Warkworth to Wellsford

Water Assessment Report

July 2019

QUALITY ASSURANCE

Prepared by

Jacobs GHD Joint Venture in association with Ridley Dunphy Environmental Ltd and Tonkin & Taylor Ltd. Prepared subject to the terms of the Professional Services Contract between the Client and Jacobs GHD Joint Venture for the Route Protection and Consenting of the Warkworth to Wellsford Project.

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GLOSSARY OF ABBREVIATIONS

The table below sets out the technical abbreviations.

Abbreviation	Term
1D	One Dimensional Model MIKE11
2D	Two-Dimensional Model MIKE 21
AEE	Assessment of Effects on the Environment
AEP	Annual Exceedance Probability
ANZECC/ ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ARI	Average Recurrence Interval
AUP(OP)	Auckland Unitary Plan Operative in Part
BNZ	Basin New Zealand
BPO	Best Practicable Option
CEMP	Construction Environmental Management Plan
CESCP(s)	Construction Erosion and Sediment Control Plan(s)
CLVT	Abbreviation for Culvert
Council	Auckland Council
DEM	Digital Elevation Model
dSedNet	Daily SedNet
ESCP	Erosion and Sediment Control Plan
FSDC	Fraction of Sediment Delivered to the Coast
FU	Functional Unit
GD01	Guideline document 2017/001. Stormwater Management Devices in the Auckland Region (GD01), Auckland Council
GIS	Geographic information system
GLEAMS	Groundwater Loading Effects of Agricultural Management Systems
ha	Hectares
HIRDS	High Intensity Rainfall Design System
hrs	Hours
IPPC	Intergovernmental Panel on Climate Change
kg	Kilograms
kg/yr	Kilograms per year
km	Kilometres

Abbreviation	Term
km^2	Square kilometres
LCDB	Land Cover Database
LIDAR	Light Detection And Ranging
m	Metres
m^2	Square metres
m^3	Cubic metres
m^3/s	Cubic meters per second
MfE	Ministry for the Environment
n	Manning's Roughness Coefficient
NES	National Environmental Standard
NES-PF	National Environmental Standard for Plantation forestry
NIWA	National Institute of Water and Atmospheric Research
NoR	Notice of Requirement
NPS	National Policy Statement
NPSFM	National Policy Statement for Freshwater Management (updated 2017)
NSE	Nash-Sutcliffe efficiency
NZLRI	New Zealand Land Resource Inventory
NZSOLD	The New Zealand Society on Large Dams
PM_{10}	Particulate matter with a diameter less than 10 micrometres.
$PM_{2.5}$	Particulate matter with a diameter less than 2.5 micrometres.
P-Wk	Pūhoi to Warkworth Project
RCPs	Representative Concentration Pathways
REC	The New Zealand River Environment Classification
RFHA	Rapid Flood Hazard Assessment
RMA	Resource Management Act 1991
SH(x)	State Highway (number)
SMAF	Stormwater Management Area Control – Flow
SSC	Suspended Sediment Concentration
TP108	Technical Publication 108 of Auckland Regional Council (1999)
TPH	Total Petroleum Hydrocarbons
Transport Agency	NZ Transport Agency
TSP	Total Suspended Particulate

Abbreviation	Term
TSS	Total Suspended Solids
USLE	Universal Soil Loss Equation
WTP	Water Treatment Plant
WW2W	Ara Tūhono Warkworth to Wellsford project

GLOSSARY OF DEFINED TERMS

The table below sets out the defined terms.

Term	Meaning
Annual Exceedance Probability	As defined in Section J1 of the AUP: The Annual Exceedance Probability (AEP) is the probability of exceeding a given threshold within a period of one year.
Amenity values	As defined in Section 2(1) of the RMA: Those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes
Annual Exceedance Probability Storm Event	The annual exceedance probability (AEP) is the probability of exceeding a given threshold within a period of one year. For flooding the value is usually a peak flowrate, depth or water level. AEP is similar to ARI, with a 1% AEP value commonly referred to as a 1 in 100-year value.
The Average Return Interval (ARI)	The Average Return Interval (ARI) is the average time period between rainfall or flow events that exceed a given magnitude.
Bore	Any hole that has been constructed to provide access to groundwater (for example, for monitoring of ground or groundwater conditions, taking of groundwater or the discharge of stormwater) or for geotechnical investigations.
Best Practicable Option (BPO)	As defined in Section 2(1) of the RMA: The Best Practicable Option (BPO) in relation to a discharge of a contaminant of an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things to- (a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and (b) the financial implication, and the effects on the environment, of that option when compared with other options; and (c) the current state of technical knowledge and the likelihood that the option can be successfully applied
Chainage	A distance measured along a straight line. For this project chainage is measured in metres and starts from the northern extent of the Project.
Construction Works	Activities undertaken to construct the Project.
Contaminant	As defined in section 2(1) of the RMA: Any substance (including gases, odorous compounds, liquids, solids and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy or heat when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water.

Term	Meaning
Culvert	A pipe or set of pipes with inlet from a watercourse and outlet to a watercourse, designed to convey water under a specific structure (such as a road).
Designation	As defined in section 166 of the RMA: a provision made in a district plan to give effect to a requirement made by a requiring authority under section 168 or section168A or clause 4 of Schedule 1.
Determinand	As defined in Appendix 1 of the National Environmental Standard for Sources of Human Drinking Water: a constituent or property of the water that is determined, or estimated, in a sample for example: • microbial determinand: total coliforms; • chemical determinand: chloride; • physical determinand: turbidity.
Discharge	As defined in section 2(1) of the RMA: include emit, deposit and allow to escape
Diversion of stormwater	As defined in section J1 of the AUP: Altering the natural course of stormwater flow, primarily through recontouring land or the establishment of impervious surfaces and associated drainage.
Earthworks	Defined in section J1 of the AUP(OP), as "disturbance of soil, earth or substrate land surfaces. Includes: blading, boring (greater than 250mm diameter); contouring; cutting; drilling (greater than 250mm diameter); excavation; filling; ripping; moving; placing; removing; replacing; trenching; and thrusting (greater than 250mm diameter). Excludes: ancillary forest earthworks; and ancillary farming earthworks."
Erosion	Erosion occurs when the surface of the land is worn away (eroded) by the action of water, wind, ice or geological processes. Through the erosion process, soil particles can be dislodged by rainfall and surface water flow.
Erosion control	Methods (both structural and non-structural) to prevent or minimise the erosion of soil, in order to minimise the adverse effects that land disturbing activities may have on a receiving environment.
First order stream	A first order stream is classified as the smallest parts of a river and stream network (headwater stream) under the River Environment Classification database.
Flocculation	The process whereby fine particles suspended in the water column coagulate together and settle. Flocculation can be used to promote rapid settling in sediment retention ponds by the addition of flocculating chemicals (flocculants).
Groundwater	Natural water contained within soil and rock formations below the surface of the ground.

Term	Meaning
Indicative Alignment	An indicative road design alignment assessed by the technical experts that may be refined on detailed design within the designation boundary. The Indicative Alignment is a preliminary alignment of a state highway that could be constructed within the proposed designation boundary. The Indicative Alignment has been prepared for assessment purposes, and to indicate what the final design of the Project may look like. The final alignment for the Project will be refined and confirmed at the detailed design stage.
Matariki Forest	The area of plantation forest owned and managed by Rayonier Matariki Forests in the Dome Valley area.
Overland flow path	As defined in section J1 of the AUP: Low point in terrain, excluding a permanent watercourse or intermittent river or stream, where surface runoff will flow, with an upstream contributing catchment exceeding 4,000 m^2.
Project	The Ara Tūhono Warkworth to Wellsford Project.
Project area	The area within the proposed designation boundary, and immediate surrounds to the extent Project works extend beyond this boundary.
Project Works	All proposed activities associated with the Project
Proposed designation boundary	The boundary of the land to which the notice of requirement applies.
River Environment Classification	The New Zealand River Environment Classification organises information about the physical characteristics of New Zealand's rivers. It is a database of catchment spatial attributes summarised for every segment in New Zealand's network of rivers.
River Flood Hazard Mapping	The Auckland Council River Flood Hazard Mapping ((RFHM) is a map that indicates areas at risk of flooding for a 100 year ARI flood event.
Sediment budget	Sediment budget refers to the balance between sediment added to and removed from the coastal system.
Sediment control	As defined in section J1 of the AUP: Measures to prevent or minimise the discharge of sediment that has been eroded.
Sediment delivery ratio	The sediment delivery ratio is defined as the sediment yield from an area divided by the gross erosion of that same area. SDR is expressed as a percent and represents the efficiency of the watershed in moving soil particles from areas of erosion to the point where sediment yield is measures. This relates to the amount of eroded material that is retained onsite in depressions and within the site's natural contours.
Sediment generation	The sediment that is generated through erosion, on land or on the site of earthwork activity, prior to treatment through any sediment retention device. This is dependent upon the generation potential of the area and is based on slope, slope length, soils, rainfall and erosion control factors.

Term	Meaning
Sediment load	The mass of sediment carried in suspension within rivers and marine waters.
Sediment yield	That sediment which leaves an area or site and enters the receiving water environment.
Sedimentation	Sedimentation occurs when soil particles suspended in water are deposited.
Stabilised area	An area inherently resistant to erosion such as rock, or rendered resistant by the application of aggregate, geotextile, vegetation or mulch. Where vegetation is to be used on a surface that is not otherwise resistant to erosion, the surface is considered stabilised once an 80% vegetation cover has been established.
State Highway	Means a road, whether or not constructed or vested in the Crown, that is declared to be a State highway under section 11 of the National Roads Act 1953, section 60 of the Government Roading Powers Act 1989 (formerly known as the Transit New Zealand Act 1989), or under section 103 of the LTMA.
The Dome	The highest elevation within the Dome Forest Conservation Area.

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1 INTRODUCTION

1.1 Overview of the Water Assessment Report

The NZ Transport Agency (Transport Agency) is lodging a Notice of Requirement (NoR) and applications for resource consent (collectively referred to as "the Application") for the Warkworth to Wellsford Project (the Project).

This Water Assessment Report (WAR) is part of a suite of technical assessments prepared to inform the Assessment of Effects on the Environment (AEE) to support the Application. In particular this WAR addresses the actual and potential effects on water quality, quantity and flooding and is an important input for the associated ecological assessments. The WAR considers both the construction and operational phases of the Project.

1.2 Project description

The Project involves the construction, operation and maintenance of a new four lane state highway. The route is approximately 26 km long. The Project commences at the interface with the Pūhoi to Warkworth project (P-Wk) near Woodcocks Road, Warkworth. It passes to the west of the existing State Highway 1 (SH1) alignment near The Dome, before crossing SH1 just south of the Hōteo River. North of the Hōteo River the Project passes to the east of Wellsford and Te Hana, bypassing these centres. The Project ties into the existing SH1 to the north of Te Hana near Maeneene Road.

1.3 Project features

The key features of the Project, based on the Indicative Alignment, are as follows:

a) A new four lane dual carriageway state highway, offline from the existing State Highway 1, with the potential for crawler lanes on the steeper grades.

b) Three interchanges as follows:

   i. Warkworth Interchange, to tie-in with the Pūhoi to Warkworth section of SH1 and provide a connection to the northern outskirts of Warkworth.

   ii. Wellsford Interchange, located at Wayby Valley Road to provide access to Wellsford and eastern communities including Tomarata and Mangawhai.

   iii. Te Hana Interchange, located at Mangawhai Road to provide access to Te Hana, Wellsford and communities including Port Albert, Tomarata and Mangawhai.

c) Twin bore tunnels under Kraack Road, each serving one direction, which are approximately 850 metres long and approximately 180 metres below ground level at the deepest point.

d) A series of steep cut and fills through the forestry area to the west of the existing SH1 within the Dome Valley and other areas of cut and fill along the remainder of the Project.

e) A viaduct (or twin bridge structures) approximately 485 metres long, to span over the existing SH1 and the Hōteo River.

f) A tie in to existing SH1 in the vicinity of Maeneene Road, including a bridge over Maeneene Stream.

g) Changes to local roads:

   i. Maintaining local road connections through grade separation (where one road is over or under the other). The Indicative Alignment passes over Woodcocks Road, Wayby Valley Road, Whangaripo Valley Road, Mangawhai Road and Maeneene Road. The Indicative Alignment passes under Kaipara Flats Road, Rustybrook Road, Farmers Lime Road and Silver Hill Road.

   ii. Realignment of sections of Wyllie Road, Carran Road, Kaipara Flats Road, Phillips Road, Wayby Valley Road, Mangawhai Road, Vipond Road, Maeneene Road and Waimanu Road.

   iii. Closing sections of Phillips Road, Robertson Road, Vipond Road and unformed roads affected by the Project.

h) Associated works including bridges, culverts, drainage, stormwater treatment systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities.

i) Construction activities, including construction yards, lay down areas for storage of materials and establishment of construction access and haul roads.

A full description of the Project including its current design, construction and operation is provided in Section 4: Description of the Project and Section 5: Construction and Operation of the AEE contained in Volume 1 and shown on the Drawings in Volume 3.

The Indicative Alignment is a preliminary alignment for a state highway that could be constructed within the proposed designation boundary. The assessment within this WAR considers the effects of the Indicative Alignment, but also considers the sensitivity to effects if the alignment shifts within the proposed designation boundary when the design is finalised.

The final alignment for the Project (including the detailed design and location of associated works including bridges, culverts, stormwater management systems, soil disposal sites, signage, lighting at interchanges, landscaping, realignment of access points to local roads, and maintenance facilities), will be refined and confirmed at the detailed design stage.

1.4 Project sections

For description purposes the Project has been divided into the following sections (as shown in Figure 1 below). These sections also reflect the indicative construction programme and sequencing.

a) Southern Section: From the southern extent of the Project at Warkworth to the northern tunnel portal.

b) Central Section: From the northern tunnel portal to the Hōteo River (southern abutment.

c) Northern Section: From the Hōteo River (northern abutment) to the northern tie in with existing SH1 near Maeneene Road.

For the purpose of this WAR the southern and central sections are sometimes grouped and referred to as Hōteo South (representing everything south of the Hōteo River) and Hōteo North representing everything north of the Hōteo River.

For this WAR and assessment purposes, the Project has been split into the three main catchments, and then within the Hōteo River catchment the construction areas have been further split into six operational areas. This is illustrated in Figure 6 within Section 4.1.1 of this WAR with the operational areas further illustrated in Figures 5 to 8 of the Catchment Sediment Modelling technical report.

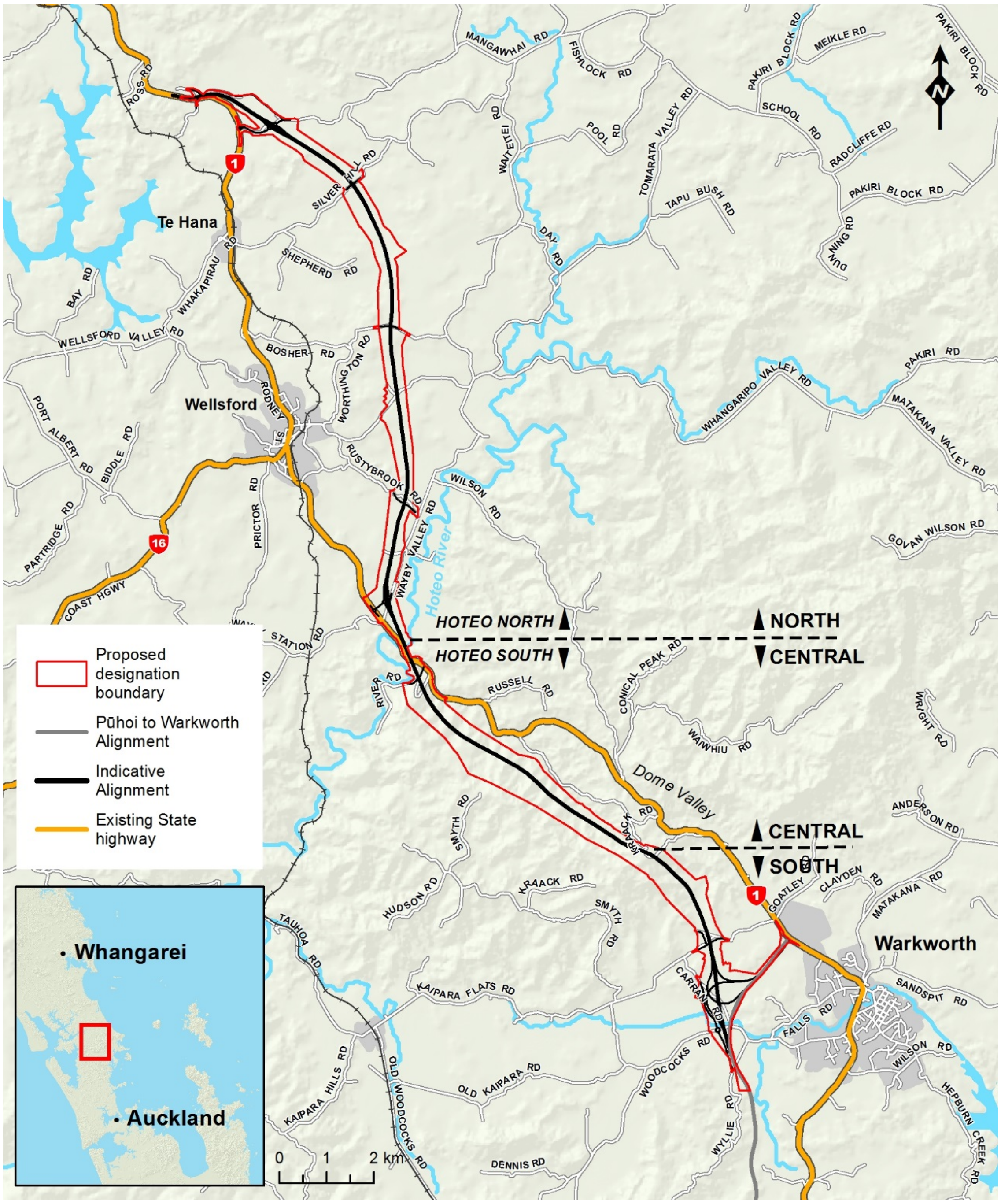

Figure 1 - Project Sections and Indicative Alignment

1.5 Scope of this report

The scope of the work undertaken to inform this WAR and to assess the construction-related water effects of the Project is as follows:

- Understand the relevant existing environment and future environment, especially water quality and existing catchment sediment loads;

- Identify relevant assessment criteria, including those that are required to be considered by relevant statutory policy and planning instruments;
- Identify the construction water management principles for the Project and outline the proposed approach for managing construction water;
- Predict changes that could occur within the existing receiving environment as a result of Project construction activities with the assistance of sediment modelling;
- Identify risks for construction activities and specific locations with associated risk management approaches;
- Assess potential environmental effects of the construction water management (earthworks) of the Project; and
- Recommend appropriate construction water management, including monitoring procedures, to avoid, remedy or mitigate effects.

The scope of the work undertaken to inform this WAR and to assess the operational-related water effects of the Project is as follows:

- Understand the relevant existing and expected future environment especially water quality, hydrology and flooding;
- Identify relevant assessment criteria, including those that are required to be considered by statutory policy and planning instruments;
- Identify the operational water management principles for the Project; develop the indicative operational water management design, including proposed mitigation measures, such as permanent stormwater management systems, indicative instream/above-stream structures (bridges and culverts) and proposed modifications to streams/floodplains for the operation of the Project;
- Predict changes that could occur to the existing receiving environment as part of the Project (arising from operational stormwater, streamworks, hydrological changes such as flooding);
- Assess the operational-related water effects of the Project during the operation of the Project; and
- Recommend appropriate indicative operational water management and monitoring procedures to avoid, remedy or mitigate effects.

1.6 Associated reports

This WAR draws on information and conclusions presented in a number of supporting water technical reports, such as details of the existing environment, the principles and indicative design of water-related management practices and structures and assessed changes to the water environment. These supporting technical reports are listed below with a short description of each:

- **Existing Water Quality technical report** – This report summarises water quality monitoring carried out by the Project team and Auckland Council in the catchments traversed by the Project to support the understanding of the existing environment.

- **Construction Water Management Design technical report –** This report contains details of the indicative construction methodology, details of proposed erosion and sediment controls and other construction phase measures and methodologies.
- **Catchment Sediment Modelling technical report** – This report confirms the hydrological sediment modelling undertaken to predict changes in sediment load and water quality within receiving watercourses associated with construction of the Project. This report summarises the modelling methodology and results of these catchment sediment models. The results of this modelling have also provided inputs to the Marine Sediment Model, Marine Ecology and Coastal Avifauna Assessment and Ecology Assessment Reports.
- **Assessment of Coastal Sediment technical report** – Harbour modelling has been developed to predict changes in the location and depth of sediment load within the marine and coastal waterbodies as a result of the Project. This harbour modelling uses the results of the Catchment Sediment Model to assess changes to the marine environment within the Mahurangi Estuary Model, Southern Kaipara Harbour Model and also an expert assessment of sediment fate within the Oruawharo Estuary.
- **Operational Water Design technical report –** This report contains details of the indicative operational water management approach.
- **Operational Water - Road Runoff technical report** – This report presents the predicted changes to water quality in relation to runoff from the operational Project through the use of two contaminant models. These models predict changes to water quality in the receiving environment in relation to metals, suspended solids and total petroleum hydrocarbons.
- **Hydrological Assessment technical report** – Catchment analysis has been developed to assess hydrological changes associated with the Indicative Alignment surface water diversions and increases in impervious area during the operational phase of the Project.
- **Flood Modelling technical report** – Three flood models have been developed to assess the changes in flood risk associated with the operational phase of the Project.

In addition to these reports there are two further assessment reports which consider water associated effects, these are:

- **Ecology Assessment Report**; and
- **Marine Ecology and Coastal Avifauna Assessment Report**.

Figure 2 below provides a flow chart for the relationships between the water related assessment and technical reports that contribute to the overall AEE for the Project. The figure also provides a summary of the technical report linkages to the construction and operational aspects of the WAR.

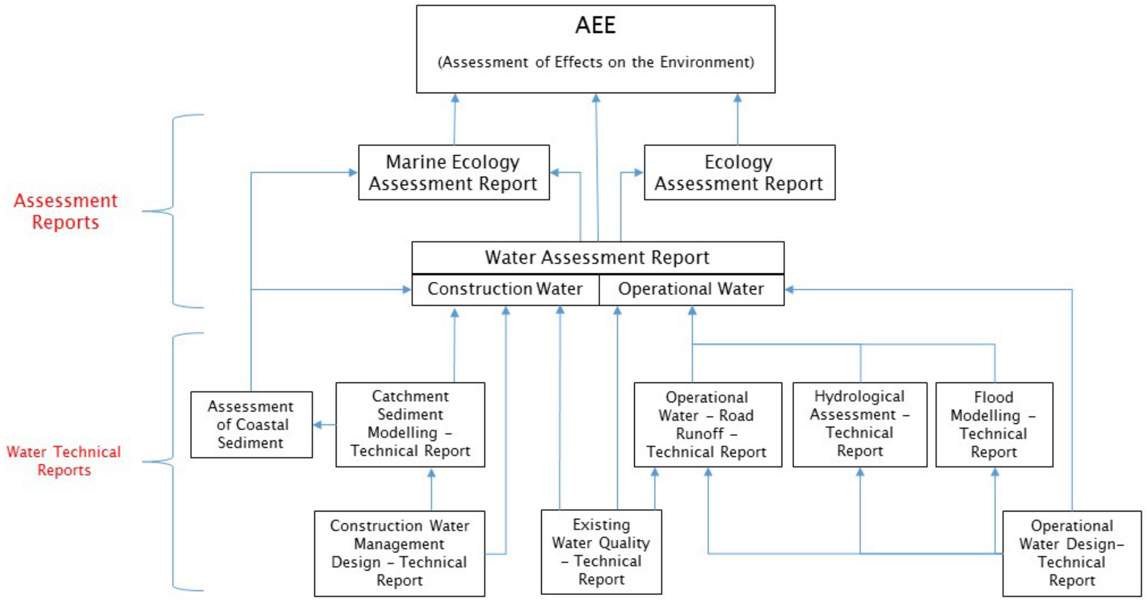

Figure 2 - Water Assessment Report – Relationship between assessment and technical reports

2 ASSESSMENT METHODOLOGY

Section Summary

The WAR assessment methodology involved the following steps:

- Characterising the relevant existing and future receiving environment of the Project supported by baseline monitoring and surveys;
- Identifying relevant assessment criteria, including those that are required to be considered by relevant statutory policy and planning instruments;
- Developing the indicative construction and operational phase water designs, including measures that mitigate environmental impacts and follow industry best practise;
- Predicting the changes that construction and operation of the Project will have on the existing water environment using models and assessment tools in addition to risk identification and management as part of the overall effects assessment;
- Assessing the effects of the modelled and predicted changes to the water environment as a result of the Project; and
- Recommending appropriate controls and monitoring to avoid, remedy or mitigate potential effects.

When assessing the construction and operational effects of the Project on the water environment, we have considered potential changes to water quality, changes to flooding and changes to hydrology.

To assess these changes, we have developed a number of models and assessments:

- A catchment sediment model – this model assessed changes to sediment load and concentration within receiving environments associated with the construction phase of the Project.
- A marine sediment model – this model assessed changes in sediment to the receiving coastal and marine environment during the construction phase.
- Road runoff models – two models (discussed below) that assessed the changes to the concentration of sediment, metals and petroleum hydrocarbons in receiving watercourses during the operational phase.
- Flooding models – this includes an assessment of changes to flooding associated with the operational phase of the Project.
- Hydrology assessment – this includes a high level assessment of changes to catchment areas and impervious areas associated with the operation of the Project.

The effects of the changes in water quality, hydrology and flooding predicted in this assessment are then assessed in this report. Environmental effects of the changes are further assessed in the Ecology Assessment and Marine Ecology and Coastal Avifauna Assessment reports.

2.1 Introduction

This section of the WAR contains a summary of the methodologies including models and assessment tools that have been used to support the assessment.

Our assessments are based on indicative construction and operational designs that are summarised in the Construction Water Management Design technical report and the Operational Water Design technical report respectively both of which follow an overall BPO approach to the construction and operation activities.

2.2 Methodology to characterise the existing water environment

The existing environment was characterised through the following:

- Desk based study of the water environment including a review of online topographical, rainfall, hydrological, flood and geological mapping and information, and a literature review of existing studies into the freshwater and marine water receiving environments.
- Assessment of existing datasets for the freshwater streams and rivers and receiving marine waterbodies associated with the Project. Data related to consents, water quality, climate, hydrology, flooding and topography were obtained from Council and NIWA.
- Site inspections by the Project team for the freshwater and marine environment including walkovers of the streams, rivers and natural wetlands within the Project area.
- Freshwater quality monitoring was carried out by the Project team between June-September 2017 to provide supplementary water quality data that was specific to the rivers and streams in the Project area.

The existing water quality has been characterised by comparison to trigger levels based upon water quality guidelines. In particular, the Australia and New Zealand Environment and Conservation Council Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) are used. These guidelines have default trigger values rather than absolute limits, whereby any exceedances of the trigger values do not mean that an effect has occurred or is inevitable, but rather that the exceedances may indicate the need for further investigation or can indicate a potential stressor in the environment.

