REF APP-123774

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER OF	discharge and land use resource consents for the operation and maintenance of the Wairoa wastewater treatment plant and sewer pump station overflows
BY	**Wairoa District Council**
	Applicant

STATEMENT OF EVIDENCE OF SHAW TREVOR MEAD ON BEHALF OF WAIROA DISTRICT COUNCIL

16 November 2020

INTRODUCTION

1. My name is **Shaw Trevor Mead.**

2. I am an environmental scientist at eCoast.

3. My evidence is given in relation to the application for resource consents for the Wairoa Wastewater Treatment Plant ("**WWWTP**") by Wairoa District Council ("**WDC**").

EXECUTIVE SUMMARY

4. This evidence presents the findings of the ecological and numerical modelling investigations for the proposed Wairoa wastewater treatment plant (WWTP) outfall, the actual and potential environmental effects and methods to mitigate them.

5. The key findings and conclusions from my investigations include:

   a) The initial monitoring of benthic impacts due to the outfall was found to be deficient, having only few monitoring sites within the zone of impact and poor temporal resolution (only 4 surveys since 1996). Therefore, an expanded ecological and sediment geochemistry survey was undertaken to include the existing sites and also investigate the seabed at locations beyond the 100 m mixing zone using a systematic approach.

   b) Sediment geochemistry characteristics in sediment samples indicated no strong evidence that the current outfall is impacting the immediate benthos. For sediment-bound contaminants and nutrients, all contaminant levels in the samples were below ANZECC (2000) Interim Sediment Quality Guidelines low threshold values and thus adverse ecological effects due to contamination would be unlikely.

   c) It was found that evaluating impacts of the outfall on benthic effects was difficult given the low species diversity and wider degraded nature of the lower Wairoa Estuary, which is considered ‘sediment-stressed’, as well as the initial monitoring only having a few sites within the zone of likely impact.

   d) The numerical model calibrated reasonably well against measured field data in this hydrodynamically complex location, and replicated the important processes and degree of stratification identified in the measured data. This provided confidence in the results of the various modelled discharge and overflow scenarios modelled.

   e) The model simulation to investigate the effects of a 3-year ARI rainfall event that resulted in a wastewater spill at 3 locations found that rapid mixing of the overflow plumes occurred in the fast-flowing river associated with the rain event reducing contaminant concentrations to levels below the ANZECC (2000) marine toxicity trigger value for the protection of 95% of species within 25 m of the overflows.

f) Simulation of 10 scenarios with different configurations of outfall flow, timing and river flow to represent potential future outfall discharge regimes from the existing outfall location found that when the estuary mouth is open, ammonia-N concentrations (the contaminant of greatest concern from the outfall) are likely to fall below the trigger value within 100 m of the outfall in all cases.

g) Additional model simulations were undertaken of the proposed 200 m extension to the pipeline, which locates the outfall diffuser in the centre of the main channel, which has significantly higher flow speeds than the existing location. These additional simulations of the extended outfall were compared to the existing outfall location.

h) The results of these comparative simulations indicate that the dilution of the discharge will be significantly increased with the outfall in the new proposed location. These results indicate that dilutions of <100x do not occur outside of the 25 x 25 m release cell/outfall location during any discharge scenarios, and dilutions of <200 do not occur over 25 m away from the outfall for most scenarios for the majority of the time.

i) The additional ecological investigations verified the presence of low densities of adult pipis along the proposed extended pipeline route (the last ~50 m) and at the diffuser, which are the likely source of the juvenile pipis found in all previous surveys of the estuary.

j) The assessment of environmental impacts of the construction and operation of the proposed 200 m extension of the outfall pipeline concluded:

   i. The direct impacts of construction/excavation in the estuary are considered *minor, and will be relatively short-term and localised impacts* (i.e., likely senescence of some benthic/infaunal organisms along the pipeline route, followed by recolonization of the disturbed area);

   ii. Indirect impacts due to suspension of fine sediments during construction/excavation are considered *minor to less than minor* given the existing nature of the lower Wairoa Estuary (sediment 'stressed' and often extremely turbid due to suspended fine sediments) and relatively short-term, and;

   iii. That the improved treatment of the discharge water and the strategic modifications to discharge management will ensure that the *environmental impacts of discharges from the outfall will be minor and localised to within 25 m of the diffuser.*

6. To minimise impacts on pipi (and the benthic ecology in general) during construction, the construction environmental management will include targeting a low flow period for riverine construction to reduce the potential spread of suspended sediments, avoiding the period of greatest pipi spawning activity in spring and early summer, minimizing the working footprint, allowance of natural infilling of the pipeline trench, utilizing silt curtains and piling from a barge to minimise disturbance of the river/estuary bed.

QUALIFICATIONS AND EXPERIENCE

7. I have the following qualifications and experience relevant to the evidence I shall give:

   (a) I have the qualification of BSc (School of Biological Sciences) and MSc (Hons) (School of Environmental and Marine Sciences) degrees from the University of Auckland, and a PhD degree from the University of Waikato (Earth Sciences).

   (b) I have over 25 years' experience in marine research and consulting, have authored/co-authored 60 peer-reviewed scientific papers and 2 chapters in a practitioner's textbook on beach management and coastal protection, and have solely or jointly produced over 450 technical reports pertaining to coastal oceanography, coastal engineering (design and impact assessments), marine ecology and aquaculture. I am a Divemaster/Occupational Scientific Diver and have undertaken over two thousand research and consulting SCUBA dives around the coast of New Zealand and overseas, and have led many comprehensive field investigations that have addressed metocean, biological and chemical components of the coastal environment.

   (c) I have a background in marine ecology, aquaculture, coastal oceanography and numerical modelling. I studied for my MSc degree at the University of Auckland's Leigh Marine Laboratory, undertaking subtidal research there from 1994 to 1996 directed at the fertilisation success of sea urchins as a basis for the sustainable management and development of the commercial market. My MSc in Environmental Science, Marine Ecology and Aquaculture included 4th year Environmental Law and a dissertation on the Quota Management System (QMS) legislative review. My PhD was primarily in coastal oceanography and numerical modelling, with the marine ecological components of my Doctorate directed towards subtidal habitat enhancement of marine structures. My professional career has included involvement in a wide range of coastal consulting and research projects that have included the design of coastal structures and developments, and assessments and monitoring of ecological and physical effects of marine construction, marine reserves (investigations for new reserves and monitoring), MPR design and surf break impact assessment, climate change resilience strategies, coastal erosion control and beach management, dredging, outfalls, oil industry, aquaculture ventures and various other coastal and estuarine projects that have included ecological assessment, hydrodynamic (waves and currents), sediment transport and dispersion modelling (including contaminants, suspended sediments, freshwater, hypersaline water, nutrients and petro-chemicals).

(d) I have considerable experience in evaluating environmental effects of construction-related activities within the coastal environment (open coasts, sheltered coasts, harbours and estuaries) throughout Australasia and the South Pacific and have been involved in a range of projects which are directly relevant to the present proposal (i.e., coastal structures within an estuary, dispersion modelling of contaminants and marine ecological effects), including:

- Oceania Ocean Outfall Dispersion Modelling, including Field Data Collection and Nearfield Plume Modelling for Boundary Input and Passive-Coupling at Oceania Outfall, Timaru.
- Clive River Entrance Ecological, Bathymetry and Sediment Surveys, Hawke’s Bay.
- Marine Ecological Impact Assessments and Expert Evidence for the Te Whau Pathway, Waitemata Harbour, Auckland.
- Silver Fern Farms WWTP Outfall – AEE Expert Review, Timaru.
- Makara Estuary Monitoring, Wellington.
- Fanga’uta Lagoon Marine Ecology Baseline Assessment and Environmental Impact Assessment, Tonga.
- Fanga’uta Lagoon Bridge Flushing Modelling, Tonga.
- Groves Road Stormwater Pump Station and Discharge Pipe: Environmental Impact Assessment, Kapiti Coast.
- Water Quality Monitoring and Beach Monitoring and Management for Port Spencer, South Australia.
- Rangitahi Bridge Environmental Monitoring Programme, Raglan.
- Coastal (Physical and Biological) Assessment of Environmental Effects for the Construction of Stilling Wells in Raglan Harbour.

- Mekong Delta: Field Data Collection, Analysis and numerical modelling, Vietnam.
- Fieldwork, Data Collection and Hydrodynamic Modelling and Residence Times of the 7 Major Waikato West Coast Estuaries.
- Whitianga WWTP Outfall – Viral Fate Modelling.
- Remediation of Pond 2 and Downstream Pollution for the Crest Processing Plant Outfall Upgrade, Suva, Fiji.
- Benthic Sampling of Porirua Harbour, Wellington.

8. I am a member of a number of relevant associations including:

   (a) the New Zealand Coastal Society (ENZ);

   (b) the New Zealand Association of Impact Assessment;

   (c) the editorial board of the Journal of Coastal Conservation, Planning and Management; and

   (d) a Registered Environmental Impact Assessment (EIA) consultant for the Fijian Ministry of the Environment (coastal processes, coastal engineering, marine ecology, numerical modelling).

CODE OF CONDUCT

9. I confirm that I have read the 'Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2014. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

BACKGROUND AND ROLE

10. My involvement in the Proposal includes leading the ecological and numerical modelling investigations for the Wairoa WTTP outfall. This included field data collection of sediment samples for analysis of sediment composition and contaminants, infaunal and epifaunal sample acquisition and processing with Dr Tim Haggitt[1], and collection of physical measurements for numerical model calibration (bathymetry survey of the lower estuary from the Wairoa Water Ski Club to the entrance, 4 weeks of current, water level and salinity data collection). I have traversed the majority of lower estuary (on jetski and on foot) and have a thorough understanding of the wider area from an ecological perspective. I was also involved with the numerical modelling of a variety of current and future outfall

[1] Haggitt, T., S. T. Mead, W.C. Mead and S. O'Neill, 2018. Assessment of effects of Wairoa District Council's existing intertidal sewage discharge on benthic sediment characteristics and ecology – Wairoa Estuary. Prepared for Wairoa District Council, November 2018.

scenarios, including extreme events for scour protection and the extended outfall location[2,3,4], and so also have a thorough understating of the hydrodynamics of the lower Wairoa Estuary.

11. In preparing my evidence I have:

(a) Visited the site on 3 separate occasions;

(b) Reviewed the reports from our investigations, which include review of a number of reports pertaining to the environmental health of the Wairoa Estuary, the existing and proposed outfall and environmental impacts;

(c) Attended 8 virtual meetings with other Wairoa Council experts and consultants;

(d) Reviewed the HBRC's expert's (Dr Shane Kelly) memos dated 4 July 2019 and 6 October 2020;

(e) Undertaken 2 virtual meetings with Dr Shane Kelly to discuss draft monitoring conditions and the proposed outfall extension;

(f) Discussed the Ngāti Kahungunu Iwi's position on the proposed outfall with respect to mahinga kai and monitoring with Shade Smith, senior analyst (Kaitātari matua) of environment and natural resources (Te taiao me ona rawa) for the iwi, and;

(g) Addressed the relevant sections of the HBRC s42a Officer's Report.

SCOPE OF EVIDENCE

12. My evidence addresses the following matters:

(a) Background to Wastewater Treatment in Wairoa;

(b) Existing Environment;

(c) Impacts of Current Discharge;

(d) Proposed Discharge Regime;

(e) Additional In-river Assessments;

(f) Modelling Undertaken;

[2] Greer, D., and S. T. Mead, 2018. Wairoa WWTP Outfall: 3D Hydrodynamic Numerical Modelling. Prepared for Wairoa District Council, September 2018.
[3] Greer, D., and S. T. Mead, 2019. Extreme Flooding Events for Scour Protection Calculation for the Wairoa WWTP Outfall. Prepared for Wairoa District Council, December 2019
[4] Greer, D., and Mead, S. T., 2020. Modelling the Wairoa Outfall at a Modified Position. Prepared for Lowe Environmental Impact Ltd, July 2020

(g) Assessment of Effects of Proposed Discharge Regime and Outfall Modifications;

(h) Monitoring for Future In-river Effects;

(i) Impact Mitigation and the Environmental Management Plan (EMP); and

(j) Response to Council Reports.

EXPERT REPORTS

13. Since mid-2018, I have prepared the following reports and other documents:

a) Stage 1: Peer Review of Estuary/Ocean Receiving Environment Report A3I1b.

b) Assessment of effects of Wairoa District Council's existing intertidal sewage discharge on benthic sediment characteristics and ecology – Wairoa Estuary.

c) Wairoa WWTP Outfall: 3D Hydrodynamic Numerical Modelling.

d) Wairoa Wastewater Treatment and Discharge – Assessment of Environmental Effects – Marine Ecology.

e) Extreme Flooding Events for Scour Protection Calculation for the Wairoa WWTP Outfall.

f) Modelling the Wairoa Outfall at a Modified Position.

g) Current Speeds at the Wairoa WTTP Outfall: for Consideration of Construction Methodology.

h) Ecological Investigations for the Extended Wairoa Outfall.

i) Concession AEE: Construction and Occupation of the Wairoa District Council's Wastewater Outfall.

14. The key findings of the above reports (in the order that they are listed above), are as follows.

a) The initial monitoring of benthic impacts due to the outfall was found to be deficient, having only few monitoring sites within the zone of impact and poor temporal resolution (only 4 surveys since 1996). It was recommended that an expanded survey should be undertaken to include the existing sites and apply the various aspects of the existing methodologies for ecological and sediment contaminant sampling, but also investigate the seabed at locations beyond the 100 m mixing zone using a systematic approach.

b) Sediment geochemistry characteristics in sediment samples indicated no strong evidence that the current outfall is impacting the immediate benthos.

For sediment-bound contaminants and nutrients, all contaminant levels in the samples were below ANZECC (2000) Interim Sediment Quality Guidelines low threshold values and thus adverse ecological effects due to contamination would be unlikely. It was found that evaluating impacts of the outfall on benthic effects was difficult given the low species diversity and wider degraded nature of the lower Wairoa Estuary, as well as the initial monitoring only having a few sites likely within the zone of impact.

c) The numerical model calibrated reasonably well against measured data in this hydrodynamically complex location, and replicated the important processes and degree of stratification identified in the measured data. This provided confidence in the results of the various modelled discharge and overflow scenarios modelled. The model simulation to investigate the effects of a 3-year ARI rainfall event that resulted in a wastewater spill at 3 locations found that rapid mixing of the overflow plumes occurred in the fast-flowing river associated with the rain event reducing contaminant concentrations to levels below the ANZECC (2000) marine toxicity trigger value for the protection of 95% of species within 25 m of the overflows. Simulation of 10 scenarios with different configurations of outfall flow, timing and river flow to represent potential future outfall discharge regimes found that when the estuary mouth is open, ammonia-N concentrations are likely to fall below the trigger value within 100 m of the outfall in all cases.

d) Collectively, the 4 prior studies and 2018 assessment[1] could find little evidence for negative environmental effects for sediment quality and benthic community composition associated with the existing wastewater discharge. This partly relates to the sampling design, but also the wider degraded environmental state of the Wairoa River and lower estuary.

e) The results of the extreme event modelling indicated that maximum currents of up to 13.21 m/s could occur.

f) The results of these comparative simulations indicate that the dilution of the discharge will be significantly increased with the outfall in the new proposed location (Figure 1). These results indicate that dilutions of <100x do not occur outside of the 25 x 25 m release cell/outfall location during any discharge scenarios, and dilutions of <200 do not occur over 25 m away from the outfall for most scenarios for the majority of the time (note, scenario 10 is discharging 10,000 m^3/day, although the existing daily limit is 5,400 m^3 and the proposed consent conditions allow unlimited discharges when the river is flowing this fast).

g) The current speeds in the area of the outfall are very complex and difficult to predict, and over 0.3 m/s most of the time, with peaks of 0.4-0.6 m/s during low to average flow rates. Flow rates were also found to be impacted in terms of velocities and duration depending on the tidal cycle (i.e. spring versus neap), and velocities also increase toward the centre of the channel along the proposed pipeline route. During high rainfall events, the maximum current velocities ranged between 5.6 and 13.2 m/s; i.e., extreme/unworkable for construction.

h) The additional ecological investigations verified the presence of low densities of adult pipis along the proposed extended pipeline route (the last ~50 m) and at the diffuser.

i) The Concession AEE included the proposed 200 m extension of the outfall pipeline and concluded:

   i. The direct impacts of construction/excavation in the estuary are considered *minor, and will be relatively short-term and localised impacts* (i.e., likely senescence of some benthic/infaunal organisms along the pipeline route, followed by recolonization of the disturbed area);

   ii. Indirect impacts due to suspension of fine sediments during construction/excavation are considered *minor to less than minor* given the existing nature of the lower Wairoa Estuary (sediment 'stressed' and often extremely turbid due to suspended fine sediments) and relatively short-term, and;

   iii. That the improved treatment of the discharge water and the strategic modifications to discharge management will ensure that the *environmental impacts of discharges from the outfall will be minor and localised to within 25 m of the diffuser.*

BACKGROUND TO WASTEWATER TREATMENT IN WAIROA

15. In 1999, a 20-year resource consent (CD940404W) was granted to Wairoa District Council (WDC), to discharge treated sewage into the lower Wairoa Estuary via a subtidal outfall; this consent requires. The maximum permitted discharge of sewage effluent as authorised by the resource consent is 5,400 m^3 per day. Additional conditions of the consent relate to the allowable timing of effluent discharge relative to tidal state, time of day and river mouth closure. The Wairoa wastewater treatment system requires a renewal consent.

