Warkworth to Wellsford

Operational Water – Road Runoff Report

Technical Report

July 2019

QUALITY ASSURANCE

Prepared by

Jacobs GHD Joint Venture in association with 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.

Revision History:

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Ailsa Robertson	Michelle Sands Tim Fisher		Brad Nobilo		05/07/2019

Quality information

Document title: Ara Tūhono Project, Warkworth to Wellsford Section; Water Assessment Technical Report 5: Motorway Runoff

Version: Final

Date: July 2019

Prepared by: Ailsa Robertson (Jacobs New Zealand Ltd)

Reviewed by: Michelle Sands (Jacobs) and Tim Fisher (Tonkin and Taylor)

Approved by: Brad Nobilo (GHD Ltd)

File name: Operational_Water_Road_Runoff_Report_5July19_FINAL.docx

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GLOSSARY AND DEFINED TERMS

Refer to the Water Assessment Report for a master glossary and defined terms table.

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1 INTRODUCTION

The Warkworth to Wellsford Project (Project) crosses the Mahurangi River, the Hōteo River and tributaries of the Oruawharo River to the north of Auckland. These freshwater environments drain into the coastal marine areas of the Mahurangi Harbour and Kaipara Harbour. The predicted change in traffic volumes from 2016 to 2046, and the increase in road surface associated with the Project in the operational phase, have the potential to impact on contaminant concentrations and loads entering fresh and marine waters and sediments in these river catchments.

1.1 Overview of the Project

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 report is part of a suite of technical assessments prepared to inform the Assessment of Effects on the Environment (AEE) and to support the Application. This assessment report addresses the actual and potential operational water road runoff effects arising from the Project. The assessment considers the effects of an Indicative Alignment and other potential effects that could occur if that alignment shifts within the proposed designation boundary when the design is finalised in the future.

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. 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.

The key components 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 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, Silver Hill Road, Mangawhai Road and Maeneene Road. The Indicative Alignment passes under Kaipara Flats Road, Rustybrook Road and Farmers Lime 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.

The Indicative Alignment shown on the Project drawings is a preliminary alignment for 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 (including the 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.

A full description of the Project including its 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. Figure 1 provides an overview of the entire length of the Indicative Alignment and extent of Proposed Designation Boundary.

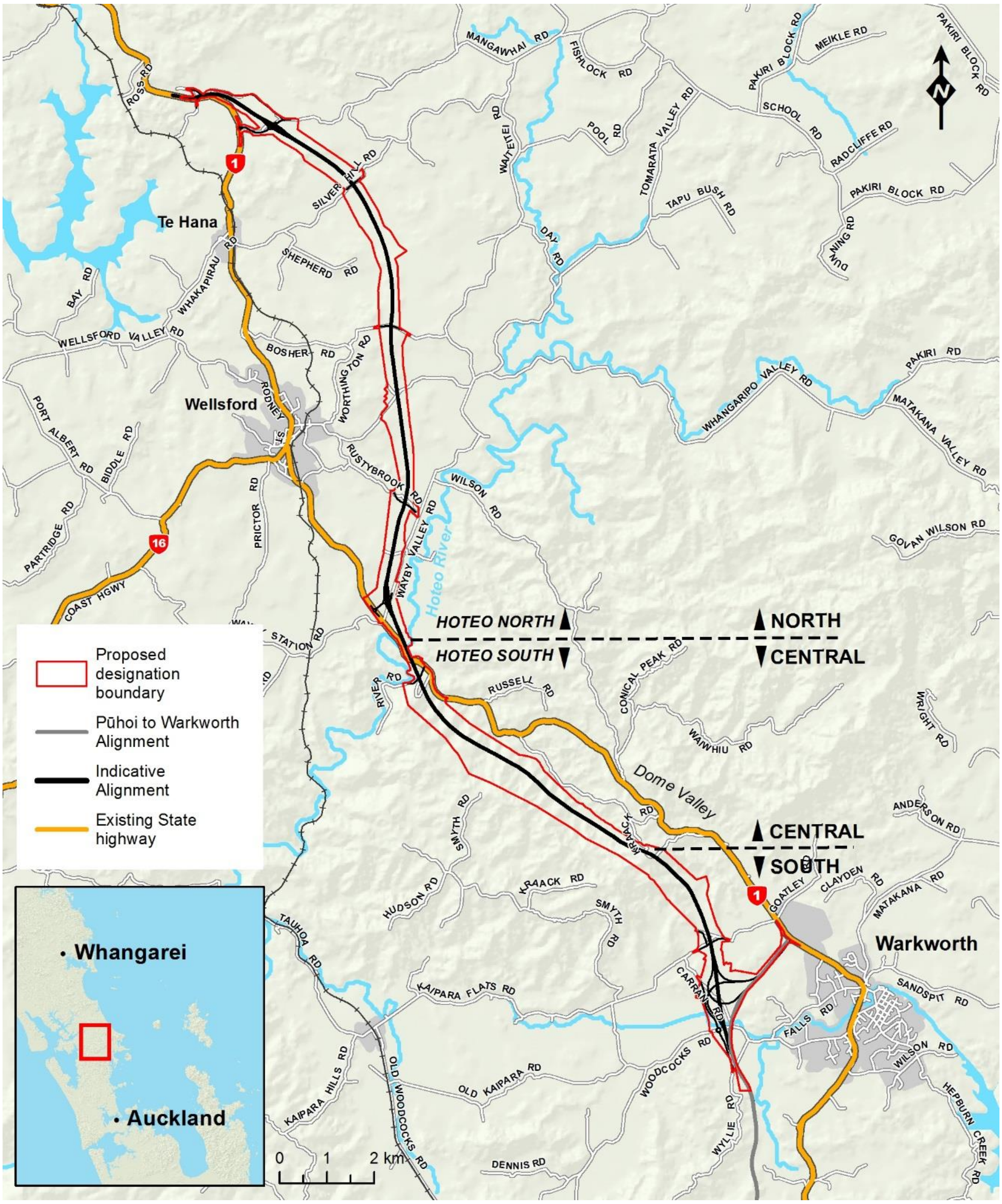

Figure 1 – Proposed Project Designation and Indicative Alignment.

1.3 Purpose and scope of this report

This Operational Water Road Runoff Technical Report (this Report) forms part of a suite of water related design and technical reports prepared for the Ara Tūhono – Pūhoi to Wellsford – Warkworth to Wellsford section (the Project).

These reports are listed below with a short description of each:

- **Water Assessment Report (WAR) –** This report contains a summary of the work carried out and assessment of water related effects associated with construction and operation of the Project.
- **Construction Water Management Design technical report** – This report contains indicative details of the proposed construction methodology, proposed erosion and sediment controls (ESCs), and other construction phase mitigation measures recommended to reduce and erosion and sediment laden stormwater discharges from entering the receiving environment during construction.
- **Operational Water Design technical report** – This report contains details of the operational stormwater management and other operational phase mitigation by design.
- **Existing Water Quality technical report** – This report summarises water quality monitoring carried out by Auckland Council and for the Project.
- **Catchment Sediment Modelling technical report** – Sediment models have been developed to predict changes in sediment and water quality within receiving watercourses associated with the Project. This report summarises the modelling methodology and results.
- **Operational Water – Road Runoff technical report (this report)** – An assessment has been carried out to predict changes to water quality in relation to the Project and pollutants.
- **Flood Modelling technical report** – A model has been developed to predict any changes to flood risk associated with the Project. This report summarises any changes.
- **Hydrological technical report** – Catchment analysis has been developed to predict catchment wide hydrological changes associated with the Project. This report summarises predicted changes to the hydrological environment.

The purpose of this report is to describe the two methodologies used to assess changes in water quality and to discuss the results. It also predicts the relative magnitude of change in water quality in the freshwater and marine receiving environments from the existing 2016 scenario to the 2046 operational phase of the Project with treated road runoff. Figure 2 below summarises the relationship between each of the water related technical and assessment reports and the AEE.

The results summarised in this report provide information for the water quality and ecological assessments developed for this Project, and the management of the operational phase of the Project.

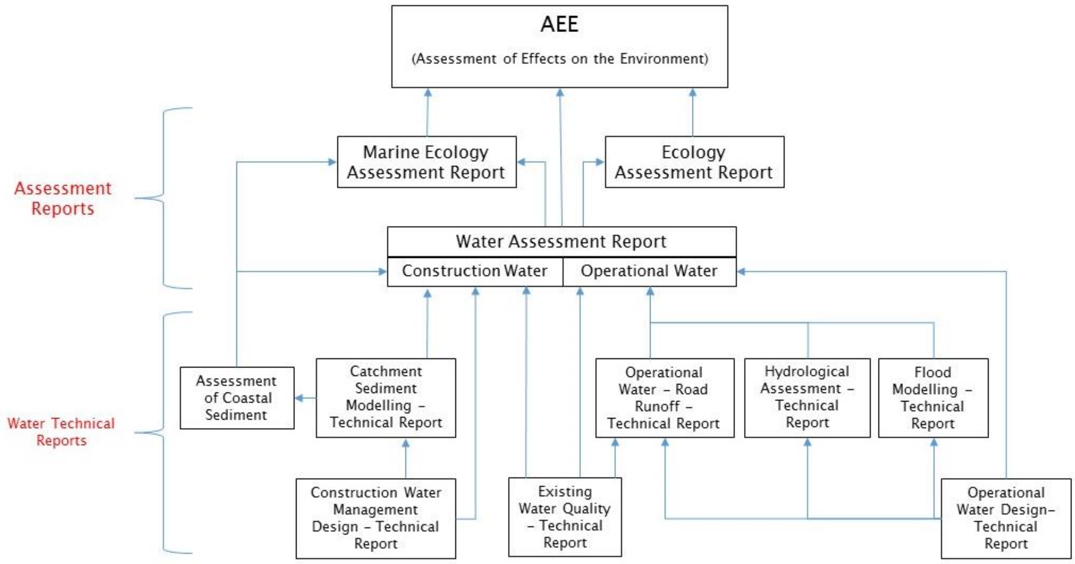

Figure 2 – Operational Water Road Runoff Technical Report – relationship to other reports.