The characterisation of the existing environment is summarised in Section 4 of this WAR, with further detail on water quality and existing sediment loads provided in the Water Quality technical report and in the Catchment Sediment Modelling technical report respectively.

2.3 Methodology to characterise changes to water environment

2.3.1 Changes in water quality – construction phase

The Project works have the potential to result in changes to water quality during the construction phase as a result of:

- discharge of sediment from earthworks during both rain and flood events;
- discharge of sediment from in-stream activities and changes to flow; and
- discharge of other contaminants (such as oils, fuels and cement).

The methodology applied to assess changes to water quality associated with the Project construction works took into account all mitigation by design and best practice principles, as described in the Construction Water Management Design technical report.

Figure 3 below shows the construction water management concepts that are considered within this WAR.

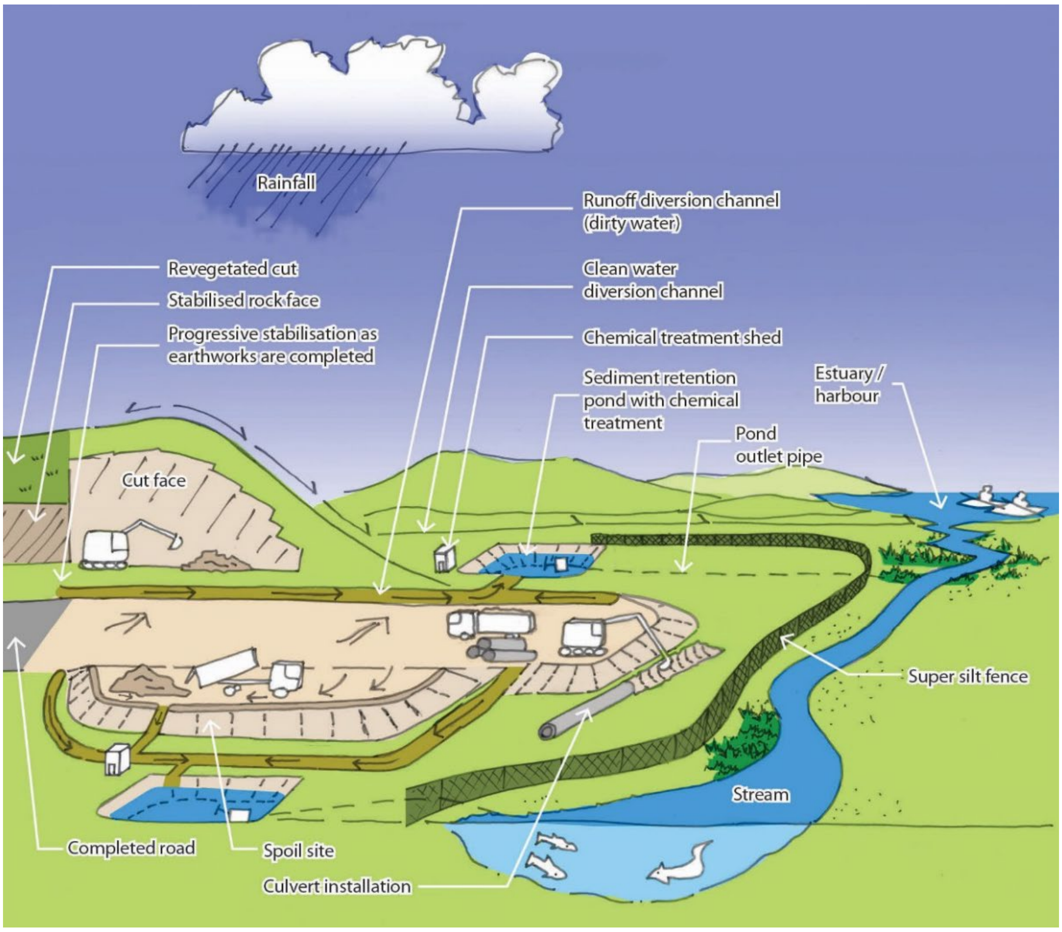

Figure 3 - Construction water management concepts and principles

With recognition of the best practice construction water management techniques we anticipate that sediment yield due to changing land use and earthwork operations is likely to be the main driver of changes to water quality due to the Project construction. These changes to water quality, and the associated assessment of effects, have been determined through a full risk assessment approach considering items such as rainfall probabilities, topography, receiving environment values and location and nature of the construction activity. To obtain an understanding of the quantum of specific changes to water quality these changes have been estimated through the development of a construction sediment model, the methodology of which is summarised below. The effects of forestry harvesting on water quality have also been considered.

Catchment Sediment modelling methodology

The purpose of the hydrological and sediment modelling that was undertaken is to predict sediment load during the construction of the Project and allow comparison to the catchment background sediment load. The river catchments that are potentially affected by the Project drain into two coastal waterbodies; namely the Mahurangi Harbour and the Kaipara Harbour.

For the construction phase of earthworks the Mahurangi River catchment was modelled by NIWA (as part of P-Wk) using a GLEAMS model. The model predicted the sediment loads within the Mahurangi River catchment and sediment loads delivered to the Mahurangi Harbour with the model described in the Catchment Sediment Modelling technical report. The model outcomes were assessed alongside a series of construction related principles and practices to provide for a comprehensive assessment of effects from the earthworks activity. This model was developed for P-Wk and is transferrable to this Project given that the Project is immediately to the north of P-Wk study area and the hydrology, topography and geology are of a similar nature.

Watercourses draining to the Kaipara Harbour and estuarine Oruawharo River, including the Hōteo River and Oruawharo River tributaries, were modelled for the Project using the eWater Source software which utilises a daily SedNet plugin. This model is a catchment-scale daily sediment model which was constructed and calibrated for this Project for all freshwater catchments draining to the southern Kaipara Harbour by the Project team. This model was used to quantify any changes to sediment load to the Hōteo River, Oruawharo River and Kaipara Harbour during the construction of the Project.

These two model outputs were then utilised within the Mahurangi Estuary Model (for the works within the Mahurangi River catchment) and the Kaipara Harbour Model (for the works within the Hōteo River catchment). For the works within the Oruawharo River catchment there was no specific harbour model and expert opinion and assessment was utilised for that purpose due to the low level of predicted change and effect from sediment and the existing knowledge of this marine environment. These harbour assessments are discussed in detail within the Catchment Sediment Modelling technical report.

The northern part of the Kaipara Harbour was not modelled for the following reasons:

- the Project does not drain to the northern Kaipara Harbour;
- a published study of the Harbour sediment indicates that sediment from the Hōteo River and Oruawharo River does not disperse into the northern part of the harbour (Gibbs et al., 2010) and therefore there is no direct linkage between the Project and the northern Kaipara Harbour.

A full description of the methodology to develop these models is contained in the Catchment Sediment Modelling technical report.

2.3.2 Changes in water quality – operational phase

The operational phase of the Project has the potential to result in changes to water quality, these changes may be associated with:

- discharge of contaminants, such as heavy metals, fuels and oils that are generated from vehicles, from the road carriage way; and
- discharge of sediment from the road carriageway.

Figure 4 below shows the indicative operational water management concepts that are proposed for the Project. These are described in detail in Section 7.

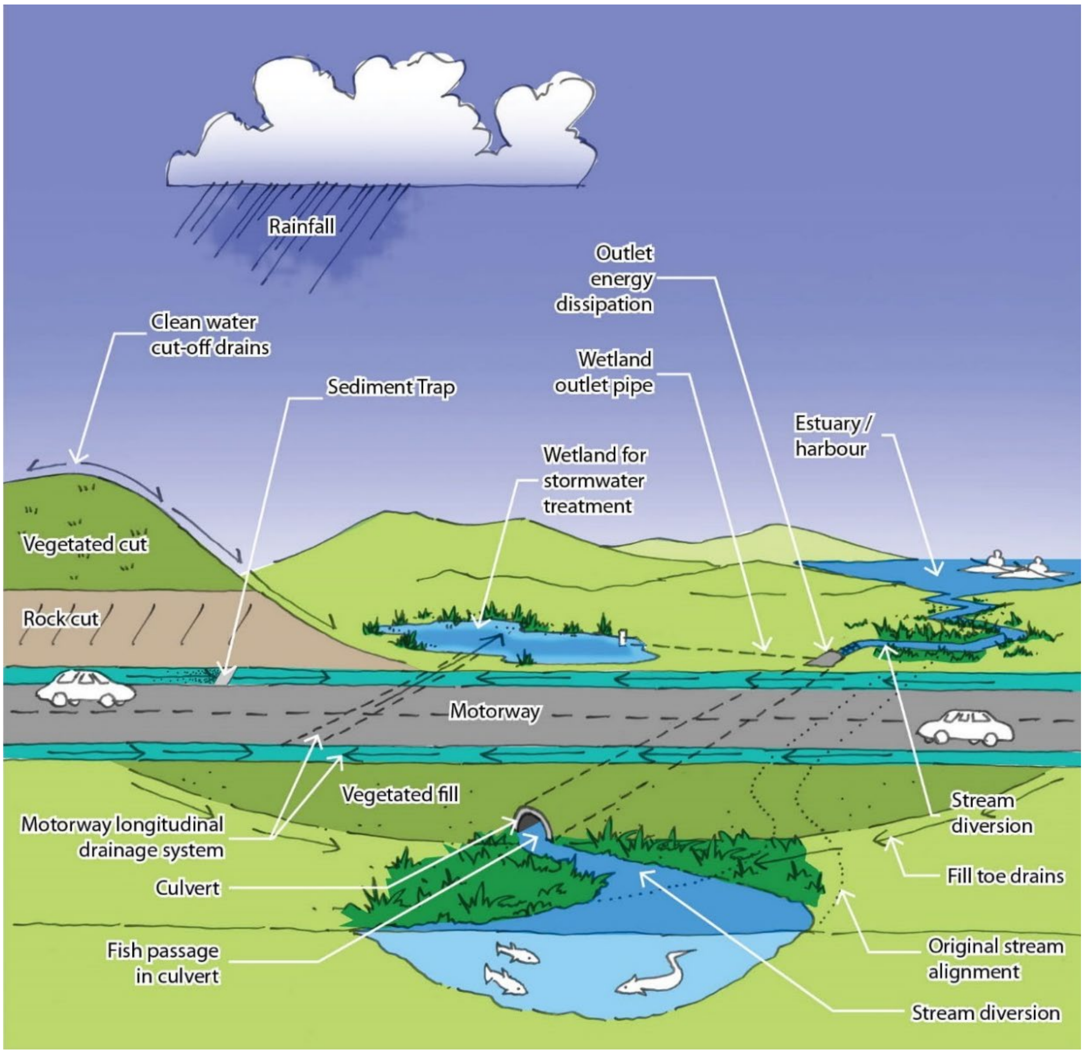

Figure 4 - Operational water management concepts and principles

Road runoff modelling (water quality – operational)

The Operational Water - Road Runoff technical report contains details of the two models used to assess the water quality during the operational phase, accounting for changes due to the road runoff.

The contaminant load model (CLM) Version 2 is a spreadsheet-based model that has been developed by Council to enable estimations of stormwater contaminant loads. The CLM was developed and calibrated to estimate the annual loads, i.e. kilograms per year (kg/yr), for certain contaminants in stormwater from large, heterogeneous urban areas of the Auckland region. The CLM estimates contaminant loads for four water quality parameters:

- Total suspended solids (TSS);
- Total zinc;
- Total copper; and
- Total petroleum hydrocarbons (TPH).

The CLM is used for catchments that are predominantly urban (i.e. greater than approximately 80% urban). The CLM user manual (Auckland Regional Council 2010) recommends that for rural catchments only the urban parts of the catchment be included in the model. Thus we have applied the CLM to simulate the change in contaminant loads from the urban parts of the catchment (including roads), and it ignores all the rural parts of the catchments and associated contaminants. Therefore, a limitation of the model is that it more accurately indicates the change in load due to the Project from a small part of the catchment on that local environment which is the most important assessment, rather than the change relative to the whole catchment loads which is less important as the effects (if any) will be less at the catchment scale.

The model uses traffic assumptions and measures of impervious areas including roads, derived from a geographic information system (GIS), as inputs to a spreadsheet-based model. The model is used to inform the change in contaminant loads due to the Project in the future case with and without the Project, and is useful for predicting relative change in contaminant loads into the marine receiving environments. The change in contaminant loads are measured as annual loads at the marine receiving environment.

The model cannot be used to inform an assessment against freshwater concentration trigger values. To address this limitation, we also used an additional assessment method to predict changes in freshwater concentrations.

The second method used for our assessment was the contaminant concentration method (CCM). This method provides site specific estimates of the predicted change in contaminant concentrations in freshwater due to road runoff. This methodology provides data for the Ecology Assessment. The method uses the 95th percentile values from our 2017 monitoring data for surface water (summarised in the Existing Water Quality technical report) and the 95th percentile values from road runoff water quality data from existing New Zealand state highways applied on a weighted catchment basis to estimate contaminant concentrations in receiving environments. The contaminant concentration method enables the water quality in the existing environment to be compared to water quality guideline values, and for the predicted change in the water quality to be assessed against those guideline values.

2.3.3 Changes in flooding – construction and operational phase

The Project may result in changes to flood risk in the streams/rivers upstream and downstream of the Project. These changes may occur due to:

- alteration of flow pathways due to culverts and stream diversions;
- change in flows and flood depths due to culverts and bridges; and
- change in flows and flood depths due to embankments located within floodplains.

The changes to flooding associated with the operational phase including the permanent structures have been modelled and assessed for events up to the 100 year ARI flood.

Potential changes to flooding have not been modelled separately for the construction phase. During construction an extreme flood event is less likely to occur because of the lower probability of a large flood occurring during the indicated construction period of approximately 7 years compared to the longer operational phase of the Project. Temporary culverts and diversions will be required to be sized to allow for flood risk during the construction activities. As an example this includes sizing temporary culverts for a 20-year rain event where practicable with a provision for a 100 year flood flow path where necessary. In addition construction yards and storage of materials will occur outside of flood plain locations where practicable.

Flooding during the construction phase may influence the water quality effects of the Project in circumstances where flood waters extend over the construction earthworks. These rain events will be able to be predicted through the use of rain forecasting and as such the earthworks area in question will be able to be managed through stabilisation and diversions to reduce such effects. It is recognised that such rain events however may result in a potential reduction in the efficiency of the temporary construction water treatment devices. We have accounted for this potential efficiency reduction factor in the catchment sediment modelling methodology by adopting conservative lower treatment efficiencies for devices that need to be installed in flood plain areas.

The flood modelling has been used to inform the design of permanent waterway crossing structures (bridges and culverts) and to assess the effects of the Project on flood levels. The modelling has also been used for the purpose of confirming the location of the 20 year flood level which during construction will be a flood level below which increased risk is recognised.

Flood modelling methodology

Three flood models were developed to assess the changes to flooding associated with the Project. Full details of the flood modelling methodology are set out in the Flood Modelling technical report.

Three models were developed for three areas of the Project that we identified as having high flood risk. These areas were identified by using results from the Auckland Council Rapid Flood Hazard Assessment (RFHA) maps of the 100 year ARI flood event, and are listed below and shown on Figure 5:

1. Hōteo River along Wayby Valley Road;
2. Kourawhero Stream (a tributary of the Hōteo River to the south of the proposed tunnel); and
3. Mahurangi River in the vicinity of Kaipara Flats and Carran Road.

New models of the Hōteo River and Kourawhero Stream were created by the Project team using MIKE FLOOD software which represents floodplains and channel flow paths, with the models using combinations of MIKE21 and MIKE11 software (further details contained in the Flood Modelling technical report.

The model of the Mahurangi was based on the Auckland Council model of the Mahurangi, which uses Infoworks ICM software. The model was further developed by the Northern Express Group (NX2) for the P-Wk project. The NX2 model was used as the basis for this assessment and was adapted to include the Indicative Alignment.

The hydrological inputs to the models were as follows:

i. The Mahurangi uses Auckland Council Technical Publication (TP108) based hydrology that was calibrated to observed flood data by NX2 (Northern Express Group, 2018).

ii. The flood-frequency method was used to establish the peak flows for Hōteo design floods used in the assessments. The flood-frequency method was applied to the gauging station named Hōteo at Gubbs, located in the vicinity of Tauhoa Road. The hydrograph shape of the Hōteo design floods are based on the observed flood hydrographs. Each sub-catchment of the Hōteo has a design flood applied to a point location within the catchment. Each sub-catchment design flood is scaled by area as per the flood-frequency method in the NZTA Bridge Manual. Using this approach the modelled flood peak replicated an observed flood and as such the Hōteo model is considered to be validated. This methodology and validation is detailed in the Flood Modelling technical report.

iii. The Auckland Council Technical Publication (TP108) hydrological methodology was used for the Kourawhero catchment. There is no data available to calibrate the Kourawhero hydrology.

The additional expected flows due to climate change as at year 2130 were included into the Project design floods. 2130 was chosen to reflect the end of the Project's design life. For the flood assessment, the climate change adjustment factor was derived using the information provided in MfE (2016), based on a mid-range climate change temperature increase scenario to 2090, linearly extrapolated to 2130, and assuming an 8% increase in rainfall intensity per 1˚C increase in temperature (MfE, 2010). This approach is generally consistent with the climate change adjustment approach recommended in the Auckland Council Code of Practice for Land Development and Subdivision (2015). However the Auckland Council Code of Practice for Land Development and Subdivision (2015) refers to the IPCC 4th assessment (MfE 2010), which predicted greater increases in temperature than in the more recent IPCC 5th assessment (MfE 2016). The higher estimate of temperature increase due to climate change was used for the culvert sizing to be conservative. The methodology is described in more detail in the Operational Water Design technical report. It is recommended that the most up to date climate change estimates that are available at the time of detailed design are used for the final design.

All three models were run for a number of flood events including the 2, 10, 20 and 100 year ARI event. Each model was run for the existing scenario (without Project, but with P-Wk) and the Project scenario (with the Project as per the Indicative Alignment and with P-Wk).

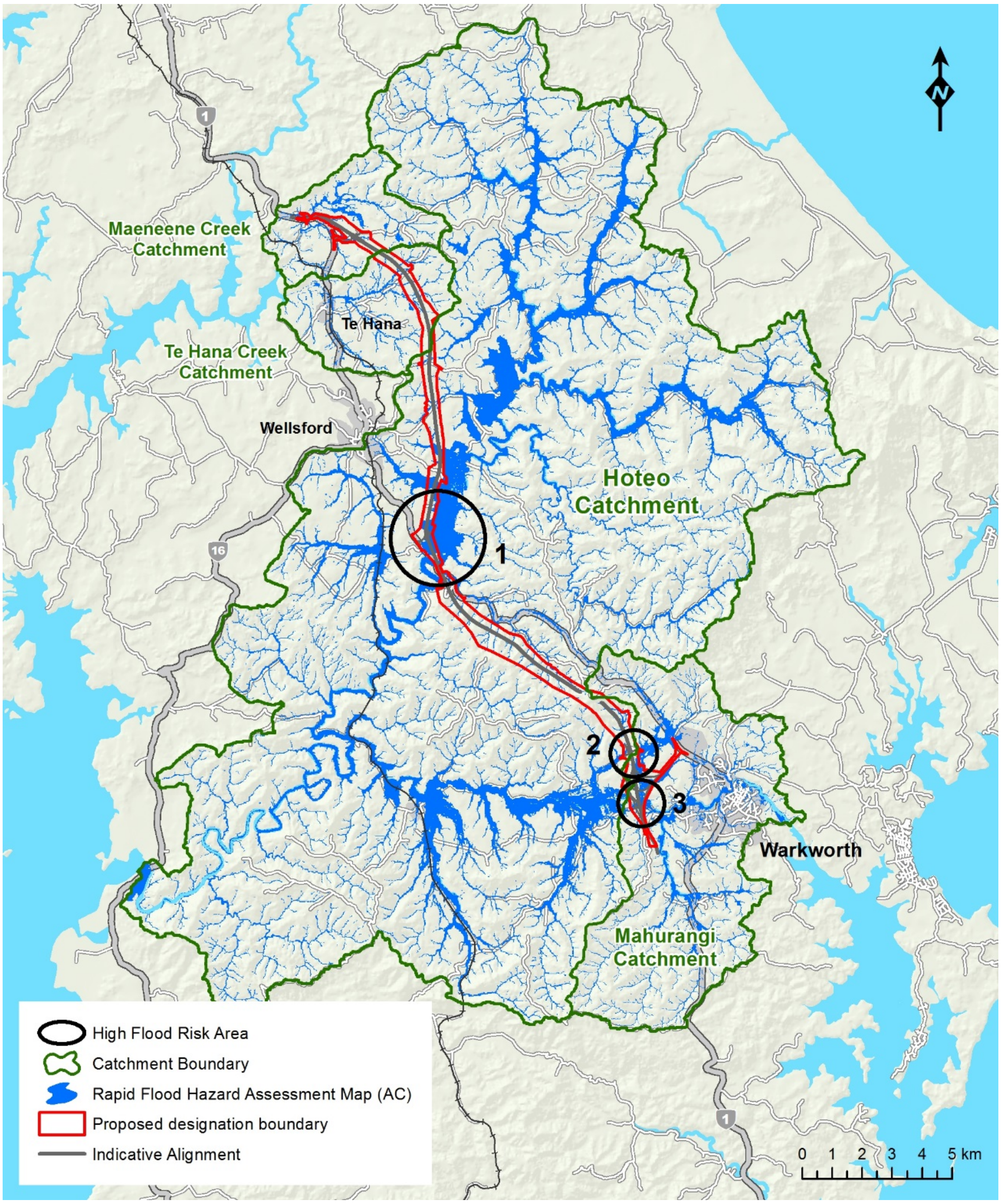

Figure 5 - Catchment Boundaries with Indicative Alignment and 100 year ARI Rapid Flood Hazard Assessment Map (Source: Auckland Council)

2.3.4 Changes in hydrology – operational phase

The Project will result in changes to catchment runoff, changes to catchments boundaries, changes to stream flow, and changes to stream channel and stream bed morphology. This may occur due to:

- alteration of catchment areas due to road embankments, culverts, stream diversions and cut-off drains;
- alteration of flow pathways and altered runoff regime (drainage features, impermeable area and slope change); and
- changes to stream channel and stream bed morphology due to stream diversions, culverts, bridges and other instream structures.

An assessment of changes to hydrology was carried out for the operational phase, this is detailed in the Hydrology Assessment technical report and the methodology is summarised in the section below.

Any changes to hydrology due the construction phase have not been modelled individually however this is likely to be similar to or less than the changes associated with the operational phases.

Hydrological assessment methodology

The hydrological assessment was carried out using GIS, which was used to measure the following catchment characteristics:

- changes in catchment area; and
- changes in impervious cover.

The existing catchments that are influenced by the Indicative Alignment were identified from the NIWA River Environment Classification (REC) GIS layer. The operational stormwater design for the Indicative Alignment was analysed to determine where proposed stream diversions or stormwater diversions would result in changes to catchment areas at the downstream limit of the affected REC sub-catchments. These changes to sub-catchment areas are presented graphically to allow the potential effects to be assessed.

Impervious cover influences stream flow, because increases in imperviousness increase the runoff to the local stream and reduce the amount of rainfall that is infiltrated into the ground. The existing imperviousness within each catchment was defined through the New Zealand Land Cover Database (LCDB) version 4.1, and compared with the increases in predicted imperviousness with the Project in place. The changes to impervious cover area in each sub-catchment was presented graphically to allow the potential effects to be assessed.

2.4 Methodology to assess effects – construction and operation

To assist with the assessment of effects a methodology of determining the magnitude of effect was adopted. This methodology allows for assessment of the level of effect magnitude from very high to negligible and provides for consistency of assessment. This is the same criteria as defined within the Marine Ecology and Coastal Avifauna Assessment Report.

Table 1 and Table 2 below contain the detail we have used to describe the magnitude of effects and the level of effect of the Project on the water environment[1].

Table 1 - Magnitude of effects

Magnitude	Description
Very High	Total loss of, or very major alteration to, key elements/ features of the baseline conditions, such that the post development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR loss of a very high proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/ features of the baseline conditions such that post development character, composition and/or attributes will be fundamentally changed; AND/OR loss of a high proportion of the known population or range of the element/feature.
Medium	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character, composition and/or attributes of the existing baseline will be partially changed; AND/OR loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character, composition and/or attributes of existing baseline condition will be similar to predevelopment circumstances/patterns; AND/OR having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the “no change” situation; AND/OR having negligible effect on the known population or range of the element/feature.

Table 2 - Criteria for describing level of effect

		Ecological Value				
		Very high	High	Medium	Low	Negligible
Magnitude	Very high	Very high	Very high	High	Moderate	Low
	High	Very high	Very high	Moderate	Low	Very low
	Medium	High	High	Moderate	Low	Very low
	Low	Moderate	Low	Low	Very low	Very low
	Negligible	Low	Very low	Very low	Very low	Very low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

[1] Derived from Ecological Impact Assessment Guidelines from Environment Institute of Australia and New Zealand

3 ASSESSMENT FRAMEWORK

Section Summary

The key assessment matters for the WAR have been developed for construction and operational water aspects based on a review of the statutory framework and relevant guidelines. These set up the assessment framework for Section 6 and 8 of the WAR.

The assessment matters for construction water are summarised as:

- Use of best practicable option approach appropriate to the nature and scale of the activity;
- Consideration of effects based on earthwork areas, construction design, site constraints and opportunities, best practice erosion and sediment controls and staging and progressive stabilisation;
- Maintaining excellent or good water quality and improving degraded areas;
- Consideration of changes in water quality after reasonable mixing;
- Objectionable odour;
- Effects on recreational uses, water uses and drinking water;
- Effects of the project on flooding; and
- Potential effects of the activity on stream systems including diversions, flooding and water quality.

The assessment matters for operational water are summarised as:

- Integrated stormwater management approach;
- Best Practicable Option approach;
- Effects on water quality;
- Effects on water quantity (hydrological changes);
- Human impacts;
- Effects from flooding; and
- Effects on streams.

The statutory framework and relevant guidelines that have been reviewed include:

Statutory framework

Resource Management Act (RMA) 1991 - The RMA is the law that sets up the statutory framework and is specifically relevant to the consenting of the Project in its requirements for Best Practicable Options and for discharges (Section 107).

The National Policy Statement for Freshwater Management 2014 (NPSFM) - The NPSFM contains objectives and policies relating to water quality, as well as attribute tables relevant for ecosystem health.

Auckland Unitary Plan Operative in Part (AUP(OP)) - the AUP(OP) contains guidance relating to water quality, sediment control, stormwater discharge, and objectives for the freshwater and coastal environment.

New Zealand Transport Agency

Transport Agency have published a number of non-statutory guidelines relevant to the Project including:

- Transport Agency Environment Plan (2008)
- Erosion and Sediment Control Standard for State Highway Infrastructure (2014);
- Transport Agency Stormwater Treatment Standard for State Highway Infrastructure (2010);
- Transport Agency Stormwater Specification (2016); and
- Transport Agency Fish Passage Guidance for State Highways (2013).

