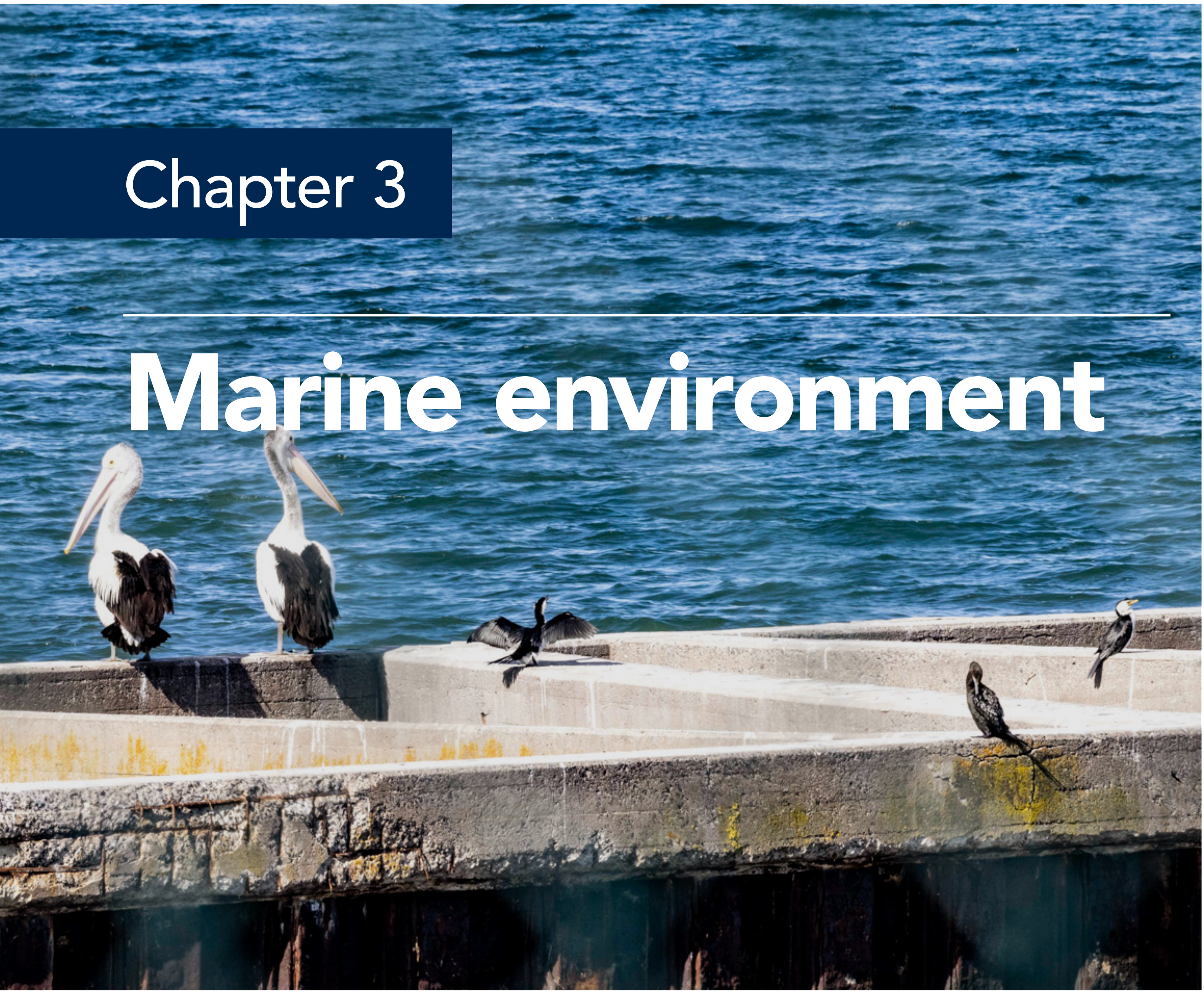
Chapter 3

Marine environment



A full assessment was completed of the potential impacts on the marine environment from the project as part of the Environment Effects Statement (EES) (Technical Report A: *Marine ecology and water quality impact assessment*, hereafter referred to as the marine EES study).

The original marine EES study concluded that construction and operation of the project is unlikely to have adverse impacts on the chemical and physical attributes of the marine environment, habitat conditions and the ecological character of Corio Bay, including the Point Wilson/Limeburners Bay section of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsular Ramsar site.