16. The outfall was constructed in 1981, concomitant with the Council Pilot Hill oxidation ponds. Effluent exits the final stage aerobic pond and is gravity fed to the outfall discharge port. The discharge port is positioned in the low intertidal zone, approximately 150 m from the western shoreline adjacent the Kopu Rd and Fitzroy Street intersection (Figure 1). Over the lifespan of the present consent there have been issues with discharges from the outfall exceeding the daily limits (volume and timing) and overflow from pumping stations attributable to the very high rate of stormwater entry into the sewer network during heavy and/or

prolonged rainfall events. Similarly, the rate of sewage disposal is restricted and the WDC has to store effluent when the mouth of the estuary is closed. However, when storage capacity is exceeded effluent is allowed to be discharged into the estuary during these "regulated flow" periods.

17. The WDC was not formally required to undertake ecological and sediment contaminant monitoring surrounding the outfall under the existing consent conditions. However, the WDC has commissioned a variety of environmental studies as they relate to the sewage outfall and wider estuarine environment. These have included ecological surveys undertaken in 1996[5], 2007[6], 2011[7] and 2017[8] and a dye dilution study in 2007[9].

EXISTING ENVIRONMENT

18. The Wairoa Estuary is a river mouth estuary approximately 9,700,000 m^3 in volume with two bar-built lagoons the Whakamahi and Ngamotu at its mobile entrance. The estuary marks the end point of Te Wairoa Hōpūpū Hōnengenenge Mātangi Rau awa which sits within a catchment area of 356,300 km^2 of which 264,547 km^2 is within the Hawke's Bay regional boundary – this is Hawke's Bay's largest catchment. The river is formed by the confluence of the Hangaroa and the Ruakituri rivers which meet at Te Reinga Falls, and flows 65 km to drain into the sea near Wairoa Township. Other rivers of note include the Waiau that meets the Wairoa River adjacent Frasertown approximately 10 km from the mouth. Main uses of the catchment include sheep and beef farming (34.5%) with indigenous forests accounting for approximately 36%. Smaller horticultural practices are common to the area as well. The Wairoa Township is a dominant feature of the lower river. Consented industrial activities associated with Affco Meat works (Wairoa) and Silver Fern Farms meat works (Frasertown) also discharge treated waste and stormwater into the Wairoa River/Estuary.

19. The Wairoa Estuary comprising the lagoon, sandspit, and mudflats is a Department of Conservation Wildlife management reserve[10] (Cheyne and Addenbrook, 2002) and is designated by HBRC as a significant conservation area due to its biodiversity values. The Wairoa Estuary, as for other estuarine areas within Hawke's Bay serves as a nursery ground for flounder, short and long-finned eel, and inanga, and is associated with several birds of significance. Both

---

[5] Larcombe, M.F., (1996). Wairoa sewage treatment plant discharge effects on Wairoa Estuary. Report prepared for Wairoa District Council – Bioresearches 61 p
[6] EAM. (2007). Assessment of ecological effects on the Wairoa River Estuary from the Wairoa Wastewater Treatment Plant outfall. Report prepared for the Wairoa District Council. EAM Ltd. Report no. EAM042.
[7] EAM. (2012). Monitoring of Benthic effects of the Wairoa District Council Wastewater Treatment Plant outfall discharge at sites in the lower Wairoa Estuary. 2011 survey. Report prepared for the Wairoa District Council. EAM Ltd. Report no. EAM042.
[8] Triplefin, S. (2018). Benthic effects monitoring of the Wairoa District Council municipal wastewater outfall discharge at sites in the lower Wairoa Estuary. 2017 survey. Report prepared for the Wairoa District Council. EAM Ltd. Report no. TFN17005.
[9] Barter, P. (2007). Wairoa District Council wastewater outfall dye dilution study. Report prepared for EAM Ltd and Wairoa District Council. Cawthron Report # 1309.
[10] Cheyne, J., Addenbrook, J. (2002). Whakamahi and Whakamahia Lagoons Management Plan, HBRC Technical Report, EMT 02/03 HBRC Plan No. 3113

cockles and pipi occur within the estuary proper and freshwater mussels (kakahi) were also historically abundant[11].

20. An early summary document of New Zealand's estuaries[12] inferred that the environmental condition of the Wairoa Estuary had worsened between 1965 and 1976, and in 1976 was classified as moderately polluted. This is still likely the case today although the replacement of Wairoa's previous untreated sewage discharges from four pump stations with the WWWTP and its single discharge of treated wastewater in 1981 will have contributed to improving pollution levels. Hawke's Bay Regional Council (HBRC) established formal benthic monitoring within the estuary in 2011 at site approximately 600 m upstream of the AFFCO outfall. Results from the monitoring suggest that sediment contaminants (trace metals, nutrients) are not problematic within the estuary, whereas impacts associated with sedimentation and recreational contact for the upper river adjacent Wairoa Water Ski Club were[13]. High levels of suspended sediment and sedimentation of the Wairoa Estuary is further supported by State of the Environment (SoE) monitoring undertaken at Wairoa by HBRC since 2011. This has indicated that despite the "highly variable" silt content measured between surveys, there is a trend for increasing mud content with a wider perception that the estuary is likely to be sediment 'stressed'[13].

IMPACTS OF CURRENT DISCHARGE

21. In 2018, we undertook the most recent environmental investigations of the Wairoa Estuary, which included ecological and sediment geochemistry data collection[1]. The purpose of the study was to evaluate any effects on sediment geochemistry and infaunal biota (ecology) that could be potentially attributable to the Wairoa community wastewater discharge. For the most-part, methodological procedures were kept consistent with that of previous 4 studies, although the number of sampling locations were increased to ensure that there were sites outside of the "zone of influence" of the outfall. In 2018, an additional 7 sites were added to the sampling programme in order to 1) evaluate potential impacts of the outfall at distances >100m away from the discharge point, and 2) provide a broader context on the present-day environmental state of the of the Wairoa Estuary[1].

22. The results of the sediment geochemistry characteristics were highly variable across sampling sites in 2018, including across all historic surveys (1996-2018). Contaminant levels were found to comparable to the SoE monitoring levels, and below ANZECC (2000) Interim Sediment Quality Guidelines low threshold values (ISQG-Low), indicating that no adverse ecological effects would be expected as a result of the current discharge. An ISQG-low exceedance was detected for lead

[11] Haggitt, T., Wade, O. (2016). Hawke's Bay Marine Information: Review and Research Strategy A report prepared for HBRC by eCoast 113 p
[12] McClay, C.L. (1976). An inventory of the status and origin of New Zealand estuarine systems. Proceedings of the New Zealand Ecological Society 23: 8-26
[13] HBRC (2016). The State of the Hawke's Bay Coastal Environment: 2004-2013. HBRC Report No. RM16-16 – 4800

immediately adjacent to the overflow opposite Fitzroy Street/Kopu Rd intersection. However, it is notable that this overflow is predominantly a stormwater outlet from the road (which contribute to heavy metal contaminants), and historically there has been dumping of materials along the coastal margin; rather than due to the overflow discharges. High silt content was characteristic of many of the survey sites, which collectively highlights the wider degraded nature of the Wairoa Estuary and its sediment stressed nature.

23. With respect to the estuarine benthic ecology, species community composition was found to differ among survey sites with historical sites having similar species composition and higher species diversity compared to the new sites added to the programme. Numerically dominant species recorded at the 3 historical sites located relatively close to the outfall are typically considered to be synonymous with degraded/impacted environments; in this case it is likely attributed to local nitrification and siltation. This was also true for the additional new sites, although abundances were lower than at historical sites close to the outfall and pipi were found to occur at much greater densities at sites further away from the outfall.

24. Evaluating impacts of the outfall on benthic effects is generally difficult given the low species diversity and wider degraded nature of the lower Wairoa estuary, as well as the initial monitoring only having a few sites within the zone of impact and poor temporal resolution[14]; our 2018 survey was only the 4th since 1996. The previous monitoring/sampling design was focussed on the mixing zone next to the outfall and so did not consider impacts on the wider estuarine environment.

25. In summary, there is evidence that benthic ecology and habitat quality in the estuary are impacted by catchment activities, which are mainly associated with high fine sediment loads. However, other than recording lower abundances of pipi at the sampling sites close to the outfall in comparison to sites further away from the outfall, which may suggest local impacts, the existing discharge does not appear to be compounding the effects of sediment stress to a substantial degree. Therefore, it is my opinion that the impacts of the existing discharge are considered to be no more than minor and localised (within 100 m of the existing outfall).

PROPOSED DISCHARGE REGIME

26. As stated above, the current permitted discharge is up to a maximum of 5,400 m^3 per day. As part of the resource consent renewal process, a series of upgrades to the Wairoa wastewater treatment plant (WWWTP), outfall, and discharge protocols are planned – these are summarised in Table 1[15]. The rationale behind the modifications is to through time, reduce the likelihood for adverse impacts emanating from treated wastewater disposal to occur within the lower Wairoa

[14] eCoast, (2018:A3D3). Stage 1: Peer Review of Estuary/Ocean Receiving Environment Report A3I1b. Mead, S. T., (2018). Prepared for Lowe Impact Assessment/Wairoa District Council, April 2018
[15] These initiatives are presented in detail in LEI (2018) Draft Conceptual Design for Wairoa Wastewater Treatment and Discharge. Report prepared for Wairoa District Council. RE-10292-WDC-C1_0

Estuary. This will be achieved through a range of best practicable option and associated mitigation methods that include:

- wastewater irrigation to a series of farms;
- reticulation renewals and upgrades to reduce flows to WWWTP;
- reductions of reticulation leakage and pump station overflows;
- filtration and UV irradiation at the outlet of the WWWTP ponds to improve the discharge quality (remove pathogens and reduce algae);
- installation of treated wastewater storage facilities;
- reducing discharges (volumes and frequencies) to the Wairoa River as a direct result of progressively implementing irrigation to land and constructing additional storage facilities; and,
- support for wider Wairoa River catchment improvement projects[15].

27. In summary, the proposed discharge regime will not increase current discharge volumes, will be better treated, leakages and overflows will be reduced, discharges will reduce, dilution will occur more quickly (discussed below in the numerical modelling Section) and the wider catchment management will be improved. Therefore, it is my opinion the impacts of the proposed discharge can be expected to be lower than current discharge impacts, which are considered minor and localised.

28. However, it is noted that the proposed outfall is now to be extended a further 200 into the approximate centre of the main channel (Figure 1), where recent ecological investigations have identified the presence of adult pipi and cockles. The extension of the outfall has the potential to impact on these species during the construction and installation of the new pipeline and outfall, as well as during operation. Additional in-river assessments to consider the 200 m extension, comparative dispersion modelling and assessment of effects of the proposed discharge regime and new outfall location are discussed in the following Sections of my evidence.

ADDITIONAL IN-RIVER ASSESSMENTS

29. The initial Assessment of Environmental Effects (AEE) was undertaken in November 2018[16], which I present below. However, the outfall/diffuser location was subsequently proposed to be modified to extend some 200 m further into the main estuary channel (Figure 1) following the initial AEE; i.e., the basis of the AEE was changed. As discussed with and noted by Dr Kelly[17,18], although we were aware that the relatively dense populations of juvenile pipi are spread throughout intertidal areas in the lower estuary[1], the subtidal area proposed for

[16] Haggitt, T., and S. T. Mead, 2018. Wairoa Wastewater Treatment and Discharge – Assessment of Environmental Effects – Marine Ecology. Prepared for Wairoa District Council, November 2018.
[17] Kelly, S., 2019. Review Memo to the HBRC, 4 July 2019.
[18] Kelly, S., 2020. Review Memo to the HBRC, 6 October 2020

the new outfall location (Figure 1) had not been surveyed. It is known that adult and juvenile pipi can live in separate areas, with pipi recruiting in the mid-intertidal zone and migrating to the lower intertidal and subtidal zone as juveniles, with the adults mainly occurred sub-tidally, forming very dense, discrete beds with juveniles missing in central parts of the beds[17]. To determine the ecology along the proposed pipeline extension and at the diffuser, additional field investigations were undertaken on 9 September 2020[19].

30. The high slack tide period was targeted on 9th September to collect grab samples along the proposed new pipeline route and diffuser site using a petite ponar grab-sampler[20]. 8 grabs samples were collected; 2x samples at 4 locations approximately 50 m apart between the proposed diffuser location and the existing outfall. As shown in Figure 2, along with cockles and the occasional mud crab, several pipi of 40 mm or greater were captured in the sampling of the mid-channel, with pipi of >40 mm being considered to be sexually mature. Unlike the intertidal samples, which included amphipods and gastropods[1], these species and insect larvae were not present in the channel samples, which may in part have been due to the relatively higher currents through the main channel of the estuary. Similar to the 2018 results, low numbers of polychaete worms were found mostly closer to the exiting outfall. These results verified the presence of adult pipis along the final ~50m of the proposed extended pipeline route and at the diffuser, which also needed to be considered for the AEE on marine ecology.

MODELLING UNDERTAKEN

31. As noted above, 3 numerical modelling reports have been produced during the investigations for the resource consent renewal of the WWWTP. These include numerical modelling of a variety of current and future outfall scenarios and overflow events[2], extreme events for scour protection calculations[3] and modelling of the new/extended outfall location with comparison to the existing outfall location[4].

32. The 3D hydrodynamic numerical modelling of the Wairoa River and the WWWTP discharge was first undertaken as part of the resource consent renewal process to better understand the dynamics of wastewater discharged into the estuarine and marine environments from the wastewater system[2]. As noted above, along with sediment geochemistry and ecological data collection, physical data was collected in the lower estuary in 2018, which included bathymetry survey of the lower estuary (from the Wairoa Water Ski Club to the entrance), and 4 weeks of current, water level and salinity data collection. These data were used to further our understanding of the hydrodynamics of the Wairoa Estuary and to calibrate the 3D numerical model.

---

[19] Mead, S. T., and E. Atkin, 2020. Ecological Investigations for the Extended Wairoa Outfall. Prepared for Wairoa District Council, October 2020.

33. Given the hydrodynamic complexity of the location, the model calibrated reasonably well against measured data and replicated the important processes and degree of density stratification (due to freshwater meeting seawater) identified in the measured data. This provided us with confidence in the results of the various modelled discharge and overflow scenarios modelled, which included both WWWTP outlet discharge simulations and pump station overflow discharge simulations. It is important to note that the morphology of the river mouth regularly changes over time, and that this will have some influence over hydrodynamics of the area, which will in turn influence the pattern of dilution of the outfall. With these changes in mind, it is my opinion that the river mouth location to the west (Figure 3) that was present at the time of our data collection and is represented in our modelling domain is likely close to the worst case scenario. As such, the model outputs can be considered conservative.