Auckland Council design guidelines

Auckland Council has a number of non-statutory guidelines in place relevant to the Project as follows:

- Guideline document 2016/05. Erosion and Sediment Control Guide for Land Disturbing Activity in the Auckland Region (GD05), Auckland Council;
- Technical Publication No. 90. Erosion and Sediment Control: Guidelines for Land Disturbing Activities (TP90), Auckland Council;
- Technical Publication No. 108. Guidelines for Stormwater Runoff Modelling in the Auckland Region;
- Guideline document 2017/001. Stormwater Management Devices in the Auckland Region (GD01), Auckland Council;
- Technical Publication No. 10. Stormwater Management Devices Design Guidelines Manual;
- Technical report 2010/003. Development of the Contaminant Load Model; and
- Technical report 2009/084. Fish Passage in the Auckland Region.

3.1 National policy and standards

3.1.1 Resource Management Act

The Resource Management Act 1991 (RMA) regulates activities that may affect the environment, including stormwater discharges. Sections 14 and 15 are the governing sections of the RMA in relation to use of and discharges to water. The RMA is given effect to by national environmental standards, national policy statements and regional plans.

Section 107 of the RMA places restrictions on the granting of certain discharge permits.

3.1.2 National Policy Statement for Freshwater Management

The National Policy Statement for Freshwater Management 2014 (NPSFM), as updated in 2017, contains objectives and policies relating to water quality, water quantity and monitoring, among other matters.

Some of the key provisions of the NPSFM as relevant to the Project are to:

- safeguard fresh water's life-supporting capacity, ecosystem processes, and indigenous species;
- safeguard the health of people who come into contact with the water;
- maintain or improve the overall quality of fresh water within a freshwater management unit;
- improve water quality so that it is suitable for primary contact more often;
- protect the significant values of natural wetlands and outstanding freshwater bodies; and
- take an integrated approach to managing land use, fresh water and coastal water.

The NPSFM also contains tables used to describe the value of the freshwater body in terms of ecosystem health or human health for recreation as scored against a range of attributes. However, these only provide guidance for aquatic indicators, nutrients and bacteriological pathogens, and these parameters are not likely to be impacted significantly by the Project.

It is noted that a significant update of the NPSFM and a proposed NES for freshwater are currently under consideration by central government. Submissions on the draft documents were provided in October 2019. The updated policy statement is intended to replace NPSFM 2014 in Full.

The NPSFM is given effect to predominantly through the regional provisions of the AUP(OP).

3.1.3 National Environmental Standard for Sources of Human Drinking Water

The National Environmental Standards for Sources of Human Drinking Water 2007 require regional councils to ensure that effects on drinking water sources are considered in decisions on resource consents and regional plans. The standard applies to potable water sources before they are abstracted (and prior to treatment in a drinking water treatment plant), and requires consent authorities to impose conditions on consents if the activity may significantly adversely affect drinking-water supply. The Project is upstream of the drinking water source for Wellsford on the Hōteo River and a previous source for Warkworth on the Mahurangi River (the consent for which has recently been surrendered). After being processed in a water treatment plant, Ministry of Health legislation and the Drinking Water Standards (2005, revised 2008) apply to the quality of the water.

3.1.4 National Environmental Standard for Forestry

The Central Section of the Project passes through commercial plantation pine forest owned by Rayonier Matariki Forests. The National Environmental Standard for Plantation Forestry 2017 (NESPF) came into force on 1st May 2018. This standard states that forestry activities are generally permitted activities provided that various standards are complied with. As such, many forestry activities do not need specific resource consents to occur.

The Auckland Council has adopted TP223 as the guideline to manage erosion and sediment control for forestry operations. This guideline has been in existence for a period of time however remains relevant and is generally adopted by most forestry operators in the Auckland region. TP223 provides activity specific guidance which generally aligns with the principles within TP90 and GD05and includes a range of forestry specific ESC measures. It is considered that TP223 remains relevant and is applicable to any forestry clearance activities associated with the Project. It is noted, however, that the current Rayioner Matatriki Forests harvest schedule anticipates that foresty lots within the designation will be cleared by them prior to project commencement.

While not containing specific objectives, the NESPF has a key direction as follows:

- to maintain or improve the environmental outcomes associated with plantation forestry activities nationally; and
- to increase certainty and efficiency in the management of plantation forestry activities. During the harvesting of any forestry areas associated with the Project the direction and specific requirements of the NESPF will apply.

3.2 Auckland Unitary Plan

The AUP(OP) provides a statutory framework for water quality, water quantity, flooding, land disturbing activities, erosion, sediment generation and deposition. This plan became operative in part in 2016. The AUP(OP) informs the identification of appropriate assessment criteria for water quality and flooding effects of the Project. It also sets out particular matters which must be given regard to when assessing applications for discharge consents.

AUP(OP) Chapter E1 Water Quality and Integrated Management sets out objectives and policies for activities that impact on water quality. This includes policies for assessing activities against ecosystem health and the National Policy Statement for Freshwater Water. These provisions address stormwater discharges in relation to water quality and erosion. Water quality objectives are set out in E1 of the AUP(OP), listed below, as well as policies relating to these objectives:

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

The AUP(OP) defines the Kaipara Harbour and Mahurangi Harbour as degraded areas : refer to AUP(OP) Figure B7.4.2.1. The AUP(OP) intends that activities should be managed to progressively improve the freshwater and sediment quality over time. The water quality of the Mahurangi and Kaipara Harbours are further detailed within the Existing Water Quality technical report.

Chapter E3 covers lakes, rivers, streams and wetlands. The objectives in E.3.2 and the policies in E.3.3 are relevant to the potential effects of the Project. E7 includes the diverting of surface water.

Chapters E8 and E9 cover stormwater quality; these chapters provide assessment criteria based on the activity type.

Chapters E11 and E12 cover land disturbance, which addresses earthworks, vegetation removal and/or clearance (such as forest harvesting), roading/tracking/trenching, and quarries. These chapters regulate land disturbing activities and make a distinction between general land and 'Sediment Control Protection Areas' (SCPAs). It identifies SCPAs as those areas:

- 100 m landward of the Coastal Marine Area, or
- 50 m landward of the edge of a watercourse, or
- 50 m landward from the edge of a natural wetland with a size of at least 1,000 m².

SCPAs are considered to be higher risk with respect to the discharge of sediment.

The earthworks required to construct the Project will include land within multiple SCPAs and resource consent will be required. The AUP(OP) restricts discretion with respect to managing erosion and sediment control to the following matters:

- The proportion of the catchment that is "exposed" or open to earthworks;
- The proximity of the earthworks operation to the receiving environment;
- The concentration and volume of any sediment that may be discharged;
- Techniques used to restrict or control sediment being transported from the site ;
- The effects or impacts of sediment on water quality from the techniques chosen;
- including the practicality and efficiency of the proposed control measures;
- The time during which the bare earth surface is exposed;
- The time of year when the activity is undertaken;
- The duration of the consent; and
- Monitoring the volume and concentration of any sediment that may be discharged.

While consent is required for the earthworks activity itself, the discharge from those associated earthworks is a permitted activity. Damming or diversion of water in respect of the control of sediment laden runoff is also permitted with compliance with the general standards as specified in E.11.6.2.

Chapter E36 addresses managing resilience and flood risk.

3.2.1 Auckland Council guiding documents

Auckland Council has a number of guidance documents of relevance to construction water management and this Project, including:

- **Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region; June 2016; Guideline Document 2016/005 (GD05); Auckland Council.** Provides information on the appropriate use, design and construction of ESC practices for the Auckland region. We consider GD05 generally represents industry best practice and generally provides the accepted design criteria for ESC measures.

- **Technical Publication No. 90. Erosion and Sediment Control: Guidelines for Land Disturbing Activities (TP90), Auckland Council** which provides information on the appropriate use, design and construction of ESC practices for the Auckland region. While remaining as the statutory document of relevance TP90 was superseded by GD05, and is referenced in the AUP(OP). TP90 contains some specific measures that are of a more stringent design than GD05 and these have been incorporated as part of the suite of best practice for that design criteria.

- **Forestry Operations in the Auckland Region a Guideline for Erosion and Sediment Control; September 2007; Technical Publication 223 (TP223); Auckland Regional Council** - TP223 provides a specific set of guidelines for earthworks and general land disturbing activities associated with forestry operations and builds on the concepts and guidance provided by TP90 or its replacement GD05 and is therefore applicable to plantation forestry clearance activities that may be associated with the Project

Other relevant Auckland Council guidance material includes draft chemical treatment guidelines, specific erosion and sediment control fact sheets and many technical reports related to management and effects of sedimentation and works within a watercourse. These documents have all been reviewed and the proposed construction design is compared against criteria included within these documents.

Auckland Council has a number of guidelines that are influential to the operational water assessment areas:

- **ARC Technical Publication Number 10: Stormwater Management Devices Design Guideline Manual (TP10)** which is referred to in the AUP(OP) E9;
- **Stormwater management devices in the Auckland region. Auckland Council guideline document, GD2017/001 (GD01)** which supersedes TP10, although it was issued after the AUP(OP) was made operational.

3.2.2 Transport Agency guiding documents

The Transport Agency has published an Erosion and Sediment Control Guidelines for State Highway Infrastructure (Transport Agency ESC Guidelines) (2014). This document contains guidelines for State highway infrastructure and was developed to assist roading practitioners with the selection and design of erosion and sediment control practices. These Transport Agency ESC Guidelines have been considered as appropriate on the Project in some circumstances, such as for dirty water diversions which are sized for the 1% AEP which can exceed other guidance documents.

The Transport Agency has published a Transport Agency Stormwater Treatment Standard for State Highway Infrastructure (2010) and Transport Agency Stormwater Specification (P46, 2016). These documents provide detailed guidance on stormwater treatment and design for road schemes and are used when there isn't guidance from Auckland Council such as GD01.

The Transport Agency has also published Fish Passage Guidance for State Highways (2013) and in association with the New Zealand Fish Passage Guidelines (2018) are being considered for the Project. The Ecology Assessment Report for the Project has considered the fish passage guidance and the Project ecologists have provided recommendations regarding design requirements as they relate to fish passage.

3.3 Assessment criteria for the Project

The assessment criteria contained in this section are derived from the above-mentioned RMA, policy, plans and guidance that need to be considered for the construction and operational phases of the Project.

For each of the assessment criteria, various matters and considerations are listed that form the background to the assessment criteria.

3.3.1 Construction phase assessment criteria

Table 3 below outlines the assessment criteria derived from the AUP(OP) and other policy and guidance that need to be considered for the construction activity associated with this Project.

Table 3 - Construction Phase Assessment Criteria and Considerations

Criteria/consideration
Best practicable option (BPO) approach The BPO will be assessed against the following RMA criteria: i. The nature of the discharge and the sensitivity of the receiving environment to adverse effects ii. The financial implications, and the effects on the environment, of that option when compared with other options; and iii. The current state of technical knowledge and the likelihood that the option can be successfully applied. Land disturbance is to be managed to retain soil and sediment on the land by the use of best practicable options for sediment and erosion control appropriate to the nature and scale of the activity (Policy AUP(OP) E11.3(2)). Prevent or minimise the adverse effects from construction activities on the quality of freshwater and coastal water by adopting best management practices and establishing minimum standards for the discharges (Policy AUP(OP) E1.3(26)).
Assessment theme: Land disturbance The potential effects of the Project arising from land disturbance are assessed against the following criteria:

Criteria/consideration
i. The amount of land being disturbed at any one time is to be managed, particularly where the soil type, topography and location is likely to result in increased sediment runoff or discharge (AUP(OP) Policy E11.3(2)) ii. Design and implement earthworks with recognition of existing environmental site constraints and opportunities, specific engineering requirements, and implementation of integrated water principles (AUP(OP) Policy E11.3(5) iii. Best practice erosion and sediment control measures must be implemented for the duration of the land disturbance. Those measures must be installed prior to the commencement of land disturbance and maintained until the site is stabilised against erosion (AUP(OP) E11) iv. Whether the extent or impacts of adverse effects from the land disturbance can be mitigated by compliance with standards, the design and suitability of erosion and sediment control measures to be implemented, or by managing the proportion of the catchment which is exposed; staging of works and progressive stabilisation; and timing and duration of works (AUP(OP) E11/E12).
Assessment theme: Water quality Freshwater and sediment quality is maintained where it is excellent or good and progressively improved over time in degraded areas (AUP(OP) Objective E1.2(1)). Manage discharges having regard to national bottom lines, guidelines and other indicators (AUP(OP) Policy E1.3(1)). Sediment discharges are to be minimised to the extent practicable having regard to the receiving environments ability to assimilate the discharged sediment (AUP(OP) E11.3(7)). ***Aesthetics and odour*** After reasonable mixing, the contaminant or water discharged shall not give rise to any of the following effects in the receiving waters: i. Conspicuous oil or grease films, scums or foams, or floatable or suspended materials (RMA and AUP(OP) E11) ii. Changes in colour and clarity than exceed ANZEEC guidelines for recreation guideline values (RMA and AUP(OP) E11) iii. Any emission of objectionable odour (RMA and AUP(OP) E11) iv. Excessive growth of aquatic plants (ANZECC) ***Monitoring*** The quality of fresh and coastal water bodies across the region and the effects of land disturbance on water quality and receiving environments is to be monitored (AUP(OP) E11.3(8)).
Assessment theme: Human impacts ***Recreational use*** The potential effects of the Project on recreational uses are assessed against the following criteria: i. the extent to which the discharge would avoid contamination and avoid more than minor adverse effects on the health of people and communities as affected by their contact with fresh water (NPS-FM). ii. the extent to which significant adverse effects are avoided where there is high recreational use (AUP(OP) E11). ***Drinking water*** The potential effects of the Project on recreational uses were assessed against the following criteria i. After reasonable mixing, the contaminant or water discharged shall not introduce or increase the concentration of any aesthetic determinands in the drinking water so that, after existing treatment, it contains aesthetic determinands at values exceeding the guideline values. (NES for sources of human drinking water)

Criteria/consideration
ii. After reasonable mixing, the contaminant or water discharged shall not have a significant adverse effect on the quality of the water at any abstraction point. (NES for sources of human drinking water) ***Water users*** The potential effects of the Project on other water users were assessed against the following criteria: i. The rendering of freshwater unsuitable for consumption by farm animals (RMA Section 107) must not occur (AUP(OP) E11). ii. the extent to which significant adverse effects are avoided where there is collection of fish and shellfish for consumption (AUP(OP) E11.3(7)).
Assessment theme: Flooding The potential effects of the Project on flooding were assessed against the following criteria: a) The diversion of water must not cause or worsen the flooding of any property in a range of flood events (AUP(OP) E7). b) Whether the earthworks and final ground levels will adversely affect overland flow paths or increase potential volume or frequency of flooding within the site or surrounding sites (AUP(OP) E12). c) Maintain the function of overland flow paths to convey stormwater runoff safely from a site to the receiving environment (AUP(OP) Policy E36.3(29)). d) Require changes to overland flow paths to retain their capacity to pass stormwater flows safely without causing damage to property or the environment (AUP(OP) Policy E36.3(30)). e) Require earthworks within the 1 per cent annual exceedance probability (20)(AEP) floodplain to do all of the following: i. remedy or mitigate where practicable or contribute to remedying or mitigating flood hazards in the floodplain; ii. not exacerbate flooding experienced by other sites upstream or downstream of the works; and **iii.** not permanently reduce the conveyance function of the floodplain. AUP(OP) Policy E36.3(20)). f) Require the storage and containment of hazardous substances in floodplains so that the integrity of the storage method will not be compromised in a flood event (AUP(OP) Policy E36.3(22)).
Assessment theme: Streams The potential effects of the Project on streams were assessed against the following criteria: i. proposals to divert surface water required to demonstrate the diversion will to the extent practicable avoid significant adverse effects and remedy or mitigate other adverse effects including where relevant, effects on existing buildings, structures and services, existing flood hazards, river bank stability, people and communities and the life supporting capacity of freshwater (AUP(OP) Policy E2.3(22)). ii. the effects on downstream lake, river or stream or wetland environments arising directly from the activity, and any effects arising from any permanent modification in stream state or function caused by the activity (AUP(OP) E3). iii. the construction methodology, including the timing and duration of the activity and erosion and sediment controls, and location of mixing of construction materials and refuelling or maintenance of equipment and best site management practice must be used to avoid contaminants discharging into the water (AUP(OP) E3). iv. upstream or downstream flooding effects (AUP(OP) E3).

3.3.2 Operational phase assessment criteria

Table 4 below outlines the assessment criteria from the AUP(OP) that need to be considered for the operational presence and use of the Project.

Table 4 - Operational Phase Assessment Criteria and Consideration

Criteria/consideration
Assessment theme: Integrated Stormwater Management approach The AUP(OP) E1.3.8 (a) requires 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 (as per E1.3.10 below. The AUP(OP) E1.3.10 requires taking an integrated stormwater management approach have regard to all of the following: (a) the nature and scale of the development and practical and cost considerations, recognising: (i) greenfield and comprehensive brownfield development generally offer greater opportunity than intensification and small-scale redevelopment of existing areas; (ii) intensive land uses such as high-intensity residential, business, industrial and roads generally have greater constraints; and (iii) site operational and use requirements may preclude the use of an integrated stormwater management approach. (b) the location, design, capacity, intensity and integration of sites/development and infrastructure, including roads and reserves, to protect significant site features and hydrology and minimise adverse effects on receiving environments; (c) the nature and sensitivity of receiving environments to the adverse effects of development, 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; (d) reducing stormwater flows and contaminants at source prior to the consideration of mitigation measures and the optimisation of on-site and larger communal devices where these are required; and (e) the use and enhancement of natural hydrological features and green infrastructure for stormwater management where practicable.
Best Practicable Option (BPO) approach The operational stormwater design described should be designed to represent the best practicable option for minimising the adverse effects on the environment of the operational stormwater discharges. The AUP(OP) adopts the best practicable option criteria as set out in section 2 of the Resource Management Act 1991. The best practicable option is assessed against the following RMA criteria: i. the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and ii. the financial implications, and the effects on the environment, of that option when compared with other options; and iii. the current state of technical knowledge and the likelihood that the option can be successfully applied. AUP(OP) E1.3.14 requires: Adopt the best practicable option to minimise the adverse effects of stormwater discharges from stormwater network and infrastructure including road, and rail having regard to all of the following:

Criteria/consideration
(a) the best practicable option criteria as set out in section 2 of the Resource Management Act 1991; (b) the reasonable timeframes over which adverse effects can be avoided as far as practicable, or otherwise minimised or mitigated; (c) the scale and significance of the adverse effects; (d) infrastructure investment priorities and the consequences of delaying infrastructural improvements in other areas; (e) the ability to prevent or minimise existing adverse effects having regard to the effectiveness and timeframes of other feasible methods, including land use controls; (f) opportunities to integrate with other major infrastructure projects or works; (g) the need to maintain and optimise existing stormwater networks and provide for planned land use and development; and (h) operational requirements and space limitations. E8.8.1.2.b and c also requires consideration of BPO ***Operation and maintenance*** The potential effects of the Project were assessed against the following criteria: i. The proposed methods for operating and maintaining stormwater treatment processes and devices to ensure their continued and ongoing effectiveness (AUP(OP) E9.8.1.1.c) Methods for monitoring and reporting on the effectiveness of the treatment process (AUP(OP) E9.8.1.1.c).
Assessment theme: Water quality ***Contaminants*** AUP(OP) E.1.3.8 requires 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: (b) minimising the generation and discharge of contaminants, particularly from high contaminant generating car parks and high use roads and into sensitive receiving environments; ***Temperature*** AUP(OP) E.1.3.8 requires (d) where practicable, minimising or mitigating the effects on freshwater systems arising from changes in water temperature caused by stormwater discharges; and ***Gross pollutants*** AUP(OP) E.1.3.8 require (e) providing for the management of gross stormwater pollutants, such as litter, in areas where the generation of these may be an issue. ***Other water quality*** After reasonable mixing, the contaminant or water discharged shall not give rise to any of the following effects in the receiving waters: i. Conspicuous oil or grease films, scums or foams, or floatable or suspended materials (RMA and AUP(OP) E8) ii. Changes in colour and clarity than exceed ANZEEC guidelines for recreation guideline values (RMA and AUP(OP) E8) iii. Any emission of objectionable odour (RMA AUP(OP) E8) iv. Excessive growth of aquatic plants (ANZECC).
Assessment theme: Water quantity AUP(OP) E.1.3.8 requires 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: (c) minimising or mitigating changes in hydrology, including loss of infiltration to: (i) minimise erosion and associated effects on stream health and values; (ii) maintain stream baseflows; and (iii) support groundwater recharge;

Criteria/consideration
AUP(OP) E8.8.1.2 requires assessment of the methods proposed for the management of the adverse effects on receiving environments, including cumulative effects, having regard to (i) The nature, volume and peak flow of the stormwater discharge; (ii) The sensitivity of the receiving environment to stormwater contaminants [refer previous section] and flows; and (iii) For discharge to streams the extents to which discharges are managed to maintain baseflow and interflow, reduce the duration and intensity of flows which will cause erosion and habitat degradation, reduce runoff to pre-development conditions and utilise natural flow paths and stream to help slow down water flows. ***Wetlands*** Stream diversions and other activities must not lower water levels in any wetlands, except for wetlands designed and used for stormwater management by a network utility (AUP(OP) E7.6.1.2(4)). ***Erosion effects*** The diversion and discharge or stormwater must not cause more than minor bed erosion, scouring or undercutting at the point of discharge or immediately upstream or downstream, or result in other instability of any land or waterbody (AUP(OP) E3, E7 & E8.8.1.2.e).
<u>Assessment theme: Human impacts</u> ***Recreational use*** The potential effects of the Project on recreational uses were assessed against the following criteria: i. the extent to which the discharge would avoid contamination and avoid more than minor adverse effects on the health of people and communities as affected by their contact with fresh water (NPS-FW) ii. the discharge should not increase the metal concentrations to toxic levels for skin contact (ANZECC) ***Drinking water*** The potential effects on human drinking water from of the Project were assessed against the following criteria: i. After reasonable mixing, the contaminant or water discharged shall not introduce or increase the concentration of any aesthetic determinands in the drinking water so that, after existing treatment, it contains aesthetic determinands at values exceeding the guideline values. (NES for sources of human drinking water) ii. After reasonable mixing, the contaminant or water discharged shall not have a significant adverse effect on the quality of the water at any abstraction point. (NES for sources of human drinking water) How potential adverse effects on water quality within water supply catchments will be avoided, remedied or mitigated (AUP(OP) E11) ***Water users*** The potential effects on existing water users from of the Project were assessed against the following criteria: i. The rendering of freshwater unsuitable for consumption by farm animals (RMA Section 107) must not occur (AUP(OP) E2, E8); ii. Minimise effects on other water users (AUP(OP) E7).
<u>Assessment theme: Flooding</u> The potential flooding effects of the Project were assessed against the following criteria: ***Vulnerability to flooding*** The type of activity being undertaken and its duration and its vulnerability to natural hazard events (E36) Consider the potential effects on public safety and other property (E36) ***Flooding effects on others*** Ensure all development does not cause or worsen the flood hazards, flood depths or velocities for a range of flood events, to other properties upstream or downstream of the site beyond

Criteria/consideration
the land or structures owned or controlled by the person undertaking the activity (AUP(OP) E3 & E36). Provide for flood mitigation measures which reduce flood-related effects and provide for culverts and bridges where those measures do not create or exacerbate flooding upstream or downstream or otherwise increase flood hazards (AUP(OP) E36). Ensure the discharge does not cause or increase nuisance or damage to other properties (AUP(OP) E9). Ensure the discharge does not create or exacerbate flood risks (AUP(OP) E1) ***Overland flow paths*** Maintain the function of overland flow paths to convey stormwater runoff safely from a site to the receiving environment. Require changes to overland flow paths to retain their capacity to pass stormwater flows safely without causing damage to property or the environment (AUP(OP) E36). ***Other*** Consider the ability to use of non-structural solutions, such as planting or the retention or enhancement of natural landform buffers to avoid, remedy or mitigate the hazard, rather than hard engineering solutions or protection structures. (E36) Consider the long-term management, maintenance and monitoring of any mechanisms associated with managing the risk of adverse effects resulting from the placement of infrastructure within a hazard area to other people, property and the environment including the management of hazardous substances. (E36)
<u>Assessment theme: Streams</u> The potential effects of the Project on streams were assessed against the following criteria: v. Surface water diversions demonstrate the diversion will to the extent practicable avoid significant adverse effects and remedy or mitigate other adverse effects on life supporting capacity of freshwater, ecosystem processes (AUP(OP) E2.3.13.b) vi. Avoid significant effects and avoid where practicable or otherwise mitigate other adverse effects on streams in the natural stream management area overlay and significant ecological area overlay (AUP(OP) E3.3.1.d) vii. Manage the effects of activities outside overlays avoiding where practicable or otherwise mitigating adverse effects and where appropriate restoring and enhancing the river, stream, wetland (AUP(OP) E3.3.2.a) viii. Effects arising from any permanent modification in stream state or function (AUP(OP) E3.8.1.c) ix. Requirement to offset adverse effects (AUP(OP) E3 various) x. Whether avoids more than minor bank erosion, stream bed erosion and land instability (AUP(OP) E3.8.2.1.f) xi. Retains sufficient stream flow conveyance capacity for all flows (AUP(OP) E3.8.2.1.g) xii. Enhancement of streams ecological functions (AUP(OP) E3.8.2.1.i and j)

4 EXISTING AND FUTURE ENVIRONMENT

Section Summary

The proposed designation passes through three catchments, the Mahurangi River catchment, the Hōteo River catchment (which includes the Kourawhero and Waiteraire sub-catchments), and the estuarine Oruawharo River catchment (which includes the Te Hana Creek and Maeneene sub-catchments). The Indicative Alignment crosses many tributaries in these areas, as well as the main branch of the Hōteo River.

The Mahurangi River flows to the Mahurangi Estuary and out to the Hauraki Gulf. The Hōteo and Oruawharo Rivers flow westward to the Kaipara Harbour. Pasture and exotic forestry are the main land uses throughout the Mahurangi River catchment and the Hōteo River catchment, while in the Oruawharo the main land use is pasture. Towns, areas of indigenous forestry, and crops also exist within the catchments. There is the potential that the exotic forestry within the Mahurangi River and Hōteo River catchments will be harvested prior to during the construction of the Project.

The steepness of the catchments varies within the proposed designation boundary, with steep topography in the Dome Valley forest area, lower gradients associated with the Mahurangi River floodplain, and Hōteo River floodplains, and rolling topography within the Oruawharo catchment.

Rainfall varies within the proposed designation boundary. Rainfall is typically high to the south, in Warkworth, and increases across the Dome Valley forest area and then decreases towards the flatter land to the north, beyond Wellsford. Rainfall is seasonal with higher monthly rainfall totals occurring in the winter months, however high rainfall events occur throughout the year.

Fine textured sedimentary and alluvial soils predominate in the Project area, as detailed in the AEE. The fine (silt and clay) fractions of these soils are relatively susceptible to erosion, particularly in steep terrain.

Sediment deposition is a key existing environmental issue in the Mahurangi estuary and Kaipara Harbour with existing pre-construction sediment deposition from surrounding catchment land uses. The AUP(OP) classifies these waterbodies as degraded.

Water quality in the Mahurangi River and estuarine Oruawharo River is generally assessed as good, while the Hōteo is fair to good. All catchments have slightly elevated suspended solid levels, turbidity and phosphorus. Metals are low within all three catchments. During rainfall water quality declines within these environments, particularly the freshwater environments. All three freshwater catchments support a range of values and are considered suitable for a range of uses.