1.4 Report outline

The structure of this remainder of this report is as follows:

- **Section 1** – Describes the Project and provides a summary of the purpose and scope this report;
- **Section 2** – Describes the contaminant concentration and contaminant load model methodologies applied in the assessment, and the assessment criteria
- **Section 3** – Describes the existing environments, and monitoring sites and parameters
- **Section 4** – Discusses the results of the contaminant concentration calculations and the contaminant load modelling
- **Section 5** – Summarises the report conclusions.

2 METHODOLOGY

Methodology summary
We have used two methods to calculate the predicted change in water quality particularly water chemistry (i.e. total suspended solids, heavy metals and total petroleum hydrocarbons) in the receiving freshwater environment as a result of road runoff in the Project's operational phase. The contaminant concentration method (CCM) uses existing water quality monitoring data and literature values from an Auckland Council road runoff study to predict contaminant concentrations of the Project's road runoff in its operational phase. Combined, the data have been used to predict the magnitude of change in contaminant concentration in the receiving freshwater environments between the existing 2016 scenario and the 2046 scenario with treated road runoff from the Project. The Contaminant Load Model (CLM) calculates predicted changes in annual average contaminant loads as a result of future urban land use and the Project, and traffic changes on a catchment scale. Comparison of predicted changes in contaminant loads at a catchment scale between the existing 2016 scenario and the 2046 scenario with the Project and treated road runoff is useful in understanding any potential effects on the marine receiving environments at the downstream end of these river catchments. Applying both methods provides a means of assessing the effectiveness of the proposed Project stormwater treatment, by comparing the mitigated and unmitigated contaminant loads and concentrations. The results are used by the ecologists in their assessment of potential effects on the freshwater and marine environments.

In the following sections of this report, we document the two methods we have used to reflect the change in water quality associated with the Project in its operational phase:

- The CCM (Section 2.2) predicts relative changes in contaminant concentrations at freshwater monitoring sites by using observed motorway runoff water quality literature values applied on a weighted catchment basis to predict contaminant concentrations in receiving environments when the Project is operational.

- The CLM method (Section 2.3) predicts relative changes in contaminant loads on a catchment scale by multiplying the area of each land use (source) within a catchment by the quantity of contaminants discharged from that land use (source yield) to provide an average annual load from that source. The loads from each source within a catchment are combined to provide an annual contaminant load for that catchment.

Both methods account for the treatment of contaminants contained within the Project's road runoff, as summarised in Section 2.2.

2.1 Proposed stormwater treatment

The Operational Water Design Report describes the proposed design for stormwater treatment wetland systems. The preferred design approach for operational stormwater treatment for the Project's impervious surfaces is treatment with constructed wetlands. Stormwater runoff will be collected in the Project's drainage systems, which will be conveyed by roadside drains, swales or underground pipes to the constructed wetlands.

These devices have been designed in accordance with the guidance of the GD01: Stormwater Management Devices in the Auckland Region, (Cunningham et al., 2017). Device designs that adhere to this guidance are expected to result in contaminant removal rates similar to Auckland Council's TP10 standards and Transport Agency Stormwater Treatment Standard (Auckland Council, 2003).

2.2 Contaminant concentration methodology

The CCM provides site specific estimates of the predicted change in contaminant concentrations in freshwater receiving environments. We have used an Auckland Council study (Moores et al., 2009) where the observed road runoff water quality values were applied on a weighted catchment basis to estimate contaminant concentrations in receiving environments. We have combined the Auckland Council study dataset with water quality grab sample monitoring data collected in 2017 for the Project to predict the magnitude of change in water quality as a result of the Project compared to water quality guideline values.

We calculated the 95th percentile contaminant concentration values of the 2017 grab sample monitoring data from 10 monitoring locations throughout the Mahurangi, Hōteo and Oruawharo river catchments, listed in Table 1.

Table 1 – Monitoring data used in the contaminant concentration methodology were collected at these sites

Site ID	Monitoring Site Name	Site description
Site 1	Mahurangi tributary	Mahurangi River (left branch) at Kaipara Flats Road (W2W-Mahurangi1-BL)
Site 2	Kourawhero Stream	Kourawhero Stream at Kaipara Flats Road (W2W-Kourawhero2-BL)
Site 3	Hōteo River upstream of viaduct	Hōteo River at State Highway 1 (W2W-Hōteo3-BL)
Site 4	Waiteraire Stream at Hōteo	Waiteraire Stream at State Highway 1 (W2W-Hōteo4-BL)
Site 5	Te Hana Creek	Te Hana Creek at Silver Hill Road (W2W-TeHana5-BL)
Site 6	Maeneene Creek	Maeneene Creek at Waimanu Road (W2W-Maeneene6-BL)
Site 8	Hōteo at Gubbs	
Site 9	Waiteraire Stream headwaters	Tributary of Waiteraire Stream at forestry track (W2W-Hōteo9-BL)

Site ID	Monitoring Site Name	Site description
Site 10	Unnamed Hōteo tributary	A tributary of the Hōteo River at Rustybrook Road (W2W-Hōteo10-BL)
	Mahurangi Mouth	data based on Pūhoi to Warkworth monitoring data

Figure 3 in Section 2.3 is a map of all freshwater monitoring locations where water quality data has been collected for this Project, with the catchment areas draining to those locations.

We calculated contaminant concentrations at each site for the following three scenarios.

2016 "without Project" is the existing case scenario in which the Project has not been built ("without Project"). This scenario uses 2016 land use, population and traffic volumes, as well as the 2017 water quality monitoring grab sample data from the receiving environments in Table 1.

2046 "with Project, without treatment" is a scenario in which the Project has been built and is in its operational phase ("with Project") but no treatment has been applied to the Project's road runoff ("without treatment"). For this scenario land use, population and traffic volumes reflect what is predicted/modelled for 2046.

2046 "with Project, with treatment" is a scenario in which the Project has been built and is in its operational phase ("with Project") and the proposed road runoff treatment with constructed wetlands described in Section 2.1 is also operational ("with treatment"). For this scenario land use, population and traffic volumes reflect what is predicted/modelled for 2046.

2.2.1 Assessing Magnitude of Change

The 95th percentile concentrations of each contaminant at each site across the scenarios have been compared to guideline trigger values (TVs) for total and dissolved Zinc and Copper in Section 4.1, and the magnitude of change in concentrations when compared to these TVs.

The TVs are based on the Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council (ARMCANZ/ ANZECC, 2000) Guidelines which are commonly used for contaminant concentrations. Specifically, guideline trigger values for 95% level of species protection in fresh and marine water quality are used. These is consistent with the TVs we used to characterise the nature of the existing freshwater environments in the Water Quality Report.

The ARMCANZ/ ANZECC (2000) Guidelines (Volume 1, Chapter 7) recommend comparing the 95th percentile of the test data (i.e. monitoring data) to guideline values for toxicants such as heavy metals as a conservative approach rather than, for example, comparing the median of the test data. We have adopted this guidance in this assessment.

The ARMCANZ/ ANZECC (2000) default guideline TVs for Zinc and Copper have been modified for site specific total hardness as recommended by the Guidelines. Total hardness is the percentage calcium carbonate measured in each surface water sample. Total hardness in water can affect how bioavailable toxicants like heavy metals are to aquatic organisms;

in simple terms the 'harder' the water (i.e. higher total hardness value) the less bioavailable the toxicant. The bioavailable fractions of heavy metals are the dissolved fractions. Modifying the default trigger values for each site accounts for site specific conditions and allows a more meaningful comparison of test data to trigger values. In all cases, the hardness modified TVs are higher than the default TVs due to generally higher hardness values measured in the existing environment – this is particularly the case of sites to the north: Sites 5 (Te Hana Creek) and 6 (Maeneene Creek) where the limestone geology results in harder waters. Default TVs for 95% level of species protection in marine waters have been used to compare predicted concentrations to the Mahurangi Mouth water quality values; marine TVs are not adjusted for total hardness.

Revised ARMCANZ/ANZECC guideline TVs for Zinc and Copper have been released in draft and are in the process of being peer reviewed through the ANZECC Guidelines committee. These revised TVs are considered in the results discussion in Section 4, but have not been graphed with the data as they are still in draft and are subject to change. The revised default guideline TVs for Zinc and Copper are lower, i.e. more stringent, than the ARMCANZ/ ANZECC (2000) Guideline default TV's. Table 2 below provides both the ARMCANZ/ ANZECC (2000) and the revised draft default guideline TVs for Zinc and Copper for 95% species protection in fresh and marine waters. The TVs apply to both total and dissolved fractions of each toxicant.

Table 2 – Default guideline TVs for 95% species protection in fresh and marine waters.

Parameter	Freshwaters		Marine waters	
	ANZECC 2000	ANZECC Revised Draft	ANZECC 2000	ANZECC Revised Draft
Zinc (mg/L)	0.008	0.003	0.015	0.0065
Copper (mg/L)	0.0014	0.0012	0.0013	0.0006

Note, these default TVs have been modified for site specific hardness and graphed with the 95th percentile contaminant concentrations in Section 4. The graphs show which sites are above or below their respective TVs in the 2016 "without Project" scenario, and the 2046 "with Project, without treatment" and 2046 "with Project, with treatment" scenarios.

For our assessment we have considered the magnitude of change in contaminant concentrations and whether the status of those sites (above or below TVs) changes from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

2.2.2 Limitations to analysis

The CCM has several limitations:

We are using the 95th percentile contaminant concentration values from the 2017 grab sample monitoring data as a conservative approach based on the guidance (see Section 2.2.1 above for more detail). This was a limited sampling programme and was undertaken in winter when stream levels will tend to be higher. By using the 95th percentile contaminant concentrations the actual water quality will be better than this 95% of the time, and worse than this 5% of the time when it is likely raining (assuming the sampling is representative).

Unlike the CLM, the CCM does not account for the change in traffic volumes due to redistributed traffic from existing SH1 and other roads onto the Project, and the associated change in contaminant distribution expected. In reality (but not included in the CLM) the expected change includes a reduction in contaminant loads in some catchments as traffic moves from the existing SH1 (which currently has no stormwater treatment) to the Project (to be treated with constructed wetlands).

The CCM does not account for cumulative effects associated with other development that may occur within these catchments in the future case in 2046. For example, future land use changes in catchments may influence TSS loads, such as forestry tree felling that increases TSS or land retirement or riparian planting that reduces TSS, but such changes have not been accounted for in this methodology as they are not part of the Project.

