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Assessment of Proposed Te Puru Stream Discharge

The following provides a summary of the modelling we have carried out to assess the effects of the current and proposed discharge of treated wastewater to the Te Puru Stream, Beachlands (Figure 1).

The wastewater treatment plant (**WWTP**) is located approximately 3.5 km upstream of the stream mouth on the central tributary of the stream that discharges to Kellys Beach.

The assessment includes estimating the level of dilution of the treated wastewater plume at Kellys Beach and the wider marine receiving environment and estimating the extent of the nutrient footprints from both the Te Puru catchment and the WWTP discharges.

WWTP discharge rates representing existing current and planned short-term and long-term scenarios have been considered.

These discharge rates and the associated Total Nitrogen (TN) and Total Phosphorous (TP) loadings for each stage before entering the constructed wetland system are shown in Table 1.

The current average dry weather discharge rate corresponds with the observed mean flow from the WWTP monitoring data for 2020.

Note that the TN and TP loads in Table 1 are those discharged to the pond system, i.e. from the WWTP outlet. Further removal of nutrients will occur as it passes through the overland flow system before the treated wastewater is discharged to the Te Puru Stream (discussed below).

Table 1. Discharge Scenario data.

	Current	**Short-Term**	**Long-Term Stage 2**
Average daily dry weather discharge (m^3)	2,000	3,600	6,000
Average daily dry weather discharge (m^3/s)	0.023	0.042	0.069
Median TN load (kg/day)	14.0	25.0	30.0
Median TP load (kg/day)	2.0	3.6	6.0

Executive Summary

A hydrodynamic model of the Te Puru Stream has been set up to assess the level of dilution that would be achieved for treated wastewater being discharged from the existing Te Puru WWTP located 3.5 km upstream of the Te Puru Stream mouth.

Three scenarios are being considered: Current, Short-Term and Long-Term Stage 2. The average dry weather flow for each of these scenarios is assumed to be 2000, 3600 and 6000 m^3/day respectively.

The model focusses on the marine receiving environment which includes the part of the stream that is influenced by tides (i.e. up to the Quarry Site), Kellys Beach, Tamaki Strait and the beaches and embayments east and west of Kellys Beach.

Because the section of Te Puru Stream up to the Quarry Site (which is approximately 2.5 km downstream of the WWTP discharge point) is influenced by tides, the level of dilution achieved is larger than the relatively low dilutions that are achieved close to the discharge point.

The model has been run for a full calendar year (2020) which includes an extended period of relatively low stream flows. During this period, the contribution of the WWTP to the Te Puru Stream is significant and so minimum levels of dilutions are achieved.

Minimum dilutions under the Current discharge scenario range from 10 to 20-fold near the Te Puru Stream Mouth and at Kellys Beach. Minimum dilutions under this scenario in Shelley Bay and at Omana (the beaches immediately adjacent to Kellys Beach) are greater than 6000-fold while at Pohutukawa Bay minimum dilutions of around 5000-fold are achieved.

Minimum dilutions under the Short-Term discharge scenario range from 5 to 10-fold near the Te Puru Stream Mouth and at Kellys Beach. Minimum dilutions under this scenario in Shelley Bay and at Omana (the beaches immediately adjacent to Kellys Beach) are greater than 3000-fold while at Pohutukawa Bay minimum dilutions of greater than 2000-fold are achieved.

Minimum dilutions under the Long-Term Stage 2 discharge scenario range from 3 to 6-fold near the Te Puru Stream Mouth and at Kellys Beach. Minimum dilutions under this scenario in Shelley Bay and at Omana (the beaches immediately adjacent to Kellys Beach) are greater than 1500-fold while at Pohutukawa Bay minimum dilutions of greater than 1000-fold are achieved.

The model has also been used to assess the relative input of nutrients from the catchment and the WWTP. Here the average level of dilution achieved over a full year are considered because mean annual TN and TP concentrations are being considered.

Immediately downstream of the Whitford-Maraetai Road bridge the predicted TN and TP concentrations due to catchment inputs and those from the Current WWTP discharge are 0.85 mg/L and 0.07 mg/L respectively.

These estimates are made up of the Current WWTP discharge contribution of 0.12 mg/L and 0.01 mg/L for TN and TP respectively and the catchment derived concentrations of 0.73 and 0.05 mg/L for TN and TP respectively.

The combined estimates (i.e. catchment plus WWTP nutrients) are very similar to actual monitoring data at Te Puru Park of 0.74 and 0.07 mg/L for TN and TP respectively.

Under the Short-Term discharge the contribution of the WWTP discharge to the mean TN and TP would increase from 0.12 mg/L and 0.01 mg/L respectively to 0.23 mg/L and 0.04 mg/L.

Under the Long-Term Stage 2 discharge, the contribution of the WWTP discharge to the mean TN and TP would increase to 0.44 mg/L and 0.07 mg/L.

The higher levels of dilution that are achieved in the wider marine receiving environment (compared to the in-stream dilutions) mean that changes in nutrient concentrations in the wider marine receiving environment due to the proposed WWTP discharges would remain below detectable limits.

Model Setup

Te Puru Stream discharges into the south-eastern corner of Kellys Beach via a small sub-tidal channel which extends approximately 1000 m across the inter-tidal flats of Kellys Beach (Figure 2).

As detailed in Zeldis et al., 2009[1], Te Puru Stream is tidally influenced some 1500 m upstream of its mouth near the Quarry site (Figure 2). The marine model focusses on this area of the Te Puru Stream and so has simplified bathymetry upstream of the Quarry Site which reflects the channel width and depth derived from LIDAR data. This ensures the mixing of the catchment inflows, WWTP discharge and marine waters are well represented in the model.

For this work we have refined the model used for assessing the potential outfall discharge options (DHI Report 44802111/02) to schematise the Te Puru stream where it is influenced by tides and included a fine resolution mesh for all the inter-tidal areas between Bucklands Beach (to the west) and the Wairoa River (to the east) embayment. To adequately resolve the Te Puru Stream a minimum element size of 5 m was used while for the inter-tidal sections of the model elements with an area of approximately 500 m^2 were used. As for the outfall assessment work, the model has five vertical layers with the discharges being released into the surface layer of the model.

Te Puru flow data was derived from gauged flows for the Mangemangeroa Stream which is located to the very west of the Whitford embayment (Figure 1). Work carried out by PDP determined that stream flow at the Quarry site could be derived by applying a factor of 2.24 to the Mangemangeroa gauged flows. Mangemangeroa gauged flows from 2020 included an extended period of lower flows over the first five months of the year, a typical number of higher winter flow events and it had a typical sequence of high Spring flow events (Figure 3). 2020 has therefore been chosen as being representative of the range of potential flows that occur within Te Puru Stream.

[1] Zeldis, J., Pattinson, P., Gray, S., Walsh, C., Hamilton, D., Hawes, I. 2009. Assessment of effects of sewage plant inflow on Te Puru Stream, Estuary and adjacent Tamaki Strait waters. NIWA Client Report : CHCO1/84.