Construction of the Project may be limited by areas by steep terrain such as the Dome Valley forest area, where construction can be confined and sediment generation risk is higher. Other low lying areas may limit construction of the Project due to relatively frequent flooding.

This section summarises the existing environment within the Project area, defined as the area within the proposed designation boundary and surrounds. Our assessment of the existing environment considers all areas that could potentially be affected by the Project. These areas include:

- the upstream and downstream catchment of all watercourses within the proposed designation boundary;
- watercourses downstream of the Project area to the coast; and
- the ultimate receiving bodies – the Mahurangi and Kaipara Harbours.

4.1 Catchment description and values

4.1.1 Catchment description

The proposed designation crosses the catchments of three major rivers, which can further be divided into subcatchments, as detailed below and as illustrated in Figure 6 below:

- Mahurangi River which flows to the Mahurangi Harbour, with subcatchments of:
    - Mahurangi River (right branch); and
    - Mahurangi River (left branch);
- Hōteo River which flows to the Kaipara Harbour, with subcatchments of:
    - Kourawhero Stream;
    - Waiteraire Stream; and
    - Several unnamed tributaries; and
- Oruawharo River which flows to the Kaipara Harbour, with subcatchments of:
    - Te Hana Creek; and
    - Maeneene Creek.

The catchment boundary between the Mahurangi River and the Hōteo River is a low ridge to the west of Warkworth, broadly in the vicinity of Carran Road. On the western side of that ridge is Kourawhero Stream, a tributary of Hōteo River, and to the east is the left branch of the Mahurangi River.

The catchment boundary between the Hōteo River and the Oruawharo River is a low ridge which runs in a north-eastern line through Wellsford, approximately following Worthington Road. The proposed designation crosses this ridge to the north-east of Wellsford.

The catchments are shown on Figure 6 below, with details of the proposed designation boundary and Indicative Alignment in relation to the catchments also provided in Table 5. Table 5 further provides details of the land use within the Project area, the local topography and some river characteristics.

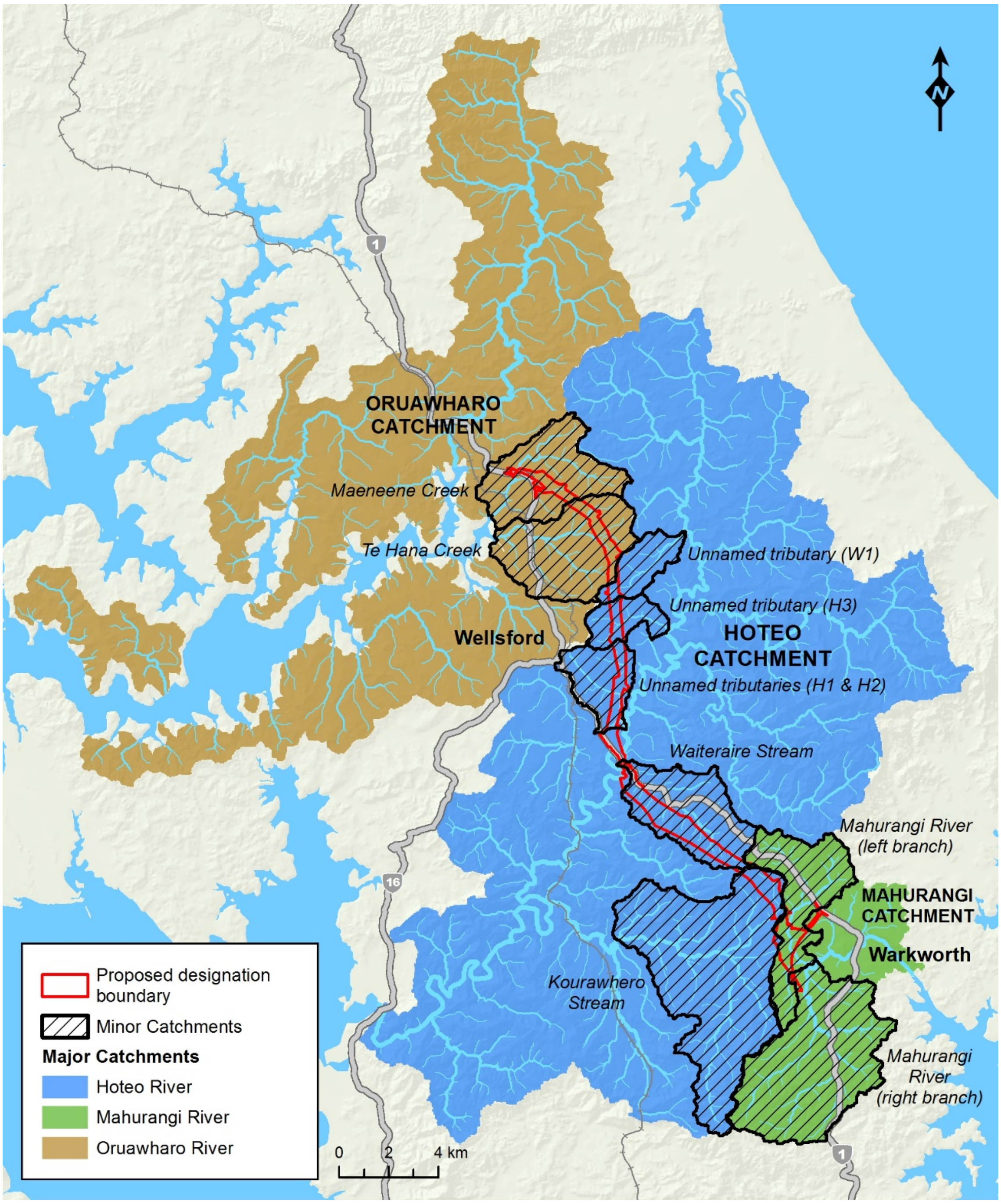

Figure 6 - Proposed designation boundary, freshwater catchments and marine environments

Mahurangi River and Mahurangi Estuary

The Mahurangi River passes through the town of Warkworth. The upstream catchment is split into two branches, that is the left branch and right branch. The left branch originates to the north-west of Warkworth and the right branch originates to the south of Warkworth. The confluence of the left and right branches occurs near Falls Road, to the west of Warkworth. The catchment is mainly rural and has rolling pasture and some steep exotic forestry to the south (Redwood Forest).

The Mahurangi River is the main tributary of the Mahurangi Estuary, a long estuary flowing southwards from Warkworth out to the Hauraki Gulf. There are many small bays and estuaries along the sides of the main estuary with two larger arms to the south. Many of the small bays and upper estuaries are dry at low tides and are comprised of soft muddy sediment.

Hōteo River and Kaipara Harbour

The Hōteo River is the largest river catchment in the Auckland region, with a catchment area of approximately 405 km^2. The Hōteo catchment drains in a south-westerly direction to the southern part of the Kaipara Harbour. The Hōteo River is meandering and the catchment is rural comprising mainly pastoral farming and exotic and indigenous forest.

The Kourawhero Stream, a tributary of the Hōteo River, is crossed by the proposed designation at the headwaters of the stream. Within and upstream of the proposed designation boundary the catchment is small and comprises steep headwaters flowing between natural wetlands. The catchment within and upstream of the proposed designation boundary is mainly forestry and pastoral farming. Downstream of the proposed designation the stream flows in a westerly direction to join the Hōteo River at the Tauhoa Road.

In addition to the Kourawhero Stream the Hōteo River has many other tributaries, including the Waiteitei Stream in the north-west of the catchment, which has a catchment of pastoral rolling hills, and the Waiteraire Stream which flows northwards through the Dome Valley forest area near SH1 with a steep catchment comprising a commercial plantation forest.

The Hōteo River drains to the southern part of the Kaipara Harbour, a large enclosed harbour estuary complex located on the West Coast. The Kaipara Harbour is a complex drowned-valley enclosed estuary on the west coast of the Northland peninsula (Gibbs et al., 2012). The harbour is composed of intertidal flat and shallow sub-tidal habitats with deep channels following historic rivers. Sand barriers form north and south heads as well as tidal deltas, beach and dune systems. The Hōteo River mouth discharges to the north-west of the southern part of the Kaipara Harbour.

Oruawharo River

The proposed designation crosses two tributaries of the Oruawharo River, Te Hana Creek and Maeneene Creek. Te Hana Creek and Maeneene Creek comprise multiple tributaries that flow together in the estuarine lower reaches of the watercourses.

Te Hana Creek flows in a westerly direction towards the Oruawharo River while Maeneene Creek flows in a south-westerly direction. The catchment land use in both catchments is predominantly pastoral farming. The slopes in this area are generally flat or rolling.

The Oruawharo River is an estuarine river, which flows into the central part of the Kaipara Harbour. The Oruawharo River is a drowned valley and includes the Hargreaves Basin. The proposed designation does not cross the main branch of the Oruawharo River.

Table 5 - Overview of catchment and river characteristics within the proposed designation boundary and along the Indicative Alignment

Catchment	Watercourse	Proposed designation boundary and landform	Indicative Alignment	Catchment land use	Channel characteristics	Tributary confluence
Mahurangi River – Total proposed earthworks of 43.3ha	Mahurangi River (Right Branch)	The proposed designation boundary extends to the west of the Mahurangi River (right branch) along the eastern face of a hillside.	The Indicative Alignment runs to the west of the tributary. There are no proposed crossings.	Catchment land use is mainly pasture and lifestyle land uses with forestry in the headwaters.	This tributary is wide and slow flowing in the vicinity of the Indicative Alignment.	The left branch combines with the right branch of the Mahurangi near the junction of Woodcocks and Falls Roads.
	Mahurangi River (Left Branch)	The proposed designation boundary extends north across the Mahurangi River (left branch) across the generally flat land comprising the floodplain.	The Indicative Alignment passes to the west of the main stem of the left branch of the river. The interchange ramps cross the left branch.	Catchment land use is predominantly pasture and lifestyle land uses.	This tributary is wide and slow flowing in the vicinity of the Indicative Alignment.	
	Mahurangi River	The proposed designation boundary extends to the north of the main stem of the Mahurangi River.	The interchange roads extend into this catchment far north of the Mahurangi River.	Predominantly pasture and lifestyle land uses.	The main stem is wide and slow flowing.	This is the main stem of the Mahurangi River, the river flows into the Mahurangi Harbour.
Hōteo River - Total proposed earthworks of 203.4ha	Kourawhero Stream	The proposed designation boundary extends across two headwaters of the Kourawhero; a stream to the west of Carran Road	The Indicative Alignment is to the east of the pasture tributary. The Indicative Alignment crosses and diverts	The catchments are a mixture of pasture and exotic forestry.	These streams are small within proposed designation. The steep headwater streams connect a number of	The Kourawhero Stream joins the Hōteo River 6.5km south-west (14km downstream) of the proposed designation boundary.

Catchment	Watercourse	Proposed designation boundary and landform	Indicative Alignment	Catchment land use	Channel characteristics	Tributary confluence
		within flat pasture land, and a series of steep streams to the north of Kaipara Flats Road.	multiple steep headwater streams.		small natural wetlands in the upper reaches.	
	Waiteraire Stream	The proposed designation boundary extends along the southern slope of the Waiteraire Stream valley. The slope in this area is steep.	The Indicative Alignment runs to the south of the stream crossing multiple tributaries, and crosses the stream at its confluence with the Hōteo River.	The land within the catchment is exotic forestry.	Waiteraire Stream flows within a steep valley in the Dome Valley.	The tributary is crossed by the proposed Hōteo River viaduct where it joins the Hōteo River.
	Hōteo River	The proposed designation boundary crosses the Hōteo River and then extends north to the west of the Hōteo River along the flat floodplain.	The Indicative Alignment crosses the Hōteo River immediately upstream of the existing SH1 road crossing.	The land use is mainly pastoral grasslands with large areas of exotic forestry in the south-east (Dome Forest).	The channel is wide and sinuous at the proposed crossing, with an upstream of approximately 200km^2.	This is the main stem of the Hōteo River, the river flows into the southern Kaipara Harbour.
	Unnamed tributaries (H1 & H2) of Hōteo River	The proposed designation boundary crosses two unnamed tributaries of the Hōteo River within the undulating pasture to the east of Wellsford.	The Indicative Alignment crosses and diverts these two unnamed tributaries.	The land use is mainly pasture; the town of Wellsford is in the upper catchment.	The streams are small channels with extensive flat floodplains.	These tributaries join east of the Indicative Alignment prior to flowing to the Hōteo River.

Catchment	Watercourse	Proposed designation boundary and landform	Indicative Alignment	Catchment land use	Channel characteristics	Tributary confluence
	Unnamed tributary (H3) of Hōteo River	The proposed designation boundary extends across the upper reaches of this unnamed tributary of Hōteo River. The land is rolling at this location.	The Indicative Alignment crosses this stream; the stream is within a steep valley.	The land in this catchment is rolling pasture, with some forestry along the stream bank.	This tributary flows within a steep valley at the location of the proposed crossing.	This tributary flows east following Whangaripo Valley Road prior to discharging to the Hōteo River.
	Unnamed tributary (W1) of Waiteitei Stream	The proposed designation boundary extends across the upper reaches of an unnamed tributary of Waiteitei Stream, a tributary of the Hōteo River.	The Indicative Alignment crosses this stream; the stream is within a steep valley.	The land use in this catchment is mainly rolling pasture.	This tributary flows within a steep valley at the location of the proposed crossing.	This tributary flows into the Waiteitei Stream, a tributary of the Hōteo River, just north of Day Road. Waiteitei Stream flows south to join the Hōteo River at Whangaripo Valley Road.
Oruawharo River - Total proposed earthworks of 63.3ha	Te Hana Creek	The proposed designation boundary extends across multiple tributaries of Te Hana Creek, along the east of the catchment.	The Indicative Alignment crosses multiple tributaries of Te Hana Creek.	The land use in this catchment is mainly undulating pasture.	Te Hana Creek comprises a number of small tributaries that flow within vegetated incised channels.	Te Hana Creek flows into estuarine Maeneene Creek and then into the Oruawharo River.
	Maeneene Creek	The proposed designation boundary extends across many tributaries of the Maeneene Creek and the main channel of the creek.	The Indicative Alignment diverts multiple tributaries of Maeneene Creek with the interchange and crosses the main creek stem.	The land in this area is undulating pasture and crops.	Maeneene Creek comprises a number of small tributaries that flow into an estuarine channel.	Maeneene Creek becomes an estuarine waterbody and flows into the Oruawharo River.

4.1.2 Project context within catchment

The extent of the proposed designation boundary and route of the Indicative Alignment within each catchment is described in Table 5 above. Table 6 details the Project earthworks area within each catchment, the Project impervious footprint within each catchment and also the proposed overall proposed designation boundary. It is important to recognise that the footprint areas detailed within Table 6 will change as detailed design matures over time. Overall it is likely that there will be a reduction in the overall earthworks areas and volumes in reflection of a detailed value engineering process (based on experiences from similar larger earthworks projects).

This table allows comparison between the various catchments and illustrates:

- For the Hōteo and Oruawharo Rivers the proposed designation area is a relatively small percentage of the total catchment area;
- For the Mahurangi River and many of the subcatchments the proposed designation area is approximately 25% of the catchment; and
- The earthworks and impervious footprint associated with the Indicative Alignment is much smaller and is a relatively small percentage of the catchment areas.

Table 6 - Areas (approximate) affected by the Project within affected catchments

Catchment and subcatchments	Total catchment area (ha)	Proposed designation area		Indicative Alignment impervious footprint[1]		Indicative earthworks footprint[2]	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
Mahurangi River catchment	5,670	225	25%	25	<1%	43.3	<1%
Mahurangi (right branch)	2,880	20	<1%	0.5	<1%	1.3	<1%
Mahurangi (left branch)	1,445	175	12%	20	1%	41	3%
Hōteo River catchment	39,815	905	2%	150	<1%	203	<1%
Kourawhero Stream	4,010	160	4%	20	<1%	23.7	<1%
Waiteraire Stream	1,415	395	28%	60	4 %	88.2	6%
Unnamed tributaries (H1 & H2)	735	150	20%	30	4%	91.5	5%
Unnamed tributary (H3)	455	75	16%	15	4%		
Unnamed tributary (W1)	500	40	8%	5	1%		
Oruawharo River	26,660	285	1%	45	<1%	63	<1%
Te Hana Creek	1,740	175	10%	20	1%	33	2%
Maeneene Creek	1,510	110	7%	25	2%	30	2%

Notes:

1 – Indicative Alignment impervious footprint from Indicative Alignment (includes the road, interchanges, side roads and cut faces)

2 – Indicative earthworks footprint derived from conceptual areas of cut, fill and soil disposal sites to construct the Indicative Alignment.

4.1.3 Catchment values and uses

The existing landform, topography, geology and land use within the Mahurangi, Hōteo and Oruawharo River catchments affect the existing water and sediment quality. Within the catchments the river and streams have a range of values and uses.

From a land use perspective, it is important to note that there are exotic commercial plantation forests located within the catchments of the Mahurangi and Hōteo Rivers,that is the Redwood Forest and the Matariki Forest respectively. There is the potential that these forests are harvested prior to or concurrent with the Project.

The Redwood Forest is located to the south of the Mahurangi River, in the catchment of the right branch of the river. The Redwood forest comprises approximately 1,625 ha of exotic plantation pine forest within the Mahurangi River catchment.

The Matariki Forest is located in Hōteo River catchment in the hills to the north and south of the Dome Valley. The Matariki forest comprises an area of approximately 4,830 ha of exotic plantation pine forest. The Matariki forest within the proposed designation boundary is currently programmed for harvest prior to Project commencement.

The harvesting of the forests would change the catchment land use within the proposed designation boundary, and could also result in changes to flows, water quality and the stream forms. We have assessed the potential changes to water quality within Section 6 of this report.

The catchments associated with the Project have the current identified values (see Table 7).

Table 7 - Existing freshwater water-uses and values

Value/use	Details
Aquatic ecology	The existing freshwater ecology values are provided in the Ecology Assessment Report. The instream water quality is a significant factor when considering overall aquatic ecology values.
Cultural values, including food gathering	Cultural values include use of freshwater resources for food and their general cultural history and significance. Cultural values are outlined in section 9.18 of the AEE.
Stock water supply	Stock water supply is provided in the catchments through direct stock access to waterways or through stock water supply systems reticulated from streams. Stock water takes from surface waters would usually be permitted activities so no consents would be held and therefore the extent of this land use is unknown.
Irrigation	Irrigation activities include horticulture and small scale pasture irrigation. No resource consents exist for irrigation from surface water downstream of the Project area. Permitted takes for small scale irrigation may be undertaken in areas the Project could affect, but no records, or consents, are available to confirm any such takes Ongoing discussions with Auckland Council will occur to determine any future takes for irrigation downstream from the Project. These will be discussed with Auckland Council such that there is an awareness of the Project and that the irrigation proposed can account for any Project discharges that may result.
Potable water supply from surface water	Until recently Watercare held two consents for the take of surface water from rivers downstream of the Project. One take from the lower Mahurangi (left branch) to provide for the Warkworth town water supply. The second is for the take of surface water from the Hōteo River to provide for the Wellsford town

Value/use	Details
	municipal water supply. Further details of these are provided in Section 4.1.3 of this WAR. The former Mahurangi consent has recently been surrendered No other consented surface water takes are known, although water may be abstracted as a permitted activity (AUP(OP) E7). Any known water takes will be assessed at the time of construction to determine the impact of any discharges that may result from the Project with Auckland Council confirming some permitted activity surface water takes.
Recreation and amenity values	Recreational activities in the Project catchments include contact recreation, fishing and general amenity use of streams from accessible reserve areas. We have not identified any bathing areas within the freshwater catchments in proximity to the proposed designation boundary. Many small streams are in private land and are unlikely to be used for contact recreation because they are small and shallow. The lower reaches of the Mahurangi and Hōteo rivers have areas where access can be gained. Occasional informal use of the streams for bathing may occur. There is a popular swimming hole at Falls Road on the Mahurangi River. Kayaking is a popular recreational activity in the lower Hōteo River. Fishing may occur in lower areas of the rivers and the estuaries. The Hōteo River is an important whitebait fishery which allows for recreational fishing. There is no evidence of fishing in the other catchments. Fishing, with the exception of eeling, is less likely to occur in streams higher in the catchment as the streams are small. Public access is limited in most of the upper streams of the Mahurangi and Hōteo rivers. The lower Mahurangi has areas within Warkworth where the general public can view the watercourse. The lower reaches of the Hōteo River and the entire reach of the Te Hana and Maeneene Creek are accessible by foot. The main recreational opportunities occur along the banks of the tidal area of the catchments.

The estuarine environments downstream of the proposed designation boundary have the current identified values as provided in Table 8.

Table 8 - Existing estuarine and harbour catchment uses and values

Value/use	Details
Marine aquatic ecology	The details and associated values of the existing ecology and assessment of effects of the Project on the marine aquatic ecology are provided in the Marine Ecology and Coastal Avifauna Assessment Report.
Cultural Values	Cultural values include use of marine aquatic ecology resources for food gathering and the general cultural history and significance of the coast, estuary and harbours and are outlined in section 9.18 of the AEE.
Aquaculture / fishing	Oyster farms are located in the Mahurangi Harbour and the Kaipara Harbour. These uses are detailed in the Marine Ecology and Coastal Avifauna Assessment Report. There is commercial fishing within the Kaipara Harbour.
Other consented activities	With the exception of aquaculture as above there are few other activities withresource consents associated with the estuarine environments recorded in information provided by Auckland Council.
Recreation and amenity values	Recreational activities include contact recreation, kayaking, boating (motor and sail), fishing, food gathering and general amenity use of coastal areas. The marine areas of the Mahurangi estuary and Kaipara Harbour are utilised for contact recreation. Kayaking is a popular recreational activity in the Mahurangi estuary and harbour, and in the Kaipara Harbour. Other surface based recreational activities such as sailing and boating occur throughout both the Mahurangi and Kaipara Harbours. Fishing and gathering of other food (e.g.

	shellfish) occurs throughout both harbours. Public access to the shorelines of the Mahurangi and Kaipara harbours is possible in many areas.

4.1.4 Relevant current consents

Auckland Council has provided details of consented abstractions and discharges within the Project area, as well as available records of permitted activity water takes (available data unlikely to cover all permitted activity takes in the area). The consented takes and discharges primarily relate to Watercare abstractions and discharges.

Surface water abstraction and discharge consents

The relevant Watercare surface water abstraction and discharge consents are listed below, and the location of these are shown on Figure 7.

- Two consented takes for the municipal water supply at Warkworth. One of these takes is from the Mahurangi River at Warkworth and the other from a groundwater bore to the west of Warkworth at Hudson road. Watercare is in the process of changing from surface water to groundwater abstraction for Warkworth and have confirmed a change from surface water to groundwater abstraction occurring at the end of 2018. The associated consent has been recently surrendered.
- Four discharge consents to the Mahurangi River, including bore and water treatment overflow discharges, and the discharge of treated wastewater from the Warkworth wastewater treatment plant.
- One consented take from the Hōteo River to the west of Wellsford for the municipal water supply of Wellsford and Te Hana. Watercare is in the process of investigating options to convert this water supply to a groundwater abstraction (based on a 2017 Project meeting with Watercare). Watercare is considering development of a bore located close to the Water Treatment Plant for the Hōteo River supply. Watercare has advised that if a groundwater supply can be confirmed, it will be several years before there would be a complete transition from the river supply to groundwater supply.
- Two discharge consents to the Hōteo River catchment. One is associated with the Watercare abstraction, while the other is the discharge consent for treated wastewater from the Wellsford and Te Hana wastewater treatment plant. Watercare currently plans to increase the capacity of the wastewater treatment plant within the next 5 years (Watercare meeting, 2017).

With the exception of the Watercare surface water abstractions, there are no consented surface water abstractions from surface water within the Mahurangi, Hōteo or Oruawharo catchments that could be affected by the Project.

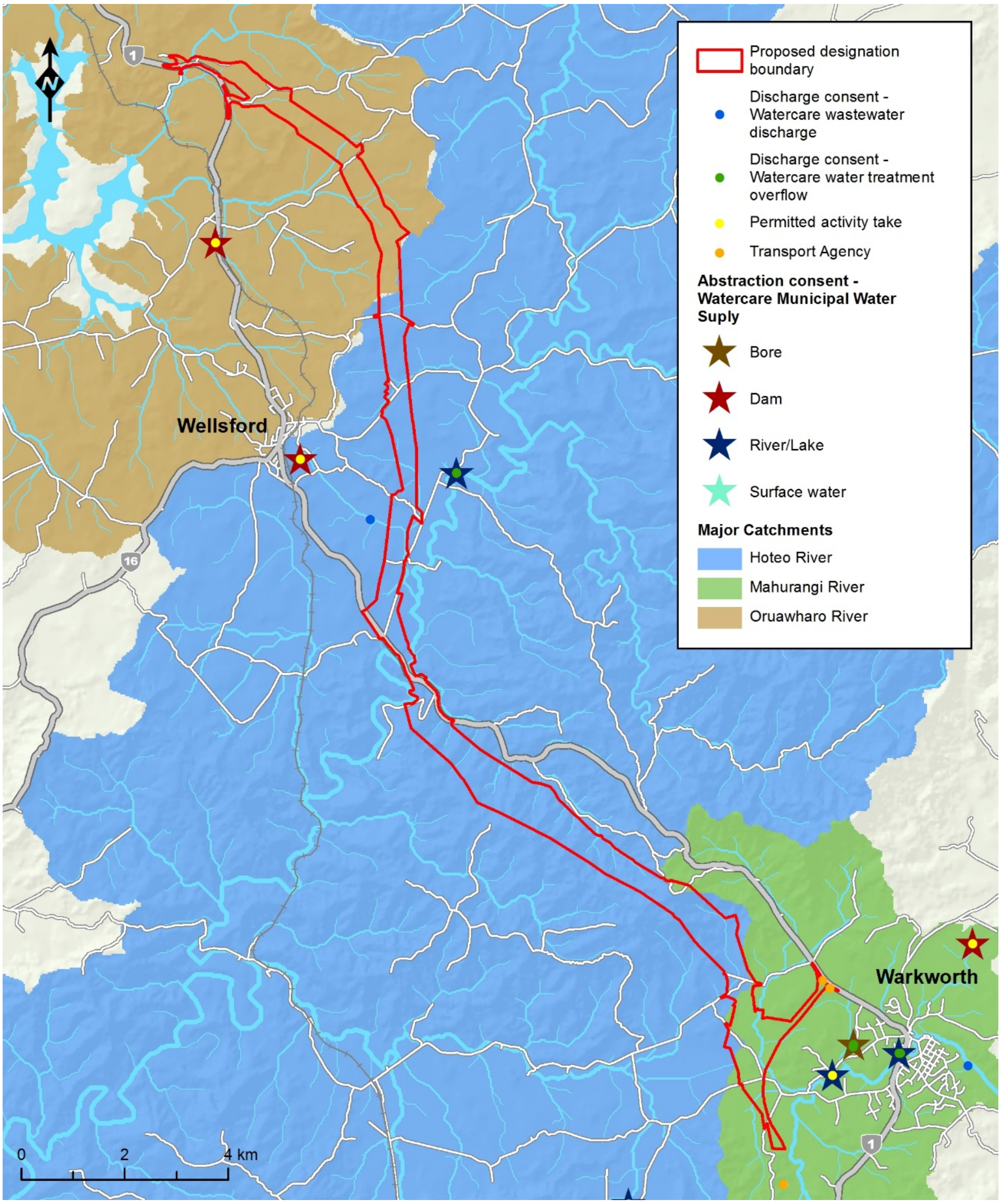

Figure 7 - Surface water abstraction and discharge consents, and permitted activity takes

Surface Water users and permitted activity takes

The permitted surface water abstraction rule in the AUP(OP) (Chapter E7, Table E7.4.1, Activity A4) allows for the taking and use of up to 5 cubic metres per day (m^3/day) of water from a river, stream or spring, subject to conditions of consent.