We have taken these limitations into account when assessing the results in Section 4 and in our conclusions in Section 5.

2.2.3 Land use

We estimated total impervious area to be created by Project's road surface for each sub-catchment, using the road length within the catchment and using the assumptions within the CLM, which estimate road width for different traffic volumes.

We expect the impervious area of the Project in its operational phase will generate similar types of contaminants to those reported in the Auckland Motorway study (Moores et al. 2009). The Moore's et al (2009) motorway research field programme in 2008 and 2009 measured road runoff volumes and collected and analysed road runoff samples at four sites. These sites were selected on the basis of traffic characteristics, road drainage characteristics and the nature of the stormwater treatment systems present. The four study sites are listed below:

- SH1 Northern Motorway @ Redvale (freely flowing traffic, treatment by a pond)
- SH1 Northern Motorway @ Northcote (congested, treatment by grass swales)
- SH18 @ Westgate (most congested, no treatment)
- SH16 @ Huapai (freely flowing traffic, drained by roadside drainage channel)

Of the four sites, Redvale and Northcote data have not been included in the CCM as they included treatment so do not reflect the contaminant concentrations in road runoff. Therefore, only Westgate and Huapai data were used to represent road runoff quality in the CCM.

The current level of treatment on existing roads was assessed by road surveys undertaken as part of this Project and described in Section 2.3.3.

The 95th percentile values for Total Suspended Solids (TSS), Zinc and Copper from the Westgate and Huapai sites, and the 95^{th} percentile values of their data together in one dataset are presented in Table 3. Available TPH values were all below laboratory detection limits and as such have not been presented.

Table 3 – 95th percentile values for TSS, Zn and Cu of Auckland Motorway data from two sites (Moores et al., 2009).

Auckland Motorway Reporting Location	Vehicles per day	95th percentile contaminant values (mg/L)				
		TSS	Total Zinc	Dissolved Zinc	Total Copper	Dissolved Copper
Westgate	36,088	512.58	0.572	0.040	0.096	0.014
Huapai	13,866	703.60	0.295	0.028	0.065	0.019
Westgate & Huapai		561.22	0.424	0.033	0.082	0.017

The 95th percentile values of the combined wet and dry 2017 baseline water quality grab sample data from each site in Table 1 represent the 2016 "without Project" scenario. All grab sample data are presented in the Water Quality Report.

The predicted change in contaminant concentration as a result of the Project was calculated using a weighted average contaminant concentration based on subcatchment area. The calculation inputs in each future 2046 scenario are described below.

To calculate the concentration of contaminants in the 2046 "With Project, without treatment" scenario, the proportion of area (in m^2) of Project road in each catchment was multiplied by the 95th percentile contaminant values of the combined Huapai and Westgate datasets, and added to the proportion of remaining catchment area multiplied by the 95th percentile values of the 2017 baseline water quality grab sample data. The area of Project road was based on the length of Indicative Alignment in each catchment as measured in GIS multiplied by the default road widths in the CLM (see Section 2.3). The formula below was replicated for each of the 10 catchments for TSS, Total Zinc, Dissolved Zinc, Total Copper and Dissolved Copper.

2046 "With Project, without treatment" =
(95th %ile Auckland Motorway data * proportion of area of Project road in catchment)
+ (95th %ile 2017 baseline water quality data * proportion of remaining catchment area)

The proposed stormwater treatment design will treat operational road runoff from the Project's impervious surfaces by constructed wetlands, (refer to Operational Water Design Report, Section 4 for the design approach). To calculate the 2046 "With Project, with treatment" scenario, load reduction factors (Table 4 Section 2.2.4) were applied to the proportion of area of Project receiving stormwater treatment, i.e. the proportion of Indicative Alignment in each catchment. The simplified formula below was calculated for each of the 10 catchments for TSS, Total Zinc, Dissolved Zinc, Total Copper and Dissolved Copper.

2046 "With Project, with treatment" =
(95th %ile Auckland Motorway data * proportion of area of Project road in catchment * load reduction factor)
+ (95th %ile 2017 baseline water quality data * proportion of remaining catchment area)

2.2.4 Load reduction factors

As described in the Operational Water Design Report and summarised in Section 2.1, the preferred design approach to operational stormwater treatment for the Project's impervious surfaces is that stormwater runoff will be collected in the Project's drainage systems and conveyed by roadside drains, swales or underground pipes to the constructed wetlands.

Table 4 below presents constructed wetland contaminant removal rates from three literature sources: the Contaminant Load Model (CLM) developed by Auckland Council (AC, 2010); Auckland Council's TP10 guidance based on measured performance of the UNITEC Carrington wetland (ARC, 2003); and the International Stormwater Best Management Practices (BMP) Database 2016 Summary Statistics report (Clary et al., 2017).

Table 4 – Contaminant load removal rates for constructed wetlands from literature.

Source	TSS %	Zinc total %	Dissolved zinc %	Copper total %	Dissolved copper %	TPH %
Contaminant Load Model	80	60	–	70	–	60
TP10 guidance (UNITEC Carrington wetland)	45 – 83	68 – 86	46 –87	79 – 81	43 – 62	–
BMP database	55 – 69	57 – 58	47 – 65	51 – 54	29 – 39	–

The CLM load reduction factors are removal percentages for constructed wetlands for TSS, Total Zinc, Total Copper and TPH from roads. As documented in The Development of the Contaminant Load Model (ARC, 2010b), load reduction factors in the CLM for various treatment devices including constructed wetlands were selected on the basis of professional judgement after reviewing the literature.

TP10 guidance (ARC, 2003) provides removal ranges for TSS and total and dissolved metals based on mean measured concentrations from UNITEC Carrington wetland, an existing vegetated wetland monitored before and after vegetation had developed to significantly contribute to treatment.

The International Stormwater Best Management Practises (BMP) database contains a range of median removal percentages for TSS and total and dissolved metals by wetland basins. The design and sizing of the wetlands in the BMP database is variable as it includes overseas data and wetlands that are not designed to meet the TP10 or GD01 criteria, therefore we have not considered this dataset further in our methodology.

As mentioned in Section 2.1, the constructed wetland devices designed to treat the road surface runoff from the Indicative Alignment have been designed to the guidance of GD01 (Cunningham et al., 2017), and the design is performance-based. This approach assumes that properly sized and designed devices will effectively remove pollutants. Device designs that adhere to this guidance are expected to result in contaminant removal rates similar to Auckland Council's TP10 standards and NZ Transport Agency Stormwater Treatment Standard (2010).

Therefore, we have adopted the CLM removal rates for TSS, total metals and TPH, and conservative, low range values based on the TP10 UNITEC Carrington wetland contaminant removal rates for dissolved metals. Table 5 presents the removal rates used in the CCM.

Table 5 - Percentage rates of contaminant load removal under the proposed constructed wetland treatment systems.

Treatment Device	TSS %	Zinc total %	Dissolved zinc %	Copper total %	Dissolved copper %	TPH %
Constructed wetland	80	60	50	70	40	60

2.3 Contaminant load model methodology

The CLM Version 2 is a spreadsheet-based model which has been developed for the Auckland Region by Auckland Council to enable estimations of stormwater contaminant loads on an annual basis. The model is very simple in principle - the area of a particular land use (source), measured by area in square metres (m^2) within the study area (the catchment), is multiplied by the model's default loads of contaminants discharged from that land use (source yield) to provide an annual load from that source. The loads from each source within the catchment are then added together to provide an annual contaminant load for the catchment of interest.

We have built CLMs for several sub-catchments intersected by the Proposed Designation, illustrated in Figure 3 and listed below:

- Mahurangi Mouth
- Mahurangi Tributary (also known as Mahurangi left branch)
- Kourawhero stream
- Waiteraire headwater
- Waiteraire at Hōteo
- Hōteo upstream Viaduct
- Hōteo Tributary
- Waiteitei Sandersons
- Te Hana Creek
- Maeneene Creek
- Hōteo at Gubbs
- Hōteo at Mouth

These catchments align with the water quality characterisation sites monitored as part of this Project (described in Section 3). Ten sites used in the CCM have also been used in the CLM methodology (listed above), and additional CLMs have been built to account for remaining subcatchment areas within the wider Hōteo, Mahurangi and Oruawharo River catchments intersected by the Proposed Designation. For example, the Hōteo at Mouth subcatchment of the Hōteo River catchment. The additional sites provide for comparison of predicted loads at a catchment scale to inform the marine ecology assessment, as well as at the finer freshwater scale to inform the freshwater ecology assessment.