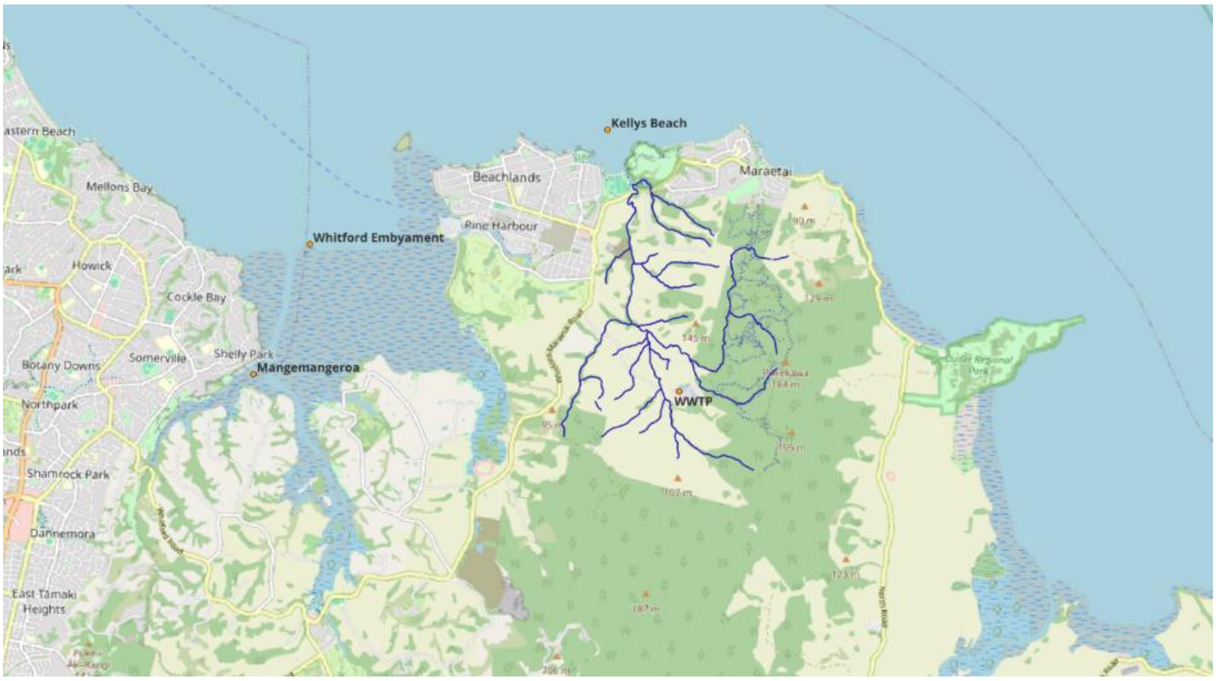

Figure 1. Te Puru stream and location of WWTP.

Figure 2. Kellys Beach where the Te Puru Stream discharges to the marine receiving environment and the Quarry site in the Te Puru Stream.

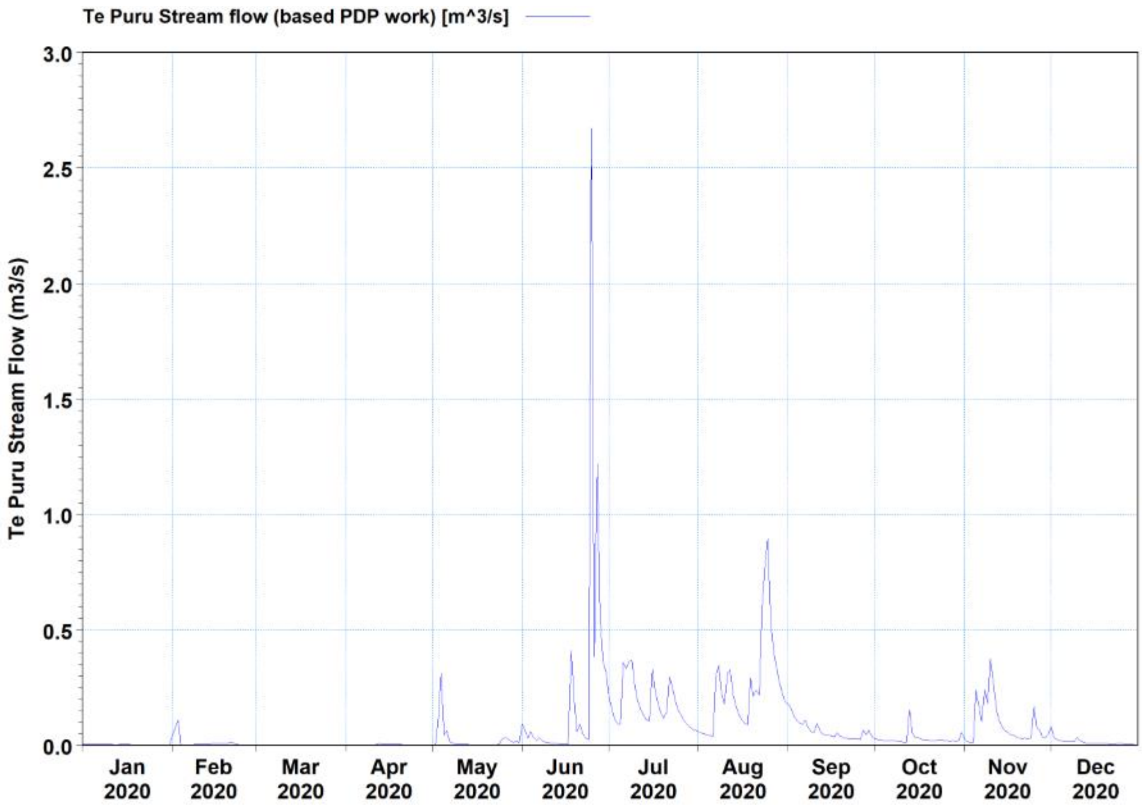

Figure 3. Estimated Te Puru stream flow at the Quarry Site (excluding the WWTP discharge) based on the scaled gauged Mangemangeroa Stream flows.

Discharge Scenarios Relative to Estimated Stream Flow

At times, the WWTP discharge will make up a significant portion of the flows in Te Puru Stream.

The estimated 50th percentile flow at the Quarry site for 2020 is 34 L/s - lower than the 50th percentile estimate for the period 2001-2022 of 47 L/s. The average levels of dilution from the modelling will be somewhat conservative but the lowest levels of estimated dilution (which occur when stream flows are very low) will be representative of worst-case conditions in terms of quantifying potential risk.

Figure 4 shows the percentage of time during 2020 that a given percentage of the Te Puru Stream flows would be due to the WWTP discharge scenarios being considered.

For example, for 40% of the time (i.e. corresponding to the extended period of low flows in early 2020) more than 90% of the flows in the stream at the Quarry site would be due to the Long-Term Stage 2 discharge and for around 75% of the time the Long-Term Stage 2 discharge will make up about half of flows in the stream at the Quarry site.

During the period of data collection of Zeldis et al. (2009) the WWTP discharge was gauged at 10 L/s (about one-half of the current mean discharge rate) and the gauged stream flow[2] at the Quarry site was 48 L/s. This is likely to be due to the extended period of dry weather in March 2001 which would have led to very low soil moisture levels so that, despite 12 hours of rain on the 2nd of April, stream flows remained relatively low for the period 6th- 11th of April 2001.

This means that around 20% of the stream flow at the time of the Zeldis observations would have been due to the WWTP discharge. This is a relatively low contribution to flows compared to WWTP discharge rates being considered and 2020 stream flows being modelled and should be accounted for if results from the modelling (detailed below) are benchmarked against any conclusions of Zeldis et al. (2009).

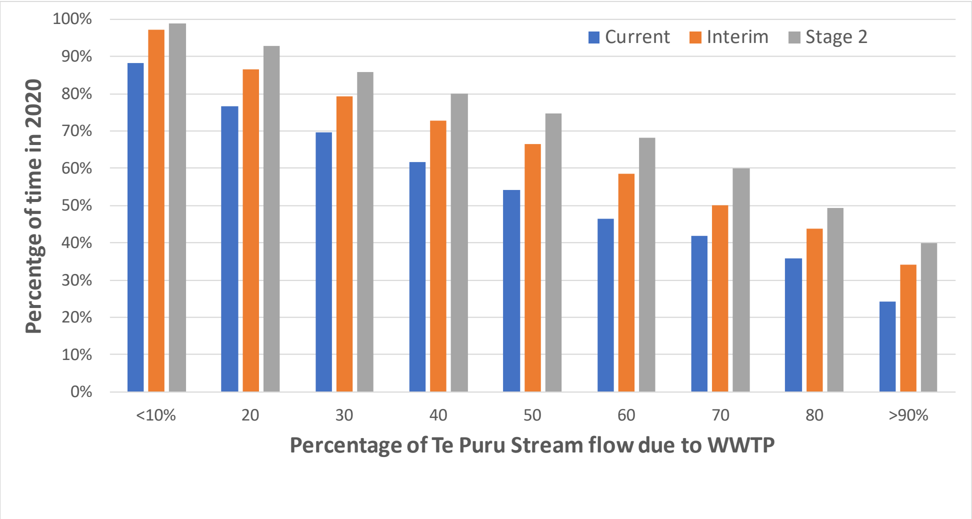

Figure 4. Percentage of time the WWTP discharge contributes a certain portion of flows within Te Puru Stream.

[2] Which would have included the WWTP discharge.

Dilution Estimates

Dilution estimates were quantified for all of 2020 based on the estimated stream flow (Figure 3) and the average dry weather flows for the Current, Short-Term and Long-Term Stage 2 WWTP scenarios (Table 1).

Spatial maps of the estimated percentile dilutions (1st, 5th and 25th) are provided below while time-series data at ten individual sites (Figure 5) and three transects across Kellys Beach (discussed below) have been supplied to input to the Quantitative Microbial Risk Assessment (Figure 5).

Figure 5. Individual sites where time-series of surface and near-bed dilution estimates for all of 2020 have been extracted for the three WWTP discharge scenarios being considered.

Because of the very dynamic nature of the hydrodynamics at Kellys Beach, quantifying the public health risk for Kellys Beach is difficult to do just considering one site.

For example, at low tide the lowest levels of dilution (and therefore highest risk) will occur along the fringes of the sub-tidal channel (Figure 2).

However, on the incoming tide there will be a zone of lowest dilution which follows the movement of the water line inshore as the tide rises. The lowest level of dilution along the beach face will be very close to those in the Te Puru Mouth towards the eastern end of the beach but dilutions towards the western end of the beach will be higher than those towards the eastern end of the beach.

At high tide, the lowest levels of dilution will occur along the beach face with a gradient from east (where lowest levels of dilution will be similar to the Te Puru Mouth dilutions) to west (with dilution at this end of the beach determined by wind conditions on any given day and proximity of the beach to the subtidal channel).

In theory, the highest level of risk for Kellys Beach will be the same as the Te Puru Stream mouth. This level of risk will occur because contact recreation along Kellys Beach could occur at the Stream Mouth at low tide (when dilutions are highest at the Te Puru Mouth site).

To give an indication of potential gradient of risk across the inter-tidal area of Kellys Beach dilution estimates have been extracted across three transects across Kellys Beach (Figure 6) and the minimum dilution across each transect (irrespective of where it happens) for each hour of the model determined.

Essentially this provides a moving QMRA site which tracks the area of highest risk (lowest dilution) over time. This area will generally correspond to the water's edge but at times water from the inter-tidal channel (where lower levels of dilution occur) could be transported into the offshore areas of Kellys Beach approaching high water.

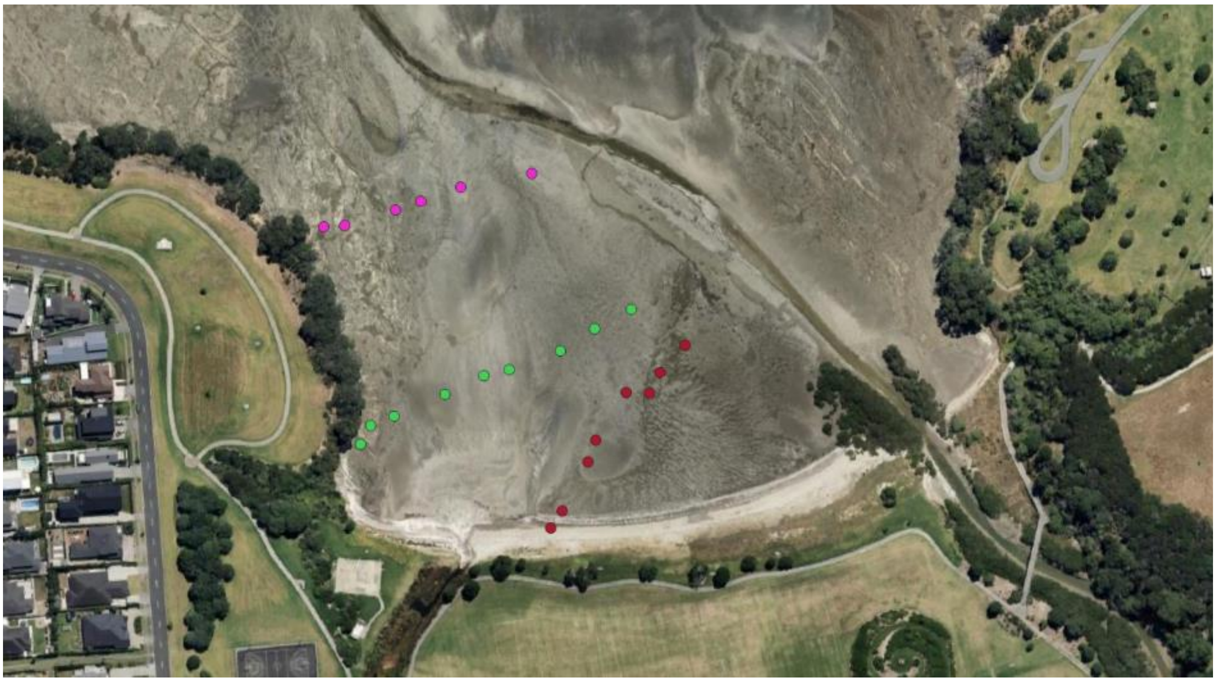

Figure 6. Aerial image of Kellys Beach showing the main subtidal channel and the sites where dilution estimates are extracted across three inter-tidal transects. The northern transect is shown as magenta symbols, the mid-transect is shown as green symbols and the eastern-transect is shown with red symbols,

The level of dilution achieved at each of the QMRA sites and transects are summarised Table 2 through to Table 7 for both the surface and near-bed layers of the model. The treated wastewater plume will become fully vertically mixed within the Te Puru Stream itself and so there is very little significant differences between the surface and near-bed layer estimates.

Figure 7 to Figure 15 show the spatial plots of the estimated 1^{st}, 5^{th} and 25^{th} dilution which show the spatial gradients in dilution that occur between Pohutukawa Bay and Omana. Outside the area shown in the figure dilutions are very high (discussed below) and beyond a zone extending some 1000-1500 m offshore between Sunkist and Magazine Bay (Figure 5) dilutions in excess of 3000-fold occur.

At the Te Puru River Mouth site, the 1^{st} percentile dilution (i.e. one that is only exceeded 1% of the time) is 10, 5 and 3 under the Current, Short-Term and Long-Term Stage 2 discharge scenarios.

For Kellys Beach the 1st percentile dilutions are very similar across all three transects – around 20-fold for the Current, 10-fold for the Short-Term and 6-fold for the Long-Term Stage 2 scenario. These dilutions are slightly higher than the Te Puru Mouth minimum dilutions and reflect the slight increase in dilution seen within the subtidal channel at low tide and the proximity of the seaward end of the transects to the subtidal channel just after low water.

For the other percentile estimates (2nd through to 50th) there is a north-mid-east gradient in dilutions with the highest dilution occurring across the Northern transect. The 2nd through to 50th percentile dilutions are significantly higher than at the Te Puru Stream site due to the influence of the tidal currents across the inter-tidal area.

Moving away from Kellys Beach the predicted level of dilution is significantly higher than within Kellys Beach itself. This is due to the treated wastewater plume being transported either into the deeper waters of the Tamaki Strait or mixing with water moving from the east (on the rising tide) or from the west (on the falling tide). In all cases this leads to the treated wastewater plume becoming much more diluted outside the area of Kellys Beach.

Figure 7. Estimated depth-averaged 1st percentile dilutions for the Current WWTP discharge scenario. Dilutions of less than those shown occur 1% of the time.

Figure 8. Estimated depth-averaged 5th percentile dilutions for the Current WWTP discharge scenario. Dilutions of less than those shown occur 5% of the time.

Figure 9. Estimated depth-averaged 25th percentile dilutions for the Current WWTP discharge scenario. Dilutions of less than those shown occur 25% of the time.

Figure 10. Estimated depth-averaged 1st percentile dilutions for the Short-Term WWTP discharge scenario. Dilutions of less than those shown occur 1% of the time.

Figure 11 Estimated depth-averaged 5th percentile dilutions for the Short-Term WWTP discharge scenario. Dilutions of less than those shown occur 5% of the time.

Figure 12 Estimated depth-averaged 25th percentile dilutions for the Short-Term WWTP discharge scenario. Dilutions of less than those shown occur 25% of the time.

Figure 13. Estimated depth-averaged 1st percentile dilutions for the Long-Term Stage 2 WWTP discharge scenario. Dilutions of less than those shown occur 1% of the time.

Figure 14 Estimated depth-averaged 5th percentile dilutions for the Short-Term WWTP discharge scenario. Dilutions of less than those shown occur 5% of the time.

Figure 15. Estimated depth-averaged 25th percentile dilutions for the Short-Term WWTP discharge scenario. Dilutions of less than those shown occur 25% of the time.

Table 2. Percentile estimates of surface layer dilutions at the ten QMRA sites and Kellys Beach transect for the Current scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	87,460	28,893	9,418	15,687	8,430	4,917	6,568	30,707	16,841	20	20	18	10
2	102,886	40,684	13,051	20,692	14,796	8,858	11,539	43,850	22,124	51	37	26	12
5	169,673	60,176	25,919	41,002	30,195	20,487	25,043	61,614	53,019	166	102	61	25
10	404,592	126,271	92,283	101,842	67,523	73,432	77,840	121,590	90,970	471	284	231	75
20	796,418	878,355	404,477	653,117	314,554	308,489	343,279	811,851	627,861	2,779	1,099	985	177
30	1,529,184	1,414,678	894,811	1,068,633	745,212	874,640	822,967	1,406,233	1,349,843	9,755	3,090	2,729	483
50	7,648,008	6,274,904	2,330,568	3,039,283	3,020,719	3,075,059	2,558,304	6,181,807	4,128,785	109,282	35,287	25,395	13,018

Table 3. Percentile estimates of near-bed layer dilutions at the ten QMRA sites and Kellys Beach transect for the Current scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	86,562	28,947	9,702	15,715	8,552	5,105	6,598	31,179	17,173	20	20	18	10
2	102,072	40,949	13,093	20,777	14,939	9,093	11,118	44,287	22,340	53	36	26	12
5	169,684	60,217	26,063	41,246	29,867	21,158	25,043	61,850	53,272	165	103	61	25
10	404,977	125,879	92,262	101,872	68,406	73,978	78,764	120,912	91,344	463	284	230	75
20	796,810	882,711	407,425	653,209	310,209	319,246	338,692	818,321	627,217	2,770	1,098	980	176
30	1,523,735	1,414,662	895,826	1,068,301	748,678	883,939	819,458	1,406,415	1,347,818	9,783	3,074	2,702	486
50	7,648,184	6,287,845	2,338,968	3,023,715	3,031,052	3,097,270	2,558,439	6,209,194	4,154,101	108,538	34,824	24,893	12,993

Table 4. Percentile estimates of surface layer dilutions at the ten QMRA sites and Kellys Beach transect for the Short-Term scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	40,061	16,070	5,124	8,144	3,327	2,133	3,005	16,447	7,056	9	10	9	5
2	47,019	19,505	6,256	10,497	5,278	3,414	5,470	18,748	9,395	22	16	12	6
5	77,641	28,399	12,404	19,304	11,187	8,532	11,519	29,520	22,525	62	41	25	10
10	182,109	57,839	38,287	45,850	23,501	26,320	33,232	55,930	38,069	141	92	73	28
20	353,346	326,394	126,483	236,530	91,293	82,324	111,794	331,880	187,430	579	283	241	61
30	619,869	537,466	340,083	390,367	228,630	224,694	309,756	528,949	365,840	1,878	600	532	123
50	2,383,171	1,635,168	628,247	1,027,488	714,192	675,055	695,563	1,677,036	1,031,517	13,302	3,680	2,782	1,352

Table 5. Percentile estimates of near-bed layer dilutions at the ten QMRA sites and Kellys Beach transect for the Short-Term scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	39,798	16,131	5,163	8,145	3,318	2,223	2,991	16,574	7,155	9	10	9	5
2	46,560	19,512	6,321	10,531	5,345	3,747	5,347	18,993	9,540	22	16	12	6
5	77,567	28,355	12,499	19,427	11,388	8,765	11,592	29,616	22,521	63	41	25	10
10	181,803	58,012	38,495	46,046	23,383	26,796	32,868	55,791	38,395	145	93	73	28
20	353,789	326,925	128,019	236,674	92,139	85,476	110,878	331,340	188,315	579	282	239	61
30	619,229	536,726	339,670	389,877	227,040	228,146	309,506	529,367	365,726	1,846	596	524	123
50	2,383,475	1,635,034	629,267	1,031,086	713,033	678,767	698,097	1,674,840	1,032,295	12,901	3,620	2,751	1,348

Table 6. Percentile estimates of surface layer dilutions at the ten QMRA sites and Kellys Beach transect for the Long-Term Stage 2 scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	19,284	8,406	3,044	4,566	1,526	1,060	1,786	8,183	3,670	6	6	5	3
2	23,092	9,405	3,638	6,136	2,413	1,601	3,178	9,467	4,833	9	8	7	4
5	38,533	15,254	7,037	10,420	5,266	3,894	6,233	16,068	10,566	29	19	12	5
10	76,648	30,483	18,891	23,155	10,560	11,273	15,944	29,893	18,160	62	38	28	14
20	169,805	153,917	49,975	86,679	29,958	26,995	46,099	156,186	73,913	174	100	82	31
30	277,446	242,315	138,760	173,324	78,380	61,716	129,498	239,920	127,862	468	179	159	53
50	917,246	664,754	275,343	377,368	212,476	180,334	263,880	652,891	298,970	2,554	646	532	309

Table 7. Percentile estimates of near-bed layer dilutions at the ten QMRA and Kellys Beach transect sites for the Long-Term Stage 2 scenario. These estimates ignore the first 10-days of the model run to allow dilution values to reach quasi-equilibrium at all the QMRA sites.

Percentiles	Wairoa West Bay, Clevedon	Umupuia Outer	Maraetai	Magazine Bay	Shelly Bay	Pohutukawa Bay	Omana	Umupuia Inner	Sunkist Bay	Northern Transect	Mid Transect	Eastern Transect	Te Puru stream mouth
1	19,292	8,404	3,066	4,596	1,542	1,106	1,775	8,198	3,706	6	6	5	3
2	22,946	9,434	3,671	6,186	2,433	1,684	3,148	9,512	4,870	9	8	7	4
5	38,485	15,203	7,040	10,447	5,317	3,992	6,267	16,144	10,659	29	20	12	5
10	76,480	30,522	18,985	23,248	10,598	11,247	15,813	29,978	18,351	63	38	28	14
20	169,616	153,923	50,430	87,501	30,421	27,714	45,970	156,160	74,622	174	99	81	31
30	277,180	242,153	138,867	173,144	77,079	62,911	129,441	239,664	128,597	467	177	158	53
50	920,336	665,517	275,059	378,016	213,688	182,850	264,803	653,672	300,189	2,474	638	524	312

Nutrient Footprints

The assumed nutrient loads discharged to the Te Puru Stream (Table 8) have been used to derive nutrient footprints for the catchment and the WWTP under the three discharge scenarios considered.

As detailed in Stewart et al. (2024)[3], it has been assumed that WWTP Total Nitrogen (TN) would be attenuated by a factor of 2.84 through the overland flow system and WWTP Total Phosphorous (TP) would be attenuated by a factor of 3.44.

Nutrients have been modelled using a conservative tracer approach which assumes no loss of water column nutrients to sediments, to the atmosphere or any uptake of nutrients by phytoplankton. As discussed in detail in Zeldis et al. (2009), this approach will provide appropriate estimates of nutrients in the marine receiving environment.

Mean annual catchment loads have been derived from data from the NZ Rivers Map portal[4] which provides mean annual flow (m^3/s) and mean annual nutrient concentrations for both TN and TP. The estimated mean annual flow for the Te Puru Stream in the NZ Rivers Map database is 0.225 m^3/s.

The 50th percentile of the Te Puru Stream Site E monitoring data (upstream of the WWTP collected Sept 23 to Jan 24) are 0.310 and 0.036 mg/L respectively for TN and TP. The NZ Rivers Map data at this monitoring site are 0.584 mg/L for TN and 0.036mg/L for TP.

For the whole of the Te Puru Catchment the mean annual TN and TP concentrations from the NZ Rivers Map database are 0.538 mg/L for TN and 0.038 mg/L for TP.

The NZ Rivers Map data therefore provides reasonable estimates of mean annual nutrient loads generated in the Te Puru Stream catchment.

Note that data from the NIWA ETI tool[5] for the Turanga Creek, Whitford (lower, left of Figure 1) indicate that mean annual TN and TP loads are generally around 25% higher than summer loads but this probably reflects higher flows rather than increased concentrations of TN an TP.

[3] Stewart, M., James, M., and Kelly, S. 2024. Beachlands Wastewater Treatment Plant – ecological and human health effects assessment. Report WSL2303–D1, Streamlined Environmental.
[4] Whitehead, A.L., Booker, D.J. 2019. Communicating biophysical conditions across New Zealand's rivers using an interactive webtool. New Zealand Journal of Marine and Freshwater Research 53: 278–287.
[5] Zeldis, J., Plew, D., Whitehead, A., Madarasz-Smith, A., Oliver, M., Stevens, L., Robertson, B., Burge, O., Dudley, B. 2017. The New Zealand Estuary Trophic Index (ETI) Tools: Web Tool 1 - Determining Eutrophication Susceptibility using Physical and Nutrient Load Data. Ministry of Business, Innovation and Employment Envirolink Tools: C01X1420.

Table 8. Derived nutrient loads for the WWTP, catchment, combined (WWTP + catchment) and percentage contribution the WWTP would have to the total nutrient load. Attenuated loads are the load discharged to the Te Puru Stream and the Bridge site following the full treatment chain.

	Current	Short-Term	Long-Term Stage 2
Attenuated WWTP loads			
Mean annual TN load (kg/yr)	1,799	3,213	3,856
Mean annual TP load (kg/yr)	212	382	637
Te Puru Catchment			
Mean annual TN load (kg/yr)	3,825	3,825	3,825
Mean annual TP load (kg/yr)	270	270	270
Combined			
Mean annual TN load (kg/yr)	5625	7038	7681
Mean annual TP load (kg/yr)	482	652	907
WWTP percentage of total load			
TN	32%	46%	50%
TP	44%	59%	70%

Based on the mean flow for 2020, catchment source concentrations of 0.74 mg/L for TN and 0.05 mg/L for TP have been applied to achieve the delivery of the mean annual catchment loads for 2020 shown in Table 8.

The model simulations do not include the role of oceanic derived nutrients or the input of other river systems, both of which will increase nutrient concentrations in the marine receiving environment above those modelled. For example, data from the NIWA ETI tool indicate that offshore of the Whitford embayment the average oceanic TN and TP concentrations are 0.04 and 0.01 mg/L respectively and the TN load from the Wairoa River (near the most eastern QMRA site, Figure 5) is around 160,000 kg/yr and the TN load for the Tamaki River is around 60,000 kg/yr.

Figure 16 shows the TN and TP footprints just for the catchment derived nutrient loads of 3,825 and 270 tonnes per year respectively.

Figure 17 shows the WWTP derived TN and TP footprints for the Current scenario and Figure 18 shows the combined WWTP + catchment TN and TP footprints for this discharge scenario.

Figure 19 shows the WWTP derived TN and TP footprints for the Short-Term scenario and Figure 20 shows the combined WWTP + catchment TN and TP footprints for this discharge scenario.

Figure 21 shows the WWTP derived TN and TP footprints for the Long-Term Stage 2 scenario and Figure 22 shows the combined WWTP + catchment TN and TP footprints for this discharge scenario.

Immediately downstream of the Whitford-Maraetai Road bridge the predicted TN and TP concentrations combining catchment inputs and the Current WWTP discharge are 0.85 mg/L and 0.07 mg/L respectively.

These estimates are made up of the Current WWTP discharge contribution of 0.12 mg/L and 0.01 mg/L for TN and TP respectively and the catchment derived concentrations of 0.73 and 0.05 mg/L for TN and TP respectively.

The combined estimates are very similar to actual monitoring data from Te Puru Park of 0.74 and 0.07 mg/L for TN and TP respectively.

Immediately downstream of the Whitford-Maraetai Road bridge the increase in mean annual TN concentration for the Short-Term discharge scenario is 0.07 mg/L while the increase in mean annual TP is 0.04 mg/L. For the Long-Term Stage 2 scenario these increases are estimated to be 0.44 mg/L for TN and 0.23 mg/L for TP.

These values reflect the combination that the WWTP discharge makes to the average Te Puru Stream flow (Figure 4) and the percentage increase in TN and TP loads shown in Table 8.

Towards the mouth of the Te Puru Stream the incoming tide provides significant additional dilution to the dilution that occurs in-stream meaning that the average level of dilution at the Te Puru Stream mouth ranges from greater than 10,000-fold under the Current scenario greater than 1,300-fold under the Short-Term and greater than 300-fold under the Long-Term Stage 2 scenario (Table 2).

This results in very low nutrient concentrations relating to the WWTP discharges in the marine receiving environment.

For example, within the mouth of the Te Puru Stream under the Long-Term Stage 2 scenario (when the predicted dilution at this site is the lowest of all the scenarios considered) the maximum increase in TN is 0.006 mg/L while for TP the maximum increase is estimated to be 0.002 mg/L.

As such, increases in TN and TP within the marine receiving environment due to all three WWTP discharge scenarios will be below detectable limits.

The effect of the WWTP discharge in terms of in-stream nutrients (i.e. upstream of the Quarry site) is discussed in detail in Stewart et al. (2024).

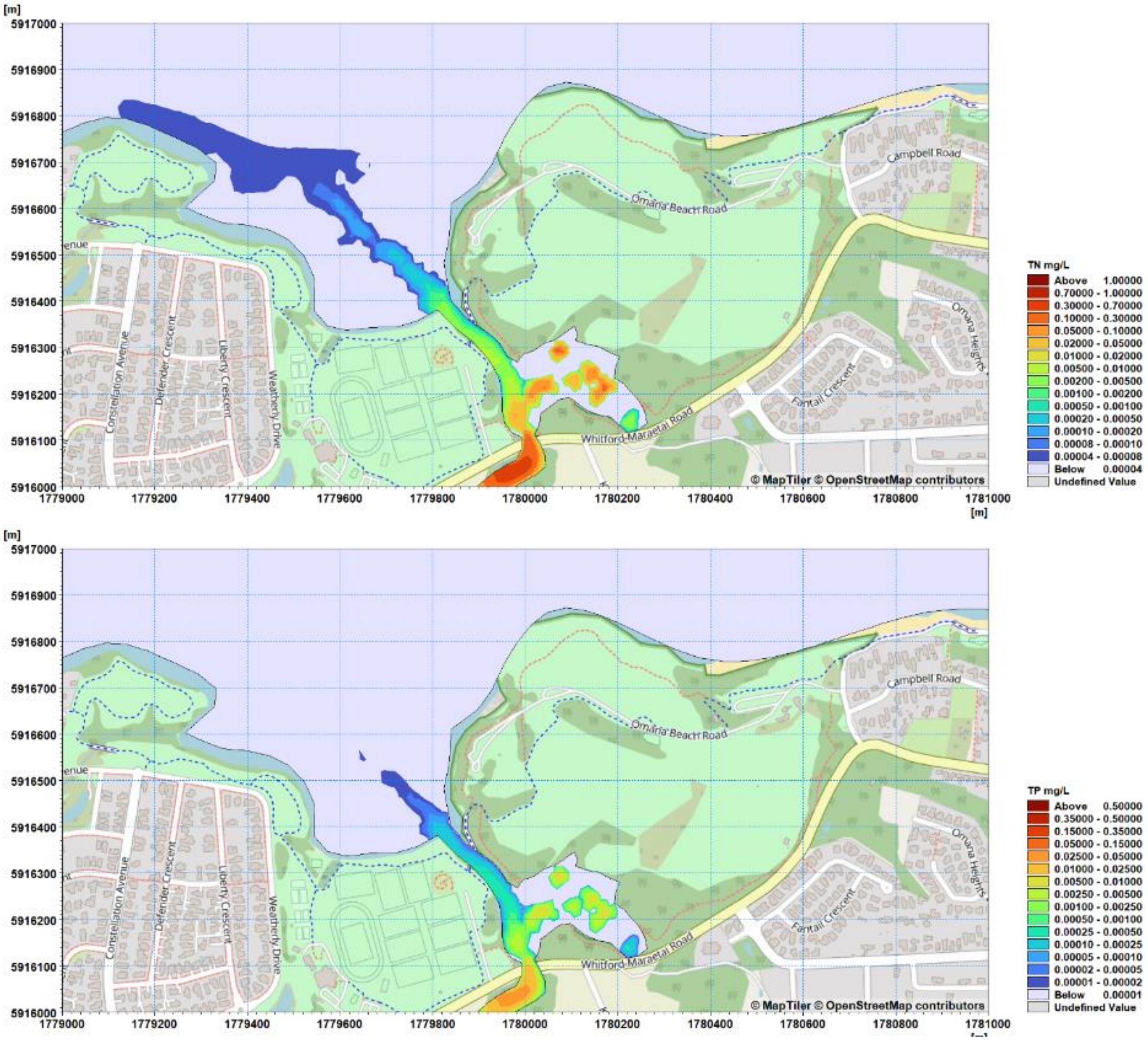

Figure 16. Total Nitrogen (top) and Total Phosphorus (bottom) footprints for the Te Puru Stream catchment (excluding any input of WWTP discharge).

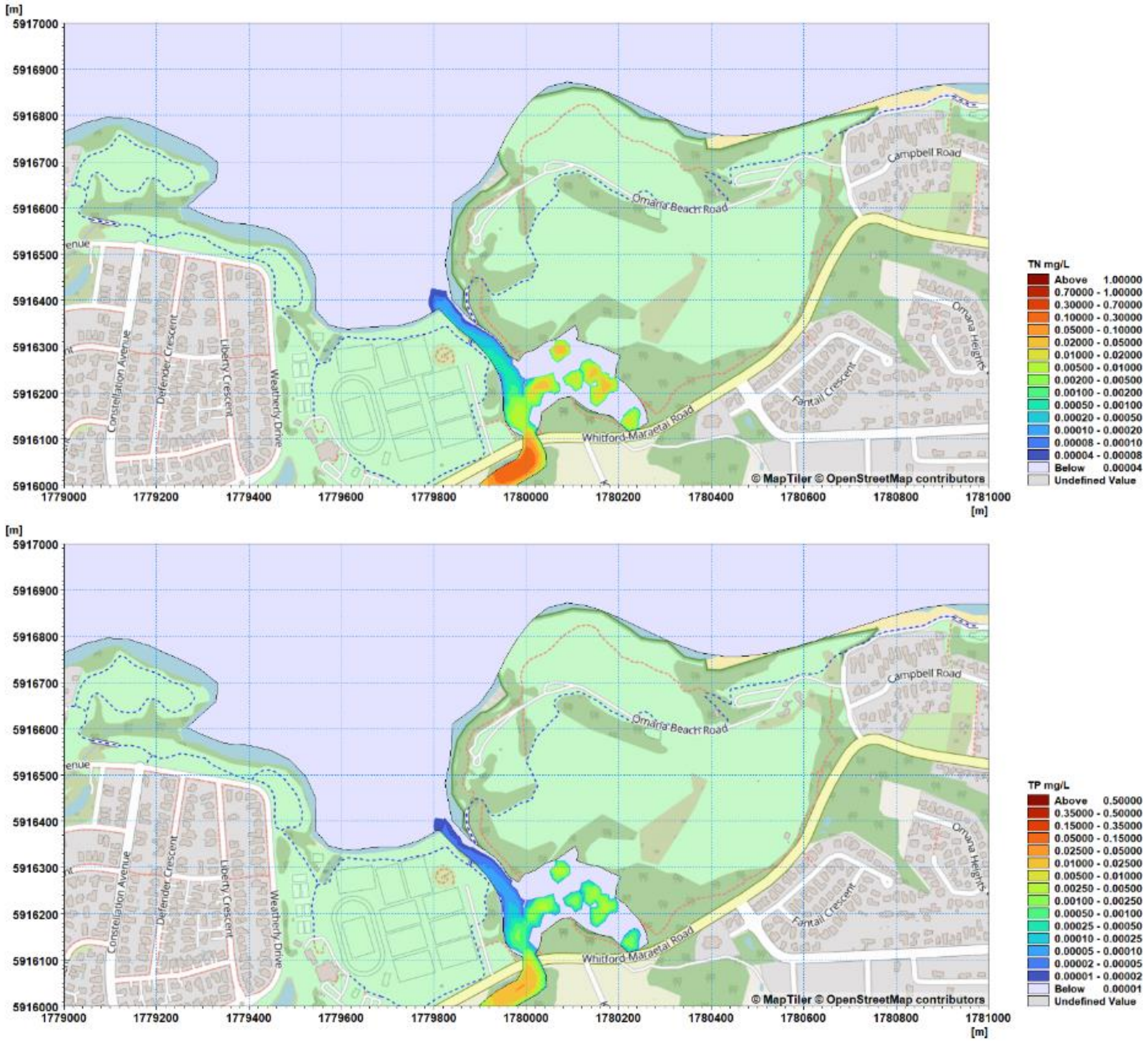

Figure 17. Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Current WWTP discharge (excluding any catchment inputs).

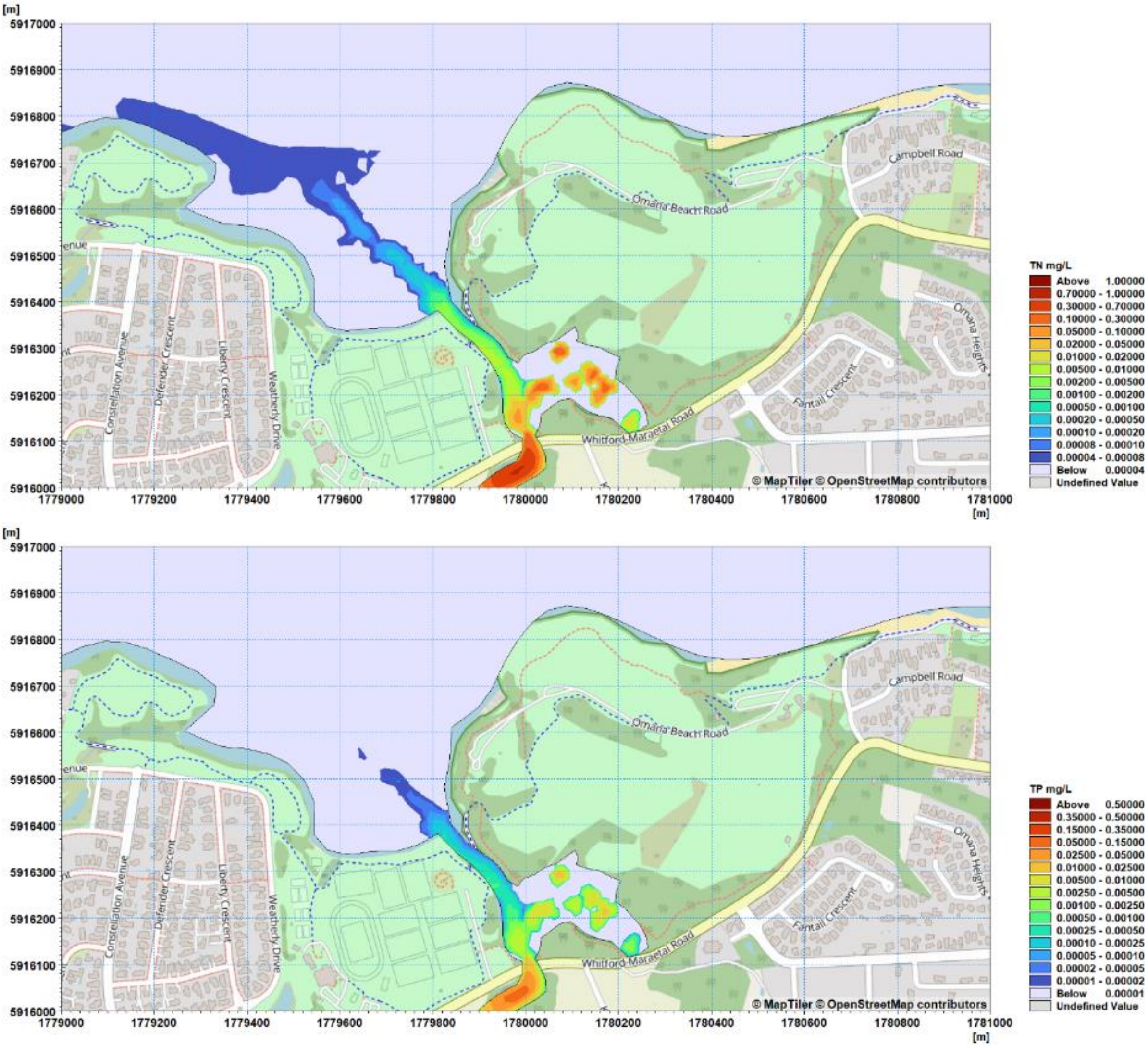

Figure 18. Combined catchment and WWTP Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Current WWTP discharge.

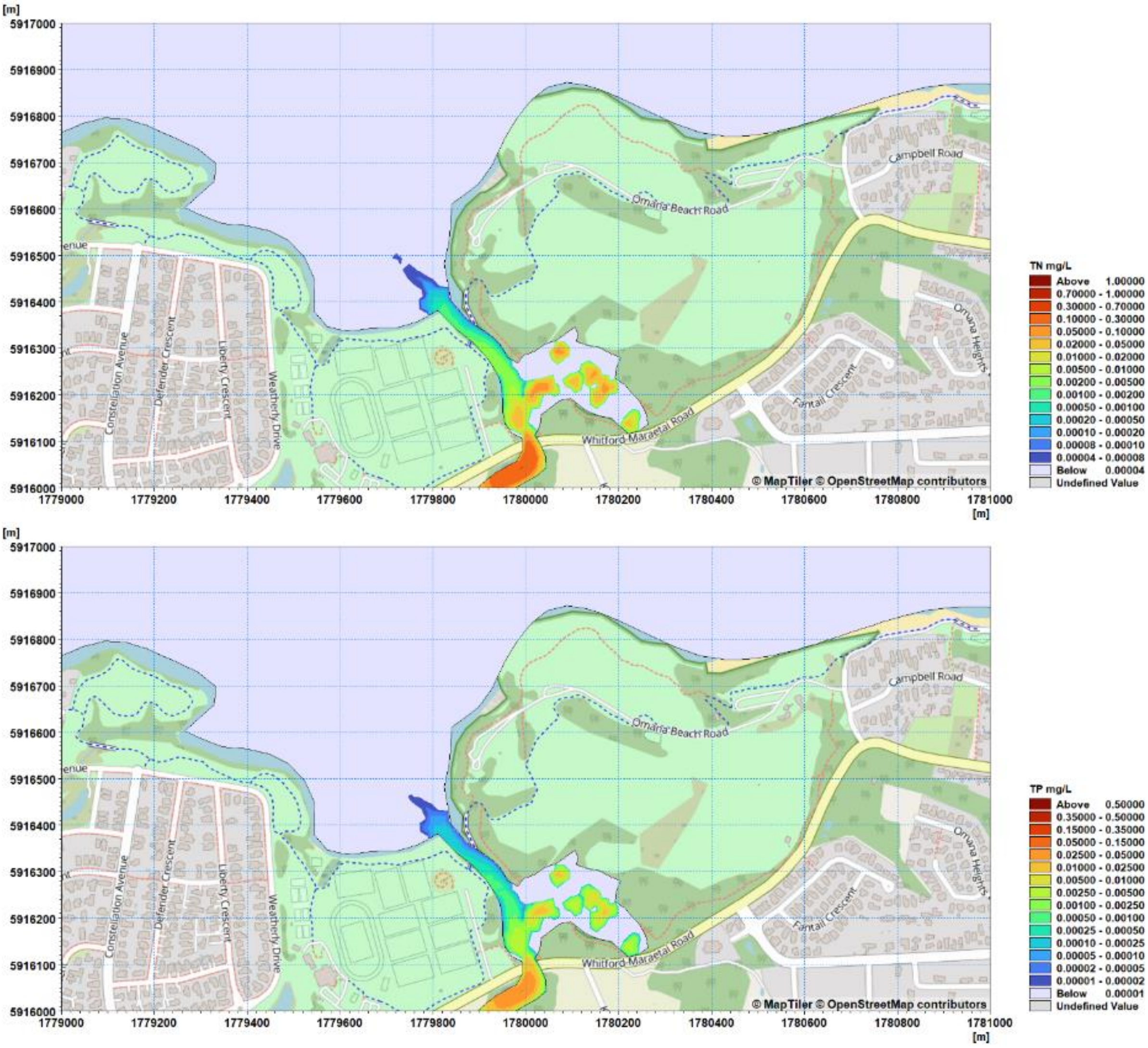

Figure 19. Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Short-Term WWTP discharge (excluding any catchment inputs).

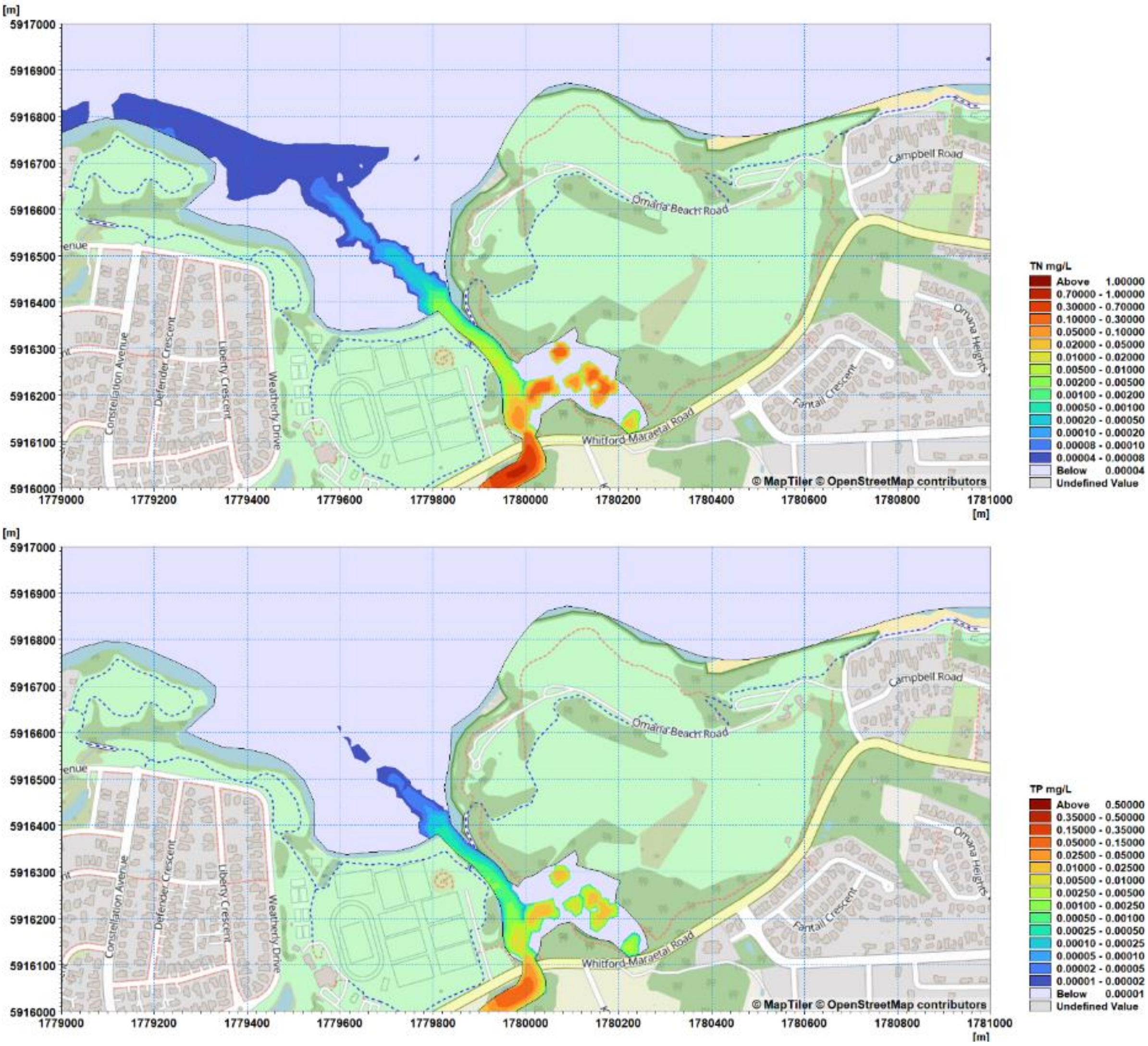

Figure 20. Combined catchment and WWTP Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Short-Term WWTP discharge.

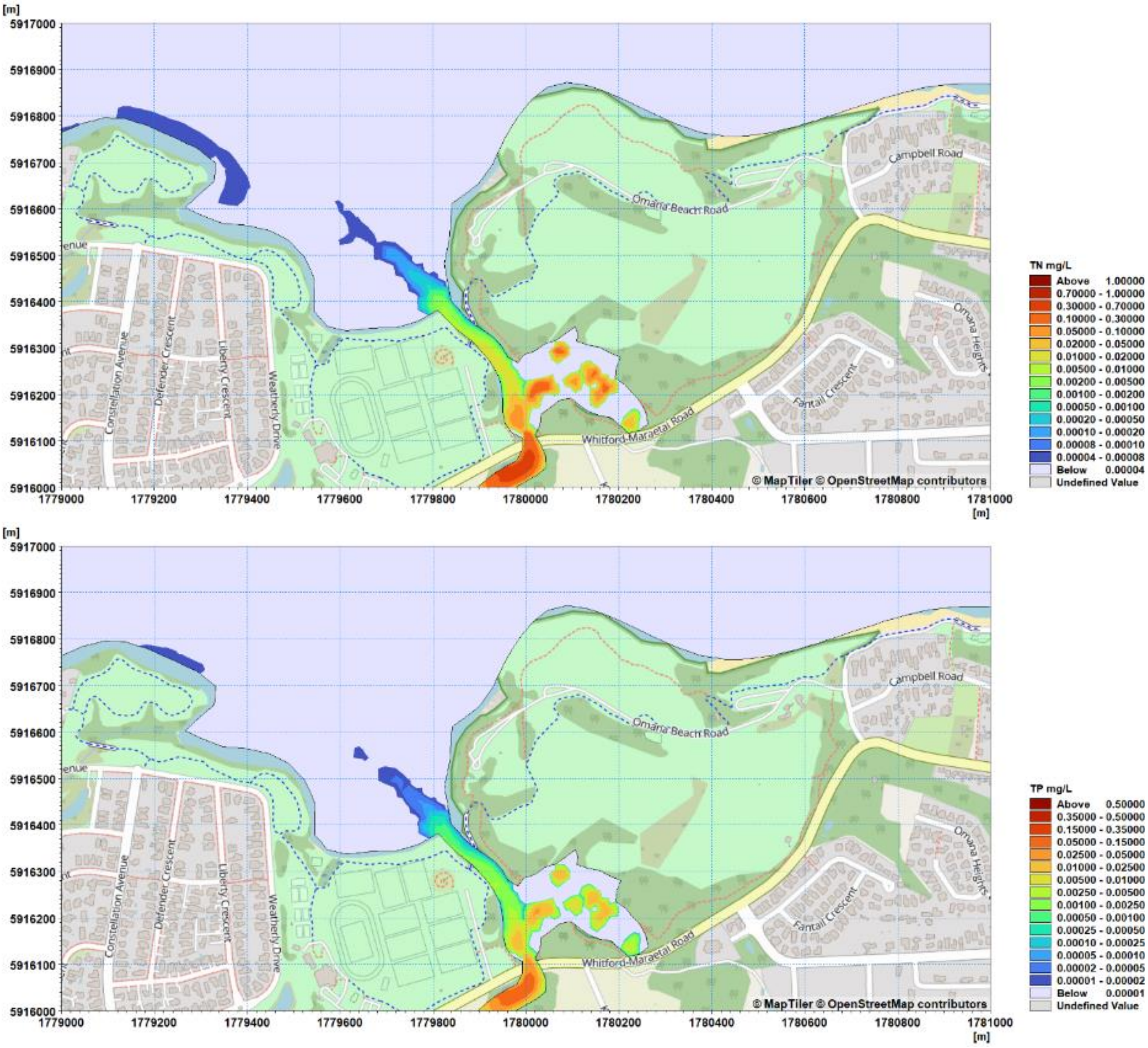

Figure 21. Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Long-Term Stage 2 WWTP discharge (excluding any catchment inputs).

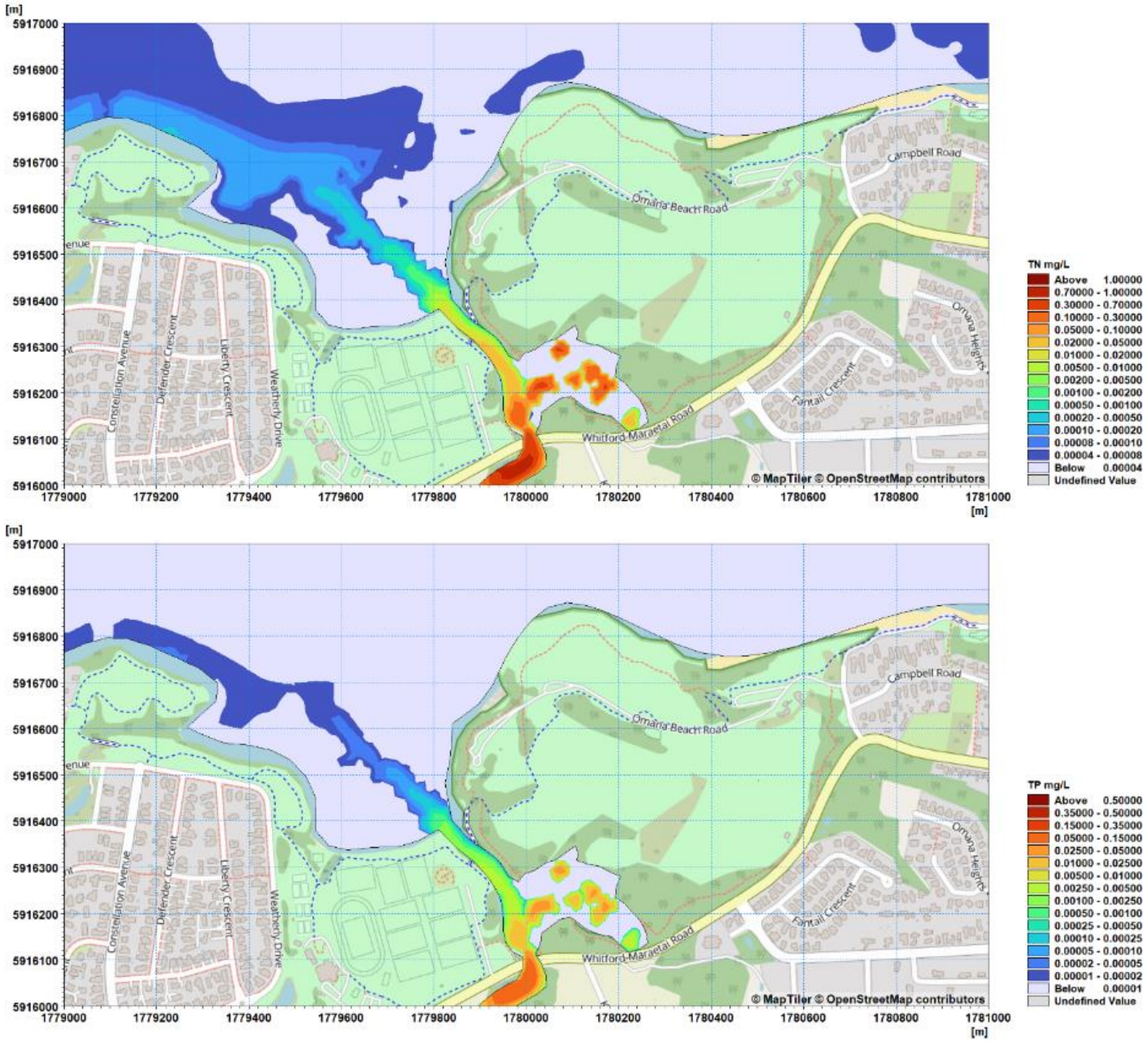

Figure 22. Combined catchment and WWTP Total Nitrogen (top) and Total Phosphorous (bottom) footprints for the Long-Term Stage 2 WWTP discharge.