Auckland Council (28/4/2017) supplied data for permitted abstractions within the Project area. The majority of these are upstream of the Project. The relevant (downstream) water users and takes are listed below:

- A permitted activity take located on Falls Road in Warkworth, downstream of the Project in the Mahurangi catchment, which is used for stock watering and garden irrigation.
- Three Transport Agency permitted activity takes within the Mahurangi catchment, relating to bore drilling.

4.2 Topography, geology and erosion risk

4.2.1 Topography

The topography within the proposed designation boundary ranges in elevation between approximately 15-300 metres Above Datum (mAD), with slopes ranging from 0-50^{0}. The topography of the Project area can be divided into three distinct topographic areas depending upon the slope angle as follows:

- Generally flat and low lying Mahurangi River valley and Kourawhero Stream to the south of the tunnel near Warkworth (Southern Section);
- Dome Valley forest area, comprising hills to the east and west of Dome Valley (Central Section);
- Low undulating to rolling hill country to the north of the Hōteo River (Northern Section).

The details of the topography for these sections is discussed in Table 9 below.

Table 9 - Topography within the proposed designation boundary

Topographic Area	Proposed designation	River catchments	Slope (degrees)	Elevation
Southern Section	Proposed designation south of the proposed Kourawhero Stream bridge	Mahurangi River and Kourawhero Stream valley	Generally flat or undulating (0-13^{0}) with increasing steepness up Kourawhero valley (up to 20^{0})	30-100 mAD
Central Section	North of the proposed tunnel to the Hōteo River crossing	Steep headwaters of Kourawhero Stream, the Waiteraire Stream and the south of the Hōteo River	Strongly rolling to very steep hills (0-46^{0}) multiple peak and valleys	40-310 mAD
Northern section	Proposed designation north of the Hōteo River crossing	Hōteo River (Hōteo north) and Ouawharo River tributaries	Undulating and flat to the south at Hōteo River floodplain, becoming rolling hills to steep further north in Oruawharo tributaries (0-24^{0})	15-110 mAD

The following area percentages (based on ha) of the various Project slope classes within the proposed designation boundary and Indicative Alignment are shown in Table 10 below.

Table 10 - Slope classes (including % and ha) within proposed designation boundary and along Indicative Alignment

Slope Classification (degrees)	Area within designation boundary (ha)	Area within earthworks footprint (ha)	Percentage of Total Area within earthworks Footprint
0 - 3	284.2	62.0	20%
3 - 6	227.36	49.6	16%
6 - 10	269.99	58.9	19%
10 - 12	99.47	21.7	7%
12 - 15	113.68	24.8	8%
15 – 18	71.05	15.5	5%
18 - 21	71.05	15.5	5%
21 - 24	56.84	12.4	4%
24 - 27	56.84	12.4	4%
27 - 30	56.84	12.4	3%
30+	113.68	24.8	8%
Total	1421	**310**	

Approximately 45% (139.5 ha) of the overall earthworks footprint area of the Indicative Alignment (310 ha) is steeper than 10 degrees, with approximately 30% (117.8 ha) of the overall earthworks footprint area being greater than 15 degrees.

For the purpose of the assessment, "steeper areas" are defined as slopes over 10 degrees. We consider that 10 degrees is an appropriate threshold as there is a higher risk of erosion generation on slopes of 10 degrees and greater.

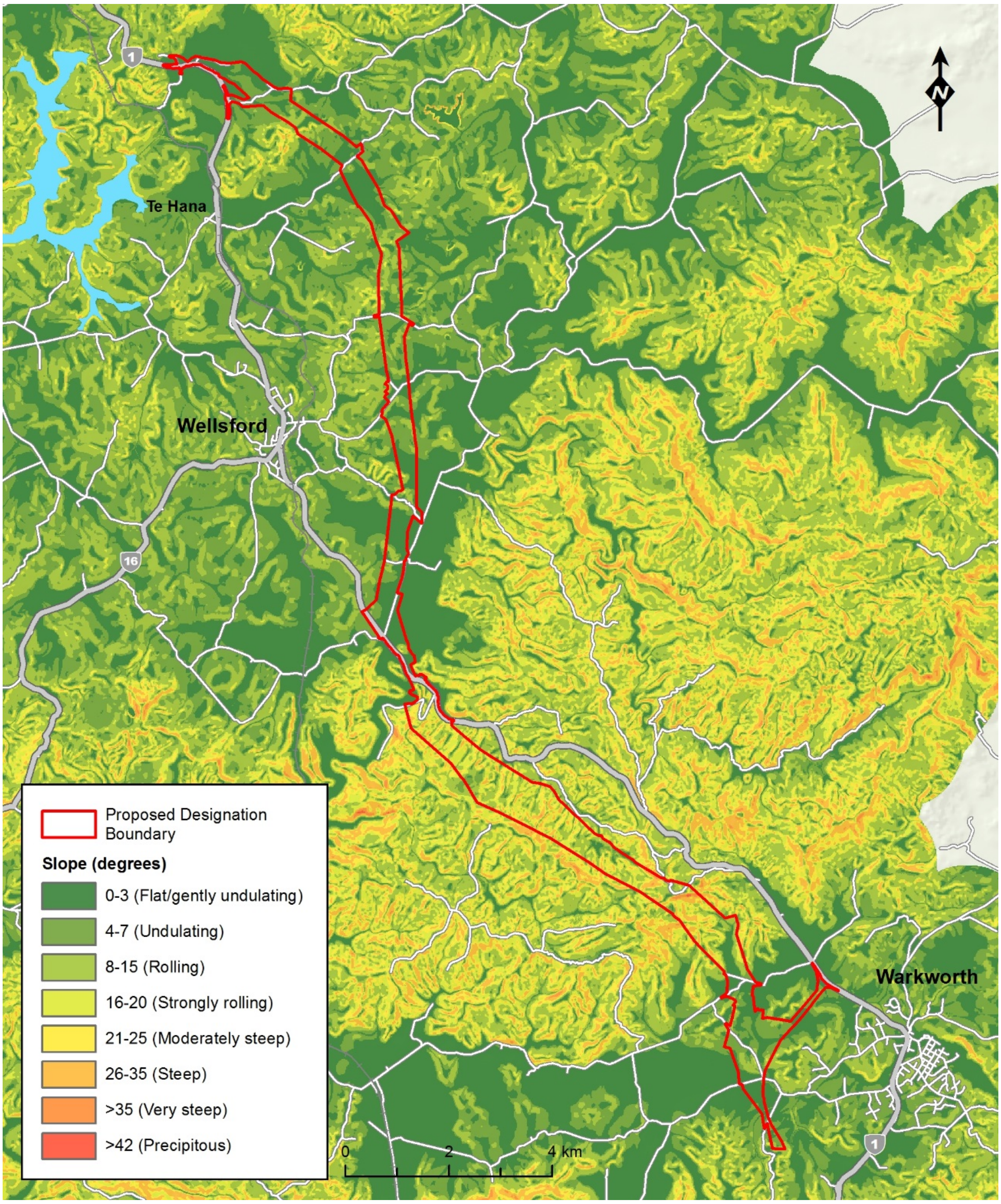

Figure 8 - Slope (in degrees) within the proposed designation boundary (in degrees)

4.2.2 Geology

The majority of the land within the proposed designation boundary is underlain by rocks of the Waitemata Group in particular the Pakiri Formation, a sedimentary formation comprising interbedded, graded sandstone and siltstone or mudstone. Present within the Project area are rocks of the Northern Allochthon (Montatau complex, Mangakahia Complex, and undifferentiated Northland Allochthon). These formations generally comprise complex units of sandstone, mudstone and limestone.

Within the valley floors including the Mahurangi River and Hōteo River valleys the Tauranga Group is recorded consisting of alluvium and colluvium with interbedded peat soils.

The geological processes, within the proposed designation boundary, have resulted in a complex arrangement and juxtaposition of weak to moderately strong sandstones and mudstones (the Waitemata Group), with large lenses or disrupted slices of significantly weaker, highly sheared mudstones, siltstones, sandstones and limestones of the Northland Allochthon.

Figure 9 below provides an overview of the Project geology and likely soil types that will be encountered within the Project.

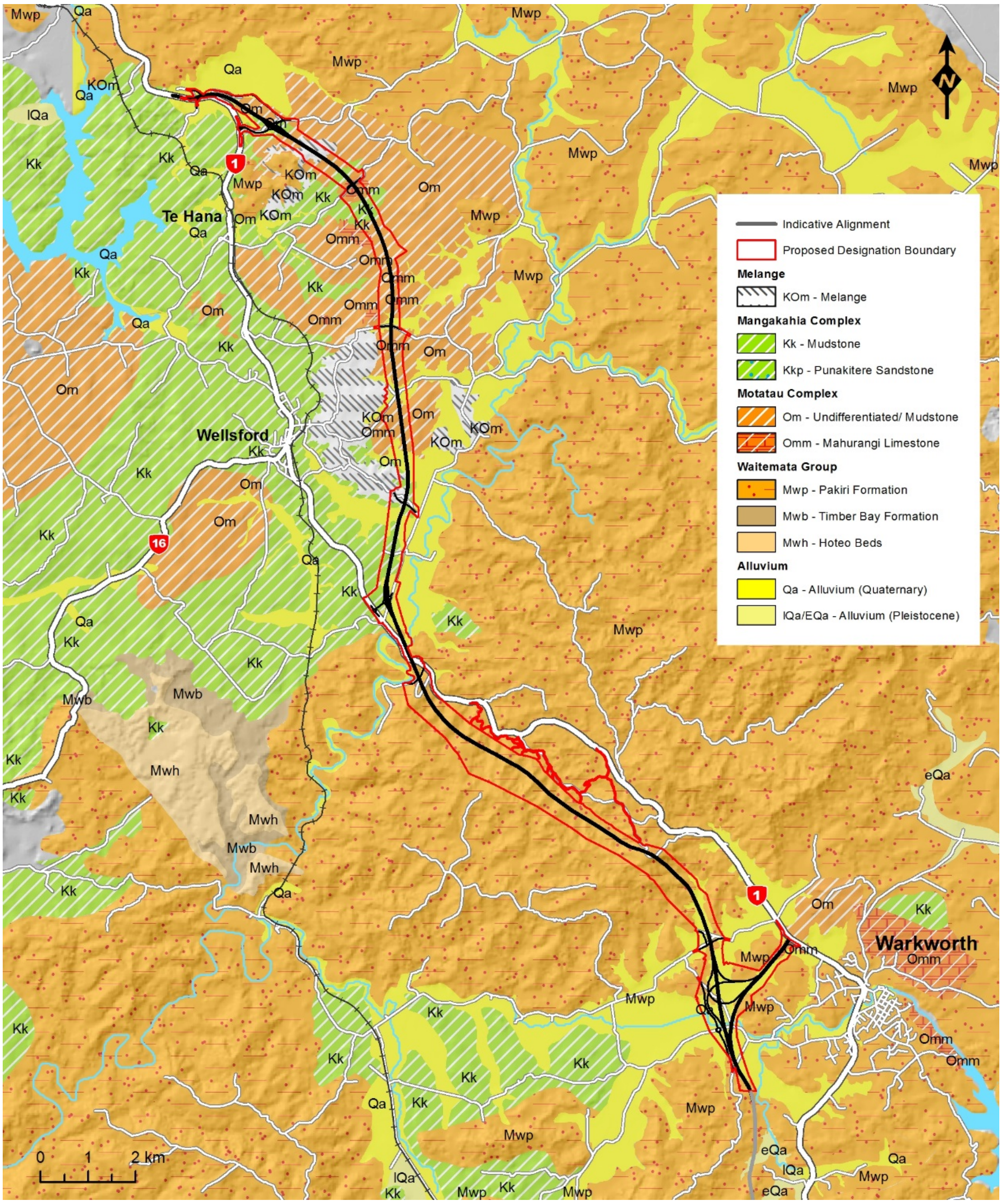

Figure 9 - Geological map for Warkworth to Wellsford

4.2.3 Erosion risk

As part of the Catchment Sediment Modelling technical report the erosion risk across the Project area was further assessed. Erosion risk has a direct relationship to the Project slope angle, as detailed above, however erosion risk is also based upon other factors including soil, landcover and rainfall. For the purpose of modelling an assessment of erosion risk was undertaken by utilising the Revised Universal Soil Loss Equation (RUSLE), through the application of various factors known as KLSC factors as detailed below.

The RUSLE assesses sediment generation (erosion) and overall sediment yield based upon a number of different factors including:

- Rainfall erosive force (intensity) (R);
- Soil particle size distribution (K);
- Slope angle and length (LS); and
- Land cover (C).

Utilising these factors (excluding rainfall) the existing erosion risk within the proposed designation boundary has been determined. This confirms that the existing erosion risk is highest in steeper locations within the Central Section as also confirmed above.

This erosion risk was used in the catchment sediment modelling, with the addition of rainfall data to identify the overall existing rainfall erosivity factor across the Project area. This confirms the Central Section as the highest risk from a sediment generation (erosion) perspective.

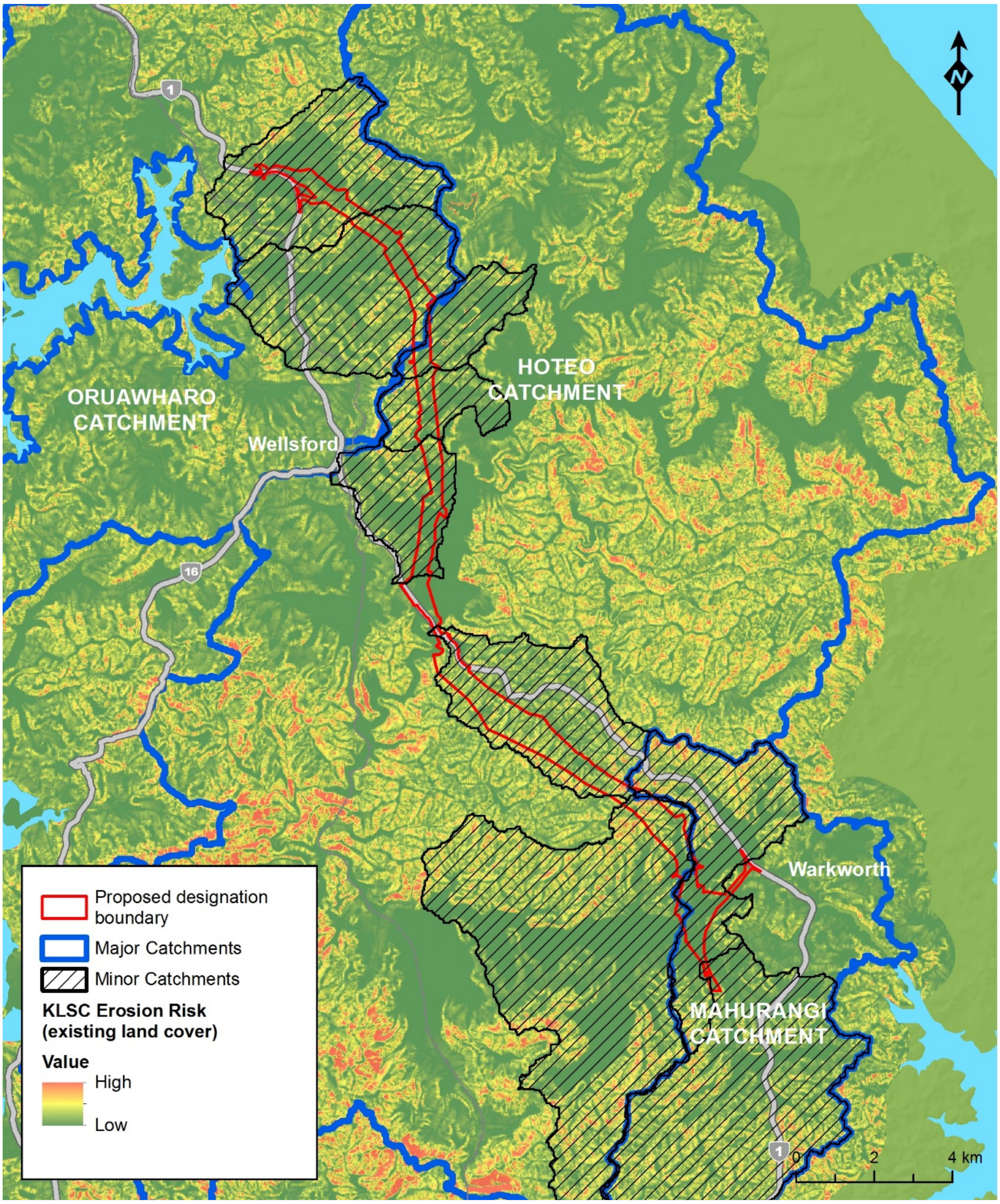

Figure 10 - Erosion risk along the proposed designation boundary using a RUSLE methodology

4.2.4 Rainfall

An overview of the rainfall data for the Project area is contained in Table 11. This data includes rainfall data from TP108 (ARC, 1999) and the High Intensity Rainfall Data System (HIRDS) V3 (NIWA, 2013). Rainfall records from the nearest Auckland Council rain gauges are also included however for the Hōteo catchment it is noted that the rain gauge is to the west of the proposed designation boundary and may not be fully representative of the Central Section due to proximity.

Table 11 – Comparison of 100 year ARI 24-hour rainfall depth (mm) along the Project route

ARI (year)	Mahurangi rainfall (mm)			Hōteo rainfall (mm)			Te Hana rainfall (mm)	
	TP108	HIRDS	Rain gauge[1]	TP108	HIRDS	Rain gauge[2]	TP108	HIRDS
100	310	279	237	310	292	206	250	248
10	210	169	166	210	175	138	160	139
2	130	113	113	130	116	85	90	87

Notes:

1 - Max of Warkworth and Mahurangi

2 - Hōteo at Oldfields rain gauge, located in the lower flat catchment

Table 12 – Predicted rainfall depths (mm) for proposed designation sections, calculated averaging data from Table 11

ARI (year)	Southern Section rainfall (mm)	Central Section rainfall (mm) (excludes rain gauge)	Northern Section rainfall (mm)
100	275	301	249
10	181	192	149
2	119	123	89

A review of the data indicates that rainfall patterns vary within the proposed designation boundary from south to north. The rainfall is high to the south in Warkworth in the Mahurangi catchment (Southern Section) and increases slightly across the hills to the east and west of Dome Valley into the Hōteo River catchment (Central Section). The rainfall then decreases towards the flatter land to the north beyond Wellsford (Northern Section).

While not fully representative of the specific propsed designation location, the observed rainfall gauge at Hōteo (Oldfields Gauge) indicates that rainfall has seasonal variation, with higher average monthly rainfalls in June, July and August, as presented in Figure 11. This figure also shows the maximum recorded monthly rainfall across the record, this indicates that these months also have the highest recorded monthly rainfalls. The daily rainfall record at Hōteo (Oldfields Gauge) does indicate, however, that large rainfall events (>2 year ARI rainfall depth) occur throughout the entire year, including during the summer months.

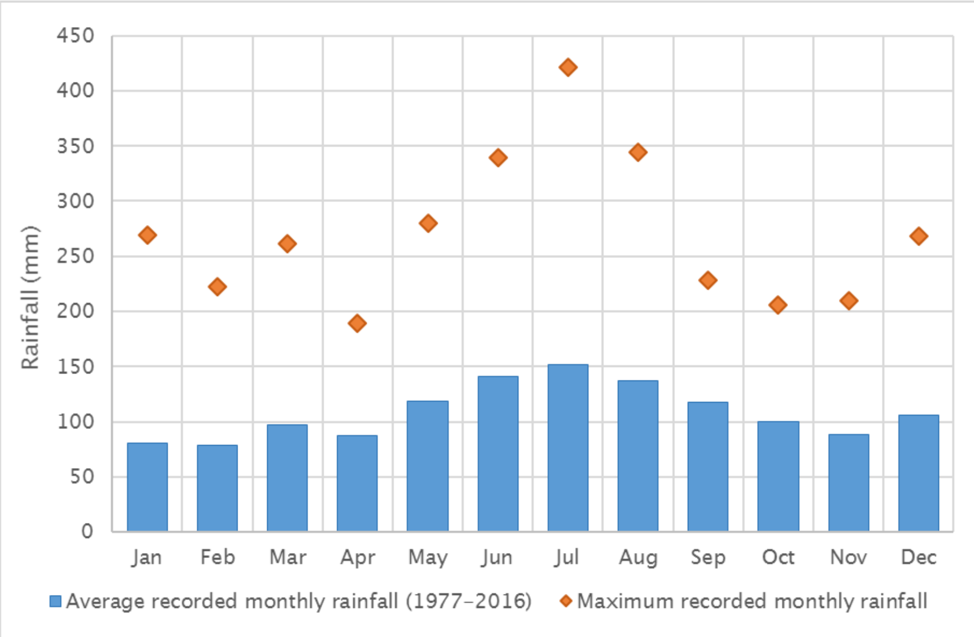

Figure 11 - Monthly rainfall at Hōteo at Oldfields rainfall gauge (1997-2016)

Rainfall data is a critical component when assessing and designing the construction water management measures to be implemented within the Project. To assist with this assessment, variable rainfall has been applied to the sediment modelling undertaken through the use of the Virtual Climate Station Network (VCSN). The VCSN is a spatially gridded synthetic rainfall and potential evapotranspiration (PET) data at a 5 km x 5 km resolution. The climate inputs for the sediment modelling are discussed in detail in the Catchment Sediment Modelling technical report.

4.2.5 Water quality

The existing water quality within the catchments affected by the Project has been summarised in detail in the Existing Water Quality technical report.

Literature review

The literature review of the Hōteo and Mahurangi River catchments identifies that there are existing water quality issues within both catchments relating to sediment and other contaminants. There are ongoing issues of sedimentation within the Mahurangi estuary and Kaipara Harbour respectively, both of which have been the subject of studies into sedimentation and water quality. The AUP(OP) classifies both of these waterbodies as degraded.

Freshwater quality – Data analysis

Freshwater quality in the Mahurangi River, the Hōteo River and the Oruawharo tributaries is discussed in the Exsiting Water Quality Report technical report. The classification of freshwater quality is based on existing long-term data (from Auckland Council and NIWA) and freshwater quality monitoring undertaken in 2017 as part of this Project assessment (10 sites within the Project area).

The Auckland Council State of the Environment Reports (2010-2015) conclude that water quality in the Mahurangi River ranges from fair to excellent. The long-term Auckland Council freshwater quality data for the Mahurangi River indicates that water quality is generally good, however there are slightly elevated concentration of phosphorus and turbidity/suspended sediments. On average the water quality is suitable to provide for the protection of aquatic ecosystems and also for uses such as stock water supply, irrigation and aquaculture. Freshwater quality data gathered by the Project team presented a similar pattern of water quality to the long-term (1986-2017) Auckland Council water quality sites. This included generally good water quality with some nutrients (primarily phosphorous) and turbidity/suspended sediments being elevated.

The Auckland Council State of the Environment Reports (2010-2015) conclude that water in the Hōteo River water quality is declining from 'good' to "poor". The long-term NIWA freshwater quality data (1989-2016) for the Hōteo River and tributaries indicates that for the majority of parameters the water quality is good, however turbidity/suspended sediments are elevated above the ANZECC guideline values for the majority of the time and phosphorus concentrations are slightly elevated. On average the water is suitable for stock water supply, irrigation and aquaculture, however the total phosphorous exceeds ANZECC irrigation guidelines. "Total" phosphorus includes the dissolved reactive phosphorus and phosphorus that is "sorbed" or attached to suspended particles in the water.

The freshwater quality data gathered by the Project team for the Hōteo River catchment presented a similar pattern of water quality to the longer term NIWA data, with elevated turbidity/suspended sediments recorded and elevated nutrients in the Hōteo River and in an unnamed tributary (H2) within grazing farmland. In addition, the monitoring recorded multiple elevated concentrations of total copper throughout the catchment, which may indicate that copper is found naturally within the soil and rock of the catchment.

There is no long-term Council or NIWA freshwater monitoring sites in the Oruawharo River tributaries. Water quality data gathered for the Oruawharo River tributaries of Te Hana Creek and Maeneene Creek by the Project team suggests that generally water quality is good. However, elevated turbidity/suspended sediments and elevated nutrients were recorded in some samples in both Te Hana and Maeneene Creek. *E. Coli* concentrations were found to be elevated at both sites likely due to the upstream grazing land use practices. Streams are observed to be fenced in downstream areas but not in all smaller tributaries. In addition, measured total copper and total zinc concentrations exceeded the respective ANZECC guideline criteria for aquatic ecosystems within Maeneene Creek.

Saline water quality – Data analysis

The saline water quality in the Mahurangi Estuary, Kaipara Harbour and the estuarine Oruawharo River is documented in the Exsiting Water Quality technical report. The classification of saline water quality is based on existing long-term data from Auckland Council and NIWA.

The Auckland Council classifies the Mahurangi Estuary as a degraded waterbody within the AUP(OP). On a scale of "poor" to "excellent", Auckland Council classified the water quality in the upper Mahurangi Estuary as good, with most parameters being below ANZECC guidelines. Average suspended sediment, phosphorus and nitrogen concentrations were slightly elevated indicating some terrestrial impacts in the upper estuary. Auckland Council reports that the lower estuary has excellent water quality.

The data indicates that the results for suspended sediments at the Hōteo River mouth are above the ANZECC guideline values for aquaculture. Total phosphorus concentrations are also elevated above ANZECC guidelines for aquatic ecosystems. The saline water quality at the Kaipara Harbour mouth indicates that the water quality is good with almost all water quality parameters below the relevant ANZECC guideline values. However, dissolved reactive phosphorus is slightly elevated above the ecological guidelines. The suspended sediment concentration at the harbour mouth is below ANZECC guideline values indicating that the elevated sediments from the river mouths settle out prior to reaching the harbour heads. Council identifies the southern Kaipara Harbour as being degraded within the AUP(OP), and on a scale of "poor" to "excellent", the water quality in the southern Kaipara harbour as "fair" in the Council State of the Environmental Reporting (2013).

Within the estuarine Oruawharo River the Auckland Council water quality data indicates that suspended solids are elevated above the guideline values for aquaculture. There are also high concentrations of dissolved reactive phosphorus which exceed the ecological ANZECC guidelines. The saline water quality improves within the northern Kaipara Harbour, however dissolved reactive phosphorus remains high.

4.2.6 Sediment quality

Details of marine (intertidal) sediment quality is contained in the Water Quality technical report. The classification of the marine sediment quality is based upon sampling undertaken in 2017 as part of the marine ecological assessment for this Project at the Hōteo River mouth and the Maeneene/Te Hana Creek mouth, and 2013 for the P2Wk project at the Mahurangi Harbour. Further detail on the sediment monitoring is provided in Marine Ecology and Coastal Avifauna Assessment Report.