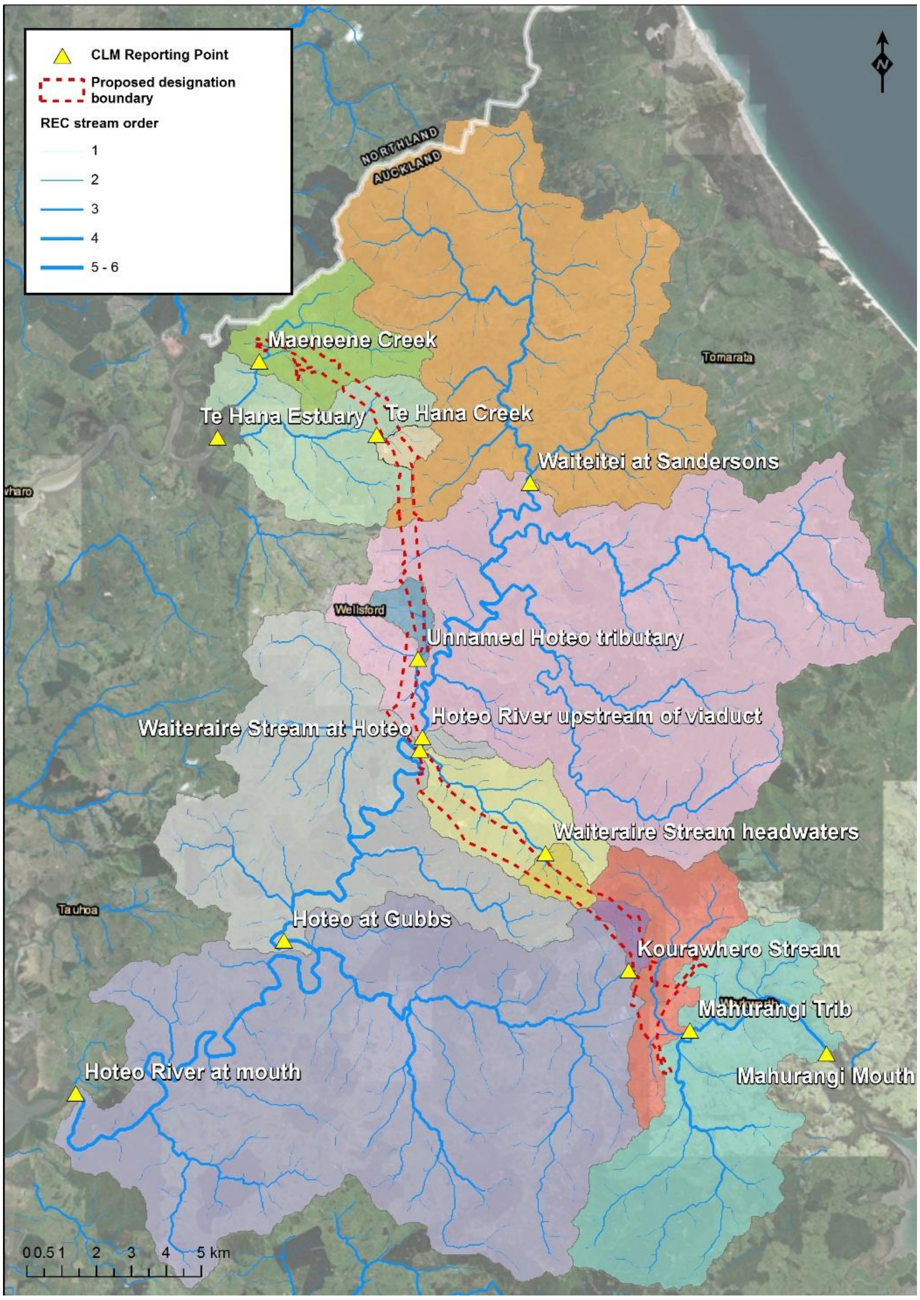

Figure 3 – Contaminant Load Model reporting points within each catchment intersected by the Proposed Designation.

The CLM was developed to estimate the annual loads in kilograms per year (kg/yr) for the following stormwater contaminants from large, heterogeneous urban areas of the Auckland region:

- TSS;
- Total Zinc;
- Total Copper; and
- Total petroleum hydrocarbons (TPH).

The CLM is designed to be used for sites that are predominantly urban (i.e. greater than approximately 80%). All the catchments in the Project have rural land well in excess of 20%.

For this study, as recommended in the CLM user's manual (ARC 2010a), we have only modelled the urban areas of these catchments using the CLM. The urban areas that were modelled are, Mahurangi, Kaipara Flats, Wellsford and Te Hana.

CLMs were built for this Project to represent traffic and landuse (sources) at a subcatchment scale for two scenarios: 2046 "without Project" and 2046 "with Project, with treatment".

The CLM considers urban areas to comprise these five sources: roofs; roads; paved surfaces; and urban grasslands and trees. These sources are further subdivided as follows:

- roofs divided into nine different types of material;
- roads divided into the following six different vehicles/day categories
  - <1000 (default width of 17 m)
  - 1000-5000 (default width of 17 m)
  - 5000-20,000 (default width of 17 m)
  - 20,000 – 50,000 (default width of 21 m)
  - 50,000 – 100,000 (default width of 24 m)
  - >100,000 (default width of 31 m);
- paved surfaces, other than roads and roadside footpaths, divided into residential, commercial and industrial;
- urban grasslands and trees divided into three different slope categories; and
- urban streams.

To calculate the land use areas within each category, we used a combination of aerial photography and a national digital elevation model (DEM), and data from Auckland Council included planning maps, a GIS layer of building footprints and a layer of impervious surfaces as polygons.

To accommodate the assumed 2046 population, the urban areas of Warkworth and Wellsford were increased based on the Auckland Unitary Plan – Operative in Part zone layer 'Future Urban Zone', which is greenfield identified as suitable for future urbanisation. The Future Urban Zone areas around Warkworth and Wellsford were incorporated into the CLM urban area categories based on the existing category split for those Township. For example, if the existing Warkworth Township contained certain percentages of residential, commercial and industrial paved surfaces, the same category percentages would apply to the Future Urban Zone area, and so on for the remaining categories.

A walk-over sample roof survey of Wellsford was undertaken in 2017 and the roofing types of 215 buildings were identified. A roof survey of Warkworth was undertaken in 2013 when data from a sample of 362 buildings in Warkworth was obtained, as presented in the Water Assessment Factual Report 11 – Motorway Runoff Report for the Pūhoi to Warkworth Project (Sands, 2013). The percentage of different roof types from the Wellsford roof survey data was extrapolated out to define the modelled roofs in Wellsford, Te Hana and Kaipara Flats. Similarly, the roof survey data from Warkworth was extrapolated out to define the modelled roof types in the remainder of Warkworth.

The change in contaminant loads in the CLM are driven by the change in traffic (vehicles per day) and Project road area. The remaining urban areas are assumed to be the same for the 2046 scenarios with and without the Project.

We have predicted average annual contaminant loads for the following two scenarios.

The 2046 "without Project" is a scenario in which the Project has not been built. Land use, population and traffic volumes reflect what is predicted/modelled for 2046. Therefore, a greater volume of traffic uses the existing State Highway 1.

2046 "with Project, with treatment" is a scenario in which the Project has been built and is in its operational phase ("with Project") and the proposed road runoff treatment with constructed wetlands described in Section 2.1 is also operational ("with treatment"). For this scenario land use, population and traffic volumes reflect what is predicted/modelled for 2046.

2.3.1 Limitations to analysis

The CLM methodology has several limitations.

- The method is applicable for urban catchments and we are applying it to rural catchments. Therefore the calculated changes in loads are only for the urban and road parts of the catchment and the loads from the rural parts of the catchment are ignored. The loads of TSS from the rural parts of the catchment will be higher in concentration due to the larger areas.

- The method assumes that contaminant loads from future roads remain the same as those that currently exist. It is likely that vehicle types or transport modes will change in the future. Examples of this are increases in electric vehicles that should lead to a reduction in TPH. Also changes in brake pad materials that target reductions in copper usage are likely. The California Brake Pad Law requires copper-free brake pads by 2025 in that state.

- The model does not account for naturally occurring concentrations of Copper and Zinc.

- The loads estimated should be treated as relative loads between the various scenarios i.e. "with and without Project" and "with and without treatment".

- The CLM produces estimates of average annual loads rather than concentrations. It can be used to inform our understanding of the relative changes in the accumulation of contaminants, for example in marine receiving environments, but cannot be used to compare directly against ecological guideline trigger values, which are related to contaminant concentrations in water and sediment.

- In this report, the ratio of the TSS and metals loads from the CLM cannot be compared to estimate metal concentrations in sediment. This is because the CLM load only accounts for the TSS from urban sources. In Mahurangi, Hōteo and Oruawharo catchments TSS from rural sources dominates.

Despite these technical limitations, we are confident in the assumptions made and satisfied that and sufficient and appropriate assessment has been undertaken to provide confidence in our indicative design, assessment of effects and proposed mitigation.

2.3.2 Traffic assumptions

The traffic assumptions used for the CLM come from the results of the traffic modelling described in Operational Transport Assessment Report. This report provides 2016 traffic volumes on SH1, and traffic modelling outputs provide estimates of the vehicles per day (VPD) volumes at 2046. The traffic modelling future land use assumptions are described in Section 2.4 of the Operational Transport Assessment Report. A summary of these volumes is provided below.

Existing weekday Annual Average Daily Traffic (AADT) 2016 SH1 volumes are 20,000 Vehicles Per Day (VPD) through Warkworth, 12,000 through the Dome Valley between Goatley Road and Wayby Valley Road, and 12,000 between Wellsford and Te Hana. Traffic volumes on Friday, Saturday and Sunday are higher than traffic volumes on other days of the week. This pattern reflects the recreational travel demand along SH1 for destinations in Kaipara and Northland (see Figure 5 in Section 3.4 of the Traffic Transport Assessment Report comparing mid-week and weekend traffic volumes).

In the 2046 "without Project" scenario, SH1 traffic volume is modelled as 22,000 – 29,000 VPD (considering locations along its length). In the 2046 "with Project" scenario, traffic volumes along SH1 vary along its length, ranging from about 2,500 VPD near Te Hana, to about 4,000 VPD through the Dome Valley, to 9,500 VPD in Wellsford and 17,000 VPD just north of Warkworth.

In the 2046 "with Project" scenario, the Indicative Alignment has an estimated traffic volume of 24,000 – 25,000 VPD south of Wayby Valley Road, and approximately 20,000 around Te Hana.

The CLM uses VPD traffic volumes for each segment of road modelled within the Proposed Designation. Road lengths within each catchment were measured in ArcGIS. Areas of road within each VPD class of the CLM were calculated by multiplying the length of road by the CLM default road widths for the applicable VPD class. The area of road in each VPD class is multiplied by a default yield of each contaminant specific to that VPD class to calculate a contaminant load. For example, 1,500 metres of road in <1000 VPD class multiplied by the default road width for that class of 17 metres, yields a total road area of 25,500 m^2. This area multiplied by the default Dissolved Copper yield of 0.0014 for that VPD class yields a Dissolved Copper load of 37.7 grams/m^2/year.

If the road is treated, a load reduction factor specific to the treatment device is applied to the contaminant load and a new 'treated' yield for that VPD class is calculated. Dissolved Copper yields for all VPD classes within the catchment are then added to calculate the total average annual Dissolved Copper load for that catchment.

2.3.3 Existing stormwater treatment

To determine the type of stormwater drainage and treatment in the existing catchments a site survey was undertaken, focusing on SH1 and other main roads in each catchment. The survey included but was not limited to the following examples; SH16, Kaipara Flats Road, Matakana Road, Sandpit Road, Woodcocks Road, Whangaripo Valley Road.

Overall the surveys found that existing road runoff treatment is dominated by open road side drains. The load reduction factor for open road side drains is uncertain in the literature.

The BMP database (Clary et al., 2017) provides ranges of load reduction factors for grass swales and wetland channels these are summarised in Table 6 below.

The Moores et al (2009) study included an analysis of treatment of TSS, Total Zinc and Total Copper loads in a roadside drainage channel on SH16 at Huapai. The roadside drainage channel at this site was vegetated by moss and sparse grasses growing in approximately 10mm deep soft sediments over an underlying gravel bed. This study found that while these drainage systems are not specifically designed or constructed as systems for the removal of contaminants, that TSS, Total Copper and Total Zinc discharged via road runoff are treated by these systems to a high level.

Given the wide range of load reduction factors, we have assumed that road side drains serving the existing SH1 will perform as well as swales from the CLM. We consider it a reasonable assumption to account for the potential treatment from the open road drains that serve SH1 and other rural roads within the catchments. The treatment values (load removal rates) for total metals used for open road side drains may be higher than is actually achieved by these systems, but if we assumed lesser potential treatment from the existing drainage, we may overestimate the water quality benefits that could be expected from the predicted movement of traffic off SH1 and onto the Indicative Alignment.

Load reduction mitigation (i.e. road runoff treatment types) for the existing roads were derived from site surveys, and CLM load reduction factors in Table 6 were applied.

Table 6 – Percentage contaminant load removal under the existing road drainage systems.

Treatment device	Data source	TSS (%)	Total Zinc (%)	Total Copper (%)	TPH (%)
Swale	CLM	75	40	50	40
Grass Swale	BMP database	16	18	5	–
Wetland Channel	BMP database	23	33	12	–
Open road side drain	Moore et al.'s (2009) study	60	80	80	N/A[1]

Notes:
1 – TPH was collected from untreated road runoff at Huapai, (Moores, et al., 2009) but all samples were below the detection limit, and therefore the performance of the open roadside drain could not be determined

In addition to the Project's preferred treatment of operational road runoff with constructed wetlands (as described in Section 2.1), load reduction mitigation in the 2046 "with Project, with treatment" scenario is based on the assumption that the entire section of Ara Tuhono – Pūhoi to Warkworth Section (currently under construction) within the Mahurangi River catchment is treated with stormwater treatment wetlands and the load reduction factors described in Table 6 were applied.

This assumption is based on the final conditions in the 2014 Board of Inquiry decision relating to Stormwater Discharge (Conditions RC61-68A applying to Consents 33/004, 33/006, 33/007, 33/013, 33/014 and 33/015), specifically Condition RC61 which states that "the Consent Holder shall ensure that all stormwater from the motorway (impervious surfaces and rock cuts) is captured, treated and discharged through wetlands (to the extent practicable)…", (Board of Inquiry into the Ara Tuhono– Pūhoi to Warkworth Section, 2014).

3 EXISTING WATER QUALITY

Freshwater monitoring sites summary

Baseline water quality was measured in 2017 in wet and dry weather at the ten sites on watercourses crossed by the Indicative Alignment. General water quality has been characterised in the Water Quality Report.

This baseline water quality data has been used to support the contaminant concentration methodology. The CLM catchments also suitably align with these monitoring sites.

3.1 Existing environment

3.1.1 Freshwater quality monitoring sites

Ten water quality sites were selected to assess the current freshwater quality of watercourses intersected by the Proposed Designation, and as such are generally catchments immediately downstream of the Indicative Alignment. The Auckland Council Mahurangi River Forestry Head Quarters (FHQ) Site is an existing water quality site with an existing dataset which was also used in this technical assessment. The general character of the freshwater quality has been summarised in the Water Quality Characterisation Report.

Table 7 provides a description of these sites and Figure 4 illustrates the site locations.

Table 7 – Freshwater quality monitoring sites

Monitoring site name	Site No.	Description
W2W-Mahurangi1-BL	Site 1	This upper-catchment site is on a major tributary of the Mahurangi River, also known as the Mahurangi left branch, and is downstream of the existing SH1, and has no urban development upstream.
Auckland Council – Mahurangi River FHQ		This upper-catchment site has no urban development upstream.
W2W-Kourawhero2-BL	Site 2	This site is on a small tributary of the Hōteo River and has no urban development upstream.
W2W-Hōteo3-BL	Site 3	This site is on the main channel of the Hōteo River, upstream of the existing SH1. The Township of Wellsford is upstream of this site.
W2W-Hōteo4-BL	Site 4	This site is on a tributary, immediately upstream of its confluence with the Hōteo River. There is no urban development upstream. The tributary runs parallel to the existing SH1 through the Dome Valley.
W2W-TeHana5-BL	Site 5	This site is on a tributary of Te Hana Creek. The Township of Wellsford is upstream of this site.

Monitoring site name	Site No.	Description
W2W-Maeneene6-BL	Site 6	This site is on the main channel of the Maeneene Creek. The small Township of Te Hana and the existing SH1 are upstream of this site.
W2W-Mahurangi7-BL	Site 7	This is the same location as Auckland Council's Mahurangi River WS monitoring site, on the main channel of the Mahurangi River as it crosses under the existing SH1/Brown Road, upstream of the Indicative Alignment and much of the Warkworth Township.
Auckland Council – Hōteo River at Gubbs	Site 8	This site is on the main channel of the Hōteo. There is no urban development upstream of the site. The Project monitoring site (W2W-Hōteo8-BL) is nearby and slightly downstream.
W2W-Hōteo9-BL	Site 9	This site is on small tributary of the Hōteo River in the Dome Valley forestry area. There is no development upstream of the site.
W2W-Hōteo10-BL	Site 10	This site is on a small tributary of the main Hōteo River channel, and has no urban development upstream.

The area of catchment upstream of each sample point and proportions of each land use within each catchment is provided in Table 8. This data relates to the cumulative area upstream that contributes flow to that sampling point, rather than just the area between the sample point and the next upstream point. A map of the catchments and related sample points is provided as Figure 4.

Table 8: Existing catchment land uses and areas upstream of Project water quality characterisation monitoring points.

Catchment	Site	total area (ha)	Land use											
			Forest		Pasture		Cropland		Scrub		Urban		Water	
			Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Mahurangi River	Site 1	892	475	53%	412	46%	4	0.4%	0	0%	2	0.2%	0	0%
	Site 7	4,905	2318	47%	2388	49%	27	0.6%	17	0.3%	150	3%	5	0.1%
Hōteo River	Site 2	184	132	72%	51	28%	0	0%	0	0%	0	0%	0	0%
	Site 9	76	75	99%	1	1%	0	0%	0	0%	0	0%	0	0%
	Site 4	1,446	1376	95%	67	5%	0	0%	0	0%	3	0.2%	0	0%
	Site 10	228	18	8%	209	92%	0	0%	0	0%	0.03	0%	0	0%
	Site 3	19,645	7,810	40%	11,644	59%	38	0.2%	61	0.3%	45	0.2%	25	0.1%
	Site 8	26,756	11,711	44%	14,821	55%	38	0.1%	79	0.3%	59	0.2%	25	0.1%
Oruawharo River	Site 5	349	36	10%	314	90%	0	0%	0	0%	0	0%	0	0%
	Site 6	1,236	309	25%	916	74%	7	0.6%	1	0.1%	0	0%	1	0.1%

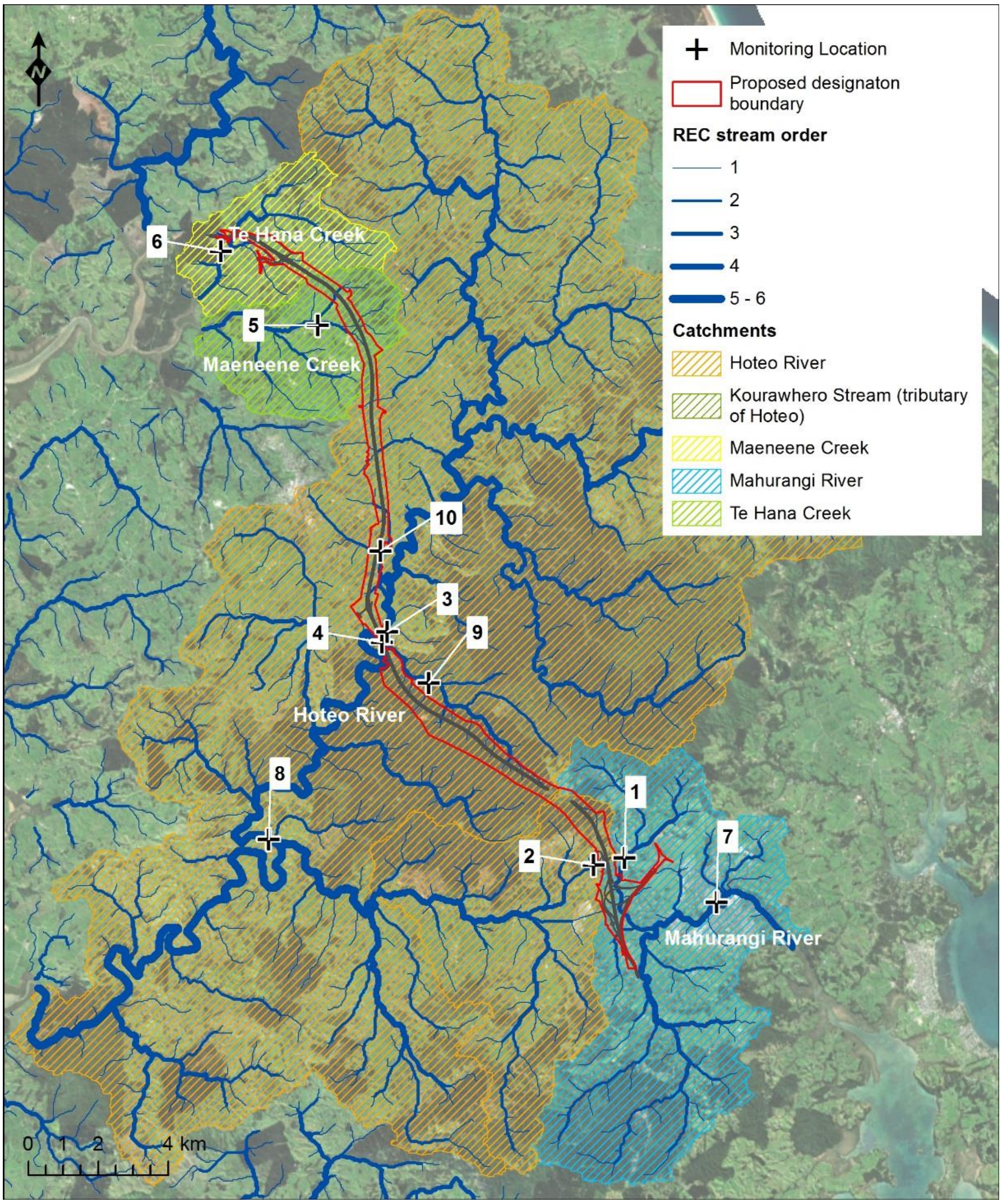

Figure 4 - Baseline Freshwater quality monitoring sites.