34. The calibrated model was first used to explore the dilution of the wastewater spatially throughout the estuary for 10 scenarios with different configurations of outfall flow, timing and river flow to represent potential future outfall discharge regimes, which are presented in Table 2. These scenarios also incorporate the future treated wastewater discharge system regimes in Table 1. It is important to put the scale of the discharge volume into perspective, which cannot be easily done by considering the 2 Tables, since the discharge is presented as cumecs (cubic metres) per day, while the river flow is presented as cumecs per second. If we convert the median river flow of 60 m^3/s to m^3/s, the result is 5,184,000 m^3/day. If we then take the maximum discharge per day of 5,400 m^3 over 5.5 hours and relate to the median river flow, it can be seen that the discharge represents 0.46% of the flow during the 5.5 hour period, that is a small proportion of total river flow. As river flow rates increases, the proportion of discharge decreases[2], until we consider the most extreme case on record, extra-tropical cyclone Bola[3] with a flow rate of 346,896,000 m^3/day, where the maximum daily discharge represents ~0.0068% of the total river flow over a 5.5 hour discharge period.

35. It should be noted that the model was not used to model specific contaminants (such as bacteria, nutrients, viruses and sediment) and specific concentrations of contaminants. Instead, the dilution maps and transect graphs developed from the model outputs were produced that can be used to provide conservative estimates of pollutant concentrations from assumed input pollutant concentration at the outfall or overflow and at varying distances from the outfall location. As no pollutant concentrations have been used no attenuation or assessments of discharge effects on river water quality were included in the modelling report. Outputs for the simulations include dilution along a transect orientated along the main axis of flow out of the estuary (Figure 4), since discharge is mostly during out-going tides) and plan views showing spatial variation in dilution.

36. In general, dilution increases with distance from the outfall, although the rate of dilution depends on both outfall flow rate and river flow (Figures 4 to 14).

Increased river flow causes more rapid dilution of the outfall waters and increased outfall flow negates this effect. However, for these scenarios the area of the dilution footprint of the outfall increases in scenarios with higher outfall flow. Scenarios 1 to 8 (only on out-going tide – Table 2) show lower dilutions towards the estuary mouth since discharge is only released on the outgoing tide (Figure 10 to 13).

37. For scenarios 9 and 10 discharge is released continuously (Table 2), which results in low dilutions also upstream from the outfall due to the incoming tide, despite the increased river flow (Figures 9 and 14). The dilutions upstream of the outfall are low and do not extend far north of the outfall because the in-coming tidal flows are reduced and often reversed at river flow rates of 3 x median (i.e., scenarios 9 and 10); that is the flows are high enough to negate the incoming tidal signal.

38. As noted by Dr Kelly[17], the model predictions indicate that under the conditions with a western estuary entrance, and for various scenarios of river flow and discharge volume (i.e., Table 2), discharges will be diluted by about 200 times within around 100-200 m of the outfall. This means that based on the final treatment quality of the discharge for the key contaminant of concern, ammonia-N, dilution will reduce concentrations to levels below the ANZECC (2000) marine toxicity trigger value for the protection of 95% of species (0.91 mg/l); when the estuary mouth is open, within 100 m of the outfall.

39. The model was next used to investigate the effects of a 3-year ARI rainfall event that resulted in a wastewater overflow at 3 locations (this event in March 2012 was the only event for which flow data is available for model simulation). Dilution maps of model outputs indicated rapid mixing of the plume in the fast-flowing river associated with the rain event (e.g. Figure 15). Dilution of >250x occurred within 40 m of the Kopu overflow sites and within 25 m of the North Clyde overflow, and >5000x within 50 m of the Alexandra Park overflow (Figure 14). During the March 2012 spill event peak river flow was 861 m^3 compared with the peak combined flow of the sewage that overflowed which was 0.09 m^3 or 0.01% of the peak river flow. Because of this disparity in flow, the spilled sewage was rapidly diluted into the ambient river water, as described above. The consequence of this is that while rain events can lead to overflows, they also create conditions where spilled substances can be rapidly diluted and flushed from the river by increased river flow.

40. Following the initial modelling work to consider future discharge regimes under varying flow scenarios, additional modelling of high river flow events were undertaken to inform the calculation of potential socur around the proposed outfall pipe and foundations. Two events were simulated:

- An event with peak flow of 2,586 m^3/s (21 September 2015) and;
- The overall largest flood event since 1988 which had a peak flow of 4,015 m^3/s (exTropical Cyclone Bola).

41. Preliminary investigations of the model results showed that under high flow conditions, peak current speeds inside the river mouth were highly constrained by the cross-sectional area of the mouth. In reality the shape and position of the river mouth changes over time and is likely to erode under high flow conditions. Google Earth (GE) historical imagry was examined to establish the variability in the width of the mouth over time and under different conditions. In the baseline model that has been used to date to study dilution effects, the river mouth width is approximately 82 m. The widest river mouth was found on an aerial image from 12 February 2011 where the mouth reached a width of 200 m and two large flood events occurred in the weeks prior to the GE image time stamp (Figure 16). Based on this information, the model bathymetry was altered to reflect the wider river mouth morphology, and 10 scenarios were developed that combined the peak flows from the two extreme events and different entrance morphologies.

42. The results of the extreme event modelling indicated that maximum currents of up to 13.21 m/s could occur. These results were then applied to the design of scour protection (undertaken by OCEL), which has been specified as a scour mat installed around the diffuser comprised of Georock 2.1m x 1.2m x 0.4 m sand-filled bags stitched together to form one unit, rather than several independent bags. This design was peer-reviewed by e2environmental consulting engineers and found to be fit for purpose[20].

43. Further simulations were recently undertaken to consider outfall discharge dilutions based on the extended pipeline location[4], which places the outfall diffuser close to the middle of the main estuary channel (Figure 1). Three of the original 10 discharge/flow scenarios were simulated in order to provide an indication of the difference between the existing location and the new location; scenarios 4, 7 and 10 from Table 2.

44. The results of these comparative simulations indicate that the dilution of the discharge will be significantly increased with the outfall in the new proposed location (Figures 17 to 19 and Table 3). These results indicate that dilutions of <100x do not occur outside of the 25 x 25 m release cell/outfall location during any discharge scenarios, and dilutions of <200 do not occur over 25 m away from the outfall for most scenarios for the majority of the time (note, scenario 10 is discharging 10,000 m^3/day, although the existing daily limit is 5,400 m^3 and the proposed consent conditions allow unlimited discharges when the river is flowing this fast). This is a significant improvement on the existing discharge location, which indicates that when the estuary mouth is open the ammonia-N concentrations are likely to fall below the trigger value within 100 m of the outfall; in the modified location, this is likely to occur within 25 m of the outfall. This is of relevance to potential impacts on the benthic ecology identified in the location of the proposed extended outfall location.

[20] Harte, P., 2020. Review Memo from e2environmental consulting engineers, 13 October 2020.

ASSESSMENT OF EFFECTS OF PROPOSED DISCHARGE REGIME AND OUTFALL MODIFICATIONS

45. The initial assessment of environmental effects (AEE) to marine ecology[16] for the resource consent renewal was undertaken in relation to the discharge of treated wastewater into the lower Wairoa Estuary via the subtidal outfall in its present location (Figure 1 – red dashed line). As described above, the present-day environmental state of the Wairoa Estuary is degraded and widely impacted by sedimentation. As a result, the benthic ecological communities (i.e., the components of the environment most likely to be impacted by the proposed activity) of the lower Wairoa Estuary are low in species diversity.

46. The ecological effects relating to the existing sewage outfall have been assessed previously in a series of monitoring events[5,6,7,8,9] and were used, in part, to support the current assessment of environmental effects[16]. Collectively, these studies (including the recent studies[1,18]) could find little evidence for negative environmental effects for sediment quality and benthic community composition associated with the existing wastewater discharge. This partly relates to the sampling design of the earlier studies, although also the wider degraded environmental state of the Wairoa River and lower estuary.

47. In an effort to reduce impacts associated with existing and future wastewater disposal into a degraded receiving environment, WDC has proposed a series of strategic modifications to land-based treatment processes, storage capacities, and disposal regimes (via the outfall), which are presented in Table 1. These will be implemented in stages.

48. Our conclusions with respect to impacts of the discharge from the existing outfall location[16], were that the strategic staged modifications will improve the wastewater quality, and thus reduce the potential for negative impacts environmental which are likely to be negligible over the longer term. However, it is my opinion that improvements to the benthic ecology will also rely on improvements being made to upstream catchments to reduce sediment and other contaminants entering the Wairoa River that are transported to the lower estuary.

49. However, as described above, the outfall/diffuser location was modified to extend some 200 m further into the main estuary channel (Figure 1) following the initial AEE. Based on the comparative modelling of the existing outfall location and the modified outfall location, dilution will occur more rapidly with the extended outfall pipeline. This is an improvement with respect to environmental impacts, since treated contaminants are diluted more quickly over a smaller spatial extent (Figures 17-19 and Table 3). With the extended outfall location, when the estuary mouth is open the ammonia-N concentrations are likely to fall below the trigger value within 25 m of the outfall; as opposed to within 100 m of the current outfall location.

50. A second AEE was undertaken to incorporate the findings of the additional fieldwork[19] to consider the marine ecology along the extended route of the

pipeline[21]. The Wairoa Estuary comprising the lagoon, sandspit, and mudflats is a Department of Conservation Wildlife management reserve and is designated by the HBRC as a significant conservation area due to its biodiversity values. Since the extended pipeline will fall into the wildlife management area, the proposed activity (i.e., replacement of the outfall pipeline and diffuser) requires a concession under the Conservation Act (1987); i.e., the concession AEE[21], which was prepared to consider the effects of the construction, and occupation of the estuary bed, for the proposed new Wairoa District Council pipeline and outfall diffuser in the lower Wairoa River/estuary. The recent investigations of marine ecology along the proposed extended pipeline found the presence of adult pipi in the central channel[19], which are likely the source of the juvenile pipi found throughout the lower estuary, and also needed to be considered with respect to ecological impacts.

51. The modified pipeline and diffuser will extend approximately 400 m into central channel (~2.0 m deep to MSL) of the lower Wairoa Estuary (Figure 1). In this part of the estuary, current meter measurements and calibrated numerical modelling demonstrate that the current velocities are usually 0.35-0.4 m/s through the central channel, and can be extreme during flood events (5.6-13.2 m/s)[3]. As a result, environmental impacts during construction have the potential to be both direct (i.e., through excavation for construction), and indirect by suspended and settling sediments during construction.

52. Based on the existing physical and biological setting of the lower Wairoa Estuary, the construction methodology and procedures described in the construction Environmental Management Plan (EMP)[22], the important points to consider and the environmental effects of the proposed activity include the following:

- Even though the lower estuary is considered degraded (due to catchment land use and other discharges into the river/estuary) and has relatively low species diversity, appropriate measures should be applied to avoid, mitigate or remedy any actual or potential environmental impacts of the proposed outfall extension;
- As noted above, recent investigations have found the presence of adult pipi in the central channel, which are likely the source of the juvenile pipi found throughout the lower estuary; given the overall aim to improve the estuary's health, it is important to minimise impacts on the adult population of this culturally important species;
- The main activity that will disturb the local environment (i.e., construction of the pipeline and diffuser) is expected to take approximately 7 days. This means that the impacts of construction/excavation for the new pipeline and diffuser will be short-term and temporary, that is a 'pulse'

[21] Mead., S. T., 2020. Concession AEE: Construction and Occupation of the Wairoa District Council's Wastewater Outfall. Prepared for Wairoa District Council, November 2020.
[22] The draft EMP is currently being developed.

event from which the environment can/will recover, rather than a ‘press’ impact that represents a permanent change/effect;

- The spatial extent of the impact is relatively small with respect to the size of the lower estuary and the ~400 m long 375 mm diameter pipeline, however, sediment suspended during construction has the potential to be distributed over a far greater spatial extent due to the currents in the lower estuary;
- This impact of suspended sediments, which have the potential to reduce light penetration (and so, primary production) and smother and result in the mortality of some benthic species should be considered with the context of the existing environment. That is, the lower Wairoa River/estuary is likely to be sediment ‘stressed’ (resulting in low species diversity) and most often extremely turbid due to suspended fine sediments, especially during and following high rainfall events (i.e., a period of high rainfall results in suspended sediment levels that will be many orders of magnitude greater than that created by the construction process);
- The benthic sampling indicates that similar species are found throughout the lower estuary, that is, the area effected by the direct disturbance of construction/excavation for burying the pipeline is not encroaching on a particularly unique or special habitat or benthic community, although the presence of adult pipi in the central channel in the area of the proposed diffuser has recently been confirmed;
- The direct impacts of construction/excavation in the estuary are considered *minor, and will be relatively short-term and localised impacts* (i.e., likely senescence of some benthic/infaunal organisms along the pipeline route, followed by recolonization of the disturbed area);
- Indirect impacts due to suspension of fine sediments during construction/excavation are considered *minor to less than minor* given the existing nature of the lower Wairoa Estuary (sediment ‘stressed’ and often extremely turbid due to suspended fine sediments) and relatively short-term;
- Construction methods and the Environmental Management Plan (EMP) include measures to mitigate these impacts along with the usual potential impacts of construction in the marine/estuarine environment (e.g. vehicle wash-down, fuel handling, rubbish management, etc.);
- Following the completion of works, the disturbed area of the estuary bed will be recolonised by similar species/organisms as were previously there in a relatively short time frame;
- With respect to the environmental impacts of occupation of the estuary bed, only the diffuser will be above the river/estuary bed, while the

pipeline will be buried to 1.5 m deep in the sediment. A scour mattress comprised of connected sand-filled geofabric containers (comprised of environmentally inert non-woven needle-punched PET) will be constructed around the diffuser to reduce/prevent local scour. These impacts are considered less than minor; there is the potential for some species to utilise the diffuser as habitat;

- As described in the AEE on the marine ecology in the Wairoa estuary[16], in an effort to reduce impacts associated with existing and future wastewater disposal into a degraded receiving environment, WDC has proposed a series of strategic modifications to land-based treatment processes, storage capacities, and disposal regimes (via the outfall). These will be implemented in stages;
- The strategic staged modifications will improve the wastewater quality and thus reduce the potential for negative environmental impacts, which are likely to be negligible over the longer term. Improvements to the benthic ecology will also rely on improvements being made to upstream catchments to reduce sediment and other contaminants entering the Wairoa River that are transported to the lower estuary[16], and;
- Therefore, it is my opinion that in combination with the new outfall/diffuser location that results in a significantly reduced mixing zone (i.e., the ammonia-N concentrations are likely to fall below the trigger value within 25 m of the outfall; as opposed to within 100 m of the current outfall location), the improved treatment of the discharge water and the strategic modifications to discharge management, that the *environmental impacts of discharges from the outfall will be minor and localised to within 25 m of the diffuser.*

IMPACT MITIGATION AND THE ENVIRONMENTAL MANAGEMENT PLAN (EMP)

53. The EMP[22] and the construction methodology[23] have been developed in order to mitigate the actual and potential impacts. Along with the usual wash-down, fuel handling, rubbish management, etc., procedures, these measures include:

    - Targeting a low flow period for riverine construction to reduce the potential spread of suspended sediments. This is complimentary to avoiding times of higher flow rates when suspended material have a greater potential to be dispersed over greater areas, which are also more difficult to undertake the works in.
    - Avoiding the period of greatest pipi spawning activity in spring and early summer; low flow periods are most likely in late summer, which supports the avoidance of the greatest spawning period.

[23] See Common Bundle of Attachments with Mr Lowe's evidence.