Sediment quality is measured against the Auckland Council Environmental Response Criteria triggers for assessing sediments, with Green, Amber and Red trigger values.

The measured concentrations of monitored contaminants in the Kaipara marine intertidal sediment were below the amber trigger thresholds (therefore classified as within the green range) with the exception of one exceedance of copper at one Maeneene/Te Hana Creek mouth site (Te Hana 1). Copper concentrations at Te Hana 1 (20 mg/kg) were just above ARC ERC amber guideline value (19 mg/kg), but below the red guideline value (34 mg/kg).

Intertidal sediment quality monitoring data from the Mahurangi (Halliday & *Cummings*, 2012) and that of a previous study by Gibbs (2004) indicated that copper, lead, zinc and HMW-PAHs were below effects thresholds (ARC ERC amber guideline value) at all sites within the Mahurangi. Contaminants often bind to fine particles and accumulate within this fraction of the sediment. The concentration of metals in the fine sediment (<63 µm) fraction was higher than in the coarser sediment (>500µm) fraction at almost all sites and for all contaminants where data is available. Sediment analysed from Jamieson Bay in 2013 indicated a concentration of HMW-PAHs approaching the ERC amber threshold.

The concentration of metals and HMW-PAHs detected in the 2013 Further North survey in intertidal surface sediment was low at most sites, both in the total sediment[2] and the <63 µm fraction[3].

Copper was detected in the >63 µm fraction in the amber ERC range at Vialls Landing (IM1a) (25.5 mg/kg) and Jamieson Bay (IM6) (24.0 mg/kg), and above both the ERC red and the ISQG-Low thresholds in total sediment at Vialls Landing (IM1a) (108 mg/kg). There is a large boat mooring area adjacent to Jamieson Bay, and at Vialls Landing boats are currently (and were historically) stored and hauled out. It is likely that there is widespread copper contamination in estuarine sediment, particularly in the upper reaches, of the Mahurangi Harbour from anti-fouling of boat hulls arising from the historic and current boating activities.

The concentration of copper was close to the AC ERC amber threshold (19 mg/kg) within both the <63µm and total fraction of sediment at IM1b located in the upper harbour and, to a lesser extent, site IM5a (15.8 mg/kg in total and 14.1 in <63 µm fraction) located within mangrove habitat in the Te Kapa Inlet. At most of the other intertidal sites, the concentration was less than half the amber threshold. These results (excluding data from site IM1a) are similar to those of Halliday & Cummings (2012), whilst we recognise that different grain size fractions were analysed.

The concentration of metals and HMW-PAHs at the subtidal sites that were surveyed was below the ERC amber threshold at all sites, in both total sediment and <63 µm fraction. These results are consistent with Halliday & Cummings (2012).

4.3 Existing and future flooding

This section summarises the flood risk within, upstream and downstream of the proposed designation boundary. The large rivers within the Project area, the Mahurangi and Hōteo Rivers', are known to experience regular flood events. This section summarises the estimated flood extent and depths based upon the Council Rapid Flood Hazard Assessment (RFHA) models and the flood model maps created for the Project.

Auckland Council Rapid Flood Hazard Assessments (RFHA)

We have identified high flood risk areas affected by the Project based on the Auckland Council 1% Annual Exceedance Probability (AEP) (100 year ARI) event map (Figure 5). The mapping as detailed above has identified three high risk areas within the proposed designation boundary that may be affected by the Indicative Alignment:

- Mahurangi River;
- the crossing of the Hōteo River; and
- the crossing of the Kourawhero Stream, a tributary of Hōteo River.

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2 Sediment sample as received by laboratory. Metals: total recoverable digestion nitric/hydrochloric acid digestion. ICP-MS, trace level. US EPA 200.2; PAHs: Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C.

3 Sediment sample wet sieved through <63µm sieve. Metals: nitric/hydrochloric acid digestion. ICP-MS, trace, US EPA 200.2; PAHs: Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C.

A summary of the Auckland Council RFHA for each stream and river within the proposed designation boundary is discussed in the following sections.

Flood Model Existing (pre-development) – 1% AEP and 5% AEP events

We have carried out flood modelling for the high flood risk areas and conducted model simulations for the existing and operational phases including climate change predictions at 2130, based on the IPCC 5th assessment (MfE 2016) and guidance provided by local government on estimating the effect of climate change on flood flow. (MfE 2010). This modelling has assessed flooding at return periods of 100 year ARI (1% AEP), 20 year ARI (5% AEP), 10 year ARI (10% AEP) and 2 year ARI (50% AEP).

The modelled floodplains for the 100 year ARI, 20 year ARI and 2 year ARI are discussed in the following sections. These return periods are most relevant to the Project because they relate to design and assessment criteria included in the AUP(OP) for both construction and operational components of the Project. The maps and discussions below also relate to the future flood risk for the year 2130.

4.3.1 Mahurangi River flood risk

The RFHA indicates that flooding is an existing issue in the lower Mahurangi catchment both within and outside of the proposed designation boundary. The RFHM 100 year ARI event floodplain extends into some areas of Warkworth, across farmland and inundates a number of local roads. This includes Woodcocks Road and Carran Road within the proposed designation boundary, and Kaipara Flats Road to the east of the proposed designation boundary.

The Project specific modelling (carried out by the Project team) shows a similar flood extent to the RFHA results. The modelled 100 year ARI event (Figure 12) indicates that the lower Mahurangi River floodplain extends beyond the river bank at many locations in the catchment. The mapping indicates that flood depths of up to 1.25 m in depth occur within the proposed designation boundary across Carran Road, Woodcocks Road and pasture. Outside of the designation boundary the model predicts further areas with depths of up to 1.25 m in depth along Kaipara Flats Road and pasture.

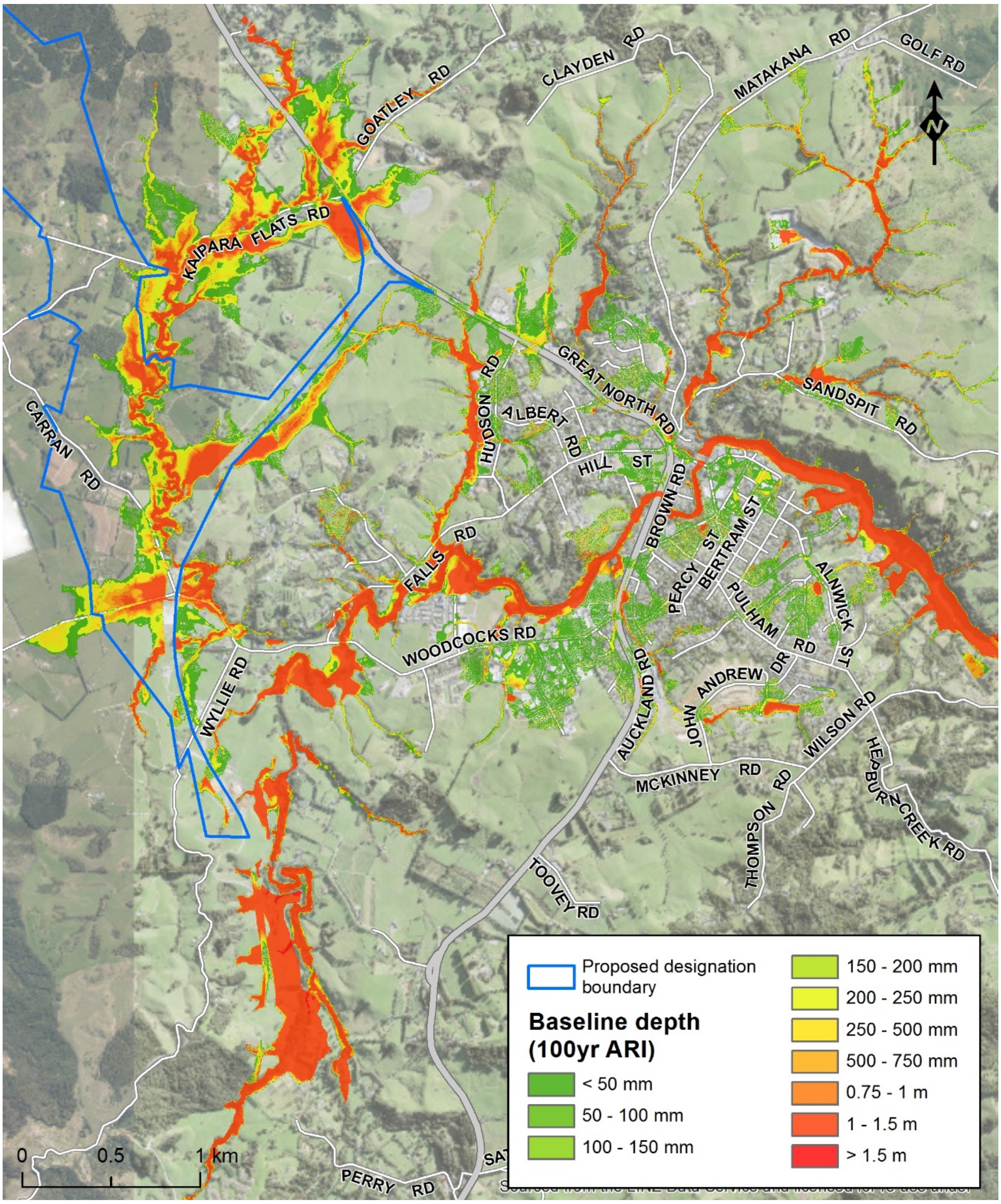


Figure 12 - Modelled flood extents and depths for the lower Mahurangi River for existing conditions for floods of 100 year ARI

The Project specific modelled 20 year ARI event (Figure 13) floodplain is slightly less extensive than for the modelled 100 year ARI event. The mapping indicates that for a 20 year ARI event flood depths are up to 1.25 m in depth within the proposed designation boundary, with 0.5m of flooding across Woodcocks Road and Carran Road, and up to 1.25 m within isolated areas of pasture.

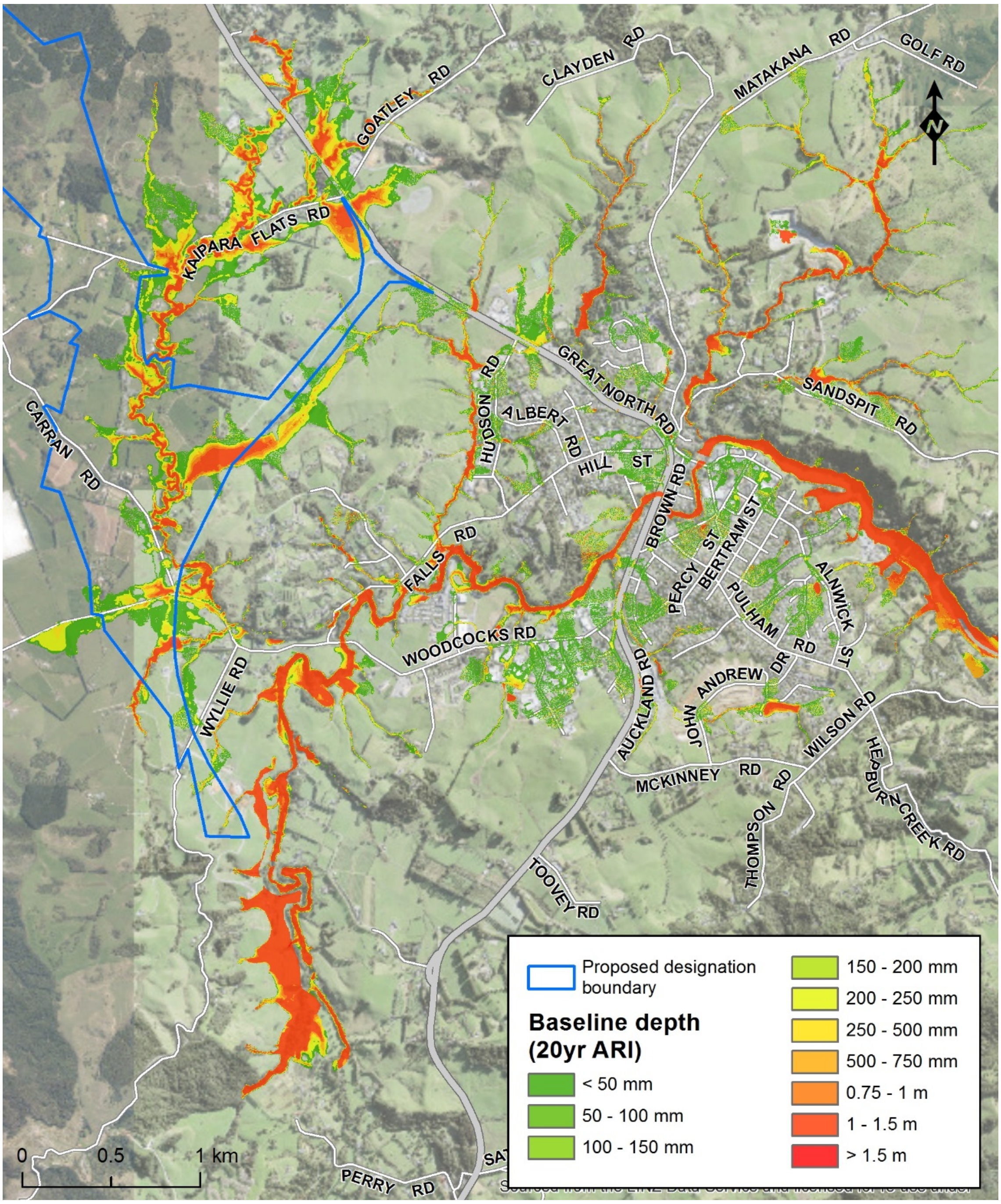


Figure 13 – Modelled flood extents and depths for the lower Mahurangi River for existing conditions for floods of 20 year ARI

The project specific modelled 2 year ARI event floodplain shows a similar flood extent to the 20 year ARI event, however flood depths are significantly less. Within the proposed designation boundary there is no predicted flooding of Woodcocks Road for a 2 year ARI event flood event, and flood depths of 0.5 m on Carran Road. In pasture to the east of Carran Road flooding is up to 1.25 m in depth.

4.3.2 Kourawhero Stream flood risk

The RFHA indicates that the Kourawhero Stream floodplain is extensive and runs along Kaipara Flats Road to the west of the proposed designation boundary. The floodplain encroaches on multiple properties within and to the west of the proposed designation boundary.

The project specific modelling (carried out by the Project team) focussed on the upper Kourawhero headwaters, and shows a similar flood extent to the RFHA results for the year 2130. The modelled 100 year ARI event (Figure 14) indicates in the upper catchment the flooding is generally confined to the stream valley (up to 1.9 m in depth), however downstream (up to 1.3 m in depth) encroaches into some residential properties towards Kaipara Flats Road within the proposed designation boundary. To the west of the proposed designation boundary the stream floods the Kaipara Flats Road to depths of up to 1 m.

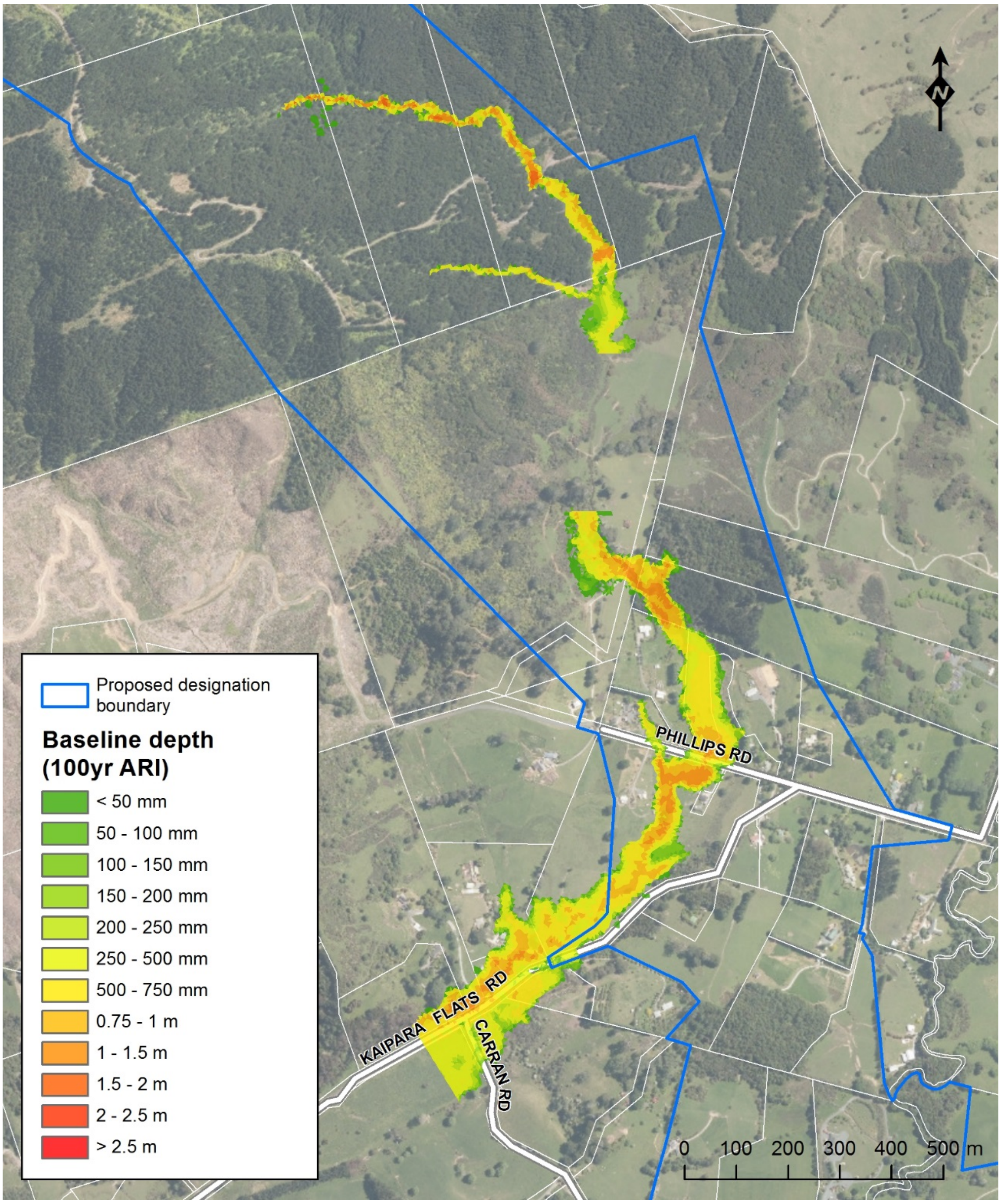


Figure 14 – Modelled flood extents and depths for the Kourawhero Stream for existing conditions for floods of 100 year ARI

The modelled 20 year ARI event has a similar flood extent to the 100 year ARI, however slightly lower flood depths. Within the proposed designation boundary the flood depths in the upper catchment are predicted to be up to 1.8 m, and in the lower floodplain 1.2 m. To the west of the designation boundary the stream floods the Kaipara Flats Road to depths of up to 1 m for the 20 year ARI event.

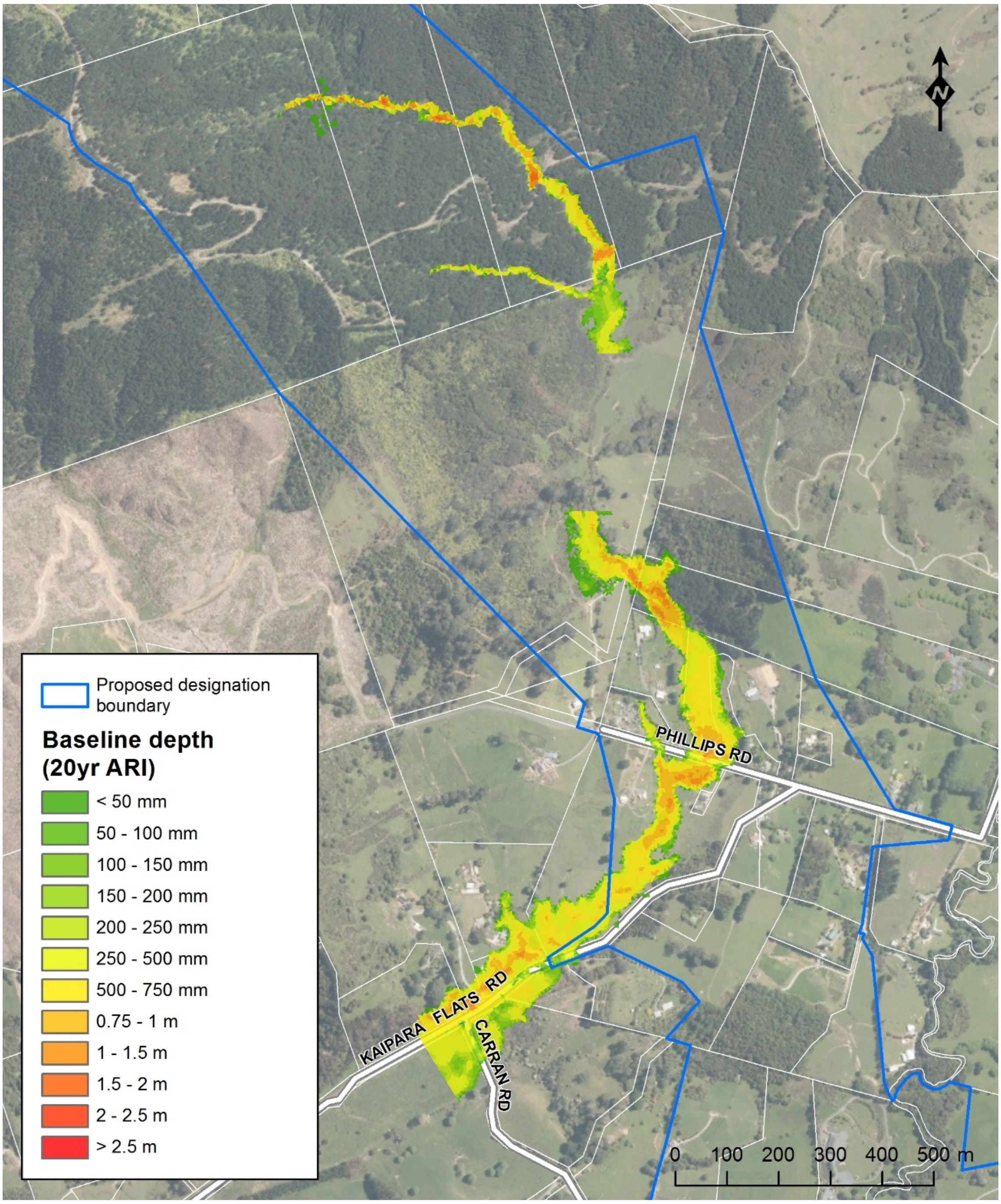


Figure 15 – Modelled flood extents and depths for the Kourawhero Stream for existing conditions for floods of 20 year ARI

The project specific modelled 2 year ARI event floodplain for the Kourawhero Stream shows a similar extent to the 20 year ARI event, however flood depths are slightly less.

Within the proposed designation boundary, the flood depths in the upper catchment are predicted to be up to 1.5 m, and in the lower floodplain 1.1 m. To the west of the designation boundary the stream floods the Kaipara Flats Road to depths of up to 0.9 m.

4.3.3 Waiteraire Stream flood risk

The Council RFHA indicates that flooding in the Waiteraire Stream is generally confined to the steep channels and is not a hazard to property or public roads. Waiteraire Stream was not modelled specifically for the Project, however the Hōteo flood model extends into the Waiteraire Stream. The outputs are similar to RAHM in that the floodplain is confined to river channel and poses a low risk of flooding.

4.3.4 Hōteo River flood risk

The Council RFHA indicates that flooding is an issue in the Hōteo River catchment extending along the Hōteo River channel and to the west across Wayby Valley Road, including the unnamed tributaries H1 and H2. The Hōteo River has an extensive floodplain to the east of Wellsford, north of the existing SH1, which extends across the Wayby Valley Road, farmland and properties including Wayby Valley within the proposed designation boundary. Downstream of the proposed designation the Hōteo River floodplain is generally confined within the river valley, however extends across properties at Tauhoa Road.

The project specific 100 year ARI modelling is comparable to the RFHA map (see Section 4 of the Flood Modelling technical report). The 100 year ARI flood modelling (Figure 16) predicts that flood flows out of bank for the Hōteo River and tributaries causing flooding across Wayby Valley Road of up to 1m in depth within the proposed designation boundary, and up to 3 m in depth to the north of the proposed designation boundary. Flood depths of up to 3.5m are modelled within the designation associated with the unnamed tributaries (H1 & H2) in pasture and up to 2.8 m in the pasture to the east of Wayby Valley Road. Outside of the proposed designation boundary the floodplain of the Hōteo River is predicted at depths of up to 5 m in pasture to the east of Wayby Valley Road.

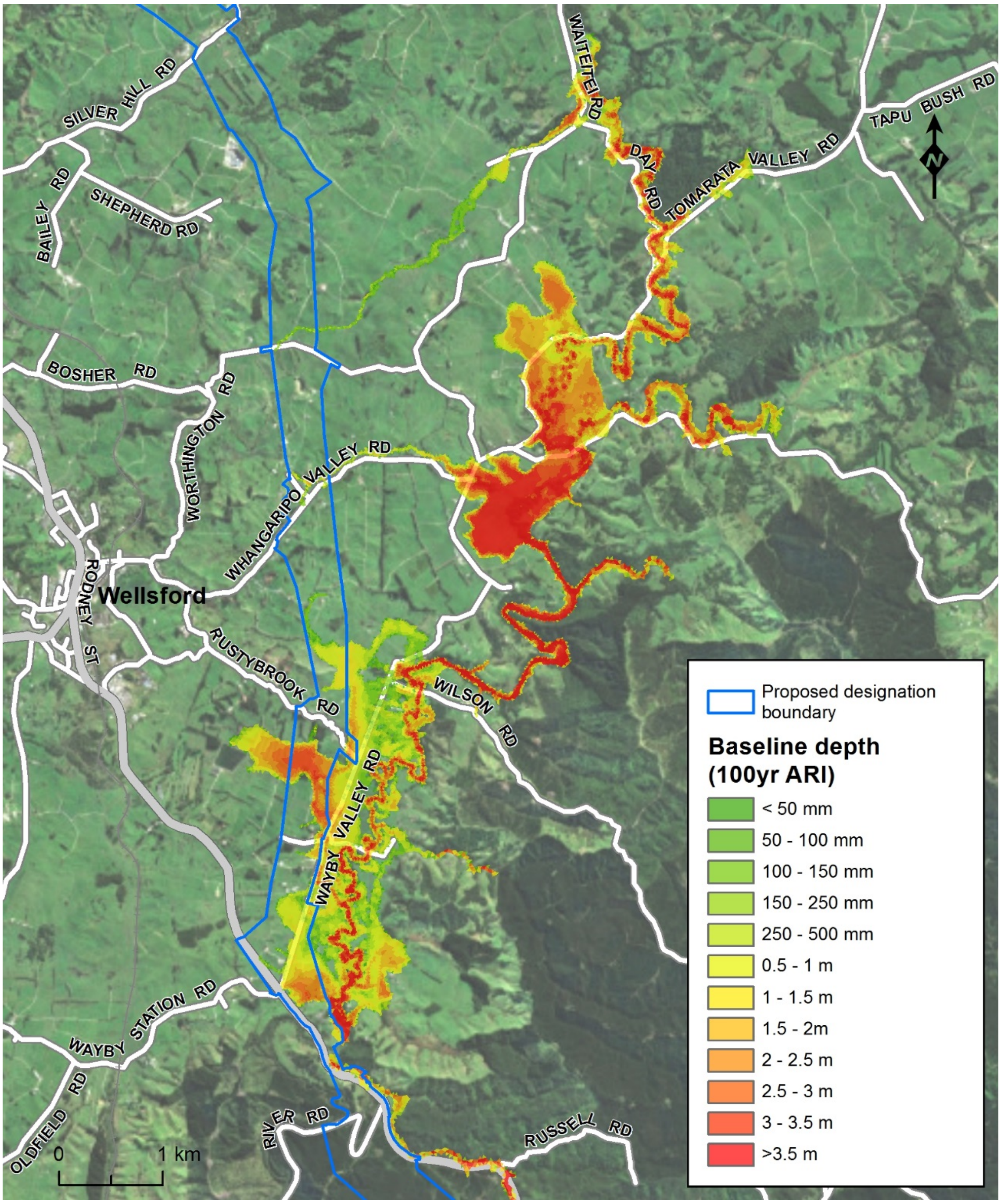


Figure 16 – Modelled flood extents and depths for the Hōteo River crossing for existing conditions for floods of 100 year ARI

The modelled 20-year ARI floodplain (Figure 17) is less extensive than the 100 year ARI and has shallower depths, although there still remains some deep areas of flooding outside of the river and stream channels. Flood depths across Wayby Valley Road are modelled to be up to 0.9 m in depth within the proposed designation boundary, and up to 2 m in depth to the north of the proposed designation. Flood depths of up to 3.1 m are modelled within the proposed designation boundary associated with the unnamed tributaries (H1 & H2) in pasture and up to 2.5 m in the pasture to the east of Wayby Valley Road. Outside of the proposed designation boundary the floodplain of the Hōteo River has depths of up to 5 m in pasture to the east of Wayby Valley Road.