4 RESULTS

Results summary

Using the CCM we calculated the predicted contaminant concentrations for two future scenarios: 2046 "with Project, without treatment" and 2046 "with Project, with treatment" for ten locations throughout the Mahurangi, Hōteo and Oruawharo (Te Hana/Maeneene) river catchments. These concentrations were compared to measured 95th percentile baseline water quality concentrations in the existing, 2016 "without Project" scenario and to the ARMCANZ/ ANZECC (2000) guideline trigger values which had been modified to reflect difference in site specific hardness.

Total and dissolved 95th percentile concentrations of Zinc and Copper are mostly below the ARMCANZ/ ANZECC (2000) guideline site specific trigger values for 95% level of species protection. The predicted magnitude of change in contaminant concentrations at each site, i.e. the status of a site (above or below) the guidelines values, as a result of the Project is expected to be negligible provided it is treated to the standard assumed in this assessment.

The CCM results predict that the proposed stormwater treatment with constructed wetland systems will be effective in reducing both the particulate and the dissolved (i.e. more bioavailable) phases of the assessed contaminants.

The CLM modelling indicates small predicted decreases in Zinc and Copper in the Mahurangi River catchment and small increases in the Hōteo and Te Hana/Maeneene catchments.

We expect the Project will result in a minor change in marine sediment quality in the estuarine receiving environments.

4.1 Contaminant concentration

As explained in Section 2.2.1, we have compared concentrations of heavy metals to the ARMCANZ/ ANZECC (2000) Guideline site specific, hardness modified trigger values (HMTVs) for 95% species protection in fresh and marine waters. The revised draft guideline TVs (in Table 2 in Section 2.2.1) are also discussed in the text, however these values have not been graphed as they are still in draft and subject to peer review.

The 95th percentile contaminant concentrations and site specific HMTVs for each freshwater site in each scenario are displayed in the graphs on the following pages. Mahurangi Mouth is the only marine site where default marine TVs (not modified for hardness) have been applied. As these are 95th percentile contaminant concentrations, assuming the sampling is representative, the actual water quality will be better than this 95% of the time, and worse that this 5% of the time (typically when it is raining).

The graphs in Figure 5 to Figure 9 display contaminant concentrations across the 2016 "without Project" scenario (based on 2017 baseline grab sample data) and the two future 2046 scenarios – "with Project, without treatment" and "with Project, with treatment".

4.1.1 Total suspended solids

Figure 5 below displays the existing and predicted 95th percentile concentrations for TSS for the three scenarios.

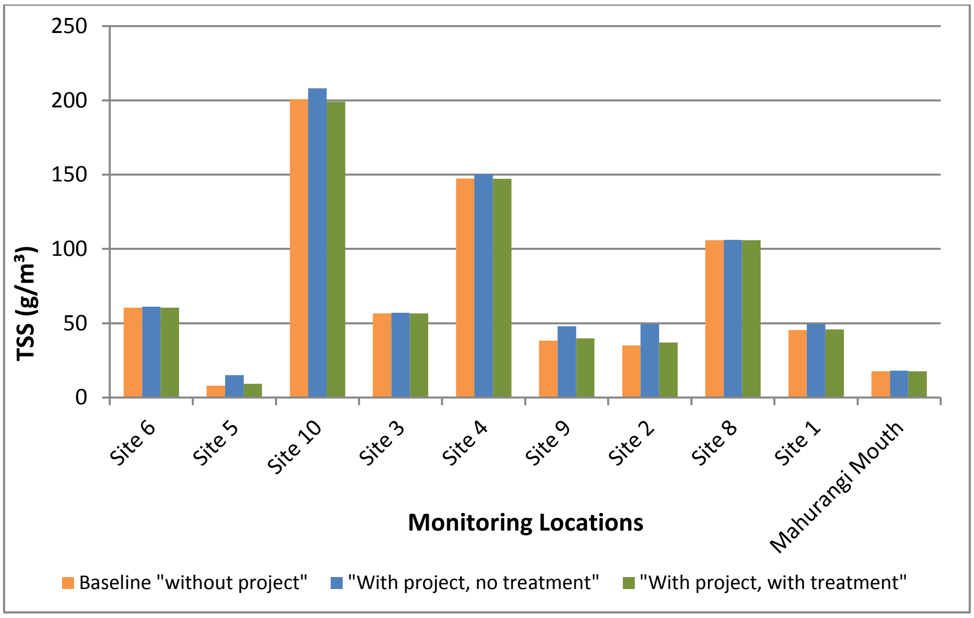

Figure 5 – Total suspended solids 95th percentile concentrations at each site for the three scenarios.

TSS is elevated in the Hōteo River and tributary (Sites 8 and 10) due to catchment activities other than the Project. It is influenced by higher TSS concentrations during wet weather.

The predicted magnitude of change in 95th percentile TSS concentrations from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario at each site are considered negligible – there is a less than 10% increase in concentrations at sites between the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario, with the exception of Site 5 (Te Hana Creek) where there is a 17% increase in TSS however the values are small (from 8.0 mg/L to 9.4 mg/L).

4.1.2 Total zinc

Figure 6 below displays the existing and predicted 95th percentile concentrations for Total Zinc for the three scenarios.

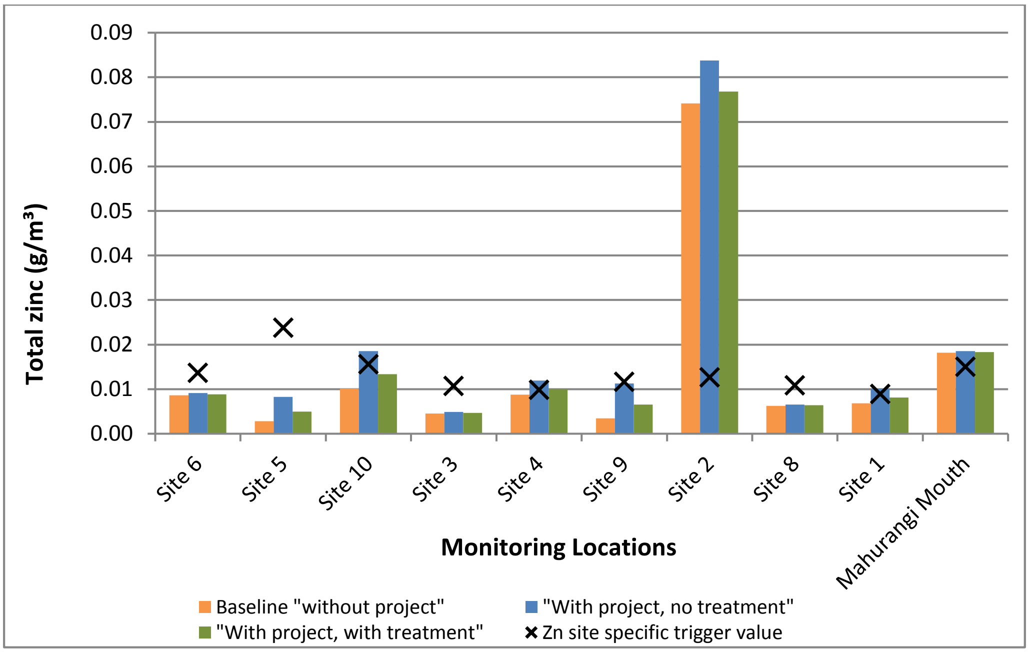

Figure 6 – Total Zinc 95th percentile concentrations at each site for the three scenarios.

In the 2016 "without Project" scenario, Total Zinc 95th percentile concentrations are mostly below ARMCANZ/ ANZECC (2000) site specific HMTVs with the exception of Site 2 (Kourawhero Stream) and the Mahurangi Mouth site. In the 2046 "with Project, with treatment" scenario, an increase in the 95th percentile value at Site 4 results in this site also exceeding its site specific HMTV. The status of all other sites with respect to their HMTVs (above or below) remain unchanged between the 2016 and the 2046 treated Project scenario.

When Total Zinc 95th percentile concentrations are compared to the more stringent revised guideline TVs in the 2016 "without Project" scenario, 8 out of 10 sites are above their respective TVs, with the exception of Site 5 (Te Hana Creek) and Site 9 (Waiteraire Stream headwaters). In the 2046 "with Project, with treatment" scenario, an increase in the 95th percentile value at Site 9 results in this site also exceeding its site specific HMTV. Site 5 is the only site below its respective revised guideline site specific HMTV in all scenarios.

The predicted magnitude of change in Total Zinc 95th percentile concentrations at sites is considered negligible as the status of sites in relation to their respective TVs (above or below) remain largely unchanged from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

4.1.3 Dissolved zinc

Figure 7 below displays the existing and predicted 95th percentile concentrations for Dissolved Zinc for the three scenarios.

