St Mary's Bay and Masefield Beach Improvement Project

Hydrodynamic Modelling of existing and proposed outfalls

Auckland Council

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Hydrodynamic Modelling of existing and proposed outfalls

Prepared for Auckland Council

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1 Introduction

The St Marys Bay and Masefield Beach improvement project will reconfigure existing outfall assets owned by Auckland Council Healthy Waters in order to reduce the impacts of combined sewer overflows currently discharging to both Bays. The project involves construction of a new storage pipeline and an offshore outfall that will replace three current on-shore outfalls that each overflow in the order of 100 times per year. The new storage pipeline will contain most of the overflows for later return to the main sewer via a new pump station and conveyance to Mangere WWTP for treatment. The overflows originate in Watercare Services Limited's combined sewer network and are authorised and regulated by Watercare's Network Discharge Consent. This document has been prepared to support the request for Manager's Approval to construct this infrastructure and provide the benefits listed in Table 1.

Table 1 - Summary of Expected Results (from the Managers Approval application).

Receiving Environment	Current System Performance			Post Improvement Project System Performance		
	Estimated Average Discharge Frequency (no. of Discharges per yr)	Estimated Average Annual Discharge Volume (m^3 per yr)	Estimated Average Volume of Domestic Wastewater (m^3 per yr)	Estimated Average Discharge Frequency (no. of Discharges per yr)	Estimated Average Annual Discharge Volume (m^3 per yr)	Estimated Average Volume of Domestic Wastewater (m^3 per yr)
Masefield Beach	107	38,400	6,900	-	-	-
St Marys Bay	99	63,400	11,400	2	<1000	20
Waitematā Harbour	-	-	-	20	34,000	680
Total	**206**	**101,800**	**18,300**	**22**	**35,000**	**700**

A summary of the hydrodynamic modelling that has been carried out for the project are provided in the following sections.

The Project has clear benefits in terms of moving the on-shore overflows away from the Masefield and St Marys Bay beaches and relocating a reduced volume of combined stormwater and wastewater into a much more dispersive discharge point in the Harbour Channel to the west of the Auckland Harbour Bridge. This means that the project meets the requirements for Manager's Approval with minimal further assessment required.

However, Auckland Council acknowledges a high degree of public interest and concern around the issue of sewer overflows generally. St Marys Bay and Masefield Beach are very high-profile areas that have suffered from overflows for decades, as have adjacent catchments and suburbs.

In order to further examine and confirm the benefits of the Project, DHI has been commissioned to undertake a hydrodynamic modelling assessment to examine the following aspects of the project:

- whether there is any significant difference in potential new outfall locations, in terms of dilution and dispersion of discharges;

- whether there are any impacts on local beaches from the new outfall discharges; and
- whether there is any impact on the Harbour receiving environment near the new discharges, given that the overall discharges to the Harbour will be reduced.

2 Methodology

The following methodology was employed:

- Identify and describe major assumptions;
- Refinement and validation of an existing harbour model;
- Examine existing situation to understand the performance of current overflows;
- Work with the project team to identify potential outfalls locations;
- Assess potential outfall locations and make a recommendation as to a preferred location; and
- Undertake further assessment of the preferred location to quantify potential benefits and/or impacts on local beaches and the Harbour receiving environment.

3 Major Assumptions

The following major assumptions have been used in developing the model and assessing impacts:

- Details of the frequency, magnitude and quality of the existing and future overflows were provided by the Healthy Waters networks modelling team
- The St Marys Bay and Masefield Beach Improvement Project is a local project dealing with only 3 existing outfalls (from 5 sewer network discharge points). To demonstrate the benefits of this project, this assessment is undertaken only considering relocating these discharges from the 3 existing outfalls.
- There are many other overflows that occur in Auckland's Central catchments which lead to contamination of the wider Harbour. Results of this assessment are put in context of the high level of background contamination within the wider Harbour due to these other overflows.
- The indicator bacteria used for the assessment is enterococci. This indicator pathogen has clear national guidelines[1] and provides a good measure of the potential health risk of pathogens in marine waters
- A key objective of the project is to reduce the health risk associated with contact recreation (including swimming and boating) at Masefield and St Marys Bay beaches. To determine whether a reasonable safety threshold has been achieved with regard to potential pathogen levels, guidelines from the Ministry of Environment (as set out below) have been used to benchmark water quality improvements:

  Alert mode

  This mode is triggered when a single sample of greater than 140 enterococci per 100 mL is observed.

  Action mode

  This mode is triggered when two consecutive samples are greater than 280 enterococci per 100 mL are observed.

- A number of 'marker' sites of local interest were selected to investigate potential impacts on local beaches and environments as shown in Figure 1.

[1] Ministry for the Environment 2002. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas.

- A representative event was used to investigate the relative performance of the outfall location options.
- Long-term model simulations covering a range of wind, tide conditions, duration and magnitudes of overflows were used to investigate the preferred option in detail.

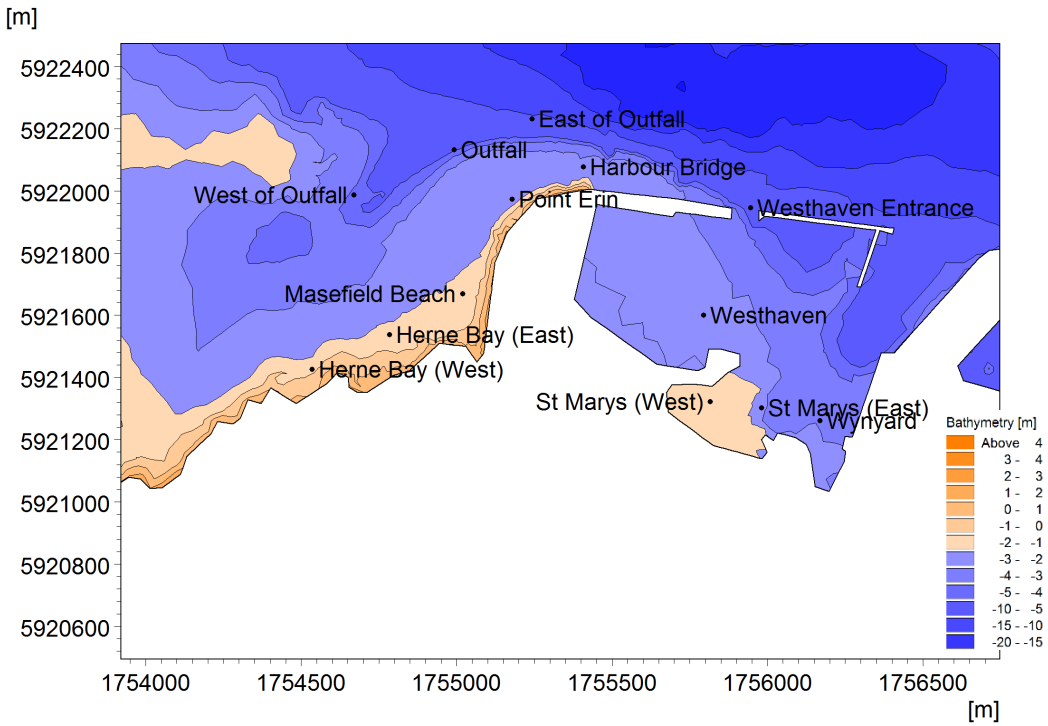

Figure 1. Key sites used to extract time-series and percentile concentrations for the existing and future overflow scenarios.

4 Refinement of Existing Harbour Model

DHI has developed the Harbour Model which is currently used by Auckland Council for its Safeswim monitoring and water quality prediction programme. This model has been through extensive testing and calibration.

For this project the following updates were applied:

- Detailed bathymetry data of the project area were incorporated into the model (Figure 2)
- The model grid near the potential outfall sites was refined
- Currents were measured near the preferred outfall site so it could be determined that the Harbour Model provided good predictions of currents at the preferred outfall site. This ensures the potential for dispersion in the area of the new outfall is well defined.

The Harbour Model is a well calibrated hydrodynamic and water quality. Details of the calibration of the model are presented in DHI (2017).

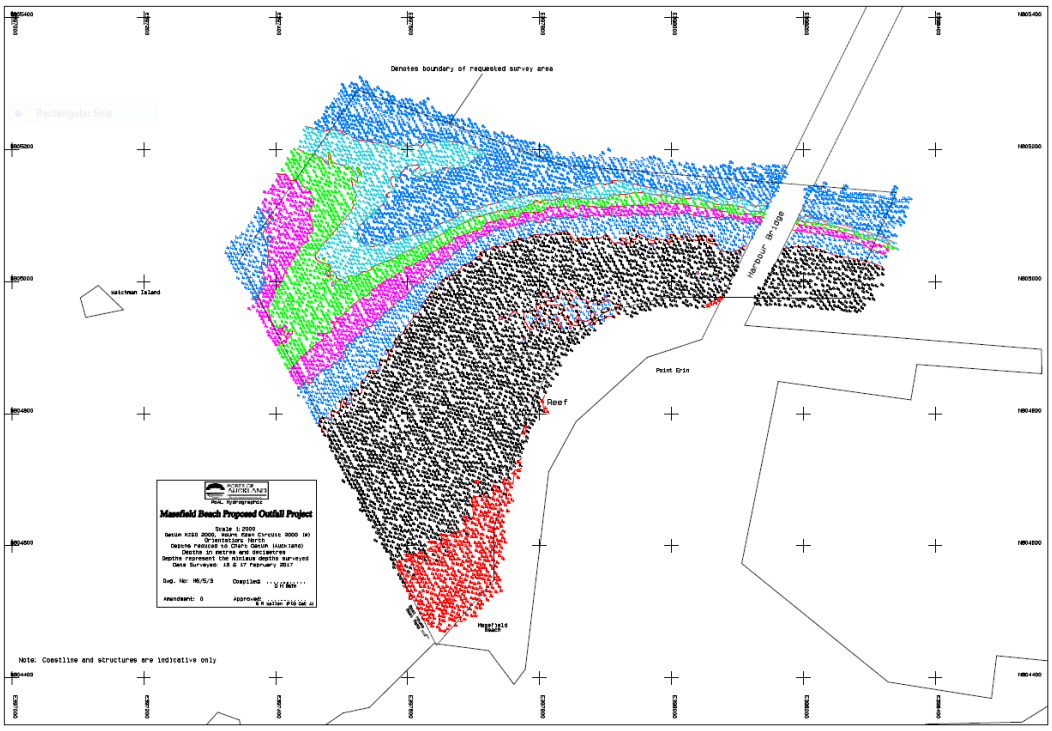

Figure 2. Area covered by the bathymetric survey carried out on the February 2017.

5 Assessment of Existing Locations

5.1 St Marys Bay

There are two major overflows which impact on water quality at St Marys Bay Beach and the Inner Bay which account for nearly two-thirds of the overflows volumes being considered in the Project (Table 1). These structure discharge directly into the Bay and are visible at low tide (Figure 3).

Figure 3. Combined Sewer Overflow to St Marys Bay showing debris resulting from its operation – odorous and visible at low tide (photograph taken 15/09/15).

5.2 Masefield Beach

The existing Masefield Beach outfall has failed and has cracks and breaks that are exposed at low tide and it is unclear how overflows may actually discharge into the marine receiving environment.

The best outcome from the existing pipe, in terms of water quality, would be if any overflow discharges towards the seaward end of the pipeline. The worst outcome (because very little dilution will occur) is that the overflow discharges directly onto Masefield Beach towards the landward end of the pipeline and the existing seawall. Given the state of the pipe, both scenarios are highly likely to occur (depending on the state of the tide) which means pathogenic contamination from wastewater at this location could be extremely high.

Figure 4. Existing pipeline at Masefield Beach (March 2017, Wilde Media Ltd).

Model runs with both a seaward or landward discharge at the Masefield site showed very little difference in predicted concentrations away from Masefield Beach itself.

A discharge towards the seaward end of the existing pipeline resulted in slightly lower levels of contamination at the discharge site. This is due to the deeper water, higher currents and greater inundation times that occur at the seaward end of the pipeline. Consequently, a seaward end overflow results in lower concentrations at the shoreline compared to a landward end discharge.

For the comparison between the existing and future situation it has been assumed the existing overflow at Masefield occurs towards the seaward end of the existing pipeline thus providing a best case comparison with the future overflow scenario (i.e. the existing situation is, at times, likely to be worse than has been modelled).

5.3 Impact of the Existing St Marys and Masefield Outfalls on the Waitematā and Local Environment

Based on long-term model simulations the calibrated Harbour Model has been used to quantify the contaminant concentrations that would occur in the Waitematā.

The period chosen for the long-term hydrodynamic simulations (January 1st 2004 through to May 31st 2004) contains a typical number of overflow events and significantly more than the predicted annual average overflow volumes shown in Table 1.

The predicted 99th percentile concentration (i.e. the concentration that would be exceeded for only 1% of the time) for the long-term simulation with just the existing St Marys and Masefield discharges is shown in Figure 5.

This figure shows the area of the Waitematā impacted by the existing discharges and an indication of the highest levels of contaminant that could be expected during a large overflow event.

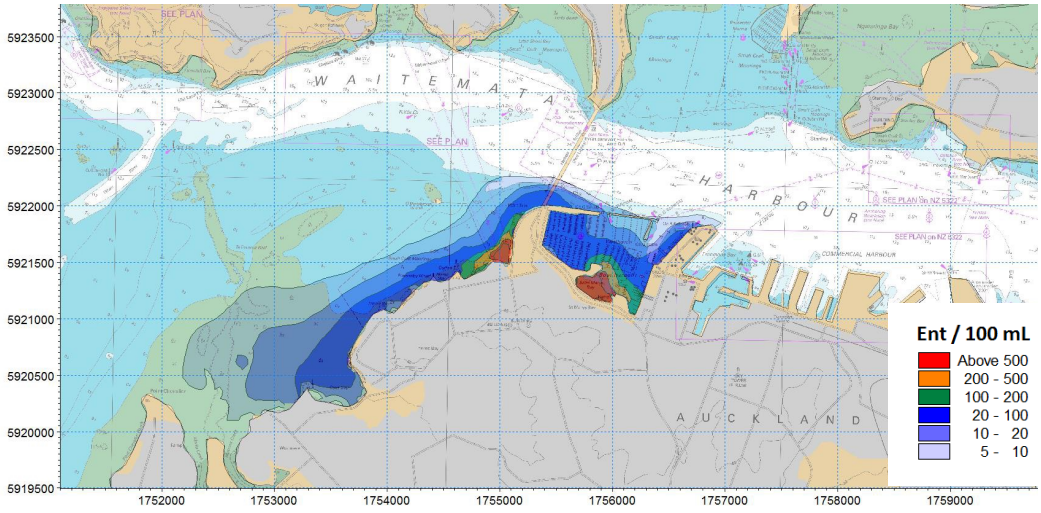

Figure 5. Predicted 99th percentile concentrations under the existing situation for overflows from St Marys Bay and Masefield Beach for the period January 1 2004 to May 31 2004. Other overflows to the Waitematā are not included in the model simulation.

Results from the long-term simulation with the introduction of the overflows via the preferred outfall show that there will be significant reductions in predicted concentrations at key shoreline sites between Herne Bay and St Marys Bay. This is due to a combination of the less frequent overflows that occur via the outfall (Table 1), the dilution achieved within the immediate vicinity of the preferred outfall and the subsequent dilution of the plume as it is transported away from the discharge site. Details of the model predictions are discussed in Section 7.

5.4 Context of these Outfalls in the wider Waitemata Harbour Environment

As discussed above, there are many other overflows outside St Marys Bay and Masefield Beach that contribute to the overall levels contamination of the wider Harbour when overflows occur.

Figure 6 shows the predicted 99th percentile concentration (i.e. the concentration that would be exceeded for only 1% of the time) for the long-term simulation with all the known overflows to the Waitematā.

Because overflows enter the harbour from many sources between Point Chevalier and the Port the zone of impact of the overflows is much larger than for the area impacted by just the St Marys Bay and Masefield Beach overflows as shown in Figure 5. Note the different scales used in the figures.

This model predictions shown in Figure 6 indicate the significant contribution that overflows from the Motion and Meola catchments have on the wider levels of contamination in the harbour and in particular the area west of Masefield Beach and beyond Point Chevalier.

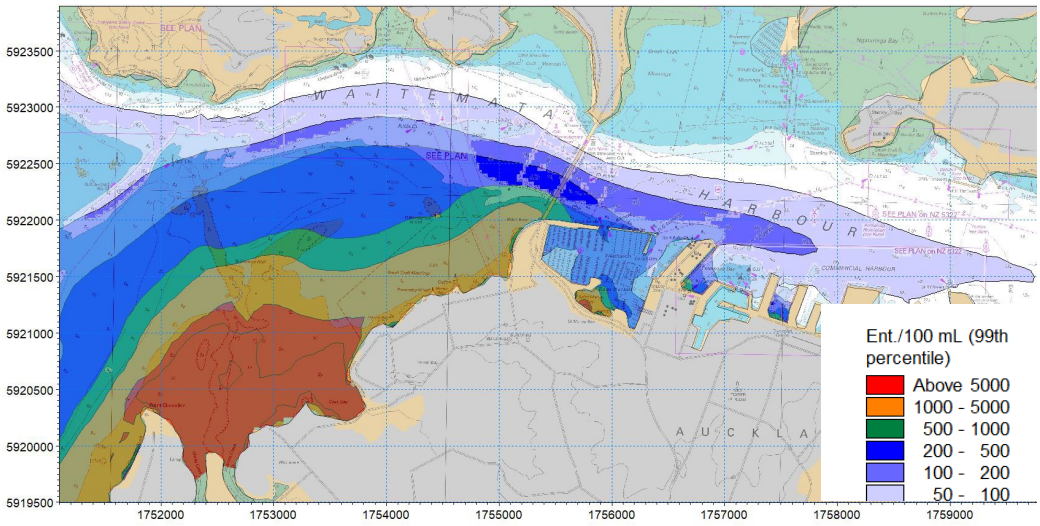

Figure 6. Predicted 99th percentile concentrations with all Waitematā overflows for the period January 1st 2004 to May 31st 2004.

6 Assessment of Alternative Outfall Locations

A dilution assessment was undertaken for the outfall locations shown in Figure 7.

Figure 7. Location of alternative outfall sites.

The levels of dilution achieved by each of the outfalls and the typical zone of impact for each of the alternative outfalls were quantified using short-term model simulations. A worse case condition of a neap tide (when tidal flows are lowest) and a schematic light onshore wind condition (5 m/s north-westerly) was chosen for the assessment. Details of this assessment (and aspects relating the consideration of the land based component of the project) are discussed in the Managers Approval assessment (Appendix B).

Data in Table 2 shows predicted level of dilution achieved at key sites in the immediate vicinity of the alternative outfall sites. Note that the higher level of dilution the lower the predicted level of contamination.

Based on the above assessment and consideration of other aspects of the construction, from the alternative outfalls, the preferred outfall site is the Western Outer site.

Table 2. Average level of dilution (fold) achieved at the key sites in the immediate vicinity of the alternative outfalls.

Outfall Site	Herne Bay	Masefield	Westhaven (West)	Westhaven (East)
Western Inner	556	364	476	690
Western Outer	1333	909	625	741
Central Inner	455	317	417	645
Central Outer	1053	741	541	690
Eastern Inner	488	182	370	714
Eastern Outer	556	364	476	690

7 Assessment of Preferred Outfall Location

The performance of the preferred outfall, in terms of improvements to water quality, have been benchmarked against the impact existing overflows have on water quality within St Marys Bay and Masefield Beach and the wider water quality of the Waitematā Harbour.

For the modelling assessment, it was assumed that the outfall itself would consist of a single open ended 1200 mm pipe.

This configuration provides a good level of initial dilution within the first few hundred metres from the outfall. The average dilution achieved 200 m from the outfall is predicted to be over 25, with a minimum dilution of 5 (occurring at high or low water when currents over the outfall are a minimum). During peak tidal flows dilutions of over 150 can occur.

Importantly, the assessment carried out has shown that, with a single 1200 mm pipe, the overflow plume is unlikely to be fully mixed in the water column in the immediate vicinity of the discharge site. When low ambient currents occur, the plume will reside in just the top 20% of the water column and for higher ambient currents the plume will reside in the top 75% of the water column.

Subsequent work by Aurecon has identified that an outfall with duck-bill valves would be preferred to prevent saline and sediment intrusion into the outfall (see Appendix A, Assessment of Environmental Effects) The use of duck-bill valves helps to maintain high velocities within the outfall ports which enhances vertical mixing of the plume. This means the plume will tend to be more fully mixed than has been assumed for the assessment. Thus, with a duck-bill valve structure, dilutions in the immediate vicinity of the discharge site are likely to be higher than have been predicted.

The predicted 99th percentile concentration (i.e. the concentration that would be exceeded for only 1% of the time) for the long-term simulation with the just the preferred outfall is shown in Figure 8. The figure shows that to the west of the Harbour Bridge the predicted concentrations are much less than with the existing situation (as shown in Figure 5) and that there is a vast improvement in predicted water quality in the St Marys Bay area.

Figure 9. shows the equivalent data with all the other overflows included in the model.

Model predictions at the key sites shown in Figure 1 is summarised in Table 3.

At all sites, except the discharge site itself, there is an improvement to water quality with the introduction of the preferred outfall. The small increase in contaminant levels at the **discharge site,** due to the preferred outfall, is small in terms of the overall level of contamination at this site (which is highly influenced by all the other overflows).

At sites within **St Marys Bay and at Masefield Beach** the contribution of the existing overflows is significant and the introduction of the preferred outfall significantly improves water quality.

At all other sites (**Herne Bay, Point Erin, Harbour Bridge and Westhaven Entrance**) the influence of the other overflows has the biggest impact on predicted water quality, so while the introduction of the preferred outfall improves water quality at these sites, the influence of the other overflows to the harbour still has a significant impact on water quality.

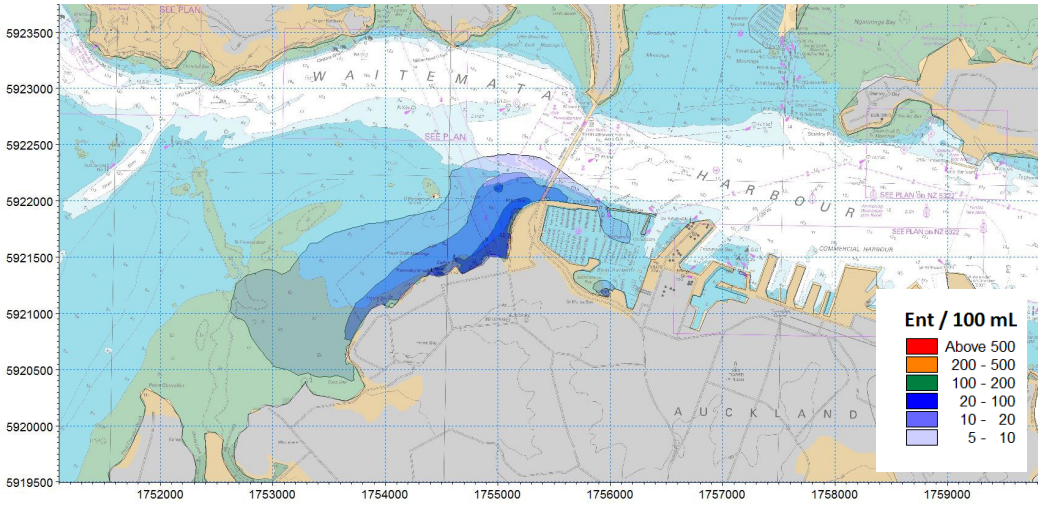

Figure 8. Predicted 99th percentile concentrations with the removal of the Masefield and St Marys overflows and the introduction of the proposed Outfall for the period January 1st 2004 to May 31st 2004. Other overflows to the Waitematā are not included in the model simulation.

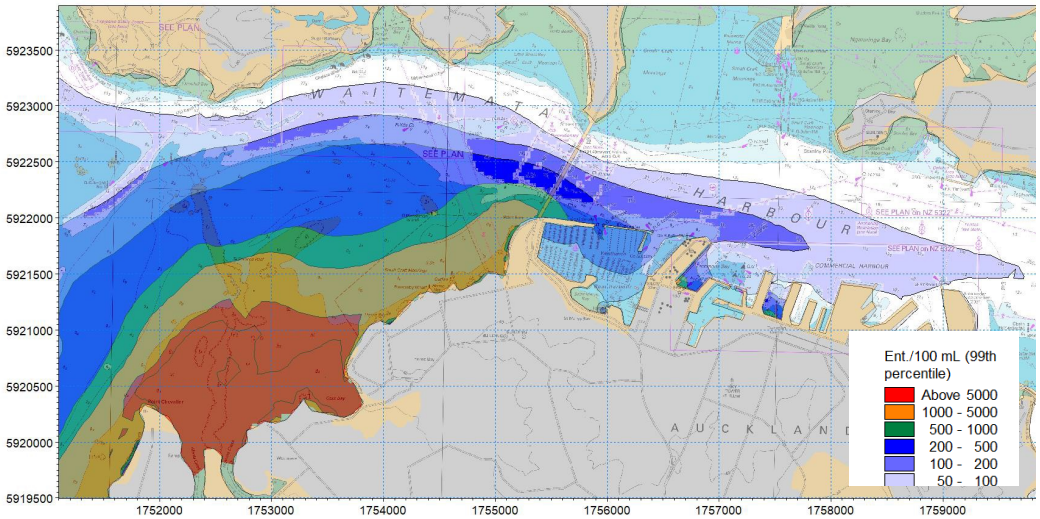

Figure 9. Predicted 99th percentile concentrations with all Waitematā overflows and the removal of the Masefield and St Marys Waitematā overflows and the introduction of the preferred outfall for the period January 1st 2004 to May 31st 2004.

8 Conclusions

The modelling investigation shows that there are no adverse impacts in the near field or far field from the proposed outfall, significant improvements to water quality will be achieved within St Marys Bay and improvements to water quality at Masefield Beach will be achieved (although the influence of other overflows to the west of Masefield Beach will still significantly impact on the overall water quality at Masefield Beach).

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Table 3. Predicted 99th percentile concentrations at key beach sites with all Waitemata overflows, just the existing overflows to Masefield Beach and St Marys Bay and with the St Marys and Masefield overflows being discharged via the preferred outfall. Sites shown in Figure 1.

Site	99th percentile concentration (Ent. counts/100 mL) with all Waitematā overflows	99th percentile concentration (Ent. counts/100 mL) with just existing Masefield and St Marys overflows	99th percentile concentration (Ent. counts/100 mL) with Masefield and St Marys overflows via preferred outfall	Comments
Herne Bay (West)	1211	36	11	Contribution of existing St Marys and Masefield overflows is relatively small. Introduction of the preferred outfall improves contaminant levels
Herne Bay (East)	1977	115	20	
Masefield Beach	1884	384	27	Contribution of existing Masefield overflows is significant. Introduction of the preferred outfall improves contaminant levels
Point Erin	1384	59	24	Contribution of existing St Marys and Masefield overflows is relatively small. Introduction of the preferred outfall improves contaminant levels
Harbour Bridge	896	35	11	
Westhaven Entrance	255	8	5	
Westhaven	107	61	3	Contribution of existing St Marys overflows is significant. Introduction of the preferred outfall significantly improves contaminant levels
St Marys (West)	2207	2209	4	
St Marys (East)	486	481	4	
Wynyard	130	128	3	
Preferred outfall	676	7	15	Contribution of existing St Marys and Masefield overflows is minor. Introduction of the preferred outfall slightly increases contaminant levels

9 References

DHI 2017c. Auckland Bathing Water Forecast Update for Safeswim, Numerical Modelling. Report prepared for Auckland Council.