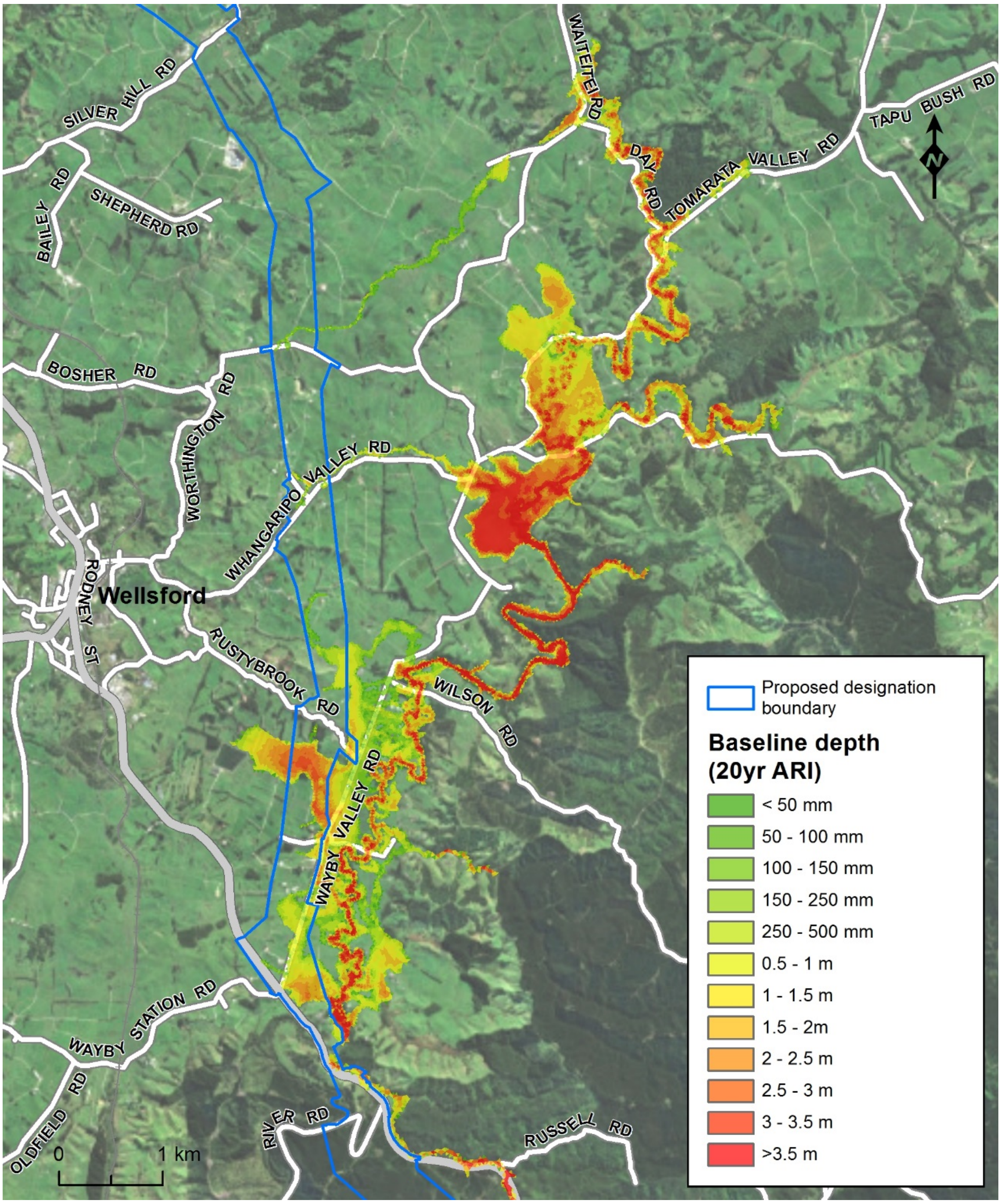


Figure 17 – Modelled flood extents and depths for the Hōteo River for existing conditions for floods of 20 year ARI

The project specific modelled 2 year ARI event floodplain for the Hōteo River is less extensive and deep than more extreme floods, however there are still areas of flooding within the proposed designation boundary associated with the unnamed tributaries (H1 and H2) and the Hōteo River.

Flood depths across Wayby Valley Road are modelled to be up to of up to 0.3m in depth within the proposed designation boundary, and approximately 1 m in depth to the north of the proposed designation. Flood depths of up to 2 m are modelled within the proposed designation boundary associated with the unnamed tributaries (H1 & H2) in pasture and up to 1.9 m to the pasture to the east of Wayby Valley Road. Outside of the proposed designation boundary the floodplain of the Hōteo River has been modelled with depths of up to 5 m in pasture to the east of Wayby Valley Road.

4.3.5 Unnamed tributaries (H3 and W1), Te Hana Creek and Maeneene Creek flood risk

The RFHA indicates that flooding in the H3 and W1 streams is generally confined to the stream channels and is not a hazard to property. The Hōteo flood model extends into the lower reaches of these tributaries and is similar to RFHM mapping in that the floodplain is confined to stream channels.

The RFHA map indicates that within the proposed designation boundary, the Te Hana Creek and Maeneene Creek floodplain is generally confined to the stream channels and does not pose a risk to existing infrastructure. No flood model was developed for these areas due to the low hazard identified in the RFHA map.

5 CONSTRUCTION WATER MANAGEMENT

Section Summary

An indicative construction methodology for the Project has been developed to assist in scoping, assessing and managing the potential effects of the Project on the water environment. This includes consideration of construction staging and sequencing and is based on a peak active area of earthworks within the various Project catchments. The Construction Water Design technical report that supports the Project provides details on:

- A description of the indicative construction strategy and implementation of ESC at detailed design;
- The construction ESC measures included within the indicative design;
- Controls of other non-sediment contaminants; and
- Indicative methodologies for site activities.

This section provides a summary of the Construction Water Design technical report and recommends a continuous improvement monitoring programme which will be implemented to ensure effectiveness of construction water management continues throughout. Construction water management is an inherent part of the Project design and reduces the potential effects of the Project. The assessment of construction effects, discussed in Section 6, provides an assessment of residual effects (based on a risk assessment and changes to water quality), with the proposed construction water management methods in place.

As detailed in Section 2.3.1 of this report the Project works have the potential to result in changes to water quality during the construction phase as a result of:

- discharge of sediment from earthworks during both rain and flood events;
- discharge of sediment from in-stream activities and changes to flow; and
- discharge of other contaminants (such as oils, fuels and cement).

These changes have been assessed based on a risk management approach including sediment yields which have been estimated through the development of a construction sediment model. Constructability, ESC principles and practices have all assisted with this assessment process and are discussed further as below.

5.1 Indicative construction strategy

The design of the ESC measures and management practices that will be required along the length of the Project are based on the construction sequencing discussed in Section 5 of the AEE, which outlines an indicative construction methodology and a construction programme developed for the Project. As with other design components, this methodology will be further refined at detailed design stage.

The indicative construction methodology is largely driven by the earthworks, estimated to be around 12 million m^3 of cut material over a totalled earthworked area of 310 ha. For description purposes the Project has been divided into the following sections as outlined in Section 1.4 and Figure 1 of this WAR. These sections also reflect the indicative construction programme and sequencing. The sections are as follows:

d) Southern Section: From the southern extent of the Project at Warkworth to the northern tunnel portal.

e) Central Section: From the northern tunnel portal to the Hōteo River (southern abutment.

f) Northern Section: From the Hōteo River (northern abutment) to the northern tie in with existing SH1 near Maeneene Road.

The southern and central sections are grouped together and referred to as Hōteo South with Hōteo North representing everything north of the Hōteo River.

5.1.1 Construction areas

To allow the effects of construction to be assessed, the indicative construction programme further split the Project into construction areas, based upon the surface water catchments as shown in Figure 6. Within the Hōteo River, the construction area is further split into six operation areas. Earthworks activities will be required in all of these construction zones listed below:

Southern Section

- Mahurangi area – the southern part of the Project up to Warkworth interchange, including majority of Warkworth Interchange and Ramps, and Woodcocks Road.
- Hōteo Operation 1 – from the Warkworth interchange to the Southern Tunnel Portal, including part of Warkworth Interchange, Carran Road, Kaipara Flats Road and Phillips Road. Figure 5 of the Catchment Sediment Modelling technical report illustrates this location.

Central Section

- Hōteo Operation 2 – from the north of the tunnel. Figure 6 of the Catchment Sediment Modelling technical report illustrates this location;
- Hōteo Operation 3 – from chainage 41,700 to Dibble Road, including Dibble Road. Figure 6 of the Catchment Sediment Modelling technical report illustrates this location.
- Hōteo Operation 4 – from Dibble Road to the Hōteo River Viaduct and River Road. Figure 6 of the Catchment Sediment Modelling technical report illustrates this location.

Northern Section

- Hōteo Operation 5 – from the Hōteo River Viaduct to the Whangaripo Valley Road, including Wayby Valley Road and Rustybrook Road. Figure 7 of the Catchment Sediment Modelling technical report illustrates this location.
- Hōteo Operation 6 – from the Whangaripo Valley Road to the Te Hana River catchment boundary (approximately Farms Lime Road), including Farms Lime

Road. Figure 7 of the Catchment Sediment Modelling technical report illustrates this location.

- Oruawharo area – the Hōteo River and Oruawharo River catchment divide to the tie in with the north of the project, including Silver Hill Road and Mangawhai Road, and Maeneene Road.

We have adopted both the construction sections and areas in this assessment of construction water management.

5.1.2 Construction sequencing

Construction activity will be sequenced to minimise sediment generation and sediment yield from the various activities. Earthworked areas will be progressively stabilised as appropriate as the works progress. There is a construction linkage with sequencing of works and any open area limits that apply. The assessment within this report is based on ensuring that any open area limits are achievable from a construction programme and sequence perspective while still ensuring that any effects can be adequately managed.

The total area of land to be earthworked for the entire Project is estimated to be 310 ha inclusive of soil disposal sites. The construction areas are illustrated below (Table 13).

Table 13 - Probable maximum construction areas

Area	Catchment(s)	Area (ha)
Mahurangi area	Mahurangi River (right branch and left branch)	43.3
Hōteo - Operation 1	Kourawhero Stream	23.7
Hōteo - Operation 2	Waiteraire Stream	91.4
Hōteo – Operation 3	Waiteraire Stream	
Hōteo – Operation 4	Waiteraire Stream and Hōteo River	
Hōteo - Operation 5	Hōteo River and unnamed tributaries of Hōteo River (H1, H2 & H3)	88.3
Hōteo – Operation 6	Unnamed tributaries of Hōteo River (H3 & W1)	
Oruawharo area	Te Hana Creek & Maeneene Creek	63.3
Project Total Earthworks		**310**

Open areas for each catchment affected by the Project were adopted for modelling purposes, as described in the Catchment Sediment Modelling technical report and are based on peak active areas of earthworks. These peak active areas have been informed by the constructability assessment and are confirmed, with current design and knowledge, as adequate to enable the Project bulk earthworks to be completed within a 6 year period. These peak active area assumptions were therefore adopted as inputs for modelling sediment loads and deposition and the transport of the sediment in the marine environment (refer to the Marine Sediment Modelling technical report). The peak active areas are provided in Table 14 below.

The indicative construction methodology has been based on a maximum area of earthworks of 43.3 ha within the Mahurangi catchment, 75 ha within the Hōteo catchment and 25 ha within the Oruawharo catchment. Project-wide earthworks areas are summarised in Table 13 with specific cut and fill locations and associated catchment boundaries to be finalised at detailed design.

Table 14 - Peak active areas assumed for the modelling purposes

Catchment	Assumed Peak Active area
Mahurangi River	43.3 ha
Hōteo River	75 Ha
Oruawharo River	25 ha

A large proportion of the Project works (approximately 17 km of the total 26 km, including all works in the steeper central section) will take place within the catchment of the Hōteo River. If an open area limit is imposed for works within the Hōteo River catchment that is aligned with the modelling assumptions (75 ha), based on constructability advice provided to the Project, such a limit is not expected to affect the construction methodology or the overall programme. A contractor would adopt erosion and sediment controls and use progressive stabilisation to manage the works within the open area limit. The works on structures such as bridges would largely be unrestricted by open area limits for earthworks.

In addition to the Hōteo catchment, earthworks will also be undertaken within the Mahurangi and Oruawharo catchments. Because any effects of construction related sediment in coastal receiving environments will be separate for each catchment, open area limits will apply separately for each catchment. This would allow a contractor to progress work concurrently in these three separate locations.

If an open area limit is imposed for works within the Oruawharo catchment that is aligned with the modelling assumptions (25 ha), based on constructability advice provided to the Project, such a limit is not expected to affect the construction methodology or the overall programme.

We note that the consents granted for P-WK provided for an open area limit of up to 109 ha in the Flat Country in the Mahurangi catchment[4], assuming there is no open area in the Hill Country at the same time. The proposed earthworks for the WW2W Project covers 43 ha within the Mahurangi catchment. It follows that an open area limit that is consistent with the P-WK project conditions of consent (effectively no limit for the WW2W Project) would not affect the construction methodology or programme.

5.2 Construction water management

5.2.1 Erosion and sediment control

Erosion control is based on the practical prevention of sediment generation in the first instance. Effective erosion control measures and practices will minimise sediment generation, reducing the reliance on sediment control measures.

Sediment control refers to management of the sediment after it has been generated. It is inevitable that some sediment will be generated through land disturbance activities even with best practice erosion control measures in place. Sediment control measures are

[4] Resource Consent Condition RC 25 Flat Country maximum 109 ha = 21.5 ha + (2.14 x 41 ha)

designed to capture this sediment to minimise any resultant sediment-laden discharges to waterways.

5.2.2 Overarching ESC principles

As detailed in Section 3.2 of the Construction Water Design technical report, physical ESC measures and site management practices are used in combination to minimise the effects of earthworks on the receiving environment. Overall CWM utilised within the Project will be undertaken and implemented with a hierarchy and priority order as follows:

- **Prevention:** Excluding clean water runoff from entering the active work areas, therefore preventing clean water runoff from combining with excavated spoil and/or construction material and will require the use of clean water diversion (CWD) channels and/or bunds to divert runoff from the upstream side of the work area.

- **Capture:** Any sediment laden runoff generated within the working area will be captured through the use of dirty water diversion (DWD) channels and/or bunds on the downstream side of the construction site which will direct sediment-laden runoff from the site to an appropriate sediment control device. Sediment capture will be implemented through one or more sediment control measures.

- **Minimisation:** Limiting the length of time and the extent of the area of exposed/disturbed soil to reduce the erosion potential to generate erosion. Timely stabilisation of exposed areas and the construction of impermeable areas will also reduce the potential for erosion to occur.

- **Staging and Sequencing of Works:** Construction activity will be carried out in stages and works within those stages will be sequenced to manage erosion and sedimentation. Working areas will be progressively stabilised as appropriate as the works progress.

With the above in mind, the ESC measures for the Project are to be designed to minimise the extent of soil erosion and to capture and retain, to the fullest practical extent, the resultant sediment yield generated from the contributing construction catchment. It is also recognised that in larger rain events, and in high intensity rain events, that the effectiveness of the sediment control systems will likely be reduced with higher sediment yields occurring. The sediment yield information will be obtained through the continuous improvement monitoring programme and will inform the marine ecology mitigation process and resultant conditions of consent related to offset mitigation requirements.

The receiving environment associated with the Project area includes a range of freshwater systems with varying ecological and amenity values. From a freshwater and terrestrial ecology perspective it is noted that the ecological assessment has confirmed that low value aquatic habitats are present in the Warkworth North and Hōt eo North Sections where many of the streams are located within grazed pasture. The Dome Valley Forest Section currently has freshwater habitats of high ecological value, with high diversity of fish and macroinvertebrate species, however that environment will change through the forestry harvest cycle. In addition, within the Warkworth North section the Indicative Alignment encroaches on a small swamp forest fragment and a raupo wetland, both of which have identified values as specified within the ecological assessment.

It is necessary that ESC measures and practices implemented during the construction phase recognise these values and manage the discharge of sediment accordingly.

The Marine Ecology and Coastal Avifauna Assessment Report has identified that the Mahurangi Harbour and the Kaipara Harbour both have high marine ecological values in the middle and lower reaches of the harbour (where species sensitive to increased fine sediment exist), and moderate marine ecological values in the upper reaches of the harbour (where silt and clay are already the largest proportion of the sediment composition).

It is important that erosion and sediment control measures are robust where there is a potential for increased sediment input to occur within SEA M1 and M2 areas (described within the Marine Ecology and Coastal Avifauna Assessment Report), or where additional sediment will potentially reach the middle and lower reaches of the Mahurangi (downstream of Hamiltons Landing) and Kaipara Harbour (downstream of Port Albert within the Oruawharo River and downstream of the mouth of the Hōteo River). Overall, with recognition of both the freshwater and marine values identified, the recommended erosion and sediment controls are designed for the values identified and are recommended to be implemented and maintained to also reflect these values. The CESCPs that will form part of the overall approach to construction will remain as the key tool in ensuring these aspects are considered within this context.

5.2.3 Key erosion and sediment control approach

Table 15 below summarises the overarching approach that we recommend be applied to the Project relating to erosion control and sediment control.

Table 15 - ESC Approach

Approach / Principle	Criteria
Erosion and Sediment Control Plan (ESCP)	The ESCP is the overarching erosion and sediment control plan that outlines and confirms the overall approach to construction water management. The ESCP includes the following elements: • ESCP Design • Education and Training of all site staff; • Implementation of a continuous improvement monitoring programme, which will form part of an overall Construction Environmental Management Plan (CEMP); • Process for the development of CESCPs; • Quality Assurance / Management System; • Proactive and reactive ESC maintenance Based on the indicative construction methodology and sequencing, and more detailed on site assessment of key activities (including looking at specific higher risk locations such as the Hōteo River bridge works), we are confident that there is the ability to ensure the methodologies identified and documented can be effectively implemented.
Construction Stage Erosion and	CESCPs are detailed erosion and sediment control plans which will be submitted for specific work areas and/or activities within the site. CESCPs will provide the detailed design, specific ESC measure location, staging and

Approach / Principle	Criteria
Sediment Control Plans (CESCPs)	sequencing of works for that location and will be developed prior to works commencing in these locations. The CESCPs will determine specific measures to be employed and will also consider any alternatives that exist. The CESCPs will determine the most effective and appropriate form of construction water management devices and management practices required to manage discharges during the construction period with recognition of the environmental values for that location. As part of the Project implementation, the CESCPs will follow the principles and approach outlined within this WAR and will also confirm specific design details. The implementation of site specific CESCPs will further allow for innovation, flexibility and practicality of approach to construction related water management. They will enable the construction team to have ongoing input into the ESC measures and practices prior to and during construction. This CESCP process allows the construction water management measures utilised within the Project to continually adapt to changing construction, environmental and climatic conditions. CESCPs will include: • Contour information; • ESC measures for the works being undertaken within a particular construction area; • Chemical treatment design and details; • Catchment boundaries; • Location of the work; • Details of construction methods; • Design criteria, typical and site specific details of ESC measures including ensuring that all sediment retention ponds and decanting earth bunds have full access track provisions for maintenance at all times; • Identification of risk and sensitive area locations and the details of management (including contingency measures) around these aspects; • Details of open areas that exist for the project at the time of the CESCP and a programme for managing ongoing non-stabilised areas; • The identification of staff and resources who will manage and maintain ESCs; • The identification of staff who will monitor compliance with conditions; • Details of specific resources and responsibilities for managing environmental issues on site to ensure that any resultant conditions of consent are complied with; • Methods and procedures for decommissioning measures; and • Design details for managing the treatment, disposal and/or discharge of contaminants (e.g concrete wash water). In addition, each CESCP must clearly illustrate on a plan the specific location and boundaries of the CESCP (in the context of the wider Project) and what activities are addressed within them.

Approach / Principle	Criteria
Construction staging and sequencing	Staging and sequencing are both important non-structural measures and will be implemented as necessary to achieve the progressive stabilisation on an ongoing basis. Detail of the staging and sequencing of works will be detailed within the CESCPs. The staging may include reduced area of working in winter. For the assessment we have assumed in the winter the active area will be 20% of the area at the peak of the previous summer season. which reflects the wet nature of the period and the inability to achieve any necessary earthwork compaction standards. The 20% is assessed as a percentage of area that may be able to be successfully earthworked with progressive stabilisation in place. Dependent upon the ability to successfully implement earthwork activities over this winter period this 20% may well increase based on monitoring outcomes from the continuous improvement monitoring programme.
Device location and discharges	All ESC devices should be located outside the 20 year ARI flood level unless no other viable alternative exists. All construction related runoff discharges are either to a land environment or direct to freshwater systems with particular emphasis on avoidance of the sensitive locations identified where practicable. We consider discharges to land to be beneficial in that a land-based buffer zone will provide a 'polishing' effect of the discharged runoff. Where discharges are direct to freshwater systems, to minimise erosion of the stream bank and bed at that point, the outlet will be protected with geotextile and riprap material in the immediate vicinity of the outlet.
Non-Structural Measures	These elements include: • Proactive monitoring and reporting programme (as per Section 9 of this Report); • Risk identification and management; • Progressive stabilisation as works progress; • Staging and sequencing of specific work/activity programmes; and • Weather response.
Progressive stabilisation for erosion and dust management purposes	Progressive and rapid stabilisation of disturbed areas utilising top soil (where necessary) and seed, mulch and geotextiles will be ongoing throughout the Project. Stabilisation will be undertaken with three key purposes: • To achieve an effective erosion and sediment control programme inclusive of progressive stabilisation; • To reduce the exposed earthwork areas within higher risk locations to assist with a reduction in sediment generation; and • In response to the continuous improvement monitoring programme to address any potential effects or undesirable monitoring trends.
Streamworks	Works within or adjacent to freshwater streams are generally considered higher risk than other earthwork activities due to the close vicinity of the sensitive receiving environment and the associated increased potential for sediment yield. Within the Project, streamworks will be undertaken in a manner that recognises and responds to this risk.

Approach / Principle	Criteria
	Where practical, streamwork activities and any associated works within these environments will be undertaken in an 'offline' dry environment. This strategy will be based upon the temporary diversion of flows around the area of works or working immediately next to the stream with no formal stream diversion required. All streamworks will also be undertaken with consideration of fish spawning and migration periods.

5.2.4 Key erosion and sediment control measures

Table 16 below summarises the key ESC design criteria that are recommended to be utilised for the Project. The table includes a summary of the ESC devices and management practices, relating to erosion control and sediment control respectively. It reflects the same detail provided within the Construction Water Design technical report. These measures have been implemented on a number of projects, including Transport Agency Roading projects, have been proven effective and are recognised within the earthworks industry as representing current best practice.

Table 16 - ESC devices/methodologies and design criteria

Device/methodology	Criteria
Erosion control measures	
Clean Water Diversions (CWD)	Clean water diversion channels and bunds will be designed to cater for the 1% AEP rainfall event.
Contour drains	Contour drains will be designed and implemented in accordance with GD05.
Dirty Water Diversions (DWD)	Dirty water runoff diversion channels will be sized to cater for the 1% AEP rainfall events. Sediment sumps with a minimum volume of 2 m^3 to be installed in all DWDs at a maximum distance of 50m between sumps.
Pipe drop structures/flumes	Flumes will be used to safely transfer runoff from the top of batters to the bottom of the batter slopes.
Rock check dams	Rock check dams will be designed and implemented in accordance with TP90.
Stabilised entrance ways	Stabilised entrance ways will be established at all entry and exit points of the site.
Sediment control measures	
Container impoundment systems	Container Impoundment Systems will be implemented as per Drawing ES-076. They will be based on a 3% volume criterion applied in relationship to catchment size and as such will apply to smaller catchment areas than DEBs and SRPs. Their primary purpose is for the initial earthworks in steep or constrained or constricted working areas prior to the formation of a SRP or DEB structures.

Device/methodology	Criteria
Decanting earth bunds (DEBs) and decant systems	All DEBs established will be based on a volume of 3% of the contributing catchment area and sized accordingly, subject to a to a maximum DEB catchment area of 3,000m^2 unless varied within the CESCPs. All DEBs will be fitted with floating decants. Decants will have a manual control mechanism (to prevent) outflow from the DEB during pumping activities to these structures.
Flocculation	Flocculation will be applied on all SRPs and DEBs based on an approved Chemical Treatment Management Plan (CTMP). Flocculation will be applied to all DEBs with a catchment area above 500m^2, and all SRPs. For all contributing catchments over 2ha in area, two flocculation sheds will be installed per device for the purpose of increasing the volume of flocculant available and also for reducing the risk of failure if one of the flocculation systems fails or has reduced performance Manual batch dosing will be applied as required. Flocculant socks to be utilised as alternative and/or additional measures as required.
Sediment retention ponds (SRPs)	All SRPs will be implemented based a 3% volume criterion applied in relationship to catchment size (i.e. 300 m^3 SRP volume per 10,000 m^2 of contributing catchment) All SRPS will be subject to a maximum catchment area of 50,000 m^2 unless varied within the CESCPs Baffles, decant pulleys and reverse slopes to be installed in all SRPs.
Super silt fences and silt fences	All super silt fences and silt fences will be based upon the design criteria within TP90. SSF fabric will be installed with at least 200mm of fabric upslope at the base of the trench. In areas where sediment control devices are within 50 m of a watercourse, SSF will be utilised as a last line of defence such that if a failure of the primary control measure eventuates then the last line of defence will capture and treat such a discharge.