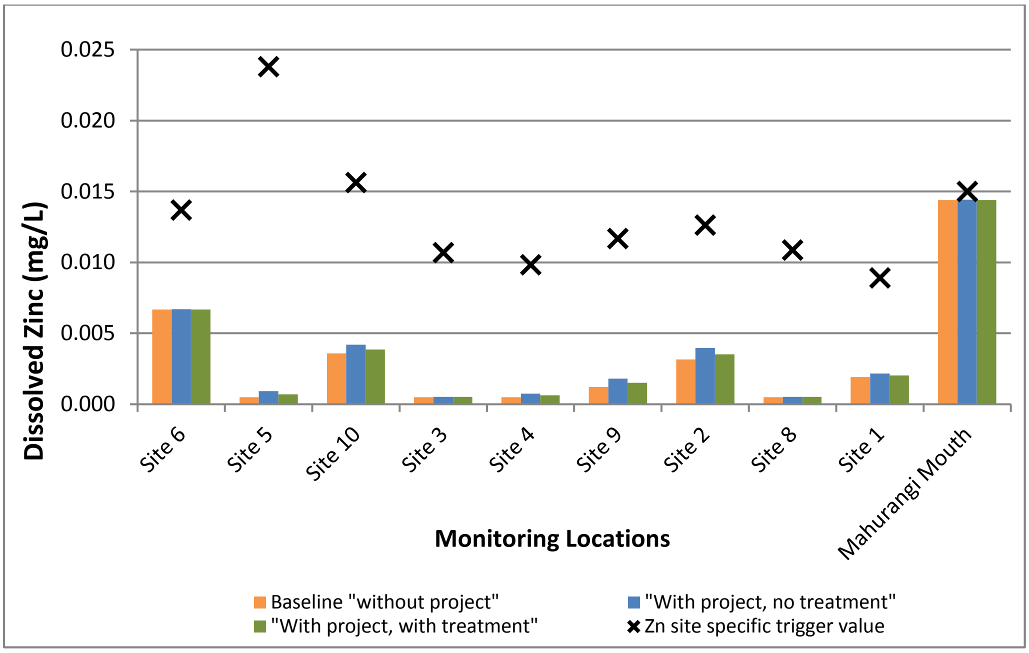

Figure 7 – Dissolved Zinc 95th percentile concentrations at each site for the three scenarios.

In all scenarios, Dissolved Zinc 95th percentile concentrations are below their respective ARMCANZ/ ANZECC (2000) site specific TVs.

Dissolved Zinc 95th percentile concentrations, when compared to the more stringent revised guideline TVs in the 2016 "without Project" scenario, are mostly below TVs with the exception of Sites 6 (Maeneene Creek) and the Mahurangi Mouth; 95th percentile concentrations at these two sites are above the revised guideline HMTVs in all three scenarios.

The predicted magnitude of change in Dissolved Zinc 95th percentile concentrations at sites is considered negligible as the status of sites in relation to their respective TVs (above or below) remain unchanged from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

4.1.4 Total copper

Figure 8 below displays the existing and predicted 95th percentile concentrations for Total Copper for the three scenarios.

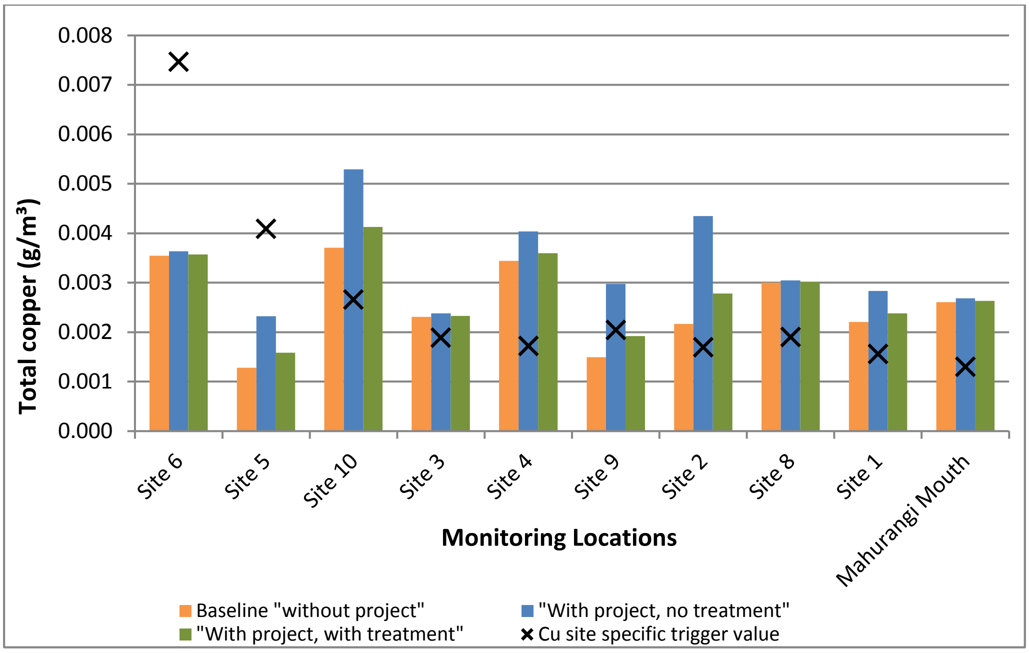

Figure 8 – Total Copper 95th percentile concentrations at each site for the three scenarios.

In the 2016 "without Project" scenario, Total Copper 95th percentile concentrations are above the ARMCANZ/ ANZECC (2000) site specific HMTVs for freshwater with the exception of Sites 5, 6 and 9, and Mahurangi Mouth above the marine default TV. In the 2046 "with Project, with treatment" scenario, the status of each site (above or below) their respective TVs does not change as a result of any increases in the 95th percentile concentrations.

When Total Copper 95th percentile concentrations are compared to the more stringent revised guideline TVs in the 2016 "without Project" scenario, most sites are above their respective TVs with the exception of Sites 5, 6 and 9. In the 2046 "with Project" scenario, an increase in the 95th percentile value at Site 9 results in this site also exceeding its site specific HMTV. Sites 5 and 6 are the only sites below their respective revised guideline site specific HMTVs in all scenarios.

The predicted magnitude of change in Total Copper 95th percentile concentrations at sites is considered negligible as the status of sites in relation to their respective TVs (above or below) does not change from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

4.1.5 Dissolved copper

Figure 9 below displays the existing and predicted 95th percentile concentrations for Dissolved Copper for the three scenarios.

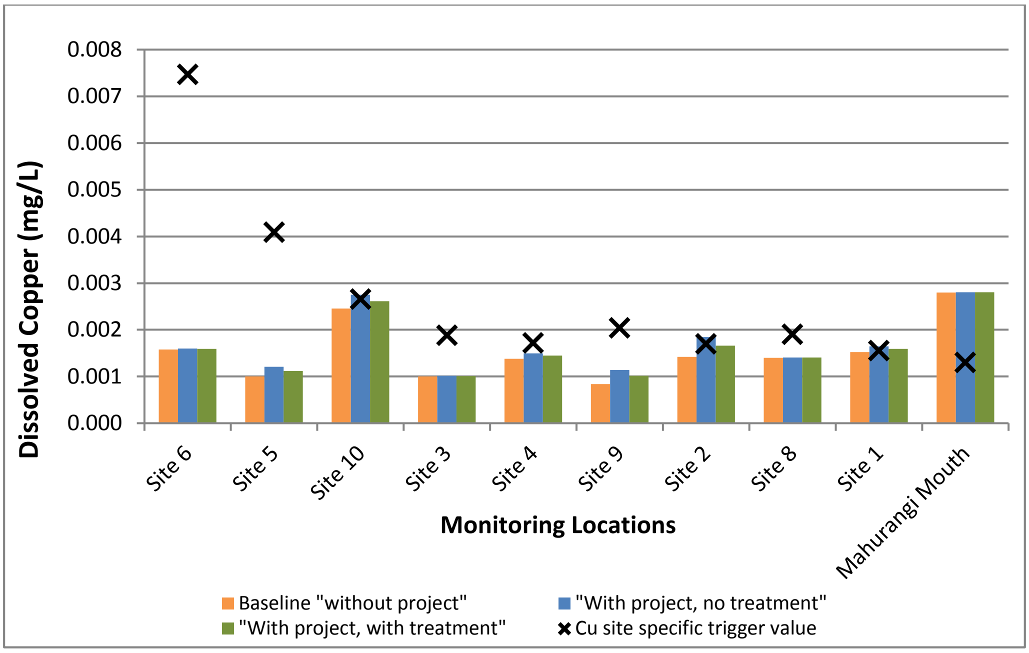

Figure 9 – Dissolved Copper 95th percentile concentrations at each site for the three scenarios.

In the 2016 “without Project” scenario, Dissolved Copper 95th percentile concentrations are all below their respective ARMCANZ/ ANZECC (2000) site specific HMTVs. Mahurangi Mouth is above the marine default TV in all scenarios.

Dissolved Copper 95th percentile concentrations compared to the more stringent revised guideline TVs in the 2016 “without Project” scenario most sites are below their respective TVs with the exception of Sites 1, 10 and Mahurangi Mouth. In the 2046 “with Project, with treatment” scenario, an increase in the 95th percentile value at Site 2 results in this site also exceeding its respective revised guideline site specific HMTV. The status of all other sites with respect to their HMTVs (above or below) remain the same between the 2016 and 2046 treated Project scenario.

The predicted magnitude of change in Dissolved Copper 95th percentile concentrations at sites is considered negligible as the status of sites in relation to their respective TVs (above or below) remain largely unchanged from the 2016 “without Project” to the 2046 “with Project, with treatment” scenario.

4.1.6 Summary of TSS results

The predicted magnitude of change in 95th percentile TSS concentrations from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario at each site are considered negligible – there is a less than 10% increase in concentrations at most sites between the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

The potential effects of the predicted magnitude of change in 95th percentile TSS concentrations on freshwater and marine ecology is addressed in the Ecology Assessment Report and the Marine Ecology and Coastal Avifauna Assessment.

4.1.7 Summary of metals results

In the 2016 "without Project" scenario, the water quality at freshwater sites is considered to be good, with all dissolved concentrations below ARMCANZ/ ANZECC (2000) site specific TVs. Total copper is elevated compared to the 95% marine guideline at the Mahurangi Mouth. When compared to the more stringent revised guideline TVs, some sites exceed their respective triggers in the 2016 "without Project" scenario both with and without upstream urban areas.

Small increases in 95th percentile contaminant concentrations from the 2016 "without Project" scenario to the 2046 "with Project, with treatment" scenario occur at most sites. At sites 6 (Maeneene Creek), 3 (Hōteo River upstream of viaduct), 8 (Hōteo River at Gubbs) and Mahurangi Mouth, total and dissolved Zinc and Copper values are approximately the same in both scenarios.

The largest proportional increases occur in the catchments where the road footprint makes up a larger proportion of the overall catchment, i.e. Site 2 (Kourawhero Stream), Site 5 (Te Hana Creek), Site 9 (Waiteraire Stream at Hōteo) and Site 10 (unnamed Hōteo tributary).

