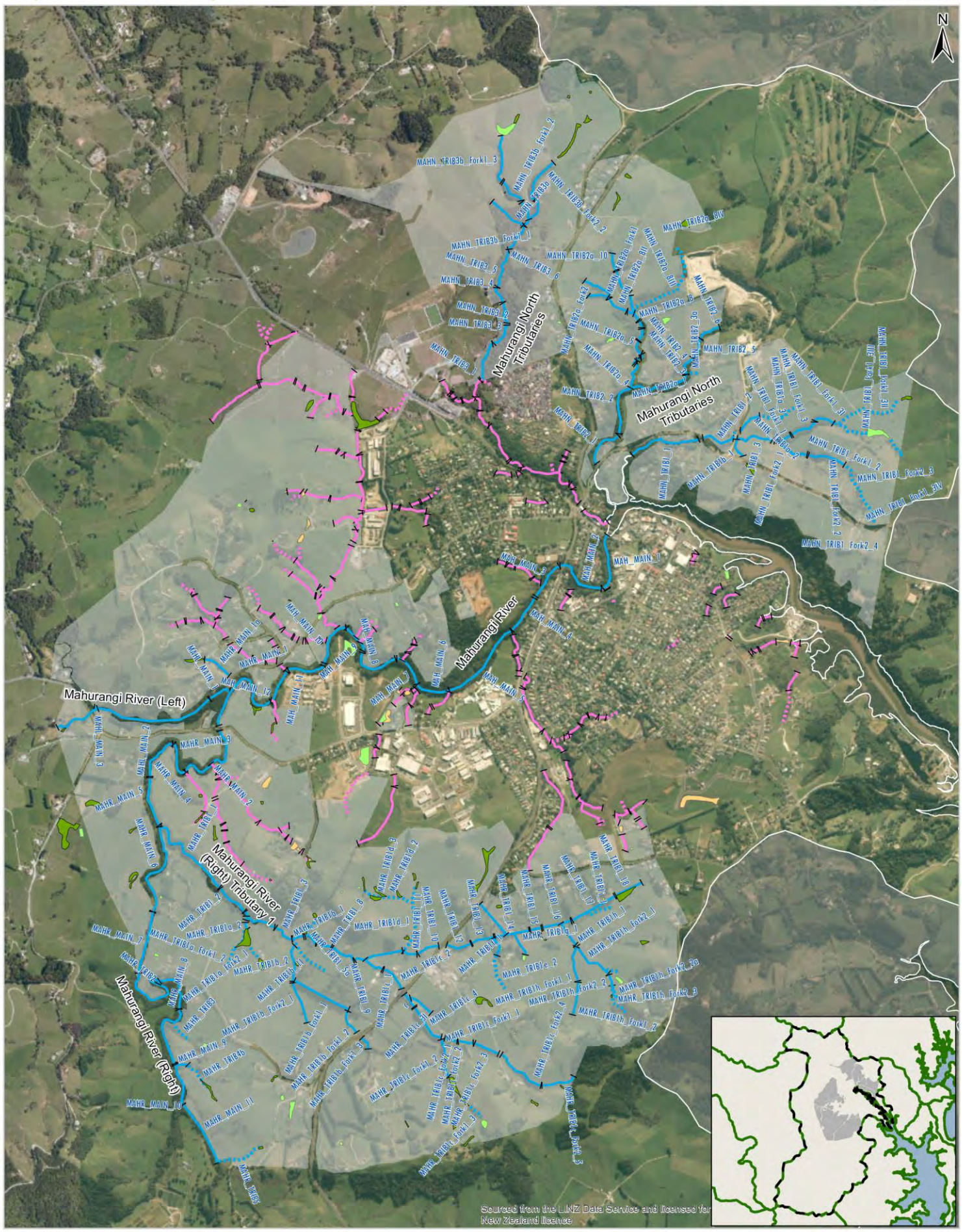
Watercourse assessment reports (previously called watercourse management plans and streamwalk reports) provide baseline information on the existing condition of waterways in both urban and rural settings. This includes the assessment of both infrastructure and environmental characteristics. Watercourse Assessment Reports aim to provide information that can be used to maintain high value streams where they exist and enhance degraded streams. The outputs if watercourse assessment reports are used by Council as key resource in the management of waterways. The following assessments have been undertaken for streams in the Warkworth Structure Plan Area to date:

- 'Stream Survey and Asset Condition Assessment- Warkworth Catchment 2007-2009'. Prepared by Morphum Environmental Ltd. for Rodney District Council (Morphum, 2009). This study involved survey of tributaries of the Mahurangi River to the west of the existing Warkworth urban area (20.75 km of stream).
- 'Mahurangi Stream Walk Assessment Report' dated May 2013 prepared by Auckland Council (Auckland Council, 2013). This study involved survey of the lower 3.5 km of the Mahurangi River from the confluences of the north and south branch until the Elizabeth Street Bridge.
- 'Warkworth Stream Classification and Esplanade Assessment' dated April 2018 prepared by Morphum Environmental Ltd. for Auckland Council (Morphum, 2018a). This study involved the verification of the stream classification model (The Stream Delineation Tool) at 141 locations, mapping and field assessment of 99 wetlands, as well as all streams wider than 3 m for potential esplanade vestment within the Future Urban Zone.
- 'Warkworth Watercourse Assessment Report' dated June 2018 prepared by Morphum Environmental Ltd. for Auckland Council (Morphum, 2018b). This study involved survey of tributaries of the Mahurangi River to the north and south of the existing Warkworth urban area (25.76 km of stream) with the western ones having being surveyed in 2009.

The June 2018 Watercouse Assessment Report (Morphum, 2018b) collates the data gathered from all the stream assessments undertaken to date and provides some interpretative commentary on stream values and pressures. The key findings of this assessment in relation to stormwater management are summarised in the following subsections. For more detailed information on the current state of streams the reader is referred to the June 2018 Watercouse Assessment Report (Morphum, 2018b).

Approximately 59.3 km of waterways within the Warkworth Structure Plan Area have been identified as 'permanent' or 'intermittent' as per the definitions and criteria within the AUP. Further to this, 143 'wetlands' were identified, as defined by the Watercourse Assessment Methodology v2.0 (Auckland Council, 2016). The location of the classified permanent and intermittent streams and wetlands within the Warkworth Structure Plan Areas are shown in Figure 4.12 below. These features are subject to the objectives and policies presented in Section E3 of the AUP.

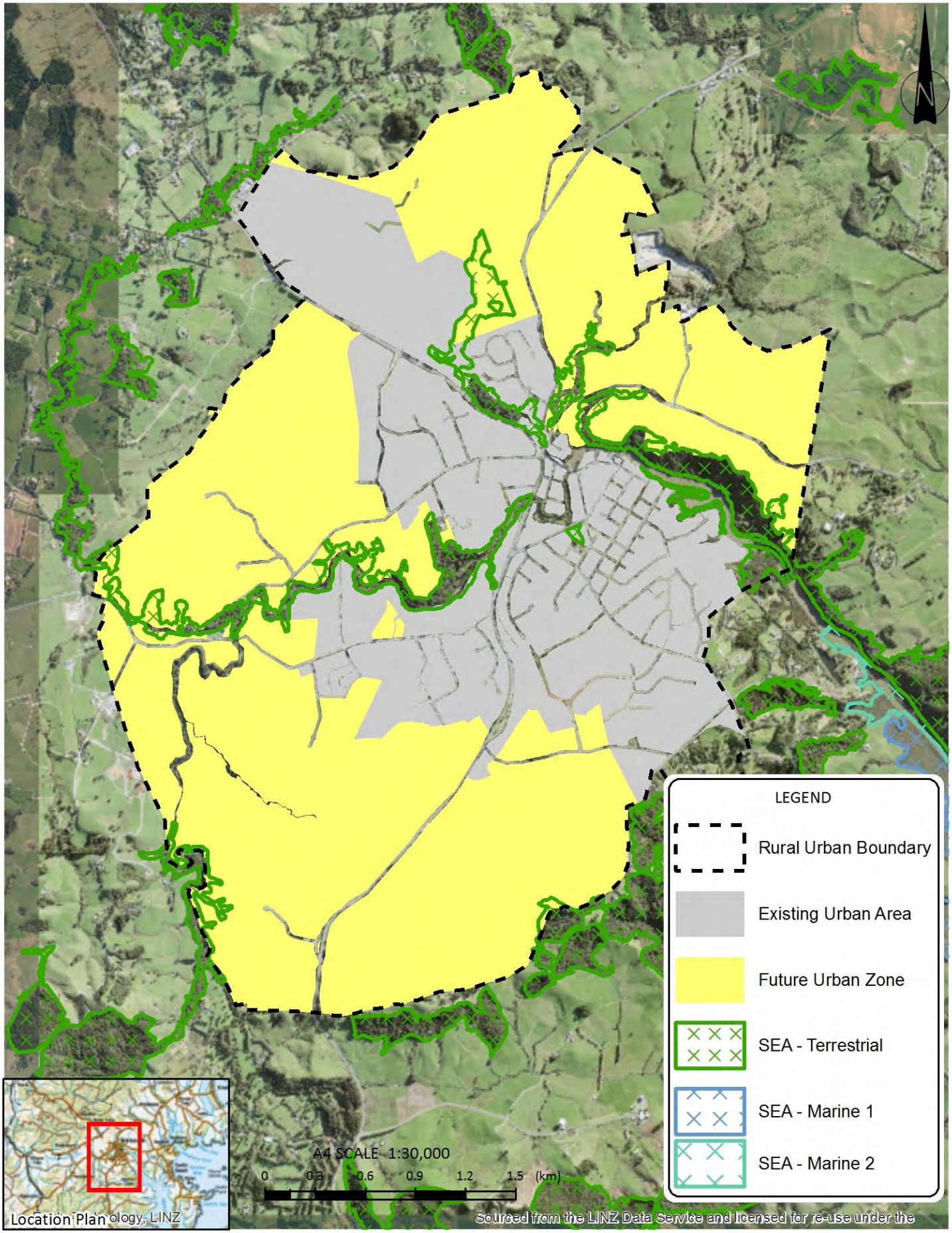
Figure 4.12: Stream classification (source: Morphum (2018b))



4.7.1 Ecology

Many streams within Warkworth are within remnant/regenerating native vegetation or mature and well-established vegetation. These areas, in many cases, have reserve status or are designated terrestrial SEAs (refer Figure 4.13). The associated stream reaches are characteristic of high value waterways with diverse habitat complexity, pool, riffle run sequences and stable undercut banks affording abundant under bank habitat, and generally stable banks supported by riparian vegetation. With regards to freshwater ecological values, the 2018 Watercourse Assessment (Morphum, 2018b) made the following conclusions:

- Streams are generally unmodified, with 79% of surveyed stream length having no modification. 20% of the surveyed stream length have undergone some channel straightening (predominantly in the floodplain areas south of the Warkworth town centre), while 2% have some form of lining.
- Overhead vegetation cover of the streams is variable and range from good to poor. Only 20% of the surveyed stream length has 70% or more riparian cover while just over half the surveyed stream length (56%) has less than 50% riparian cover. Most of the northern streams have good cover for at least some of their length. The areas where cover is most deficient were the watercourses in the floodplains south of Warkworth and the tributaries of the Mahurangi to the west. Here many of the streams have less than 10% riparian cover.
- Generally, the streams were found to have less than 20% periphyton or macrophytes (emergent or submergent). Significant macrophyte growth (greater than 50% coverage by emergent macrophytes) is present within 24% of the surveyed stream length, while 65% of surveyed stream length has less than 20% emergent macrophyte coverage. A common area for emergent macrophytes was the Mahurangi Right Branch, although some were also noted on the tributary alongside Sandspit Road. Periphyton has greater than 50% coverage in approximately 16% of the surveyed stream length, with communities generally dominated by green and/or brown filamentous algae. Extensive algal growth can indicate raised nutrient levels, or high light conditions (green algae).
- A total of ten species of native fish (inanga, shortfin eel, longfin eel, banded kokopu, redfin bully, common bully, giant bully, torrentfish, common smelt and Cran's bully) and two species of exotic fish (perch and mosquitofish), plus the freshwater crayfish koura (Paranephrops planifrons), the freshwater shrimp Paratya curvirostris and the freshwater mussel kakahi (Hyridella menziesii) – all of which are endemic – have been recorded in the wider Warkworth catchment. These records include historic records from the NZ Freshwater Fish Database (NZFFD), observations by Morphum staff while carrying out stream assessments in 2006/7 and 2018, and fish caught by Auckland Council staff undertaking whitebait trap-and-transfer operations.
- There is a large amount of potential suitable habitat available for native fish in the upper catchment. The relative lack of records for fish other than eels in the upper catchment suggests that the distribution of species is likely to be influenced by the presence of downstream barriers to fish passage. A total of 142 potential fish passage barriers (natural and artificial) have been identified in streams across the Warkworth Structure Plan Area. The most noteable are the defunct Bridgehouse Weir located immediately downstream of the Elizabeth Street Bridge (outside the Structure Plan Area) and the Auckland Council owned hydrological gauging weir located adjacent to Mahurangi College. Removal and/or fish pass retrofit of both the Bridgehouse and Council gauging weirs, would allow whitebait and other migratory native fish species to access the extensive amount of upstream available habitat that is currently under-utilised, as a result of these barriers.



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Warkworth Structure Plan Area

Stormwater Management Plan

Ecology Overlays

FIGURE No. Figure 4.13

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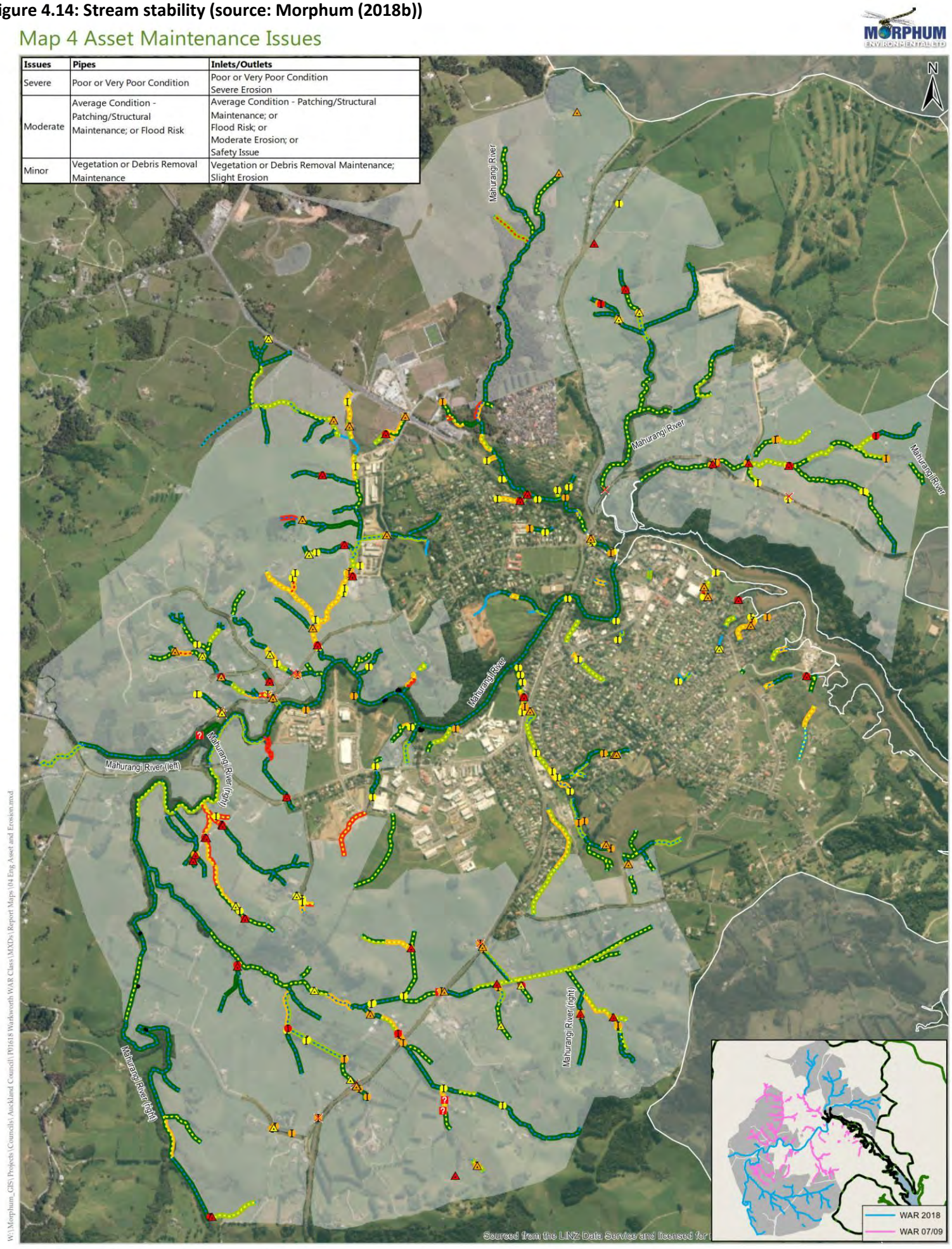
4.7.2 Erosion

Stream bank erosion is evident in the surveyed streams within the Warkworth Structure Plan Area. Within the Warkworth Structure Plan Area, high erosion potential is linked to the soil types, underlying substrates, steep ground and land use, particularly within the northern tributaries. Erosion contributes to sedimentation within streams and the downstream marine environment and can result in an adverse effect to instream habitat. Further to this, ongoing bed lowering or channel widening could impact infrastructure on the bed and banks of watercourses (both existing and proposed) if left unmitigated. Increasing impervious area through development is likely to increase the erosion risk and sediment load in the watercourses.

Channel bank stability was assessed for the main streams and tributaries in the Warkworth Structure Plan Area in Morphum (2018b). 52% of the surveyed stream length is classified as 'Good' in terms of stream bank stability and 43% is classified as 'Fair', while only 2% is classified as 'Poor' as calculated using the modified Pfankuch bank stability scoring methodology as described in Auckland Council (2016). Fair to poor bank vegetation providing low density root mass to stabilise banks was the most common limiting factor of bank stability. 70% of surveyed stream bank surveyed has less than 20% erosion scarring while 5% of stream bank had more than 60% erosion scarring. Figure 4.14 shows the Pfankuch stability classification for the assessed streams within the structure plan area as well as the degree of erosion scarring observed. Stream stability should be taken into account for plan changes and resource consents when considering changes in hydrology and effects on receiving streams in the context of the objectives and policies of the AUP (refer Section 3.5.6).

Figure 4.14: Stream stability (source: Morphum (2018b))



4.7.3 Water quality

Factors influencing current water quality within the Warkworth Structure Plan Area include the removal of riparian vegetation, livestock access to waterways and pollution from agricultural runoff. These factors have influenced water quality, as well as reduced habitat diversity and biodiversity. However, as the catchment currently has a low extent of impervious surfaces, a low degree of channel modification, and comparatively low pollution from stormwater and wastewater discharge, the water quality overall for the catchment is rated as "good" in Auckland Council's 2016 freshwater report card (Auckland Council, 2018b). Since monitoring began in 1993, nutrient concentration has declined at Auckland Council's long-term monitoring sites (Auckland Council, 2018b).

Despite a number of studies and initiatives undertaken in recent years, sedimentation remains a key issue in the wider Mahurangi harbour catchment. Sedimentation management will be an important consideration in planning and implementation as Warkworth is developed and impermeable areas increase. Recent sediment deposition in streams has been assessed as part of the Warkworth Watercourse Assessment (Morphum, 2018b). At the time of survey 54% of the surveyed stream length were estimated to have greater than 40% active sediment deposition over the stream bed. The mean percentage cover of active sediment deposition was 48%, however some reaches were estimated to have the entire channel bed covered with sediment.

The watercourse assessment protocol does not assess water turbidity, but observations during the assessment were that following heavy rain events, the main watercourses had elevated turbidity and high associated sediment loads. Whilst some of this likely came from bank erosion, the source was not identified. It is likely that the main sources of sediment load are from the first order streams, in the upper catchment areas which are affected widely by stock damage. Land use and stocking effects have resulted in poor condition of many ephemeral and intermittent reaches. Additionally, clear-felled forestry practice and construction such as the Ara Tūhona Pūhoi to Warkworth highway are also likely sources (noting that earthworks consents with erosion and sediment requirements are in place, but all projects with earthworks still discharge some sediment).

Anaerobic conditions occur when dissolved oxygen levels within the water and sediment column decline to low levels. Adequate dissolved oxygen levels are necessary for maintaining aerobic conditions, and supporting the health of aquatic organisms. Oxygen levels can be depleted through aquatic plant (macrophytes and phytoplankton) respiration and decaying organic matter. In the Warkworth Structure Plan Area five observations of anaerobic conditions were made, all located in watercourses with agricultural land use, low (< 30%) canopy cover, high (> 70%) macrophyte cover, and stock access on both banks. Severe stock damage was recorded at 40% of these sites, with a further 40% sites with minor stock damage (Morphum, 2018b). Stock access to watercourses, apart from the physical bank damage, increases the nutrient loading in the watercourse as well as the introduction of E.coli from defecation.

4.7.4 Stream management and enhancement opportunities

The watercourses in the Warkworth Structure Plan Area have valuable ecology with many largely intact streams and riparian areas. Whilst there are large areas that have been modified for agricultural purposes (including clearance of riparian vegetation and channel modification), these can be rehabilitated through greenfield development processes to reconnect the riparian corridors and re-develop hydraulic and habitat diversity. Morphum (2018b) has identified a number of water management actions to support the general outcomes sought by the AUP:

- There are known risks of sediment discharge, and consequent elevated turbidity within this catchment. It is encouraged to manage erosion and sedimentation risks through best practice and to strive to exceed the minimum standards in this susceptible catchment.
- Preservation of all existing intermittent and permanent open watercourses through avoidance of any further reclamation or diversion.
- Protection and enhancement of ecological values including the protection of existing open watercourse, development setbacks, and planting of riparian corridors.
- Stormwater management including, at source, bioretention to manage effects on the receiving environment, to mitigate and regulate baseflows, and to maintain ecological biodiversity values.
- Construction and upgrade of stormwater treatment wetlands to promote integrated, catchment based stormwater quality and flood management measures.
- Restoration of wetlands to help regulate stream flows and enhance ecological functions.
- Restoration of riparian areas to promote ecological connectivity between Significant Ecological Areas and reduce fragmentation.
- Naturalisation of modified watercourses to re-develop hydraulic and habitat diversity.

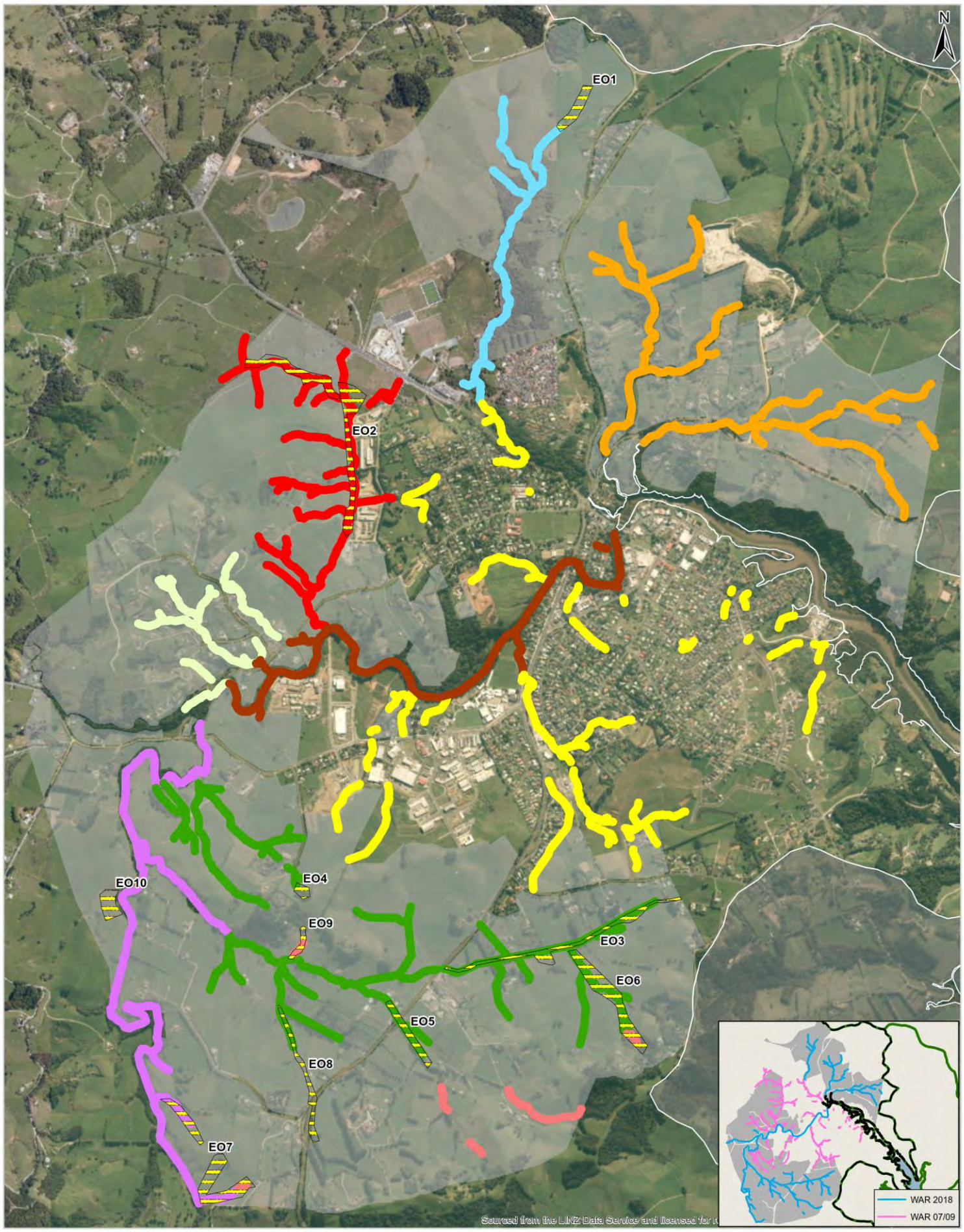
Morphum (2018b) has divided the streams within the Warkworth Structure Plan Area into nine management zones based on reaches with similar pressures, issues, and enhancement drivers. A summary of proposed management objectives for each management zone is summarised in Figure 4.15 below. The extent of each management zone is shown on Figure 4.16.

Table 3: Summary of Management Zones and Objectives

	Management Zones	Stream Naturalisation	Online Pond Remediation	Water quality treatment	Fish Passage Remediation	Erosion Remediation	Water sensitive Communities	Fencing	Riparian vegetation enhancement	Weed Control	Sediment control	Wetland restoration	Industrial Pollution Control and Compliance	Ecological connectivity
MZ1	North East - Sand Spit and Quarry Road				✓	✓		✓	✓		✓			✓
MZ2	North - Showgrounds		✓		✓	✓		✓	✓	✓				✓
MZ3	North - Hudson Road Industrial Zone	✓				✓		✓	✓	✓			✓	
MZ4	North - Residential Hills					✓			✓	✓				✓
MZ5	Mahurangi Right Branch		✓		✓			✓	✓		✓			✓
MZ6	South - Floodplains	✓						✓	✓	✓		✓		✓
MZ7	South - Headwaters					✓		✓	✓		✓			✓
MZ8	Mahurangi Main					✓	✓		✓		✓		✓	✓
MZ9	Mahurangi Urban			✓		✓	✓		✓	✓			✓	

Figure 4.15: Summary of management zones and objectives (source: Morphum (2018b))

Figure 4.16: Management Zones (Source: Morphum (2018b))



4.8 Knowledge gaps

The following information is required to further inform the production of a detailed stormwater management plan and/or to support plan change hearings:

- Final proposed land use and development type/layout. This is currently being developed during the structure plan process, taking into account this preliminary SMP. A draft Warkworth Structure Plan has been reviewed with regards to stormwater management and this review has been summarised in Auckland Council (2019).
- Site investigations to confirm soil types and extents, groundwater levels and soil permeability. This will identify which areas are more conducive to infiltration so these characteristics can be preserved and utilised for stormwater management.
- Confirmation of the hydrological parameters (rainfall depths and curve numbers) and potentially the reassessment of the catchment flood flows and flood extents. The context for this is that Auckland Council (2017b) used guidance (TP108) based assumptions hydrological parameters, whereas NZTA/NX2 for Ara Tūhona Pūhoi to Warkworth Road (SH1) Road has developed a calibrated model that estimates lower flood flows.
- Floor level survey to confirm which existing buildings are at risk of potential flooding. Assessments of how the landuse and infrastructure changes might cause flood effects. This analysis is currently being undertaken by Healthy Waters at the time of writing.
- Assessment to determine whether minimising or mitigating hydrological changes requires more than hydrological mitigation (i.e. retention and detention outlined in AUP Section E10). This assessment should give consideration to:
  - The extent of development and the likely changes to the hydrological regime.
  - The erosion susceptibility of streams prior to development and their sensitivity to changes in hydrology. This may involve further interpretation of the Watercourse Assessment data collected to date but may also involve targeted site visits to confirm geomorphic processes.
  - What degree of hydrological mitigation (i.e. detention and retention) can practicably be achieved for the development (e.g. viability of infiltration and water reuse).
  - What opportunities exist to mitigate any changes in hydrology that remain after hydrological mitigation (e.g. in-stream works).
- Groundwater study to determine the effect of increased imperviousness on the Mahurangi Waitematā Aquifer and the interaction with the Mahurangi River.

5 Stormwater constraints and opportunities

Table 5.1 below identifies site specific constraints and opportunities for stormwater management in the Warkworth Structure Plan Area.

Table 5.1: Stormwater constraints and opportunities

Managing flood risk	**Constraints**	• Upstream development may increase the flood risk to existing buildings in Warkworth. If this is found to be the case then catchment scale attenuation devices may be required to avoid increasing flooding to habitable floors. • Any new development should occur outside of the 100 year floodplain as identified in Figure 4.6. • Allow for conveyance of overland flow.
	Opportunities	• Protection of 100 year floodplain also provides an opportunity to enhance riparian corridors. This provides enhanced stormwater management functions, contributes to the ecological values of stream corridors and provides public amenity. Green corridors should be considered to manage the flood hazard, protect ecological values, provide amenity and for walking and cycling tracks.
Minimising and mitigating hydrological change	**Constraints**	• The presence of low permeability ultic clays in the structure plan area may preclude the use of infiltration devices in some areas. • Slope instability risk may preclude the use of infiltration devices in some areas. • The viability of water reuse as a stormwater management tool is contingent on land use activity and will need to be assessed on a site by site basis.
	Opportunities	• The structure plan area is a greenfield area which provides an opportunity to incorporate integrated stormwater management to maintain pre-development hydrology. • Providing opportunity for on-site infiltration to improve aquifer recharge and stream baseflows. • Providing opportunities for water reuse especially for housing and for industrial/commercial activities (depending on water demand).
Opportunities to enhance freshwater systems	**Constraints**	• Permanent and intermittent streams will need to be protected. • Riparian buffer areas around streams needs to be included. In some areas existing riparian vegetation has been classified as a terrestrial SEA and must be protected.
	Opportunities	• Water quality in the water bodies within the structure plan area is currently relatively good for an urban catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality. • Design stormwater management for future urban areas that provides for a high level of water quality to protect the high ecological values and good water quality present in the area. • Use riparian margins as part of the water conveyance system and to provide connections to other freshwater systems and other habitat types. • The change in land use from rural land to urban is an opportunity to revert to natural sedimentation loading in freshwater systems and in the harbour. • Naturalisation of existing modified watercourses to re-develop hydraulic and habitat diversity. • Removal/modification of artificial fish passage barriers to improve the ability of migrant fish species to access upstream habitat. • Restoration of wetlands to help regulate stream flows and enhance ecological functions. • Erosion and sedimentation management during development applying best practice that responses to the sensitive receiving environments and aspirations for freshwater management set out in the SMP and AUP

6 Implementing integrated stormwater management

This section presents high level guidance on how stormwater will be managed within the Warkworth Structure Plan Area. It provides a framework for stormwater management which should be considered as part of an interdisciplinary planning process to allow for implementation of an integrated design approach. More specific guidance to reflect area specific management issues and infrastructure requirements will be given in the final SMP for the structure plan area. An overview of integrated stormwater management is presented in Section 3.5.3.

6.1 Stormwater management requirements

General

- Use an integrated stormwater management approach involving WSD (refer Section 6.2).
- Remove or modify artificial fish passage barriers where possible to improve the ability of migrant fish species to access upstream habitat.

Water quality

- Provide near-source water quality treatment of runoff for all roads and High Contaminant Generated Carparks (>30 carparks). Water quality treatment to target sediment, metals and gross pollutants.
- Use “inert” building materials, or otherwise site-specific treatment is required.
- Minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges.
- Erosion protection within the stormwater network including discharges to streams. Consider green outfalls for discharges to streams.

Minimising and mitigating hydrological change

- Further assessment that considers the site-specific constraints of the Warkworth Structure Plan Area is required to determine how to minimise or mitigate any changes in hydrology and whether it can practicably be achieved. If there are residual impacts on streams after implementing hydrological mitigation then other solutions such as in-stream works should be considered to mitigate the effects of changes in hydrology.
- After exploring location specific options in accordance with greenfields policies and where those options are demonstrably not practical to implement, the minimum standard shall be to provide ‘hydrological mitigation’ in accordance with Table E10.6.3.1.1 of the AUP where the specific effect to be managed is in-stream erosion.
- Utilise stormwater infiltration for retention where it is possible to do so in a safe, and effective manner.
- Utilise rainfall harvesting for retention for residential buildings and industrial/commercial where there is re-use demand.

Flood management

- Use streams and their associated riparian margins to provide storage and conveyance to manage flood waters.
- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be design to be resilient to flood related damage.

- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.
- Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.

6.2 Application of water sensitive design

In addition to the stormwater management requirements listed above the following water sensitive design approach is recommended for the Warkworth Structure Plan Area as part of an integrated stormwater management approach. This framework is a hierarchy of recommended WSD solutions adapted from guidance in GD04. The hierarchy begins with the most effective top of catchment interventions (source control and at-source management) and finishes with bottom of catchment interventions such as enhancing the receiving environment.

Figure 6.1 below summarises the water sensitive design approach for the Warkworth Structure Plan Area. The following subsections describe each of these measures in further detail.

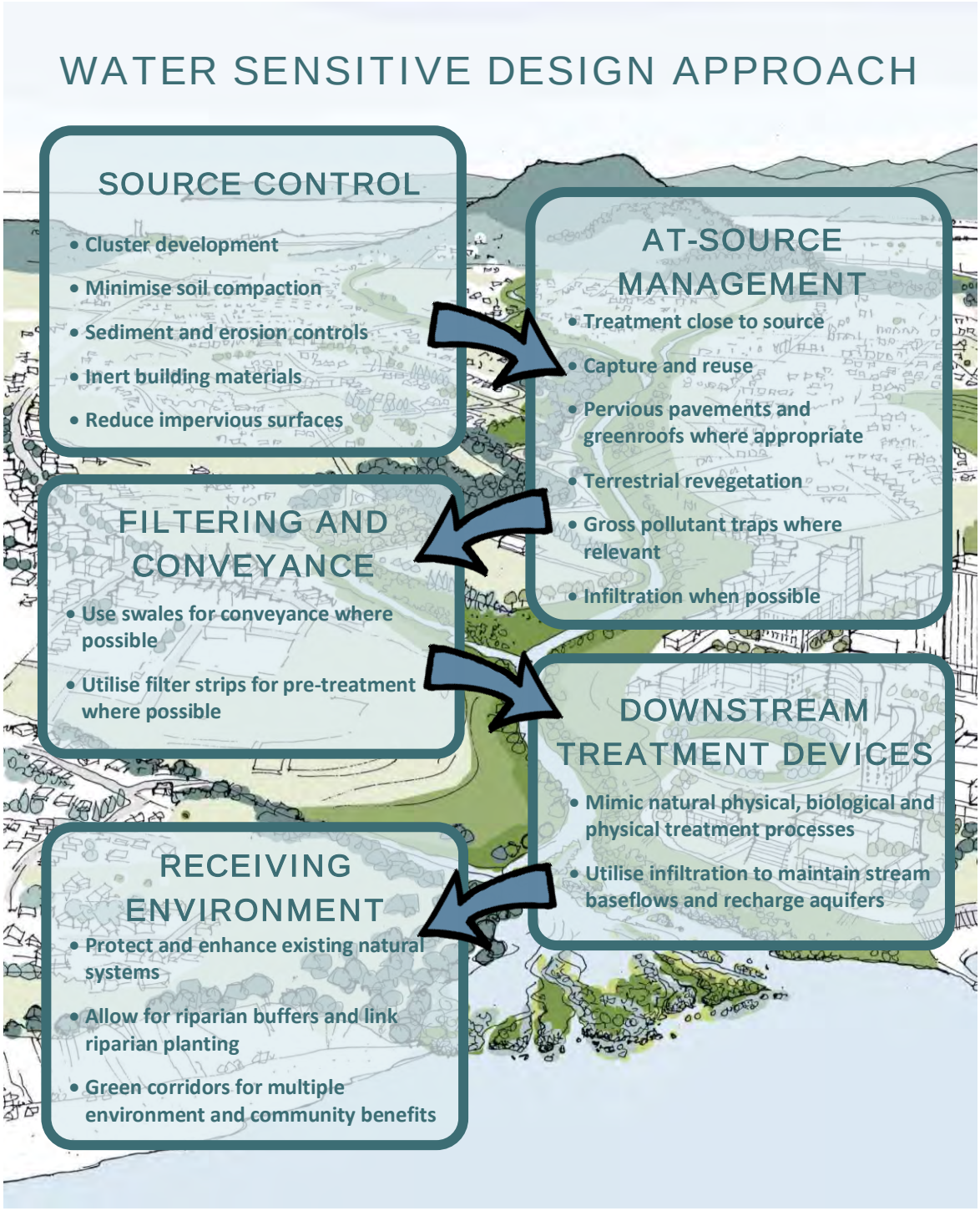


Figure 6.1: Water sensitive design approach summary (background picture sourced from GD04 (Auckland Council, 2015))

This is essentially forms a preliminary version of the stormwater treatment train. A treatment train is the combination of sequential stormwater management responses that collectively deliver stormwater quality and quantity objectives for a site. The treatment train is based on a logical sequence of stormwater flowing through a catchment, beginning with stormwater runoff controls at-source, followed by capture and treatment of overland flows, and finally the enhancement of receiving environments to enhance their stormwater management function. Figure 6.2 and Figure 6.3 provide examples of treatment trains.

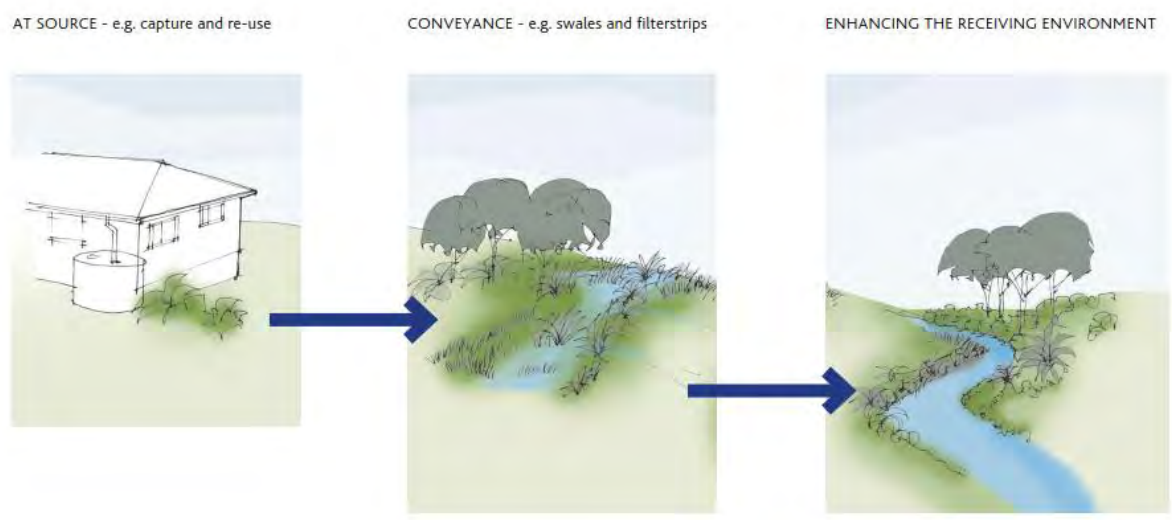


Figure 6.2: Example of a treatment train for water quantity (source: GD04 (Auckland Council, 2015))

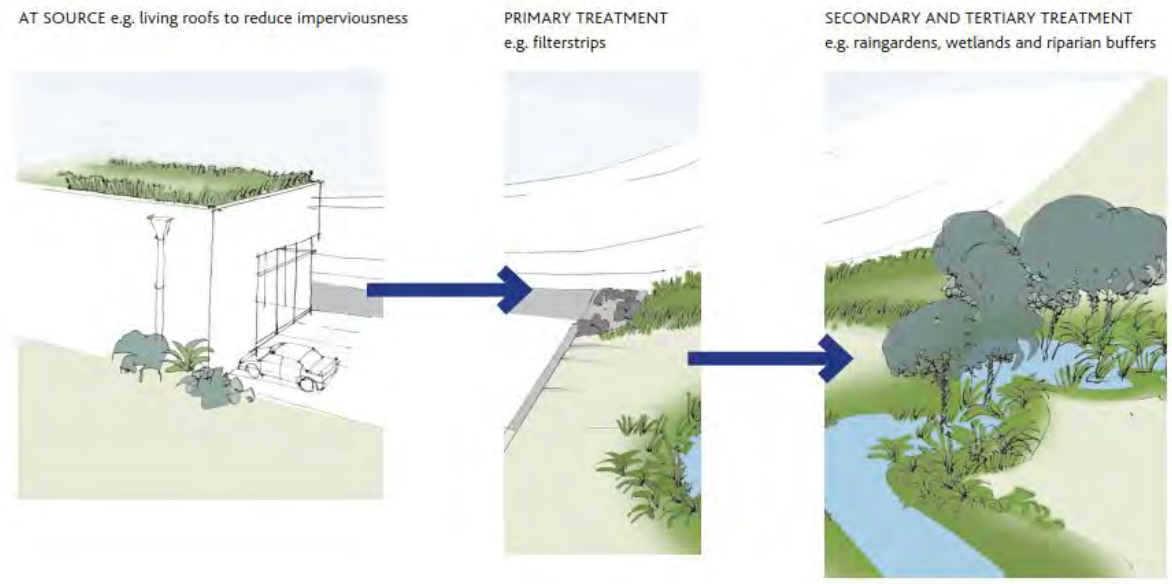


Figure 6.3: Example of a treatment train for water quality (source: GD04 (Auckland Council, 2015))

6.2.1 Source control

Source controls seek to minimise the generation of stormwater runoff and its associated contaminants. The following source control measures should be considered for the Warkworth Structure Plan Area:

- Minimise land disturbance and cluster development. 'Clustered development' involves increased density or built form in appropriate areas of a site or catchment in order to preserve the balance of area for ecosystem services.
- Minimise the degradation and compaction of site soils. This may also involve consideration of alternative land development approaches, other than the traditional 'cut-to-fill' operations for site levelling, in some areas or the protection of some communal infiltration areas.
- Apply best practice or enhanced (i.e. exceeding minimum requirements in GD05) sediment and erosion controls during construction to reduce sediment runoff.

- Design buildings using “inert” materials to minimise contaminant generation.
- Minimise impervious surfaces in the development. Reduced imperviousness increases opportunities for rainfall to be attenuated within vegetation and soils and is also likely to reduce the contaminant load, since there is less surface area for deposition of contaminants and more vegetated areas to capture and transform contaminants. Minimising impervious surfaces may include the following approaches:
  - Shared driveways.
  - Shared road surfaces for low traffic environments.
  - Replacing impervious surfaces with pervious paving, living roofs, etc.
  - Aggregating buildings and ancillary structures to reduce total footprint and access requirements.

6.2.2 At-source stormwater management

WSD promotes the management of stormwater runoff as close to source as possible to reduce the potential for lower catchment stormwater effects. The following measures are proposed for the Warkworth Structure Plan Area:

- Capture and reuse of rainwater for buildings and landscape areas where appropriate.
- Use at-source stormwater management devices such as pervious pavements, living walls and green roofs where appropriate.
- Include terrestrial re-vegetation throughout the catchment to reduce runoff volumes, decrease runoff temperature and provide some water quality treatment.
- Use gross pollutant traps in areas where litter may be an issue.

6.2.3 Filtering and conveyance

Both filter strips and swales achieve some degree of stormwater treatment of runoff while conveying it through the catchment. Specific mechanisms include contact with soil to detain runoff, increased roughness to slow flow velocities and increase time of concentration and filtering sediment through plant and soil materials. The following measures are proposed for the Warkworth Structure Plan Area:

- Use swales for stormwater conveyance where possible as an alternative to pipes.
- Consider filter strips as a pre-treatment before other stormwater devices such as raingardens and tree pits.
- Erosion protection throughout water sensitive design. Where outfalls are required use green outfalls/channels for energy dissipation prior to the receiving environment.

6.2.4 Downstream treatment devices

- Treat stormwater as close to the source as possible.
- Utilise stormwater treatment devices that mimic natural physical, biological and physical treatment processes (e.g. bioretention).
- Utilise infiltration where possible to maintain stream baseflows and recharge aquifers.

6.2.5 Receiving environment

- Protect and enhance existing natural systems such as mature vegetation, watercourses and wetlands for their stormwater management function.

- Identify intermittent and permanent streams and preserve a riparian buffer around them in the development layout. Development planning should allow for a 10 m riparian margin either side of intermittent streams and a 20 m riparian margin either side of permanent streams (confirm these requirements with ecologists).
- Preserve and restore riparian vegetation along banks, natural floodplains and wetland margins including linking areas of riparian vegetation to create continuous green corridors.
- Protecting and enhancing natural stream morphologies and processes. This may include assessing pre-development geomorphic trends in waterways, and mitigating these processes on a catchment scale. This could include maintaining stream headwaters where possible, revegetating riparian margins that may be susceptible to erosion, installing naturalised bed control structures where long term incision trends are present. An important consideration with be potential hydrological changes due to development and how these can be mitigated.

7 References

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8 Applicability

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

Tonkin & Taylor Ltd

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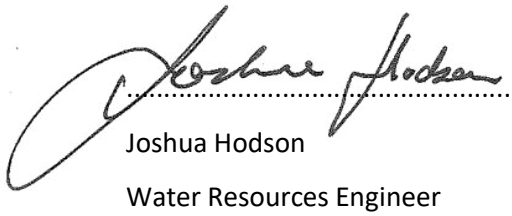

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Joshua Hodson

Water Resources Engineer

Authorised for Tonkin & Taylor Ltd by:

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Tim Fisher

Project Director

JTIH
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Appendix A: Catchment characteristics and constraint maps (A3 size)

- **Figure 4.1: Catchment setting**
- **Figure 4.2: Existing topography**
- **Figure 4.3: Existing land use**
- **Figure 4.4: Geology**
- **Figure 4.5: Existing stormwater infrastructure**
- **Figure 4.6: Flooding**
- **Figure 4.9: Stream overlays**
- **Figure 4.10: Aquifer overlays**
- **Figure 4.12: Stream classification**
- **Figure 4.13: Ecology overlays**
- **Figure 4.14: Stream stability**
- **Figure 4.16: Management zones**

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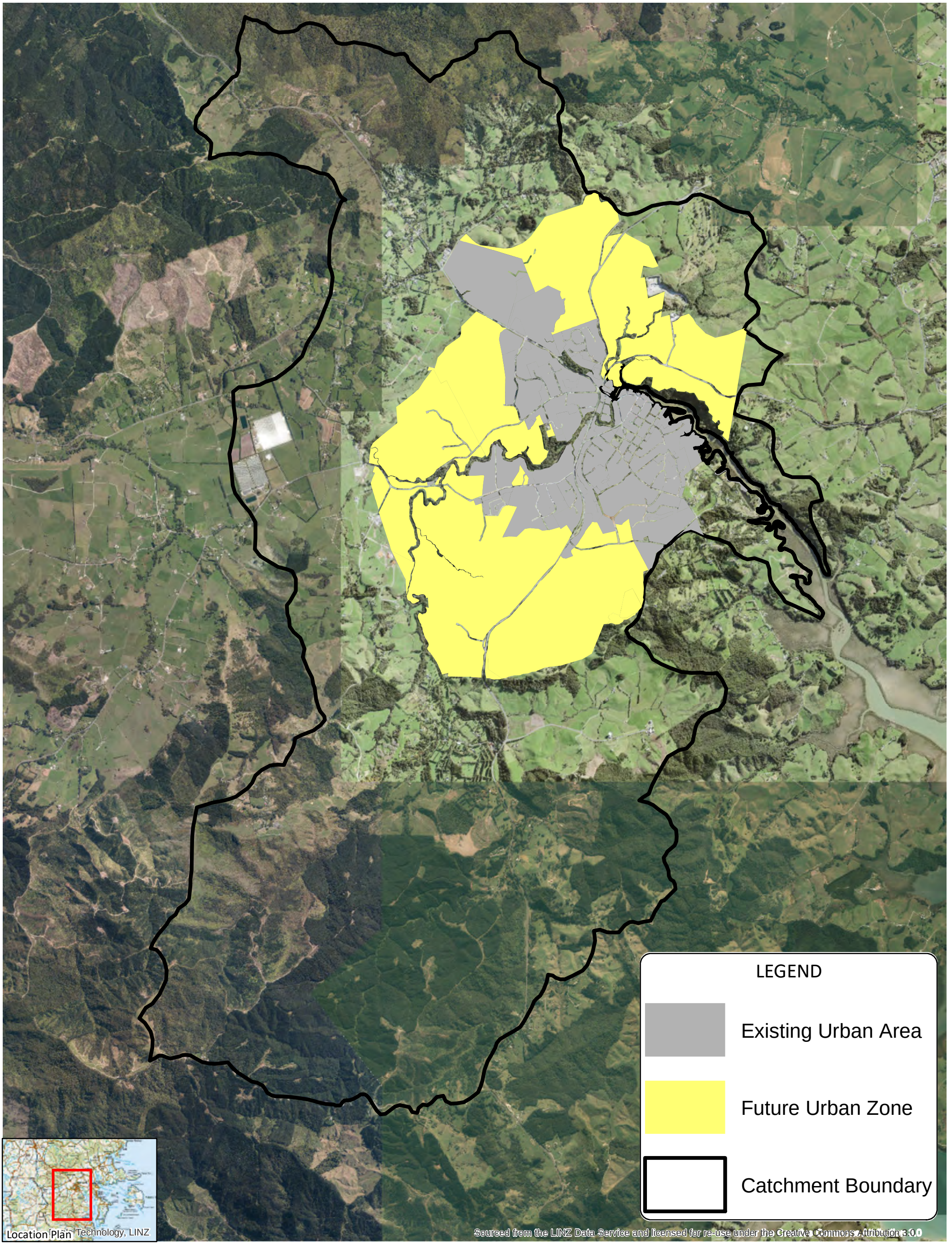

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Warkworth Structure Plan Area

Stormwater Management Plan

Catchment Setting

FIGURE No. Figure 4.1

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LEGEND

Existing Urban Area

Rural Urban Boundary

Other Catchments

Elevation

(m RL)

0 - 10

10 - 20

20 - 30

30 - 40

40 - 50

50 - 60

60 - 70

70 - 80

80 - 90

90 - 100

100 - 110

110 - 120

120 - 130

Location Plan

ology, LINZ

Notes:

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Warkworth Structure Plan Area

Stormwater Management Plan

Existing Topography

FIGURE No.: Figure 4.2

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LEGEND

Rural Urban Boundary

Future Urban Zone

Artificial Surfaces

Built-up Area (settlement)

Surface Mines and Dumps

Urban Parkland/Open Space

Water Bodies

Lake or Pond

Estuarine Open Water

Cropland

Orchard Vineyard and Other Perennial Crops

Grassland, Sedge and Saltmarsh

High Producing Exotic Grassland

Scrub and Shrubland

Manuka and/or Kanuka

Broadleaved Indigenous Hardwoods

Forest

Forest - Harvested

Indigenous Forest

Exotic Forest

Mangrove

Location Plan ology, LINZ

Notes:

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

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Warkworth Structure Plan Area

Stormwater Management Plan

Existing Land Use

FIGURE No. Figure 4.3

Rev. 0

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LEGEND

- Existing Urban Area
- Rural Urban Boundary
- Waitemata Group
- Holocene Age Alluvium
- Undifferentiated Northland Allochthon
- Undifferentiated Tauranga Group

Location Plan ology, LINZ

Notes:

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Warkworth Structure Plan Area

Stormwater Management Plan

Geology

FIGURE No. Figure 4.4

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LEGEND

- Rural Urban Boundary
- Existing Urban Area
- Future Urban Zone
- Open Drains
- SW Pipe Network
- Streams
- Main Culverts
- Bridges

Location Plan

Notes:

A3 SCALE 1:20,000

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Warkworth Structure Plan Area

Stormwater Management Plan

Existing Stormwater Infrastructure

FIGURE No. Figure 4.5

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LEGEND

- Rural Urban Boundary
- Existing Urban Area
- Future Urban Zone
- 20 m LINZ Contours
- 100yr ARI Floodplain
- Flood Prone areas

Location Plan

Notes:

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Warkworth Structure Plan Area

Stormwater Management Plan

Flooding

FIGURE No. Figure 4.6

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LEGEND

- Rural Urban Boundary
- Existing Urban Area
- Future Urban Zone
- High-Use Stream Management Areas
- Natural Stream Management Areas
- Mahurangi River
- Mahurangi Tributaries

Location Plan

Notes:

A3 SCALE 1:20,000

0 0.2 0.4 0.6 0.8 1 (km)

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Warkworth Structure Plan Area

Stormwater Management Plan

Stream Overlays

FIGURE No. Figure 4.9

Rev. 0

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LEGEND

- Rural Urban Boundary
- Existing Urban Area
- Future Urban Zone
- High-Use Aquifer Management Area

Location Plan

Notes:

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Warkworth Structure Plan Area

Stormwater Management Plan

Aquifer Overlays

FIGURE No. Figure 4.10

Rev. 0

Figure 4.12: Stream classification (Morphum (2018b))

Map 1 - Overview Map

Figure 4.10

Mahurangi North Tributaries

Mahurangi River

Mahurangi River (Left)

Mahurangi River (Right) Tributary 1

Mahurangi River (Right)

Sourced from the LINZ Data Service and licensed for New Zealand licence

Ecoline 2018 (WAM)
- Permanent
- Intermittent
- Ephemeral

Ecoline 2009 (Stream Assessment)
- Permanent
- Intermittent
- Ephemeral

Wetland 2018
- Natural
- Artifical

Wetland 2009
- Natural
- Artifical

- Stormwater Catchments
- Warkworth FUZ

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0 400 800 m

Project no. P01618
Date 10 May 2018

Drawn CU
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LEGEND

- Rural Urban Boundary
- Existing Urban Area
- Future Urban Zone
- SEA - Terrestrial
- SEA - Marine 1
- SEA - Marine 2

Location Plan

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Notes:

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Warkworth Structure Plan Area

Stormwater Management Plan

Ecology Overlays

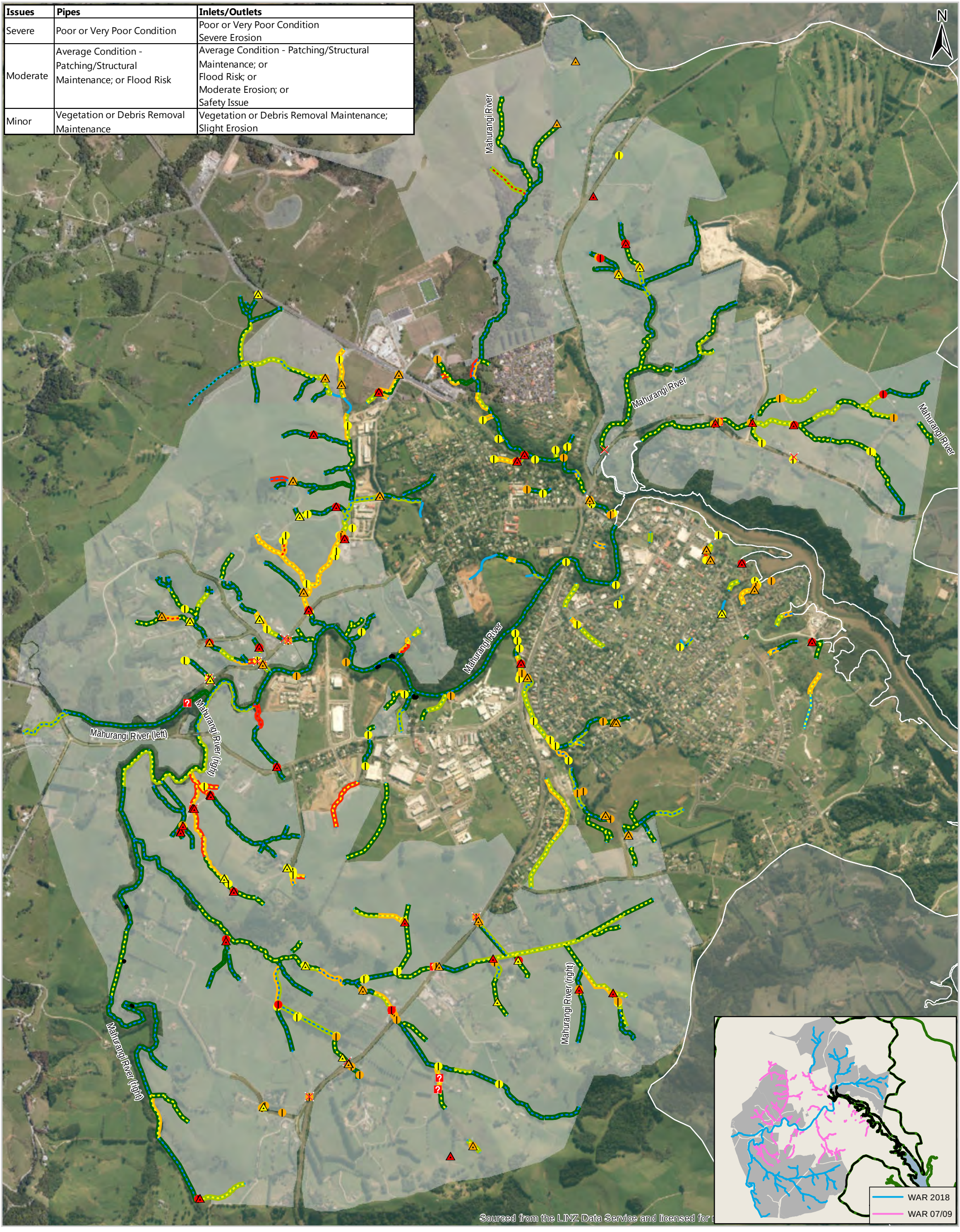
FIGURE No. Figure 4.13

Rev. 0

Figure 4.14: Stream stability (Morphum (2018b))

Map 4 Asset Maintenance Issues

Issues	Pipes	Inlets/Outlets
Severe	Poor or Very Poor Condition	Poor or Very Poor Condition Severe Erosion
Moderate	Average Condition - Patching/Structural Maintenance; or Flood Risk	Average Condition - Patching/Structural Maintenance; or Flood Risk; or Moderate Erosion; or Safety Issue
Minor	Vegetation or Debris Removal Maintenance	Vegetation or Debris Removal Maintenance; Slight Erosion



Erosion Scars
- <20%
- 20-40%
- 40-60%
- >60%

Inlet/Outlet Asset Issues
- Minor
- Moderate
- Severe
- Could not locate

Bank Stability
- Excellent
- Good
- Fair
- Poor
- Erosion Hotspot

Pipe Asset Issues
- Minor
- Moderate
- Severe
- Misc. 2018
- Misc. 2009
- Stormwater Catchments
- Warkworth Future Zone

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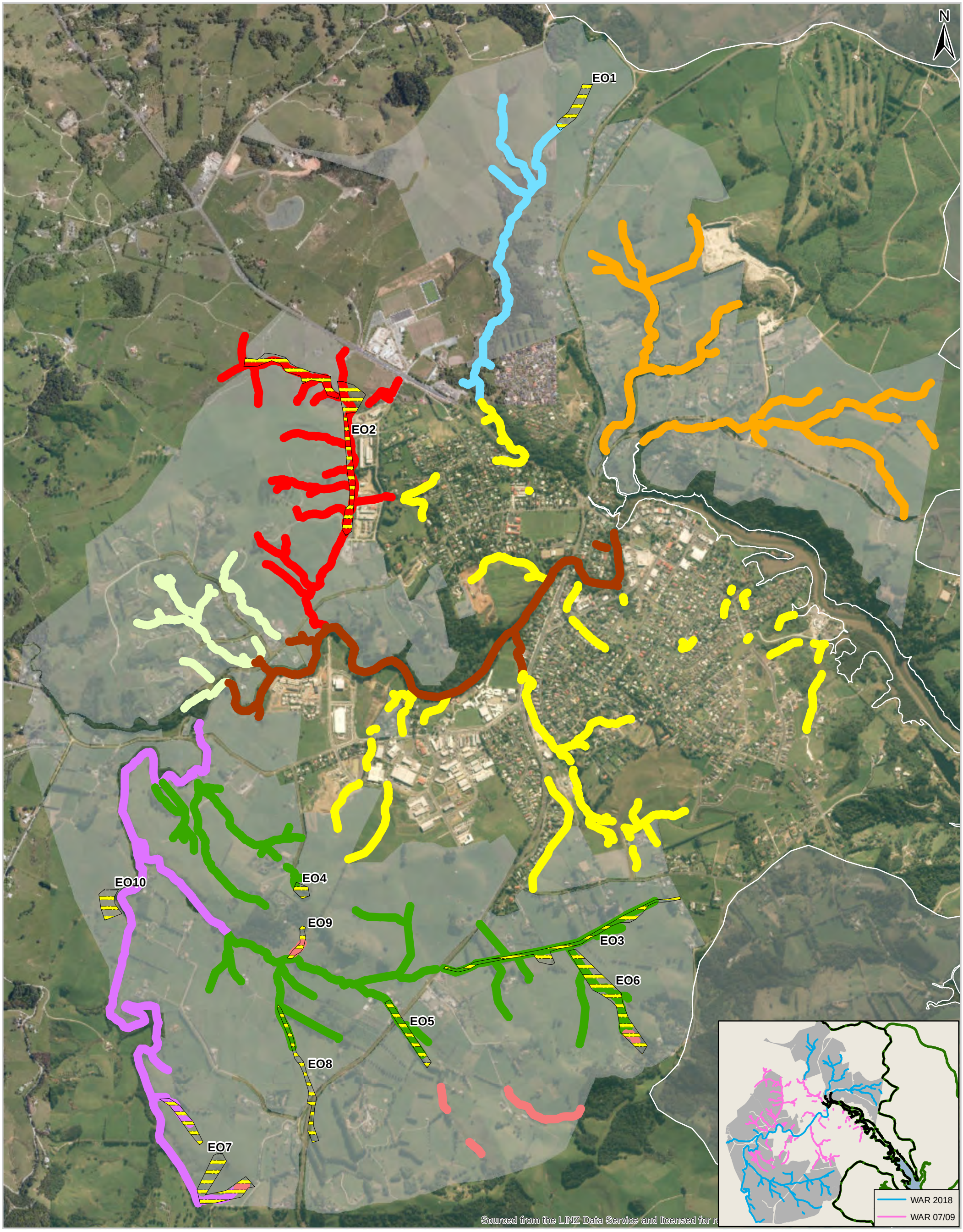
Figure 4.16: Managment zones (Morphum (2018b))

Map 7 - Management Zones and Enhancement Opportunities



Management Zones

- MZ 1
- MZ 2
- MZ 3
- MZ 4
- MZ 5
- MZ 6
- MZ 7
- MZ 8
- MZ 9

Enhancement Opportunities

Stormwater Catchments

0 400 800 m

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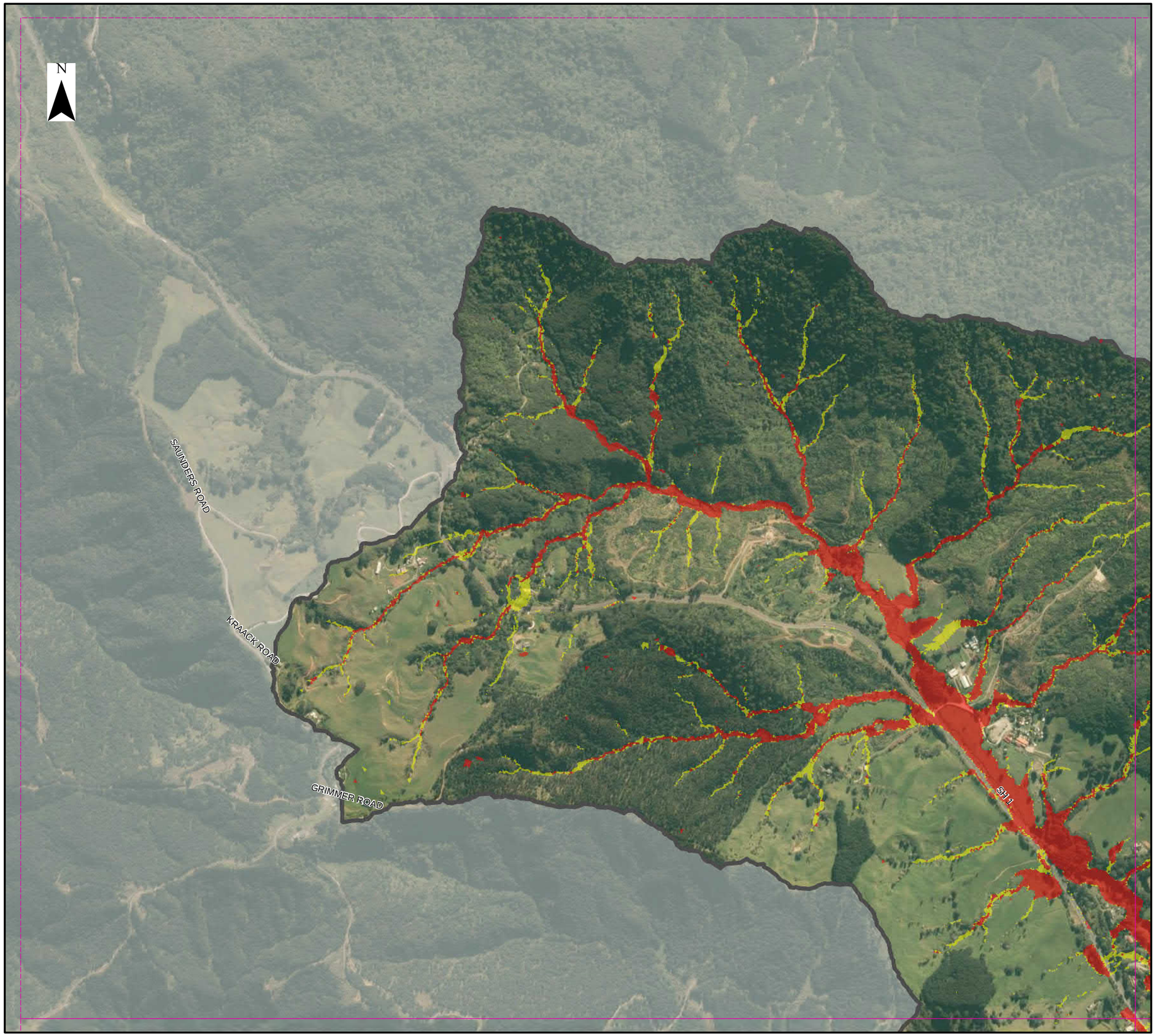
Appendix B: Flood hazard maps



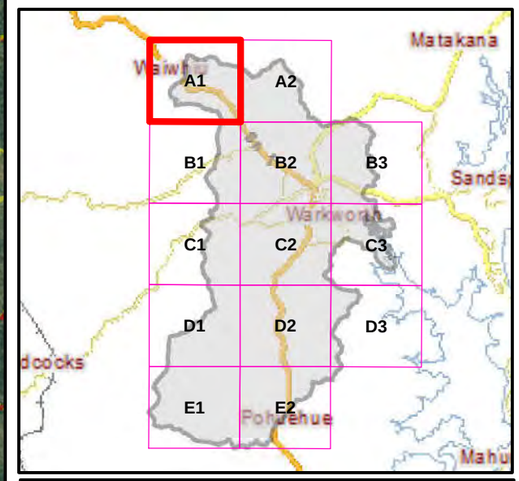
LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



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Meters

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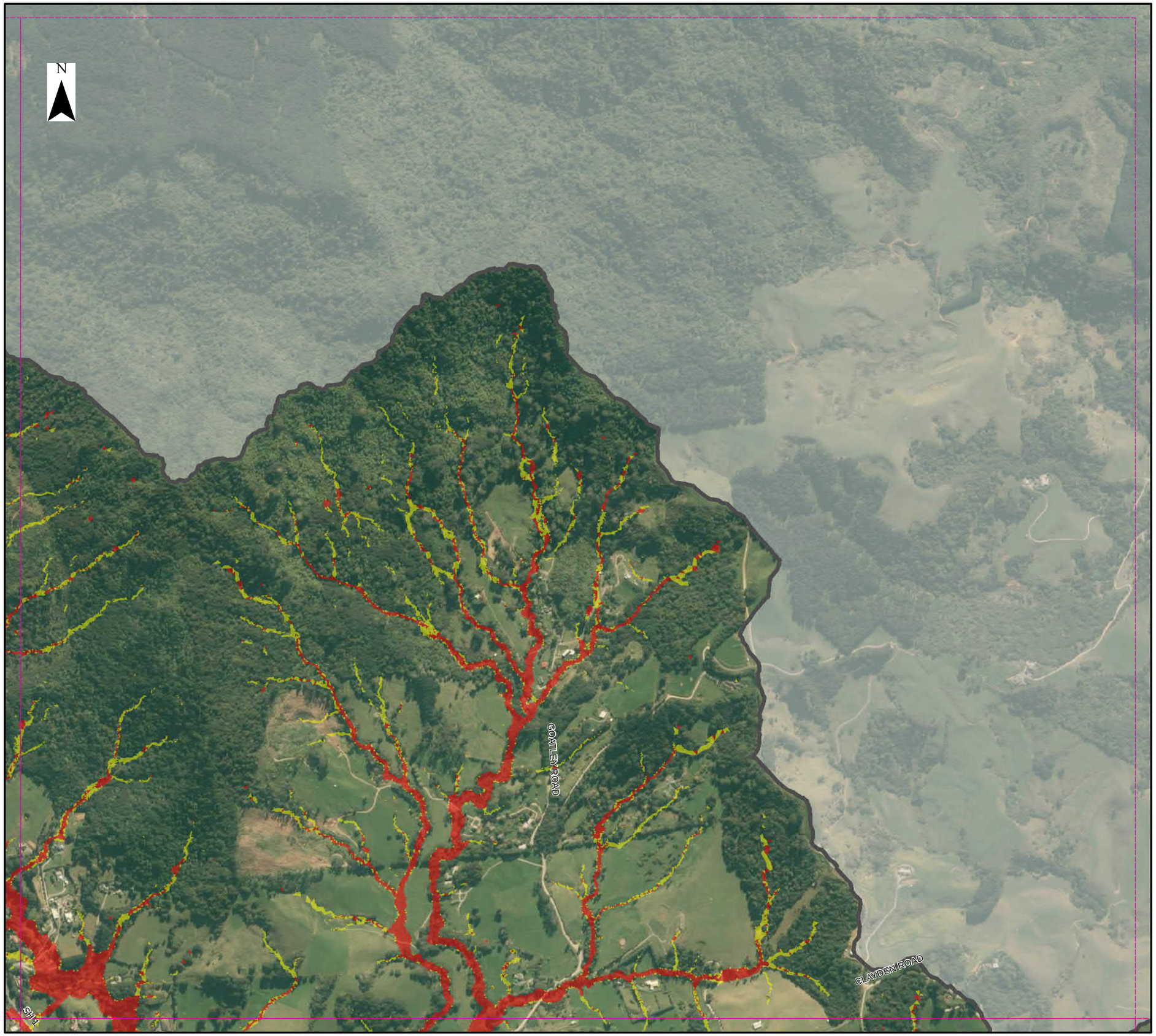
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 1 of 13



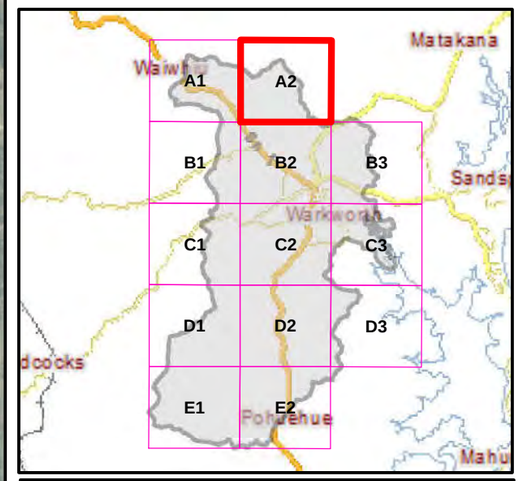
LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



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WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 2 of 13

N

SMYTH ROAD

PHILLIPS ROAD

MARUA WAY

CARRAN ROAD

SMYTH ROAD

KAIPARA FLATS ROAD

LEGEND

building_inundation

MapIndex_1_in_10000

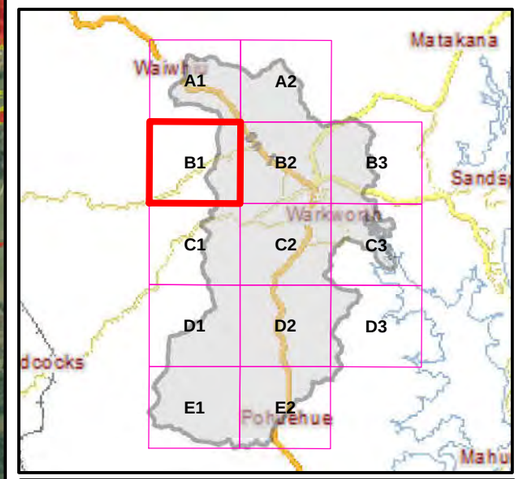
Hazard Classification

Rating

Minor Hazard

Significant Hazard

WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF

FINAL CHECKED:

0 40 80 160 240 320 400 Meters

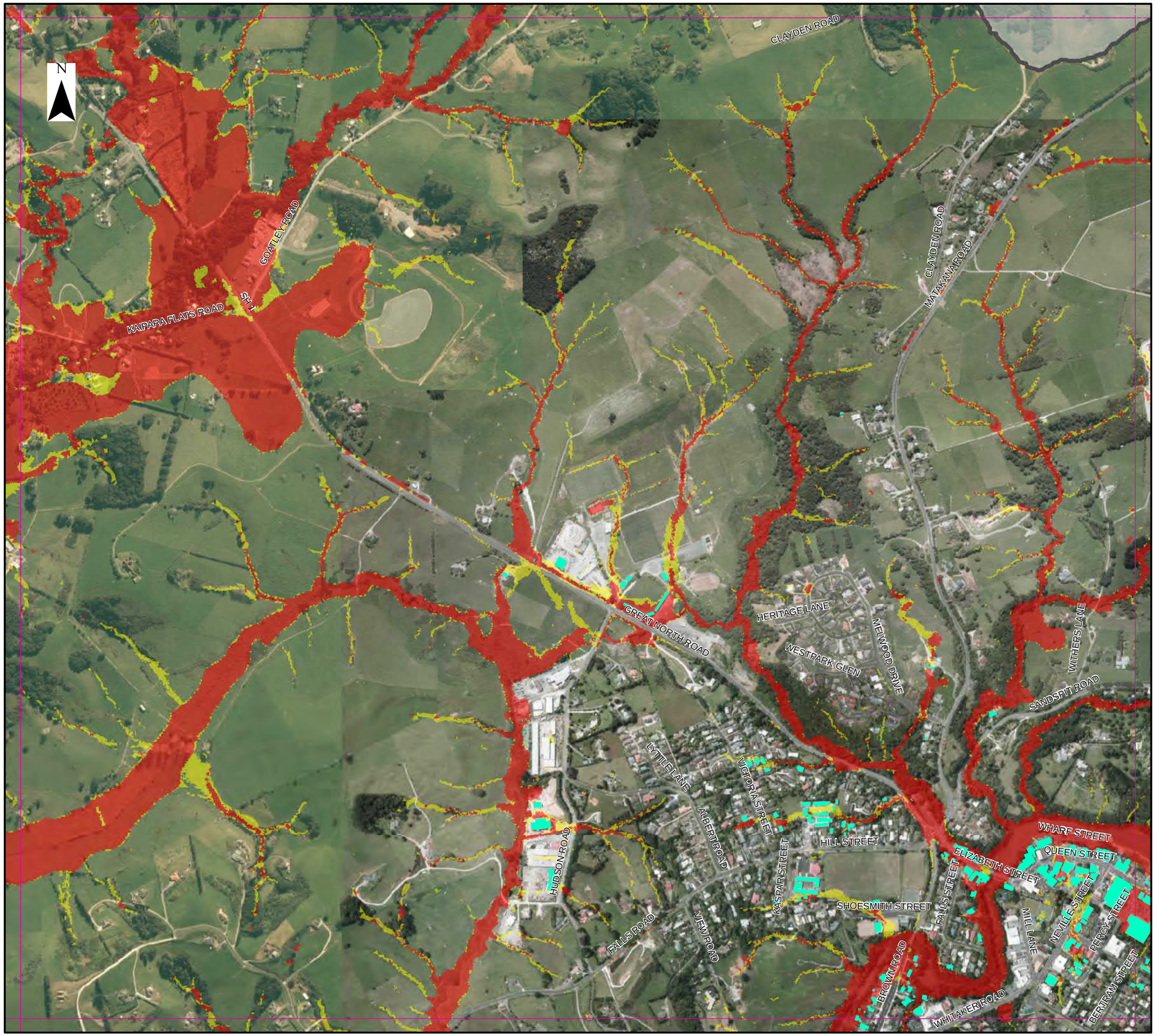
SCALE (A3): 1:10,000

Auckland Council

Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA
ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 3 of 13

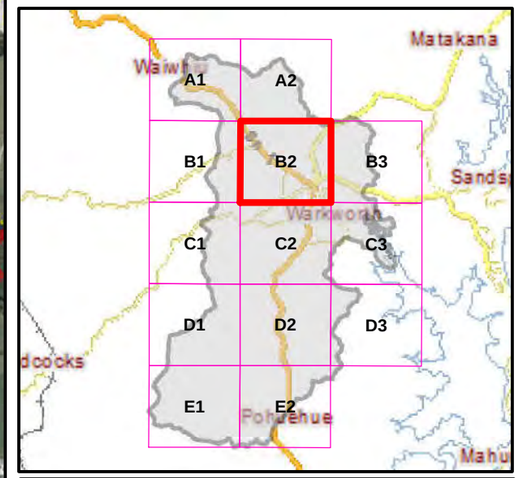


LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF
FINAL CHECKED:

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SCALE (A3): 1:10,000

Auckland Council
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 4 of 13

LEGEND

building_inundation

MapIndex_1_in_10000

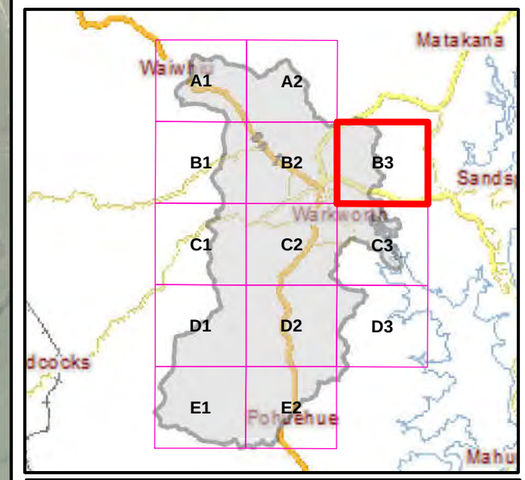
Hazard Classification

Rating

Minor Hazard

Significant Hazard

WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF

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SCALE (A3): 1:10,000

Auckland Council

Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA
ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 5 of 13

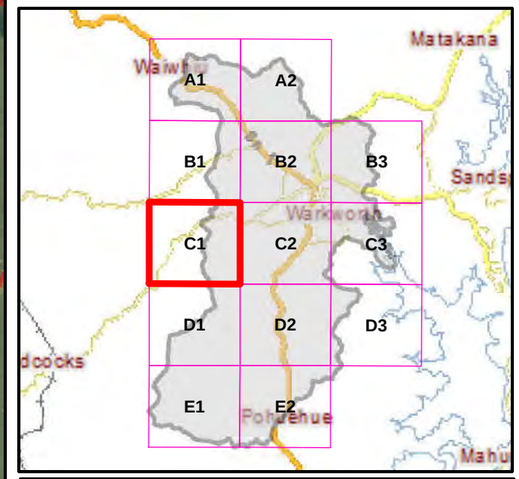
LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



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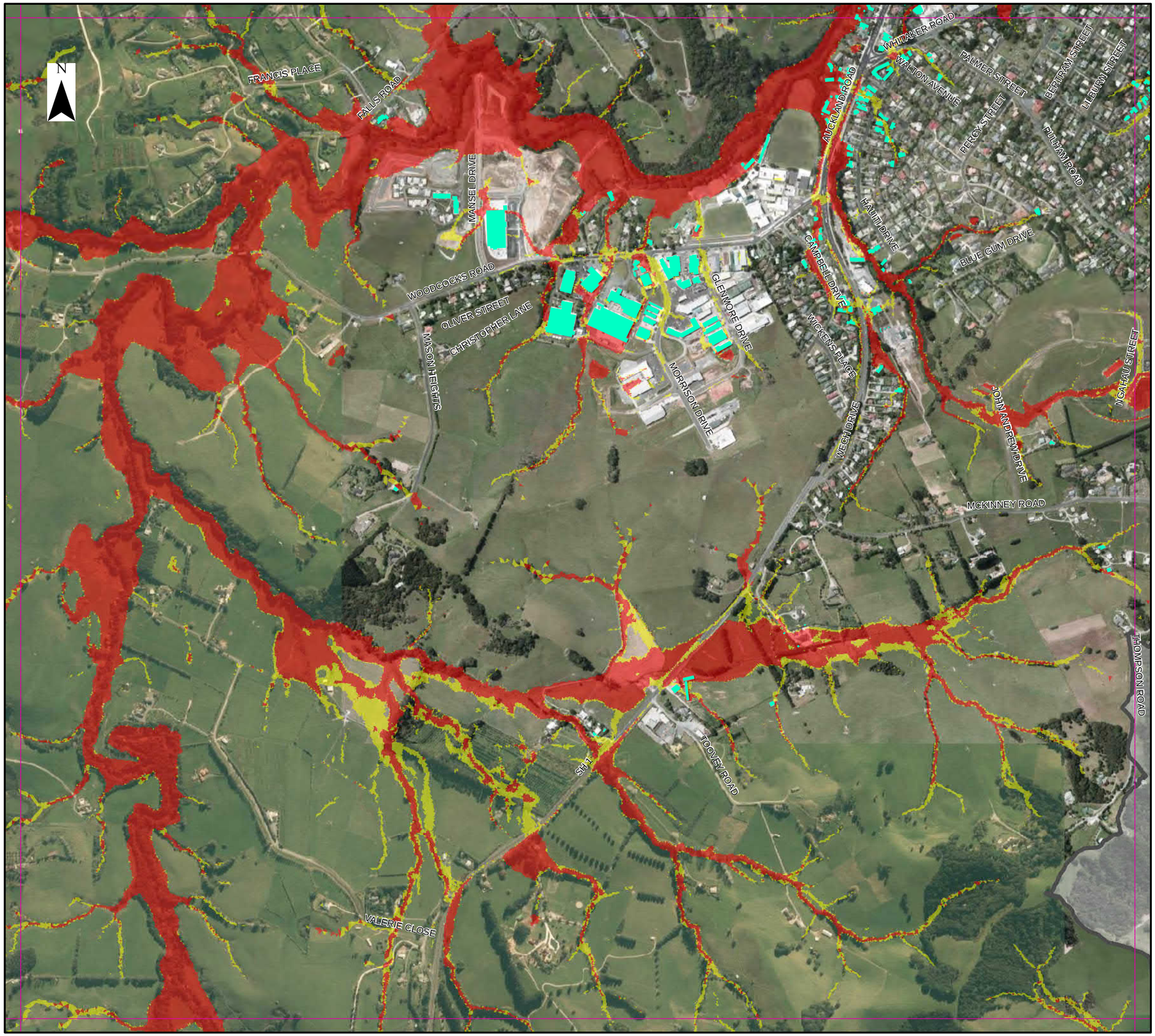
Meters

SCALE (A3): 1:10,000

Auckland Council
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 6 of 13



LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
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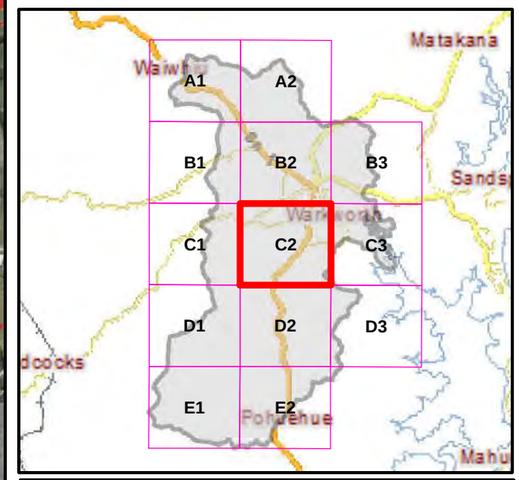

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SCALE (A3): 1:10,000

Auckland Council
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 7 of 13

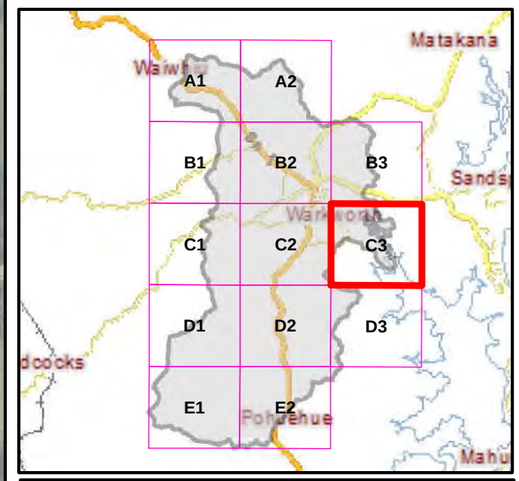
LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



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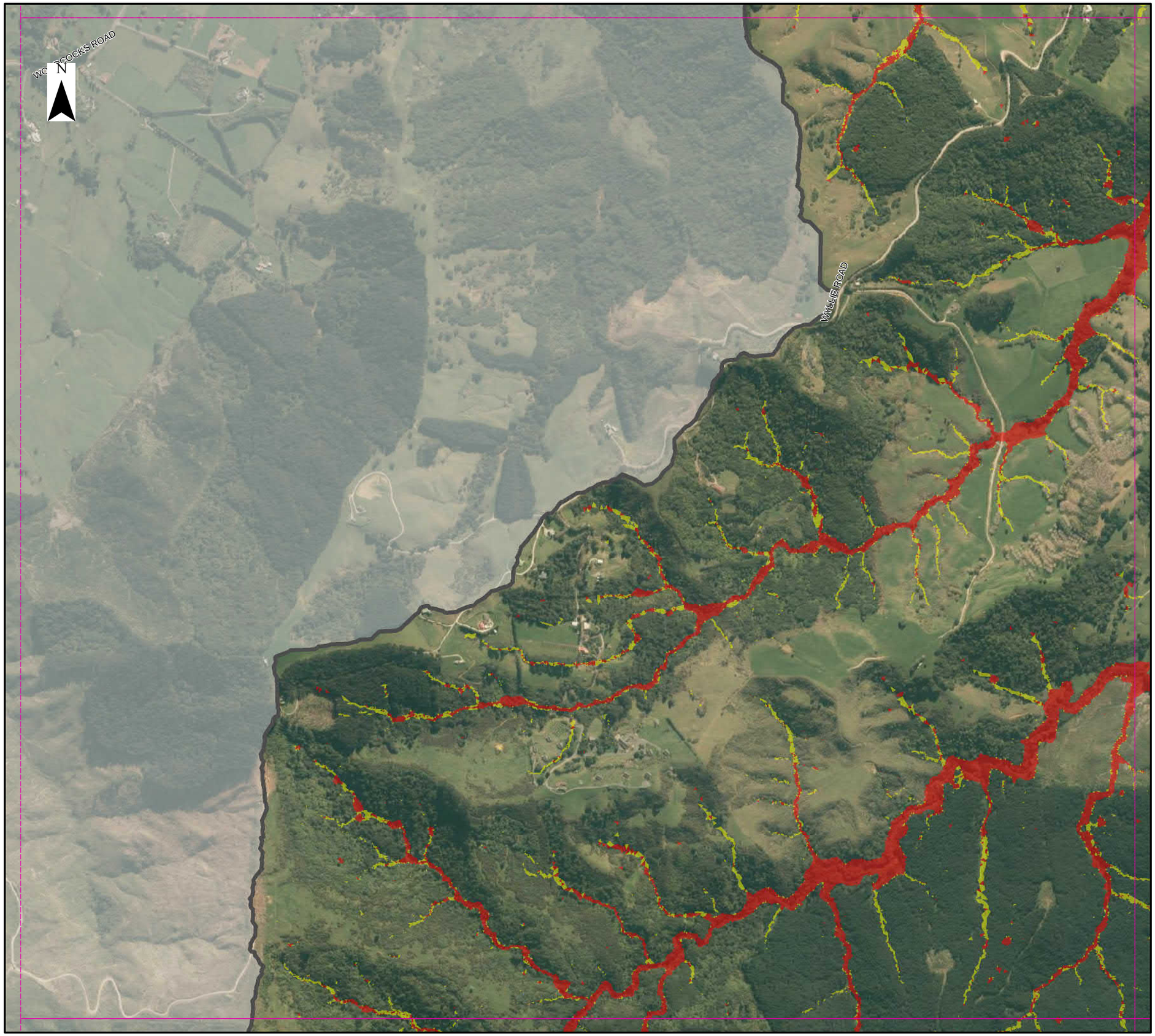
SCALE (A3): 1:10,000

Auckland Council
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 8 of 13



LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification

Rating

- Minor Hazard
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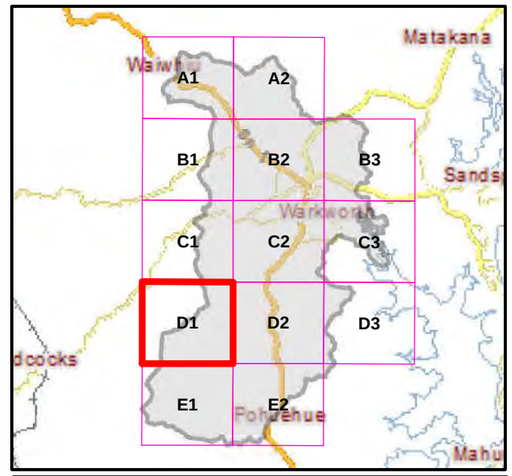
- WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF
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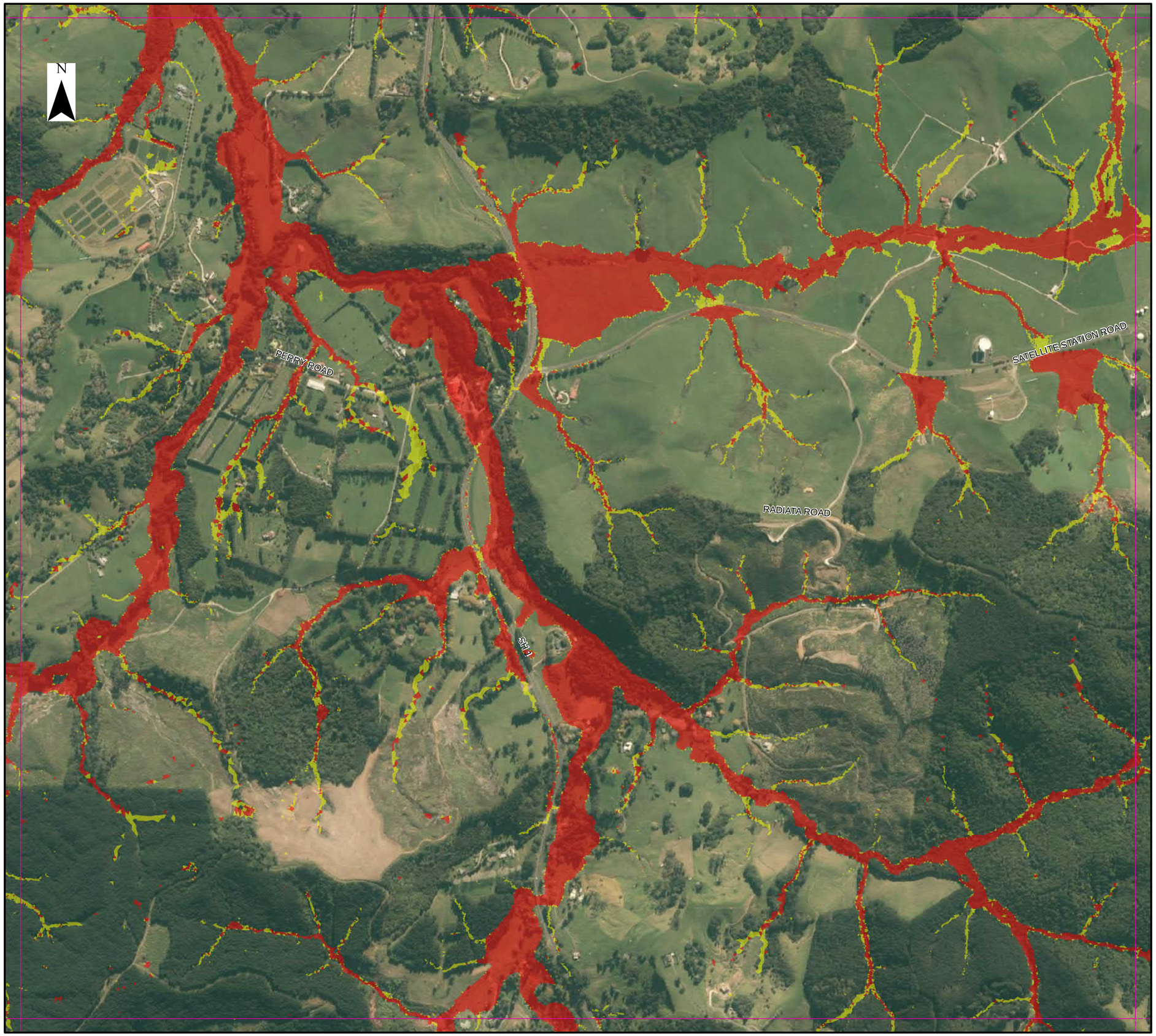
Meters

SCALE (A3): 1:10,000

Auckland Council
Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 9 of 13

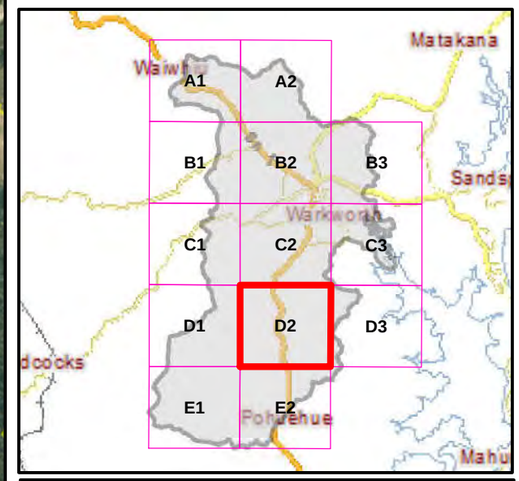


LEGEND

- building_inundation
- MapIndex_1_in_10000

Hazard Classification Rating

- Minor Hazard
- Significant Hazard
- WARKWORTH CATCHMENT



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SCALE (A3): 1:10,000

Auckland Council
Te Kaurihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 10 of 13

LEGEND

building_inundation

MapIndex_1_in_10000

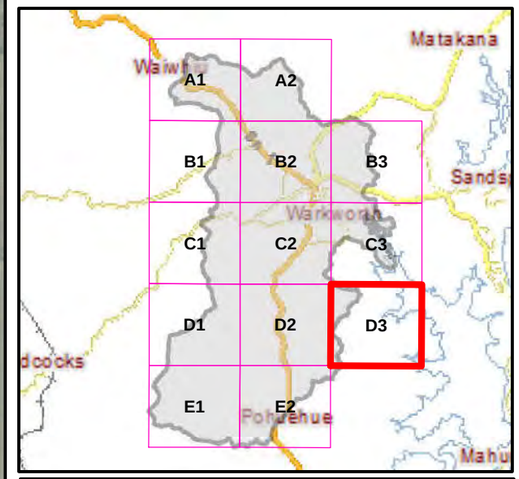
Hazard Classification

Rating

Minor Hazard

Significant Hazard

WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF

FINAL CHECKED:

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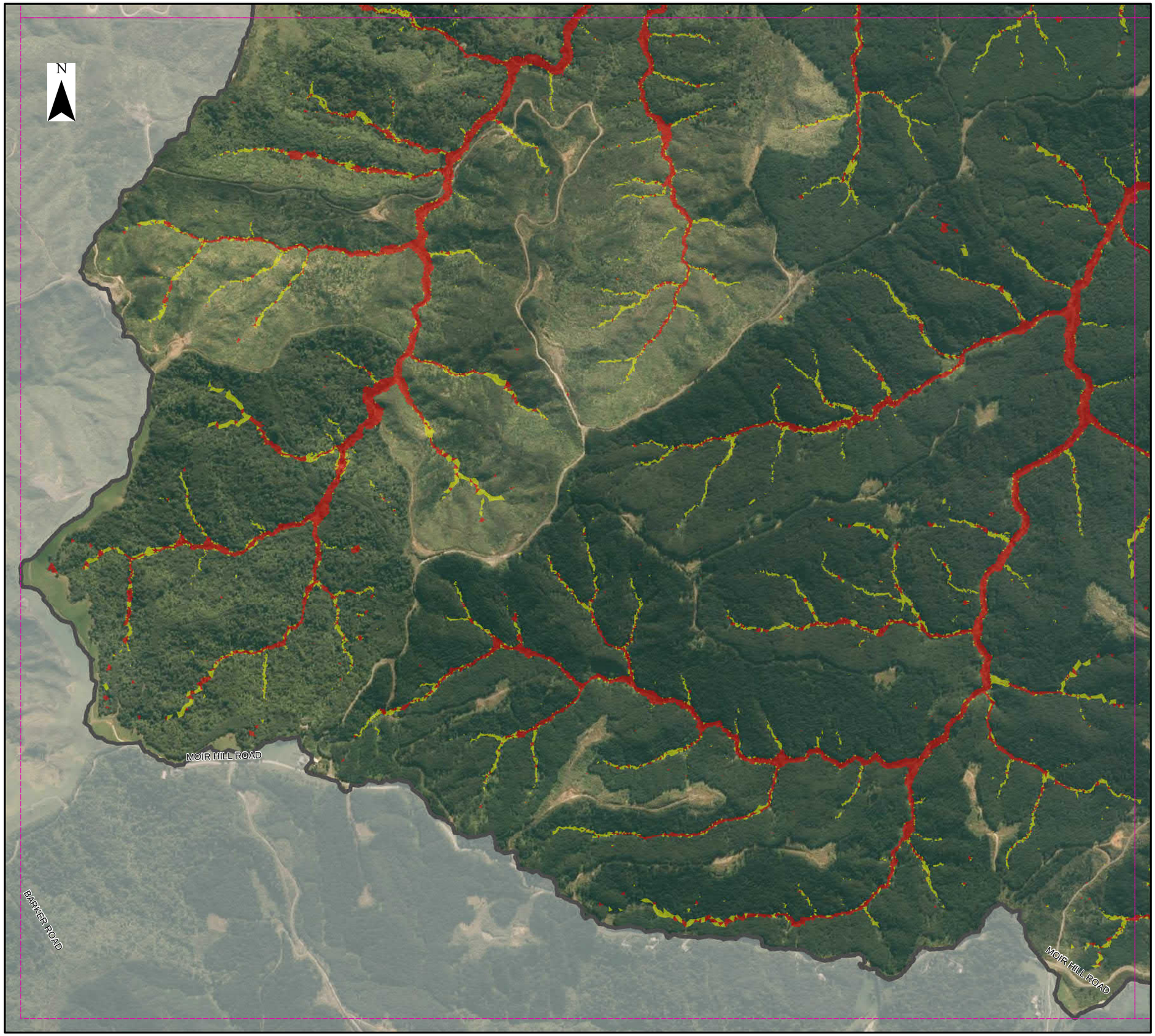
SCALE (A3): 1:10,000

Auckland Council

Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 11 of 13



LEGEND

building_inundation

MapIndex_1_in_10000

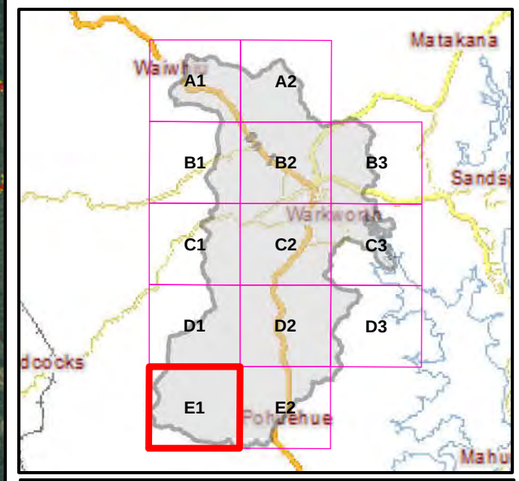
Hazard Classification

Rating

Minor Hazard

Significant Hazard

WARKWORTH CATCHMENT



NOV 2012 DRAWN: KF

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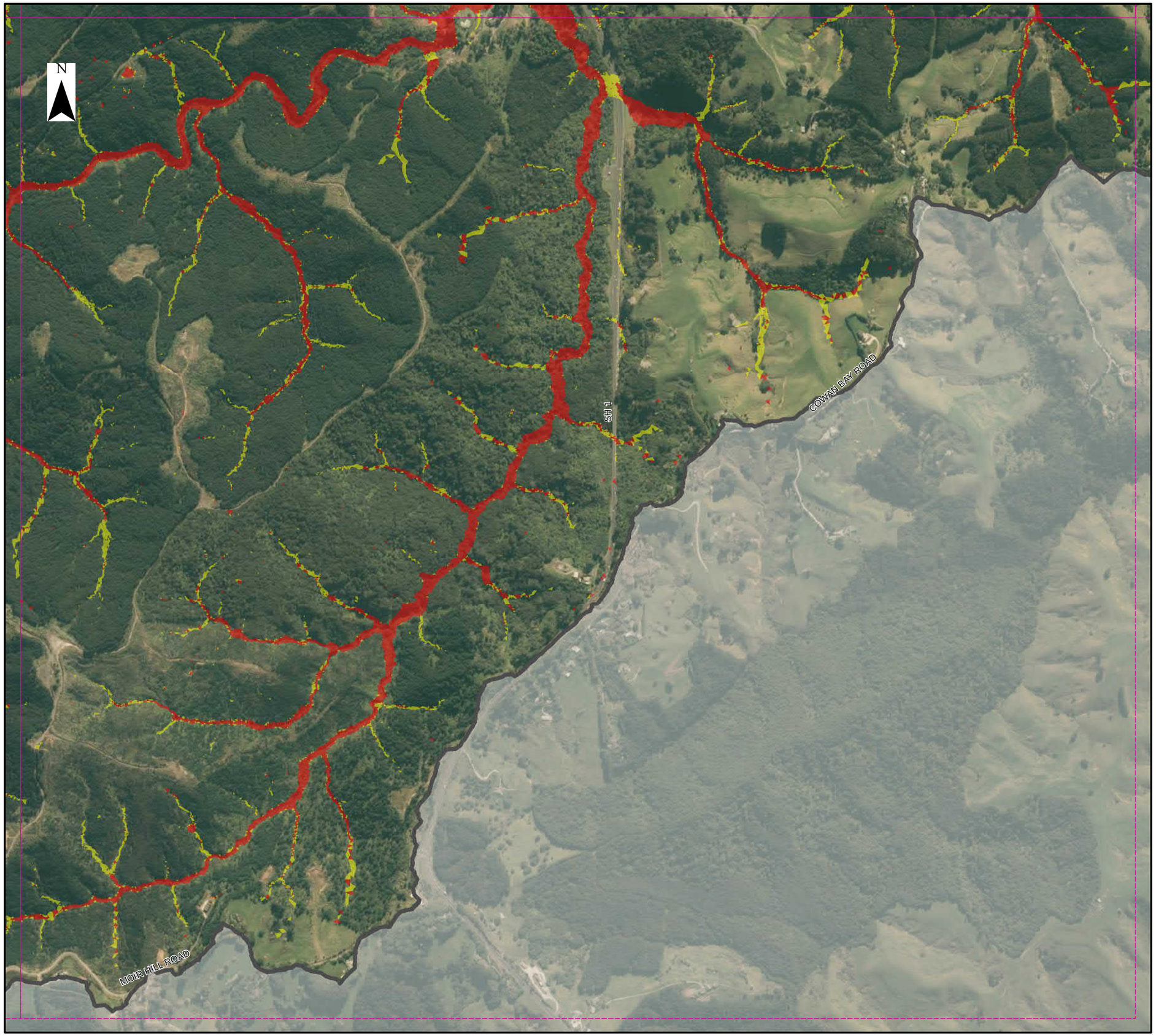
Auckland Council

Te Kaurihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 12 of 13



LEGEND

building_inundation

MapIndex_1_in_10000

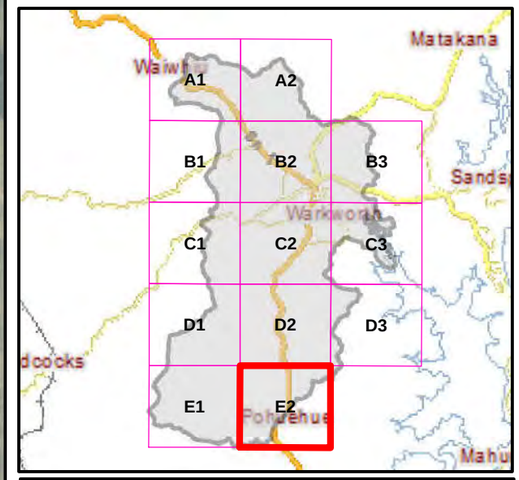
Hazard Classification

Rating

Minor Hazard

Significant Hazard

WARKWORTH CATCHMENT



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Te Kaunihera o Tāmaki Makaurau

AUCKLAND COUNCIL
WARKWORTH CATCHMENT
MODEL EXTENTS AND DATA
ASSESSMENT

Figure 6 Rapid Flood Hazard Assessments
Sheet 13 of 13

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