Whilst this report refers to various erosion and sediment control guidelines, such as TP90, GD05 and the Transport Agency Standards, it is noted that some ESC measures recommended for the Project will exceed the design guidance provided in those documents through a more conservative design. The adopted design will ensure that best practice and knowledge applies. The measures identified that “exceed” the current guidelines criteria include as follows:

- All sediment retention ponds and decanting earth bunds are sized at 3% of the catchment area with full access track provisions for maintenance at all times;
- The adopted silt fence design, follows the design provided in TP90 and Transport Agency ESC Guidelines with a return upslope to ensure robustness of the device;
- The sizing of temporary diversions is for the 100 year ARI event;
- We propose quantitative monitoring of the performance of devices and the receiving environment to inform design and operational improvements over time (continuous improvement);

- Marine mitigation will be determined and applied based on actual sediment yields that are measured from the project earthwork activities; and
- Through the design and construction phases of the Project, we recognise that there will be scope for innovation and alternative means of achieving the same environmental outcome as specified in consent conditions.

It is our recommendation that the ESC measures will be planned during the detailed design phase of the Project and constructed on site and maintained during construction, in accordance with the principles and practices as outlined in the Construction Water Design technical report.

5.2.5 Non-sediment contaminants

There are a number of non-sediment contaminants arising from construction activities, which generally consist of site and materials management measures, that may directly or indirectly discharge into the receiving environment from site activity. The Transport Agency ESC Guidelines (2014) lists a range of potential non-sediment contaminants which are listed in Table 17.

The management of these non-sediment contaminants will be subject to specific best management practice and industry guidelines. It is currently too early in the design process to specify the nature of these non-sediment contaminants and the associated volumes. However Table 17 below provides some generic guidance as to the expected management approach. The CEMP will address the management approach to be applied during construction, reflecting current best practice at the time of construction.

Table 17 - Potential non-sediment contaminants and management approach

Product / activity	Potential contaminants	Management approach
Adhesives	Adhesives, Glues, Resins, Epoxy and PVC Cement	• Store materials in an area that is not subject to rainfall contact • Use adhesives carefully and clean up any spilled material • Properly dispose of containers once they are empty
Asphalt paving	Hot and Cold Mix Asphalt	• Water runoff should discharge to a treatment system designed to capture hydrocarbons
Cleaning products	Cleaners, ammonia, lye, caustic sodas, bleaching agents, chromate salts	• Store materials in an area that is not subject to rainfall contact • Use carefully and clean up any spilled material • Properly dispose of containers once they are empty
Concrete	Cement	• Concrete truck chutes, pumps and internals should only be washed out into the formed areas awaiting installation of concrete • Unused concrete remaining in trucks shall be returned to the concrete batching plant • Hand tools should only be washed out into the formed areas awaiting installation of concrete

Product / activity	Potential contaminants	Management approach
Flocculants	Specific to Flocculant used but can include pH and aluminium	• Ensure the use of flocculants follows an approved flocculant management plan and industry best practice. • Regularly measure pH of the discharge from sediment retention devices.
Sanitary waste	Portable Toilets, disturbance of sewer lines	• Place portable toilets away from site vehicle movement areas, to minimise the risk that they will be knocked over • Service portable toilets regularly • Empty portable toilets before they are moved. • Avoid breaking sanitary sewer lines that may exist onsite by proactive monitoring and knowledge of existing infrastructure
Vehicle and equipment use	Equipment operation, maintenance, washing, refuelling	• Fuel storage tanks shall be bunded to store a minimum of 100% of the tank's capacity. It is unlikely for this Project that bulk fuel storage will occur and mobile refuelling will remain as the predominant methodology. • Procedures and practices shall be put in place to minimise or eliminate the discharge of lubricants, coolants or hydraulic fluids to the receiving environment • Have spill prevention and control measures and procedures in place

5.3 Construction activity specific methodologies

The Construction Water Design technical report includes details of construction water management practices required to manage construction runoff from a variety of key construction activities on the Project.

The works methodologies are conceptual in nature and have been developed to provide details of the various ESC measures and practices to be put in place to address erosion and sedimentation issues during the construction phase. The construction methodologies for the various construction activities will be further developed and specific detail will be provided in the CESCPs, which will be produced by the principal contractor prior to construction works commencing.

We have 'tested' the methodologies within specific locations of the site to ensure practicality and workability and have also assessed the transferability of the method to the same activity type within other Project locations. This "testing" has included specific site visits and methodology establishment for construction of specific activities identified within the Project. These drawings can be found in the Volume 3 Drawing Set of the AEE.

Section 5.3 of the Construction Water Design technical report should be referred to for the activity detail methodologies.

5.4 Continuous Improvement monitoring programme

We recommend that a continuous improvement monitoring programme be developed and implemented for the construction phase of the Project.

The primary objectives for the monitoring programme are outlined as follows:

1. To provide information for making effective decisions on necessary continuous improvement of erosion and sediment control measures (both structural and non structural);

2. To assist in understanding the outcome of on-site decisions to water quality and stream ecology, and support any determination of potential ecological effects from sediment discharged by the Project earthworks and

3. To quantify potential sediment discharges from the Project and enable appropriate site management responses and mitigation to be identified to reflect sediment yields.

As part of this process there is also the ability to understand the potential for downstream effects and managing the construction activity and associated controls to minimise any effects.

The monitoring programme will be implemented by suitably qualified and experienced staff in construction water management to identify changing site conditions and continuous improvement opportunities in response to the monitoring outcomes.

Overall the monitoring programme provides certainty that the construction activity continues to utilise best practice, allows for innovation to be implemented, allows for identification of risk, provides a scientific and robust basis (based on water quality outcomes) for making decisions on site and finally provides a realistic and effective "backstop", should effectiveness of the measures be compromised, prior to any effects occurring. It further allows for the amendment and adoption of a change to earthwork open areas in direct response to effectiveness of measures implemented.

This monitoring programme includes ongoing site monitoring to check that the proposed water management measures have been installed correctly and that methodologies are being followed and are functioning effectively throughout the duration of the works. Monitoring triggers may be identified that will determine a potential action point at which further site investigation and continuous improvement opportunities can be further considered by the construction team. The triggers determined may relate to water quality, SRP clarity, accidental spills and comparative analysis with any baseline data collected.

Water management measures and methodologies may be identified as requiring modification or improvement based on the monitoring results with a continual feedback loop until it has been verified that the implemented responses have been successful in minimising sediment yields (and effects) from the Project. As detailed above the monitoring will also allow for an overall assessment of effectiveness of the construction water management approach and in doing this allow for consideration of any amendments to open earthwork areas that may be implemented on site. This applies to both a reduction and/or an increase in open areas accordingly.

It will further allow for an assessment of overall sediment yields in any rain event and a comparative assessment against the modelled sediment discharges to ensure that the quantum of sediment and therefore any quantum of mitigation remains appropriate.

The key components of the continuous improvement monitoring will include:

- Weather forecasting;
- On-site monitoring of devices;
- Receiving environment visual assessments;
- Flocculation monitoring; and
- Quantitative water quality and flow monitoring.

5.4.1 Weather forecasting during Project implementation

Weather forecast monitoring will form an important part of the Project implementation to ensure that higher risk activities, such as those associated with the stream diversions, will only occur during a suitable fine weather window.

We note the extensive use of weather forecasting that now occurs with most land-disturbing activities and the value that it provides in informing contractors of upcoming weather systems. The forecasting tools include publicly available forecasting services (i.e. MetService and MetVUW) and this has proven successful in the past and will continue to be utilised used for this Project. Forecasting has proven to be a successful management tool in avoiding high risk stream works over wetter periods of the year. It also provides guidance for activities such as when temporary stabilisation must occur.

5.4.2 On-site monitoring of water management practices and devices

Monitoring of onsite devices is based upon the appropriate installation, location, maintenance, and monitoring of control devices. It is important that within the context of monitoring, the devices are not restricted to physical structures and will also include work practices and methodologies.

The purpose of the devices monitoring is to check that all practices, control measures and devices are designed, constructed, operated and maintained so they remain fully effective at all times. The requirement to undertake as built certification of the control measures once constructed will assist with ensuring that controls are appropriately installed to the necessary design criteria.

5.4.3 Receiving environment visual assessments

Visual assessments of the receiving environment will be undertaken regularly throughout the works period with particular attention paid before, during and after periods of rainfall. In the context of visual assessment, the receiving environment is defined as the immediate receiving environment adjacent to the area of works including receiving rivers and streams.

Any noticeable change in water clarity in a receiving river or stream as a result of the earthworks activity, compared to the water clarity prior to the rainfall event or upstream of the site of works, will result in a review of the construction water measures and practices. Additional measures may need to be implemented and changes made as necessary under the continuous improvement management procedures.

5.4.4 Flocculation monitoring

While the careful use of chemicals (e.g. coagulants and flocculants) at SRP's and DEBs at the correct dose rate has the positive effect of improving treatment efficiencies, overdosing can have negative impacts if residual compounds leave with the pond discharge and enter receiving waters. Overdosing should, as far as practicable, be avoided or addressed by identifying the indicators below.

Low pH and residual dissolved aluminium in any SRP or DEB outflow is an indication of over dosing with PAC and a common visual indicator is that the water appears to be tinted blue-green.

When utilising Poly Aluminium Chloride (PAC), it is proposed to adopt visual observation and pH testing to monitor SRPs and DEBs where this chemical treatment is used, and apply the following management triggers:

- Water visually appears to be tinted blue-green; and/or
- pH of less than 5.5 at the SRP or DEB outflow.

Chemical use should be reassessed if data shows that the current chemical flocculation methods are exceeding the above triggers. It is noted that some of the flocculants available have no effect on pH levels and if such chemicals are used on this Project then there will be no requirement to monitor discharge pH levels. Where other chemical flocculants are used, specific monitoring parameters (if any) shall be set out in the relevant CESCP's.

5.4.5 Quantitative water quality and flow monitoring

In addition to the on-site qualitative monitoring of water management devices, quantitative monitoring is recommended on the Project. The objective of this monitoring programme is to provide water quality data for an array of rainstorms of different magnitudes and intensities, as well as providing information on the total sediment yield from the site during the earthworks period for comparative analysis with modelled outcomes. This information will further assist with the interpretation of the ecological monitoring during construction.

The quantitative sediment monitoring programme has the aim of providing sediment yield data. The data will assist with determination of any effects that may result downstream, the need for modifications to the erosion and sediment control mechanisms, and adjustments to the mitigation requirements, including any determination of effects on the marine environment and any offset marine mitigation that may apply, for the Project.

Manual monitoring

It is recommended that following a rainfall trigger event (defined as 25 mm within a 24 hour period or 15 mm within a 1 hour period) that manual monitoring of outflows associated with all SRPs and a selection of DEBs (a minimum of 50% of the operational DEBs) will occur where practicable. This manual monitoring supplements the automatic sampling (as below) and allows for comparative analysis between samples and with the existing baseline sampling. In addition, monitoring of the receiving environment through manual sampling, both upstream and downstream of discharges, will occur where practicable.

Flow monitoring

It is recommended that continuous discharge flow monitoring will occur on the outflows from four selected sediment retention ponds with two of these to best represent a high risk location of the earthworks on the Project (steeper locations or those with a catchment greater than 5.0 ha) and two of these to represent the design and construction for general earthwork activities. The process for identification of the location of these devices is recommended to be detailed within the monitoring programme as recommended in section 6.4.6 below. The flow monitoring device can be moved as the Project progresses. Flows will be recorded electronically, and this information will enable sediment yields to be calculated.

Sediment discharge automated monitoring

Automatic continuous sediment sampling will occur to measure the suspended solids concentration through storm events from the same four SRPs subject to flow measurement.

Sediment monitoring will be undertaken using an automatic water sampler at the flow monitoring site to take samples spaced at volume (flow proportional) intervals that will be selected to ensure that as close as practicable to the total construction runoff from a major rainstorm event is monitored. It is recommended that the suspended solids concentrations of the samples be tested (or an alternative water quality parameter that can be related to suspended solids concentrations), and in association with the flow data will be used to determine the sediment yields for that location. This data will also inform the total Project actual sediment yields over time.

5.4.6 Response to management triggers

Management triggers will be identified as part of a monitoring programme and will include a percentage increase over baseline of suspended solids in the discharge from site and a percentage increase of suspended solids (average values) from previous rain events for that same device.

These management triggers do not indicate potential effects however do allow early detection of potential on site issues. Baseline monitoring prior to commencement of works will assist with determination of these triggers.

If monitoring results confirm management triggers are exceeded the following steps are recommended:

- In the first instance, investigate a possible (cause-effect) association with the Project;
- Should this investigation establish linkages between any effect and on-site practices, then investigate alterations to the operational methods (including modifications to environmental control measures and methodologies) as a first order response;
- Assess the effectiveness of the alterations in construction methods by conducting further monitoring to alleviate/avoid adverse effects on the environment; and
- Assess the need for, and nature of, any remedial action including ecological response.

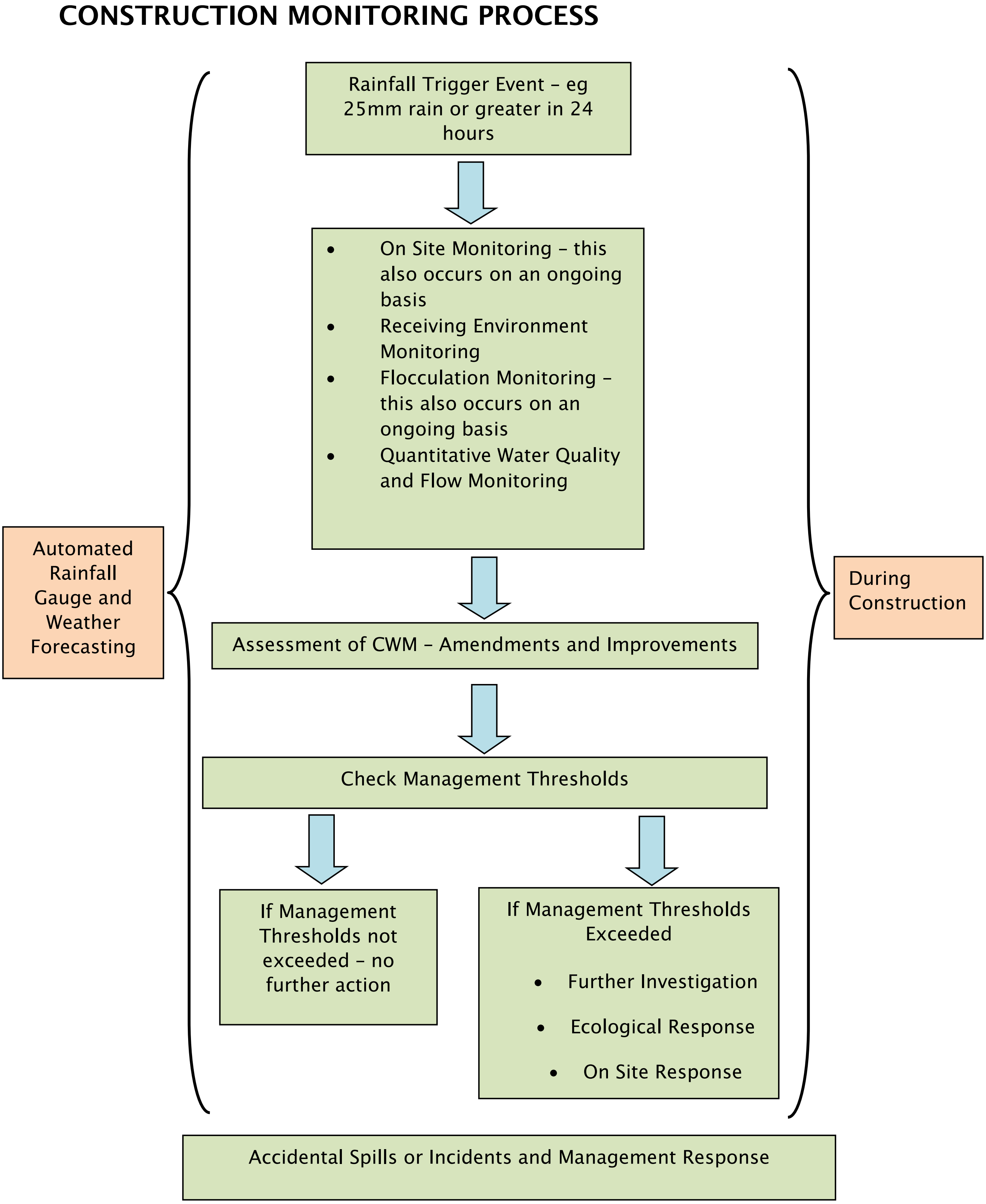
The most likely causes for effects are:

- Incorrect installation of devices;
- Sub-optimal performance of the measures and methodologies implemented; and/or
- Damage from heavy rainfall/storm events.

We consider that the implementation of the overall continuous improvement monitoring programme will provide ‘checks and balances’ and will ensure that potential effects are identified early to allow intervention and that there is the opportunity for continuous improvement as necessary throughout the construction period.

Figure 18 below provides an overall summary of the continuous monitoring programme that will apply and will be detailed within a monitoring programme to be developed. It is recommended that this be developed as part of the consent conditions.

Figure 18 - Construction monitoring process



6 ASSESSMENT OF CONSTRUCTION EFFECTS

Section Summary

We have assessed the overall environmental effects of construction related water discharges, including those associated with sediment yields. Our assessment methodology has two stages; these are:

- Firstly, we undertake a risk assessment and also identify the predicted changes in water quality, to the existing environment, taking into account the proposed design including construction water management techniques. The assessment of changes draws upon technical analysis, detailed in the technical reports.
- Secondly, we assess the Project against the assessment matters which includes design and BPO criteria and the assessment of environmental effects of the predicted changes on aesthetics and odour, recreational use, drinking water, water users and flood risk.

The catchment sediment model confirms that generally changes to sedimentation are more acute within smaller tributaries, with generally smaller changes in the Mahurangi, Hōteo and Oruawharo Rivers. The largest changes to sediment load were observed in the Waiteraire Stream, the Kourawhero Stream headwaters, and the unnamed tributaries (H1 & H2) of the Hōteo River.

A Best Practicable Option approach will be implemented for the construction of the Project and will assist in achievement of effective management.

An assessment of the effects of the Project identifies that the construction-related potential effects of the Project on aesthetics and odour, recreational use, drinking water, water users and flooding are minor or less, with any effects temporary in nature.

This section also recommends an approach for managing effects relating to construction water management and monitoring which will need to be applied at the construction stage of the Project.

The ecological assessments described in the Ecology Assessment and the Marine Ecology and Coastal Avifauna Assessment Reports are informed in part by the predicted changes in water quality described in Section 6.1 and 6.2.

6.1 Risk Assessment of Construction Water Management

The Project is linear in nature and will involve concurrent works occurring in several construction areas. As detailed in Section 5 of the AEE, these earthworks areas will be subject to deliberate timing of works and ongoing stabilisation as works progress to minimise the potential for erosion.

Construction related environmental risk for the Project is primarily related to exposure of bare land (from earthworks) to rainfall (particularly within steep topography) and works within or adjacent to watercourses.

To assist with understanding the nature and magnitude of this risk, the topography has been assessed, from which a range of slope classifications have been identified within the Project footprint. As detailed in the Construction Water Design technical report, there are steep slopes associated with the Indicative Alignment with approximately 45% of the Project indicative earthwork footprint on slopes of greater than 10 degrees.

All earthworks will be subject to a high level of detailed erosion and sediment control planning, design and a continuous improvement monitoring programme. The continuous improvement monitoring programme will have a particular focus on ensuring all controls are working as intended and are achieving the required outcomes with the ability to amend (continuously improve) controls as necessary.

It also recognised that wetter periods of the year (e.g. May to September), which also correspond to colder air and soil temperatures, may pose a higher risk for sediment discharges. This is due to increased rainfall, saturated soil profiles and also cooler temperatures reducing the ability for revegetation to occur. Construction activity within this period will need to reflect this higher risk. This will be achieved through the CESCP process, whereby works during wetter periods will require additional management procedures. This is supported by winter works “restrictions” where works over that period will be aligned with the climatic conditions and also the CESCP process which includes the identification of risk and risk management.

Overall sediment yield risk is assessed for the proposed earthworks within the Project area, in the context of both event probability and associated consequence. The area of Project earthworks is relatively large however will be undertaken in various stages in a lineal fashion. The risk from the earthworks themselves can be reduced by reducing exposed open areas at any one time and as part of this, progressively stabilising as works proceed. In addition, the reduction of slope length as much as practically possible through the provision of contour drains across cut slopes while earthworks are occurring will also provide a sediment generation reduction.

A 14 day maximum period of leaving exposed areas with no works occurring is assessed as a critical risk reduction element, and will in itself, encourage progressive stabilisation. In addition, the implementation of a continuous improvement monitoring programme (as per Section 5 of this WAR) will allow for a further reduction in risk with a more complete understanding of sediment yields as works progress.

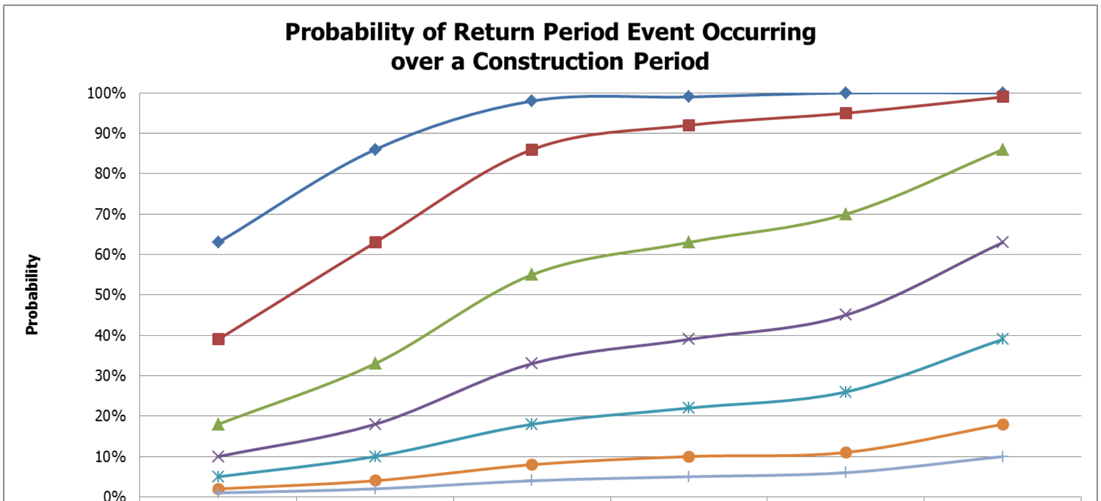
Within all earthworks, and in particular the higher risk locations and those locations identified as of higher sensitivity, both erosion and sediment controls will be installed to minimise, capture and treat sediment laden runoff that may enter the receiving environments. Chemical treatment within SRPs and DEBs will allow for improved treatment efficiencies of these devices and is another critical element of reducing potential risk of sediment yields. Additionally, for the higher risk locations the duration and timing of works will be minimised as far as practical to minimise disturbed soils exposed to heavy rainfall. It is recommended that as part of the CESCP process, this risk be specifically identified, the nature of the risk understood, the exposure of works to heavy rainfall are assessed and specific actions to manage this risk are identified and implemented.

6.1.1 Rainfall probability

Rainfall is recognised as the key parameter influencing sediment yield. Whilst extreme rainfall events with high return periods occur relatively infrequently, when a construction project extends over several years the probability of a high return period event occurring over the construction period increases.

For example, the probability of a 100-year Annual Recurrence Interval (ARI) rainfall event occurring in any given year is 1%. However, the probability of its occurrence increases by 1% per year (i.e. for a 6-year bulk earthworks programme the probability of a 100-year rainfall event occurring is approximately 6%).

Figure 19 shows the probability of a rain event being equalled or exceeded in a range of construction periods from one to ten years.



	1	2	4	5	6	10
1 yr ARI	63%	86%	98%	99%	100%	100%
2 yr ARI	39%	63%	86%	92%	95%	99%
5 yr ARI	18%	33%	55%	63%	70%	86%
10 yr ARI	10%	18%	33%	39%	45%	63%
20 yr ARI	5%	10%	18%	22%	26%	39%
50 yr ARI	2%	4%	8%	10%	11%	18%
100 yr ARI	1%	2%	4%	5%	6%	10%

Figure 19 - Rainfall probability graph

During a 6 year bulk earthworks programme (as proposed for the Project), there is a 100% probability of a 1 year ARI rainfall event occurring and a 70% probability of a 5 year ARI rainfall event occurring. For the 20 year and 50 year ARI rainfall events the probability of occurrence are 26% and 11% respectively.

Given the probabilities for the anticipated Project duration, rainfall up to the 5 year ARI rainfall event is considered to present the highest risk to Project works.

The rainfall analysis also demonstrates that should the indicative period extend beyond the 6-year bulk earthworks programme, then the probability of a higher return period rainfall event occurring also increases. From a rainfall analysis only this confirms a direct benefit of achieving the earthworks programme within a short time period whereby probability of higher return period events reduces.

6.2 Assessment of changes to the water environment

When considering construction water management, a key factor that needs to be assessed as part of the overall effects is an assessment of the potential changes to the water quality as a result of construction. For this Project we have assessed these quantitatively, using a sediment modelling approach. The modelling establishes sediment yields, based on a series of input assumptions, which are then used to assess changes in water quality. Further to this the modelling outputs will be assessed against actual measured yields during construction and the final extent of mitigation (with respect to coastal sediment deposition) then determined (see section 6.2.2 for outputs of the harbour modelling).

This section summarises:

- the results of the Catchment Sediment Modelling technical report;
- the potential changes to water quality associated with in-stream construction, including stream diversions and increased erosion of streams;
- the potential changes to water quality associated with tunnelling and dewatering of foundations;
- the implications of Matariki Forest harvest;
- the potential changes to water quality associated with the use of non-sediment contaminants in the construction of the Project; and
- outcomes of the harbour sediment modelling

6.2.1 Catchment sediment model results

Catchment wide sediment models have been developed for the Mahurangi estuary catchment and the southern Kaipara Harbour (including Oruawharo River). The model utilised for the Mahurangi Estuary catchment is the same model as used for the P-WK project. The methodology and results of these models are contained in the Catchment Sediment Modelling technical report. The Catchment Sediment Modelling technical report provides the linkages between the various models used and catchments of interest.

The models utilised assume that the existing land cover is the baseline scenario. This is assessed as conservative within the southern Kaipara Harbour model. This is because the forestry within this catchment is assessed to be harvested prior to construction thus changing this baseline condition and increasing background sediment concentrations. This has been considered and is reported within the Catchment Sediment Modelling technical report and within section 6.2.7 of this report.

For both sediment models the land use within the indicative earthwork areas is changed to reflect the indicative construction staging as identified within Section 5 of the AEE, while the land use outside of the indicative earthwork areas remains the same. Within the proposed designation boundary, the ground cover is progressively changed to reduce existing vegetated surface and increase bare ground. The models include two different construction outputs: