IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents and notices of requirement in relation to the Ōtaki to North of Levin Project
BY	**WAKA KOTAHI NZ TRANSPORT AGENCY**
	Applicant

ŌTAKI TO NORTH OF LEVIN HIGHWAY PROJECT

TECHNICAL ASSESSMENT H: WATER QUALITY

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GLOSSARY

Clarity: The distance that can be seen through the water.

Dissolved oxygen (DO): The amount of gaseous oxygen present in water.

SoE (State of Environment) monitoring: A programme of observations intended to provide information about environmental conditions, trends and pressures.

Suspended solids or **suspended sediment:** Mineral sediment grains suspended in moving water

Suspended sediment load: The instantaneous mass rate at which suspended sediment is carried through a river or stream cross-section, usually derived from the product of concentration in g/m³ and flow in m³/s.

Suspended solid yield: Suspended sediment load integrated over some specified period of time, usually a year.

Turbidity: An optical property of a solution; the degree of loss of transparency, ie cloudiness, caused by the effect of suspended particulate and colloidal material.

Water quality variables

Variable	Nomenclature	Units
Physico-chemical properties		
Water temperature – field	Temp	ºC
Dissolved oxygen – field percentage saturation	DO % sat	%
Dissolved oxygen – field	DO	mg/L
pH – laboratory	pH	
Specific electrical conductivity (also EC at 25ºC)	COND	µS/cm
Suspended sediment concentration	SSC	mg/L
Optical properties		
Visual clarity (horizontal black disk)	BDISC	m
Turbidity	TURB	FNU, NTU
Total suspended solids	TSS	mg/L
Nutrients		
Nitrate nitrogen	NO3-N	mg/L

Variable	Nomenclature	Units
Nitrite nitrogen	NO2-N	mg/L
Nitrite-nitrate nitrogen (also total oxidised nitrogen)	NNN	mg/L
Ammoniacal nitrogen (also total ammonia)	NH4-N	mg/L
Total nitrogen – direct	TN-A (TN)	mg/L
Total nitrogen – indirect	TN-K	mg/L
Dissolved reactive phosphorus	DRP	mg/L
Total phosphorus	TP	mg/L
Dissolved organic carbon (non-purgeable)	DOC	mg/L
***Microbiological* properties**		
Escherichia coli (*E. coli*)	*E.coli*	MPN/100 mL
Faecal coliforms	FC	MPN/100 mL
Chlorophyll a – laboratory	CHLA	mg/m^3

Unit abbreviations

°C	degrees Celsius
%	percent (parts per hundred)
% Sat	percent saturation
FNU	Formazin Nephelometric Unit
g/m^3	grams per cubic metre or g m^{-3} (1 g/m^3 = 1 mg/l)
kg	kilogram
km^2	square kilometres
l or L	litres (1000 l = 1 m^3)
l/s or L/s	litres per second or l s^{-1} (1000 l/s = 1 m^3/s)
ln	natural logarithm to base e
m	metre
m/L	milligrams per litre (= 1 ppm)

mg/m^3	milligrams per cubic meter (= 1 ppb)
m/s	metres per second or m s^{-1}
m^2	square metres
m^3/s	cubic metres per second (cumecs)
nm	nanometers
NTU	Nephelometric Turbidity Units
ppb	parts per billion (1 ppm = 1000 ppb)
ppm	parts per million (1 ppm = 1000 ppb, 1% = 10,000 ppm)
s	second(s)
μS/cm	micro Siemens per centimetre

Source: NEMS (2016) and NEMS (2019).

EXECUTIVE SUMMARY

1. The Ōtaki to north of Levin highway Project ("**Ō2NL Project**" or "**Project**") involves the construction, operation, use, maintenance and improvement of approximately 24 kilometres of new four-lane median divided state highway (two lanes in each direction) and a shared use path ("**SUP**") between Taylors Road, Ōtaki (and the Peka Peka to Ōtaki expressway ("**PP2Ō**")) and State Highway 1 ("**SH1**") north of Levin. The Ō2NL Project route will cross five surface water catchments, these are:

   (a) tributaries to the Waitohu Stream;

   (b) Waikawa Stream (including its tributaries of the Manakau Stream and Waiauti Stream);

   (c) Kuku Stream;

   (d) Ohau River; and

   (e) Koputaroa Stream.

2. The Ō2NL Project also crosses the groundwater catchment of Punahau / Lake Horowhenua.

3. The current water quality in these catchments is variable, and largely dependent upon upstream land use, ranging from generally high (in the Ohau River and Waikawa Stream) to poor (in the Koputaroa Stream and tributaries of the Waitohu Stream).

4. My assessment identifies the potential effects of the Ō2NL Project on surface water quality during construction and operation; namely:

   (a) Potential construction impacts including sediment discharges, hazardous chemicals (including concrete), and vegetation clearance; and

   (b) Stormwater discharges from long-term operation of the road.

5. Assessing the effect of sedimentation during construction was informed by using sediment yield models (found in the **Erosion and Sediment Control Report** attached to Design and Construction Report ("**DCR**"), Appendix Four to Volume II) to estimate the increase in catchment sediment load due to Project earth works. Assessing the effects of long-term stormwater discharges was informed by the Contaminant Load Model ("**CLM**").

6. The bulk earthworks during construction could increase sediment runoff to streams, resulting in more suspended sediment and lower water clarity. This will be more apparent during high flow events where the risk of overland flow is greater.

7. The effects on downstream water quality can be minimised by applying industry best practice to erosion and sediment control (**ESC**) as described in the **Erosion and Sediment Control Report** (attached to the DCR). With the proposed controls in place, the magnitude of effects from construction sediment ranges from “Low” to “High”. The catchments with a higher risk of sediment increase are: catchment B (Waitohu), catchment C (Waitohu, with Forest Lakes downstream), and Catchment I (Mangahuia). The overall level of effects varies depending on sensitivity of aquatic life in the receiving stream and is discussed in Technical Report K (Freshwater Ecology).

8. Concrete batching plant(s) will be established on site, and cement and uncured concrete pose a risk to water quality (pH). Provided appropriate management practices are implemented, the risk of concrete causing adverse water quality effects on streams will be low. A Hazardous Substances Procedure should be developed as part of an **Erosion and Sediment Control Plan** ("**ESCP**") to describe the processes to be implemented to minimise potential risks to water quality and aquatic life – including correct storage, handling, bunding and spill procedures.

9. The effect of vegetation clearance on stream water quality is expected to be negligible. I recommend that the **Ecological Management Plan** ("**EMP**") includes measures to avoid the leaching of wood chip residue to waterways, including ensuring that wood chip and mulch from cleared vegetation are not stored by waterways or overland flow paths.

10. Stormwater discharges from the operation of the highway can have multiple levels of effects on waterways by affecting stream hydrology and morphology, water quality and the water temperature regime. The effect of operational stormwater from the Ō2NL Project (after treatment and attenuation) on stream hydrology or water temperature is likely “low” in all catchments except for small tributaries directly receiving stormwater in catchments P, M and I (shown in **Figure H.1**). In these receiving tributaries, the Project causes the imperviousness of the catchment to increase above a nominal threshold of 10% - indicative of potential effects in the upper reaches. Potential “moderate” effects are mitigated by the use of stormwater

detention basins and wetland, but would reduce further if the treatment train could include retention/infiltration.

11. The Ō2NL Project will result in a **net reduction in road related contaminants** (including total suspended solids, zinc, copper and total petroleum hydrocarbons) entering waterways of all the major catchments (ie Waitohu, Manakau, Waikawa, Ohau, Koputaroa) crossed by the route. This is because traffic will be shifted from the current SH1 and State Highway 57 ("**SH57"**) which have no formal stormwater treatment, to the new highway which will have extensive stormwater treatment. Some sub-catchments will have an increase in contaminant load (generally those with a small length of SH1 draining to their catchment relative to a larger length of the new road). However, the risk of adverse ecological effects is low because the concentration of contaminants in the stormwater discharges after treatment are expected to be within guideline values either at the point of discharge or after reasonable mixing.

INTRODUCTION

12. My full name is Keith David Hamill. I am an Environmental Scientist and Director at River Lake Limited. My technical speciality is in water quality and aquatic ecology. I have prepared this technical assessment on water quality in collaboration with Kristy Harrison, Principal Environmental Scientist and Julia O'Brien, Environmental Scientist, Stantec.

Qualifications and experience

13. I hold a Bachelor of Science degree (Geography) from the University of Auckland (1992) and a Master of Science (1st Class Hons) in Ecology and Resource and Environmental Planning from the University of Waikato (1995).

14. I have 24 years' experience in the area of resource management and environmental science. I have the following experience relevant to this assessment:

    (a) Assessing the effects on water quality and preparation of evidence for Te Ahu A Turanga: Manawatū Tararua Highway Project, Waka Kotahi NZ Transport Agency ("**Waka Kotahi**");

    (b) Leading the assessment for freshwater ecology and water quality for Mt Messenger State Highway 3 Bypass Project, Waka Kotahi;

(c) Numerous ecological and water quality investigations contributing to the Best Practicable Option review for Palmerston North City Council Totara Road Wastewater Treatment Plant; and

(d) Contributing to the single environmental indicators and dependable monitoring projects for the Ministry for the Environment.

Code of conduct

15. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

16. My role with the Ō2NL Project has been to assess the potential effects of the construction and operation of the new highway on surface water quality and to recommend measures to address adverse effects. This assessment:

(a) describes the current state of water quality in streams affected by the Ō2NL Project;

(b) describes the potential effects of the Ō2NL Project on stream water quality during construction and operation; and

(c) recommends measures to avoid, minimise and mitigate potential adverse effects on water quality.

Assumptions and exclusions in this assessment

17. This assessment focuses only on the effects of the Ō2NL Project on surface water quality. Effects on aquatic ecology are covered in Technical Assessment K (Freshwater Ecology) by **Dr Alex James**. In practice, water quality is strongly interconnected with aquatic ecology and many of the guidelines used are set to minimise potential effects on aquatic life. The effects of the Ō2NL Project on groundwater quality (including Punahau / Lake Horowhenua) are addressed in Technical Assessment G (Hydrogeology and Groundwater).

18. This assessment relies on the input from other technical assessments undertaken for the Ō2NL Project, including:

(a) the DCR (Appendix Four to Volume II) and which includes a Stormwater Management Design report by Mr Nick Keenan and,

(b) ESC report by Mr Gregor McLean;

(c) Technical Assessment J:(Terrestrial Ecology) by **Mr Nick Goldwater**;

(d) Technical Assessment K (Freshwater Ecology) by **Dr Alex James**;

(e) Technical Assessment F (Hydrology and Flooding) by **Mr Andrew Craig**.

PROJECT DESCRIPTION

19. The Ō2NL Project involves the construction, operation, use, maintenance and improvement of approximately 24 kilometres of new four-lane median divided state highway (two lanes in each direction) and a SUP between Taylors Road, Ōtaki (and the PP2Ō and SH1 north of Levin. The Ō2NL Project includes the following key features:

(a) a grade separated diamond interchange at Tararua Road, providing access into Levin;

(b) two dual lane roundabouts located where Ō2NL crosses SH57 and where it connects with the current SH1 at Heatherlea East Road, north of Levin;

(c) four lane bridges over the Waiauti, Waikawa and Kuku Streams, the Ohau River and the North Island Main Trunk ("**NIMT**") rail line north of Levin;

(d) a half interchange with southbound ramps near Taylors Road and the new PP2Ō to provide access from the current SH1 for traffic heading south from Manakau or heading north from Wellington, as well as providing an alternate access to Ōtaki.

(e) local road underpasses at South Manakau Road and Sorensons Road to retain local connections;

(f) local road overpasses to provide continued local road connectivity at Honi Taipua Road, North Manakau Road, Kuku East Road, Muhunoa

East Road, Tararua Road (as part of the interchange), and Queen Street East;

(g) new local roads at Kuku East Road and Manakau Heights Road to provide access to properties located to the east of the Ō2NL Project;

(h) local road reconnections connecting:

  (i) McLeavey Road to Arapaepae South Road on the west side of the Ō2NL Project;

  (ii) Arapaepae South Road, Kimberley Road and Tararua Road on the east side of the Ō2NL Project;

  (iii) Waihou Road to McDonald Road to Arapaepae Road/SH57;

  (iv) Koputaroa Road to Heatherlea East Road and providing access to the new northern roundabout;

(i) the relocation of, and improvement of, the Tararua Road and current SH1 intersection, including the introduction of traffic signals and a crossing of the NIMT;

(j) road lighting at conflict points, that is, where traffic can enter or exit the highway;

(k) median and edge barriers that are typically wire rope safety barriers with alternative barrier types used in some locations, such as bridges that require rigid barriers or for the reduction of road traffic noise;

(l) stormwater treatment wetlands and ponds, stormwater swales, drains and sediment traps;

(m) culverts to reconnect streams crossed by the Ō2NL Project and stream diversions to recreate and reconnect streams;

(n) a separated (typically) three metre wide SUP, for walking and cycling along the entire length of the new highway (but deviating away from being alongside the Ō2NL Project around Pukehou (near Ōtaki)) that will link into shared path facilities that are part of the PP2Ō expressway (and further afield to the Mackays to Peka expressway SUP);

(o) spoil sites at various locations along the length of the Project; and

(p) five sites for the supply of bulk fill / earth material located near Waikawa Stream, the Ohau River and south of Heatherlea East Road.

20. The Ō2NL Project will treat stormwater using a "treatment train" approach. A stormwater treatment train is the combination of sequential stormwater management treatments that collectively improve stormwater quality and quantity. For the Ō2NL Project, the treatment train will consist of sheet flow over grassed or vegetated batters, grassed or vegetated swales, treatment wetlands, and detention basins. The final point of discharge will be to existing watercourses or soakage to groundwater where soil conditions permit. Over 95% of the highway length will receive some form of stormwater treatment. The road sections without treatment are due to practical constraints of unsuitable geology or limited space.

METHODOLOGY

Introduction

21. My assessment focuses on the potential surface water quality effects of the Ō2NL Project and makes comparisons with guideline values and targets in the National Policy Statement for Freshwater Management 2020 ("**NPS-FM**"), Australia and New Zealand Guidelines (2018) and the Manawatū - Whanganui Regional Council ("**Horizons**") One Plan ("**One Plan**"). In the absence of water quality targets in the operative Greater Wellington Regional Council ("**GWRC**") Regional Freshwater Plan, the water quality targets in the Proposed Natural Resource Plan (Appeals Version) ("**PNRP**") have been referenced.

22. In this report I have assessed the magnitude of potential effects of the Ō2NL Project on surface water quality using the approach described in the Ecological Impact Assessment guidelines (EIANZ 2018) ("**EcIA**"). This contributes to Technical Assessment K (Freshwater Ecology), which assesses the ecological value of streams and rivers and the overall level of effects of the Ō2NL Project on aquatic ecology.

23. The EcIA approach provides a structured, consistent and transparent method of assessing effects. However, it does not replace the need for sound ecological judgement. In simple terms, the EcIA uses a matrix to assess the overall level of effects of an activity based on the ecological values of the site affected and the magnitude of effect. Key steps in the EcIA process are:

(a) Assess the ecological values of the environment;

(b) Assess the magnitude of effects of the activities on the environment. This considers the intensity, spatial scale, duration, reversibility, and timing of the effects. Risk / uncertainty and confidence in predictions is also considered.

(c) Assess the overall level of effect. This uses a matrix to combine the ‘ecological values’ and the ‘magnitude’ of effect in order to describe the ecological effect on a scale of ‘positive’ to ‘very high adverse’.

24. The assessment was applied to the Ō2NL Project activities assuming standard mitigation proposed as part of the Ō2NL Project (eg the proposed stormwater treatment) but excluding any biodiversity offsets. This is consistent with the approach taken in Technical Assessment K (Freshwater Ecology).

Assessing the magnitude of water quality effects

25. The potential effects of the Ō2NL Project are assessed for construction activities and for the long-term operation of the proposed new highway. The main risk to water quality during construction is the release of sediment during bulk earthworks. In addition, other water quality effects may result from vegetation clearance, concreting activities and potential spills of fuels or other hazardous substances. The main risk during operation relates to stormwater quality and quantity.

26. In assessing the magnitude of effects, I first describe the potential effects of the activity based on scientific literature, and then make a more detailed assessment of the potential effects of different Ō2NL Project activities on water quality and the likely changes relative to One Plan targets, the attribute criteria in the NPS-FM, and relevant guideline values.

Sediment during construction

27. The change in suspended sediment loads in streams during construction earthworks was estimated using the results of two models; the Universal Soil Loss Equation (**USLE**) (as described in the **ESC** report (attached to the **DCR**, Appendix Four to Volume II)) was used to calculate the change in sediment load from the Project’s earthwork footprint, and the NIWA Suspended Sediment Yield (**SSY**) Estimator was used to estimate the sediment loads at a stream catchment scale. The method was as follows:

(a) The increase in sediment load from the Project footprint due to the earthworks was calculated using the USLE, with the result expressed as a fractional increase in load.

(b) The sediment load from each stream catchment was calculated using sediment yields in the NIWA SSY Estimator integrated for each catchment area.

(c) The increase in catchment sediment load due to earth works was estimated for each catchment by multiplying the sediment load of the earthwork footprint (using yields relevant to the footprint from the NIWA SSY Estimator) by the fractional increase in sediment load due to earthworks previously calculated using the USLE model.

(d) This was expressed as a percentage increase from the catchment sediment load before the Project earthworks.

(e) To express loads into the context of instream concentrations the percent increase in TSS loads was applied, where data was available, to measured concentrations of TSS and turbidity.

28. The NIWA SSY Estimator was used so as to provide a better estimate of stream catchment suspended sediment than the USLE approach, and to extrapolate the USLE change in yield from earthworks on the Project footprint to a catchment scale.[1] It predicts long-term average suspended sediment in rivers. Note that different models used to calculate sediment load can provide very different results for sediment yield and load. They are most useful for estimating relative changes in load (eg sediment load from an area with and without earthworks), but absolute values of sediment load estimated by the different models should not be compared.

29. The model calculations assumed a Project earthwork footprint equivalent to the road alignment plus 20m either side of the alignment.

Operational stormwater

30. The potential effects of stormwater from the Ō2NL Project during long term operation were assessed for each surface water catchment by first comparing the relative change in stormwater contribution to each catchment before and after the Ō2NL Project. We assessed the magnitude of effect by:

1 The sediment yields per unit area in the SSY Estimator were derived from a model that related sediment yield to annual rainfall and an 'erosion terrain' classification, and this was calibrated with data from river gauging sites.

(a) Modelling the load of key road stormwater contaminants discharged from the Ō2NL Project to each stormwater catchment. This was done using the Contaminant Load Model ("**CLM**") version 2.[2]

(b) The CLM was applied to the 11 sub-catchments that will receive discharges of treated stormwater. It was also applied to the four sub-catchments that receive stormwater from the current SH1 or SH57 but will not receive stormwater from the new road. In addition, there are sections of catchments intersecting with the current SH1 and SH57 that have no streams, meaning that proposed road stormwater will go to soakage. For most catchments we applied the CLM at a location immediately downstream of the current SH1, the exceptions being Koputaroa Stream which receives stormwater from SH57, and the Waiauti Stream at Manakau Road which joins the Manakau Stream between SH1 and the new road. The new highway proposed by the Ō2NL Project is close to the current SH1 (mostly within ca. 0.8km, increasing to 1.6km at the Ohau River) and the approach integrated the effects of the Ō2NL Project on both road networks (**Figure H.1, Table H.1**).

(c) The CLM was applied to estimate the net increase or decrease in contaminant load derived from road stormwater with and without the Ō2NL Project.

(d) The average concentration of contaminants discharged from stormwater devices during rain events was calculated for each catchment. This assumed average annual runoff to stormwater treatment devices of 731mm per year.[3] The result approximates an average concentration of contaminants in stormwater during rain events and before dilution with the receiving water.

(e) The results were used to calculate a minimum hydraulic dilution required to achieve acute toxicity guideline values (which are discussed further below). The minimum hydraulic dilution required was compared with the dilution available in each stream (calculated from the ratio of the stormwater catchment area to stream catchment area). The results are presented as an average for each catchment and should be used

2 Auckland Regional Council. 2010. Contaminant Load Model User's Manual. Auckland Regional Council Technical Report TR2010/003.
3 Calculated by multiplying the annual average rainfall at Levin (1040mm) by the runoff coefficient of 0.703 (see. Stormwater Management Design by Mr Nick Keenan (attached to the DCR, Appendix Four to Volume II)). Rainfall of 1040mm is the 26 year average (1995-2021) from Levin NIWA site.

as a broad assessment of risk to aquatic life rather than a prediction of water quality for any particular storm-event.

31. The CLM was developed for use in the Auckland region, so some caution is needed when using in other regions. Contaminant yields from traffic on roads is considered more nationally applicable than contaminant yields from general land use. For this report, the CLM was primarily used to assess relative risk (with and without the Project) and risk from changes in the road extent and traffic volumes.

Stormwater Treatment Approach

32. The potential effects of operational stormwater from the Ō2NL Project are largely dependent upon the design and maintenance of stormwater treatment devices. The types of treatment devices are inputted into the CLM (refer to steps (c) and (d) above) in order to calculate the reduction in load and thus the resultant discharge of contaminants.

33. The Project treats stormwater from the road using multiple treatment devices in a treatment train (see Stormwater Management Design attached to the DCR (Volume II) and Drawings and plans in Volume III). Generally, this takes the form of:

(a) Vegetated or grassed batter slopes where the road is elevated;

(b) Vegetated or grassed swales running parallel to the highway, with vegetation dependent on spatial constraints;

(c) Vegetated treatment wetlands with sediment forebay;

(d) A wetland swale in one section of highway near Manakau Stream (WS) (chainage 30200-30350, sub-catchment E. installed instead of a wetland due to the small size of the contributing stormwater catchment (150m of road length);

(e) Detention basins to allow for attenuation of storm flows;

(f) Soakage to groundwater where ground conditions allow, ie in the area east of Levin at the Tararua interchange and/or Queens Street flyover; and

(g) Discharge outlet to watercourse, with appropriate erosion protection.

34. The treatment train applied for each stormwater device is shown in **Table H.1** and the length of road contributing to each catchment in **Table H.2**. Stormwater from the road alignment discharge to surface water except for area between the Ohau River and the Koputaroa Stream east of Levin, where the permeable substrate and absence of surface watercourses allows soakage / infiltration of stormwater. Note that some small catchments (ie A, D, H, K) receive no stormwater from the new road because it is conveyed along the road edge to a treatment device that discharges to an adjacent catchment. In most cases this stormwater is treated and discharged to a different tributary of the same major catchment, the exception is catchment K, which is has road stormwater conveyed to the two adjacent catchments.

35. Note that the Waiauti Stream (catchment E) is a tributary to the Manakau Stream (catchment F) and their confluence is between the current SH1 and the proposed new highway. This report defines the bottom of the catchment as the current SH1, thus the results for catchment F (Manakau) includes the Waiauti Stream (catchment E) as its tributary. Road stormwater from the *c.* 150m section of bridge over the Manakau will have stormwater conveyed to treatment in the Waiauti, which then joins the Manakau about 300m downstream.

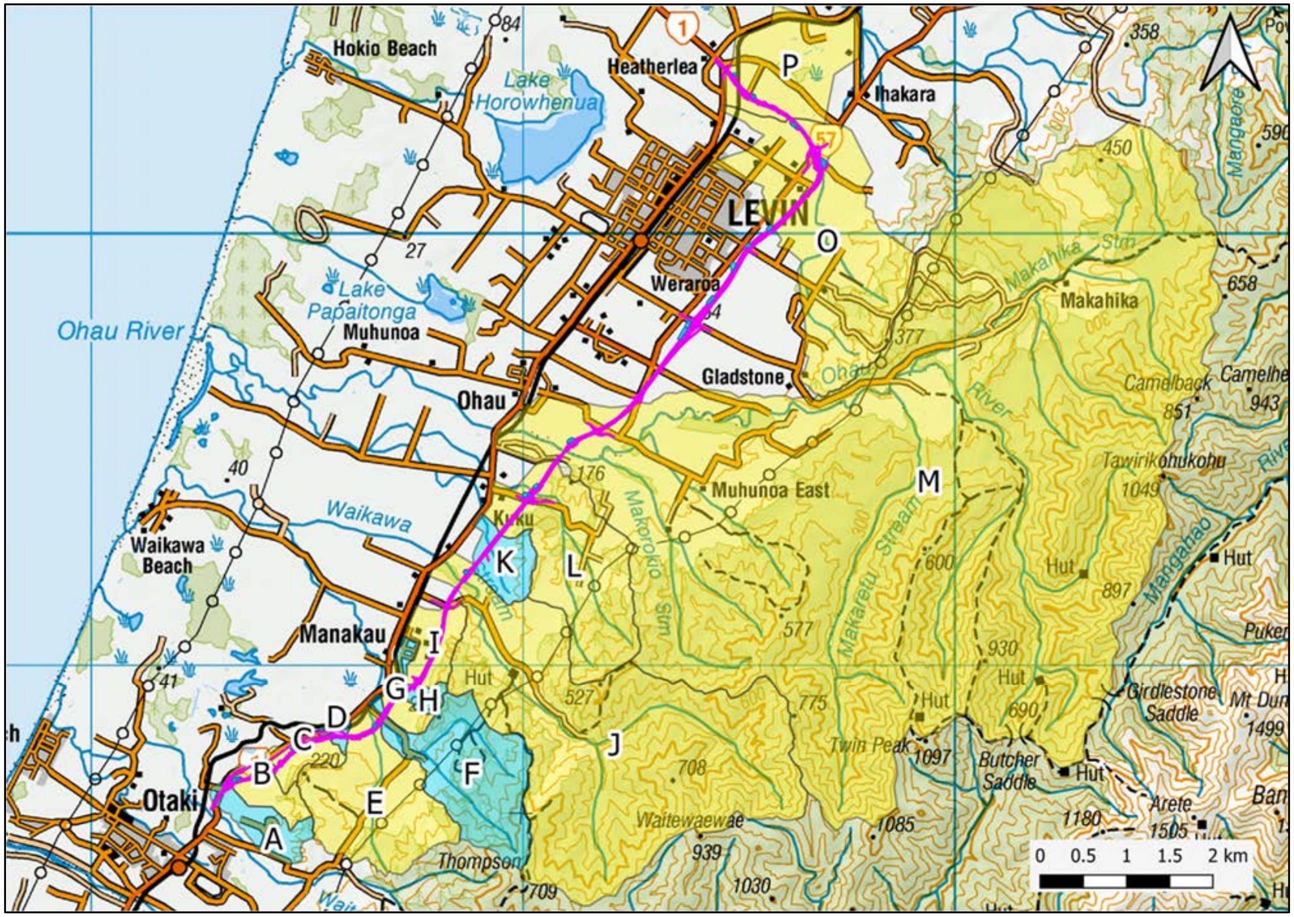


Figure H.1: **Locations of stream catchments in the Ō2NL Project area where the CLM was applied**.

Catchments receiving treated stormwater discharges from the Ō2NL Project are shown in yellow. Catchments with no discharges from the Ō2NL Project are shown in blue. The uncoloured area north of Ohau and east of Levin (between catchments M and O) has near complete infiltration to groundwater. The Project alignment is shown in purple.

Table H.1: Sub-catchments of Ō2NL route, proposed stormwater treatment and new road length contributing to treatment.

ID	Length SH1 (m)	Length SH57 (m)	Length local roads (m)	Length New SH to SW (m)	Traffic current SH1 without Project (vpd)	Traffic current SH57 without Project (vpd)	Traffic current SH1 with Project (vpd)	Traffic current SH57 with Project (vpd)	Traffic New SH1 (vpd)
A	442		2,600	0	23,900		200		27,400
B	697		400	1,520	23,900		2,200		25,300
C	1,660		0	2,200	23,900		2,200		25,300
D	832		290	0	23,900		2,000		25,300
E	333		2,830	900	23,900		2,000		25,300
F	*723*		*5,380*	*1,000*	*24,600*		*2,500*		25,300
G	717		900	1,350	24,700		2,500		25,300
H	490		2,430	0	24,600		2,500		25,300
I	785		1,830	2,360	27,200		5,300		25,300
J	806		4,700	650	27,600		5,700		25,300
K	337		0	0	27,600		5,700		25,300
L	877		5,470	3,150	27,600		5,700		25,300
M	1,345		11,600	2,230	28,600		6,700		25,300
M-O	7,070	6,300	35,000	4,750	21,800	14,000	9,200	10,100	25,300
O	1,400	2,830	17,600	3,950	18,500	16,200	10,600	8,300	19,800
P	900		10,700	1,100	16,900		9,700		13,300
A, D, H, K	2,101	0	5,320	0	24,600		2,500	0	25,300
d/s A-F	288		0	0	23,900		2,500		25,300
d/s F-I	982		0	0	24,600		2,500		25,300
d/s I-M	1,735		1,800	0	27,600		5,700		25,300
d/s P	678		1,600	220	16,900		9,700		13,300
d/s Tot.	3,682	0	3400	220	23,250		5,100		22,300

Contaminant Load Model

36. The CLM is a simple mathematical model to estimate the annual loads of TSS, total zinc ("**TZn**"), total copper ("**TCu**") and total petroleum hydrocarbons ("**TPH**") from stormwater networks. It was developed by Auckland Council but is widely used around New Zealand. The contaminant load of a particular source (eg roading) is calculated by multiplying the yield (kg/ha/yr) by the area (ha). Where the stormwater is treated, the source load is reduced by a load reduction factor ("**LRF**") (ARC 2010). This load reduction factor is applied to the fraction of the area where the stormwater is being treated or managed.

37. The results provide high level estimates of stormwater contamination. However, because of the model's simplicity, the CLM should be viewed as a tool for understanding relative effects rather than reliably predicting contaminant loads.

38. The CLM recognises that there will be a higher specific yield of contaminants in stormwater from roads with more traffic, and applies different yields based on broad categories of traffic volume as shown in **Table H.3**. Using contaminant yields based on categories of traffic volume is ‘clunky’, and when traffic volumes are near the boundary of a category, only small changes in traffic volume can cause step changes in contaminant yield. Conversely, the categories can allow large (3 to 4 times) changes in traffic volume with the CLM reflecting no change in contaminant yield. To address this issue, we have modified the CLM to apply the contaminant yields based on formulas derived from the CLM yield tables; this allowed yields to change smoothly based on the predicted traffic volumes. The formulas were derived by fitting a polynomial curve to the CLM yield data using the mid-point of each traffic volume category (eg 500 v/d for <1000 v/d, 3000 v/d for 1000 to 5000 v/d) (see **Appendix H.4** for more details).

39. The traffic volumes used in the CLM for each catchment, major road and scenario are shown in **Table H.2**. The traffic scenarios used are the medium growth (75 percentile) traffic volumes in 2039 for “*Do minimum without East West Arterial*” (without the Project) and “*With Project Queen Street Over Bdg*” (with the Project) (described in Technical Assessment A (Transport)).

40. Two alternative traffic scenarios were considered, but not presented, because they had a negligible effect on overall traffic volumes at the river catchment scale. "*Do minimum with East West Arterial ("**EWA")***" had

negligible difference on overall traffic volumes at a water quality catchment scale compared to "*without EWA*". The EWA primarily changed the distribution of traffic between roads in catchment M - O. In catchment O, traffic on SH57 for "with EWA" and "without EWA" were 16,100 and 15,900 vpd respectively, and in catchment P the traffic on the current SH1, were 16,900 and 17,000 vpd respectively. "*With Project Queen Street diverted*" has a negligible effect on overall traffic volumes at a water quality catchment scale compared to the "*Over-Bridge*" option. Traffic volumes in catchment O on SH57 for "*Queen Street Over-Bridge*" and "*Queen Street Diverted*" were 8300 and 7500 vpd respectively and there was no change on the new SH (19,800 vpd). Traffic volumes in catchment P on the new SH for the "*Queen Street Over-Bridge*" and "*Queen Street Diverted*" scenarios were 13,600 and 13,300 vpd respectively (-2.2% difference).

41. The LRFs used in the CLM are based on Auckland Regional Council (2010a) and are set out in **Table H.4**. Of particular note:

    (a) Grass swales were applied a lower LRF than vegetative swales;

    (b) A wetland swale is a linear vegetated treatment device with permanent water; they were assigned a LRF midway between a constructed wetland and a swale; and

    (c) All LRFs assume correctly designed, implemented and maintained management options.

Table H.2: **Approximate length of roads discharging to each catchment and 2039 traffic volumes 'with Project' (With Project Queen Street Over Bdg) and 'without Project' ("Do minimum without East West Arterial"). Vpd = vehicles per day.**

ID	Length SH1 (m)	Length SH57 (m)	Length local roads (m)	Length New SH to SW (m)	Traffic current SH1 without Project (vpd)	current SH57 without Project (vpd)	Traffic current SH1 with Project (vpd)	current SH57 with Project (vpd)	Traffic New SH1 (vpd)
A	442		2,600	0	23,900		200		27,400
B	697		400	1,520	23,900		2,200		25,300
C	1,660		0	2,200	23,900		2,200		25,300
D	832		290	0	23,900		2,000		25,300
E	333		2,830	900	23,900		2,000		25,300
F	*375*		*2,550*	*1,000*	*24,600*		*2,500*		25,300
G	717		900	1,350	24,700		2,500		25,300
H	490		2,430	0	24,600		2,500		25,300
I	785		1,830	2,360	27,200		5,300		25,300
J	806		4,700	650	27,600		5,700		25,300
K	337		0	0	27,600		5,700		25,300
L	877		5,470	3,150	27,600		5,700		25,300
M	1,345		11,600	2,230	28,600		6,700		25,300
M-O	7,070	6,300	35,000	4,750	21,800	14,000	9,200	10,100	25,300
O	1,400	2,830	17,600	3,950	18,500	16,200	10,600	8,300	19,800
P	900		10,700	1,100	16,900		9,700		13,300
A, D, H, K	2,101	0	5,320	0	24,600		2,500	0	25,300
d/s A-F	288		0	0	23,900		2,500		25,300
d/s F-I	982		0	0	24,600		2,500		25,300
d/s I-M	1,735		1,800	0	27,600		5,700		25,300
d/s P	678		1,600	220	16,900		9,700		13,300
d/s Tot.	3,682	0	3400	220	23,250		5,100		22,300

42. Most stormwater from the Ō2NL Project will be treated by multiple treatment devices in series (the treatment train referred to above), providing greater benefit than individual devices (NZTA 2010). The CLM applies a simplified equation for total removal of a contaminant for two or more stormwater management practices that accounts for reduced percent removal efficiency of subsequent devices, the equation is:

Total removal = A + B – [(A x B)/100]
Where: A and B are the LRF of the first and second device respectively.

43. The road length and treatment train applying to each device is described in **Table H.1** and **Table H.2**. The current roads in the area have no stormwater treatment, but we have conservatively assumed a proportion of the current roads (20% to 50% depending on the road) have stormwater treatment equivalent to a vegetative filter strip. Due to the highly permeable ground east of Levin, we assumed 50% of the current SH57 has treatment equivalent to a treatment train of vegetative filter strip followed by infiltration (using a LRF of porous paving).

44. The CLM calculates contributing road area using the road length and assumed widths relevant to specific traffic loads. The actual catchment draining to wetland devices also includes batter slopes, grass margins, conveyance channels and the treatment devices; the contaminant load to treatment devices from the non-road catchment area of the alignment was assumed to be “retired pasture <20-degree slope” to reflect its vegetative cover.

45. Annual contaminant loads were estimated at the catchment level (generally downstream of the current SH1/SH57) (**Figure H.1**). For calculating total catchment loads, we applied the slope classes and land use categories in **Appendix H.1** and calculated the length of local roads in each catchment.

46. The CLM only covers a selection of common contaminants from road runoff, ie sediment, copper, zinc and TPH. However, if stormwater treatment adequately manages these contaminants, it provides confidence that other contaminants will also be appropriately managed.

Table H.3: Contaminant load yields for selected land uses including roads at various traffic counts as applied in the CLM v2 (ARC 2010).

Landuse	Sediment	Zinc	Copper	TPH
	(g/m^2/yr)	(g/m^2/yr)	(g/m^2/yr)	(g/m^2/yr)
Roads (vehicles/day)				
<1,000	21.30	0.0044	0.0015	0.0335
1,000-5,000	27.81	0.0266	0.0089	0.201
5,000-20,000	52.56	0.1108	0.0369	0.839
20,000-50,000	95.60	0.2574	0.0858	1.947
50,000-100,000	158.4	0.471	0.157	3.56
>100,000	234.3	0.729	0.243	5.58
Farmed pasture <10^o	152	0.0053	0.0011	0
Farmed pasture 10-20^o	456	0.016	0.0032	0
Farmed pasture >20^o	923	0.032	0.0065	0
Retired pasture <10^o	21	0.0007	0.0001	0
Retired pasture 10-20^o	63	0.0022	0.0004	0
Retired pasture >20^o	125	0.0044	0.0009	0

Table H.4: Load reduction factor for road runoff for various treatment options (ARC 2010a). Highlighted cells show treatment options applied by the Ō2NL Project.

Treatment Option	TSS	Zn	Cu	TPH
Biomediafiltration	0.75	0.6	0.7	0.7
Catchpit filter	0.4	0.2	0.25	0.3
Catchpits	0.2	0.11	0.15	0.15
Constructed wetland	0.8	0.6	0.7	0.6
Dry pond	0.6	0.2	0.3	0.1
Porous paving	0.5	0.3	0.4	0.5
Storm-filter	0.75	0.4	0.65	0.75
Swale	0.75	0.4	0.5	0.4
Grassed swales	0.55	0.3	0.3	0.37
Vegetative filter strips	0.3	0.1	0.2	0.3
Wet extended pond	0.8	0.4	0.5	0.2
Wet pond	0.75	0.3	0.4	0.15
Wet pond with flocculation	0.8	0.5	0.6	0.5

National Standards, Guidelines and Regional Plans

Horizons One Plan water quality targets

47. The Horizons One Plan establishes 29 surface water management zones within the 11 parent catchments of the Manawatū-Whanganui Region. The One Plan sets water quality targets that apply throughout the region, as well

as specific targets for each sub-catchment (termed water management sub-zone).

48. The rivers and streams within the Ō2NL Project are located within four parent catchments: Manawatū (Mana), Ohau (Ohau), West Coast (West) and Punahau / Lake Horowhenua (Hokio). Schedule A of the Horizons One Plan identifies that the streams affected by the Ō2NL Project fall within the following water management sub-zones:

(a) Mana_13e (Koputaroa Stream);

(b) Ohau_1b (Ohau River and Kuku Stream);

(c) West_9a and West_9b (Waikawa Stream and Manakau Stream); and

(d) Hoki_1a and Hoki_1b (Punahau / Lake Horowhenua and Hokio Stream catchment).

49. The targets for sub-zone West_9a and West_9b are the same, as are targets for sub-zones Hoki_1a and Hoki_1b (**Table H.5**).

Table H.5: One Plan Schedule E surface water quality targets for relevant management sub-zones.

Variable	Units	Koputaroa Mana-13e	Ōhau, Kuku Ōhau _1b	Waikawa, Manakau West_9a, West_9b,	Hokio Hoki_1a, Hoki_1b	Condition criteria
pH range		7 to 8.5	7 to 8.5	7 to 8.5	7 to 8.5	within range
pH Δ		0.5	0.5	0.5	0.5	must not change by more than
Temp. <	^oC	24	22	22	24	must not exceed
Temp. Δ	^oC	3	3	3	3	must not change by more than
DO	% sat.	60	70	70	60	must exceed
$scBOD_5$		2	2	2	2	
POM	mg/L	5	5	5	5	Average when flow < median
DRP	mg/L	0.015	0.01	0.01	0.015	Annual average when <20th flow exceedance
SIN	mg/L	0.444	0.11	0.167	0.167	Annual average when <20th flow exceedance
NH4	mg/L	0.4	0.4	0.4	0.4	Average
NH4.Max	mg/L	2.1	2.1	2.1	2.1	Maximum
Clarity %Δ	%	30	30	30	30	must not be reduced by more than
Clarity >	mg/L	2.5	2.5	2.5	2.5	must exceed when river < median flow
Ecoli.Bathing	cfu/100mL	260	260	260	260	summer max. when flow < median flow
Ecoli.Year	cfu/100mL	550	550	550	550	annual max. when <20th flow exceedance
Tox. or Toxicants	%	95	95	95	95	Relevant protection level in ANZECC (2000) Table 3.4.1. For metals use dissolved fraction after hardness adjustment.
Deposited sediment	% cover	25	20	20	25	Maximum cover of fines on stream bed
MCI		100	100	100	100	
QMCI	% change	20	20	20	20	% change between upstream and downstream
Peri Chla	mg/L	200	120	120	200	Annual max. when < 20th flow exceedance
Peri. Cover Mats	% cover	60	60	60	60	
Peri. Cover Fils	% cover	30	30	30	30	
Cyano. Cover Alert	% cover	20	20	20	20	
Cyano. Cover Action	% cover	50	50	50	50	

Greater Wellington Regional Council

50. The PNRP contains proposed guidelines for river and stream aquatic ecosystem health in Table 3.4. The guidelines set in the PNRP relate to macrophytes, periphyton biomass, periphyton cover, macroinvertebrates and fish, with limits also set for *E. coli* and cyanobacteria with respect to contact recreation. The values set for these variables are broadly similar to those set in the One Plan and, as the PNRP is still subject to appeal, for the purpose of water quality assessments we have used the One Plan (see **Appendix H.3** for a comparison of the targets in the PNRP and the One Plan).

ANZECC guidelines for metals

51. The Australian and New Zealand Environment and Conservation Council Guidelines for Fresh and Marine Water Quality 2000 ("**ANZECC**") and the updated Australia and New Zealand Guidelines for Fresh and Marine Water Quality 2018 ("**ANZG**") set default guideline values ("**DGVs**") to protect freshwater systems. The DGVs for toxicants generally correspond to the 95 percent protection level applied to 'moderately disturbed ecosystems', but stricter values can be applied to waterways with higher ecological values. For metals the ANZECC (2000) 95% protection level equates to the ANZG (2018) DGVs. Generally, these DGVs are compared with the 95-percentile statistic from the test waterbody of interest. These toxicant DGVs relate to chronic toxicity (ie long-term exposure)[4] and are suited to apply to baseflow monitoring or long-term average values. They should apply to dissolved metals in receiving waters after adjusting guideline values for the relevant hardness or dissolved organic carbon values in the receiving water (ANZG 2018, Gadd et al 2017).

52. The toxicity of metals to aquatic life is strongly dependent on the form and whether it is bound to other substances. Many metals are strongly adsorbed to suspended material and toxicity often decreases with increasing hardness and dissolved organic carbon. The ANZECC guidelines set default trigger values for cadmium, chromium, copper, lead nickel and zinc assuming water hardness of 30 mg/L as ($CaCO_3$), but the value can be modified for actual water hardness using the appropriate formula. Based on monitoring results, we have assumed a lower hardness value of 20 mg/L for the Manakau, Waiuiti, Waikawa, Kuku Streams and Ohau River.

4 Typically defined as between 4 to 21 days exposure depending on the organism being tested.

53. Dissolved organic carbon ("**DOC**") also has a strong influence on metal toxicity, particularly for copper. Revisions (not yet "approved") to the ANZECC guidelines for copper propose adjusting the DGVs for copper according to DOC so that the modified DGV for copper approximately doubles as the concentration of DOC doubles. In waters with a DOC of 1 mg/L, 2 mg/L and 3 mg/L the Waititi DGV for copper would be respectively 3.1, 6.8 mg/m^3, and 10.4 mg/m^3 (Gadd et al 2017). The concentration of DOC in streams crossing the Ō2NL Project are typically: Ohau River 1.2 mg/L; Waikawa 2.0 mg/L; Koputaroa 4.8 mg/L; and Manakau 3.2 mg/L.

54. Chronic toxicity guidelines are conservative when applied to stormwater discharges which tend to be short term and intermittent. Acute toxicity guidelines are generally more appropriate to apply to short duration stormwater discharges, unless these are very frequent with a short recovery time (<2 days) between events (Gadd et al 2017, Bearr et al. 2006). The United States Environment Protection Agency ("**USEPA**") (2006) Criteria Maximum Concentration ("**CMC**") which protects against acute effects have been referenced for this purpose (**Table H.6**).

55. The ANZG (2018) DGV for total petroleum hydrocarbons ("**TPH**") is calculated as 0.01 times the lowest 96-hour LC_{50} (a measure of chronic lethal effects). However, this value has 'low reliability' and is less than the detection limit of most laboratories. We have applied TPH of 0.5 mg/L as a trigger for acute toxicity which equates to the lower detection limit commonly used by laboratories.

Table H.6: Water quality guideline values for dissolved metals to avoid chronic effects (ANZG 2018 DGVs) and acute effects (USEPA 2006).

Hardness (mg/L)	20	30	50	30	20
	Chronic (µg/L)			Acute (µg/L)	
Variable	ANZG DGV	ANZG DGV	ANZG DGV	USEPA CMC	
Chromium (Cr III)	nd	nd	nd	212	153
Chromium (CrVI)	1	1	1	16	
Copper (DOC of 0.6 mg/L)	1.0	1.4	2.2	4.3	2.9
Copper (DOC of 1 mg/L)	*3.1*	*3.1*	*3.1*		
Copper (DOC of 2 mg/L)	*6.8*	*6.8*	*6.8*		
Copper (DOC of 4 mg/L)	*14*	*14*	*14*		
Lead	2.0	3.4	6.5	17	10.8
Zinc	5.7	8	12.3	42.2	30
TPH *	7	7	7		

The DGV for TPH is based on 0.01 times the lowest 96-h LC50. The value has "low reliability" and is less than the detection limit for standard laboratory analysis.

ANZECC guidelines for physical-chemical stressors

56. The ANZG (2018) DGV for physical-chemical stressors in freshwater have been developed for the second-level River Environment Classification ("**REC**") classes (climate by typography), these were derived as the 80th percentile of values at sites in reference condition (McDowell et al. 2013). They are intended to be used as a trigger and indicate that the water quality deviates from typical reference conditions and that there is a 'potential risk' of adverse effects at a site. The physical-chemical DGVs are intended to be compared to median values. **Table H.7** shows the relevant physical-chemical stressors for streams crossing the Ō2NL Project alignment according to their level 2 REC.[5]

57. For microbiological contaminants ANZG (2018) refers to the microbiological water quality guidelines (MfE and MoH 2003) and the NPS-FM (MfE 2020).

Table H.7: ANZG (2018) Default Guideline Values (DGV) for physical-chemical stressors for water classifications relevant streams crossing the Ō2NL Project alignment.

		Koputaroa	Ōhau, Waikawa	Kuku, Manakau	Waitohu Trib.
Indicator	**units**	**DGV WW/L**	**DGV CW/H**	**DGV CW/L**	**DGV WD/L**
Clarity	m	0.8	1.6	1.4	0.7
COND	µS/cm	115	95	145	86
E.coli	cfu/100mL	628	92	395	454
NH4-N	mg/m^3	10	6	9	17
NO3-N	mg/m^3	65	87	170	195
TN	mg/m^3	292	238	272	281
DRP	mg/m^3	14	8	11	7
TP	mg/m^3	24	16	18	23
TURB	NTU	5.2	2.4	2.3	4.2
TSS	mg/m^3	8.8	2.6	1.8	4.6
pH		7.7	7.8	7.8	7.8
TEMP	^{o}C	16.2	13.9	13.4	16.6

National Policy Statement for Freshwater Management water quality attributes

58. The National Policy Statement for Freshwater Management 2020 ("**NPS-FM")** sets out objectives and policies that direct local government to manage water in an integrated and sustainable way. The NPS-FM includes a

5 Climate level: warm wet (WW), cold wet (CW), warm dry (WD). Source of flow level: Hill (H), lowland (L). Geology level: Hard sedimentary (HS), soft sedimentary (SS), Alluvial (Al), Miscellaneous (M).

National Objectives Framework ("**NOF")** which sets compulsory national values for freshwater including: 'human health for recreation' and 'ecosystem health'. Appendix 2 of the NPS-FM sets water quality attributes that contribute to these values, and ranks attributes into bands to help communities make decisions on water quality. This includes setting minimum acceptable states called 'national bottom lines'. For some attributes in the NPS-FM (eg river turbidity) the values assigned to bands differ depending on the REC classification.

59. Appendix 2A of the NPS-FM describes attributes that require limits on resource use; those relevant to rivers include: periphyton, total ammoniacal nitrogen (**NH4-N**) toxicity, nitrate (**NO3-N**) toxicity, dissolved oxygen (**DO**) below point sources, visual clarity[6] and *E.coli* bacteria (human contact); while those specifically relevant to lakes include: total nitrogen (**TN**), total phosphorus (**TP**), phytoplankton and cyanobacteria (**Table H.8**). The NOF bands set for NO3-N and NH4-N relate to their potential toxicity to aquatic life rather than their role as nutrients which influences algae growth.

60. Appendix 2B of the NPS-FM describes attributes that require action plans; those relevant to rivers include: Fish IBI, macroinvertebrates (MCI and ASPM), deposited fine sediment (% fine sediment cover), dissolved oxygen, dissolved reactive phosphorus (DRP), ecosystem metabolism, and *E. coli* bacteria for primary contact sites (**Appendix H.2**). The streams crossing the Ō2NL Project alignment fall into Suspended Sediment Class 2 (Koputaroa, Waitohu Tributaries) or 3 (Ohau Kuku, Waikawa, Manakau, Waiauti).

61. The One Plan targets use different statistics compared to the NOF, but would roughly correspond to NOF bands C, A and A for the attributes of NH4-N, NO3-N and *E.coli* respectively. For the purpose of assessing water quality in this assessment I have focused on the One Plan targets.

6 The streams crossing the Ō2NL Project alignment fall into Suspended Sediment Class 2 (Koputaroa, Waitohu Tributaries) or 3 (Ohau Kuku, Waikawa, Manakau, Waiauti).

Table H.8: Summary of NOF attributes requiring limits on resource consents that are relevant to rivers (NPS-FM Appendix 2A). ***National bottom-line values are in bold.***

Attribute	Statistic	units	Band A	Band B	Band C	Band D	Band E
NH4-N	Median	mg/L	≤0.03	**≤0.24**	≤1.3	>1.3	
NH4-N	Maximum	mg/L	≤0.05	**≤0.4**	≤2.2	>2.2	
NO3-N	Median	mg/L	≤1	**≤2.4**	≤6.9	>6.9	
NO3-N	95%ile	mg/L	≤1.5	**≤3.5**	≤9.8	>9.8	
E.coli bacteria	% samples >260 cfu/100ml	%	≤20%	≤30%	≤34%	≤50%	>50%
E.coli bacteria	% samples >540 cfu/100 ml	%	≤5%	≤10%	≤20%	≤30%	>30%
E.coli bacteria	Median	*E.coli* / 100mL	≤130	≤130	≤130	≤260	>260
E.coli bacteria	95%ile	*E.coli* / 100mL	≤540	≤1000	≤1200	≤1200	>1200
Periphyton default class	Exceeded <8% of samples	mg *chl-a* /m^2	≤50	≤120	**≤200**	>200	
Periphyton productive class	Exceeded <17% of samples	mg *chl-a* /m^2	≤50	≤120	**≤200**	>200	
DO	7-day min	mg/L	≥8	≥7	**≥5**	<5	
DO	1-day min.	mg/L	≥7.5	≥5	**≥4**	<4	
Visual clarity (Class 2)	Median	m	≥0.93	≥0.76	**≥0.61**	<0.61	
Visual clarity (Class 3)	Median	m	≥2.95	≥2.57	**≥2.22**	<2.22	

Water Quality Monitoring

62. Water quality is regularly monitored by Horizons at sites in the Koputaroa Stream, Ohau River, Waikawa Stream, Manakau Stream, and inflow streams of Punahau / Lake Horowhenua. GWRC regularly monitors water quality in the lower Waitohu Stream (**Figure H.2**).

63. In 2021 Waka Kotahi commissioned additional water quality monitoring of streams crossed by the Ō2NL Project route to improve the spatial resolution and range of variables being monitored. This monitoring included:

    (a) Monthly grab samples from nine monitoring sites collected by Stantec since July 2021 plus one-off samples from an additional two sites (site 3A Kuku Stream and site 6B Waitohu Tributary)[7] (**Figure H.2**);

    (b) Commissioning Horizons to analyse additional variables in their monthly grab samples at three sites;

    (c) Collecting sediment samples at 11 sites on 21 December 2021;

7 Landowner permission could not be obtained to continue samples at site 3A Kuku Stream at Kuku East Road.

(d) Commissioning NIWA to instal turbidity loggers at four sites (Koputaroa, Ohau, Waikawa and Manakau) (November 2021).

64. The Waka Kotahi monitoring analyses the water quality for the following variables: temperature, electrical conductivity (**EC**), Total suspended solids (**TSS**), turbidity, total nitrogen (**TN**), nitrate-nitrite nitrogen (**NNN**), total ammoniacal nitrogen (**NH4-N**), total phosphorus (**TP**), dissolved reactive phosphorus (**DRP**), pH, total hardness, dissolved organic carbon (**DOC**), total petroleum hydrocarbons (**TPH**), polyaromatic hydrocarbons (**PAH**), total and dissolved copper (**Cu**), Zinc (**Zn**), chromium (**Cr**) and lead (**Pb**).

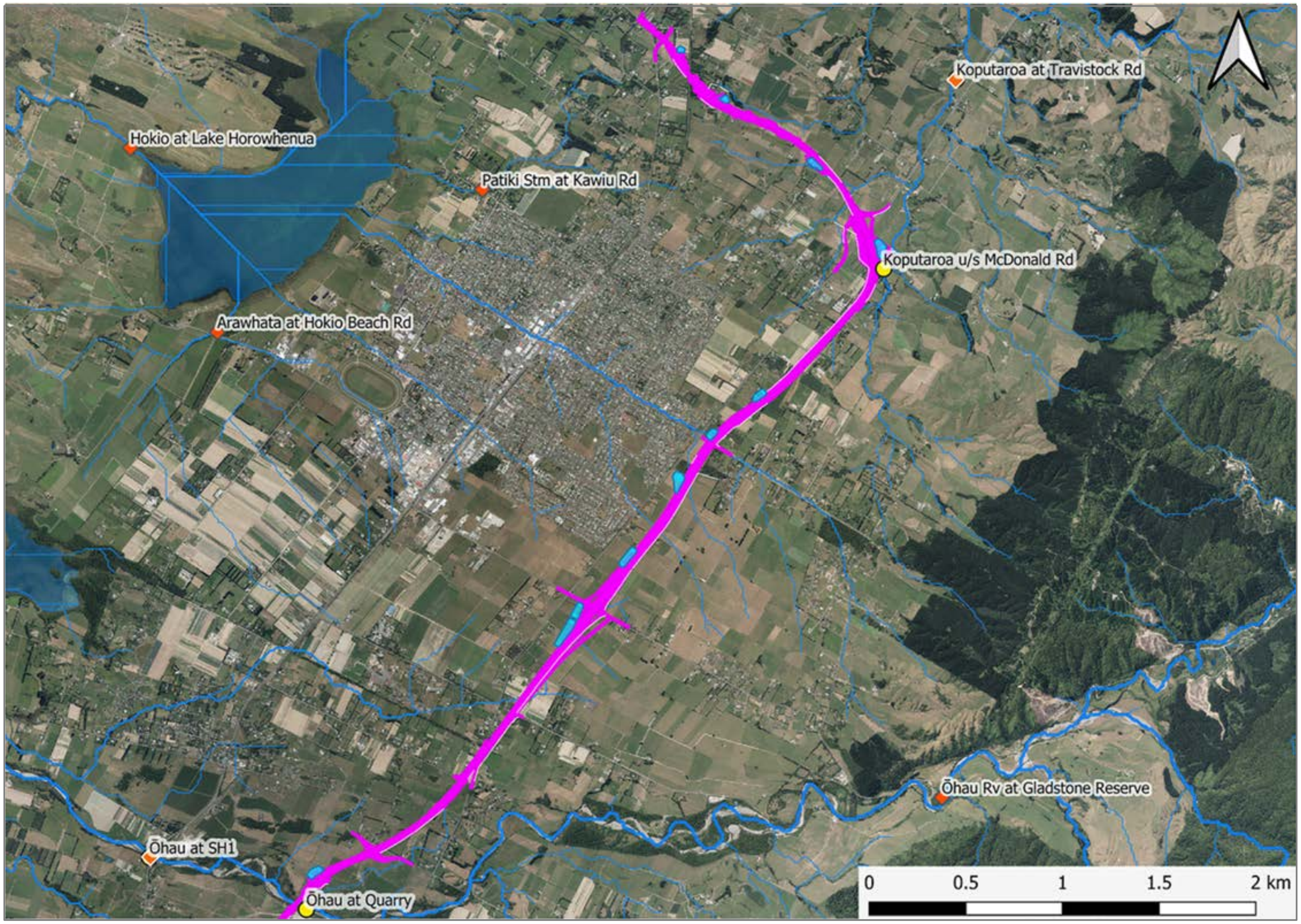


Figure H.2a: Sites in catchments affected by the Ō2NL Project with water quality monitoring by Horizons Regional Council (orange diamonds) and Waka Kotahi (yellow dots).

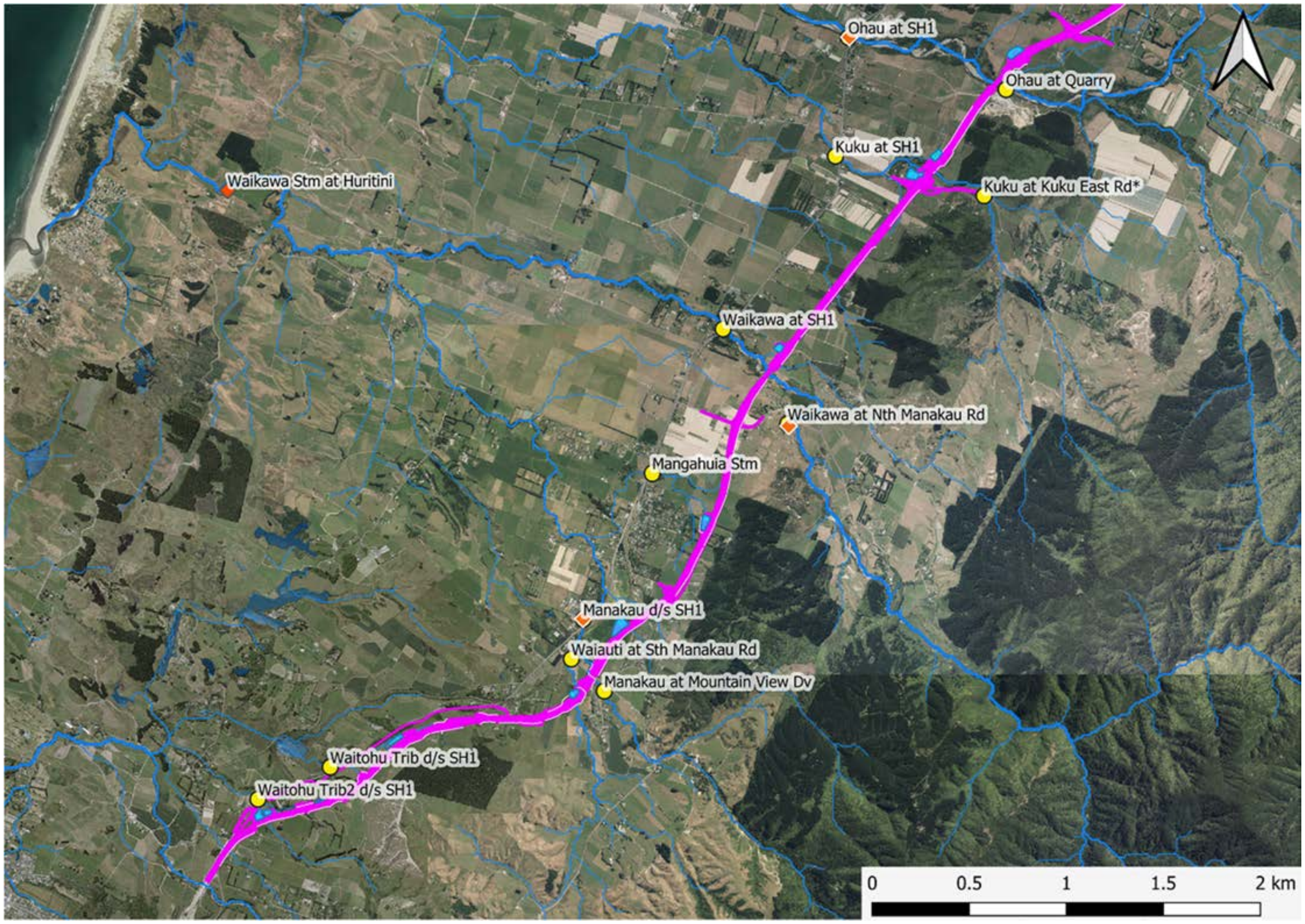


Figure H.2b: Sites in catchments affected by the Ō2NL Project with water quality monitoring by Horizons Regional Council (orange diamonds) and Waka Kotahi (yellow dots).

EXISTING ENVIRONMENT

65. Five main surface water catchments are crossed by the Ō2NL Project, these are:

    (a) Waitohu Stream;

    (b) Waikawa Stream (including the Manakau Stream and Waiauti Stream);

    (c) Kuku Stream;

    (d) the Ohau River; and

    (e) Koputaroa Stream (tributary to the Manawatū River).

66. The Ō2NL Project also crosses the groundwater catchment of Punahau / Lake Horowhenua.

67. The land use in all of the catchments is predominantly pastural farming, although there are substantial areas of native and exotic forest in the headwaters of the Waiauti, Manakau, Waikawa, Kuku, Ohau, and Koputaroa. There are small areas of market gardening in the Kuku and Koputaroa catchments. Catchment characteristics are described in **Table H.9**, Catchment land use is summarised in **Appendix H.1**.

68. Water quality is regularly monitored by Horizons at sites in the Koputaroa Stream, Ohau River, Waikawa Stream, Manakau Stream, and inflow stream of Punahau / Lake Horowhenua. GWRC regularly monitors water quality in the lower Waitohu Stream. The summary results and 10-year trend from sites near the Ō2NL Project route are shown in **Table H.10** and **Table H.11**.

69. Water quality monitoring of additional sites and variables have been undertaken for the Ō2NL Project (discussed in Methodology section). The results of sampling between 29 July 2021 and 8 February 2022 are presented in **Table H.12**. All dissolved metals were within the ANZG DGVs for all sites except chromium at Site 6A Waitohu Trib at SH1 (Puruaku). Sediment sampling found total metals all within ANZG DGVs (**Table H.13**).

70. Turbidity loggers in the Manakau Stream, Waikawa Stream, Ohau River and Koputaroa Stream found high variability in results associated with flood events, that can increase turbidity 100 to 1000 times above baseflow levels. The baseflow turbidity was lowest in the Ohau River (c. 0.5 NTU) and Waikawa Stream (c. 1 NTU), compared to the Koputaroa Stream (4 NTU)

and Manakau Stream (5 NTU) (**Figure H.3 and Figure H.4**). Recent data from the Waikawa Stream needs to be treated with caution due to work in the channel and shifting of the main river flow. The prolific periphyton growth in the Manakau Stream appears to have affected the turbidity readings and the sensor may have been clogged by periphyton in late January 2022.

Table H.9: Catchments affected by the Project. Catchment area, mean flow and mean annual low flow ("MALF") is based on State Highway 1. Flow and REC class is from the River Environment Classification ("REC"). WMZ = Water Management Zone.

ID	Name	Receiving Stream	SW discharge	Catchment area (ha)	MALF	Mean Flow	WMZ	REC class	NOF SS Class
A	Greenwood	WQ0	No	188	0.005	0.029		WD/L/Al/P/LO/LG	2
B	Waitohu Trib 2	WQ2	**Yes**	144	0.007	0.043		WD/L/SS/P/LO/LG	2
C	Waitohu Trib 1	WQ5 -> 10	**Yes**	128	0.006	0.033		WD/L/SS/P/LO/LG	2
D	Waitohu Trib 3	WQ11	No	27	neg.	neg.		WD/L/SS/P/LO/LG	2
E	Waiauti	WQ14	**Yes**	792	0.020	0.121	West_9b	CW/L/HS/P/MO/MG	3
F	Manakau	WQ15	**Yes**	1,542	0.049	0.305	West_9b	CW/L/HS/P/MO/LG	3
G	Manakau Trib	WQ17	**Yes**	85	0.002	0.010	West_9b	WD/L/Al/P/LO/MG	2
H	Manakau Trib	WQ18	No	85					
I	Mangahuia	WQ19 ->25	**Yes**	202	0.006	0.152	West_9a	WD/L/SS/P/LO/LG	2
J	Waikawa	WQ27	**Yes**	3,212	0.24	1.39	West_9a	CW/H/HS/P/MO/LG	3
K	Waikokopu	WQ29	No	198	0.007	0.038	Ōhau_1b	WD/L/Al/P/LO/LG	2
L	Kuku	WQ32	**Yes**	960	0.032	0.181	Ōhau_1b	CW/L/HS/P/HO/MG	3
M	Ōhau	WQ33	**Yes**	13,687	1.07	5.56	Ōhau_1b	CW/H/HS/P/HO/LG	3
M-O	East Levin		Infiltration	n.a.					
O	Koputaroa	WQ39 -> 40	**Yes**	1,490	0.045	0.232	Mana_13ε	WW/L/MP/MO/LG	2
P	Koputaroa Trib	WQ41 -> 43	**Yes**	596	0.004	0.020	Mana_13ε	WW/L/SS/P/MO/LG	2

Table H.10: Median water quality from monitoring sites period 2015 to 2020. Shaded yellow cells exceed ANZG DGVs, bolded cells exceed One Plan targets (source Horizons and LAWA).

Site Name	BDISC	DRP	ECOLI	NH4-N	TN	NO3-N	TP	TURB	MCI
Koputaroa at Tavistock Rd	**0.55**	**0.018**	**1500**	0.010	2.67	**2.25**	0.049	5.3	**88**
Ohau at Gladstone Reserve	4.16	0.008	41	0.005	0.12	0.06	0.011	0.70	131
Ohau at State Highway Bridge	2.8	0.008	72	0.005	0.27	**0.19**	0.011	0.72	112
Ohau at Haines Property	2.9	0.008	87	0.005	0.41	**0.31**	0.014	1.3	102
Waikawa at North Manakau Road	3.3	**0.011**	44	0.005	0.15	0.09	0.014	0.9	128
Waikawa at Huritini	**1.05**	**0.015**	**350**	0.021	1.20	**1.02**	0.040	4.8	**99**
Manakau at S.H.1 Bridge	**1.05**	**0.011**	**460**	0.010	0.50	**0.26**	0.034	4.7	**95**
Waitohu Stream at Norfolk Crescent	**0.93**	**0.016**	**965**	0.027	0.70	**0.38**	0.041		**87**
Patiki Stream at Kawiu Road	**0.6**	**0.034**	**330**	0.020	6.33	**5.81**	0.067	4.5	**81**
Arawhata Drain at Hokio Beach Road	**1.1**	**0.024**	**680**	0.075	10.6	**10.4**	0.060	4.2	**69**
Horowhenua Inflow at Lindsay Road	**0.4**	**0.028**	**180**	**0.480**	3.56	**1.80**	0.124	15.6	
Hokio at Lake Horowhenua	**0.41**	**0.017**	64	0.010	2.40	**0.54**	0.121	11.4	**68**

Table H.11: Water quality trends for the 10-year period 2010 to 2020 (LAWA)

Site Name	BDISC	DRP	E. COLI	NH4-N	TN	NO3-N	TP	TURB
Koputaroa at Tavistock Rd	ND	ND	ND	ND	ND	ND	ND	ND
Ohau at Gladstone Reserve	↓	→	↑	↑	↗	→	↗	↗
Ohau at State Highway Bridge	→	↗	↗	→	ND	→	ND	→
Ohau at Haines Property	↗	↗	↘	↑	↑	↗	↗	↗
Waikawa at North Manakau Road	↓	↓	↓	↗	→	↓	→	↓
Waikawa at Huritini	→	↗	↗	↗	→	↓	↗	→
Manakau at S.H.1 Bridge	↓	↗	↑	↗	→	↓	→	→
Waitohu Stream at Norfolk Crescent	↑	↑	↓	→	↗	↑	↘	ND
Patiki Stream at Kawiu Road	ND	ND	ND	ND	ND	ND	ND	ND
Arawhata Drain at Hokio Beach Road	ND	ND	ND	ND	ND	ND	ND	ND
Horowhenua Inflow at Lindsay Road	ND	ND	ND	ND	ND	ND	ND	ND
Hokio at Lake Horowhenua	ND	ND	ND	ND	ND	ND	ND	ND

Key
- ↑ Very likely improving
- ↗ Likely improving
- → Indeterminate
- ↘ Likely degrading
- ↓ Very likely degrading
- ND Not Determined

Table H.12: Median water quality monitoring results for streams crossed by the Ō2NL Project, July 2021 to July 2022. Highlighted cells do not achieve the ANZECC DGVs. nd = not detected.

Id	Site	Temp. oC	%DO	Clarity m	EC mS/m	pH	TURB NTU	TSS mg/L	*E.coli* cfu/100mL	TN mg/L	NH4-N mg/L	NNN mg/L	TP mg/L	DRP mg/L
1A	1A Koputaroa at McDonalds Rd	14.5	83.6	0.63	142	7.2	9.5	5.5	1733	0.93	0.014	0.54	0.044	0.012
1B	1B Koputaroa at Travistock Rd	14.3	72.0	0.64	202	7.3	5.6	4	1046	2.95	0.018	2.50	0.046	0.016
2A	2A Ohau at Quarry	14.8	95.4	0.86	76.5	7.1	1.56	<3.0	53	0.365	<0.01	0.29	0.007	0.005
2B	2B Ohau at SH1 Bridge	10.5	99.9	4.85	72.9	7.3	1.21	<3.0	43.5	0.465	0.005	0.42	0.017	0.012
3A	3A Kuku at Kuku East Rd	10.2	88.4	0.73	132	6.9	4.25	4	183	0.49	0.011	0.31	0.023	0.011
3B	3B Kuku at SH 1	14.2	91.7	0.74	131	7.3	4	3.5	548	0.425	0.012	0.23	0.029	0.012
4A	4A Waikawa at North Manakau R	9.6	99.6	4.20	79.5	7.4	0.62	<3.0	59.2	0.14	0.005	0.09	0.018	0.015
4B	4B Waikawa at SH 1	13.8	95.8	0.79	83.3	7.1	0.77	<3.0	246.5	0.15	<0.01	0.09	0.011	0.007
5A	5A Manakau at Mountain View R	14.9	94.9	0.69	109	7.1	4.2	3.5	219	0.22	<0.01	0.12	0.019	0.008
5B	5B Manakau at SH1 Bridge	10.7	100.6	1.45	128	7.4	3.95	3	714	0.48	0.013	0.18	0.038	0.017
5C	5C Waiauti at South Manukau Rd	14.9	89.2	0.63	129	7.2	5.9	7	770	0.525	0.02	0.22	0.042	0.016
5D	5D Mangahuia Stm	17.6	79.4	0.71	187	6.9	24	8	1120	4.1	<0.01	2.60	0.096	0.046
6A	6A Waitohu Trib at SH1 (Puruaku	13.8	66.3	0.64	300	6.9	2.65	4	72	6.7	<0.01	6.50	0.052	0.035
6B	6B Waitohu Trib. 2	12.4	81.3		1536	6.9	18.2	14	365	2.4	0.124	1.59	0.091	0.023

Id	Site	Hardness g/m3	DOC mg/L	Diss. Cr mg/L	Total Cr mg/L	Diss. Cu mg/L	Total Cu mg/L	Diss. Pb mg/L	Total Pb mg/L	Diss. Zn mg/L	Total Zn mg/L	TPH max mg/L	PAH mg/L
1A	1A Koputaroa at McDonalds Rd	26	4.85	<0.0005	0.001	0.001	0.001	<0.0001	<0.0001	0.002	0.002	<0.7	nd
1B	1B Koputaroa at Travistock Rd	49.5	3.75	<0.0005	<0.0005	0.001	0.001	<0.0001	<0.0001	0.002	0.002	<0.7	nd
2A	2A Ohau at Quarry	15.1	1.55	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.7	nd
2B	2B Ohau at SH1 Bridge	16	1.4	<0.0005	<0.0005	<0.0005	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.5	nd
3A	3A Kuku at Kuku East Rd	19.35	2.7	<0.0005	<0.0005	0.001	0.001	<0.0001	<0.0001	0.002	0.001	<0.7	nd
3B	3B Kuku at SH 1	22	4.2	<0.0005	<0.0005	0.001	0.001	<0.0001	<0.0001	0.001	0.001	<0.7	nd
4A	4A Waikawa at North Manakau R	18	1.75	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.5	nd
4B	4B Waikawa at SH 1	16.65	1.6	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	<0.7	nd
5A	5A Manakau at Mountain View R	19	3.1	<0.0005	<0.0005	0.001	0.001	<0.0001	<0.0001	<0.0001	0.001	<0.7	nd
5B	5B Manakau at SH1 Bridge	25.5	3.6	<0.0005	0.001	0.001	0.001	<0.0001	<0.0001	<0.0001	0.001	<0.5	nd
5C	5C Waiauti at South Manukau Rd	25.5	4.35	<0.0005	<0.0005	0.001	0.001	<0.0001	<0.0001	<0.0001	0.001	<0.7	nd
5D	5D Mangahuia Stm	34	8.8	0.001	0.001	0.001	0.001	<0.0001	<0.0001	0.002	0.002	<0.7	nd
6A	6A Waitohu Trib at SH1 (Puruaku	78	2.85	0.004	0.005	<0.0005	0.001	<0.0001	<0.0001	<0.0001	0.002	<0.7	nd
6B	6B Waitohu Trib. 2	54		0.001	0.001	0.001	0.001	<0.0001	0.001	0.002	0.005	<0.7	nd

NB Site 1B Koputaroa at Travistock Rd had the July 2021 sampled collected at SH57. Site 2A Ohau at Quarry had the July 2021 sample collected Site 3A Kuku at Kuku East Road amd Site 6B Waitohu Trib. 2 were sampled only once (29 July 2021).

Table H.13: Sediment quality in streams crossed by the Ō2NL Project on 21 December 2021.

	Site	Total Cr	Total Cu	Total Pb	Total Zn	TOC
		mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	g/100g dw
us	1A Koputaroa at McDonalds Road	7.1	3.2	6.4	36	0.17
ds	1B Koputaroa at Travistock Road	6.1	1.9	4	30	0.16
us	2A Ohau at Mahunoa East Road	14.1	9.1	11.7	54	0.22
ds	2B Ohau at SH1	13.2	8.8	11.7	54	0.23
ds	3B Kuku at SH1	6.9	3.4	7.4	35	0.39
us	4A Waikawa at North Manukau Road	13.4	9.4	14.5	64	0.43
ds	4B Waikawa at SH1	11.6	7.8	12.5	55	0.3
us	5A Manakau at Mountain View Road	18.4	5.6	9.5	43	0.21
ds	5B Manakau at SH1 Bridge	11.5	5.5	9.6	41	1.04
us	5C Waiuti South Manukau Road	8.6	3	6	30	0.21
ds	6A Waitohu Trib at SH1 (Puruaku)	12.6	3.2	7.5	25	0.57
	DGV	80	65	50	200	
	GV-High	370	270	220	410	

71. **Table H.14** compares the water quality in main streams crossing the Ō2NL Project route with One Plan targets. For some streams and variables there is limited data and a judgement has been made using the best dataset available.

72. Many of the streams have occasional occurrences of low pH below the One Plan target of 7.0. DRP exceeds the target in all streams except the Ohau. Soluble inorganic nitrogen ("**SIN**") exceeds the target for all streams except the Waikawa. All NH4-N is within the target for all streams, but the concentration exceeds the NPS-FM bottom-line in the lower Waitohu. Clarity only complies with the target in the Ohau, and *E. coli* only complies in the Ohau, Waikawa and possibly the Kuku Stream (based on very few samples). Most dissolved metals are within ANZG DGVs (and One Plan targets) for all streams. A possible exception was the Waitohu Tributary where chromium exceeded the DGV for hexavalent Cr(VI), however this is conservative because the laboratory analysis did not distinguish the oxidation state of chromium and Cr well within the DGV for Cr(III) which is typically more common.

Table H.14: Compliance to One Plan targets for main streams.

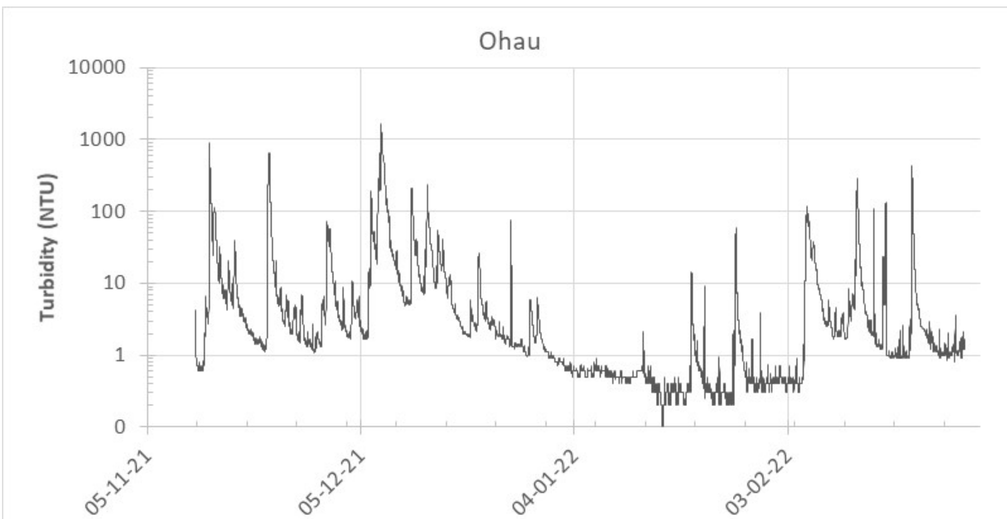
Y = likely meets target, N = unlikely to meet target. nd = not determined.

Variable	Koputaroa	Ōhau	Kuku*	Waikawa	Manakau	Waiauti*	Waitohu*	Hoki
pH range ^	N	N	N	N	N	N	N	N
Temp. < ^	Y	Y	Y	Y	Y	nd	nd	N
%DO ^	N	Y	nd	Y	N	nd	nd	N
POM	nd	nd	nd	nd	nd	nd	nd	nd
DRP	N	Y	N	N	N	N	N	N
SIN	N	N	N	Y	N	N	N	N
NH4	Y	Y	Y	Y	Y	Y	Y	Y
Clarity >	N	Y	N	N	N	N	N	N
E. coli	N	Y	N	N	N	N	N	N
Deposited sediment	N	Y	Y	Y	Y	Y	N	nd
Metals - ANZG DGV	Y	Y	Y	Y	Y	Y	N**	nd

* best estimate using available data.

** Dissolved Cr exceeds the DGV set for hexavalent Cr(VI).

^ Estimate based on available grab samples.



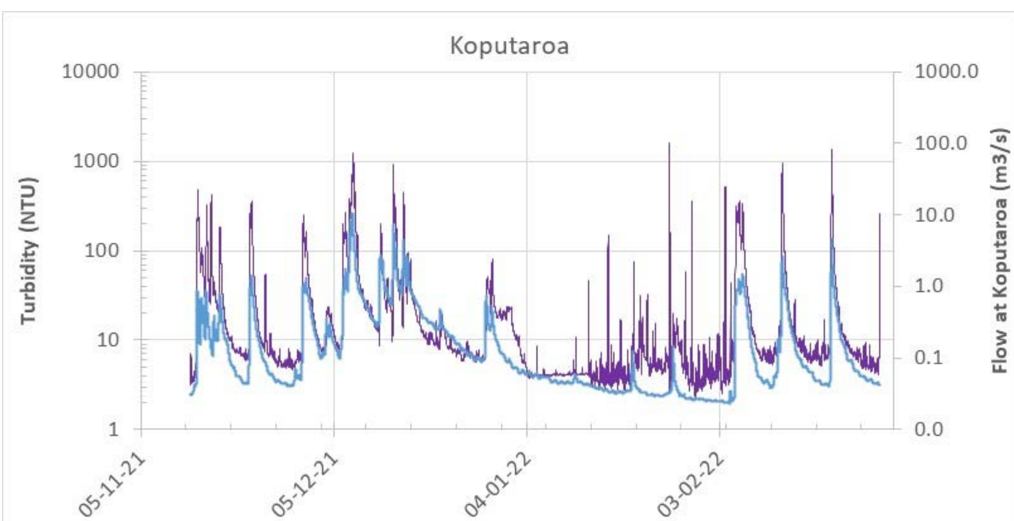
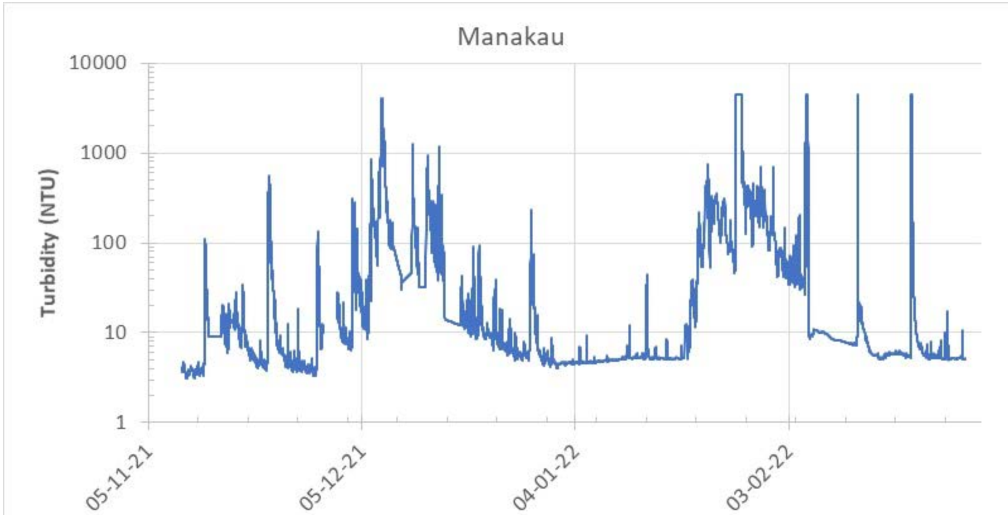


Figure H.3: Turbidity in the Ohau River and Koputaroa Stream (30-minute median of 10-minute readings).



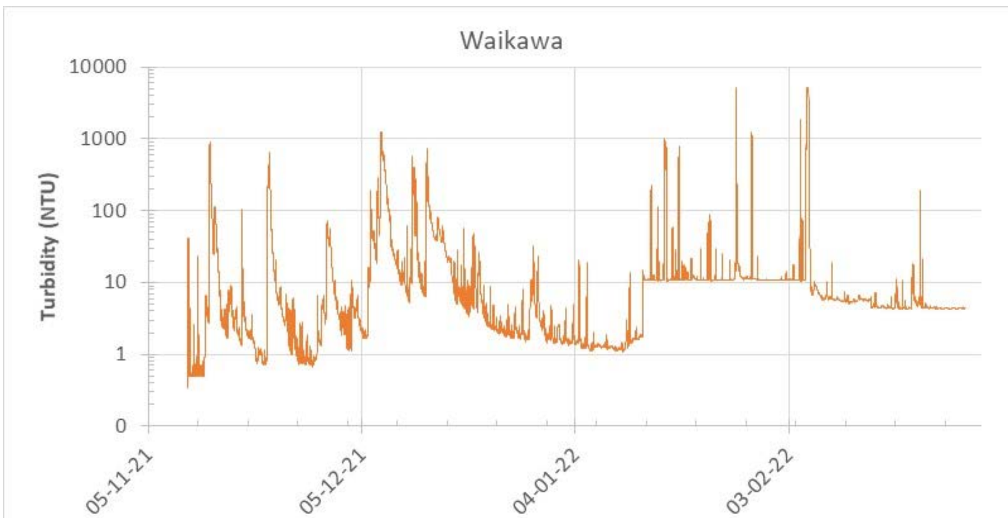


Figure H.4: Turbidity logger in Manakau Stream and the Waikawa Stream (30-minute median of 10-minute readings).

73. Detailed catchment descriptions (moving from north to south) are provided below, along with an overview of how the Ō2NL Project crosses and interacts with each catchment (identified in Figure H.1 above).

Koputaroa Stream (catchments O&P)

74. The Koputaroa Stream is a lowland tributary of the Manawatū River with a mean flow at SH57 of 0.327 m^3/s (REC). The catchment has alluvial / soft sedimentary geology and has a predominantly pastural landcover. There is important wetland habitat in the northeast of the catchment near Koputaroa

township (outside of the Ō2NL Project footprint) and small wetlands that provide a network of habitats west of Punahau / Lake Horowhenua.

75. The Koputaroa has a soft sediment substrate and poor water quality characterised by low water clarity (0.55 m), high concentrations of phosphorus (**P**), particularly high (poor) concentrations of nitrogen (**N**) and *E. coli* bacteria. The macroinvertebrate community index (**MCI**) scores (MCI = 88) are also indicative of NPS-FM Band D.

76. The Ō2NL Project will cross several tributaries of the Koputaroa Stream. Treated stormwater will be discharged to the headwaters of tributaries in catchment P (stream ID 42.3, 43), to stream ID 40 (mean flow 75 l/s) 900m from the main steam of the Koputaroa Stream, and directly to the Koputaroa Stream (catchment O). Streams 40 and 43 are both soft-bottom streams with a macroinvertebrate community indicative of fair-poor ecological health (MCI score of 74 and 83 respectively) (Technical Assessment K (Freshwater Ecology)).

Punahau / Lake Horowhenua catchment

77. The catchment is lowland and dominated by pasture, market gardens and urban land use. mean flow leaving Punahau / Lake Horowhenua is 0.97 m^3/s (REC) and measured median flow is 0.907 m^3/s (Horizons, 2013-2021).

78. Punahau / Lake Horowhenua has very poor water quality characterised by low water clarity (0.6 m in Patiki Stream), very high N and P, and high concentrations of *E.coli* bacteria. High N is of particular concern because N is more likely to be the limiting nutrient in Punahau / Lake Horowhenua during summer when there is internal P release from the lake sediments.

79. The Ō2NL Project alignment is within the groundwater catchment of Punahau / Lake Horowhenua; east of Levin and SH57 this catchment infiltrates to groundwater except during extreme rain-events (ie1 in 10-year events).

Ohau River (catchment M)

80. The Ohau River has an estimated mean flow of 5.6 m^3/s (REC) and a median flow at SH1 of 4.12 m^3/s (Horizons, 2011-2021 at Gladstone Reserve). The catchment land use is predominantly pasture at SH1 but there is extensive indigenous forest cover in the upper catchment upstream of Gladstone Reserve. The river terraces have patches of indigenous treeland (titoki, manatu, te kouka, and pukatea), and there are some lowland river terraces

with swamp forest (maire, tawake, pukatea) (Technical Assessment J (Terrestrial Ecology)).

81. There is a considerable decline in water quality in the Ohau River between Gladstone Reserve and SH1. Nevertheless, the Ohau River at SH1 has good water quality, with water clarity of 2.8 m and low concentrations of *E.coli* bacteria (median of 72 cfu/100 ml). DRP is within the One Plan targets and ANZG DGVs but DIN is just above the DGV. The concentration of SIN and DRP are still sufficiently low to exerts some limit on the rate of periphyton growth (Rier and Stevens, 2006) but SIN still exceeds the One Plan targets.

82. Downstream of SH1 the nitrogen concentrations considerably increase but the river still retains good water clarity and low *E. coli* bacteria.

83. The Ō2NL Project crosses the Ohau River with a bridge. Treated stormwater from the Ō2NL Project will be discharged to the Ohau River via a small tributary (stream ID 34, mean flow 37 l/s, 219ha) about 600m from the confluence with the Ohau River.

Kuku Stream (catchments K&L)

84. The Kuku Stream is a small lowland tributary to the Ohau River with a mean flow at SH1 of 0.142 m^3/s (REC). It has hard sedimentary geology, and the landcover in the catchment is predominantly pasture with scrub and wetland on riparian margins. Some indigenous tree cover (titoki and manuka and black beech) is present on the stream alluvium terraces.

85. The stream has a gravel bed and the macroinvertebrate community indicates “good” water and habitat quality with possibly mild pollution (MCI = 119). Horizons monitors the lower Kuku Stream at N Johnstone Farm Bridge, which indicates elevated nutrient levels in the downstream catchment. Grab samples collected for the Ō2NL Project indicate lower nutrient concentrations near SH1 (ie SIN of 0.4 mg/L and DRP 0.011 mg/L).

86. The Ō2NL Project crosses the Kuku Stream with a bridge with an armoured bed. Treated stormwater will discharge to the mainstream of the Kuku Stream (stream ID 32).

Waikawa Stream (catchment F)

87. The Waikawa Stream is a small hill-country stream with a mean flow of 1.36 m^3/s (REC) and a median flow of 0.905 m^3/s (Horizons, 2017-2021). The

catchment geology is hard sedimentary rock. The land cover is predominantly pasture catchment at SH1 but indigenous forest is dominant upstream of North Manakau Road. Riparian margins are well vegetated.

88. The Waikawa Stream at SH1 has good water quality, high water clarity (3.3 m) and low nitrogen. The concentration of P is just above the ANZG DGV and One Plan target, but is still sufficiently low to partially control periphyton growth.

89. The water quality of the Waikawa Stream considerably deteriorates downstream of SH1, with reduced clarity, very high N and *E.coli* bacteria concentrations well above ANZG DGVs and One Plan targets.

90. The Ō2NL Project will cross the Waikawa Stream with a 140m bridge. Treated stormwater from the Ō2NL Project will be discharged to the Waikawa Stream via an unnamed tributary (stream ID 27.1, mean flow 34 l/s, 221ha) about 70m from the confluence with the main stem. This small tributary has a gravel substrate with a high proportion of silt / sand (17%) and macroinvertebrate community indicative of moderate ecological health (MCI = 107) (Technical Assessment K (Freshwater Ecology)).

Manakau Stream (catchment F)

91. The Manakau Stream is a medium size lowland, gravel bed stream. At SH1 it has a mean flow of 0.305 m^3/s (REC) and a median flow at SH1 of 0.187 m^3/s (HRC, 2011-2021). The catchment geology is predominantly hard sedimentary, and the land use is predominantly pasture with some indigenous and exotic forest upstream. The stream bed substrate is predominantly large gravel.

92. The water quality is moderately-poor, with a median clarity of 1.0 m, and high concentrations of *E.coli* bacteria. Concentrations of N and P do not meet ANZG DGVs or One Plan targets, but are likely still sufficiently low to partially restrict the rate of periphyton growth (Rier and Stevenson, 2006).

93. The Mangahuia Stream (catchment I) is a tributary to the Manakau Stream with a mean flow of 47 l/s (REC) and a predominantly pastoral catchment. It has a gravel substrate with a high (30%) proportion of silt / sand. Macroinvertebrate sampling indicate it is on NOF band D (eg MCI of 90) (Technical Assessment K (Freshwater Ecology)). A single water quality sample from the Mangahuia Stream in 2015 indicated very high nitrate (4.9 mg/L) but this may not be representative.

94. The Ō2NL Project will cross the main stem of the Manakau Stream with a bridge. Treated stormwater from the Ō2NL Project will be discharged to the Mangahuia Stream (Catchment I), and to a small tributary of the Manakau (stream ID 17, catchment G) with mean flow of 10 l/s. This small tributary has substrate of about 60% silt / sand and low MCI scores of 63. The discharge point would be about 300m upstream of its confluence with the Manakau Stream.

Waiauti Stream (catchment E)

95. Waiauti Stream is a major tributary to the Manakau Stream that enters the Manakau just upstream of SH1 with a mean flow 0.121 m^3/s (REC). This small lowland stream has a catchment with hard sedimentary geology, and landcover predominantly in pasture or cropping. The substrate is predominantly gravel but silt and sand cover almost 20% of the stream bed (Technical Assessment K (Freshwater Ecology)).

96. The water quality of the Waiauti Stream is worse than that of the Manakau main stem, with turbidity, nitrogen and phosphorus levels about twice as high as the Manakau Stream. This probably reflects a greater proportion of farming in the catchment, with less forest cover.

97. The Ō2NL Project will cross Waiauti Stream with a bridge. Treated stormwater from the Ō2NL Project will be discharged directly to the Waiauti Stream (Catchment E).

Waitohu Stream Tributaries (catchments A,B,C,D)

98. The alignment crosses several small tributaries of the Waitohu Stream, each with a mean flow of about 0.034 m^3/s (REC). These are small, soft-bottomed lowland streams running through soft sedimentary geology. The substrate of the Waitohu and its tributaries is predominantly silt / sand. The catchment landcover is predominantly pasture catchment. The catchment is in the GWRC region.

99. These tributaries drain to the Forest Lakes and wetland system before entering the main stem of the Waitohu Stream (mean flow of 0.974 m^3/s at Norfolk Cres monitoring site).

100. The main stem of the Waitohu Stream at Norfolk Cres has low water clarity (0.93m), very high *E.coli*, and moderately high N and P concentrations. NH4-N is slightly elevated which may reflect the wet pastural landscape.

101. Treated stormwater from the Ō2NL Project will be discharged to several small tributaries of the Waitohu Stream, these are the section downstream of stream ID 7 to 10 (mean flow 33 L/s) (catchment C), and to stream ID 2 (catchment B) with mean flow of 43 l/s.

ASSESSMENT OF EFFECTS

Sedimentation from earthworks during construction

Potential effects of sediment in streams

102. Bulk earthworks, enabling works and vegetation removal associated with the Ō2NL Project's construction activities present a risk of erosion and sediment release. Sediment has a number of effects on stream water quality and aquatic life, including reducing water clarity, increasing turbidity and potential sediment deposition on the stream bed. High sediment loading can cause a combination of environmental changes that adversely affect fish, even when most taxa are tolerant of high sediment concentrations in the water itself for a short duration. These effects are discussed in detail in Technical Assessment K (Freshwater Ecology).

103. The native galaxiid, banded kōkopu (*Galaxias fasciatus*) reduce feeding and show avoidance behaviour when water turbidity is over 25 Nephelometric Turbidity Units ("**NTU**") (Richardson et al. 2001), but numerous studies have shown that sublethal turbidity has little direct effect on most other fish species (Rowe et al., 2002). Rowe et al. (2002) found that the supposedly 'sensitive' invertebrate and fish taxa were tolerant of very high levels of turbidity (over 24 hours), and even repeated exposures to 1000 NTU had no adverse effects on their survival. They concluded that;

> *"…their absence from urbanised catchments and their relative scarcity in turbid rivers and streams is not caused by turbidity per se, but most likely reflects a combination of other environmental changes associated with high loadings of suspended solids."*

104. The main ways in which suspended sediment affects aquatic macroinvertebrate abundance and diversity are:

(a) smothering and abrading;

(b) deposition reducing their periphyton food supply or quality; and

(c) deposition reducing available interstitial habitat.

105. Moreover, sediment deposition can alter substrate composition and change substrate suitability for some taxa (Wood and Armitage, 1997). These effects persist long after a rain event has stopped.

Mitigation proposed by ESC Assessment

106. The approach to ESC for the Ō2NL Project is described in the **Erosion and Sediment Control Report** (appended to the DCR (Appendix Four to Volume II). It is based on an overarching ESC framework, provided through an ESC Management Plan ("**ESCP**") coupled with Site Specific Erosion and Sediment Control Plans ("**SSESCPs**") (to be finalised in advance of earthworks commencing). These provide a hierarchy of measures including minimising sediment generation, and implementing sediment control for all sediment laden discharges - primarily by using chemically treated sediment retention ponds ("**SRPs**"). Importantly, **Mr Gregor McLean** (author of the ESCP) notes that the Project does not present any unique challenges and a high standard of ESC is achievable. These measures have been factored into the assessment below.

Potential effects of sediment from the Ō2NL Project

Suspended sediment loads

107. The sediment load from the Project footprint was estimated using USLE to be between 3.7 and 5.9 times higher during earthworks compared to before the earthworks (**Table H.15**). However, the estimated percentage increase in the suspended sediment load during earthworks for each stream is smaller, ranging from a 0.07% to 102% increase (**Figure H.16**). This is because the Project's earthwork footprint occupies only a fraction (and sometimes a very small fraction) of each catchment; and the suspended sediment yield ($t/km^2/yr$) was typically lower along the alignment than higher in the catchments where slopes were steeper.

108. The catchments with the highest percent increase in sediment load were those with the largest earthwork footprint relative to catchment size. These were Waitohu Tributaries (catchments B, C, D), Manakau tributary catchment G and Mangahuia Stream (catchment I).

Table H.15: Sediment load from earthwork sites after ESC measures as estimated using the USLE.

ID	Name	Earthwork Footprint from USLE calculations				
		Earthwork area (ha)	Sediment load with earthworks (t/yr)	Sediment load from Project footprint before earthworks (t/yr)	Increase in sediment load from Project footprint (fraction)	Project footprint as % of catchment
A	Greenwood	7.38	0.35	0.07	3.70	3.9%
B	Waitohu	20.30	18.27	2.64	5.92	14%
C	Waitohu 1	22.70	20.43	2.95	5.92	18%
D	Waitohu Trib 3	8.57	7.71	1.11	5.92	32%
E	Waiauti	11.75	10.58	1.53	5.92	1.5%
F	Manakau	2.73	2.46	0.35	5.92	0.4%
G	Manakau Trib	9.59	8.63	1.25	5.92	11.3%
H	Manakau Trib	3.85	0.18	0.04	3.70	4.5%
I	Mangahuia	28.87	4.91	0.87	4.67	14%
J	Waikawa	7.35	0.35	0.07	3.70	0.23%
K	Waikokopu	9.59	0.45	0.10	3.70	4.8%
L	Kuku	29.14	1.37	0.29	3.70	3.0%
M	Ohau	27.94	1.31	0.28	3.70	0.20%
O	Koputaroa	43.75	7.44	1.31	4.67	2.9%
P	Koputaroa Trib	27.19	4.62	0.82	4.67	4.6%

Table H.16: Sediment loads from catchments before and during earthworks. Based on sediment yields from NIWA SSY Estimator and increase in load from Table H.14.

ID	Name	Stream catchment (sediment yield from NIWA SSY Estimator)				
		Stream Catchment area (ha)	Catchment sediment Load before (t/y)	Footprint sediment Load before (t/y)	Footprint Sediment Load during earthworks	% increase in catchment sediment load during earthworks
A	Greenwood	187	76	1.9	7.0	6.7%
B	Waitohu	144	69	5.5	32.3	38.9%
C	Waitohu 1	127	79	4.2	24.9	26.2%
D	Waitohu Trib 3	27	8.0	1.7	9.9	102%
E	Waiauti	792	837	3.1	18.4	1.8%
F	Manakau	750	1,106	0.9	5.5	0.41%
G	Manakau Trib	85	45	3.3	19.4	36.0%
H	Manakau Trib	85	55	1.3	5.0	6.6%
I	Mangahuia	202	117	10.2	47.8	32.2%
J	Waikawa	3,211	8,153	2.5	9.2	0.08%
K	Waikokopu	198	163	3.3	12.3	5.5%
L	Kuku	960	1,088	9.4	34.6	2.3%
M	Ohau	13,687	32,426	8.9	33.1	0.07%
O	Koputaroa	1,489	1047	11.4	53.1	4.0%
P	Koputaroa Trib	595	81	3.0	14.0	13.5%

<u>Concentration of TSS and clarity in streams</u>

109. An indication on how the estimated changes in sediment load due to earthworks may influence concentrations of TSS and water clarity in the streams is provided in **Table H.17**. This table shows the current measured

average concentration of TSS in streams, and calculates a corresponding TSS during earthworks based on the previously estimated percent increase in catchment sediment loads. A corresponding clarity value was approximated using relationships derived from national datasets[8] (Franklin et al. 2019, Davies-Colley and Smith, 2001). There were no measured TSS concentrations for values in Catchment D, so a TSS concentration was assigned based on the concentrations in adjacent catchments. The analysis indicates that the estimated decline in water clarity due to earthwork induced sediment load is within the One Plan target of <30% change for all catchments except Catchment D, where the estimated decline is just under 40%.

110. The sediment load discharged from the earthwork sites will be skewed towards heavy rain events, when there will be more runoff from the site and less efficient treatment. Most of the additional load from the earthwork sites will be entering the stream during higher flows and flood events, while there is likely to be relatively little change in sediment loads during baseflow conditions.

Wetlands and downstream waterbodies

111. Technical Assessment J (Terrestrial Ecology) by **Mr Nick Goldwater** describes the terrestrial and wetland habitats along the Project route and the potential effects of the Project on these ecosystems. Seven catchments (catchments B, C, D, O and P) have wetlands downstream of the Project footprint that may be affected by discharges during construction or operation. These effects are briefly described in **Table H.23** in the context of operational stormwater; potential effects of sediment from construction are described below.

112. Catchment C and D are tributaries of the Waitohu Stream that discharge to the Paruauku Swamp and associated wetland downstream of the existing SH1. These tributaries will have a moderate to high increase in sediment load due to earthworks although the relative increase will be less at the wetland due to the larger catchment size. Potential effects on Paruauku Swamp will be partially buffered by dense *Glyceria maxima* in the tributary from Catchment D. Nevertheless, it is important that the SSESCP includes measures for minimising sediment discharges to these catchments.

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8 The formula used to convert TSS to black disk clarity (BD) was BD = 2.63 * (TSS * 0.6)^-0.807. Derived from relationships in national datasets (Franklin et al., 2019, Davies-Colley and Smith, 2001).

113. Te Waiaruhe Swamp is downstream of the Project alignment in the area between catchments M - O. The SSESCPs for this area should have a particular focus on minimising discharges to Te Waiaruhe Swamp, although the risk of construction sediment effects is considered low given the high infiltration properties of the soil.

114. Catchment P has several open water ponds and wetland features (eg creeping buttercup herbfield, and *Isolepis* sedgeland) which are potentially affected by construction sediment discharges. This catchment is predicted to have a moderate (14%) increase in sediment loads during earthworks, however, the overall increase will be higher at the head of the catchment, closer to the Project footprint and wetland features. The SSESCPs should include measures to minimising sediment discharges to these catchments.

Table H.17: Average TSS concentration in streams and a calculated TSS during earthworks based on the previously estimated percent increase in catchment sediment loads in Table H.16

ID	Name	TSS Before (mg/L)	TSS After (mg/L)	Clarity BD (m)	Clarity before (m) *	Clarity after (m) *	Clarity change (m)
A	Greenwood						
B	Waitohu	9.0	12.5	0.43	0.67	0.52	-23%
C	Waitohu 1	14.0	17.7		0.47	0.39	-17%
D	Waitohu Trib 3	20.0	40.5		0.35	0.20	-43%
E	Waiauti	65.0	66.2	0.65	0.14	0.13	-1.5%
F	Manakau	29.0	29.1	0.75	0.26	0.26	-0.3%
G	Manakau Trib						
H	Manakau Trib						
I	Mangahuia	89.0	117.7	0.63	0.11	0.08	-20%
J	Waikawa	2.5	2.5	1.73	1.90	1.89	-0.1%
K	Waikokopu						
L	Kuku	22.0	22.5	5.10	0.33	0.32	-1.8%
M	Ohau	1.7	1.7		2.59	2.59	-0.1%
O	Koputaroa	100	104	0.50	0.10	0.09	-3.1%
P	Koputaroa Trib						

Flocculants

115. For aquatic life, the deposition of sediment on the stream bed is more relevant than water column concentrations during flood events. The risk of sedimentation from discharges from treatment devices is reduced because appropriately designed treatment devices like SRPs with chemical treatment are particularly effective at removing the fraction of sediment most prone to settling.

116. However, chemical treatment using flocculants like PAC can reduce the pH of the treated water. Potential adverse effects of lowering pH in the receiving environment can be avoided by ensuring appropriate dosing rates – as described in the ESC Management report (attached to the DCR, Appendix Four to Volume II).

Summary

117. The bulk earthworks during construction will increase sediment loss, and this will be particularly apparent during high flow events. The analysis highlights the need for robust ESC management, including the use of chemically treated SRPs, and robust monitoring. The construction effects on water clarity were calculated to be within One Plan targets for all catchments except Catchment D, where there may be a 40% decline in clarity. I estimate that the magnitude of effects of sediment after E&SC mitigation ranges from **'Low' to 'High'** for different catchments. However, the overall effects on aquatic life will depend in part on the sensitivity of the aquatic life in the streams which is discussed in Technical Assessment K (Freshwater Ecology).

118. I recommend that during the construction phase, instream monitoring is prioritised for catchments that have both a high risk of sediment release from earthworks and high ecological values. Catchments recommended for monitoring because of higher risk of sediment increase are: catchment B (Waitohu); catchment C (Waitohu) (also sensitive due to Forest Lakes being downstream); and Catchment I (Mangahuia). In addition, some catchments with low risk of sediment increase due to the Project may be prioritised for monitoring if they have high ecological sensitivity as identified in Technical Assessment K (Freshwater Ecology). Monitoring sites will be confirmed in the Environmental Monitoring Plan (EMP).

Water quality effects from vegetation clearance

Potential effects of wood slash in streams

119. Vegetation clearance can have a number of potential effects on nearby streams. Felling and removal of trees can expose soil, make it more prone to erosion and cause sedimentation, the effects of which are discussed above. In addition, the accumulation or storage of sawdust, chip or mulch near or over waterways can cause serious water quality effects if it occurs.

120. The bulk storage of woodchip and wood residue can produce leachate with a high Biological Oxygen Demand ("**BOD**") as well as organic dissolved organic matter that promotes the growth of heterotrophic organisms (eg bacterial mats and 'sewage fungus'). Both the BOD load and heterotrophic growths deplete dissolved oxygen from the water and sediments, with consequent adverse effects on aquatic life.

121. Leachate from storage of wood residue can also leach potentially toxic compounds in the form of tannins, phenols, and resin acids. The toxicity of these compounds tends to reduce with increasing pH (Samis et al., 1999).

122. The effect on streams of woodchip residue from vegetation clearance depends on the amount stored, proximity to waterways, size of the waterways and mitigation. A moderate amount of woodchip beside a stream has negligible effects and is commonly used to positive effect as part of restoration planting. Similarly, small amounts of woodchip entering a stream will have negligible adverse effects. However, if situations occur where vegetation clearance causes piles of woodchip to cover a waterway, the effect on the aquatic life can be large, due to deoxygenation causing the loss of invertebrate and fish life downstream, until sufficient reaeration or dilution occurs. To reiterate, coarse woody debris is an important part of stream habitat, but excessive amounts of fine material like mulch can cause adverse effects to watercourses.

Potential effects from the Ō2NL Project

123. Only relatively small amounts of large woody vegetation will need to be cleared for the Ō2NL Project in any one catchment. Large woody vegetation within the Ō2NL Project footprint is mostly shelterbelts, scattered trees and scrubland. The largest stand of trees that may need to be cleared is 4300m^2 near a tributary of Waitohu Stream (stream ID 11 in catchment D). Also, there is about 2700m^2 of trees downstream of the Waikawa Stream crossing (catchment J) but little (if any) will require clearing. The wood chip from these relatively small areas should be easy to manage.

124. To avoid and minimise the risk of vegetation clearance affecting water quality, it is recommended that the **EMP** includes measures to avoid and minimise leaching of wood chip residue to waterways. Procedures for avoiding and minimising adverse effects of mulch on water quality include:

(a) minimising the area and duration of soil exposure from vegetation clearance;

(b) minimising the volume of vegetation to be mulched;

(c) locating wood residue piles with an appropriate separation distance from any waterways (ie 10 - 20m); and

(d) managing potential leachate from these piles.

(e) The Ō2NL Project should set aside large woody debris for later use in rehabilitating the site and streams.

125. Overall, the effect of vegetation clearance on stream water quality is expected to be **negligible**, but good practice should be followed to prevent leaching of wood chip residue to waterways or overland flow paths.

Water quality effects from concrete and other hazardous chemicals during construction

Potential effects of concrete in streams

126. Water that comes in contact with cement, uncured concrete, concrete fines, concrete dust or concrete wash water can become very high in pH. If this runoff enters receiving waters untreated it can have adverse effects on aquatic life and ecosystems. There is a wide range of sensitivities of freshwater fish and invertebrates to pH, but most aquatic invertebrates and fish are tolerant to pH in the range of 6 – 9 (Davies-Colley et al., 2013). Causing pH to extend outside this range has the potential to adversely affect aquatic ecosystems directly and indirectly (eg by increasing the toxicity of total ammoniacal nitrogen) and is likely to change some geochemical processes.

127. The One Plan Schedule E surface water quality targets for river pH is to remain in the range 7 to 8.5 and for discharges to not change the pH by more than 0.5 units. The PNRP requires that point source discharges do not change the pH by more than 0.5 units.

128. The strongest effect of concrete on pH occurs while the concrete is curing and the hydration process releases hydroxyl ions into the water. Concrete curing can take up to four weeks and the effect on pH reduces over this time.

Potential effects of hazardous chemicals

129. The improper storage and use of hazardous chemicals during construction can negatively impact water quality. A wide range of chemicals such as oil, diesel, lubricants, sealants, paint etc. are used on construction sites. Leaks and spills can pollute groundwater and surface water. This can lead to toxic conditions and adversely impact water quality and aquatic ecology.

Potential effects from the Ō2NL Project

130. Construction for the Ō2NL Project is likely to require the pouring of concrete in or near waterways for bridge piles, culvert installation, and the lining of some open channels. Concrete batching plants will also be established on site. In situations where cement or uncured concrete may come into contact with surface water, high pH water will need to be contained, collected and/or treated (Law and Evan, 2013, Fitch, 2003, Setunge et al, 2009). Particular care is needed when there are large areas of curing concrete near small or sensitive waterways.

131. The risk to water quality associated with uncured concrete can be avoided by the use of pre-cast concrete. If in-situ concreting is required, impacts can be minimised by:

(a) locating concrete batching plants away from watercourses;

(b) undertaking works in dry conditions;

(c) containing the concrete (eg through the use of bunding or sheet piles);

(d) use of anti-washout admixture or colloidal grout mixes:

(e) minimising the surface area of curing concrete exposed to the water (eg dewatering; using covers and containment structures);

(f) managing the rate of pumping relative to the flow of water;

(g) washing contaminated vehicles and equipment in designated areas away from streams; and

(h) collecting and treating contaminated water prior to discharge.

132. Measures to control potential contamination with concrete curing need to be in place for four weeks until the concrete curing is complete.

133. A Hazardous Substances Procedure ("**HSP**") should be developed as part of the Construction Environmental Management Plan ("**CEMP**") to describe the processes to be implemented to minimise potential risks of hazardous chemicals (including cement) to aquatic life. These are standard practices to avoid and minimise adverse effects and, provided appropriate management practices are implemented, the risk of cement and concrete causing adverse water quality effects on streams will be **low**. Technical Assessment K (Freshwater Ecology) further discusses this risk in the context of ecological sensitivity of the receiving waters.

134. The HSP should also cover procedures to avoid and minimise the risk from other hazardous chemicals such as oil, diesel, lubricants entering the water. This should include storing those materials in bunded containment facilities, minimising the volumes kept on site, staff training and emergency procedures in case of a spill.

Road stormwater runoff during long term operation

Potential effects of road stormwater runoff on streams

135. Stormwater discharges can have multiple levels of effects on streams by affecting stream hydrology and morphology, water quality and the water temperature regime (Storey et al., 2013, Walsh et al., 2005). The magnitude of these effects is generally a function of:

(a) the percentage of impervious surface in the catchment;

(b) type of land use;

(c) amount of traffic on the road;

(d) how the stormwater is treated; and

(e) sensitivity of the receiving waterbody.

136. In this section I have addressed potential hydrology, water temperature and water quality effects as they relate to aquatic ecosystem health. These issues have been considered together here, rather than split between different reports, because they have a common driver with extent of effective impervious surface and a similar approach to assessing their effects. I have not assessed flood risk. Hydrological and flooding issues are specifically addressed in Technical Assessment F (Hydrology and Flooding) and Technical Assessment G (Hydrogeology and Groundwater).

Hydrology and morphology

137. Stormwater discharges can alter stream hydrology. An increase in impervious surfaces from roads and urbanisation can increase flood peaks and volume causing them to be more ‘flashy’ than natural streams, and result in greater downstream erosion. As a result, urban streams are often deeper and wider than natural streams, become simpler and uniform, and have more fine sediment on the beds. This can result in less diversity and abundance of macroinvertebrates and fish in the stream. Significant ecological degradation of streams can occur when the total impervious area in the catchment is as low as 10% or less, but the response of streams is variable and often there is a gradient of deterioration due to multiple pressures rather than a threshold response. The adverse effects of imperviousness can be minimised by reducing the direct hydraulic connection of stormwater to streams (eg by using stormwater retention or soakage) to reduce the “effective impervious surface” (Storey et al., 2013, Walsh et al., 2005). Importantly, managing the hydrological effects is more than just managing the effects of large floods, but considers the total volume of runoff and the magnitude and volume of small events.

138. The potential effects of stormwater on hydrology can be minimised by reducing the amount of impermeable area, and by using stormwater management devices that enhance infiltration and flow detention. It is more ecologically beneficial to increase infiltration rather than rely solely on detention of collected stormwater as this helps maintain baseflows and minimises the volume of flood flows (Storey et al., 2013).

Thermal pollution

139. Water temperature has a strong influence on the distribution of aquatic biota. It directly affects metabolism and indirectly affects biota by influencing pH, dissolved oxygen and algae growth.

140. Stormwater runoff from roads can lead to thermal pollution of streams and rivers. Runoff from roads and pavements has been found to increase the temperature of small urban streams by as much as 12°C (James and Xei, 1999).

141. Runoff from treatment devices like wet ponds can still have high water temperatures. The frequency and severity of warm water discharges from ponds reduces with smaller surface area, increased shading and shorter

retention periods. The quantity of runoff is dependent on the water level of the pond prior to a storm event. Elevated water temperatures from ponds can persist in small waterways for several hundred metres downstream of ponds as water cools at a rate of about 1°C per 100m (Maxted et al., 2005), but thermal effects can be small if there is good riparian vegetation or if water is conveyed underground prior to discharge (Chung, 2007).

142. Thermal pollution from stormwater can be reduced by reducing the amount of impermeable area, maximising infiltration (eg grass swales and infiltration trenches), using vegetated treatment wetlands and increasing shading (of the stream or treatment devices). Swale vegetation cools the first flush of stormwater. Vegetated treatment wetlands can mitigate thermal pollution by providing shading, evapotranspiration and infiltration. Wetlands also mitigate the thermal load by capturing small rain events entirely (Young et al., 2013).

<u>Water quality</u>

143. Stormwater runoff from roads can contain a wide range of contaminants including: TSS, chemical oxygen demand, BOD, oil and grease, TPH, polycyclic aromatic hydrocarbons ("**PAH**"), heavy metals (most commonly cadmium (Cd), copper (Cu), lead (Pb), Nickel (Ni) and zinc (Zn)), faecal indicator bacteria (eg *E. coli*) and nutrients (nitrogen and phosphorus). The concentration of nutrients and faecal bacteria are typically less than that found in runoff from agricultural land. Stormwater from rural road runoff typically has little microbiological contamination (eg *E. coli* bacteria) due to low loading and bacteria die-off between rain events (Fernandes and Barbosa, 2018).

144. The contaminants most commonly monitored in road runoff are TSS, heavy metals (eg Cu, Zn and Pb), and hydrocarbons (eg PAH or TPH). Copper and zinc are important constituents in brake linings and tyres respectively. Braking and tyre wear results in the emission of brake pad and tyre debris, containing these metals, to the road surface. Hydrocarbon compounds are emitted to the road surface from oil, grease and fuel leakages and spills, and from exhaust emissions. Metals and hydrocarbons are strongly associated with sediment fractions, but some are also in a dissolved form (Waka Kotahi, 2010, Fernandes and Barbosa, 2018).

145. The CLM models TSS, Cu, Zn and TPH. Treating for these contaminants is also effective at removing a wider range of other associated contaminants. For example, road stormwater typically has lead concentrations less than that

of copper, but lead is much more strongly bound to sediment (typically 90% as particulate) and therefore more easily treated (Cunningham et al., 2017, Fernandes and Barbosa, 2018).

146. PAHs are sourced from vehicle exhaust fumes, lubricating oils, and seal wear. They sorb strongly to sediments and are more persistent and in higher concentrations in colder climates. The amount of PAH emitted from vehicles has considerably reduced since vehicle emission standards were introduced in 2003 (Kennedy et al., 2016, Fernandes and Barbosa 2018).

147. TPHs are a common measure of hydrocarbons and a useful indicator of petroleum contamination. Analysis can divide TPH into fractions to give an indication or the likely source of contamination.

Typical stormwater quality from roads

148. NIWA has compiled contaminant concentrations in stormwater monitoring from around New Zealand in the Urban Runoff Quality Information System (**URQIS**). **Table H.18** shows the median and mean concentration of contaminants in untreated stormwater from motorways and roads. It shows that relative to ANZG DGVs, typical road stormwater can be high (two to five times the DGV) in sediment, copper and zinc, but generally low in lead. The DGVs applied in the table for Cu, Zn and Pb relate to chronic toxicity and have not been adjusted for hardness or dissolved organic carbon, but nevertheless illustrate the value in treating road runoff.

149. There is limited data available for nutrients and *E.coli* bacteria, but the available data points to rural stormwater having higher concentrations of nitrogen and *E.coli* bacteria, but lower concentrations of phosphorus compared to high traffic roads. Again, the data indicates value in treating road runoff to reduce nutrient loads to streams.

Table H.18: Typical untreated stormwater water quality in reported in NIWA Urban Runoff Quality Information System (URQIS), compared to guideline values (https://urqis.niwa.co.nz).

Variable mg/L; (cfu/100mL)	Motorways NIWA URQIS median	 mean	Road 5000-20000 vpd NIWA URQIS median	 mean	Rural NIWA URQIS median	 mean	ANZG DGV WW/L	 CW/H	 CW/L
TSS	59	150	47	170	9.5	25	8.8	2.6	1.8
TN			*1.5*	*1.4*	*3.1*	*3.7*	0.292	0.232	0.272
NO3-N			*0.52*	*0.42*			0.065	0.087	0.17
NH4-N			*0.12*	*0.22*	0.12	0.43	0.01	0.006	0.009
TP			*0.24*	*0.24*	*0.094*	*0.21*	0.024	0.016	0.018
DRP			*0.064*	*0.14*	*0.026*	*0.074*	0.014	0.008	0.011
E.coli bacteria			*860*	*6800*	*2800*	*22000*	628	92	395
Zn total	0.083	0.14	0.07	0.12	*0.057*	*0.088*			
Zn dissolved	0.017	0.03	0.017	0.02	*0.052*	*0.054*	0.008	0.008	0.008
Cu total	0.018	0.026	0.013	0.023	*0.0028*	*0.0048*			
Cu dissolved	0.0072	0.0084	0.0034	0.005	*0.0016*	*0.0018*	0.0014	0.0014	0.0014
Pb total			0.0084	0.021	*0.0005*	*0.001*			
Pb dissolved			0.00033	0.00044	*0.0001*	*0.0002*	0.0034	0.0034	0.0034

Values in italics are based on a small (n<50) sample size.

Stormwater treatment proposed

150. Almost all stormwater from the Ō2NL Project will be treated by multiple treatment devices in series. The proposed treatment train has been previously discussed and summarised for each catchment in (Table H.1); details are in the Stormwater Management Design attached to the DCR (Volume II) and Drawings and plans in Volume III. I support the proposed treatment train as an effective approach to minimising and mitigation combined effects of stormwater on water quality, water temperature, and the hydrology.

151. Treatment wetlands can also provide ecological benefits in the landscape. These benefits have not been specifically considered in this assessment, but are discussed in Technical Assessment K (Freshwater Ecology).

Potential effects of stormwater from the Ō2NL Project

<u>Hydrology and Temperature</u>

152. The effect of operational stormwater from the Ō2NL Project on the hydrology and temperature changes of receiving water is determined by its contribution to the percentage of impermeable land in the catchment and the type of treatment and attenuation. For those catchments receiving treated

stormwater, the total impermeable surface from roads after the Ō2NL Project (SH1, SH57, local roads and the new road) is highest in catchments C (5.8%), G (5.5%), I (3.7%) and B (3.2%). These are small percentages with a **low risk** of causing hydraulic or temperature effects on the streams.

153. Some of the proposed stormwater treatment wetlands (noting that the design shown is in concept only) will discharge to tributaries or near the head of the catchment, ie:

(a) Koputaroa catchment P (WP1 to head of stream ID 42.3, WP2 to stream ID 42);

(b) Koputaroa catchment O (WP3 to stream ID 40);

(c) Ohau catchment M (WP10 to stream ID 34);

(d) Waikawa catchment J (WP13 to stream ID 27.1);

(e) Mangahuia Stream catchment I (WP14 to stream ID 22 and 23); and

(f) Waitohu Trib catchment C (WP17 to Stream ID 6 to 10).

154. The total impermeable area to the receiving tributary sub-catchments after the Project will be:

(a) catchment P (stream ID 42/ 43), 17.4%;

(b) catchment O (stream ID 40), 7.3%;

(c) catchment M (stream ID 34) 10.6%;

(d) catchment J (stream ID 27) 2.7%;

(e) catchment I (stream ID 22 to 23) 17.6%; and

(f) catchment C (stream ID 6 to 10) 7.7%.

155. For receiving tributaries in catchments P, M and I the total impermeable area indicate a potential risk of adverse ecological effects from changes in hydrology or temperature for these streams. The risk is partially mitigated with the use of the proposed stormwater treatment devices and could be further mitigated with infiltration. The risk is also mitigated by the nature of these systems: Stream 42 is a pond environment, and Stream 34 is a remnant flood channel and only flows ephemerally. Stream 22 and 23 are

already deeply incised streams with flashy hydrology due to the topography (Alex James pers. com., 2022).

156. Some catchments (A, D, H and K) will not receive any stormwater as the road stormwater will discharge via the swales and treatment system to adjacent catchments. The percent of the catchment covered by the Project in catchments A, D, H and K is 0.8%, 4.8%, 1.1% and 1.3% respectively – which will correspond to "**negligible**" to "**low**" changes in hydraulic conditions.

157. Overall, the effect of operational stormwater from the Ō2NL Project (after treatment) on changes in the hydrology or water temperature of streams is likely "**Negligible**" or "**Low"** in all catchments. The highest risk (albeit still relatively low) is with treatment wetlands WP 1 (catchment P), WP2 (catchment P), WP10 (catchment M) and WP14 (catchment I).

Water Quality

158. Estimates from the CLM show that during the operational phase of the Ō2NL Project, there will be an overall net reduction in contaminants (TSS, Zn, Cu, TPH) entering waterways of all the major catchments (ie Waitohu, Manakau, Waikawa, Ohau, Koputaroa). This is because of the high level of treatment provided by the Ō2NL Project (**Table H.19**) and the reduction in traffic loads on the current SH1 and SH57 (which have no formal treatment).

159. While the Ō2NL Project will result in an overall reduction in contaminant loading, there is a small predicted increase in TPH due to the Project in the Waitohu Trib. (catchment B), Kuku Stream (catchment L) and Koputaroa Trib. (catchment P) (**Table H.20**).

160. The net reduction in contaminant load occurs because the Project will shift traffic from the current SH1 and SH57 (which have no formal stormwater treatment), to the new road (which will have extensive stormwater treatment). The sub-catchments calculated to have an increase in contaminant load (or only a small decrease) are those with a small length of SH1 draining to their catchment relative to a larger length of the new road draining to their catchment. In addition, the Ō2NL Project is predicted to cause an overall increase in traffic volumes due to induced demand.

161. If the CLM calculations are restricted to contaminants derived from road surfaces only, then there are theoretical increases in TPH, Zn, and/or TSS for Catchments B, E, L and P (**Table H.21**). The difference between calculations

for the “whole-of-catchment” compared to “roads only” is because the “whole-of-catchment” load accounts for the footprint of the new road replacing pasture and its corresponding contaminant yield.

162. **Table H.22** shows a high-level estimate of the mean concentration of contaminants discharged from treatment devices, the minimum hydraulic dilution ratio required to achieve guideline values, and the hydraulic dilution available in the modelled catchment and (where applicable) the tributary receiving the stormwater. A hydraulic dilution ratio of “1” indicates the mean discharge concentration would be at the applied guideline value, while a hydraulic dilution ration of “2” indicates a minimum dilution of at least twice as much volume downstream of the discharge compared to the discharge itself. The analysis indicates that typical discharges have an event-average concentration of TSS and TPH within the guideline for all catchments, while the typical event-average concentration of Zn and Cu are close to the guideline values. The sub-catchments requiring the highest dilution are the Waikawa Stream and the Ohau River, these require a hydraulic dilution of 3.7 and 2.1 respectively for copper to meet guideline values after mixing. This amount of dilution will easily be achieved during rain-events, even in the small tributary stream that will receive the discharge in the Waikawa catchment.

163. The analysis should be viewed as a risk assessment rather than a prediction of discharge quality, because it makes simplistic assumptions about the volume of annual rainfall that discharges via the treatment devices and the relationship between concentrations and flow. The analysis is conservative because road contaminant concentrations are typically highest in the first flush of rain, and for smaller rain-events much of the first flush will go to infiltration. The analysis for metals is also conservative because the CLM predicts total contaminant concentrations, while the guideline values are applicable to dissolved concentrations – which are much lower.

164. Overall, the Ō2NL Project will result in a net reduction in road related contaminants (TSS, Zn, Cu and TPH) entering waterways of all the major catchments (ie Waitohu, Manakau, Waikawa, Ohau, Koputaroa) crossed by the route. This is because traffic will be shifted from the current SH1 and SH57 (which have no formal stormwater treatment), to the new road (which will have extensive stormwater treatment). Catchments B, L and P may have an increase in contaminant load of TPH, in part due to the small length of SH1 draining to the catchment relative to a larger length of the new road.

The risk of adverse ecological effects is low for all catchments and contaminants, because the modelled concentration of contaminants in the stormwater discharges after treatment are within guideline values either at the point of discharge or after reasonable mixing (also refer to Technical Assessment K (Freshwater Ecology)).

Table H.19: The load of contaminants from the Project stormwater discharges (including batter slopes) and percent removal by the treatment train.

Cat id	Name	Before Treatment				After Treatment				Percent load reduction			
		TSS (kg/yr)	Zn (kg/yr)	Cu (kg/yr)	TPH (kg/yr)	TSS (kg/yr)	Zn (kg/yr)	Cu (kg/yr)	TPH (kg/yr)	TSS	Zn	Cu	TPH
A	Greenwood												
B	Waitohu Trib 2	4,168	6.15	2.24	43.3	582	2.49	0.689	17.7	86%	60%	69%	59%
C	Waitohu Trib 1	6,964	8.94	3.25	62.7	476	2.47	0.678	15.8	93%	72%	79%	75%
D	Waitohu Trib 3												
E	Waiauti	3,378	3.67	1.33	25.6	276	1.16	0.270	6.7	92%	69%	80%	74%
F	Manakau	3,401	4.07	1.48	28.5	216	1.12	0.235	6.3	94%	72%	84%	78%
G	Manakau Trib	3,787	5.47	1.99	38.5	268	1.52	0.416	9.7	93%	72%	79%	75%
H	Manakau Trib												
I	Mangahuia	7,027	9.57	3.48	67.2	489	2.65	0.727	16.9	93%	72%	79%	75%
J	Waikawa	2,146	2.64	0.96	18.5	460	1.45	0.467	9.4	79%	45%	51%	49%
K	Waikokopu												
L	Kuku	11,796	12.86	4.66	89.8	836	3.69	1.024	23.6	93%	71%	78%	74%
M	Ōhau	7,494	9.07	3.29	63.5	662	2.88	0.822	18.3	91%	68%	75%	71%
M-O	East Levin	32,351	19.90	7.13	135.3	1,436	3.24	0.635	16.2	96%	84%	91%	88%
O	Koputaroa	14,346	10.70	3.88	74.5	879	2.91	0.802	18.8	94%	73%	79%	75%
P	Koputaroa Trib	3,773	2.05	0.74	14.3	398	0.87	0.273	5.7	89%	58%	63%	60%
	Average									91%	68%	76%	71%

Table H.20: Change (After Ō2NL Project - Before Ō2NL Project) and percent change in whole of catchment contaminant loads as estimated using the CLM.

Cat id	Name	TSS (g/yr)	Zn (g/yr)	Cu (g/yr)	TPH (g/yr)	TSS % Δ load	Zn % Δ load	Cu % Δ load	TPH % Δ load
A	Greenwood								
B	Waitohu Trib 2	-7,589,486	-161	-218	1,400	-2%	-1%	-5%	8%
C	Waitohu Trib 1	-13,603,625	-3644	-1443	-22,943	-4%	-19%	-29%	-54%
D	Waitohu Trib 3								
E	Waiauti	-6,387,626	-212	-185	-1,155	0%	0%	-1%	-12%
F	Manakau	-6,662,632	-1611	-709	-10,878	0%	-1%	-3%	-51%
G	Manakau Trib	-7,230,676	-1232	-530	-7,392	-6%	-17%	-28%	-38%
H	Manakau Trib								
I	Mangahuia	-13,193,154	-552	-343	-1,584	-4%	-3%	-9%	-7%
J	Waikawa	-4,061,112	-1510	-565	-9,678	0%	-1%	-2%	-38%
K	Waikokopu								
L	Kuku	-22,261,564	-140	-204	3,508	-1%	0%	-1%	13%
M	Ōhau	-14,220,054	-2200	-853	-10,406	0%	0%	-1%	-25%
M-O	East Levin								
O	Koputaroa	-29,547,250	-2320	-876	-8,634	-1%	-2%	-3%	-13%
P	Koputaroa Trib	-8,045,239	-224	-64	606	-1%	-1%	-1%	3%
A, D, H, K	No discharge	-1,142,165	-7295	-2614	-49,863	0%	-15%	-24%	-87%
d/s Tot.	Downstream	-1,171,448	-9994	-3508	-65,266	-16%	-68%	-68%	-68%

Table H.21: Change (After Ō2NL Project - Before Ō2NL Project) and percent change in contaminant loads due to roads only, for each catchment as estimated using the CLM.

Cat id	Name	TSS (g/yr)	Zn (g/yr)	Cu (g/yr)	TPH (g/yr)	TSS % Δ load	Zn % Δ load	Cu % Δ load	TPH % Δ load
A	Greenwood								
B	Waitohu Trib 2	-100,989	101	-165	1,400	-9%	4%	-18%	8%
C	Waitohu Trib 1	-1,150,037	-3208	-1356	-22,943	-50%	-52%	-61%	-54%
D	Waitohu Trib 3								
E	Waiauti	-52,143	10	-141	-1,155	-4%	1%	-27%	-12%
F	Manakau	-503,507	-1395	-666	-10,878	-18%	-45%	-59%	-51%
G	Manakau Trib	-448,904	-995	-482	-7,392	-34%	-35%	-48%	-38%
H	Manakau Trib								
I	Mangahuia	-292,211	-100	-253	-1,584	-16%	-3%	-21%	-7%
J	Waikawa	-342,865	-1380	-539	-9,678	-12%	-37%	-40%	-38%
K	Waikokopu								
L	Kuku	-9,383	639	-48	3,508	0%	16%	-3%	13%
M	Ōhau	-551,663	-1721	-758	-10,406	-10%	-26%	-34%	-25%
M-O	East Levin	-2,461,764	-12258	-4496	-74,571	-12%	-39%	-42%	-39%
O	Koputaroa	-193,010	-1293	-671	-8,634	-2%	-13%	-18%	-13%
P	Koputaroa Trib	197,721	65	-6	606	5%	2%	-1%	3%
A, D, H, K	No discharge	-2,092,237	-7328	-2621	-49,863	-44%	-87%	-87%	-87%
d/s Tot.	Downstream	-2,836,448	-10052	-3519	-65,266	-38%	-68%	-68%	-68%

Table H.22: Average concentration of contaminants in stormwater (after treatment and before mixing), dilution required to meet guideline values (assuming runoff of 731mm/yr), and dilution available from the catchment and receiving tributary.

Cat id	Name	Mean concentration discharged TSS (g/m3)	Zn (g/m3)	Cu (g/m3)	TPH (g/m3)	Minimum hydraulic TSS	Zn	Cu	TPH	Dilution catchment	Dilution receiving Trib.
A	Greenwood										
B	Waitohu Trib 2	13.2	0.056	0.016	0.40	0.3	1.3	1.6	0.8	24	24
C	Waitohu Trib 1	6.4	0.033	0.009	0.21	0.1	0.8	0.9	0.4	13	9
D	Waitohu Trib 3										
E	Waiauti	7.5	0.032	0.007	0.18	0.2	1.1	0.7	0.4	158	158
F	Manakau	as above				as above				307	307
G	Manakau Trib	6.7	0.038	0.010	0.24	0.1	0.9	1.0	0.5	15	11
H	Manakau Trib										
I	Mangahuia	6.5	0.035	0.010	0.23	0.1	0.8	1.0	0.5	20	4
J	Waikawa	17.6	0.055	0.018	0.36	0.4	1.8	4.2	0.7	897	62
K	Waikokopu										
L	Kuku	6.5	0.029	0.008	0.18	0.1	1.0	0.8	0.4	55	51
M	Ōhau	8.0	0.035	0.010	0.22	0.2	1.2	2.3	0.4	1214	13
M-O	East Levin										
O	Koputaroa	5.3	0.018	0.005	0.11	0.1	0.4	0.5	0.2	66	58
P	Koputaroa Trib	6.1	0.013	0.004	0.09	0.1	0.3	0.4	0.2	67	7
Guideline applied *		50	0.03 / 0.042	0.0043/ 0.01	0.5						

Water quality effects on wetlands

165. This section discusses the potential water quality effects on wetlands from discharges associated with the Project operation and construction. It should be read in conjunction with Technical Assessment J (Terrestrial Ecology) by Mr Goldwater, which describes the potential effects of the Project on wetlands, including those within the footprint and immediately adjacent to the construction buffer.

166. Wetlands that may be affected by discharges from the Project are identified in **Table H.23**. Three stormwater treatment devices (located in catchments C and P) will have discharges that could affect a downstream natural wetland. The effects of operational stormwater on these wetlands are discussed below:

167. In Catchment C (Waitohu Trib. 1) water treatment device WP17 discharges to the Waitohu Tributary which enters into the Paruauku Swamp about 600 m downstream of the existing SH1. The CLM shows a net reduction in key contaminants (TSS, Zn, Cu, TPH) from the Project. This is a positive

outcome, although the overall effect on the waterbodies will be very small compared to the catchment loads.

168. In Catchment P (Koputaroa Trib.) the stormwater treatment device WP1 will discharge to an open water pond. Part of the existing pond and most of the associated wetlands will be lost under the construction footprint. Also in catchment P, the discharge from stormwater treatment device WP2 is about 120m upstream of a series of seepage wetlands (characterised by *Isolepis prolifera* sedgeland), but drainage water is expected to have little connection with the wetlands on the gully slopes. The Project will result in a small net reduction in most contaminants (TSS, Zn, Cu); there may be an increase in TPH, but it will remain well within guidelines values after mixing.

Table H.23: Wetlands potential effected by discharges from the Project.

Cat id	Name	Stormater device u/s	Wetlands persent downstream of new road
A	Greenwood	None	None
B	Waitohu	None	Water celery herbfield wetland (EWH3) on north branch of Waitahu Trib 2. is u/s of operational SW discharge and likely lost under footprint
C	Waitohu 1	WP17	Paruauku Swamp d/s SH1 receives Waitahu Trib., which receives discharge from treatment wetland WP17. Small wetland (MWG1d) adjacent to WP17 likley lost under footprint.
D	Waitohu Trib 3	None	Head water of catchment that connects to Paruauku Swamp d/s of the current SH1. No operational SW. Focus for E&SC to avoid/minimise sediment from construction (low risk)
E	Waiauti	None	None d/s, but some small wetlands (EWH7 -waterpeper mercer grass) are lost under footprint.
F	Manakau	None	None
G	Manakau Trib	None	None
H	Manakau Trib	None	None
I	Mangahuia	None	None d/s, but small mixed exotic grassland wetland lost under footprint.
J	Waikawa	None	None
K	Waikokopu	None	None d/s, but small MWG1d (mixed exotic grassland) lost under footprint.
L	Kuku	None	None d/s, but exotic herbfield (EWH9) lost under footprint.
M	Ohau	None	None
M-O		None	Te Waiaruhe Swamp d/s of alignment. No operational discharge. Focus for E&SC to avoid/minimise sediment from construction (low risk).
O	Koputaroa	(WP4)	Small wetland of mixed exotic grassland immediately d/s of WP4. This wetland is within the footprint and stormwater is expected to bypass it via an open channel or pipe.
P	Koputaroa Trib	WP1, WP2	Open water pond partially lost under the footprint, with remaining pond to receive discharge from WP1. WP2 discharging to drain adjacent to Isolepis sedgeland.

Summary Rating of Effects

169. **Table H.26** provides a summary of potential effects from the Ō2NL Project during construction and operational phases. The assessment is after mitigation has been applied as required by conditions and described / to be described in relevant management plans. The overall effects are determined by comparing the magnitude of effects with the ecological values associated with each stream using the EIANZ matrix framework – this is done in Technical Assessment K (Freshwater Ecology).

Table H.26: Summary of potential effects from the Ō2NL Project during construction and operational phases. SW = stormwater. SW Hydrology refers to effects on ecosystem health and excludes flood risk.

		Magnitude of effect after standard mitigation					
		Construction effects			Operational effects		
Id	Stream	Sediment	Vege. Clearance	Concrete / Hazardous Substances	SW hydrology	SW WQ	Comments
A	Greenwood	Low	Negligible	Low	Negligible	Positive	No SW discharges
B	Waitohu Trib 2	Moderate	Negligible	Low	Low	Negligible	
C	Waitohu Trib 1	Moderate	Negligible	Low	Low	Positive	Substantial reduction in contaminant load to catchment.
D	Waitohu Trib 3	High	Low	Low	Low	Positive	Risk from vegetaion removal near stream 11, but can be minimised.
E	Waiauti	Low	Negligible	Low	Negligible	Negligible	
F	Manakau	Low	Negligible	Low	Negligible	Negligible	
G	Manakau Trib	Moderate	Negligible	Low	Low	Positive	Substantial reduction in contaminant load to catchment.
H	Manakau Trib	Low	Negligible	Low	Negligible	Positive	No SW discharges
I	Mangahuia	Moderate	Negligible	Low	Low *	Negligible	Hydrology risk "low" but "moderate" in immediate receiving tributary.
J	Waikawa	Low	Negligible	Low	Low	Negligible	Incr. load SW contaminants to Trib. 27.
K	Waikokopu	Low	Negligible	Low	Negligible	Positive	No SW discharges
L	Kuku	Low	Negligible	Low	Negligible	Low	Incr. load SW contaminants but conc. within guidelines
M	Ohau	Low	Negligible	Low	Low *	Negligible	Hydrology risk "low" but "moderate" in immediate receiving tributary.
O	Koputaroa	Low	Negligible	Low	Low	Negligible	
P	Koputaroa Trib	Moderate	Negligible	Low	Low *	Negligible	Hydrology risk "low" but "moderate" in immediate receiving tributary.
Mitigation:		ESCP	EMP	HSP	SW treatment train		

ESCMP: Erosion and Sediment Control Management Plan; EMP: Ecology Management Plan; HSP: Hazardous Substances

CONCLUSIONS

170. The construction and operation of the Ō2NL Project has the potential to lead to water quality impacts on downstream receiving environments. However, the application of standard erosion and sediment control, hazardous chemical management (including at concrete batching plants), and a high level of stormwater treatment and attenuation, can adequately avoid or minimise the effects.

171. The bulk earthworks during the construction phase of the Ō2NL Project have potential to increase sediment loss and reduce water clarity. This will be more apparent during high flow events and in smaller sub-catchments. The effects on downstream water quality can be minimised and mitigated with good practice, these should be described in the Ō2NL Project's ESC Management Plan, SSESCPs, and ESC Monitoring Plan.

172. The use of cement and concrete has the potential to result in highly alkaline discharges. The management of contaminated wash water shall be covered in the **Hazardous Substances Management Plan** as part of the **ESCP** and

should include locating concrete batching plants away from watercourses. This plan shall also cover the management of other hazardous chemicals during construction to minimise potential risks to water quality and aquatic life.

173. During the operational phase, well-treated stormwater from the Ō2NL Project will result in overall improvement in water quality of all the major catchments crossed by the route. Three sub-catchments will have a higher loading of TPH from road, but the magnitude of effects on these catchments will be very low. The hydraulic effects of stormwater will be low in most catchments due to the use of detention, infiltration where possible and the Ō2NL Project contributing a relatively small amount of impervious surface to the catchments. However, there are three small tributaries that directly receive stormwater in catchments P, M and I where the magnitude of hydraulic effects may be “moderate”.

174. The overall effects are determined by comparing the magnitude of effects with the ecological values associated with each stream – this is done in Technical Assessment K (Freshwater Ecology).

Keith Hamill

14 October 2022

BIBLIOGRAPHY

ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality Vol. 1. Australian and New Zealand Environment and Conservation Council.

Auckland Regional Council 2010. Development of the Contaminant Load Model. Auckland Regional Council Technical Report 2010/004.

Auckland Regional Council 2010. *Contaminant Load Model User's Manual*. Auckland Regional Council Technical Report TR2010/003.

Bearr JS, Diamond J, Latimer H, Bowersox M. 2006. Effects of pulsed copper exposures on early life-stage *Pimephales promelas*. Environmental Toxicology and Chemistry 25(5), 1376-1382.

Collier KJ, Haigh A, Kelly J. 2007. Coupling GIS and multivariate approaches to reference site selection for wadeable stream monitoring. *Environmental Monitoring and Assessment* 127:29–45.

Cunningham, A., Colibaba, A., Hellberg, B., Silyn Roberts, G., Simcock, R., S. Speed, Vigar, N and Woortman, W 2017. *Stormwater management devices in the Auckland region*. Auckland Council guideline document, GD2017/001

Davies-Colley RJ, Smith DG 2001. Turbidity, suspended sediment, and water clarity: A review. *Journal of the Americal Water Resources Association 37* (5): 1085-1101.

Davies-Colley R., Franklin P., Wilcock B., Clearwater S., Hickey C. 2013. National Objectives Framework - Temperature, Dissolved Oxygen & pH Proposed thresholds for discussion. Prepared for Ministry for the Environment by NIWA. NIWA Client Report No: HAM2013-056.

Environment Institute of Australia and New Zealand (EIANZ) 2018. Ecological Impact Assessment (EcIA) EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems [2nd Edition]. https://www.eianz.org/document/item/4447

Fernandes JN, Barbosa AE 2018. Prediction of pollutant loads and concentrations in road runoff. Proper Project WP1. Conference of European Directors of Roads (CEDR). Task 1.1. Literature review on road runoff pollution on Europe.

Fitch GM. 2003. Minimising the impact on water quality of placing grout underwater to repair bridge scour damage. Virginia Transportation Research Council In Cooperation with the U.S. Department of Transportation Federal Highway Administration, Virginia.

Franklin P, Stoffels R, Clapcott J, Brooker D, Wagenhoff A, Hickey C 2019. *Deriving potential fine sediment attribute thresholds for the National Objectives Framework*. Prepared for Ministry for the Environment, by NIWA, June 2019

Gadd J, Milne J, Hickey C 2017. Copper and zinc aquatic toxicity. Frequently asked questions. Prepared for Environment Canterbury. NIWA Client Report 2017129AK.

Henderson R, Diettrich J 2007. *Statistical analysis of river flow data in the Horizons Region*. Prepared for Manawatū-Whanganui Regional Council. NIWA Client Report CHC2006-154.

Herb WR, Mohensi O, Stefan HG 2007. Heat export and runoff temperature analysis for rainfall event selection. Prepared by St Anthony Fall Laboratory for the Minnesota Pollution Control Agency. Project Report No. 283.

Kennedy, P., Allen, G and Wilson, N 2016. *The management of hydrocarbons in stormwater runoff: a literature review*. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR 2016/010

Law DW and Evans J 2013. Effect of leaching on pH of surrounding water. *ACI Materials Journal Technical Paper* May-June 2013, 110-M24.

McDowell RW, Snelder TH, Cox N 2013. *Establishment of reference conditions and trigger values for chemical, physical and micro-biological indicators in New Zealand streams and rivers.* AgResearch Client Report. Prepared for the Ministry for the Environment.

Ministry for the Environment and Ministry of Health 2003. *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*. Ministry for the Environment

Moores J, Pattinson P, Hyde C 2009. Enhancing the control of contaminants from New Zealand's roads: results of a road runoff sampling programme. New Zealand Transport Agency research report 395. 161p.

New Zealand Government 2020. *National Policy Statement for Freshwater Management* 2020. https://www.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwater-management-2014-amended-2017.

NZTA 2010. *Stormwater Treatment Standard for State Highway Infrastructure*. New Zealand Transport Agency. ISBN 978-0-478-35287-0

Olsen DA, Tremblay L, Clapcott J, Holmes R 2012. Water temperature criteria for native aquatic biota. Prepared for Auckland Council, Environment Waikato and Hawkes Bay Regional Council. Cawthron Report No. 2024. Auckland Council Technical Report 2012/036.

Rier S.T., Stevenson R.J. 2006. Response of periphytic algae to gradients in nitrogen and phosphorus in streamside mesocosms. *Hydrobiologia 561*:131–147

Rowe, D.K., A. M. Suren, M. Martin, J. P. Smith, B. Smith, E. Williams 2002. Lethal turbidity levels for common freshwater fish and invertebrates in Auckland streams. Auckland Regional Council Technical Publication Number 337. 37 p.

Richardson J, Boubee JAT, West D 1994. Thermal tolerance and preference of some native New Zealand freshwater fish. New Zealand Journal of Marine and Freshwater Research 28: 399-407.

Richardson, J.; Rowe, D.K.; Smith, J. 2001. Effects of turbidity on the upstream movement of migratory banded kōkopu (*Galaxias fasciatus*) in a stream. *New Zealand Journal of Marine and Freshwater Research* 35: 191-196.

Setunge, S.; Nguyen, N.; Alexandar, B.; and Dutton, L. 2009. Leaching of Alkali from Concrete in Contact with Waterways. *Water Air and Soil Pollution Focus, V. 9, 2009*, pp. 381-391.

Storey R, Brierley G, Clapcott J, Collier K, Kilroy C, Franklin P, Moorhouse C and Wells R 2013. Ecological responses to urban stormwater hydrology. Prepared by NIWA for Auckland Council. Auckland Council technical report TR2013/033.

Shaver E., Suren A. 2011. *Assessing impacts of State Highway stormwater runoff on stream invertebrate communities*. Prepared by Aqua Terra International and NIWA for NZ Transport Agency.

Young D, Afoa E, Meijer K, Wagenhoff A, Utech C 2013. Temperature as a contaminant in streams in the Auckland region, stormwater issues and management options. Prepared by Morphum Environment Ltd for Auckland Council. Auckland Council technical report, TR2013/044

USEPA 2006. National recommended water quality criteria for toxic pollutants. United States Environmental Protection Agency.

Walsh CJ, Roy AH, Feminella JW, Cottongham PD, Groffman PM, Morgan II RP 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society, 24(3): 706-723.

West D.W., Boubee J., Barrier R.F.G. 1997. Responses to pH of nine fishes and one shrimp native to New Zealand freshwaters. New Zealand Journal of Marine and Freshwater Research 31: 461-468.

Wood, P. J.; Armitage, P. D. 1997. Biological effects of fine sediment in the lotic environment. Environmental Management 21: 203-217.

APPENDIX H.1: CATCHMENT LAND USE AND SLOPE

Percentage land use in each catchment used in the Contaminant Load Model based on LCDB4.

id	Name	Full Catchment area (Km^2)	Exotic production forest <10	Exotic production forest - 20	Exotic production forest - >20	Stable forest <10	Stable forest - 20	Stable forest - >20	Farmed pasture <10	Farmed pasture - 20	Farmed pasture - >20	Retired pasture <10	Retired pasture - 20	Retired pasture - >20	Horticulture <10	Horticulture - 20	Urban
A	Greenwood	1.878	0.05	0.02	0.10	0.01	0.00	0.00	1.24	0.18	0.21	0.00	0.00	0.01	0.04	0.00	0.00
B	Waitohu	1.441	0.00	0.01	0.12	0.00	0.01	0.02	0.74	0.23	0.28	0.00	0.00	0.01	0.00	0.00	0.00
C	Waitohu 1	1.279	0.01	0.04	0.38	0.00	0.00	0.00	0.41	0.23	0.20	0.00	0.00	0.00	0.00	0.00	0.00
D	Waitohu Trib 3	0.272	0.00	0.00	0.01	0.01	0.00	0.00	0.14	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00
E	Waiauti	7.922	0.07	0.21	1.01	0.02	0.01	0.07	2.28	1.13	2.51	0.01	0.06	0.52	0.00	0.00	0.00
F	Manakau	7.499	0.13	0.61	1.46	0.13	0.40	2.17	0.96	0.47	0.73	0.06	0.07	0.31	0.00	0.00	0.00
G	Manakau Trib	0.852	0.00	0.00	0.00	0.00	0.00	0.02	0.55	0.05	0.02	0.00	0.00	0.06	0.13	0.00	0.00
H	Manakau Trib	0.89	0.01	0.02	0.09	0.00	0.02	0.12	0.32	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.21
I	Mangahuia	2.098	0.01	0.02	0.24	0.00	0.00	0.00	1.27	0.17	0.11	0.00	0.00	0.01	0.18	0.00	0.08
J	Waikawa	32.12	0.33	0.90	2.19	0.78	2.66	20.32	2.72	0.78	0.94	0.08	0.08	0.23	0.02	0.00	0.00
K	Waikokopu Kuku Trib	1.983	0.06	0.06	0.23	0.04	0.03	0.24	0.86	0.11	0.11	0.00	0.01	0.04	0.18	0.00	0.01
L	Kuku	9.604	0.27	0.61	1.38	0.13	0.32	1.53	2.69	0.81	1.19	0.03	0.05	0.19	0.38	0.01	0.00
M	Ohau	136.892	1.25	2.46	5.60	6.73	14.39	73.57	17.61	4.76	5.88	0.21	0.19	0.94	1.03	0.00	0.02
O	Koputaroa	14.902	0.30	0.47	2.18	0.12	0.03	0.05	7.96	0.99	1.31	0.00	0.00	0.00	1.10	0.01	0.38
P	Koputaroa Trib	5.959	0.09	0.03	0.04	0.02	0.00	0.00	3.92	0.64	0.30	0.00	0.00	0.00	0.86	0.03	0.00

APPENDIX H.2: NATIONAL OBJECTIVE FRAMEWORK ATTRIBUTES IN THE NPS-FM 2020

Summary of NPS-FM Appendix 2A: Attributes requiring limits on resource consents

The streams crossing the Ō2NL Project alignment fall into Suspended Sediment Class 2 (Koputaroa, Waitohu Tributaries) or 3 (Ohau Kuku, Waikawa, Manakau, Waiauti).

River/Lake	Attribute	Statistic	units	Band A	Band B	Band C	Band D	Band E
River, Lake	NH4-N	Median	mg/L	≤0.03	**≤0.24**	≤1.3	>1.3	
River, Lake	NH4-N	Maximum	mg/L	≤0.05	**≤0.4**	≤2.2	>2.2	
River	NO3-N	Median	mg/L	≤1	**≤2.4**	≤6.9	>6.9	
River	NO3-N	95%ile	mg/L	≤1.5	**≤3.5**	≤9.8	>9.8	
River, Lake	*E.coli* bacteria	% samples >260 cfu/100ml	%	≤20%	≤30%	≤34%	≤50%	>50%
River, Lake	*E.coli* bacteria	% samples >540 cfu/100 ml	%	≤5%	≤10%	≤20%	≤30%	>30%
River, Lake	*E.coli* bacteria	Median	*E.coli* / 100mL	≤130	≤130	≤130	≤260	>260
River, Lake	*E.coli* bacteria	95%ile	*E.coli* / 100mL	≤540	≤1000	≤1200	≤1200	>1200
River/Lake	Periphyton default class	Exceeded <8% of samples	mg *chl-a* /m^2	≤50	≤120	**≤200**	>200	
River/Lake	Periphyton productive class	Exceeded <17% of samples	mg *chl-a* /m^2	≤50	≤120	**≤200**	>200	
River point source	DO	7-day min	mg/L	≥8	≥7	**≥5**	<5	
River point source	DO	1-day min.	mg/L	≥7.5	≥5	**≥4**	<4	
River	Visual clarity (Class 1)	Median	m	≥1.78	≥1.55	**≥1.34**	<1.34	
River	Visual clarity (Class 2)	Median	m	≥0.93	≥0.76	**≥0.61**	<0.61	
River	Visual clarity (Class 3)	Median	m	≥2.95	≥2.57	**≥2.22**	<2.22	
River	Visual clarity (Class 4)	Median	m	≥1.38	≥1.17	**≥0.98**	<0.98	
Lake	Phytoplankton	Median	mg *chl-a* /m^3	≤2	≤5	**≤12**	>12	
Lake	Phytoplankton	Maxium	mg *chl-a* /m^3	≤10	≤25	**≤60**	>60	
Lake	TN (stratified)	Median	mg/m^3	≤160	≤350	**≤750**	>750	
Lake	TN (polymictic)	Median	mg/m^3	≤300	≤500	**≤800**	>800	
Lake	TP	Median	mg/m^3	≤10	≤20	**≤50**	>50	

Summary of NPS-FM Appendix 2B: Attributes requiring action plans

The streams crossing the Ō2NL Project alignment fall into Deposited Sediment Class 3 (Koputaroa), 4 (Ohau Kuku, Waikawa, Manakau, Waiauti) or are classed as naturally soft-bottomed (Waitohu Tributaries).

River/Lake	Attribute	Statistic	units	Band A	Band B	Band C	Band D	Band E
Lake	Cyanobacteria biovolume	80%ile of potentially toxic cyanobacteria	mm^3/L	≤0.5	≤1.0	**≤1.8**	>1.8	
Lake	Submerged Plants Native Condition Index)		%	>75	>50	**≥20**	<20	
Lake	Submerged Plants Invasive Condition Index)		%	≤1	≤25	**≤90**	>90	
River	Fish IBI	Mean		≥34	≥28	≥18	<18	
River	Macroinvertebrates QMCI	Median		≥6.5	≥5.5	**≥4.5**	<4.5	
River	Macroinvertebrates MCI	Median		≥130	≥110	**≥90**	<90	
River	Macroinvertebrates ASPM	Median		≥0.6	≥0.4	**≥0.3**	<0.3	
River	Deposited fine sediment (Class 1)	Median	%	≤7	≤14	**≤21**	>21	
River	Deposited fine sediment (Class 2)	Median	%	≤10	≤19	**≤29**	>29	
River	Deposited fine sediment (Class 3)	Median	%	≤9	≤18	**≤27**	>27	
River	Deposited fine sediment (Class 4)	Median	%	≤13	≤19	**≤27**	>27	
River	DO	7-day min	mg/L	≥8	≥7	**≥5**	<5	
River	DO	1-day min	mg/L	≥7.5	≥5	**≥4**	<4	
Lake	Lake-bottom DO	annual minimum	mg/L	≥7.5	≥2	**≥0.5**	<0.5	
Lake	Mid-hypolimnetic depth	annual minimum	mg/L	≥7.5	≥5	**≥4**	<4	
River	DRP	Median	mg/L	≤0.006	≤0.01	≤0.018	>0.018	
River	DRP	95%ile	mg/L	≤0.021	≤0.03	≤0.054	>0.054	
River, Lake	*E.coli* bacteria Primary Contact sites	95%ile	*E.coli* / 100mL	≤130	≤260	**≤540**	>540	
River	Ecosystem metabolism		g O_2/m/d					

APPENDIX H.3: PNRP GWRC DISCHARGE WATER QUALITY TARGETS

Proposed GWRC discharge water quality targets (PNRP section 3.5 and 4.8.2)

Variable	Units	Target	Condition Criteria	Comparison to One Plan
pH Δ	pH units	±0.5	Must not change by more/less than	Same
Temp Δ	°C	Class 1&2: ≤1.2	Must not change by more than	More stringent (applies to 2 x Class 2 tributaries)
		Schedule F1: ≤2	Must not change by more than	More stringent (but N/A)
		All others: ≤3	Must not change by more than	Same (applies to 2 x Class 6 tributaries)
Clarity Δ[9]	%	Class 1: ≤20%	Must not be reduced by more than	More stringent (N/A)
		Class 2-6: ≤33%	Must not be reduced by more than	Less stringent (applies)
DO[10]	mg/L	≥5 (7 day mean)	Mean 7 day minimum	Different measurement
		≥4 (daily minimum)	Daily minimum	Different measurement
E. coli	Cfu/100ml	≤540 (95%ile)[11]	Must not exceed (for significant contact recreation sites only)	Similar (but N/A)
		≤1,000 (median)	Must not exceed	Different measurement
MCI[12]	MCI	Class 2: ≥105	Median must be greater or equal to	More stringent
		Class 6: ≥100	Median must be greater or equal to	Same
QMCI Δ	QMCI	≤20%	Decrease of no more than	Same
Peri Chla[13]	mg/m^3	Class 2: ≤120	Not to be exceeded by >8% of samples	Similar to Oahu, Kuku, Waikawa, Manakau
		Class 6: ≤120	Not to be exceeded by >17% of samples	As above.

9 Applies at less than median flows.
10 01 November to 30 April only
11 Applies to significant contact recreation rivers at all flows below 3x median flow, September to April inclusive
12 There are various targets according to River Class and for Schedule F1 sites with high macroinvertebrate community health.
13 Refer previous bullet.

APPENDIX H.4: CONTAMINANT YIELD CURVES USED FOR THE CATCHMENT LOAD MODEL

The CLM was modified to apply the contaminant yields based on formulas derived from the CLM yield tables; this allowed yields to change smoothly based on the predicted traffic volumes. The formulas were derived by fitting a polynomial curve to the CLM yield data using the mid-point of each traffic volume category. This resulted in the following formulas for yield, each with an R^2 of 0.9999:

(i) TSS = (-0.000000006*power(x,2))+(0.0023*x)+20.3

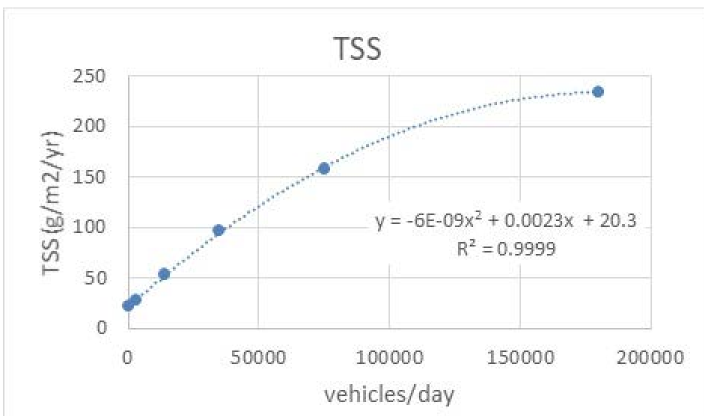
(ii) Total Zn = (-0.000000000011*power(x,2))+(0.000008*x)

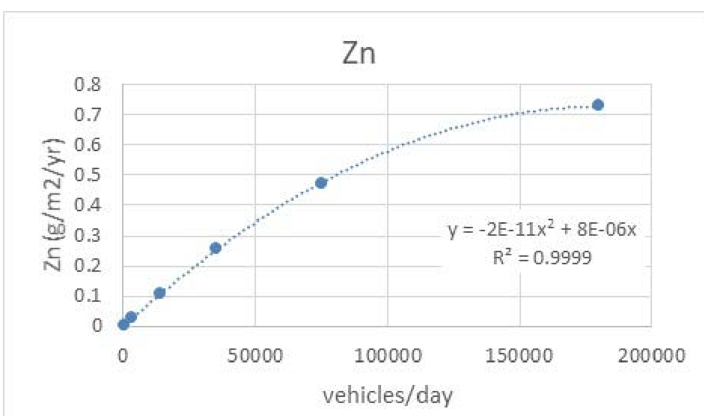
(iii) Total Cu = (-0.000000000007*power(x,2))+(0.000003*x)

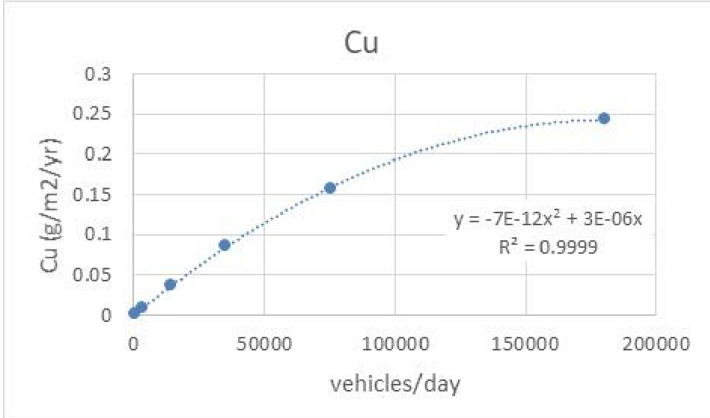
(iv) TPH = (-0.0000000002*power(x,2))+(0.00006*x)

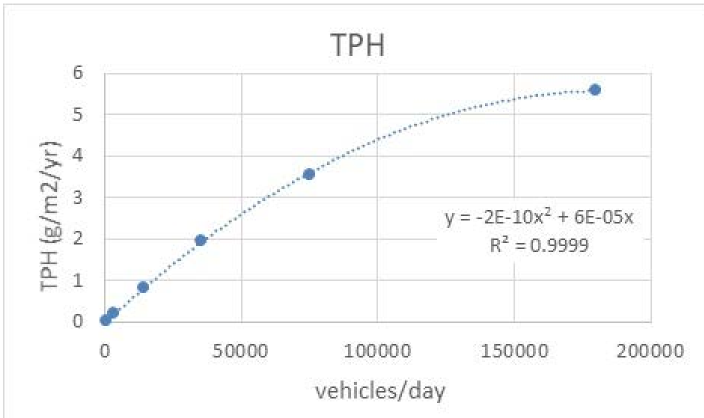
Where: x = vehicles per day.

Graphs of the yield curves for TSS, Zn, Cu and TPH are below.






Cu
Cu (g/m2/yr)
vehicles/day
y = -7E-12x2 + 3E-06x
R² = 0.9999
0
0.05
0.1
0.15
0.2
0.25
0.3
0
50000
100000
150000
200000


TPH
TPH (g/m2/yr)
vehicles/day
y = -2E-10x2 + 6E-05x
R² = 0.9999
0
1
2
3
4
5
6
0
50000
100000
150000
200000