Overall, there is a decrease, or at some sites no apparent change, in the predicted 95th percentile concentrations between the 2046 "with Project, without treatment" and 2046 "with Project, with treatment" scenarios, which is expected from the proposed treatment of Project operational road runoff with constructed wetland systems. Where there is no apparent change, these catchments have 1% or less area comprising the Indicative Alignment, and therefore the magnitude of change as a result of Project road runoff (with and without treatment) is negligible when compared to the 2016 "without Project" scenario concentrations.

With the wetland treatment accounted for in the 2046 "with Project, with treatment" scenario, the predicted dissolved Zinc and Copper concentrations at the freshwater sites are at or below ARMCANZ/ ANZECC (2000) guideline site specific TVs for 95% level of species protection. We only expect a very small change in freshwater quality and freshwater sediment quality as a result of the Project.

4.1.8 Total petroleum hydrocarbons

TPH concentrations were only available from the grab sample monitoring data. There are no ARMCANZ/ ANZECC (2000) guideline trigger values for TPH. All monitored TPH concentrations for all petroleum hydrocarbon fractions and total hydrocarbons were below the laboratory limits of reporting (standard limit of reporting is 0.7 mg/L). Conservatively, all monitored values for TPH were thus taken to equal 0.7 mg/L. The 95th percentile value for TPH from the combined Transport Agency research road runoff data/State Highway grab-sample data was also 0.7 mg/L. As such, for the 2046 "with Project, with treatment" scenario, TPH values were equal to 0.7 mg/L at all sites indicating that no change is expected to TPH concentrations as a result of the treated Indicative Alignment.

4.2 Contaminant load model results

Table 9 displays the predicted relative change in average annual loads (in kilograms per year) for TSS, Zinc, Copper and TPH for each modelled catchment intersected by the Indicative Alignment. These results reflect relative changes in contaminant loads from two scenarios: the 2046 "without Project" scenario and the 2046 "with Project, with treatment" scenario. These scenarios have been described in Section 2.3.

Table 9 –Change in contaminant load from urban sources for all CLM reporting locations at 2046.

Reporting Location	Average Annual Total Loads (kg/yr)			
	TSS	Zinc	Copper	TPH
Mahurangi Mouth	-3,519	-17	-5	-126
Mahurangi Tributary	-1,351	-9	-3	-70
Kourawhero Stream	938	5	1	38
Waiteraire Stream headwaters	833	4	1	34
Waiteraire at Hōteo	-1,444	-10	-3	-73
Hōteo upstream Viaduct	-149	6	1	44
Hōteo Tributary	521	3	1	27
Waiteitei Sandersons	19	2	0.4	12
Te Hana Creek	399	2	1	16
Maeneene Creek	-2,672	-3	-1	-100
Hōteo at Gubbs	-2,682	-9	-4	-70
Hōteo at Mouth	-1,709	-4	-3	-30
Te Hana estuary	-1,506	-4	-2	-30

The CLM model generally predicts increases in contaminant loads entering the freshwater environments because at a catchment scale resolution, there are low levels of urban contaminants in these catchments as discussed in the CCM in Section 4.1.

Based on the study by Kamarina, et al. (2016) *Nonlinear Changes in Land Cover and Sediment Runoff in a New Zealand Catchment Dominated by Plantation Forestry and Livestock Grazing*, combined with our monitoring experience, we conclude that fine sediment is generally likely to pass through the hill streams. In the lowland rivers, deposited sediments are likely to periodically flush through the freshwater system with most deposition of fine sediment occurring in the marine receiving environment. Therefore, in our view the relative change in contaminant load at the marine receiving environment is a more meaningful indication of the potential for changes in the sediment quality in the receiving environments.

Results in Table 10 to Table 12 summarise the predicted changes in contaminant loads at the mouths of the Mahurangi River, the Hōteo River, and the Te Hana Estuary downstream of the confluence of Te Hana Creek and Maeneene Creek.

Table 10 – CLM predicted relative change in contaminant loads from urban sources in the Hōteo River catchment at 2046.

Scenario	Average Annual Total Load (kg/yr)			
	TSS	Zinc	Copper	TPH
2046 Baseline "without Project"	168,569	149	28	565
2046 "With Project, with treatment"	166,860	145	25	535
Percentage change	-1%	-3%	-10%	-5%

The CLM predicts decreases in all contaminants from the baseline 2046 "without Project" scenario to the 2046 "with Project, with treatment" scenario.

Table 11 below provides the CLM results at the Mahurangi River mouth (refer to Figure 3) for the 2046 "without Project" scenario and the expected contaminant loads for the 2046 "with Project, with treatment" scenario.

The Mahurangi River catchment includes the proposed designation (and Indicative Alignment), and the Warkworth urban area. The 2046 "without Project" scenario assumes that the entire section of the Aro Tuhono – Pūhoi to Warkworth Section within the Mahurangi River catchment would be treated with constructed wetlands as required by the final consent conditions and as is proposed for this Project.

Table 11 – CLM predicted relative change in contaminant loads from urban sources in the Mahurangi River catchment at 2046.

Scenario	Average Annual Total Load (kg/yr)			
	TSS	Zinc	TSS	TPH
2046 Baseline "without Project"	2,848,135	1012	113	1046
2046 "With Project, with treatment"	2,844,615	995	107	921
Percentage change	-0.1%	-2%	-5%	-12%

The CLM predicts a decrease in all contaminant loads from the baseline “without Project” scenario to the “with Project, with treatment” scenario.

Table 12 summarises the CLM results in the Oruawharo River catchment, downstream of the confluence of the Maeneene Creek and the Te Hana Creek.

Table 12 – CLM predicted relative change in contaminant loads in Oruawharo River catchment at 2046.

Scenario	Average Annual Total Load (kg/yr)			
	TSS	Zinc	TSS	TPH
2046 Baseline “without P`roject”	38,496	37	9	218
2046 “With Project, with treatment”	36,989	33	7	189
Percentage change	-4%	-11%	-19%	-14%

The CLM predicts a decrease in all contaminant loads from the baseline “without Project” scenario to the “with Project, with treatment” scenario.

In the 2046 “with Project, without treatment” scenario, the Indicative Alignment would result in an increase in area of road in the catchment and therefore generally an increase in contaminant loads in road runoff in those catchments (as can be seen in the upstream freshwater catchments in Table 9). In the 2046 “with Project, with treatment” scenario, the shift in most traffic from the existing SH1 onto the Indicative Alignment, to be completely treated with constructed wetlands, would result in a slight decrease in contaminant loads in those catchments from the 2046 “without Project” scenario to the 2046 “with Project, with treatment” scenario from the mouths of the Mahurangi River, the Hōteo River and at Te Hana Estuary downstream of the confluence of Te Hana Creek and Maeneene Creek. This can be seen in the modelled results in Table 10 to Table 12 above.

4.2.1 Predicted change in marine sediment quality

These predicted changes in contaminant loads are only for urban sources of contaminants at the mouths of the Rivers and do not include the contaminant loads from the wider catchments draining to these marine receiving environments, or any future land use changes in these catchments that may influence contaminant loads or concentrations.

Estuarine sediment quality assessed in the Marine Ecology Assessment Report identifies that stormwater contaminants in surface sediment are below biological effects thresholds in both the Kaipara and Mahurangi Harbours, apart from copper at upper harbour site IM1 (Vialls Landing – Mahurangi Harbour) and Te Hana 1 (Oruawharo River – Kaipara Harbour).

The heavy metal contaminants in their dissolved phases are likely to be diluted within the marine environment and flushed from the Mahurangi Harbour within two days (Aro Tuhono – Pujoi to Wellsford Road of National Significance: Pūhoi to Warkworth Section Coastal Processes Report). The motorway runoff data reported in Moores et al. (2009) indicates that on average 45% of the Total Copper and 31% of the Total Zinc in runoff was in the dissolved phase. Oldman et al., (2009) suggest that 80% of the sediment entering the Mahurangi Harbour is deposited in the estuary with the majority of sediment deposited in the upper estuary. The Harbour modelling undertaken for Ara Tuhono Pūhoi to Warkworth Section

Project and described in the Harbour Modelling Report supports Oldman et al.'s (2009) conclusions.

Sediment cores collected in the Kaipara Harbour show that mud from the Hōteo River is preferentially depositing on the intertidal Kakaraia Flats in the vicinity of the Hōteo River mouth, a location considered a "major fine-sediment accumulation zone" within the Kaipara Harbour (Swales et al., 2013).

There are no predicted overall increases in contaminants in the three river catchments from the existing "without Project" scenario to the "with Project, with treatment" scenario. As a result of the Indicative Alignment, assumed to be treated with constructed wetlands along its entire length, we expect that any change in sediment quality in the estuarine receiving environments would be negligible.

5 CONCLUSIONS

Conclusions summary

Two methods have been used to estimate the change in water quality predicted to occur at 2046 during the operational phase of the Indicative Alignment. These methods have limitations and as such we have adopted both methods to provide better confidence in predicted changes in contaminants as a result of the treatment of Project road runoff.

The CCM compares predicted increases in concentrations from the measured baseline (2016) to the Project with treated road runoff, and the CLM method predicts changes in contaminant loads under future land use scenarios with and without motorway runoff treatment in place.

The CCM uses existing freshwater quality data and literature values of the concentrations of contaminants from road runoff. Existing freshwater quality as measured for this Project in 2017 has low concentrations of metals and TPH. Small increases in contaminant concentrations from the 2016 “without Project” scenario are predicted in the 2046 “with Project, with treatment” scenario across the sites. Overall, however the relative magnitude of these changes in metal concentrations in the freshwater receiving environments predicted to occur as a result of the Project are expected to be very small.

The CLM results show a predicted decrease in contaminant loads from urban and Project areas at a catchment scale when without and with treatment scenarios are compared. Therefore, with treatment in place, a decrease in contaminant loads is predicted at the mouths of the Hōteo and Mahurangi Rivers and at Te Hana Estuary downstream of the confluence of Te Hana Creek and Maeneene Creek. These results, when considered in conjunction with the existing sediment quality within the Kaipara and Mahurangi Harbours, suggest an expected minor change in the long term estuarine sediment quality as a result of the Project

The outputs from these two assessment methods, illustrate the value and effectiveness of the proposed stormwater treatment measures in minimising changes in water quality and contaminants in marine sediments due to the Project.

This report will inform the Water Assessment Report, the Ecology Assessment Report, and the Marine Ecology and Coastal Avifauna Assessment.

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