Selfs Point WWTP Expansion EIS– Predicted Impacts to Derwent Estuary

November 2023, Revision I

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Revision	Date	Description	Approved
A	7/4/22	Draft report to TasWater CDO	B Bonneville
B	16/5/22	Revised report addressing comments	B Bonneville
C	24/5/22	Final report	B Bonneville
D	3/8/22	Final report with minor correction (Section 7.3.2)	B Bonneville
E	21/2/23	Draft report addressing EPA comments	B Bonneville
F	10/3/23	Minor amendment to references	B Bonneville
G	27/3/23	Minor amendment to Chlorine DGV	B Bonneville
H	31/3/23	Minor amendment to effluent N median	B Bonneville
I	28/11/23	Update for 2054 future scenario	B Bonneville

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Executive Summary

The objective of this report was to address the 'Predicted Impacts' segment of Section 6.2 Water Quality (Surface and Discharge) of the Project Specific Guidelines (EPA Tasmania, September 2020) as part of the Environmental Impact Statement (EIS) for Selfs Point WWTP Expansion for TasWater's Capital Delivery Office. The 'Predicted Impacts' section specified an assessment of water quality impacts associated with the effluent discharge arrangements at Blinking Billy Outfall, Selfs Point Local Outfall and Macquarie Point Local Outfall. The assessment was based on design effluent quality and volumes, and in conjunction with seasonal effluent and receiving environment conditions.

Future effluent volumes generated from Selfs Point STP are expected to increase up to ADWF of 24.9 ML/d in 2054. In future, treated effluent will be discharged to the Derwent Estuary according to the following discharge management practices:

- **Dry weather discharges to Blinking Billy Outfall (BBO):** Treated effluent from Selfs Point STP will be preferentially discharged to the Lower Derwent Estuary via the BBO. The peak capacity of BBO is 345 L/s (29.8 ML/d)
- **Storage in 4 ML Selfs Point balancing tank:** Effluent volumes that exceed the BBO capacity will be stored in balancing storage at Selfs Point
- **Wet weather discharges to Selfs Point Local Outfall (SPLO):** When the peak capacity of BBO is exceeded (>345 L/s) and the Selfs Point balance storage is full, effluent will be discharged to the Middle Derwent Estuary via the SPLO at a peak hydraulic capacity of 1340 L/s for the new SPLO
- **Emergency discharges from Macquarie Point Local Outfall (MPLO):** Flows that exceed the pumped capacity to Selfs Point (587-625 L/s) will be stored at the on-site storage emergency storage. The emergency storage is sized to ensure a total of 4 hours ADWF storage is provided within the upstream network capturing a 1 in 1 year ARI event. When the emergency storage is full, additional flows will be discharged as raw sewage from the MPLO. This has been modelled as part of the EIS, with the emergency overflow of raw sewage at the Macquarie Point SPS based on a 1 in 1 year ARI event equating to 3 ML over 5 hours at a rate of 167 L/s.

Environmental Risks to lower Derwent Estuary at Blinking Billy Outfall (BBO)

Results from the mixing zone and environmental risk assessment showed that Selfs Point STP effluent discharges from BBO presents a low risk to environmental values in the receiving environment. The effluent plume is buoyant and receives mixing not just from the high number of discharge ports and high exit velocity, but also as the plume rises from the 32 m depth. The ambient currents are low in the bottom waters and travel in a northerly direction. However, as the plume rises to the surface it is met with higher velocity currents that transport the plume southward towards the Southern Ocean. The residence time and accumulation of nutrients in the estuary (far-field) is predicted to be short (i.e. days) due to the transport out to the ocean.

While nutrient concentrations may be elevated above guideline values in the near-field environment, it is unlikely that there will be any significant eutrophication related effects at Blinking Billy due to the high level of dilution in the far-field environment and the short residence time in the estuary.

Chlorine and associated disinfection by-products in the effluent presents a low risk of direct toxicity to aquatic life. The mixing zone will be approximately 20 m from the outfall. The zone of impact is small in deep water and 850 m away from known sensitive habitat for the critically endangered spotted handfish.

Environmental Risks to Middle Derwent Estuary from wet-weather discharges at Selfs Point Local Outfall

Results from the mixing zone and environmental risk assessment showed that fully treated wet-weather discharges from Selfs Point STP via the SPLO presents a low risk to environmental values in the receiving environment.

A new outfall with a diffuser at placement depths of 2 m, 6 m (existing), 8 m and 12 m were modelled. Near-field modelling suggests that the dilution and dispersion of the effluent plume at the peak capacity of 1340 L/s is improved with increasing water depth (e.g., 12 m) into the main Middle Derwent River channel. However, the depth of the outfall does little to reduce the size and extent of the footprint of nutrient enrichment that results from peak wet-weather discharges. The model suggests that nutrients will exceed DGVs into the mid- and far-field environment, for up to one kilometre in the direction of the current.

Given the short, intermittent nature of the wet-weather discharges from SPLO (i.e., predicted to be nine events per year), there is a low risk to environmental values in the Middle Derwent Estuary from all contaminants of concern in the effluent.

Environmental Risks to Lower Derwent Estuary from emergency overflows at Macquarie Point Local Outfall

Emergency overflows of raw sewage present a high risk to recreational users within 1000 m of the outfall due to elevated pathogens during the first 24 hours after a wet-weather event. The discharge presents a cumulative risk with high pathogen loads in stormwater and urban runoff, which makes the lower Derwent Estuary in this location unsuitable for recreational activities during and immediately after heavy rainfall. This risk only applies 1-2 days per year.

Whole of estuary risks from the Selfs Point Expansion Proposal

The Selfs Point STP expansion proposal, including decommissioning Macquarie Point STP, presents significant benefits to the Derwent Estuary compared to the current arrangement. Enhanced sewage treatment at the future Selfs Point STP means that the overall nutrient loads to the estuary will be significantly reduced despite the increase in effluent volume. Preferential effluent discharges at Blinking Billy Outfall will move the effluent discharges further downstream into one of the deepest parts of the estuary where there is good dilution and dispersion.

Effects on sediment quality

Environmental impacts to sediment quality from the effluent discharges around the BBO will be localised and minor. This presents a low risk to the environmental values of the lower Derwent Estuary.

Monitoring recommendations

Effluent screening, plume dilution studies, 12-months of water quality monitoring, mixing zone verification and 5-yearly sediment quality assessments have been recommended for the effluent discharges at BBO, to commence post-commissioning of the Selfs Point STP expansion.

Outfall modelling is indicative only and may not accurately reflect actual conditions. The mixing zone assessment is subject to the limitations of the Visual Plumes modelling software and the available data used to inform the model.

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1. Introduction

The objective of this report is to address the 'Predicted Impacts' segment of Section 6.2 Water Quality (Surface and Discharge) of the Project Specific Guidelines (EPA Tasmania, September 2020) as part of the Environmental Impact Statement (EIS) for Selfs Point STP Expansion for TasWater's Capital Delivery Office.

The 'Predicted Impacts' section specifies an assessment of water quality impacts associated with the effluent discharge arrangements at Blinking Billy Outfall, Selfs Point Local Outfall and Macquarie Point Local Outfall. The assessment is to be based on design effluent quality and volumes, and in conjunction with seasonal effluent and receiving environment conditions (**See Chapters 2 and 3)**.

The specific tasks specified were to:

- Undertake hydrodynamic dispersion modelling for each outfall. This must consider near-field (mixing zone) and far-field impacts (e.g., nutrient enrichment and algal blooms) - **see Chapters 4, 5, and 6**
- Based on the dilution modelling, and with consideration of identified PEVs and draft water quality objectives, propose mixing zones at each outfall within the meaning of Section 20.3 of the *State Policy on Water Quality Management 1997* and demonstrate how the proposed mixing zones meet the requirements outlined in that section - **see Chapters 4, 5, and 6**
- Evaluate expected annual mass nutrient loads to be discharged in the context of the characteristics of the receiving environment, including catchment loads – **See Chapter 7**
- Discuss any potential impact on sediment quality or the potential for remobilisation of contaminants in sediment – **See Chapter 8**
- Identify management practices and verification procedures to ensure that the mixing zone will be maintained or reduced during the operation of the proposed activity. – **See Chapter 9**

This report draws from previous investigations including:

- DEP (2020). *State of the Derwent estuary — 2020 update*: *An update and review of environmental data and activities*, U. Taylor, S. Whitehead, I. Visby A. Weller-Wong and B. Proemse, Derwent Estuary Program (Hobart, Australia).
- Jacobs (2016)a. *Ambient monitoring of sewage treatment plant discharges to the Derwent Estuary*. A report prepared for TasWater, December 2016.
- Jacobs (2016)b. *Environmental Risk Assessment: Selfs Point Sewage Treatment Plant Effluent Discharges to Derwent Estuary*, Macquarie Point Relocation: Scenario 6, Draft A. A report prepared by Jacobs for TasWater, 4 November 2016.
- GHD (2021). *Selfs Point STP Upgrade Concept Design Report*. A report prepared for CPB UGL JV by GHD, 13 December 2021.

2. Selfs Point STP effluent discharges

This chapter outlines the assumptions for future effluent discharge management practices for the Selfs Point STP expansion. This includes proposed effluent discharge volumes to Blinking Billy Outfall (BBO) and Selfs Point Local Outfall (SPLO) and the proposed effluent quality design parameters for Selfs Point STP.

2.1 Influent projections

Current and projected influent average dry weather flows (ADWF) for the new Selfs Point STP were provided up to 2054 in the *Selfs Point STP Upgrade Concept Design Report* (GHD 2021, Table 2-1). The new Selfs Point STP has a design peak wet weather flow (PWWF) capacity of 1470 L/s. The project being assessed for the EIS is up to year 2054.

Table 2-1 Flow projections by catchment (GHD 2021, Table 4)

Catchment	ADWF (ML/d)					
	2020	2025	2035	2040	2045	2054
Macquarie Point Catchment	10.3	10.8	11.8	12.3	12.9	14
Selfs Point Catchment	8.0	8.4	9.2	9.6	10.0	10.9
Total flows	18.5	19.2	21.0	21.9	22.9	24.9

2.2 Effluent discharge management

Treated effluent from Selfs Point STP, located in the Hobart suburb of New Town, is currently discharged from two outfalls into the Derwent Estuary (Figure 2-1). The bulk of the STP effluent is transferred down to Sandy Bay under a pressurised pipeline and discharged through long diffusers at BBO, off Blinking Billy point in the lower estuary. SPLO, near the STP, receives wet-weather and emergency discharges and discharges intermittently into the middle estuary.

Macquarie Point STP, to be decommissioned, also has a local outfall (MPLO) that discharges treated effluent under the wharf within the Hobart central business district (Figure 2-1). MPLO will be retained as part of the sewage pump station emergency storage and discharge arrangements.

Figure 2-1 Location of Selfs Point STP outfalls

Future effluent volumes generated from the new Selfs Point STP are expected to increase up to ADWF of 24.9 ML/d in 2054. In future, treated effluent will be discharged to the Derwent Estuary according to the following discharge management practices (Table 2-2):

- **Dry weather discharges to Blinking Billy Outfall (BBO):** Treated effluent from Selfs Point STP will be preferentially discharged to the Lower Derwent Estuary via the BBO. The peak capacity of BBO is 345 L/s (29.8 ML/d)
- **Storage in 4 ML[1] Selfs Point balancing tank:** Effluent volumes that exceed the BBO capacity will be stored in balancing storage at Selfs Point
- **Wet weather discharges to Selfs Point Local Outfall (SPLO):** When the peak capacity of BBO is exceeded (>345 L/s) and the Selfs Point balance storage is full, effluent will be discharged to the Middle Derwent Estuary via the SPLO at a peak hydraulic capacity of 1340 L/s for the new SPLO
- **Emergency discharges from Macquarie Point Local Outfall (MPLO):** Flows that exceed the pumped capacity to Selfs Point (587-625 L/s) will be stored at the on-site storage emergency storage. The emergency storage is sized to ensure a total of 4 hours ADWF storage is provided

[1] Storage volume is subject to change.

within the upstream network capturing a 1 in 1 year ARI event. When the emergency storage is full, additional flows will be discharged as raw sewage from the MPLO. This has been modelled as part of the EIS, with the emergency overflow of raw sewage at the Macquarie Point SPS based on a 1 in 1 year ARI event equating to 3 ML over 5 hours at a rate of 167 L/s.

Table 2-2 EIS discharge management scenarios

Discharge type	Blinking Billy Outfall	4 ML[1] SP storage	Selfs Point local outfall	Macquarie Point Local Outfall
ADWF	345 L/s – Peak Capacity at Blinking Billy Outfall	-	-	-
Wet weather	345 L/s – Peak Capacity at Blinking Billy Outfall	4 ML storage	1340 L/s peak hydraulic capacity for the new outfall at Selfs Point	-
Emergency discharges	345 L/s – Peak Capacity at Blinking Billy Outfall	4 ML storage	1340 L/s peak hydraulic capacity for the new outfall at Selfs Point	Discharge/storage at Macquarie Point

2.3 Discharge scenarios

The following sections outline the modelling scenarios to assess the predicted impacts to the Derwent Estuary.

2.3.1 Dry weather flow discharges to Blinking Billy Outfall

The adopted volume for the outfall modelling to assess the predicted impacts to the Lower Derwent Estuary is **345 L/s (29.8 ML/d)** *peak capacity* flow to BBO from Selfs Point STP. The projected ADWF for 2054 is 24.9 ML/d.

2.3.2 Wet-weather discharges to Selfs Point Local Outfall

Wet weather discharges at the SPLO will occur when the BBO capacity is exceeded (>345 L/s) and the 4 ML[1] Selfs Point balance storage is full. The adopted volume for the SPLO outfall modelling to assess the predicted impacts to the Middle Derwent Estuary is the *peak capacity* flow of **1340 L/s (115 ML/d)** for the new outfall.

Only 1.9 % of the annual total effluent volume is expected to be discharged at the SPLO over approximately 9 discharge events per year. This amounts to a total volume of approximately 130 ML per year (689 ML over five years; Table 2-3, Figure 2-2).

Table 2-3 Model results for discharge frequency and volume at SPLO with a 4 ML[1] balancing storage (after GHD 2022)

Parameter	Unit	Over 5 years	Av. per year
Total hours of discharge at SPLO	Hrs	251	47
Total days with discharge at SPLO	Days	93	18
Total discrete discharge events	Days	50	9
Total volume discharged at SPLO	ML	689	130
Proportion of discharge volume	%	1.9 %	

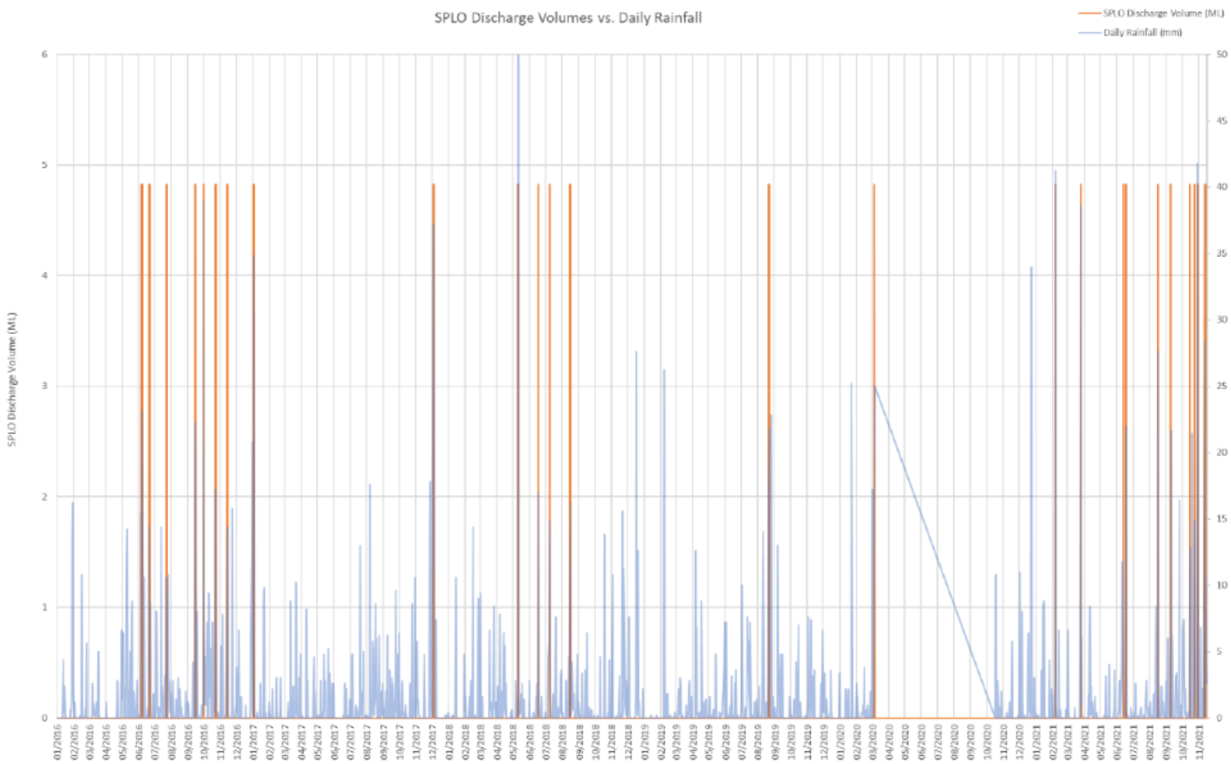


Figure 2-2 Modelled frequency and volume of discharge events at SPLO versus rainfall (Hobart Botanical Gardens), after GHD 2021b

2.3.3 Emergency Discharges at Macquarie Point Local Outfall

The capacity of the proposed pump station to transfer raw sewage from Macquarie Point catchment to Selfs Point for treatment is 587 – 625 L/s dependent on final pump capacity adopted (GHD 2022). When sewage exceeds this capacity, it will be stored or discharged at Macquarie Point via the MPLO. Likewise, when sewage inflows to Selfs Point STP exceed all the combined capacities of BBO and SPLO and on-site storage, the excess will be stored or discharged at MPLO.

The emergency storage is sized to ensure a total of 4 hours ADWF storage is provided within the upstream network capturing a 1 in 1 year ARI event. When the emergency storage is full, additional flows will be discharged as raw sewage from the MPLO. This has been modelled as part of the EIS, with the emergency overflow of raw sewage at the Macquarie Point SPS based on a 1 in 1 year ARI event equating to 3 ML over 5 hours at a rate of 167 L/s.

2.4 Effluent quality

Treated effluent quality design parameters were provided in the GHD (2021) *Concept Design Report* (Table 2-4). All peak wet weather flows are assumed to be treated to this level.

The proposed 90th percentiles match the Accepted Modern Technology limits for all parameters, except for total phosphorus (TP, where the 90th percentile adopted is 5 mg/L).

Table 2-4 Treated effluent design parameters, after GHD (2021, Table 17).

Parameter	Adopted 50th percentile	Adopted 90th percentile	AMT (marine) 50th percentile	AMT (marine) 90th percentile	AMT (marine) Max
BOD (mg/L)	10	15	10	15	20
TSS (mg/L)	10	20	10	20	30
Faecal Coliforms (cfu/100ml)	200	500	200	500	750
Oil and Grease (mg/L)	2	5	2	5	10
TN (mg/L)	7	10	7	10	15
Ammonia (mg/L)	1	2	1	2	5
TP (mg/L)	2	5	1	3	5
Chlorine		1			

Chlorine will be added to effluent for secondary disinfection and to reduce bacterial regrowth and biofouling in the outfall pipeline. Wet weather discharges from SPLO will not be chlorinated.

3. Derwent Estuary Receiving Environment

This section describes the Derwent Estuary, including Protected Environmental Values, water quality conditions, hydrodynamics, and the nature of the receiving environment for Selfs Point Local Outfall and Blinking Billy outfall.

3.1 Functional zones

The Derwent Estuary is divided into broad management zones characterised by different physical, chemical and biological conditions (Figure 3-1). These zones are used by the EPA Tasmania to delineate Protected Environmental Values (PEVs, EPA 2003) and default guideline values (DGVs, EPA 2019), and by Derwent Estuary Program for their State of the Derwent Estuary reports (DEP 2020).

- Upper Derwent Estuary: New Norfolk Bridge to west of Green Point/Whitestone Point
- Middle Derwent Estuary: East of Green Point/Whitestone Point to North of Tasman Bridge
- Mid-Estuary Bays: Prince of Wales, New Town, Geilston and Lindisfarne Bays
- Lower Derwent Estuary: South of Tasman Bridge to Tinderbox/South Arm
- Ralphs Bay: East of Gellibrand Point/Trywork Point

The Middle Derwent Estuary (East of Green Point/Whitestone Point to North of Tasman Bridge) is the receiving environment for the SPLO.

The lower Derwent Estuary (South of Tasman Bridge to Tinderbox/South Arm) is the receiving environment for the Blinking Billy Outfall. It is also the receiving environment for the Macquarie Point STP outfall (to be decommissioned) and pump stations around the Hobart docks and Hobart Rivulet.

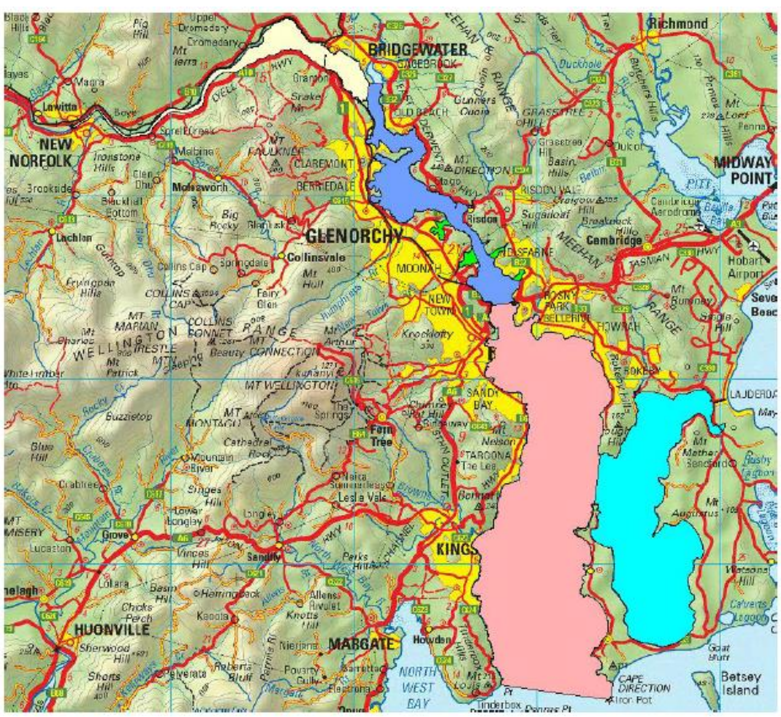


Figure 3-1 Derwent Estuary Functional Zones (After EPA 2019)

3.2 Hydrodynamics

The Derwent estuary is an open-mouthed estuary with a micro-tidal range of 1 m (EPA 2019, Herzfeld *et al.* 2005). The upper and middle Derwent estuary channel and mid-estuary bays are strongly stratified. A salt wedge moves marine water upstream in the bottom waters, while a freshwater surface layer flows downstream (Figure 3-2). Tidal movement of the salt-wedge causes horizontal and vertical mixing across the pycnocline (Wild-Allen *et al.* 2009, 2014a,b). Stratification is less pronounced in the lower estuary and Ralphs Bay.

The whole of estuary flushing time was simulated by tracer modelling to be approximately 11 days (Herzfeld *et al.* 2005, as cited in Wild-Allen *et al.* 2009). The middle estuary flushing time was approximately 4 days. The retention time of the marine based bottom waters increases with increasing distance up the estuary.

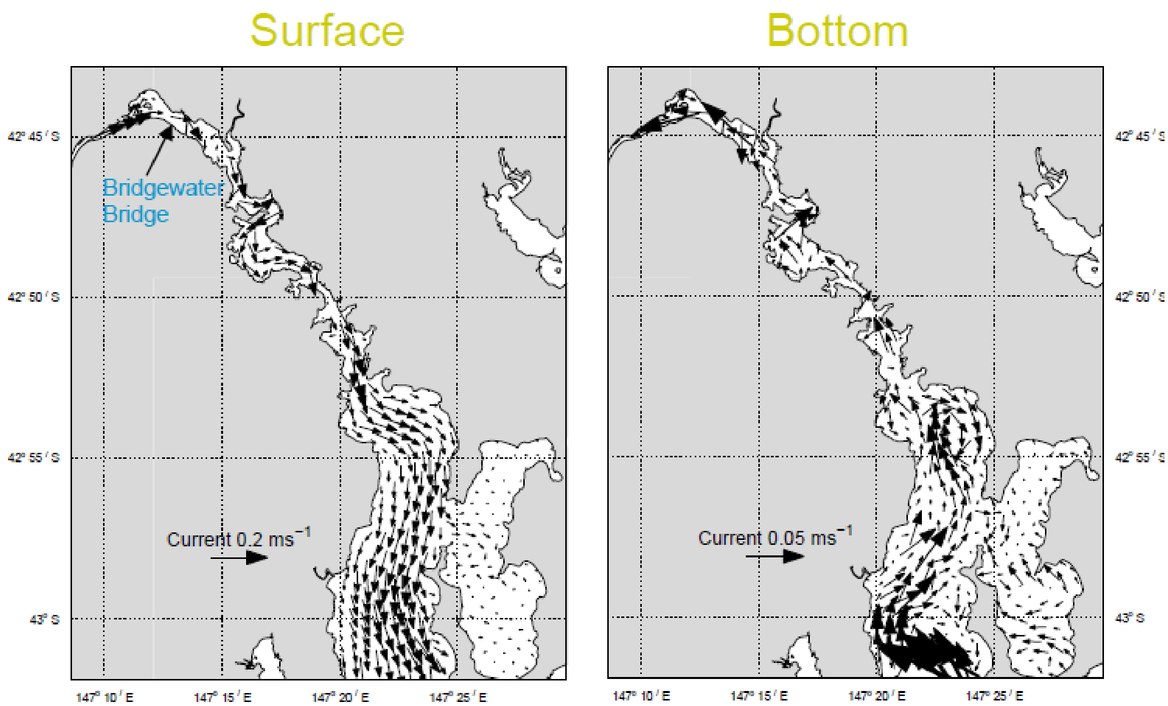


Figure 3-2 Surface and bottom water circulation in the Derwent Estuary (from Herzfeld et al. 2005).

3.3 Biogeochemistry

The biogeochemistry of the Derwent Estuary has been studied through ongoing ambient monitoring by the Derwent Estuary Program (DEP 2020) and the development of a high-resolution 3D biogeochemical model by CSIRO (Wild-Allen et al. 2009).

Over 80 % of the Derwent Estuary is eutrophic through a combination of freshwater and marine influxes of nutrients, augmented by anthropogenic loads from industrial discharges (including STPs) and stormwater (Wild-Allen et al. 2009). Nutrients were highest in the middle estuary, particularly in proximity to the major STP discharges (DEP 2020). Nutrients accumulate in deep water in the middle estuary at the front of the salt wedge particularly in winter and spring when the marine water is seasonally enriched. Movement of the salt wedge front causes vertical exchange of nutrients across stratified layers and stimulates a persistent bloom of phytoplankton biomass in the middle estuary (Wild-Allen et al. 2014a).

Simulated phytoplankton biomass show seasonal succession with dinoflagellates dominating in summer and autumn, large phytoplankton in winter and mixed populations in spring, throughout much of the estuary (Wild-Allen et al. 2009). Chlorophyll levels are highest adjacent to the salt wedge where phytoplankton have access to nutrients and clear marine water (Figure 3-3). This is also in proximity to STP discharges from Cameron Bay and Prince of Wales Bay STPs and SPLO. Isotopic analysis of macroalgae found that the two main sources of nitrogen were marine influxes and from sewage. This study showed that 30-50% of the nitrogen used by macroalgae in the estuary was derived from sewage (DEP 2020).

In summer and autumn, the surface water nutrient concentrations in the upper and lower estuary deplete due to local productivity and reduced influx. Redfield ratios suggest that primary production in the estuary in summer is controlled by access to nitrogen and light for photosynthesis (Wild-Allen et al. 2009). Phosphorus concentrations are elevated in the mid estuary throughout the year and are relatively lower in other parts of the estuary. In comparison to nitrogen, they remain in excess of Redfield ratio (16N:1P) and are therefore thought not to limit primary production in the estuary (Wild-Allen et al. 2009, p.52). See *Appendix B* for Redfield Ratio calculations for the estuary at key sites.

Reduced oxygen (<50% sat) were modelled in bottom waters in the upper estuary and the mid and lower reaches of the estuary, particularly in autumn. Regions of low dissolved oxygen saturation were simulated adjacent to the salt wedge front, similar to the distribution of elevated nutrient concentration and likely associated with local remineralisation of organic material (Wild-Allen et al. 2009, 2014). Estuary sediments have high rates of denitrification which mitigate the accumulation of nutrients in the estuary.

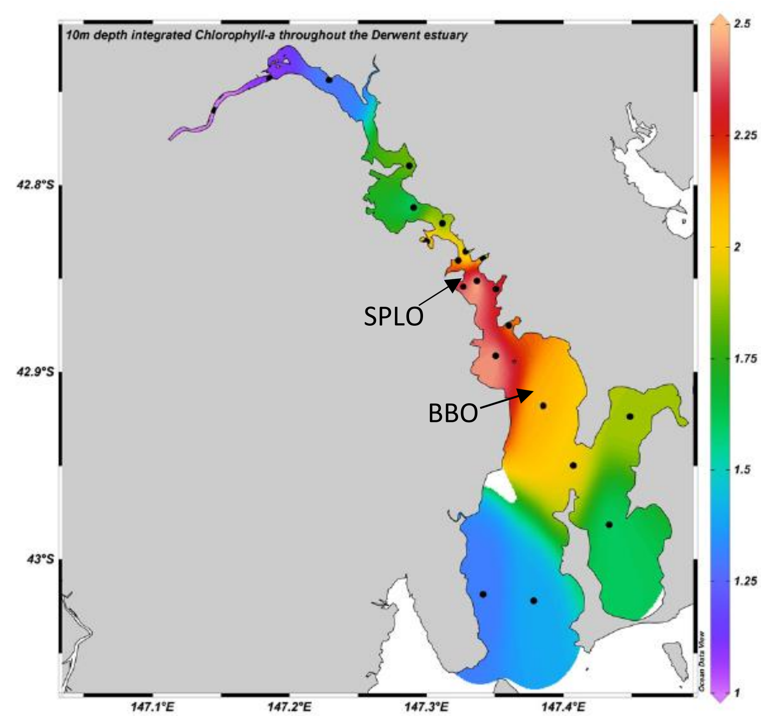


Figure 3-3 Median chlorophyll-a concentrations, depth-integrated from the DEP dataset (from Figure 2.54, DEP 2020)

3.4 Protected Environmental Values

Protected Environmental Values for the relevant functional zones of the Derwent Estuary under the *State Water Quality Management Policy 1997* are summarised below.

3.4.1 Middle Derwent Estuary: East of Green Point/Whitestone Point to North of Tasman Bridge

The Protected Environmental Values for the Middle Derwent are defined as follows (EPA 2003):

A: Protection of Aquatic Ecosystems:

(ii) Protection of modified (not pristine) ecosystems from which edible fish, but not shellfish or crustaceans, are harvested, and having particular regard to the ecological values identified in paragraph below

B: Recreational Water Quality and Aesthetics:

(i) Primary contact water quality

(ii) Secondary contact water quality

(iii) Aesthetic water quality and having particular regard to the recreational uses identified in paragraph below

E. Industrial Water Supply (Nyrstar Hobart Smelter)

Ecological values

This region of the Derwent Estuary is considerably narrower than downstream areas and is partially sheltered from prevailing westerlies. The shoreline is relatively convoluted with numerous embayments (the largest of these is Herdsmans Cove, where the Jordan River joins the estuary). Water depths between the Bowen and Tasman bridges are deep to intermediate, permitting the passage of large ships. Above the Bowen Bridge, however, the channel becomes more well-defined and is bordered by extensive subtidal flats. Salinities in this area are intermediate, and the water column ranges from strongly stratified at the Bridgewater Causeway to partially mixed at the Tasman Bridge. Important estuarine habitat types include numerous bays and coves, rocky promontories, silt/pebble beaches, saline and intertidal flats, salt marshes and seagrass beds. Wetlands were formerly present at the heads of many embayments, but have been largely reclaimed with the exception of a few remnants (e.g., Goulds Lagoon, Risdon Cove). Major conservation areas include the East Risdon Nature Reserve, Green Point Nature Reserve and Goulds Lagoon Wildlife Sanctuary. Threatened/protected species found in this area include dolphins, occasional seals, green and gold frog, and southeast seastars. Goulds Lagoon and Risdon Cove also provide important habitat for a range of waterbirds. Finfish are harvested from the lower Derwent by recreational fishermen, however shellfish harvesting has been prohibited due to high concentrations of heavy metals.

Recreational values

The middle Derwent is primarily used secondary recreation, particularly small boat sailing, rowing and fishing. Some primary contact uses also occur, such as swimming, water skiing and wind-surfing, and the annual Cross-Derwent Swim occurs near the southern boundary of this area.

Industrial values

Nyrstar Hobart zinc smelter at Lutana extracts approximately 30 GL per annum of estuarine water from this area for use in the foreshore gas scrubbers.[2]

[2] [modified and updated from EPA 2003] based on estimates from Nyrstar (2021, Figure 4-11).

3.4.2 Lower Derwent Estuary: South of Tasman Bridge to Tinderbox/South Arm

The Protected Environmental Values for the Lower Derwent are defined as follows (EPA 2003):

A: Protection of Aquatic Ecosystems:

(ii) Protection of modified (not pristine) ecosystems from which edible fish, crustaceans and abalone, but not other shellfish, are harvested, and having particular regard to the ecological values identified in paragraph below.

B: Recreational Water Quality and Aesthetics:

(iv) Primary contact water quality

(v) Secondary contact water quality

(vi) Aesthetic water quality and having particular regard to the recreational uses identified in paragraph below

Ecological values

This area of the Derwent Estuary is characterised by relatively high salinities, intermediate to deep water depths and is well-mixed by winds and currents. Important estuarine habitat types include rocky cliffs, intertidal and subtidal rocky reefs, macroalgae beds, seagrass beds, sandy beaches and coastal dunes. Major conservation areas within this area include the Cape Direction Muttonbird Sanctuary, Tinderbox Marine Reserve, Kingston Beach Golf Course Wildlife Sanctuary and Alum Cliffs Recreation Reserve. Threatened/protected species found in this area include whales (southern right, humpback, orca), dolphins, seals, wedge tailed eagles, southeastern seastars and the spotted handfish. Other species of conservation significance include giant string kelp, seahorses/sea dragons, threefins and muttonbirds.

Finfish are harvested from the lower Derwent by recreational fishermen, however shellfish harvesting has been prohibited due to high concentrations of heavy metals (1). Abalone, crayfish and sea urchins are also harvested from the area, particularly along the western shoreline, south of Taroona.

Recreational values

The lower Derwent is used for both primary and secondary recreation. Popular swimming beaches include Howrah Beach and Bellerive Beach, Opossum Bay, Half Moon Bay, Blackmans Bay, Kingston Beach, Taroona and Long Beach/Sandy Bay. The area is also widely used for recreational boating and fishing. The Tinderbox Marine Reserve and surrounding areas are popular sites for snorkelling and scuba diving.

3.5 Default Guideline Values

Draft default guideline values (DGVs) for the waters of the Derwent Estuary are given for each functional zone (EPA 2019).

Each of the functional zones have been identified as being within the Slightly to Moderately Disturbed (SMD) ecosystem category.

3.5.1 Middle Derwent Estuary: East of Green Point/Whitestone Point to North of Tasman Bridge

The DGVs for physiochemical indicators for aquatic ecosystems in the Middle Derwent Estuary: East of Green Point/Whitestone Point to the North of Tasman Bridge are given in Table 3-1.

Table 3-1 DGVs for physiochemical indicators for aquatic ecosystems of the Middle Derwent Estuary

Indicator		Surface (above the halocline)					Bottom (below the halocline)				
	Units	Annual	Summer	Autumn	Winter	Spring	Annual	Summer	Autumn	Winter	Spring
DO (mg/L)	lower	7.5	7.4	7.1	8.7	8	5.8	5.1	5.3	6.9	6.2
	upper	9.1	8.3	8.7	10.1	9.3	7.1	7	6.4	7.6	7.3
DO (% sat)	lower	87.8	92.8	83.6	89.9	92.9	68.5	64.2	67.1	79.4	72.8
	upper	98.1	103.2	96	95.6	98.5	87	87	80.2	89.4	85.4
Salinity	(PPT)	32	33.1	32.2	27.5	31.8	36.5	36.2	36.7	36.6	36.5
Cond	mS/cm	49.3	50.5	50.2	42.8	48.8	55.2	55	55.6	55.2	55
pH	lower	7.7	7.6	7.7	7.7	7.6	7.7	7.7	7.7	7.7	7.6
	upper	8.1	8.1	8.1	8.1	8	8.1	8	8.1	8	8
Temp (C)	lower	10.6	16.8	12.6	8.1	12.2	12.2	14.1	14.6	11.6	11.8
	upper	17.3	19.8	16.2	11	15.4	16	16.1	16.5	13.2	13.1
Turb	NTU	10.5	14.7	8.7	12.9	5	9.4	6.6	9.8	10.6	5.6
Chl a	(µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAN as N	(µg/L)	10.4	4.1	11.5	9.8	10.1	15.8	16	13.9	6.1	29.2
NOx as N	(µg/L)	49.3	9.4	47.2	63.1	31.8	60.9	28.2	59.1	75.7	58.2
Total N as N	(µg/L)	330	328	340	330	272	368	330	372	380	352
Total P as P	(µg/L)	30	27	33	27	29	46	48	46	41	45
PO4 as P	µg/L)	13.7	7.8	15	14.3	11.4	18.3	15.3	18.2	18.3	22
SiO4 as Si	(µg/L)	613.9	513.6	565.6	731.2	534.4	143.6	169.5	152.9	130.8	109.5
Redox	(mV)	428.4	428	426.8	422.4	439	434.4	433	433.4	435.6	444.2

3.5.2 Lower Derwent Estuary: South of Tasman Bridge to Tinderbox/South Arm

The DGVs for physiochemical indicators for aquatic ecosystems in the Lower Derwent Estuary: South of Tasman Bridge to Tinderbox/South Arm are given in Table 3-2.

Table 3-2 DGVs for physiochemical indicators for aquatic ecosystems of the Lower Derwent Estuary

Indicator		Surface (above the halocline)					Bottom (below the halocline)				
	Units	Annual	Summer	Autumn	Winter	Spring	Annual	Summer	Autumn	Winter	Spring
DO (mg/L)	lower	7.5	7.6	7.2	8.1	8	6.2	6.1	6	7.4	6.8
	upper	8.7	8.6	8.1	9.1	8.8	7.6	7.3	6.9	8.1	7.7
DO (% sat)	lower	90.9	96.3	86.4	91.4	94.3	75.8	74.2	74.2	86.5	80.6
	upper	101.8	107.6	100.6	96.7	101.4	90.6	89	86.5	92.5	90.7
Salinity	(PPT)	35.4	35.5	35.7	33.8	34.5	36.6	36.4	36.6	36.9	36.6
Cond	mS/cm	53.7	53.8	54.3	51.4	52.4	55.3	55.1	55.5	55.6	55.2
pH	lower	7.8	7.7	7.8	7.8	7.8	7.7	7.8	7.8	7.8	7.7
	upper	8.1	8.2	8.1	8.1	8.1	8.1	8.2	8.1	8.1	8.1
Temp (C)	lower	11.7	16.6	13.8	10.1	12.7	12.2	14.2	14.4	11.5	11.8
	upper	17.4	18.1	16.7	11.8	15.4	15.7	15.7	16.3	13.1	13.1
Turb	NTU	9.4	13.3	9	16.2	4.1	12.4	8.7	12.9	12.7	11.2
Chl a	(µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TAN as N	(µg/L)	7.2	3.4	7.2	8.4	7.7	17.5	22.2	11.2	6.2	20.4
NOx as N	(µg/L)	56.1	4.4	43.3	72.5	33.3	57.2	28.7	47.1	67.4	57.3
Total N	(µg/L)	328	270	326	334	292	346	316	350	352	304
Total P as P	(µg/L)	34	34	33	32	37	43	42	44	39	41
PO4 as P	µg/L)	13	5.2	12.9	14.5	13.4	18	17.9	17.7	16.4	20.9
SiO4 as Si	(µg/L)	344.4	286.5	269.9	672	205.8	119.7	135.7	130.4	94.3	94.1
Redox	(mV)	435	431	435	431.8	438.6	440	433	437	437.6	443.2

3.5.3 National Guidelines for Toxicants

Toxicant default guideline values (DGVs) are given by the Australian and New Zealand Guidelines for fresh and marine water quality for the protection of 95% of species in slightly to moderately disturbed ecosystems. Relevant DGVs are provided in Table 3-3.

Table 3-3 Toxicant ANZG (2018) default guideline values for 95% species protection

Indicator	DGV (mg/L)
Ammonia	0.910
Nitrate	2.4^

^interim freshwater guideline from Hickey (2013) that is adopted as an interim guideline value for marine waters

3.5.4 Microbiological guidelines

NHMRC (2008) provides risk-based guidelines for recreation based on the pathogenic indicator *Enterococci*. ANZECC (2000) gives a guideline value for recreational water based on the indicator thermotolerant coliforms.

Table 3-4 Microbiological guidelines for recreational waters

Indicator	Guideline value (cfu/100ml)
Enterococci	40 – Category A recreational guideline
Thermotolerant coliforms	150 – Low risk guideline for recreation

3.5.5 Ambient trigger values for chlorine disinfection by-products

EPA Tasmania has compiled ambient trigger values for chlorine (as chlorine-produced oxidants (CPO)) and associated disinfection by-products (DBPs) from a range of national and international literature sources (Table 2-3).

Table 3-5 EPA Tasmania provided ambient trigger values for chlorine and associated DBPs (modified from Table 2 - EPA Tasmania 2022)

Indicator	Marine (µg/L)	Sources
Chlorine (as CPO)	7.2*	Batley and Simpson (2020)
Bromoform	10	USEPA 2005 Low reliability National WQ trigger
Chloroform	370	ANZG 2018 low reliability
Chlorate	8	Toxikos report for marine waters
Dibromochloromethane	13	USEPA human health WQ criteria 2014
Dichlorobromomethane	14	USEPA "organisms only" WQ criteria 2014
Dichloromethane	4000	ANZG 2018
Total Trihalomethanes	250	ADWG (2011)
NDMA	0.002	USEPA action limit was 0.002 µg/L
2,3 Dichlorophenol	31	ANZECC guidelines (marine waters)
2,4 Dichlorophenol	120	ANZECC guidelines (marine waters)
2,5 Dichlorophenol	3	ANZECC guidelines (marine waters)
2,6 Dichlorophenol	34	ANZECC guidelines (marine waters)
3,4 Dichlorophenol	2	ANZECC guidelines (marine waters)
3,5 Dichlorophenol	4	ANZECC guidelines (marine waters)
3 Chlorophenol	4	ANZECC guidelines (marine waters)

* The ANZG (95%) DGV for chlorine of 3 µg/L for freshwater is still the published marine low reliability trigger value for chlorine. However, EPA (2022) recommended the DGV of 7.2 µg/L derived for marine waters by a recent study of Batley and Simpson (2020), which has been adopted for this study.

3.6 Mixing zones

The *Framework for ambient monitoring of receiving waters in relation to wastewater treatment plant discharges* (EPA 2013) specifies that the "role of the mixing zone is to manage controlled discharge of non bioaccumulatory toxicants whose impacts on local biota are primarily related to their concentrations" (EPA 2013, p.22). By this definition, the mixing zone for Selfs Point STP discharges should be based on chlorine as the non-bioaccumulatory toxicant with the highest dilution requirements (332:1).

A mixing zone is a three-dimensional area around the point of discharge that must be as small as practical and not occupy a significant proportion of the receiving waters. The water quality is permitted to be outside of the normal range for the receiving environment within the mixing zone, provided it does not detract from the values or uses of the waters. Mixing zones will not be designated in areas that:

- Receive significant and regular use for primary contact recreation
- Are recognised areas of significant value as spawning or nursery areas
- Are close to areas used for aquaculture
- Are close to potable water supply intakes
- Are of outstanding ecological or scientific importance
- For which the PEVs include protection of pristine aquatic ecosystems

The mixing zone must not create a significant barrier to the migration of fish or other aquatic organisms.

4. Blinking Billy Outfall

This section provides a mixing zone and environmental risk assessment for BBO for the predicted impacts associated with the Selfs Point STP Expansion proposal.

4.1 Context

Under the Selfs Point STP expansion proposal, the bulk of the Selfs Point STP treated effluent will be transferred down to Sandy Bay under a pressurised pipeline and discharged through long diffusers at BBO, off Blinking Billy point in the Lower Derwent Estuary. Blinking Billy outfall is located approximately 550 m offshore in one of the deepest areas of the Derwent Estuary at a depth of 32 m. The estuary is predominantly marine water with only a weak halocline observed at depth.

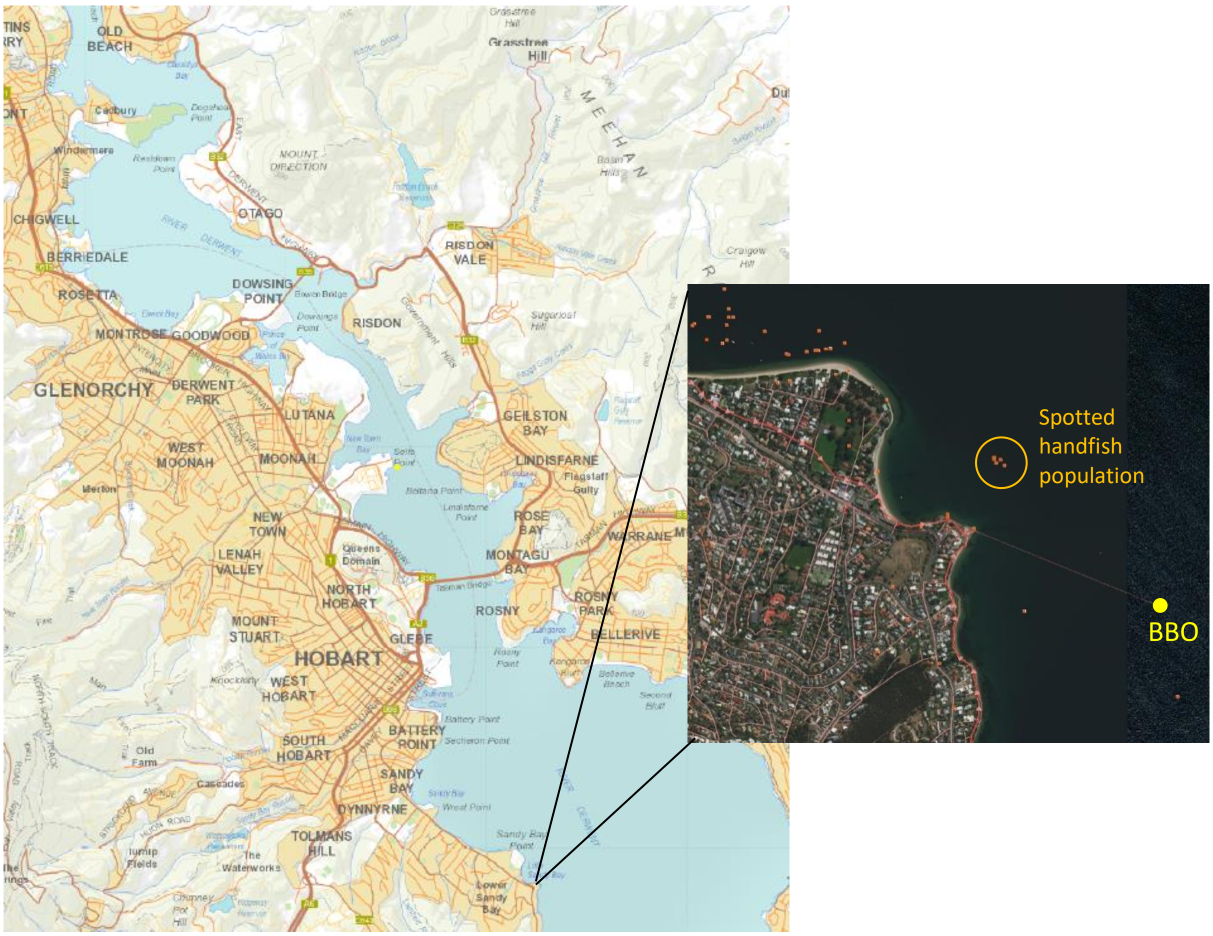


Figure 4-1 Blinking Billy Outfall (BBO) (listmap 2022)

The most notable ecological value within the vicinity of BBO is an isolated population of the critically endangered spotted handfish (*Brachyonichthes hirsutus*). The population was detected approximately 850 m north-west and inshore of the outfall (Figure 4-1). The spotted handfish is a Critically Endangered species listed by the *Environment Protection and Biodiversity Conservation Act 1999* and the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The spotted handfish is a small benthic fish endemic to south-eastern Tasmania. It is currently known to occur at only two sites on the western shore and seven sites on the eastern shore in the Derwent estuary (State of Derwent Estuary, DEP 2022). There are also discrete seagrass beds both upstream and downstream of the outfall, in much shallower water (<10 m) than the outfall.

Recreational values in the Blinking Billy Point area include fishing (for human consumption), boating (sailing, kayaking, rowing) and water sports such as kite boarding and windsurfing. There is also a walking track along the shoreline to Blinking Billy Point.

4.2 Currents and hydrodynamics

Current velocity and direction data were collected at BBO from 17th March to 14th April 2015 as part of the Derwent Ambient Monitoring Program (Jacobs 2016). Water currents and directions were highly variable over the tidal cycle and with water depth. Surface waters (0-10m) did not flow in any consistent direction and had higher current speeds than at depth. The currents at 5-8 m deep moved in a south-easterly direction towards the ocean. The lower layer of the estuary generally moved north and south eastward at low speed with the tides. The outfall may be in an eddy that has a complex interaction with the tides (Figure 4-2, Jacobs 2016).

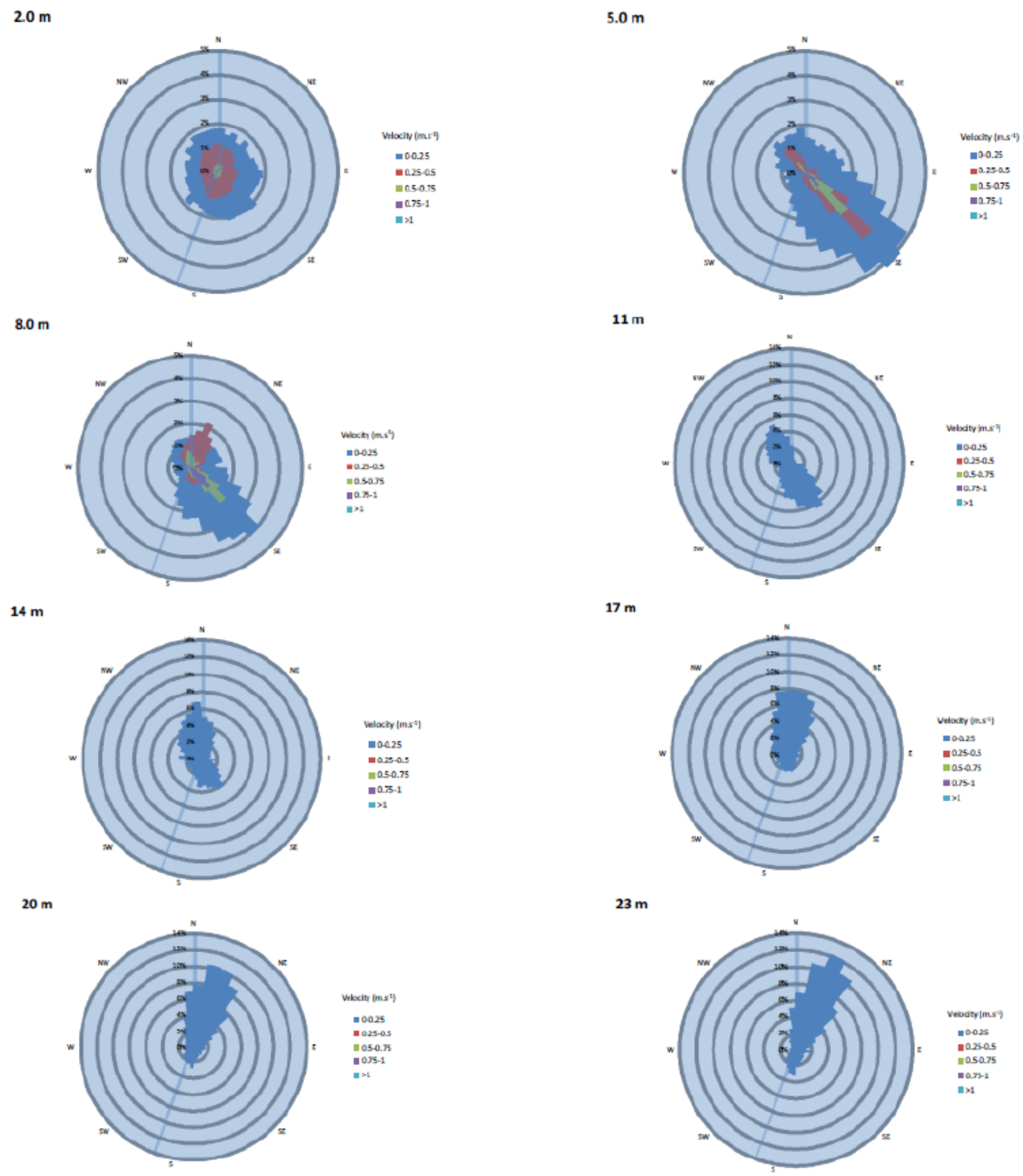


Figure 4-2 Water current speeds and directions at the Blinking Billy outfall at various depths (after Jacobs 2016)

Backscatter plume dilution studies (Marine Solutions 2015, as reported in Jacobs 2016) showed that the effluent plume rises through the water column and disperses from the surface in the direction of the tides (Figure 4-3).

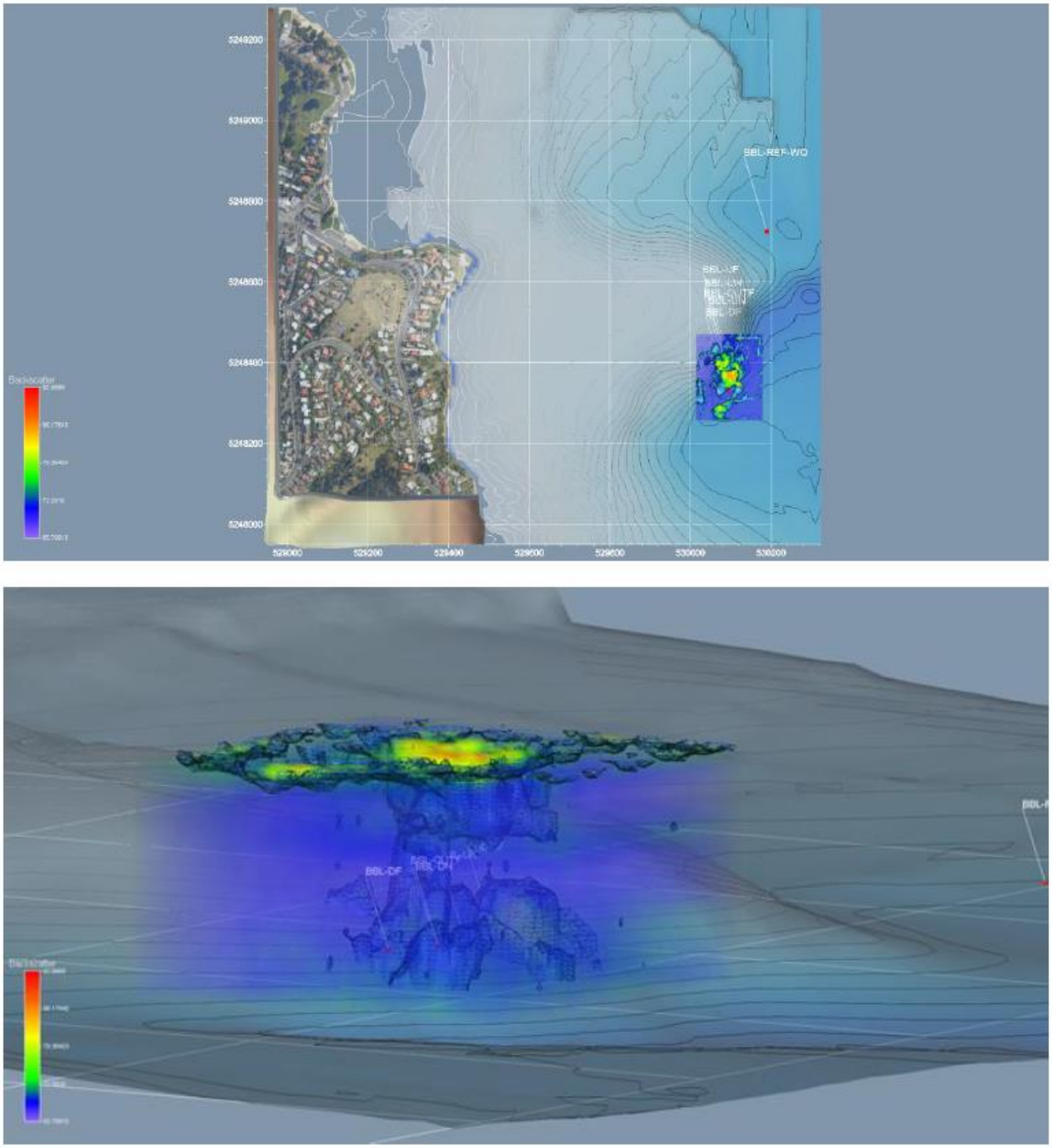


Figure 4-3 Blinking Billy Outfall, Sandy Bay, plume tracer study (backscatter) on the outgoing tide (Marine Solutions)

4.3 Effluent dilution requirements

Effluent dilution requirements (Sreq) required to achieve ambient default guideline values (*Cdgv)* for water quality were calculated according to the EPA Tasmania (2020) *Regulatory Framework for the Sustainable Discharge of Treated Wastewater from Level 2 WWTPs* (Table 4-1). The 90th percentile effluent quality (*Ceff*) and the 95th percentile ambient background quality (*Camb*) for toxicants and 50th percentile for ecosystem stressors, were applied using the dilution equation in Equation 1:

Equation 1 Sreq = (Ceff – Cdgv) / (Cdgv – Camb)

Where the *Camb* > *Cdgv,* the *Camb* has been set at 0 mg/L for a revised calculation (C*eff*/*Cdgv*).

Chlorine (as CPO) is the toxicant of concern in the STP effluent with a dilution requirement of 143:1 to achieve the Batley & Simpson (2020) Guideline value of 0.0072 µg/L). Nutrients, particularly total phosphorus (708:1), are the ecosystem stressors with the highest dilution requirements to achieve the EPA DGVs for the Lower Derwent Estuary.

Table 4-1 Dilution requirements for treated effluent design parameters, after GHD (2021, Table 17). Highlighted cells are the indicators of concern.

Parameter	Adopted 90th percentile	Applied DGV (annual, bottom)	Ambient background^	Dilution requirement (X:1)
Ecosystem stressors				
BOD (mg/L)	15	<5	-	2
TSS (mg/L)	20	6^	3^	5
Oil and Grease (mg/L)	5	<1	-	4
TN (mg/L)	10	0.346	0.27	127
Nitrate (mg/L)	7.5*approx.	0.0561	0.004	143
Ammonia (mg/L)	2	0.0175	0.009	233
TP (mg/L)	5	0.043	0.036	708
Toxicants	Ceff	ANZG DGVs	Camb	
Nitrate (mg/L) – toxicant	7.5	2.4	0.056	2
Ammonia – toxicant	2	0.91	0.018	1
Chlorine (mg/L) - toxicant	1	0.007#		143
Microbiological indicators (cfu/100ml)				
Faecal Coliforms	500	150~	<10	2
Enterococci	500%	40	<10	12

^Jacobs (2016) DEP data summary median background concentration and 80th percentiles for WQOs
~ANZG thermotolerant coliforms low risk guideline for recreational waters
Batley and Simpson (2020) Guideline value recommended by EPA Tasmania (2022)
% *Enterococci* concentrations are assumed to be commensurate to faecal coliforms

4.4 Mixing zone modelling

The near field dilution and dispersion of the effluent plume from BBO was simulated using the US EPA software *Visual Plumes* to determine the size and extent of the mixing zone.

4.4.1 Model set up

BBO is in the Lower Derwent Estuary in one of the deepest areas of the Derwent Estuary at a depth of 32 m. The outfall flows through a 700 mm diameter concrete pipeline which extends approximately 550 m from the shoreline at Blinking Billy Point, Sandy Bay. There are 11 diffuser ports spread over 50 m, consisting of five 100 mm diffuser ports, positioned 5 m apart, on each side of the pipeline (Table 4-2). The final diffuser port is positioned vertically in the top of the pipe. Jet-induced turbulent entrainment of the discharge occurs due to the high exit velocities of 1.5 m/s for each nozzle.

The outfall specifications and the ambient conditions used in the modelling are provided in Table 4-2 and Table 4-3.

Table 4-2 Blinking Billy outfall characteristics

Outfall Characteristic	Base model
Port diameter	100 mm
Vertical angle	20 degrees
Horizontal angle	N & S
No. ports	11 (5 N, 6 S)
Spacing	5 m
Port depth (m)	32 m
Effluent volume	29.8 ML/d
Effluent salinity	0 psu
Effluent temperature	15 ℃
Diffusion co-efficient	0.0003
Diffuser port contraction coefficient	1.0 (default)
Light absorption coefficient	0.16 (default)
UM3 aspiration coefficient	0.1 (default)
Farfield diffusivity option	4/3 power diffusivity
Decay rate	50 d-1 for chlorine

Table 4-3 Ambient scenarios based on ADCP data and ambient conditions (annual, DEP; Jacobs 2016)

Tides	NEAP TIDE Ambient currents (m/s)	SPRING TIDE Ambient currents (m/s)	Direction	Temperature °C	Salinity (psu)
Incoming	Surface – 0.3 5 m – 0.1 8 m – 0.45 10 m – 0.05 23 m – 0.01	Surface – 0.05 5 m – 0.35 8 m – 0.1 10 m – 0.1 23 m – 0.05	N-NW S-SW	Surface -15 Bottom – 14	Surface – 35 Bottom – 36.5
Outgoing	Surface – 0.3 5 m – 0.1 8 m – 0.7 10 m – 0.05 23 m – 0.05	Surface – 0.15 5 m – 0.15 8 m – 0.1 10 m – 0.1 23 m – 0.05	S-SE N-NE	Surface -15 Bottom – 14	Surface – 35 Bottom – 36.5
Slack	Surface – 0.7 5 m – 0.2 8 m – 0.15 10 m – 0.1 23 m – 0.05	Surface – 0.1 5 m – 0.8 8 m – 0.2 10 m – 0.1 23 m – 0.1	S-SE N-NE	Surface -15 Bottom – 14	Surface – 35 Bottom – 36.5

4.4.2 Model outputs

The model outputs showing the plume dispersion and directions under spring and neap tidal cycles, including incoming, outgoing and slack tide conditions are provided in Figure 4-4 and Figure 4-5.

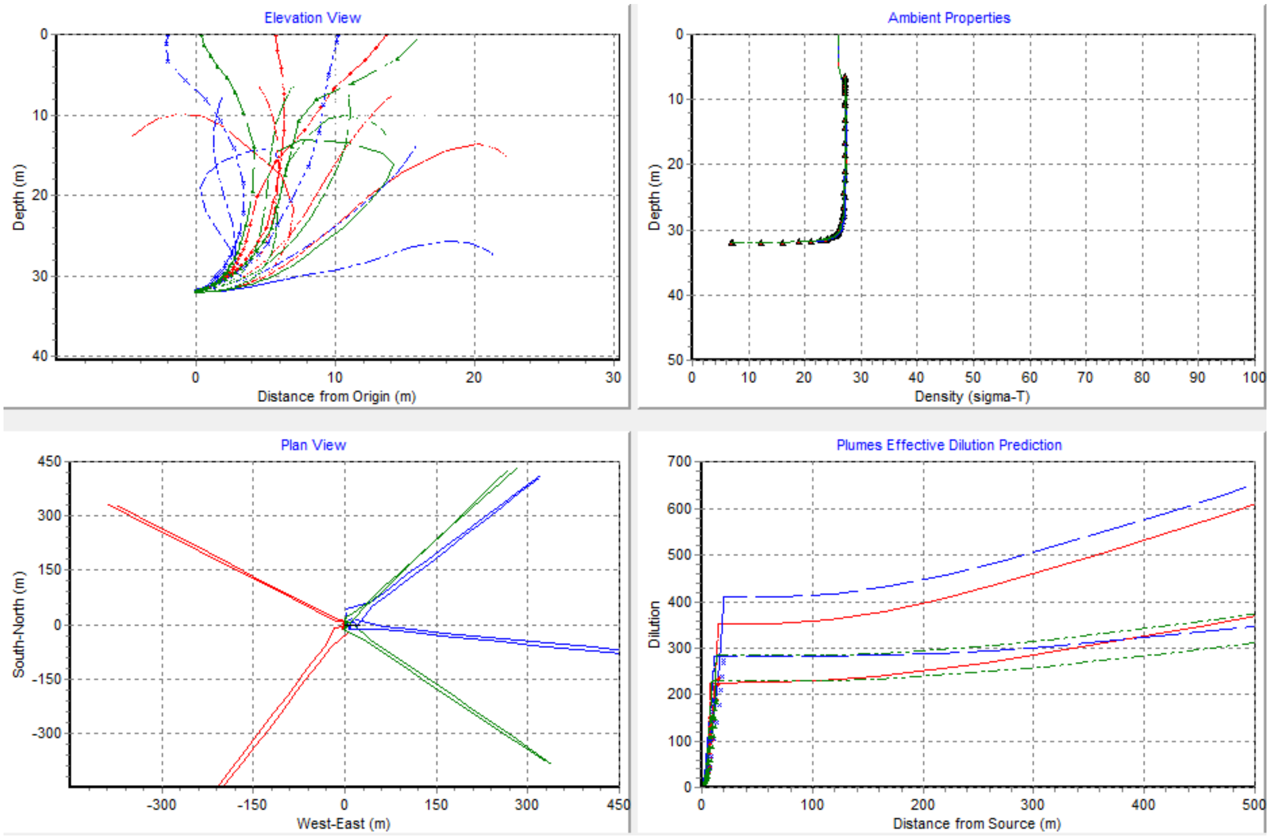


Figure 4-4 Spring tide – incoming (green), outgoing (red) and slack (blue)

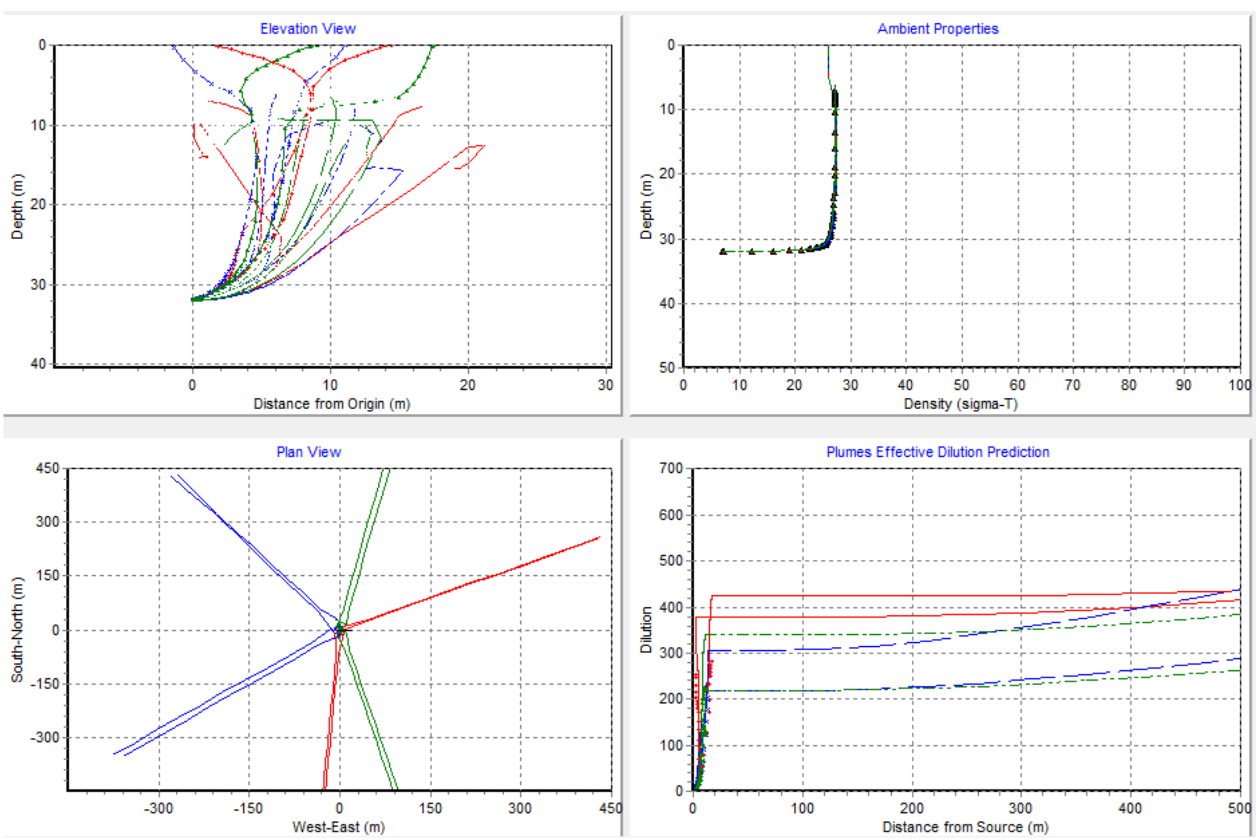


Figure 4-5 Neap tide – incoming (green), outgoing (red) and slack (blue)

4.4.3 Dilutions with distance

The effluent plume receives good dilution and dispersion as it rises through the water column. Dilution requirements for all indicators, except chlorine and nutrients, will be met within 5 m of the outfall in all conditions (Table 4-4). After the initial rise and dispersion of the plume through the water column, the effluent travels with the prevailing current.

Table 4-4 Modelled Blinking Billy Dilutions (X:1) at 5 m, 10 m, 50 m and 500 m from outfall (peak capacity – 29.8 ML/d). The ranges given are for N & S facing ports

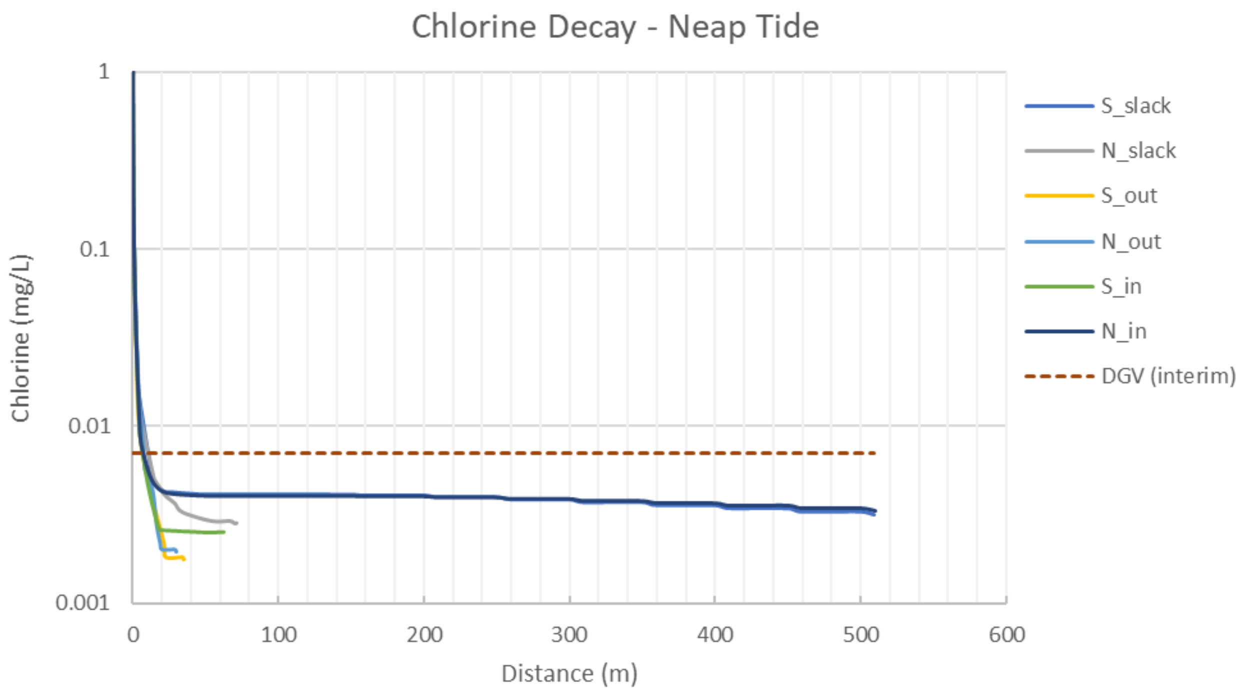
Dilution (X:1)	Distance from Blinking Billy Outfall			
	5 m	10 m	50 m	500 m
Neap Incoming	100-125	175-200	220-340	266-383
Neap Outgoing	110-150	200-260	380-425	415-440
Neap Slack	75	170-185	220-305	290-440
	5 m	**10 m**	**50 m**	**500 m**
Spring Incoming	40-70	140-250	230-284	300-375
Spring Outgoing	40-70	220-350	220-350	360-600
Spring Slack	50-100	150-250	290-410	350-650

4.4.4 Chlorine mixing zone

Effluent chlorine concentrations (1 mg/L) require a 143:1 dilution to achieve the Batley & Simpson (2020) revised DGV of 0.0072 mg/L (which was recommended as an ambient trigger value by EPA (2022)). Given that chlorine (as CPO) is highly reactive in the environment, the chlorine in the effluent plume was modelled in the receiving environment applying a literature-based decay rate of 50 d^{-1} (see Bonneville Consulting 2022 for a review of decay rates).

Chlorine concentrations are diluted to below 0.005 mg/L in the initial dispersion and rise of the plume through the water column (10-20m from the outfall) under all tidal conditions (Figure 4-6). Once the plume reaches the surface, further dilution is based on the tidal movement in the surface waters and the decay over time. **The ambient trigger value of 0.0072 mg/L is met within 20 m of the outfall in all conditions**.

While chlorine has been modelled non-conservatively in this study, there remains significant uncertainty as to the fate of chlorine in aquatic environments as its concentration and ecological effects are unable to be easily measured.



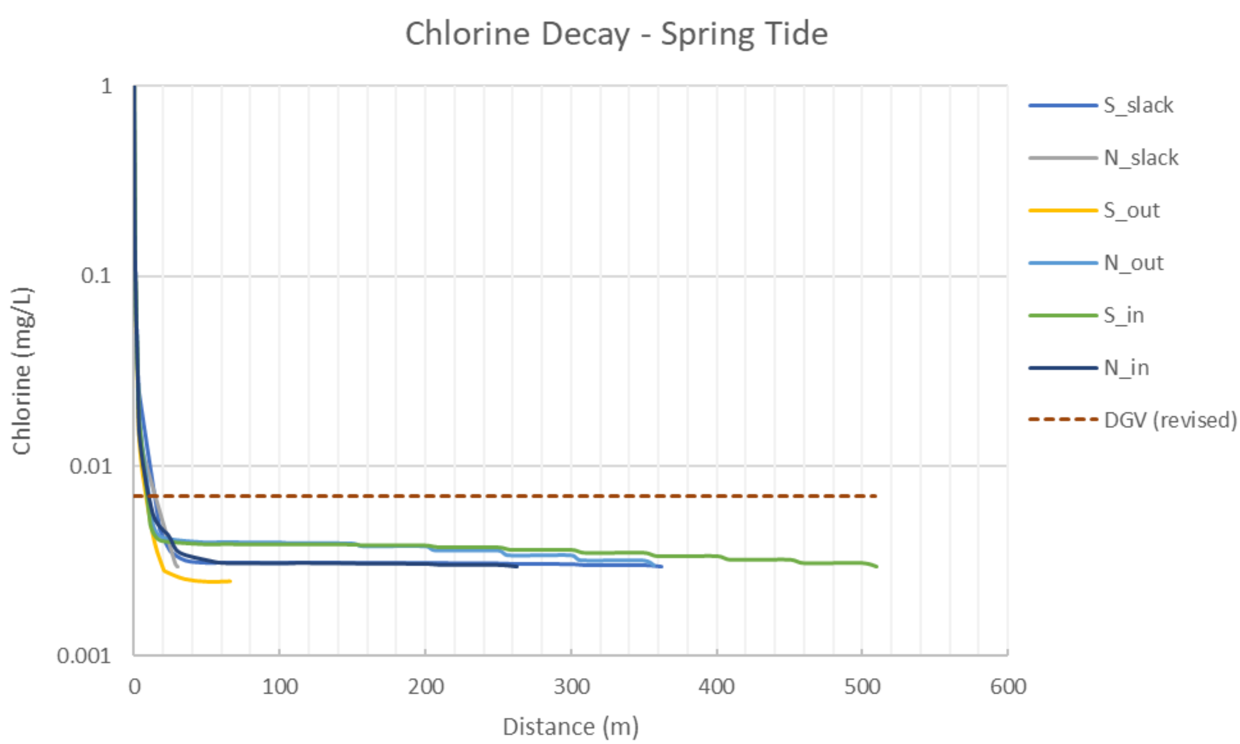


Figure 4-6 Chlorine decay curves under neap and spring tide conditions for BBO under a full capacity discharge of 29.8 ML/d effluent through N and S facing ports

4.4.5 Enterococci mixing zone

The mixing zone for *enterococci* as the microbial indicator with dilution requirement of 12:1 to meet the Category A recreational guidelines will be 1-2 m from the outfall under all tidal conditions.

4.4.6 Nutrient footprint

Effluent phosphorus concentrations (5 mg/L, 90th percentile) has the highest dilution requirement (708:1) for all indicators classified as ecosystem stressors to meet the EPA DGVs. The footprint where phosphorus concentrations may be elevated about the DGVs may extend up to 1 km from the outfall. Effluent nitrogen concentrations (10 mg/L, 90th percentile) will be diluted to the DGVs within 10 m of the outfall.

4.5 Environmental Risk Assessment

This section contains an environmental risk assessment for nutrients and chlorine, which have the highest dilution requirements to meet water quality objectives, in effluent discharges from BBO to the lower Derwent Estuary at peak capacity of 29.8 ML/d.

4.5.1 Potential threats and stressors to environmental values

A summary of the stressors, known threats and other factors influencing the risk to environmental values from the indicators present in the Selfs Point STP effluent discharges at the BBO are provided in a value/ threat matrix (Table 4-6, Appendix A).

Table 4-5 Value versus threat matrix

Stressor	Threat	Other factors influence risk
Protection of Aquatic Ecosystems		
Chlorine (as Chlorine-produced oxidants)	Direct toxicity to aquatic organisms	Oxidation, exposure time, temperature, species; ability for biota to seek refuge
Disinfection by-products	Direct toxicity to aquatic organisms	pH, bromine, organic carbon, temperature
Nutrient enrichment (nitrogen and phosphorus)	Eutrophication and algal growth causing low dissolved oxygen and reduction in habitat quality	N:P ratios, currents and flushing rates, dissolved oxygen, temperature, pH
Recreational water quality and aesthetics		
Nutrient enrichment (nitrogen and phosphorus)	Algal growth reducing aesthetics	N:P ratios, type of recreational activities, exposure

4.5.2 Exposure

Effluent will be continuously discharged from BBO to the lower Derwent Estuary. The average rate will be approximately 24.9 ML/d (in 2054), with a peak capacity of 29.8 ML/d. Most of the contaminants of concern in the effluent discharges to BBO will be diluted to achieve the DGVs of the receiving environment within 10 m of the outfall. The only exceptions are chlorine and nutrients. The mixing zone for chlorine is expected to be approximately 20 m. The footprint where total phosphorous levels may be elevated is approximately 1 km in the direction of the current.

4.5.3 Sensitivity of environmental value to threat

Chlorine (as chlorine-produced oxidants) toxicity

Chlorine is the toxicant of concern for Selfs Point effluent discharges to BBO. It will be dosed in the effluent to 1 mg/L for secondary disinfection and to prevent biofouling of the pressurised pipeline. Chlorine (as CPO) is a concentration-based toxicant, so aquatic organisms are sensitive to both acute and chronic exposure to concentrations greater than the EPA Tasmania (2022) recommended ambient trigger value of 0.007 mg/L. It acts as an active oxidising agent that damages cell membranes, proteins and nucleic acids of marine and freshwater organisms affecting biochemical and physiological processes.

A 143:1 dilution of the Selfs Point STP effluent is required in the receiving environment to meet the trigger value of 0.007 mg/L. This dilution requirement makes chlorine the limiting contaminant of concern for the mixing zone designation around the outfall. The ambient trigger value of 0.007 mg/L is met within 20 m of the outfall in all tidal conditions.

Chlorine reacts quickly with bromine in seawater to create a wide range of brominated oxidants and other compounds (Jenner *et al.* 1997). The same guideline values for chlorine are assumed to apply to brominated oxidants as residual chlorine and bromine have similar toxicities (Lewis *et al.* 1997). Brominated compounds are produced naturally by a range of marine biota, notably marine algae. While these compounds may be toxic to freshwater biota, they are part of the natural halogen cycle in the marine environment. Marine biota can regulate the concentration of these chemicals. Consequently, marine biota are less sensitive to chlorine and bromine than their freshwater ecological equivalents (Tarek *et al.* 2019).

An isolate population of the critically endangered EPBC Act listed spotted handfish (*Brachyonichthes hirsutus*) has been found approximately 850 m north-west and inshore of the BBO location. Given the small impact zone from the outfall of 20 m, the effluent discharges from BBO present a low risk to the handfish populations in the Derwent Estuary. Given the small size of the mixing zone (20 m) compared to the surrounding channel (4 km), transitory species, such as marine mammals and fish, would likely pass through the area unaffected or be able to retreat to refuge habitat as required. This presents a low risk to the overall aquatic ecosystem.

Disinfection by-products

Chlorine is highly reactive and does not persist for extended periods in water. Concentrations are reduced through chemical and physical pathways, including:

- *Dissociation:* chlorine (Cl_2), hypochlorous acid (HOCl) and the hypochlorite ion (OCl-), also chlorate (ClO_3^-) ions.
- *Volatilisation:* chlorine (Cl_2) off-gasses to the atmosphere
- *Chloramine formation:* Reaction with ammonia to form chloramines and N-nitroso-dimethylamine (NDMA)
- *Bromination* – Reaction with bromine present in seawater to form hypobromite (OBr^-) and hypobromous acid (HOBr) and bromoform ($CHBr_3$); bromamines can also form
- *Oxidation:* Reaction with organic matter including fulvic and humic acids, and amino acids, to produce a range of DPBs including trihalomethanes (THMs), haloacetic acids (HAA) and chlorophenols (CEE 2016).

These pathways produce chlorination by-products (DBPs) that may persist longer than chlorine in the environment (Figure 4-7). The chemical characteristics of the receiving waters will affect the amounts and types of by-products produced. Most of the DPBs are present as THMs and over 95% of the THMs in seawater are bromoform (Figure 4-7; Boudjellaba *et al.* 2016).

The EPA Tasmania (2021) recommended ambient trigger value for bromoform is 10 µg/L. Given the dilution and dispersion of the chlorine (as chlorine produced oxidants) in the effluent plume at BBO, the bromoform concentrations are not expected to exceed 10 µg/L outside of the initial mixing zone of 20 m. Therefore, DBPs present a low risk to the ecological values of the lower Derwent Estuary.

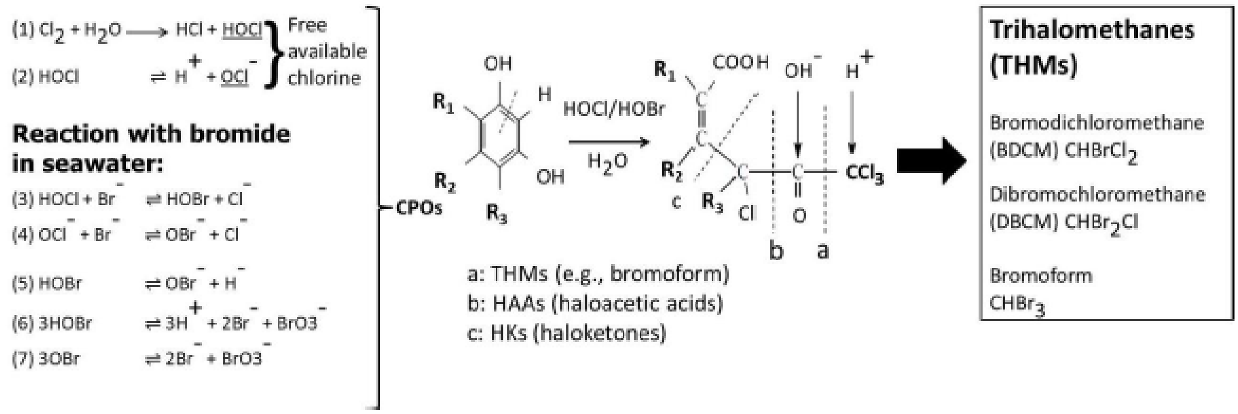


Figure 4-7 Chlorine and bromine pathways (from Saeed et al 2015)

Nutrient enrichment

Total nitrogen and total phosphorus from the effluent may cause ecosystem stress through eutrophication-related impacts in the Lower Derwent Estuary. These effects are load-based and not necessarily related to concentration. Nutrient enrichment may cause shifts in ecological communities or cause aesthetic impacts (e.g., algal blooms, nuisance plants). While nutrients, particularly total phosphorus may be elevated around the outfall, they are unlikely to cause a shift in ecological communities in open water. The marine-dominated lower estuary is thought to be nitrogen-limited, particularly in summer (Wild-Allen *et al.* 2009). Total nitrogen is being reduced with the new treatment process compared to current practice. There is also good flushing of the estuary daily in the lower estuary.

4.5.4 Risk Assessment

The risk posed by contaminants of concern in the Selfs Point STP effluent discharges from BBO to the environmental values in the Lower Derwent Estuary was determined based on the exposure and sensitivity assessment. Overall, continuous effluent discharges at the BBO are low risk (Table 4-6).

Table 4-6 Applied risk assessment (see Appendix A) for contaminants of concern in BBO effluent discharges to environmental values in the Lower Derwent receiving environment.

Stressor	Sensitivity	Exposure	Risk
Protection of Aquatic Ecosystems			
Chlorine as toxicant	Moderate	Short	Low
Disinfection by-products	Moderate	Short	Low
Nutrient enrichment -nitrogen and phosphorus	Minor	Medium	Low
Recreational water quality and aesthetics			
Nutrients - nitrogen and phosphorus	Minor	Medium	Low

4.6 Limitations

Outfall modelling is indicative only and may not accurately reflect actual conditions. The mixing zone assessment is subject to the limitations of the *Visual Plumes* modelling software and the available data used to inform the model:

- One month of current speed and direction measurement during March/April 2015
- Ambient water quality based on sampling from May 2014 to April 2015

4.7 Conclusion

Selfs Point STP effluent discharges from BBO present a low risk to environmental values in the receiving environment. The effluent plume is buoyant and receives mixing not just from the high number of discharge ports and high exit velocity, but also as the plume rises from the 32 m depth. The ambient currents are low in the bottom waters and travel in a northerly direction. However, as the plume rises to the surface it is met with higher velocity currents that transport the plume southward towards the Southern Ocean. The residence time and accumulation of nutrients in the estuary (far-field) is predicted to be very short (i.e., days) due to the transport out to the ocean.

Nutrient concentrations may be elevated above the DGVs in the near-field. Given the high level of dilution in the far-field and the short residence time in the estuary, it is unlikely that there will be any significant eutrophication related effects at Blinking Billy.

Chlorine and associated disinfection by-products in the effluent presents a low risk of direct toxicity to aquatic life. The mixing zone will be approximately 20 m from the outfall. The outfall location is in deep water and 850 m away from known sensitive habitat for the critically endangered spotted handfish.

5. Selfs Point Local Outfall

This section provides a mixing zone and environmental risk assessment for SPLO for the predicted impacts associated with the Selfs Point STP Expansion proposal.

5.1 Context

SPLO, near the STP, receives wet-weather and emergency discharges and discharges intermittently into the middle estuary. The existing SPLO has significant condition issues so a new outfall will be constructed as part of the Selfs Point STP expansion project. The new outfall will be in the same general area as the existing outfall unless studies and advice indicate otherwise.

SPLO is within a narrow area of the middle Derwent Estuary. Water depths between the Bowen and Tasman bridges are deep to intermediate, permitting the passage of large ships (Figure 5-2). The existing outfall extends approximately 20 m offshore into the main channel of the middle Derwent Estuary to a water depth of 6 m. Further into the channel, the water depths increase to 10-15 m. The full channel width from Selfs Point to Limekiln Point on the Eastern Shore is 750 m.

Salinities in this area are intermediate and the water column is stratified with a semi-permanent salt-wedge in the bottom waters. The depth of the halocline varies between 1.0 and 3.5 m (Jacobs 2016).

Figure 5-1 Selfs Point Local outfall (listmap 2022)

Figure 5-2 Derwent Estuary bathymetry (After Elgin Associates 2022)

5.2 Currents and hydrodynamics

Current direction and velocity at the existing SPLO were measured at various depths from 29th January 2015 to 2nd March 2015 as part of the Derwent AMP (Jacobs 2016). The ADCP current direction was found to move primarily downstream in a south easterly direction, but there was a large movement of water upstream in a northerly direction at greater depths (Figure 5-3). The rhodamine plume tracer showed that the plume surfaces then move in a northerly direction on the flood tide and south-easterly during the ebb tide, consistent with the current directions (Figure 5-4, Figure 5-5).

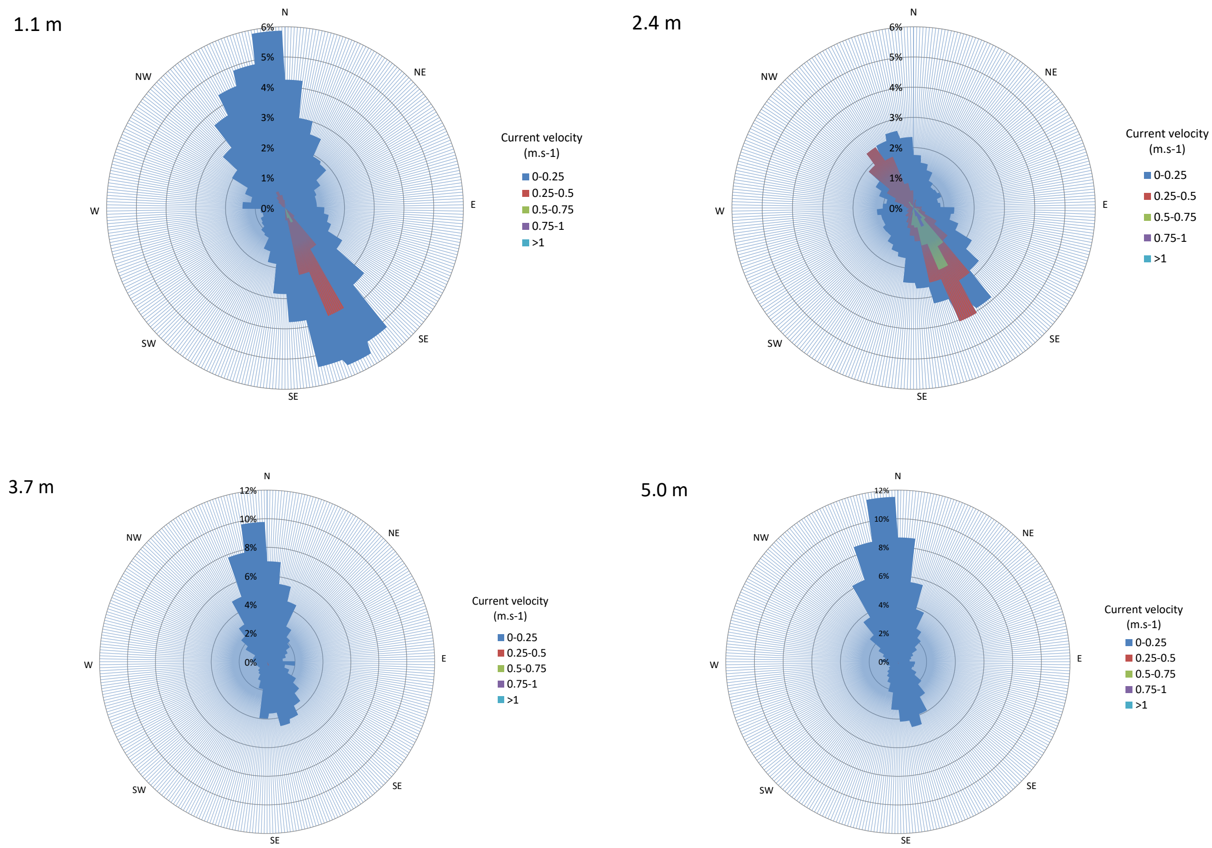


Figure 5-3 Selfs Point outfall ADCP results, showing current velocity and direction at depths of 1.1 m, 2.4 m, 3.7 m and 5.0 m (Jacobs 2016)

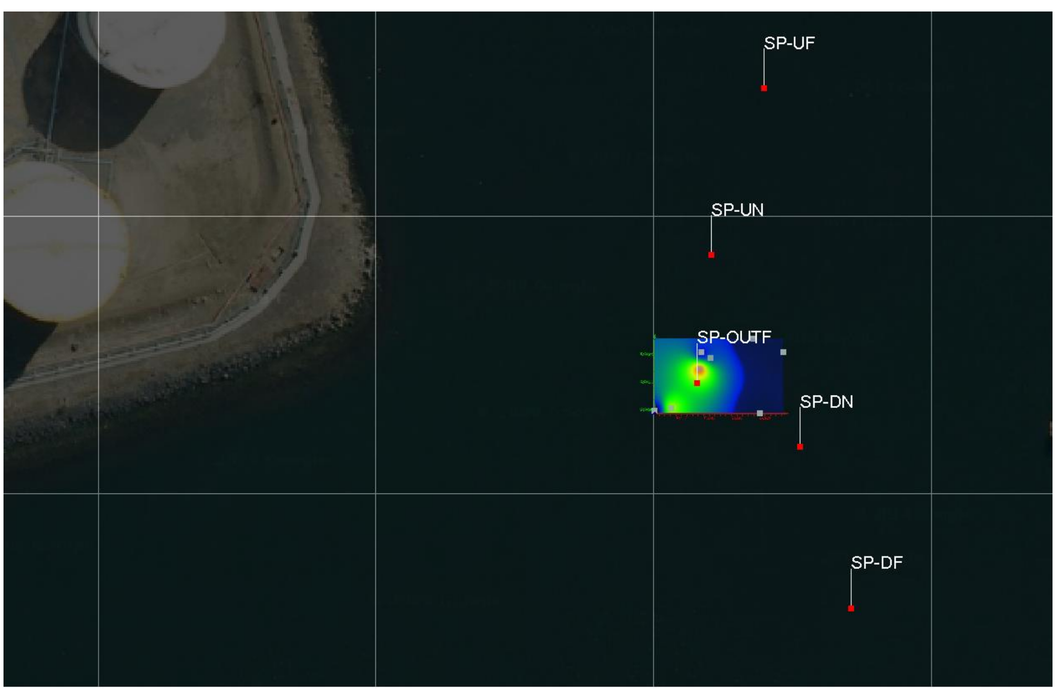


Figure 5-4 Selfs Point outfall rhodamine plume tracer results during the incoming tide (Jacobs 2016)

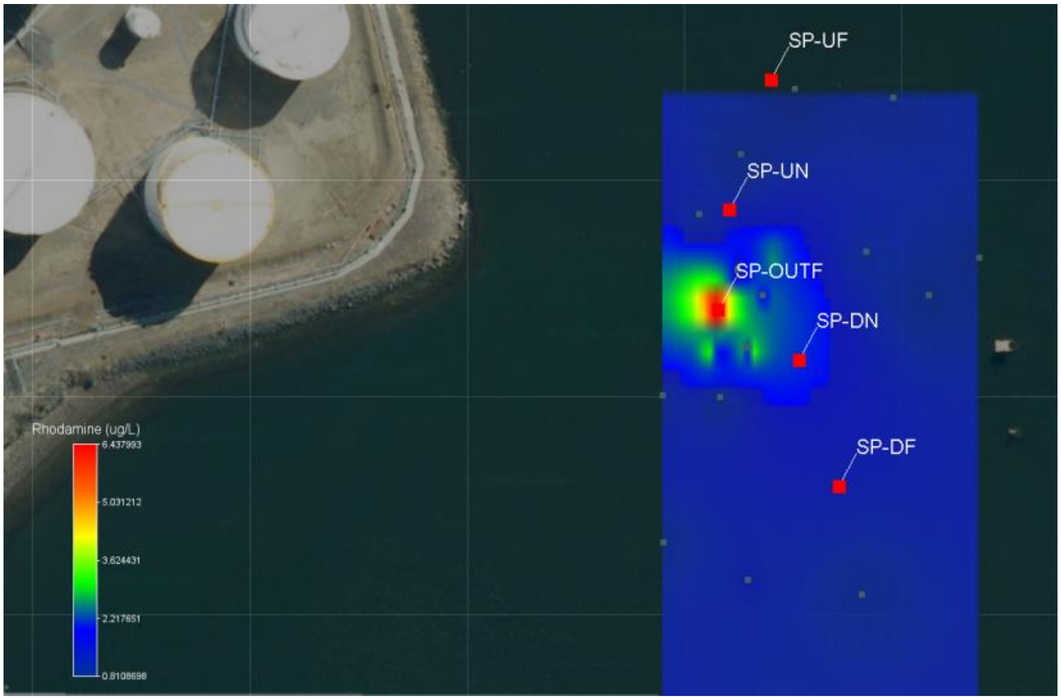


Figure 5-5: Selfs Point outfall rhodamine plume tracer results during the outgoing tide (Jacobs 2016)

5.3 Effluent dilution requirements

Effluent dilution requirements (Sreq) required to achieve ambient default guideline values (*Cdgv)* for water quality were calculated according to the EPA Tasmania (2020) *Regulatory Framework for the Sustainable Discharge of Treated Wastewater from Level 2 WWTPs* (Table 5-1). The 90th percentile effluent quality (*Ceff*) and the 95th percentile ambient background quality (*Camb*), for toxicants and 50th percentile for ecosystem stressors, were applied using the dilution equation in Equation 2:

Equation 2 $$Sreq = (Ceff – Cdgv) / (Cdgv – Camb)$$

Where the *Camb* > *Cdgv,* the *Camb* has been set at 0 mg/L for a revised calculation (C*eff*/*Cdgv*).

Nitrate is the toxicant of concern in the STP effluent with a dilution requirement of 2:1 to achieve the ANZG (2018) DGV (95% species protection).[3] Nitrogen (particularly nitrate) and Phosphorus are the ecosystem stressors with the highest dilution requirements (160:1) to achieve the EPA DGVs for the Middle Derwent Estuary.

Table 5-1 Dilution requirements for treated effluent design parameters, after GHD (2021, Table 17). Highlighted cells are the indicators of concern.

Parameter	Adopted 90th percentile	Applied DGV (annual, surface)	Ambient background^	Dilution requirement (X:1)
Ecosystem stressors				
BOD (mg/L)	15	<5	-	2
TSS (mg/L)	20	7^	4^	4
Oil and Grease (mg/L)	5	<1	-	4

[3] This assumes that chlorine is not added to wet-weather discharges from SPLO

Parameter	Adopted 90th percentile	Applied DGV (annual, surface)	Ambient background^	Dilution requirement (X:1)
TN (mg/L)	10	0.330	0.270	161
Nitrate (mg/L)	7.5*approx.	0.0493	0.020	254
Ammonia (mg/L)	2	0.0104	0.013	191
TP (mg/L)	5	0.030	0.036	166
Toxicants	Ceff	ANZG DGVs	Camb	
Nitrate (mg/L) – toxicant	7.5	2.4	0.05	2
Ammonia – toxicant	2	0.91	0.011	1
Microbiological indicators (cfu/100ml)				
Faecal Coliforms	500	150~	<10	2
Enterococci	500	40%	<10	12

^Jacobs (2016) DEP data summary median background concentration
~ANZG thermotolerant coliforms low risk guideline for recreational waters; ‘NHMRC (2008) Cat A guideline
% *Enterococci* concentrations are assumed to be commensurate to faecal coliforms

5.4 Mixing zone modelling

5.4.1 Model set up

The near field dilution and dispersion of the effluent plume was simulated using the US EPA software *Visual Plumes.* The outfall placement at depths of 2 m, 6 m (existing), 8 m and 12 m were modelled. A proposed diffuser configuration, consisting of 25 ports (150 mm, N & S), spaced 4 m apart along a 50 m length, perpendicular to the Derwent River currents, was modelled (Table 5-2). The outfall specifications and the ambient conditions used in the modelling are provided in Table 5-3 and Table 5-4.

Table 5-2 SPLO outfall configurations

Outfall Characteristic	Scenario	Status
Peak capacity	1340 L/s	Confirmed
Pipe Size	1.2 m	Confirmed
Water Depth	6 m 2 m 8 m 12 m	Existing depth Scenario: above halocline Scenario: sub-halocline Scenario: sub-halocline
Number of ports **Spacing** **Port diameter**	25 (12 N, 13 S) 4 m 150 mm	Scenario Scenario Scenario

Table 5-3 Outfall specifications for modelling. All parameters are held constant, except where indicators are varied for depth and diffuser scenarios.

Outfall Characteristic	Base model
Port diameter	150 mm
Vertical angle	20 degrees
Horizontal angle	N & S
No. ports	25 (12 N, 13 S)
Spacing	4 m
Port depth (m)	2, 6, 8 and 12 m
Effluent volume	1340 L/s
Effluent salinity	0 psu
Effluent temperature	15℃
Diffusion co-efficient	0.0003
Decay rate (chlorine)	50 d-1
Decay rate (pathogen)	Mancini decay equations
Channel width	750 m
Diffuser port contraction coefficient	1.0 (default)
Light absorption coefficient	0.16 (default)
UM3 aspiration coefficient	0.1 (default)
Farfield diffusivity option	Constant eddy (applicable for inland channels)

Table 5-4 Ambient scenarios for ADCP data and ambient conditions (site GB, annual, DEP; Jacobs 2016)

Tides	NEAP TIDE Ambient currents (m/s)	SPRING TIDE Ambient currents (m/s)	Direction	Temperature °C	Salinity (psu)
Incoming	Surface – 0.125 2.5 m – 0.1 3.7 m – 0.14 5.5 m – 0.09	Surface – 0.15 2.5 m – 0.25 3.7 m – 0.1 5.5 m – 0.12	N-NW	Surface - 13.9 Bottom – 13.8	Surface – 24.3 Bottom – 32.6
Outgoing	Surface – 0.16 2.5 m – 0.325 3.7 m – 0.12 5.5 m – 0.025	Surface – 0.05 2.5 m – 0.70 3.7 m – 0.025 5.5 m – 0.025	S-SE	Surface - 13.9 Bottom – 13.8	Surface – 24.3 Bottom – 32.6
Slack	Surface – 0.1 2.5 m – 0.025 3.7 m – 0.025 5.5 m – 0.03	Surface – 0.05 2.5 m – 0.2 3.7 m – 0.05 5.5 m – 0.05	S-SE	Surface - 13.9 Bottom – 13.8	Surface – 24.3 Bottom – 32.6

5.4.2 Model outputs

Model outputs for an outfall placement at 12 m depth are shown in Figure 5-6.

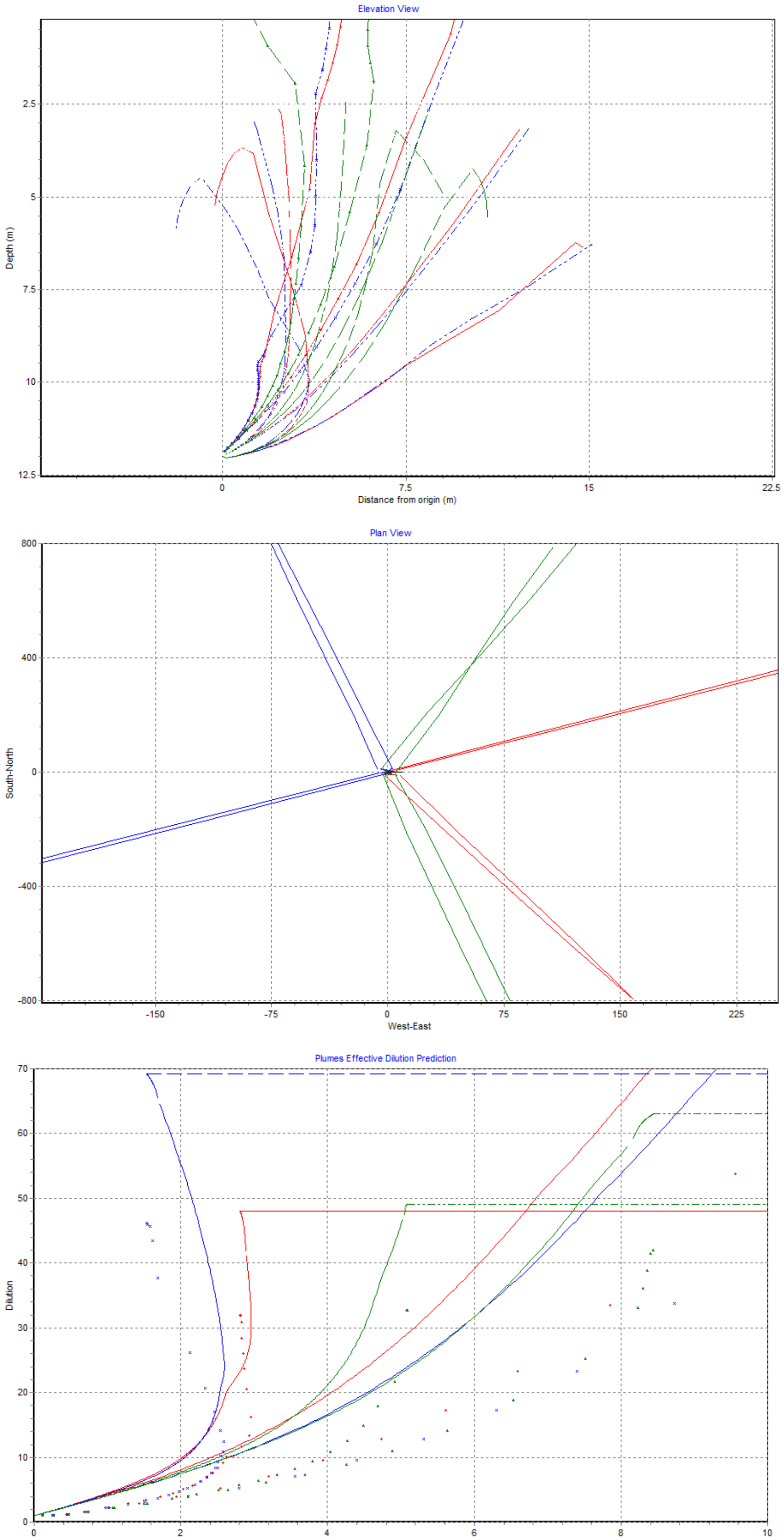


Figure 5-6 Effluent plume rise (top), plume direction (middle) and dilutions (bottom) from N & S facing ports at 12 m outfall depth with the tides – outgoing (red), incoming (blue) and slack (green)

5.4.3 Dilutions with distance

Dilution requirements for all indicators, except nutrients, will be met within 10 m of the outfall in all conditions and for an outfall at all placement depths (Table 5-5). After the initial rise and dispersion of the plume through the water column, the effluent travels with the prevailing current.

Nutrient enrichment of the Middle Derwent Estuary may occur around the outfall during the effluent discharges. Total nitrogen and total phosphorus require a dilution of 161:1 and 166:1 to meet the site-specific DGVs, which is not met in the immediate vicinity of the outfall.

Table 5-5 Modelled SPLO Dilutions (X:1) at 10 m from outfall (peak capacity – 1340 L/s). The ranges given are for N & S facing ports

Dilution (X:1)	**Tidal Conditions**		
Depth (m)	Neap Incoming	Neap Outgoing	Neap Slack
2	12	16-18	12
6	24-35	24-35	20
8	31-50	34-43	30
12	55-75	52-62	50
Depth (m)	Spring Incoming	Spring Outgoing	Spring Slack
2	15	12-21	10-12
6	24-36	24-42	23-28
8	31-55	32-42	33-38
12	70	52-58	50-64

5.4.4 Mixing zone for toxicants

The mixing zone for nitrate, the toxicant of concern with the highest dilution requirement of 2:1, will be within 1-2 m of the outfall under all tidal conditions.

5.4.5 Mixing zone for microbiological indicators

The mixing zone for *enterococci* as the microbial indicator with dilution requirement of 12:1 to meet the Category A recreational guidelines will be 1-2 m from the outfall under all tidal conditions.

5.4.6 Nutrient footprint

The extent of nutrient enrichment from peak discharges from SPLO are likely to extend beyond 1 km in the direction of the current.

5.5 Environmental Risk Assessment

This section contains an environmental risk assessment for wet-weather SPLO discharges to the Middle Derwent Estuary.

5.5.1 Potential threats and stressors to environmental values

A summary of the stressors, known threats and other factors influencing the risk to environmental values from the indicators present in the Selfs Point STP discharge at the SPLO are provided in a value/ threat matrix (Table 5-6).

Table 5-6 Value versus threat matrix

Stressor	Threat	Other factors influence risk
Protection of Aquatic Ecosystems		
Nutrient enrichment (nitrogen and phosphorus)	Eutrophication and algal growth causing low dissolved oxygen and reduction in habitat quality	N:P ratios, currents and flushing rates, dissolved oxygen, temperature, pH
Recreational water quality and aesthetics		
Nutrient enrichment (nitrogen and phosphorus)	Algal growth reducing aesthetics	N:P ratios, type of recreational activities, exposure
Industrial water supply (Nyrstar)		
Nutrients (nitrogen and phosphorus)	Algal growth clogging pipes and infrastructure	N:P ratios, currents, dilution rates

5.5.2 Exposure

All contaminants of concern in the effluent discharges to the SPLO at peak capacity (1340 L/s) will be diluted to achieve the DGVs of the receiving environment within 10 m of the outfall. The only exception is nutrients, which are likely to exceed the DGVs for at least 1 km from the outfall.

Wet weather discharges at the SPLO will occur when the Blinking Billy Outfall capacity is exceeded (>345 L/s) and the Selfs Point balance storage is full. The adopted volume for the SPLO outfall modelling to assess the predicted impacts to the Middle Derwent Estuary is the *peak capacity* flow of **1340 L/s (115 ML/d)** for the new outfall. Only 1.9% of the total effluent volume is expected to be discharged at the SPLO over approximately nine discharge events per year. This amounts to a total volume of approximately 130 ML per year (689 ML over five years, Figure 2-2).

5.5.3 Sensitivity of environmental value to threat

Nutrient enrichment

Total nitrogen (including nitrate and ammonia) and total phosphorus may cause ecosystem stress through eutrophication-related impacts. These effects are load-based. Short, intermittent discharges that only occur 9 times per year for a combined total of 48 hours over the year will not have the same impact as continuous discharges.

Nutrient enrichment may cause shifts in ecological communities or cause aesthetic impacts (e.g., algal blooms, nuisance plants). While nutrients will be elevated around the SPLO for a short period, they are unlikely to cause a shift in ecological communities in open water. There is good flushing of the estuary daily.

The Middle Derwent Estuary may become phosphorus-limited during winter from high freshwater inflows. The influx of phosphorus in the wet-weather discharge events may cause localised growth in plants and algae. However, the eutrophication-related risks to the Derwent Estuary from effluent discharges decrease in winter due to lower ambient light and colder water temperatures that inhibit growth of plants and algae. The risk of eutrophication-related impacts to the Derwent Estuary marginally increases during spring due to increased light and warming water temperatures.

The Middle Derwent Estuary shifts from winter conditions, where DIN:PO4 is in relative balance (6:8:1), towards strong nitrogen-limitation in summer and autumn (according to the DIN:PO4 ratio, See APPENDIX B). High nitrogen loads in the effluent may cause small-scale increases in plant and algal growth. However, the small volume of wet-weather effluent discharges is likely to be offset by increased freshwater inflow corresponding to the wet-weather event. High chlorophyll-a levels have been occasionally observed in Cornelian Bay, which is immediately downstream of the SPLO.

The intermittent wet-weather discharges from Selfs Point outfall will only cause a small and temporary increase in nitrogen and phosphorus levels in the near-field environment, mostly during winter and spring, and is unlikely to have any significant effects on the mid and far field nutrient dynamics of this area. Overall, the eutrophication-related risks to the Middle Derwent Estuary from wet-weather discharge events during winter, spring, summer, and autumn are *low.*

5.5.4 Risk Assessment

The risk posed by contaminants of concern in the Selfs Point STP effluent discharges to the environmental values in the Middle Derwent Estuary was determined based on the exposure and sensitivity assessment. Overall, wet-weather effluent discharges at the SPLO are low risk (Table 5-7).

Table 5-7 Applied risk assessment (see Appendix A) for contaminants of concern in SPLO effluent discharges to environmental values in the Middle Derwent receiving environment.

Stressor*	Sensitivity	Exposure	Risk
Protection of Aquatic Ecosystems			
Nutrient enrichment -nitrogen and phosphorus	Moderate	Short	Low
Recreational water quality and aesthetics			
Nutrients - nitrogen and phosphorus	Moderate	Short	Low
Industrial water supply (Nyrstar Hobart)			
Nutrients - nitrogen and phosphorus	Minor	Short	Insignificant

5.6 Limitations

Outfall modelling is indicative only and may not accurately reflect actual conditions. The mixing zone assessment is subject to the limitations of the *Visual Plumes* modelling software and the available data used to inform the model:

- One month of current speed and direction measurement during January/February 2015
- Ambient water quality based on sampling from May 2014 to April 2015

5.7 Conclusion

Results from the mixing zone and environmental risk assessment showed that fully treated wet-weather discharges from Selfs Point STP via the SPLO presents a low risk to environmental values in the receiving environment.

A new outfall with a diffuser at placement depths of 2 m, 6 m (existing), 8 m and 12 m were modelled. Near-field modelling suggests that the dilution and dispersion of the effluent plume at the peak capacity of 1340 L/s is improved with increasing water depth (e.g., 12 m) into the main Middle Derwent River channel. However, the depth of the outfall does little to reduce the size and extent of the footprint of nutrient enrichment that results from peak wet-weather discharges. The model suggests that nutrients will exceed DGVs into the mid- and far-field environment, for up to one kilometre in the direction of the current.

Given the short, intermittent nature of the wet-weather discharges from SPLO, there is a low risk to environmental values in the Middle Derwent Estuary from all contaminants of concern in the effluent.

6. Macquarie Point Local Outfall

This section draws from the *Emergency Discharge Scenarios*– an addendum to the Jacobs (2016) *Environmental Risk Assessment for Macquarie Point STP Relocation* to provide a mixing zone and environmental risk assessment for MPLO for the predicted impacts associated with the Selfs Point STP Expansion proposal.

6.1 Context

This assessment addresses emergency overflows of raw sewage from a new pump station at Macquarie Point. The existing Macquarie Point STP local outfall (MPLO) will be converted to an emergency outfall for discharges from the Macquarie Point Sewage Pump Station (SPS). The raw sewage would discharge from the existing MPLO, located at a depth of approximately 12 m under the Macquarie Wharf apron, Hobart City.

The proposed emergency storage and emergency relief structures for the Macquarie Point SPS is consistent with the requirements listed in the performance objectives in the EPA SPS Guidelines for a medium sensitivity location. This includes four hours ADWF storage within the upstream network and duel pumps each capable of pumping full design flow.

The capacity of the proposed pump station to transfer raw sewage from Macquarie Point catchment to Selfs Point for treatment is 587 - 650 L/s (GHD 2022) dependent on final pump capacity adopted (GHD 2022). When sewage exceeds this capacity, it will be stored or discharged at Macquarie Point via the MPLO. Likewise, when sewage inflows to Selfs Point STP exceed all the combined capacities of BBO and SPLO and on-site storage, the excess will be stored or discharged at MPLO.

The emergency storage is sized to ensure a total of 4 hours ADWF storage is provided within the upstream network capturing a 1 in 1 year ARI event. When the emergency storage is full, additional flows will be discharged as raw sewage from the MPLO. This has been modelled as part of the EIS, with the emergency overflow of raw sewage at the Macquarie Point SPS based on a 1 in 1 year ARI event equating to 3 ML over 5 hours at a rate of 167 L/s.

6.2 Emergency discharge frequency and volumes

Plume dilution and dispersion modelling for emergency discharges from MPLO was undertaken as part of the *Environmental Risk Assessment for Macquarie Point STP Relocation* (Jacobs 2016). This study modelled an emergency overflow of raw sewage at the Macquarie Point SPS for a 1 in 1 year ARI event (3 ML over 5 hours at a rate of 167 L/s).

6.3 Emergency discharge quality

The quality of the raw sewage to be discharged as an emergency overflow is assumed to have a dilution factor of four (4x) on the typical influent quality expected at Macquarie Point SPS due to wet-weather dilution.

Table 6-1 Raw Sewage Concentrations (GHD 2021, Jacobs 2016)

Raw Sewage indicators	Macquarie Point STP influent	Emergency overflow quality
BOD (mg/L)	320	80
COD (mg/L)	724	181
TSS (mg/L)	354	88
VSS (mg/L)	333	83
TKN (mg/L)	56	14
Ammonia (mg/L)	40	10
Total Phosphorus (mg/L)	9.5	2.4
Orthophosphate (mg/L)	5.2	-
Alkalinity (mg/L)	275	-
Conductivity (uS/cm)	2340	-
Temperature (C)	12-22	-
Thermotolerant Coliforms (org/100ml)		$10^{7.5}$
***Enterococci* (org/100ml)**		$10^{6.5}$

6.4 Risk assessment

Given there are no material changes to the emergency overflow scenario at MPLO since the Jacobs (2016) *Environmental Risk Assessment for Macquarie Point STP Relocation*, the risk assessment findings of that study remain valid. The findings of this study were:

- The indicators of concern were pathogenic organisms (thermotolerant coliforms and *enterococci*) in the raw sewage presenting human health risks to recreational users. Raw sewage contains pathogens such as viruses, bacteria and protozoa that may pose a human health hazard. The likelihood of illness depends on the dose and the susceptibility of the individual.
- The distance required for the decay and dilution of both thermotolerant coliforms and *enterococci* levels to meet recreational primary contact and NHMRC (2008) category A level guidelines would be around 1000 m from the outfall. A mixing zone of 600 m would be required assuming the wet-weather objective of 500 cfu/100ml for *enterococci* (typical of the ambient environment around the outfall during a 1:1 ARI event from diffuse stormwater and urban runoff).
- Pathogens have the potential to impact on human health during recreational activities such as swimming and boating and reduce the aesthetic appeal of the receiving environment. Macquarie Point outfall is in a highly modified wharf environment adjacent to the Hobart CBD. Recreational values may include types of boating (rowing, sailing), recreational diving (under the wharf is a popular night dive), fishing and swimming (i.e., the annual trans-Derwent race). Large vessels moor alongside the wharf, including cruise ships.
- Macquarie Point SPS overflows are likely to coincide with wet-weather events in the catchment where pathogen levels will be elevated in the receiving environment from stormwater and urban runoff. While emergency overflows will present a cumulative risk to the

receiving environment during wet-weather, the receiving environment is already high risk and not recommended for recreation during and 48 hours after wet-weather events.

- Given the emergency overflow has only an average duration of five hours and an annual recurrence interval, the acute threat is only present within the five hours of discharge and will dissipate immediately thereafter.

6.5 Conclusion

Emergency overflows of raw sewage present a high risk to recreational users within 1000 m of the outfall due to elevated pathogens during the first 24 hours after a wet-weather event. The discharge presents a cumulative risk with high pathogen loads in stormwater and urban runoff, which makes the lower Derwent Estuary in this location unsuitable for recreational activities during and immediately after heavy rainfall. This risk only applies 1-2 days per year.

7. Whole of Estuary Risk Assessment

This section considers the whole-of-estuary effects of the proposed changes in the volumes and locations of STP effluent discharges with the Selfs Point STP expansion.

7.1 Context

Whole-of-Estuary risks were assessed in the Jacobs (2016) *Environmental Risk Assessment for Macquarie Point STP Relocation*. The findings of that study remain valid but have been briefly updated with recent data in the sections below.

7.2 Current arrangement

7.2.1 Macquarie Point STP

Macquarie Point STP discharges approximately 10 ML/d of secondary treated effluent into the lower-Derwent Estuary at Macquarie Point in Hobart city. Macquarie Point STP effluent has elevated concentrations of heavy metals, nutrients, pathogens, suspended solids and chlorine compared to water quality objectives for the receiving environment. It is the largest contributor of pollutant loads of the nine STPs that discharge effluent into the Derwent Estuary. Nutrients in the Macquarie Point STP effluent present a medium risk of eutrophication-related impacts to the ecological and recreational values of the receiving environment. Pathogens present a medium risk to human-health impacts to recreational values and chlorine presents a medium risk of direct toxicity to ecological values (Jacobs 2019).

7.2.2 Selfs Point STP

Selfs Point STP discharges approximately 9.5 ML/d of secondary treated effluent into the lower-Derwent Estuary at Blinking Billy Point in lower Sandy Bay. The outfall is 32 m deep and in one of the deepest areas of the Derwent Estuary. Selfs Point STP effluent has elevated concentrations of heavy metals, nutrients, pathogens, and chlorine compared to water quality objectives for the receiving environment. However, the plume receives good dilution and dispersion as it enters at a depth of 32 m into a deep channel of the lower Derwent Estuary. Contaminants of concern in the Selfs Point STP effluent all present a low risk to the ecological and recreational values of the receiving environment (Jacobs 2019). Occasional wet-weather bypasses are discharged at the Selfs Point Local outfall.

7.2.3 Impacts of cumulative STP effluent discharges to Derwent Estuary

STP effluent discharges are the main source of bioavailable nutrients to the Derwent Estuary (Figure 7-1). There are 10 STPs that discharge directly into the Derwent Estuary, of which Macquarie Point, Prince of Wales Bay and Selfs Point STPs discharge approximately 70 % of the combined effluent volume (DEP 2020). Through plant optimisations and reuse schemes, the contribution of STP effluent to nutrient loads, particularly phosphorus, in the Derwent Estuary has reduced over recent years.

A. Dissolved inorganic nitrogen sources

B. Dissolved phosphate sources

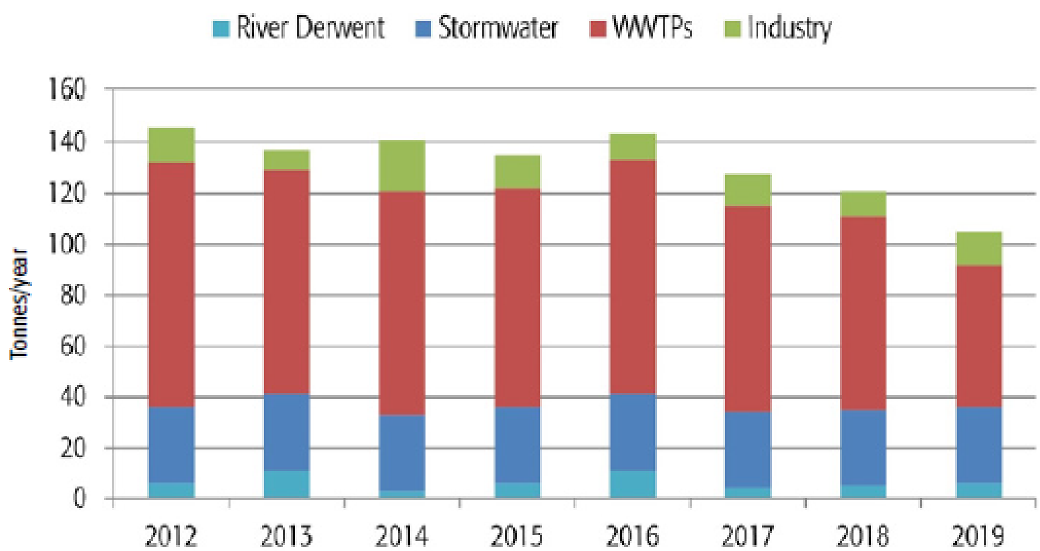


Figure 7-1 Sources and contribution of dissolved inorganic nitrogen (top) and phosphate (bottom) bioavailable nutrient loads to the Derwent Estuary (after DEP 2020, Figure 2.43 and 2.44)

Nutrients are highest in the mid-estuary in proximity to the highest density of STPs, particularly Prince of Wales Bay (Figure 7-2; Figure 7-3). Chlorophyll-a levels, indicating phytoplankton biomass, are elevated in the mid-estuary.

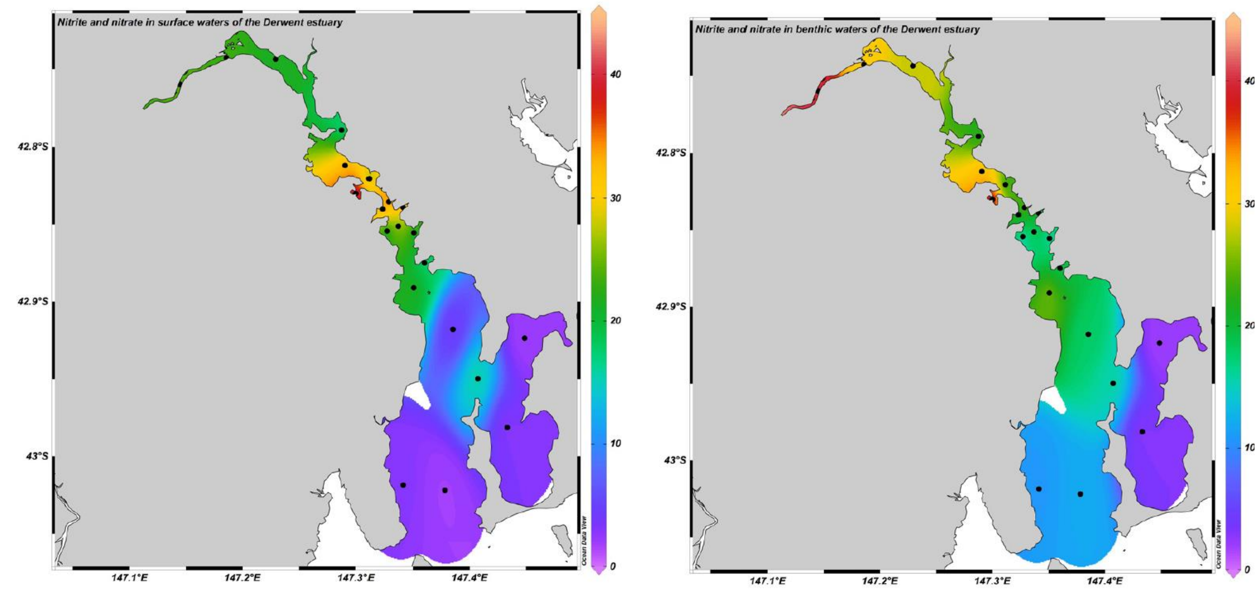


Figure 7-2 Median NOx in the surface waters (left) and bottom waters (right) of the Derwent Estuary (DEP 2020, Figure 2.56)

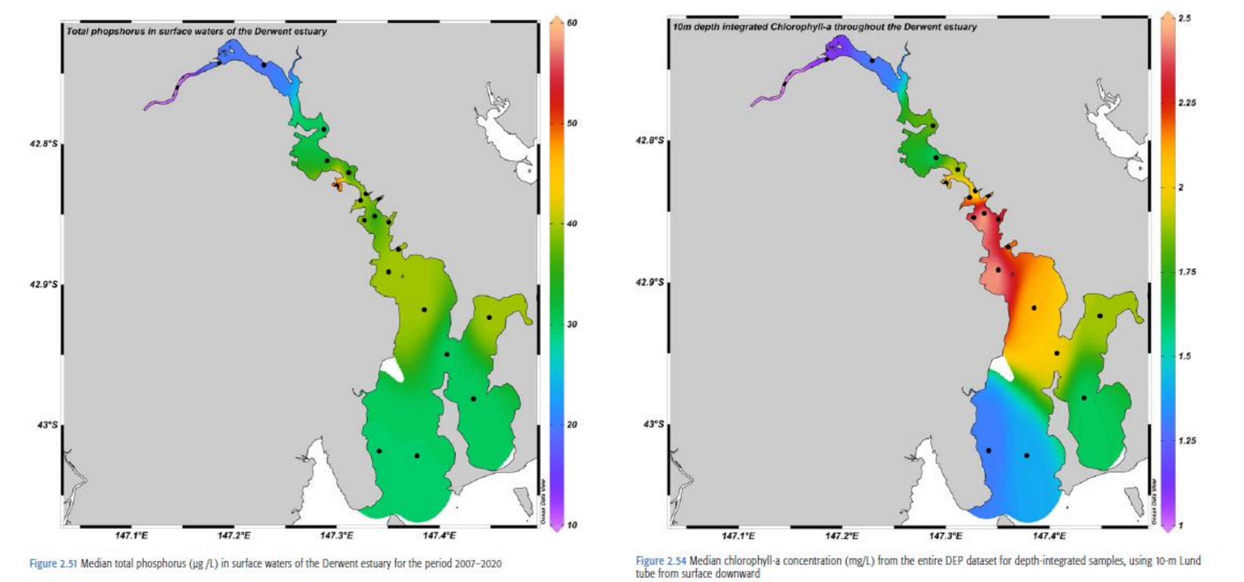


Figure 7-3 Median total phosphorus (left) and chlorophyll-a in the surface waters of the Derwent Estuary (DEP 2020, Figure 2.5

7.3 Future arrangement

7.3.1 Proposed changes

The proposal is to decommission Macquarie Point STP in the Hobart CBD and expand the capacity of Selfs Point STP in New Town to accommodate the Macquarie Point influent. The capacity of Selfs Point STP will also be increased to receive sewage generated by future growth in the Hobart region up to 2054.

Future effluent volumes generated from Selfs Point STP are expected to increase up to ADWF of 24.9 ML/d in 2054. Treated effluent from Selfs Point STP will be preferentially discharged to the Lower Derwent Estuary via the Blinking Billy outfall. Treated effluent will no longer be discharged from Macquarie Point Local Outfall (MPLO), except in emergency overflow scenarios. The peak capacity of Blinking Billy Outfall is 345 L/s (29.8 ML/d). Wet weather discharges that exceed the peak capacity of Blinking Billy outfall will be discharged at the Selfs Point Local Outfall.

7.3.2 Impact of proposed changes on nutrient loads

The proposed changes to effluent discharge volumes and locations under the Selfs Point Expansion project means that effluent volume will increase by 33% due to future growth projected up until 2054. ADWF effluent discharges will cease from MPLO. Treated effluent from the combined sewerage catchments will be treated at Selfs Point and discharged at the BBO in Sandy Bay (Figure 7-4).

Enhanced sewage treatment processes at the future Selfs Point STP compared to the current combined Macquarie Point STP and Selfs Point STP mean that the nitrogen and phosphorus loads entering the estuary will be reduced by 58 % and 41 % respectively (Figure 7-4). This is a significant reduction. Selfs Point STP Expansion project will also relocate nutrient loads from the Macquarie Point catchment, currently discharged from MPLO, to further down the estuary at the BBO, which increases flushing rates from the estuary.

7.4 Risk summary

The Selfs Point STP expansion proposal, and the decommissioning of Macquarie Point STP (not part of this EIS), presents significant benefits to the Derwent Estuary compared to the current arrangement. Enhanced sewage treatment at the future Selfs Point STP means that the overall nutrient loads to the estuary will be significantly reduced despite the increase in effluent volume. Preferential effluent discharges at Blinking Billy Outfall will move the effluent discharges further downstream into one of the deepest parts of the estuary where there is good dilution and dispersion.

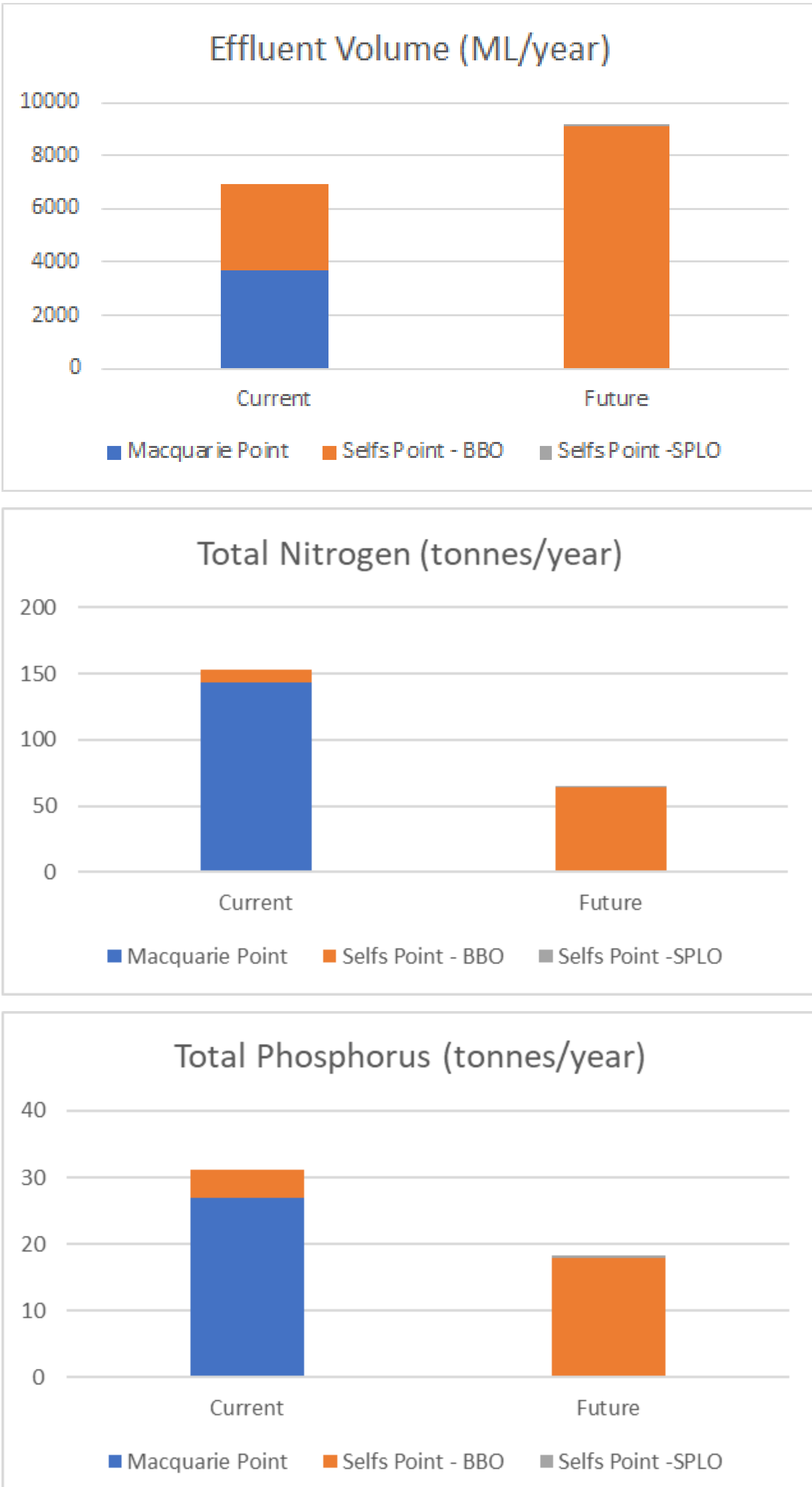


Figure 7-4 Effluent volume and nutrient loads – future (2054) versus current (2009-2013 data)

8. Effects on Sediment Quality

This section outlines potential impacts on sediment quality or the potential for remobilisation of contaminants in sediment from the Selfs Point Expansion proposal.

8.1 Context

A recent nutrient study (Stevens et al., 2020 as cited in the DEP 2020) using stable-isotope techniques and sediment cores collected from the estuary showed that the mid and lower-estuary cores were influenced by STP effluent discharges, marine organic matter, and aquaculture waste. Total nitrogen and total phosphorus concentrations in the mid-estuary sediment showed an increase in nutrients over the past 65 years, peaking over the past 35 years. This trend correlates with an increasing population around Hobart and associated STP effluent over the last two to three decades. Overall, TN accumulation rates were highest in the upper middle estuary and decreased towards the open ocean. More recently, accumulation rates have started to drop, in line with decreasing effluent loads (DEP 2020).

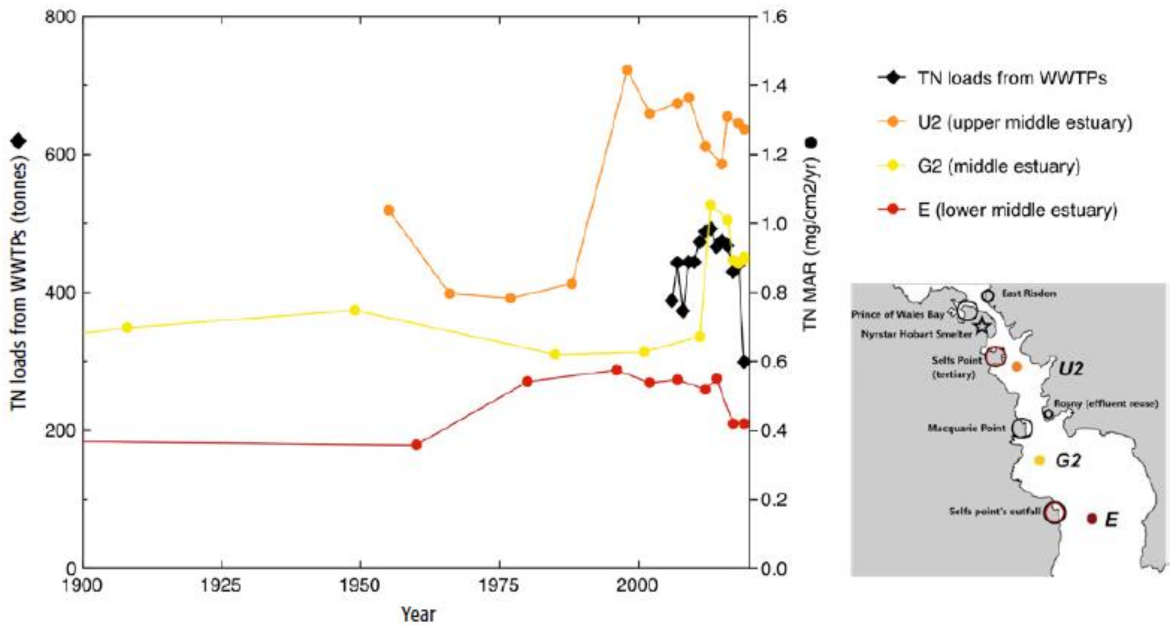


Figure 8-1 Total nitrogen accumulation rates in sediment over time with TN loads from STPs (after DEP 2020, Figure 2.47)

8.2 Current arrangement

Sediment quality was monitored and assessed around the Blinking Billy Outfall and Selfs Point Local Outfall by TasWater as part of the *Ambient monitoring of sewage treatment plant discharges to the Derwent Estuary* (Jacobs 2016a). The sediment around Macquarie Point Local Outfall was unsuitable for sampling.

The sediment around Blinking Billy Outfall was a dynamic mix of sand, fine mud and gravel. No clear trends in sediment redox, metals or nutrients were observed at varying distances from the outfall that could be confidently attributed to the effluent discharges.

Sediment around the SPLO was predominantly sand with small amounts of fine muddy sediments and gravel at the outfall. There was evidence of nutrient enrichment and total petroleum hydrocarbons around the outfall. Sediment heavy metals were elevated above ANZECC ISGQ – high values but not in a predictable pattern around the outfall, suggesting secondary sources.

8.3 Future arrangement

Given the effluent discharges will predominantly discharge from BBO in the future, the impacts on sediment quality and remobilisation of contaminants will be limited to this lower part of the Derwent Estuary. The dynamic mix of sediments within this deep channel of the estuary (32 m) is likely to experience low level impacts from nutrients and potentially heavy metals from the effluent discharges.

8.4 Risk summary

Environmental impacts to sediment quality from the effluent discharges around the BBO are localised and minor. This presents a low risk to the environmental values of the lower Derwent Estuary.

9. Conclusion and Recommendations

9.1 Conclusion

The objective of this report is to address the 'Predicted Impacts' segment of Section 6.2 Water Quality (Surface and Discharge) of the Project Specific Guidelines (EPA Tasmania, September 2020) as part of the Environmental Impact Statement (EIS) for Selfs Point STP Expansion for TasWater's Capital Delivery Office.

Environmental Risks to lower Derwent Estuary at Blinking Billy Outfall (BBO)

Results from the mixing zone and environmental risk assessment showed that Selfs Point STP effluent discharges from BBO presents a low risk to environmental values in the receiving environment. The effluent plume is buoyant and receives mixing not just from the high number of discharge ports and high exit velocity, but also as the plume rises from the 32 m depth. The ambient currents are low in the bottom waters and travel in a northerly direction. However, as the plume rises to the surface it is met with higher velocity currents that transport the plume southward towards the Southern Ocean. The residence time and accumulation of nutrients in the estuary (far-field) is predicted to be very short (i.e. days) due to the transport out to the ocean.

Nutrient concentrations may be elevated above the DGVs in the mid-field. Given the high level of dilution in the far-field and the short residence time in the estuary, it is unlikely that there will be any significant eutrophication related effects at Blinking Billy.

Chlorine and associated disinfection by-products in the effluent presents a low risk of direct toxicity to aquatic life. The mixing zone will be approximately 20 m from the outfall. The zone of impact is small in deep water and 850 m away from known sensitive habitat for the critically endangered spotted handfish.

Environmental Risks to Middle Derwent Estuary from wet-weather discharges at Selfs Point Local Outfall

Results from the mixing zone and environmental risk assessment showed that fully treated wet-weather discharges from Selfs Point STP via the SPLO presents a low risk to environmental values in the receiving environment.

A new outfall with a diffuser at placement depths of 2 m, 6 m (existing), 8 m and 12 m were modelled. Near-field modelling suggests that the dilution and dispersion of the effluent plume at the peak capacity of 1340 L/s is improved with increasing water depth (e.g., 12 m) into the main Middle Derwent River channel. However, the depth of the outfall does little to reduce the size and extent of the footprint of nutrient enrichment that results from peak wet-weather discharges. The model suggests that nutrients will exceed DGVs into the mid- and far-field environment, for up to one kilometre in the direction of the current.

Given the short, intermittent nature of the wet-weather discharges from SPLO (i.e., approximately nine events per year), there is a low risk to environmental values in the Middle Derwent Estuary from all contaminants of concern in the effluent.

Environmental Risks to Lower Derwent Estuary from emergency overflows at Macquarie Point Local Outfall

Emergency overflows of raw sewage present a high risk to recreational users within 1000 m of the outfall due to elevated pathogens during the first 24 hours after a wet-weather event. The discharge presents a cumulative risk with high pathogen loads in stormwater and urban runoff, which makes the lower Derwent Estuary in this location unsuitable for recreational activities during and immediately after heavy rainfall. This risk only applies 1-2 days per year.

Whole of estuary risks from the Selfs Point Expansion Proposal

The Selfs Point STP expansion proposal, and decommissioning Macquarie Point STP (not included in this EIS), presents significant benefits to the Derwent Estuary compared to the current arrangement. Enhanced sewage treatment at the future Selfs Point STP means that the overall nutrient loads to the estuary will be significantly reduced despite the increase in effluent volume. Preferential effluent discharges at Blinking Billy Outfall will move the effluent discharges further downstream into one of the deepest parts of the estuary where there is good dilution and dispersion.

Effects on sediment quality

Environmental impacts to sediment quality from the effluent discharges around the BBO are localised and minor. This presents a low risk to the environmental values of the lower Derwent Estuary.

9.2 Recommendations

The following recommendations are given to be implemented post-commissioning of the proposed Selfs Point STP expansion:

1. Four-week effluent screening to identify contaminants of concern in the Selfs Point STP effluent
2. Backscatter plume dilution study to study plume dynamics in the BBO receiving environment and to decide on the location of sampling sites
3. 12 months of ambient water quality monitoring around the BBO, including sampling the surface, mid and bottom waters for:
    - Physiochemical indicators (temperature, salinity, dissolved oxygen, turbidity, pH)
    - BOD and TSS
    - Chlorophyll-a (surface only)
    - Nutrients
    - Heavy metals (as informed by effluent screening)
    - Pathogens
    - Chlorine and disinfection by-products (see pt. 4)
4. Verification of the mixing zone by a special investigation to determine the fate of chlorine in the ambient environment
    - Quarterly monitoring of disinfection by-products in the effluent and receiving environment to report on any positive detections of: total residual chlorine, NDMA, THMs, bromate/chlorate, chlorophenols and bromophenols
    - A laboratory based experiment to determine the site-specific decay rates of total residual chlorine using water collected from the bottom and surface waters at BBO and at SPLO. These site-specific decay rates may be used to update the mixing zone modelling
5. 5-yearly sampling of sediment quality around BBO to characterise any trends for:
    - Hydrocarbons
    - Nutrients (consider isotope analysis)
    - Heavy metals

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11. Appendix A - Environmental Risk Assessment Framework

The risk assessment framework applied for this environmental risk assessment is presented in Table 11-1. Table 11-2 describes each environmental risk classifications.

Table 11-1 Risk Matrix

Risk = likelihood x consequences		**Sensitivity of environmental value to threat**		
		Minor	Moderate	Major
Exposure	Short (<10 % of time)	Insignificant	Low	Medium
	Medium (10-50% of time)	Low	Medium	High
	Long (>50% of time)	Medium	High	Extreme

Table 11-2 Environmental risk assessment categories.

Descriptor	**Consequence**
Insignificant	Negligible effect on the environment
	Ecosystem processes and community structure remain largely unchanged
	No breach of sustainable discharge framework (EPA 2020)
	No public concern or detriment to TasWater's image
Low	Minor, short term stress on the environment with rapid recovery, no disruption to breeding cycles
	No breach of SPWQM 1997 obligations, possible non-conformance with EPA sustainable discharge framework recommendations
	Low level of public concern
Medium	Environment stress observed, short term disruption to breeding cycles and ecological processes
	Minor breach of SPWQM 1997 obligations, prosecution unlikely, non-conforming with EPA sustainable discharge framework recommendations
	Several public complaints and possible detriment to TasWater's image with local media exposure, isolated state media exposure
High	Significant damage to the environment observed, including impact on threatened species and shift in underlying ecosystem processes
	Breach of SPWQM 1997, regulator investigation
	Short term detriment to TasWater's image with ongoing state media coverage, repeated attention from stakeholders
Extreme	Widespread environment destruction, irreversible damage, potential loss of threatened species, catastrophic shift in ecosystem processes
	Severe breach SPWQM 1997, high probability of prosecution

	Widespread public outrage and long-term detriment to client image with extensive ongoing state and/or national media coverage

12. Appendix B – Redfield Ratio

Extract from Jacobs (2016b, p. 80)

The Redfield ratio for marine phytoplankton suggests a molecular C:N:P ratio of 106:16:1 (or 50:7:1 by weight). Any departure from this ratio implies a nutrient deficiency.

Redfield ratios were calculated for nutrient data collected by the Derwent Estuary Program water quality monitoring program at sites in the middle and lower Derwent (data provided by Derwent Estuary Program and partners Norske Skog and Nyrstar). This data set provided a monthly time-series of nutrient concentrations (with a few gaps) over the past 11 years (2004-2015).

N:P and DIN:PO4 ratios were calculated for summer and winter using nutrient data from monitoring sites (with complete datasets) in closest proximity to the outfalls. The ratios were calculated for both the surface waters and bottom water layers (Table 9-4 and Table 9-5). N:P showed nitrogen limitation in summer and phosphorus limitation in winter at all sites and in the surface and bottom waters. The nitrogen limitation is stronger in the bottom waters due to intrusion of marine waters. DIN:PO4 ratios indicated nitrogen limitation all year round at all sites, particularly in summer.

Table 9-4 Ratio of N:P and DIN:PO_4 in the surface waters in summer (December-February) and winter (June-August) using the Derwent long-term monitoring sites (2004-2015), based on median monitoring data from DEP and partners

SURFACE WATER	U2 (closest to Selfs Pt)		G2 (closest to Mac Point)		E (closest to Blinking Billy)	
50th percentile	Summer	Winter	Summer	Winter	Summer	Winter
TN (mg/L)	0.255	0.300	0.245	0.297	0.240	0.320
TP (mg/L)	0.040	0.033	0.039	0.037	0.034	0.039
Ratio N:P	6.7	9.4	6.1	8.3	7.0	8.3
NO_x (mg/L)	0.002	0.060	0.002	0.062	0.002	0.057
NH_4 (mg/L)	0.005	0.028	0.005	0.022	0.004	0.018
PO_4 (mg/L)	0.010	0.013	0.007	0.015	0.006	0.014
Ratio DIN:PO_4	1.0	6.8	0.9	5.4	1.0	5.5

Table 9-5 Ratio of N:P and DIN:PO_4 in the bottom waters in summer (December-February) and winter (June-August) using the Derwent long-term monitoring sites (2004-2015), based on median monitoring data from DEP and partners

BOTTOM WATER	U2 (closest to Selfs Pt)		G2 (closest to Mac Point)		E (closest to Blinking Billy)	
50th percentile	Summer	Winter	Summer	Winter	Summer	Winter
TN (mg/L)	0.270	0.320	0.250	0.310	0.250	0.310
TP (mg/L)	0.047	0.040	0.044	0.038	0.044	0.040
Ratio N:P	5.9	7.7	6.3	7.8	5.9	7.3
NO_x (mg/L)	0.004	0.059	0.002	0.058	0.004	0.055
NH_4 (mg/L)	0.012	0.017	0.0.8	0.010	0.007	0.012
PO_4 (mg/L)	0.014	0.017	0.011	0.016	0.012	0.015
Ratio DIN:PO_4	1.4	4.5	1.1	4.4	1.1	4.5

*Note: a ratio of <7 implies Nitrogen limitation, > 7 implies Phosphorus limitation