- Minimizing the working footprint. This will be achieved by having a 'point source' of disturbance (i.e., a single amphibious excavator), and keeping the disturbance to the excavation of the pipeline trench and the placement of the excavated material adjacent to it.
- Trench filling will be undertaken using the excavated material adjacent to the trench (however much remains in place) and natural infilling, rather than scraping the nearby riverbed, in order to reduce the working footprint.
- Utilizing silt curtains to reduce the dispersion of suspended fine sediment during the construction. These will need to focus on the amphibious excavator and the design will need to be suitable/adjustable for both outflowing and inflowing currents, and;
- Piling from a barge to minimise disturbance of the river/estuary bed.

54. An environmental monitoring programme is proposed that will provide essential data that can evaluate the extent and magnitude of both positive and negative effects to benthic ecology for current operations and future planned modifications, which I present in the following section

MONITORING FOR FUTURE IN-RIVER EFFECTS

55. As noted by Dr Kelly, it is important to understand that the effects of wastewater discharges on coastal environments are complex, and that robust data and a good understanding of the processes involved is required to disentangle the effects of the discharge from other sources of variation. The complexity of the Wairoa river mouth and proposed discharge regime makes this even more important, although with the various upstream catchment activities that deliver sediment and other contaminants into the Wairoa River which are then transported to the lower estuary. Associated with this is the results of the numerical model simulations, which is a very effective method of considering impacts of an outfall, although really only a sophisticated tool; monitoring provides actual data to allow for management options as set out in the monitoring objectives in draft condition 25. Therefore, there are at least 3 components of monitoring to consider:

   i. Monitoring of the effects due to the proposed activity;
   ii. Monitoring to measure the effects of wider catchment issues (e.g. the AFFCO outfall delivers up to 2x the effluent to the Wairoa River than the treatment plant outfall; forestry and farming catchment inputs of fine sediments and nutrients), and;
   iii. Cultural monitoring (e.g. the mauri compass assessments).

The monitoring described here relates to i and ii.

56. As noted in Paragraph 92 of the officer's report[24], the monitoring plan was still to be developed at the time of writing, although Dr Kelly had provided proposed consent conditions to provide for a suitable monitoring framework[25]. Dr Kelly has considerable experience in the monitoring of the impacts of the wastewater outfalls (as described in Paragraph 4 of the officer's report[24]), and has provided details of a suggested monitoring programme, which I have incorporated here; I have not repeated the rationale that Dr Kelly has provided in his 6 October 2020 memo, although I am in agreement with it. Water quality is the immediate environmental receptor, and consistency between river water and wastewater parameters allow direct linkages to be made between cause and environmental effect[25].

57. With respect to water quality monitoring parameters, the following set of parameters should be monitored monthly (which are listed as 'a-m' in the officer's report[24]):

- total ammoniacal nitrogen;
- nitrate nitrogen;
- nitrite nitrogen;
- total nitrogen;
- soluble reactive phosphorus;
- total phosphorus;
- chlorophyll *a*;
- total suspended solids;
- temperature;
- dissolved oxygen;
- salinity;
- pH;
- enterococci; and
- faecal coliforms.

58. A minimum of five monitoring sites have been proposed in the draft monitoring conditions in the officer's report[24], which are based on the recommendations of potential water quality monitoring sites in the original AEE in 2018[16]. However, since then the proposed outfall has been relocated 200 m further into estuary, which makes monitoring of the discharge site more difficult. This is also associated with the discussion around timing of monitoring being only of value in river water quality sampling if they are collected while the discharge is occurring, with discharge generally at night-time or at times of high flow, when sampling

[24] Assessment of resource consent application s.42a officer's report. Tania Diack, 6 November 2020.
[25] Dr Shane Kelly's memo dated 6 October 2020

would not be practical or safe. Timing of, and safety during monthly sampling will need to be addressed, and consideration given to the recommended daily sampling when the river mouth is closed; it may not be necessary if no discharge will occur, although it will provide valuable information relating to the effects of inputs from the wider catchment area. In order to disentangle the effects of the discharge from other sources of variation, the monitoring plan will require sites up-river of the discharge, close to or at the discharge, and down-river of the discharge (as originally proposed in 2018[16]). In my opinion there should be two sites up-river, 100 m and 1,000 m, one at or close to the outfall and two down-river at 100 m away in the central channel (to confirm mixing predictions), with the second potentially being a 'floating' sample site based on the location of the river mouth.

59. Infauna, or benthic monitoring such as that undertaken in 2018 is included as item 'n' in draft condition 26. This monitoring should be undertaken annually, at least initially; it could be extended to bi-annually based on the monitoring results after a few years. A benthic survey plan has been provided in the original AEE in 2018[16]. However, this was based on the existing location of the outfall. Therefore, this monitoring plan and the 12 monitoring sites will need to be revisited to incorporate monitoring close to and around the proposed discharge in the middle of the main channel. During the repositioning of sampling locations, the variability of the river mouth should also be taken into account by including sites in the western and eastern arms of the lower estuary, which will also provide information to support the monitoring of the wider estuary.

60. I also support Dr Kelly's proposed approach to provide for a trial period in the monitoring plan to identify monitoring sites and sampling methods, that allow sampling to be carried out safely and for robust results to be obtained. As noted above, it is a complex system, there are likely timing and safety issues to address, variables such as the changing location of the estuary mouth require consideration.

61. With respect to the analysis and reporting of water quality and ecological data, I agree with Dr Kelly's assertion that it needs to be done by scientists with specific experience and expertise on those topics. Annual monitoring reports should include:

    a) A summary of all monitoring undertaken as required by this consent, including cultural health monitoring, and may include additional monitoring undertaken by the consent holder to better characterise the effects of the discharge on the Wairoa River.

    b) daily discharge volumes and times, corresponding river flows, river mouth conditions and tidal conditions

    c) An assessment of compliance with the discharge quality standards specified in condition 14. Any exceedances of these standards shall be clearly identified and reasons for each exceedance (if known) provided. A summary of any remedial action taken to mitigate or remediate the impacts of the exceedance and any actions taken to prevent a recurrence of the exceedance; and

d) comment on any operational issues during the period and steps taken to address these

62. The following shall be included in every second annual report:

a) A critical analysis of the results of sampling required by conditions 14, 23 and 26.

b) identification and comment on any trends in discharge data collected, both within the annual period and compared to previous years, including comment on the potential environmental implications of these trends;

c) details of any works undertaken or proposed to improve performance of the treatment system, and timeframes for any proposed works. and

d) The volume discharge to alternative receiving environments.

RESPONSE TO COUNCIL REPORTS

63. Paragraph 8 requests further information in dot point 1 with respect to potential effects on mahinga kai, particularly as a result of the installation/construction of the proposed replacement outfall structure. As described in the letter report detailing the additional ecological investigations along the extended pipeline route[19], and in paragraphs 29 and 30 above, low densities of adult pipi were found at the proposed new diffuser location and some 50 m shoreward of this location, and likely inhabit the main channel throughout the lower estuary. Given the overall aim to improve the estuary's health, it is important to minimise impacts on the adult population of this culturally important species, with pipi also having historically been an important kaimoana in the lower estuary (S. Smith, pers. comm.).

64. To minimise impacts on pipi (and the benthic ecology in general) during construction, the construction environmental management will include targeting a low flow period for riverine construction to reduce the potential spread of suspended sediments, avoiding the period of greatest pipi spawning activity in spring and early summer, minimizing the working footprint, allowance of natural infilling of the pipeline trench, utilizing silt curtains and piling from a barge to minimise disturbance of the river/estuary bed, as described in paragraph 53 above.

65. As a result, the direct impacts of construction/excavation in the estuary are considered *minor, and will be relatively short-term and localised impacts* (i.e., likely senescence of some benthic/infaunal organisms along the pipeline route, followed by recolonization of the disturbed area)

66. Paragraph 84 of the officer's report[24] notes that "specific contaminants such as bacteria, nutrients, viruses and sediment were not used in the modelling as monitoring data is not available therefore an assessment of the discharge effects on the river water quality was not included in the modelling". This approach was taken so that any contaminant dilution could be assessed from the known input concentrations from the outfall. As noted in Paragraph 83 of the officers report, Dr Kelly reviewed the modelling and determined that the toxicity effects the key contaminant of concern is likely to be ammonia-N, which will be rapidly diluted to levels below the ANZECC (2000) trigger value for slightly to moderately disturbed systems within 100 m of the outfall when the River mouth is open. With the extended pipeline/outfall location, greatly increased dilution is achieved, with dilution levels below the ANZECC (2000) trigger value occurring within 25 m of the outfall (Paragraph 44 above).

67. Paragraph 84 of the officer's report refers to absence of modelling when the river mouth is closed and the additional modelling of the new outfall location. Modelling with a closed river mouth was not undertaken because the proposed increase of storage (to 10,000 m^3) and development of irrigation will mean that discharge during closure will most likely not occur. The current storage capacity is up to a week during normal flow rates, and 1-2 days during high flow rates, noting that the latter leads to re-opening of the entrance. It is noted that there are no records of the dates and durations of historical closure. Anecdotal information indicates that it has been closed for 1-2 days in the past before reopening, and that it will 'blow out' after a couple of days (S. Heath, pers. comm.). Furthermore, when closure occurs the movement of water in and out of the estuary is not fully blocked since it is a shingle bank and water can pass through it. As noted in the officer's report, there are various proposed consent conditions relating to when the river mouth is restricted such as the timing of discharging wastewater into the river and the applicant notifying Council prior to or when the there is a river mouth restriction observed using a camera. In addition, the entrance of the river is often reported to be closed, when it is in fact still open because the opening is out of sight; the Council responses to reports of closure with a drone can easily determine the status of the entrance (S. Heath, pers. comm.).

68. The modelling of the new outfall location is detailed in Greer and Mead (2020)[4] and described above in Paragraphs 43 and 44. The results indicate that due to the increased flows in the central channel, with the extended pipeline/outfall location, greatly increased dilution is achieved in comparison to the existing location, with dilution levels below the ANZECC (2000) trigger value occurring within 25 m of the outfall.

69. Paragraph 92 of the officer's report[24] refers to concerns raised by Dr Kelly, with blooms of nuisance marine macroalgae, disturbance of pipi beds, potential effects on kaimoana and the development of a monitoring plan being within my areas of expertise. Disturbance of pipi beds and the development of a monitoring plan have been addressed in my evidence above.

70. With respect to impacts on kaimoana, discussion with Shade Smith indicated that the kaimoana species of importance in the lower estuary are mainly fish species. These mostly include eels, flatfish, whitebait, and snapper; Mr Smith referred to the ‘red-tide’ that occasionally comes into the estuary through the entrance. Pipi have also historically been an important kaimoana in the lower estuary. The potential effects on kaimoana due to the proposed extended outfall and proposed discharge regime include the direct impacts of construction/excavation in the estuary in the area of low density pipi are considered *minor, and will be relatively short-term and localised impacts* (i.e., likely senescence of some benthic/infaunal organisms along the pipeline route, followed by recolonization of the disturbed area), and the positive effects of increased dilution and improved treatment. However, I note that increased dilution and improved treatment does not address the issue of the reduced mauri of the water due to discharge, although reducing discharge and directing it to land is the long term aim. It is also my opinion that improvements to the benthic ecology (and kaimoana resources) will also rely on improvements being made to upstream catchments to reduce sediment and other contaminants entering the Wairoa River that are transported to the lower estuary.

71. As Dr Kelly has noted, blooms of nuisance marine macroalgae are a key indicator of nutrient effects, but no information was provided on their presence or absence in the estuary. I have not found any reference to algal blooms in the lower Wairoa Estuary, and refer to the s92 responses on this subject, that periphyton growth is unlikely to develop in soft-bottomed rivers such as the lower Wairoa River, regardless of dissolved nutrient concentrations. And that, this in combination with the occasionally high water flow rates and poor water quality in terms of light penetration (very turbid), indicate that periphyton blooms are unlikely to occur in the Wairoa estuary. As noted by Dr Kelly, the observations and local knowledge of submitters may provide insights into whether or not they occur.

72. There are 3 additional factors that should be considered with respect to linking the discharge to the cause of nuisance algal blooms (should they occur), which include:

   a) degradation of the existing receiving environment is a result of the cumulative effects from various sources within the catchment

   b) The proposed wastewater treatment will include best practicable options and associated mitigation methods to reduce the nutrient load in the discharge, and;

   c) The new discharge location greatly increases dilution rates and the increased storage capacity and development of irrigation means that no discharge will be necessary if the entrance is closed.

Shaw Trevor Mead
16 November 2020

Figures

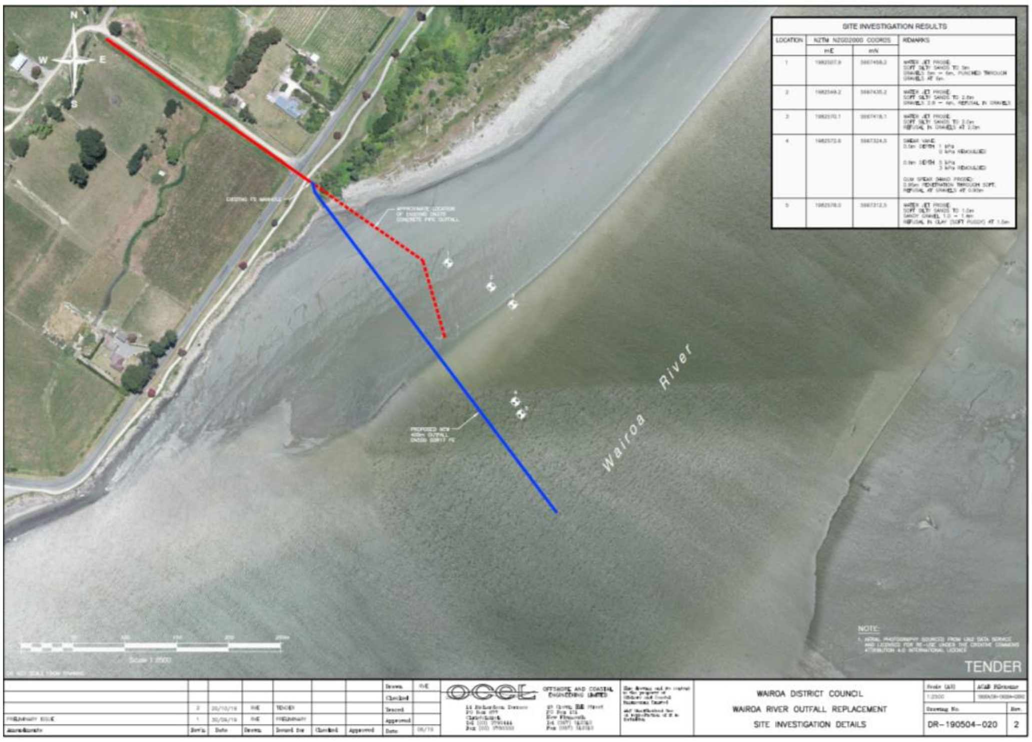


Figure 1. Location plan of the existing pipeline and outfall (red dashed line), which will be decommissioned and removed; the blue line indicates the replacement pipeline and diffuser.

Figure 2. The organism captured in grab sample 1 (close to the proposed diffuser location), with several pipi between 40 and 50 mm long (the 20c piece is 22 mm for scale), with pipi of 40 mm or greater being considered sexually mature.

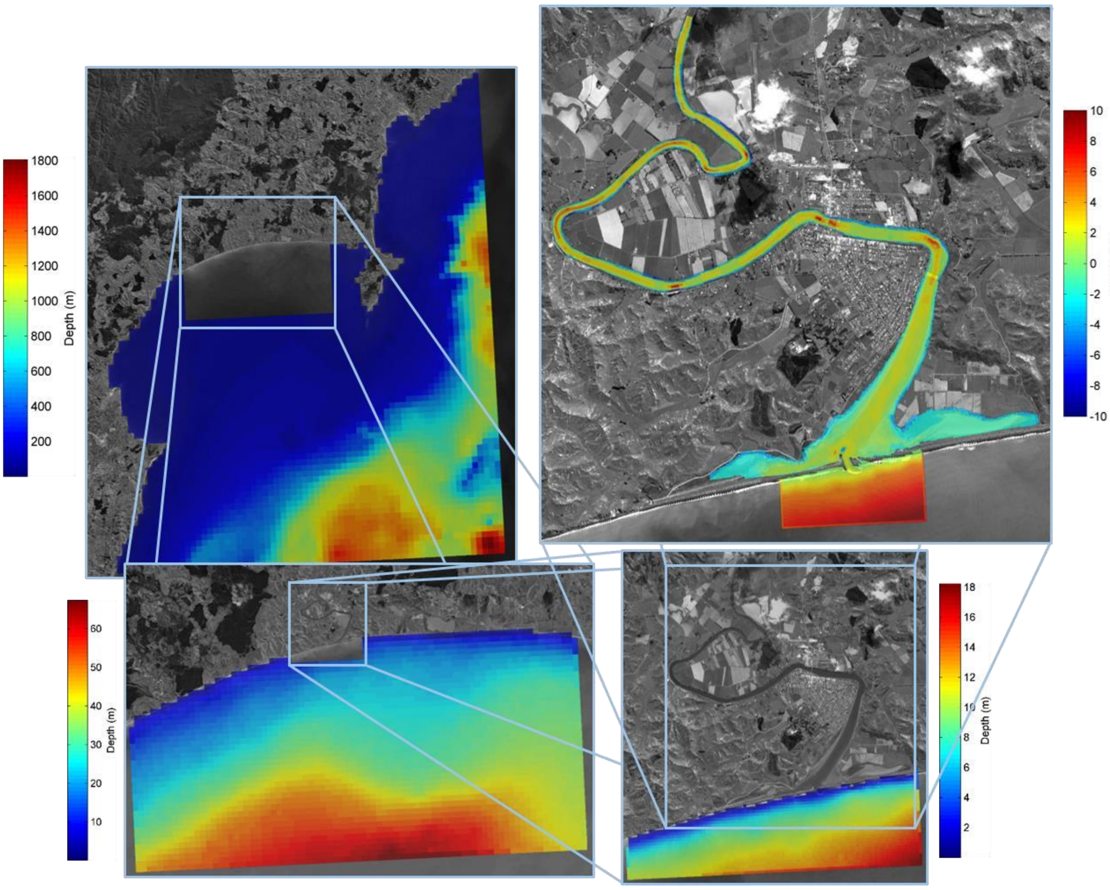


Figure 3. Nested bathymetry grids used in the hydrodynamic model.

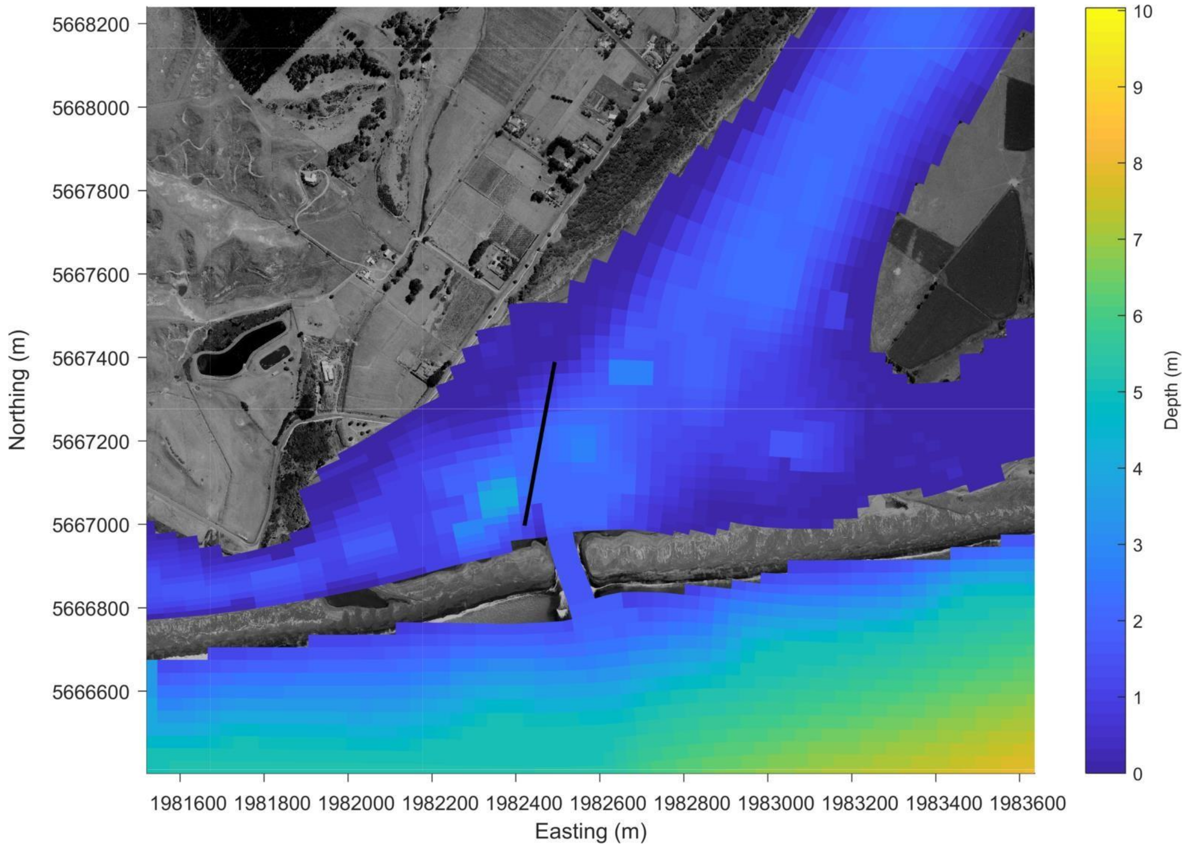


Figure 4. Dilution transect line used for subsequent transect dilution plots.

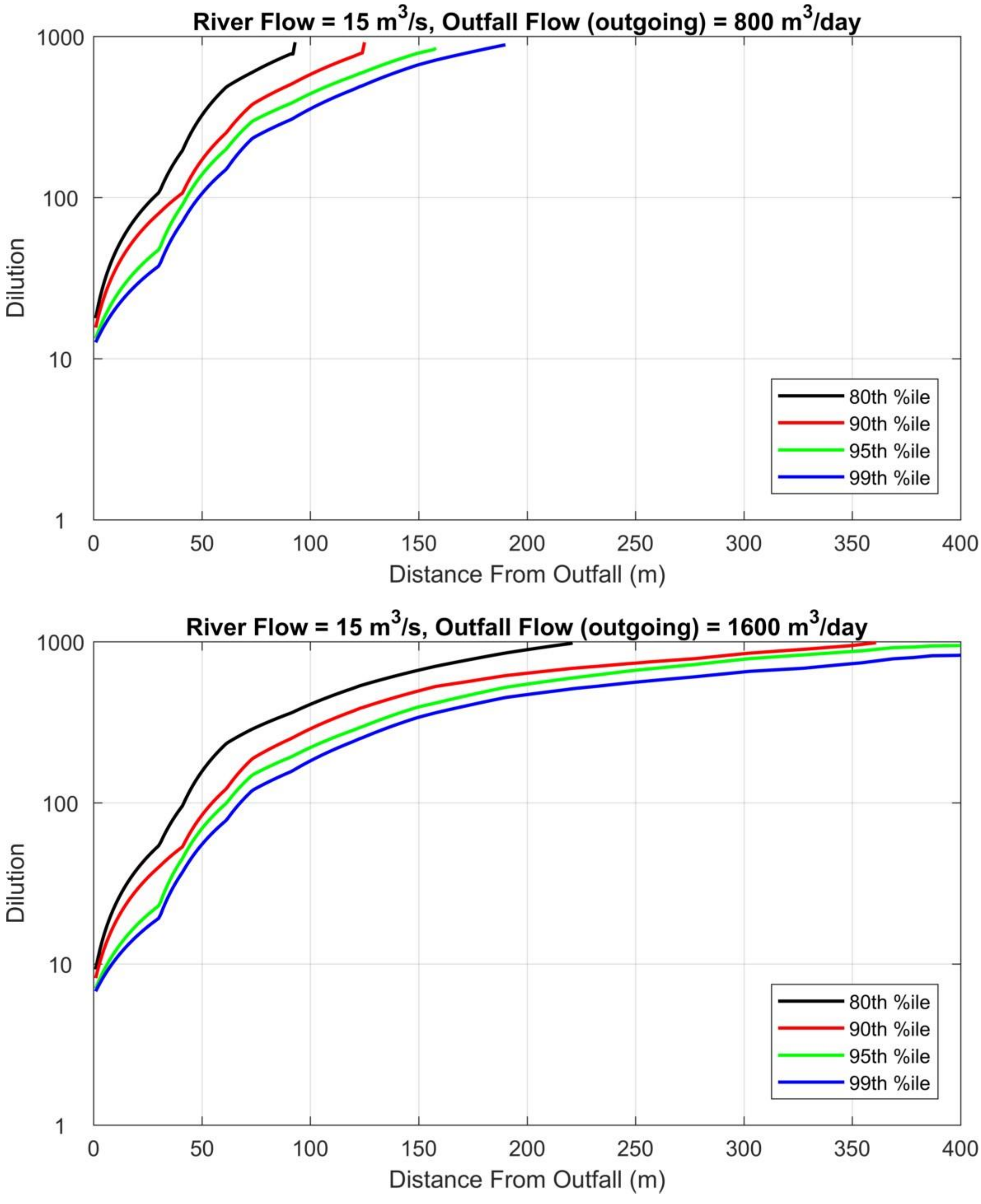


Figure 5. Scenario 1 (upper panel) and Scenario 2 (lower panel) dilution for a range of percentiles.

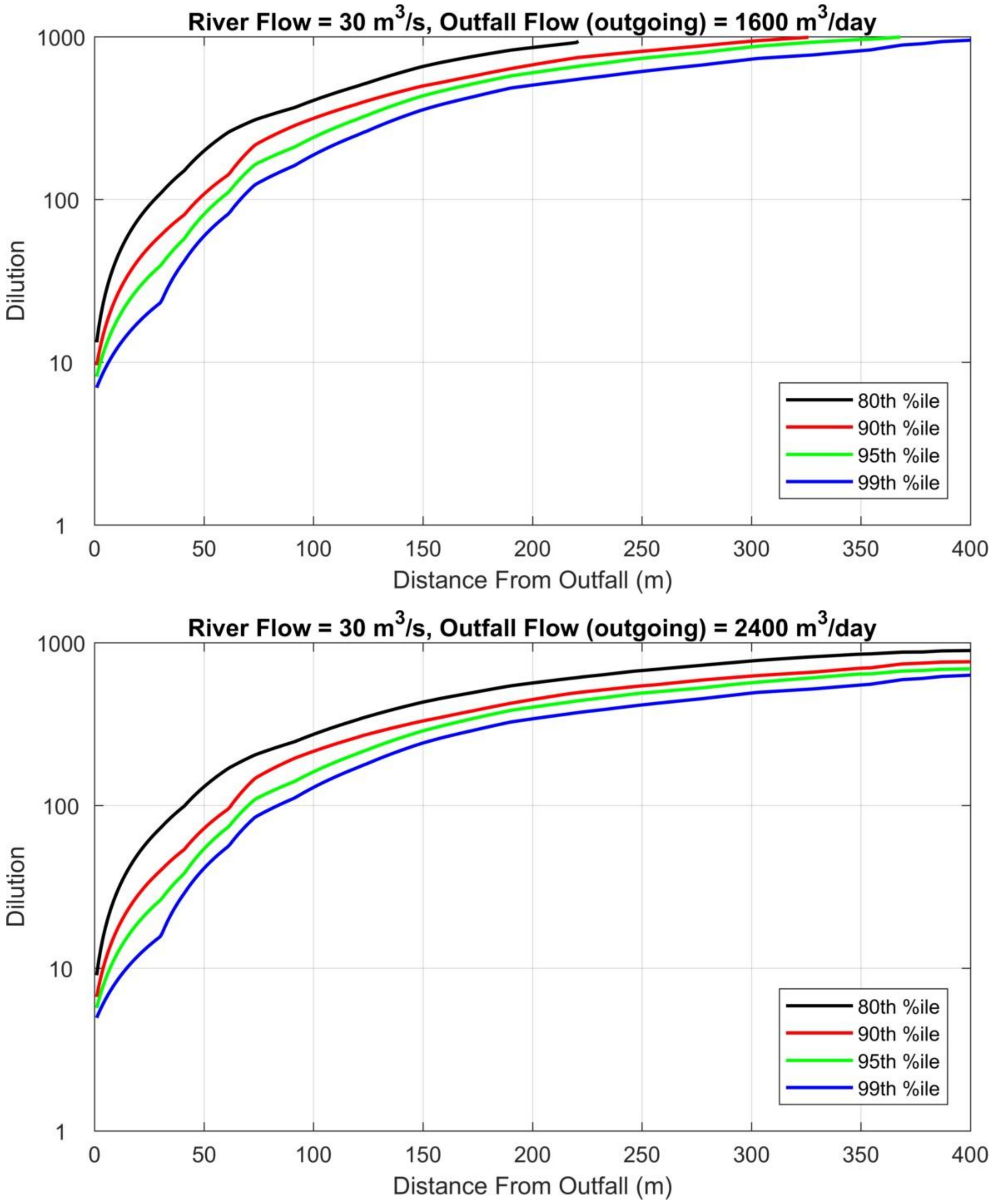


Figure 6. Scenario 3 (upper panel) and Scenario 4 (lower panel) dilution for a range of percentiles.

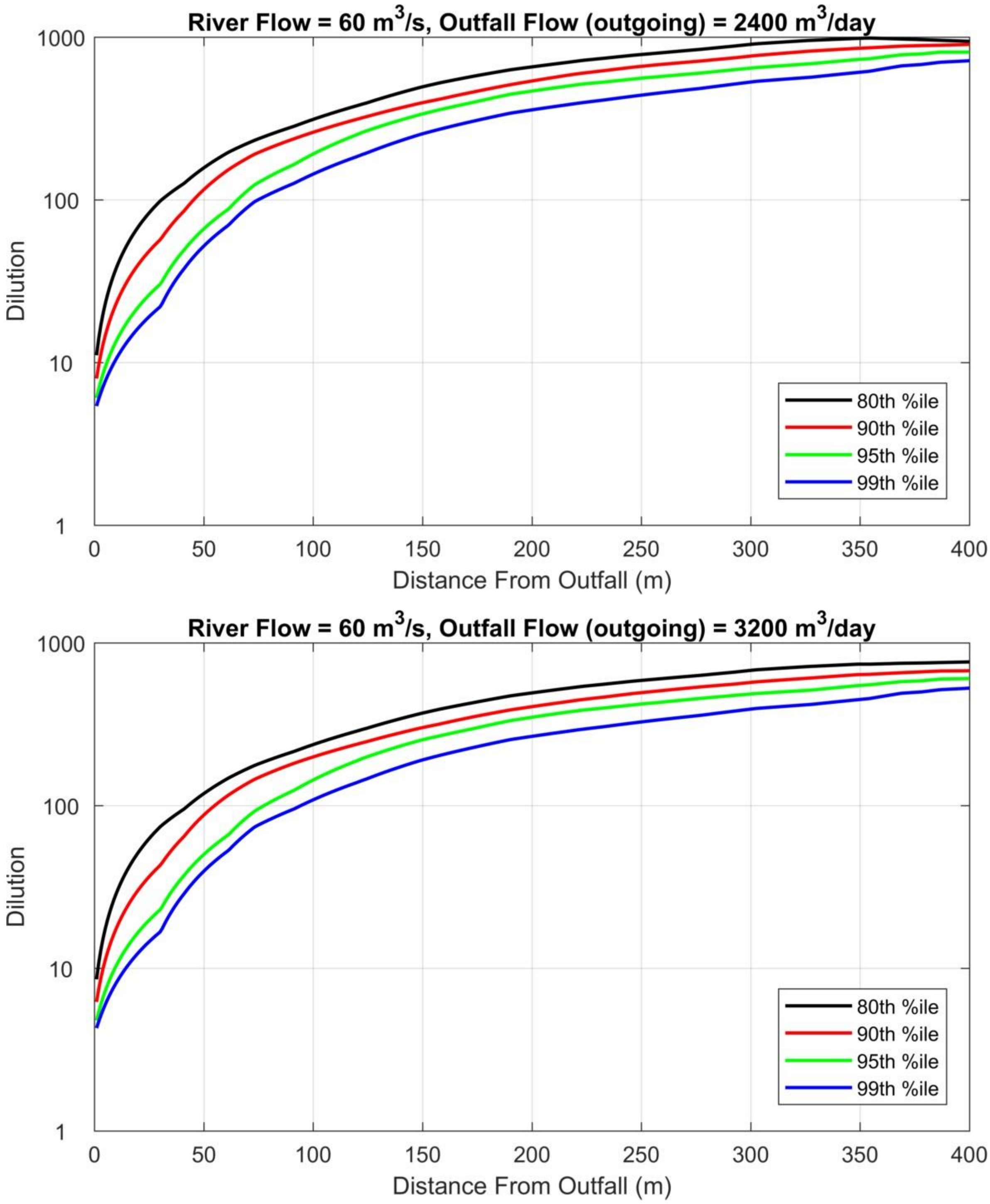


Figure 7. Scenario 5 (upper panel) and Scenario 6 (lower panel) dilution for a range of percentiles.

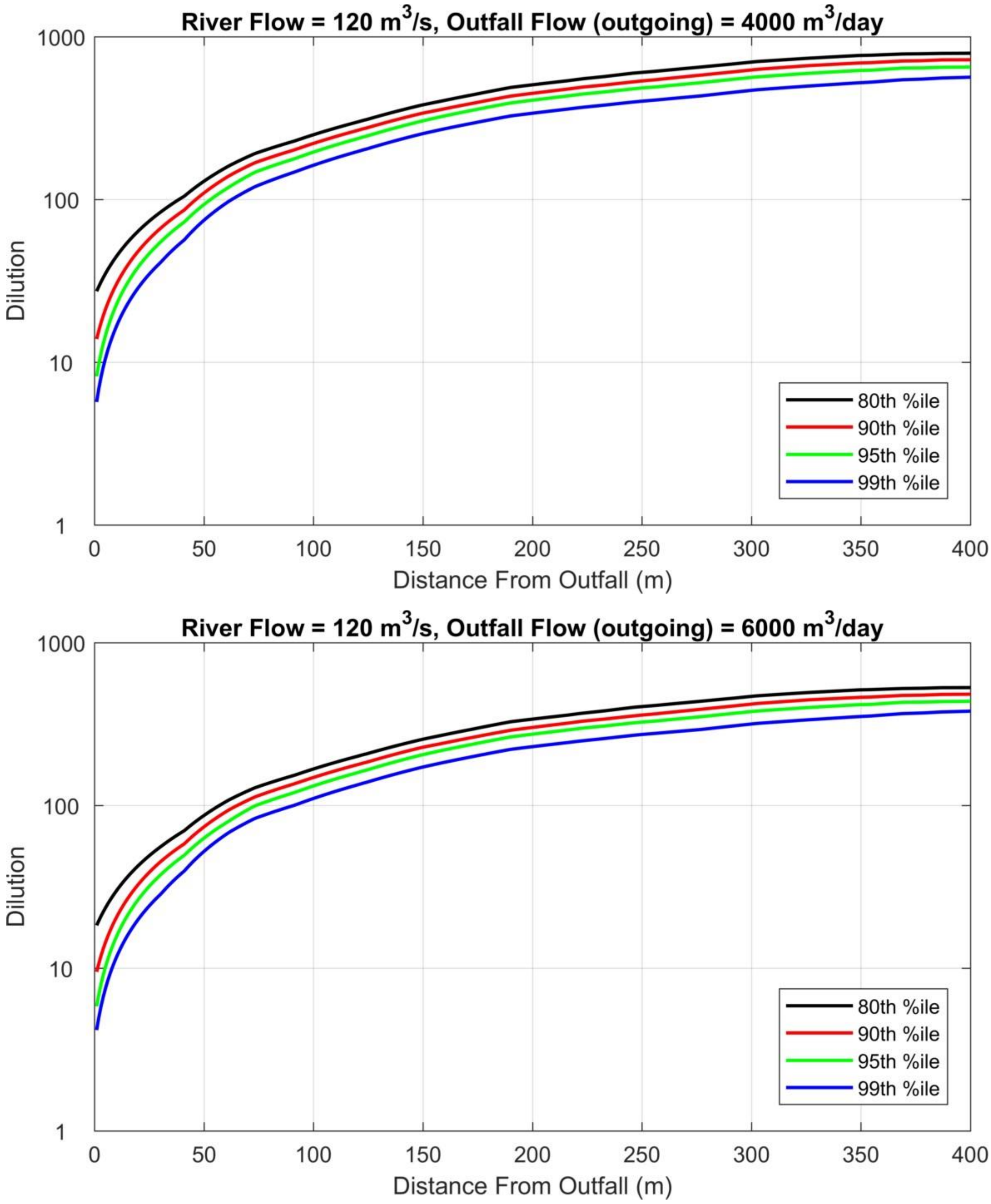
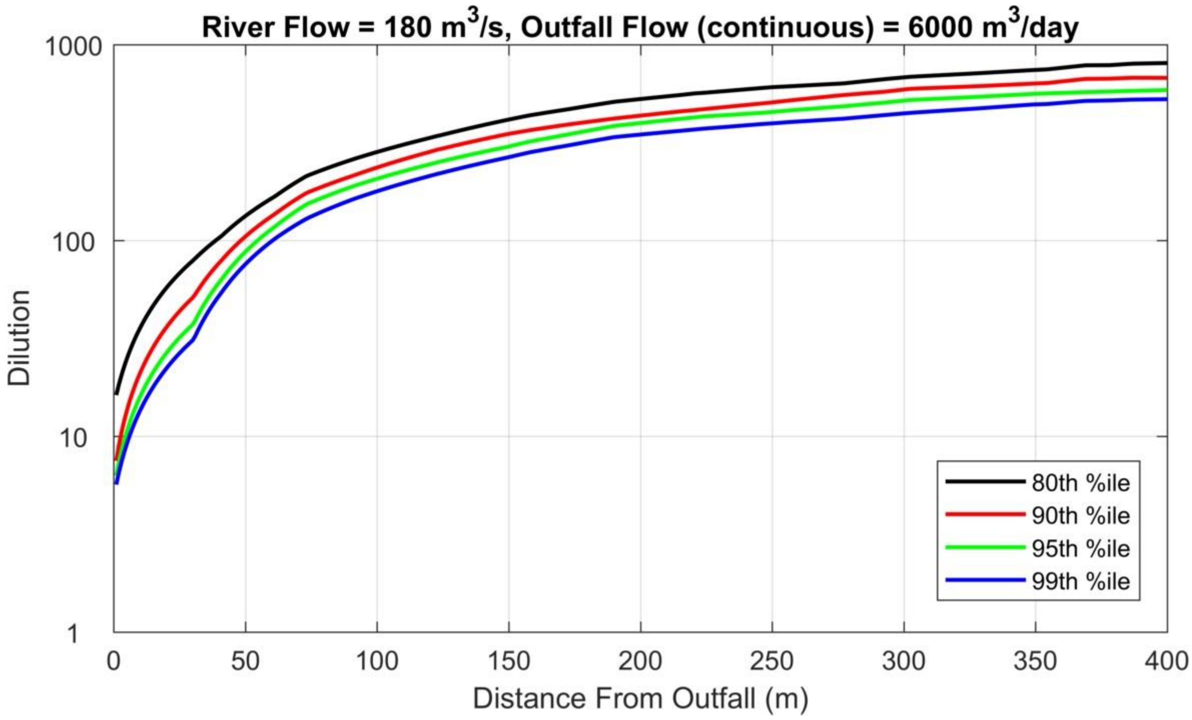


Figure 8. Scenario 7 (upper panel) and Scenario 8 (lower panel) dilution for a range of percentiles.



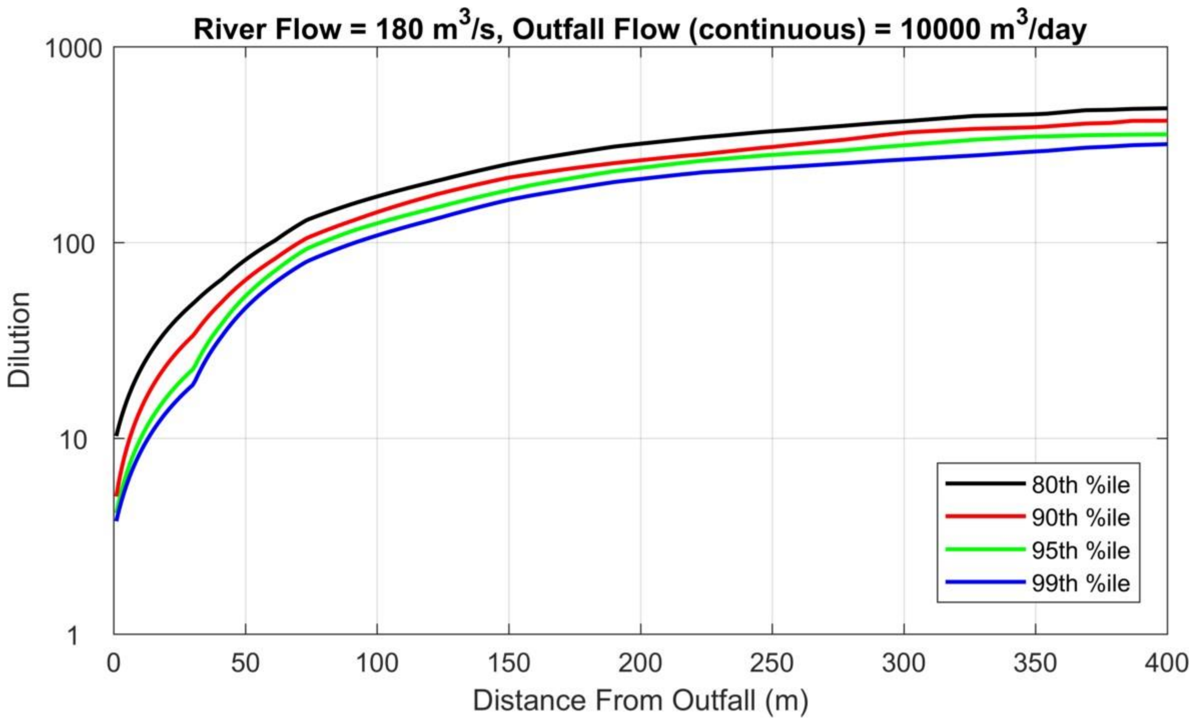


Figure 9. Scenario 9 (upper panel) and Scenario 10 (lower panel) dilution for a range of percentiles.

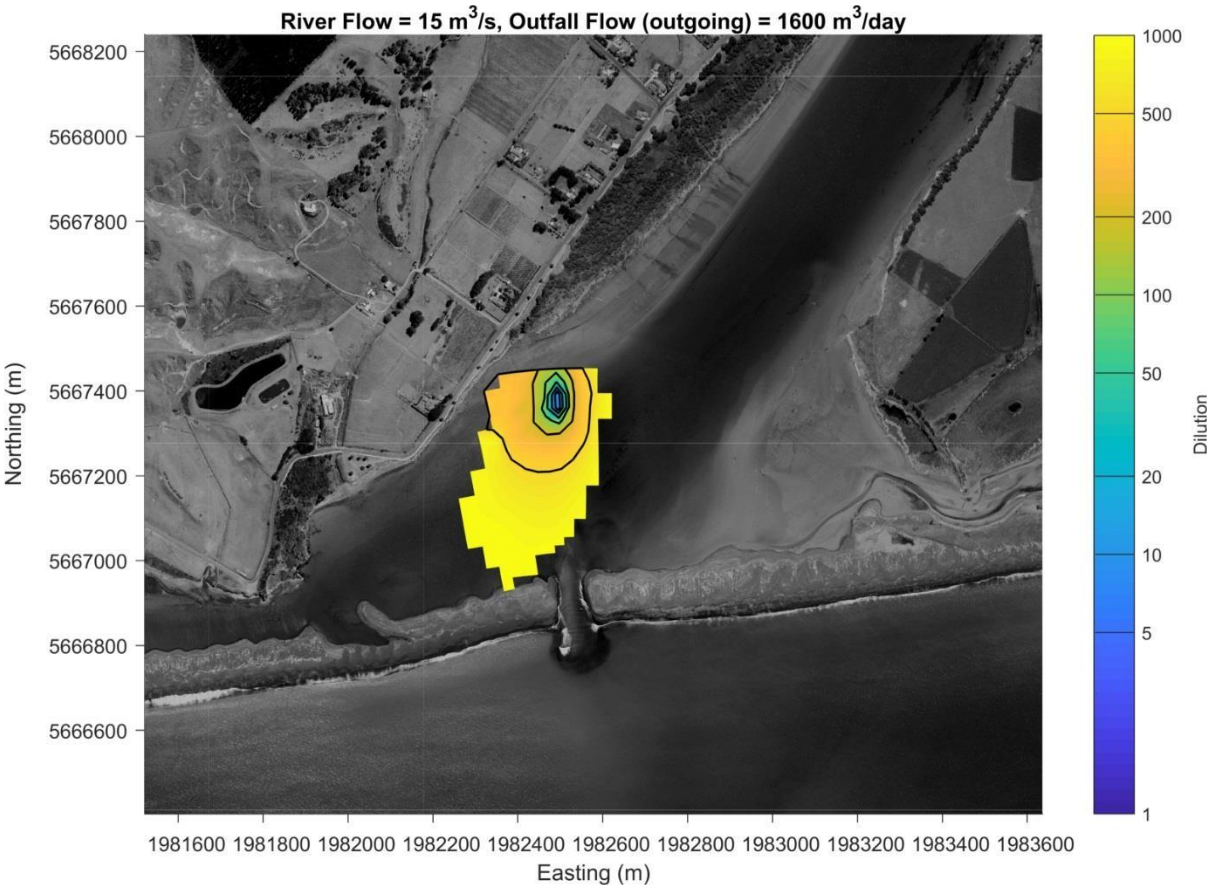


Figure 10. Scenario 1 (upper panel) and Scenario 2 (lower panel) 95th percentile dilution.

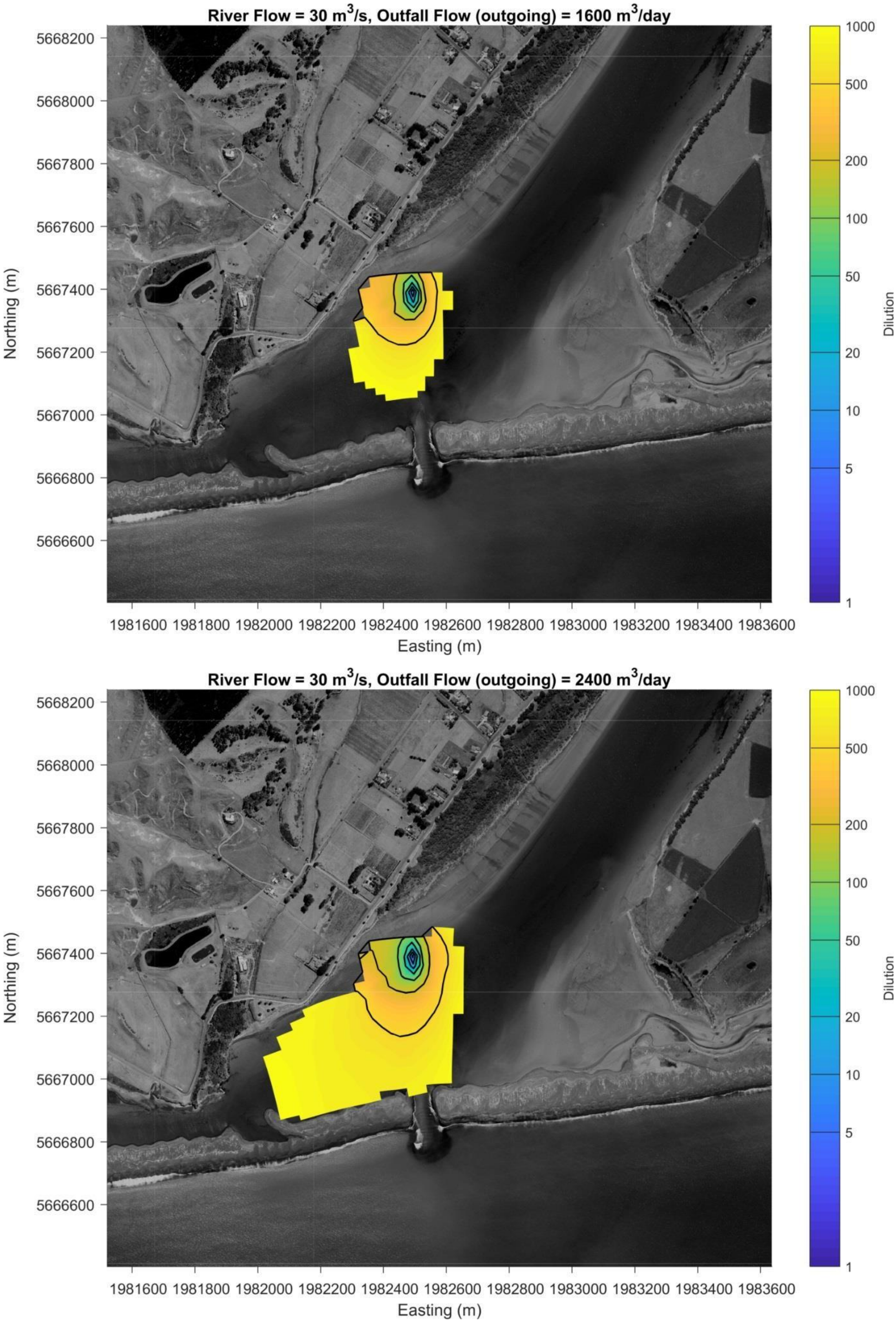


Figure 11. Scenario 3 (upper panel) and Scenario 4 (lower panel) 95th percentile dilution.

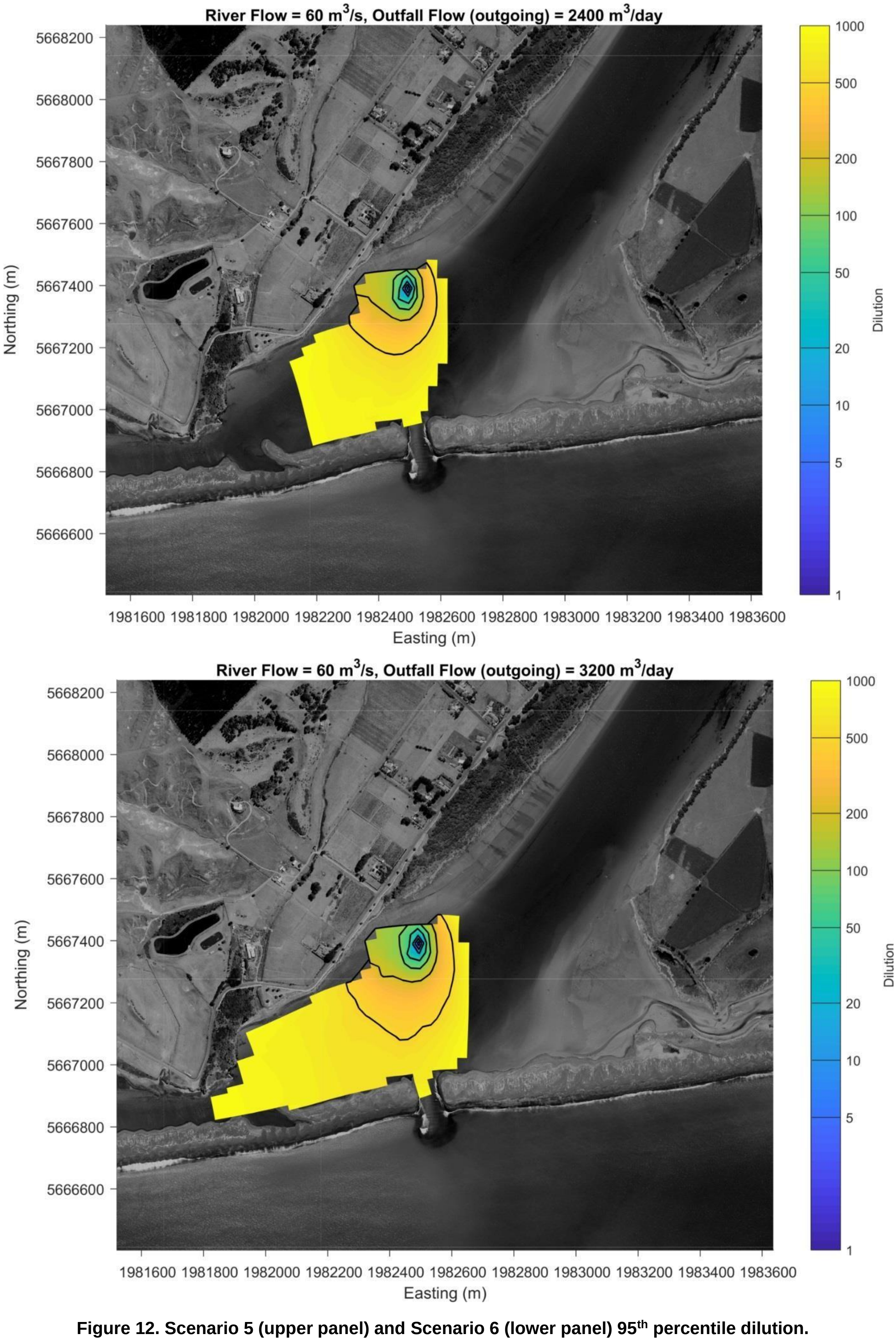


Figure 12. Scenario 5 (upper panel) and Scenario 6 (lower panel) 95th percentile dilution.

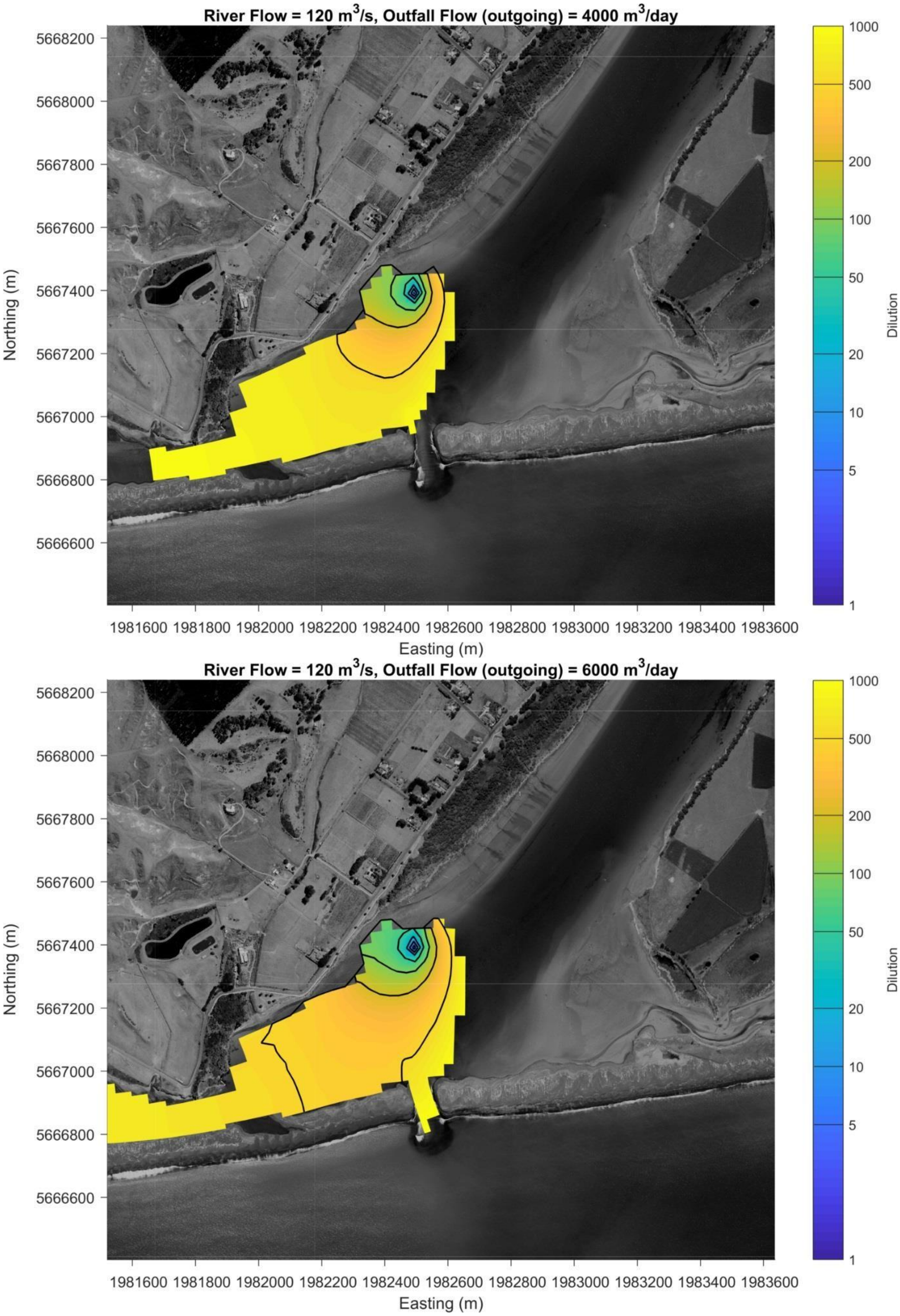


Figure 13. Scenario 7 (upper panel) and Scenario 8 (lower panel) 95th percentile dilution.

Figure 14. Scenario 9 (upper panel) and Scenario 10 (lower panel) 95th percentile dilution.

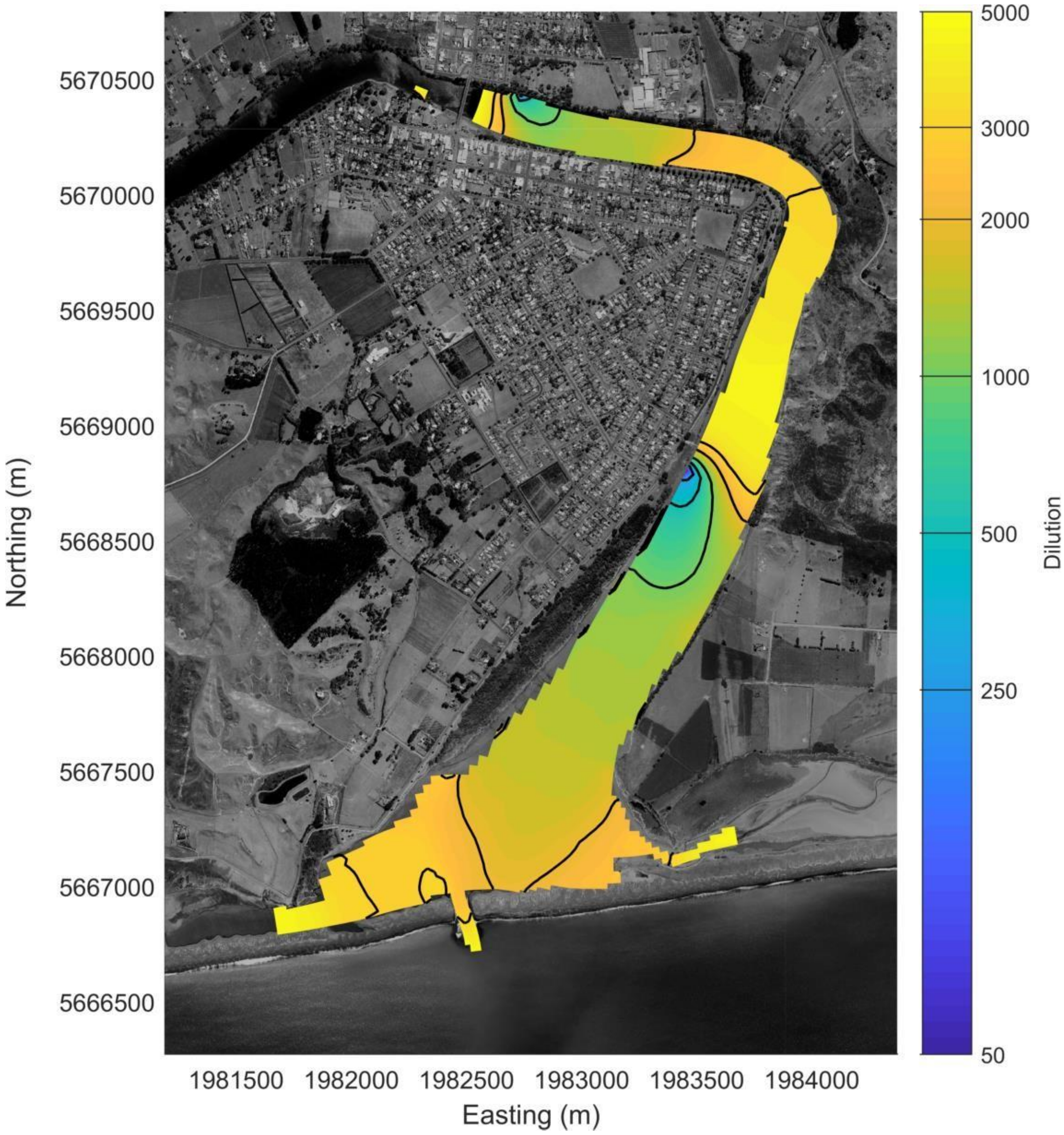


Figure 15. 99th percentile dilution of the spill for the 19-20 March 2012 rainfall event. Dilution of >250x occurs within 50 m of all of the overflows.

Figure 16. The Wairoa River mouth on 12 February 2011 showing a river mouth width of approximately 200 m.

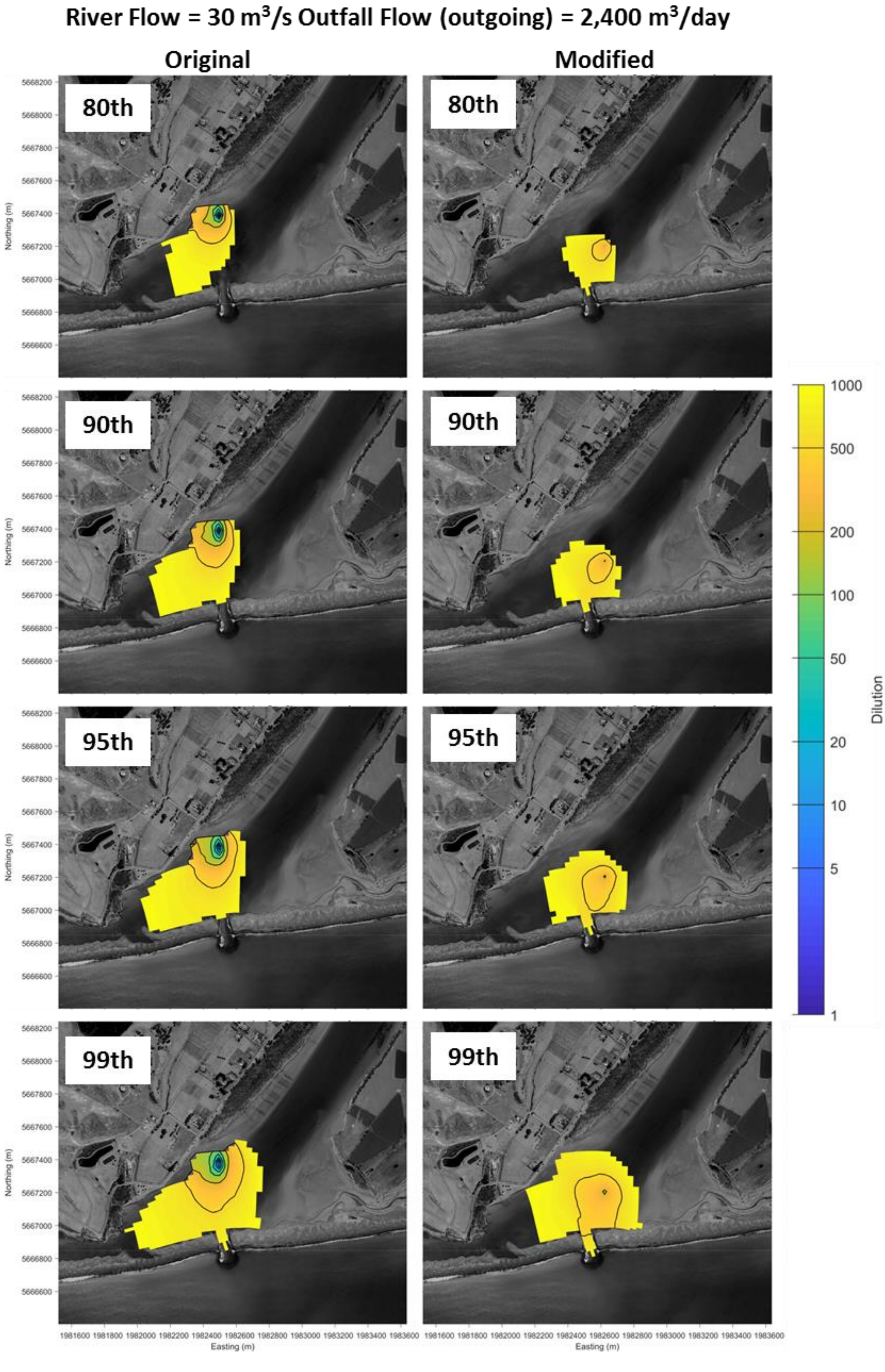


Figure 17. Wastewater dilution with the outfall located at the original position (left) and at the modified position in the channel (right) for a range of percentiles (80^{th}, 90^{th}, 95^{th} and 99^{th}) for Scenario 4.

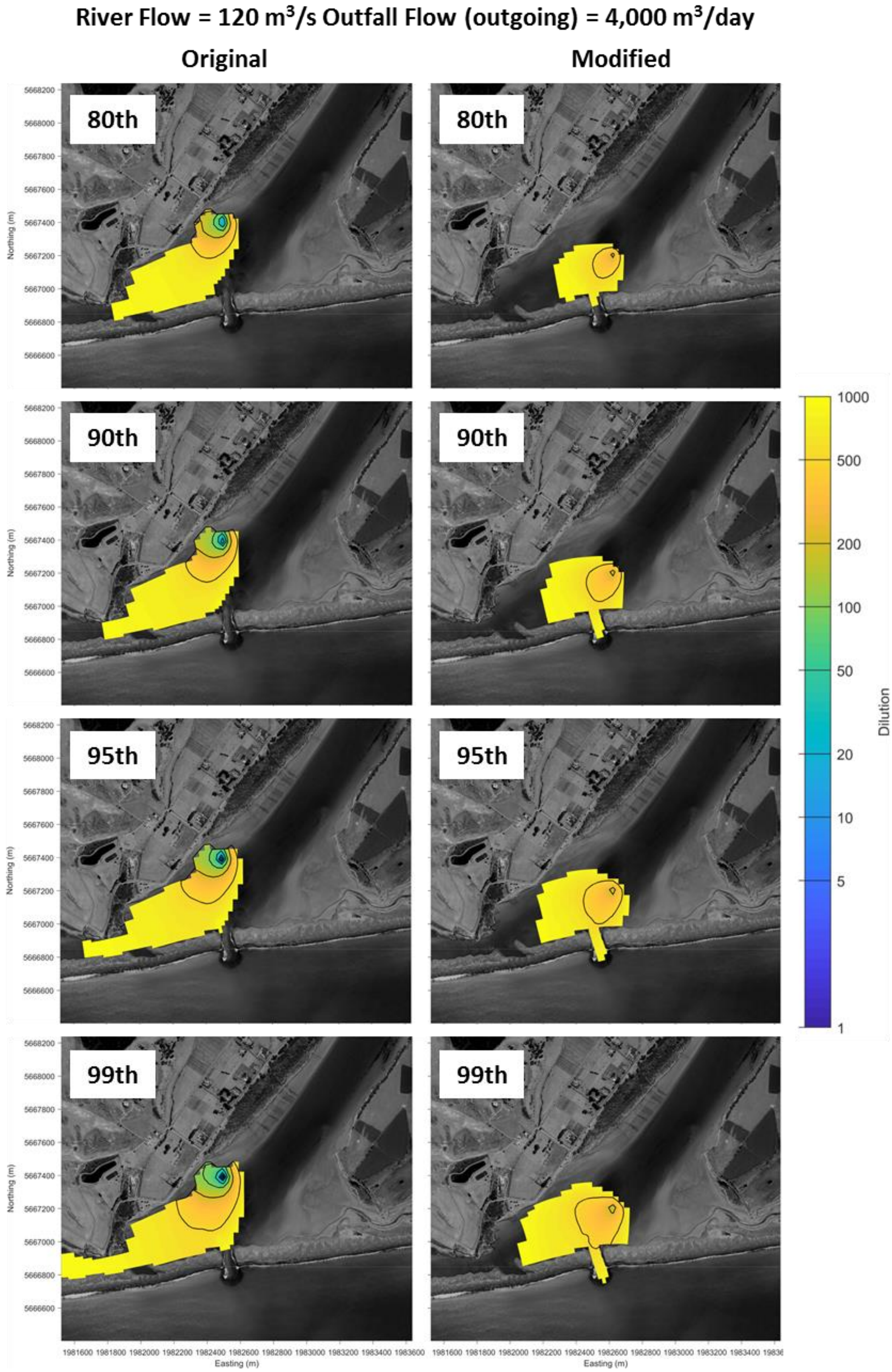


Figure 18. Wastewater dilution with the outfall located at the original position (left) and at the modified position in the channel (right) for a range of percentiles (80th, 90th, 95th and 99th) for Scenario 7.

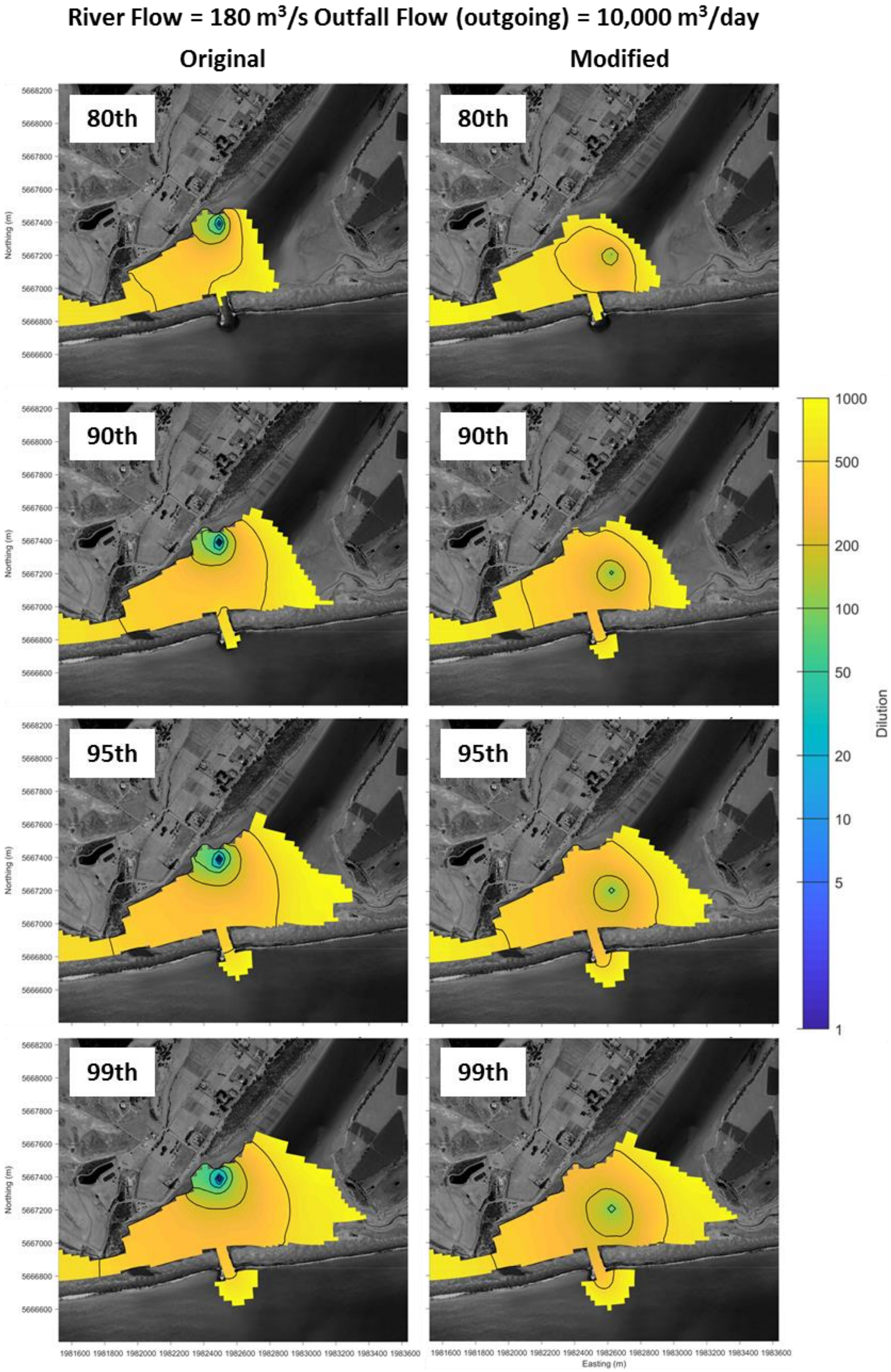


Figure 19. Wastewater dilution with the outfall located at the original position (left) and at the modified position in the channel (right) for a range of percentiles (80th, 90th, 95th and 99th) for Scenario 10.

Tables

Table 1. Summary of Wairoa's Future Treated Wastewater Discharge System.

Stage Timing	Storage Capacity#	Irrigation Area#	River Discharge Parameters*	Pump Station Overflows#
Stage 1 0-5 years	No change (5,400 m^3 within the 2^{nd} WWWTP pond).	Develop up to 50 ha	Below ½ median river flows: <1,600 m^3/d discharge on outgoing tide at night only. ½ median to median river flows: <3,000 m^3/d discharge on **any** outgoing tide. Median to 3 x median river flows: <5,000 m^3/d discharge on **any** outgoing tide. Above 3 x median river flows: unlimited discharge at any time.	Occur less often than now (<10 events/year). Triggered during larger storms.
Stage 2 6-10 years	Increase total to about 10,000 m^3	Expanded up to 100-150 ha total	Below ½ median river flows: <1,600 m^3/d discharge on outgoing tide at night only **but limited to no more than 30 days discharge in December to March**. ½ median to median river flows: <3,000 m^3/d discharge on any outgoing tide. Median to 3 x median river flows: <5,000 m^3/d) discharge on any outgoing tide. Above 3 x median river flows: unlimited discharge at any time.	Rare (<8 events/year); only during larger storms.
Stage 3 11-20 years	Increase total to 50-100,000 m^3	Expanded up to 300 ha total	Below ½ median river flows: **no discharge at any time**. ½ median to median river flows: <3,000 m^3/d discharge **only on outgoing tide at night**. Median to 3 x median river flows: <5,000 m^3/d discharge on any outgoing tide. Above 3 x median river flows: unlimited discharge at any time.	Very rare (<4 events/year); only during very large storms.
Stage 4 21-30 years	Increase total to 200-400,000 m^3	Expanded up to 600 ha total	Below **median** river flows: no discharge at any time. Median to 3 x median river flows: <5,000 m^3/d discharge **only on outgoing tide at night**. Above 3 x median river flows: unlimited discharge at any time.	Very rare (<4 events/year); only during unusually large storms.

Notes: * bold text highlights what is changing within each stage.
intended changes which depend on commitments outside resource consent processes.

Table 2: River and outfall flow 3D numerical modelling scenarios

	River Flow	River flow (m^3/s)	Discharge Flow (m^3/d)	Timing of Discharge
Scenario 1	MALF	15	800	During out-going tides
Scenario 2	MALF	15	1,600	During out-going tides
Scenario 3	½ Median	30	1600	During out-going tides
Scenario 4	½ Median	30	2,400	During out-going tides
Scenario 5	Median	60	2,400	During out-going tides
Scenario 6	Median	60	3,200	During out-going tides
Scenario 7	2 x Median	120	4,000	During out-going tides
Scenario 8	2 x Median	120	6,000	During out-going tides
Scenario 9	3 x Median	180	6,000	Continuous 24hour
Scenario 10	3 x Median	180	10,000	Continuous 24hour

Table 3. Area (m^2) of model domain taken up by a specific dilution for specific percentiles for each scenario comparing the existing location of the outfall and the proposed extended location. Note, the 25 m x 25 m release cell is omitted in tabular format tabular presentation, considered unreliable since it does not take into account near field processes

			Percentile											
			River Flow = 30 m^3/s, Outfall Flow (Outgoing) 2400 m^3/day				River Flow = 120 m^3/s, Outfall Flow (Outgoing) 4000 m^3/day				River Flow = 180 m^3/s, Outfall Flow (continuous) 10,000 m^3/day			
			80	**90**	**95**	**99**	**80**	**90**	**95**	**99**	**80**	**90**	**95**	**99**
Dilution	Original Position	**1 to 5**	0	0	0	0	0	0	0	0	0	0	0	0
		5 to 10	0	0	0	975	0	0	0	0	0	0	0	0
		10 to 20	0	0	975	0	0	0	0	0	0	0	975	975
		20 to 50	964	1939	964	2767	1848	964	2827	2827	1939	3803	3731	5679
		50 to 100	2854	4707	6525	6672	3878	7712	6890	14766	6479	14746	22374	31962
		100 to 200	10475	14549	20132	28510	19319	25065	28734	22760	33,836	38,353	41,429	46,083
		200 to 500	39,782	43,373	50,846	68,330	42114	43037	48097	77052	204,770	318,598	369,609	410,310
		500 to 1000	133,804	184,704	209,774	258,292	217,470	222,374	237,438	277,678	269,108	304,795	364,799	387,405
			80	**90**	**95**	**99**	**80**	**90**	**95**	**99**	**80**	**90**	**95**	**99**
	Modified Position	**1 to 5**	0	0	0	0	0	0	0	0	0	0	0	0
		5 to 10	0	0	0	0	0	0	0	0	0	0	0	0
		10 to 20	0	0	0	0	0	0	0	0	0	0	0	0
		20 to 50	0	0	0	0	0	0	0	0	0	0	0	0
		50 to 100	0	0	0	0	0	0	0	0	0	0	0	0
		100 to 200	0	0	0	0	0	0	0	1955	6,814	21,937	35,316	63,706
		200 to 500	12,791	21,517	38,814	82,497	24,214	35,808	44,531	61,188	140,029	308,503	392,970	423,334
		500 to 1000	893,88	130,149	164,225	237,715	114,207	154,764	180,060	213,332	379,234	335,947	343,985	381,161