The Inquiry and Advisory Committee (IAC) wrote that the four existing discharges from the refinery have been operating for years and that there would be no change in the flow rates or chlorine concentrations in the discharges, whether or not the project proceeds. However, the IAC concluded that "it is difficult to conclusively determine that existing Refinery discharges are having acceptable impacts".

The IAC recommended that "a monitoring program should be established to assess the existing impacts of refinery discharges more rigorously and establish a better baseline for ongoing monitoring of the effects of the project on the marine environment" (IAC Report No. 1, section 7.4 (iii)).

Additionally, the IAC concluded that because the regional hydrodynamic model underpins the assessment of the project's marine impacts, further work should be undertaken to refine the calibration of the model "so that it more closely reproduces observed tidal range, tidal exchange and currents" to provide "a more reliable basis" on which to assess the project's effects on the marine environment (IAC Report No. 1, section 7.5 (iii)).

Furthermore, because "the regional hydrodynamic model provides key input parameters for the modelling on which the assessment of the project's marine impacts is based" the IAC recommended that wastewater and sediment transport and modelling be re-run based on the refined model (IAC Report No. 1, sections 7.6 (iii) and 8.3 (iv) respectively).

The refinery has been taking in seawater for many years and the volume of seawater extracted will not change whether or not the project proceeds. The IAC findings stated that the impacts of entrainment as a result of the project (when compared to existing conditions) "are likely to be relatively contained, as indicated by the entrainment modelling" but recommended re-running the entrainment modelling based on the refined regional hydrodynamic model to confirm this (IAC Report No. 1, section 7.7 (iv)).

The IAC stated that the source-path-receptor approach utilised in the EES to determine the impacts of dredging on seagrass was acceptable but recommended further work to assess potential impacts on seagrass utilising the revised sediment transport modelling and updated seagrass mapping. The IAC noted that it was appropriate for the EES to adopt a minimum light threshold approach for assessing impacts of dredging on seagrass but recommended adopting 10% Surface Irrandance (SI) and 20% SI light availability thresholds when undertaking the further assessment work (IAC Report No. 1, section 8.5 (iii)).

This chapter provides a summary of the supplementary marine environment study that has been undertaken in response to Recommendations 1 to 8 in Table 1 of the Minister for Planning's Directions (Minister's Directions) for the Viva Energy Gas Terminal Project (the project) Supplementary Statement.

This chapter summarises the outcomes of the following technical assessment:

- Technical Report A: Supplementary marine environment impact assessment.

The objectives of this chapter are to:

- Provide a summary of the technical responses to Recommendations 1 to 8 of the Minister's Directions.
- Integrate the outcomes of the supplementary marine environment study with key outcomes of the original marine EES study. Provide an update to the EES marine environment mitigation measures where necessary.

Overview

The Minister's Directions relevant to the supplementary marine environment study were Recommendations 1 to 8 which required:

- Further survey work to better establish the existing environment and the impacts of existing wastewater discharges from the refinery to enable the better understanding of project impacts.
- Further targeted investigations into the effects of existing chlorine discharges from the refinery to confirm likely project impacts resulting from chlorination by-products.

- Refinement of the regional hydrodynamic model.
- Re-running of the wastewater discharge, entrainment and sediment transport modelling based on the refined regional hydrodynamic model.
- Further assessment of dredging impacts and confirmation that dredging would not impact the Ramsar site.

Extensive field surveys were undertaken to measure and assess the existing temperature plume from the refinery discharge points. The temperature measurements were also used to infer chlorine concentrations in the discharge plume. It was determined that the existing temperature and chlorine discharge plumes are within guideline values and do not reach the Ramsar site. In addition, extra seagrass mapping was undertaken to further understand the impacts of existing refinery discharges. Surveys undertaken adjacent to the refinery and at the Ramsar site indicated that there was no significant difference in seagrass cover. This suggested that existing refinery discharges are not having a significant impact on seagrass.

The regional hydrodynamic model was updated to include a greater horizontal and vertical resolution and the FSRU as a barrier. The refined regional hydrodynamic model was peer reviewed and determined to be fit for purpose to assess potential impacts to Corio Bay from the project. The refined regional hydrodynamic model was able to satisfactorily simulate the measured extent and temperature of the existing refinery discharge plumes. The wastewater discharge model, entrainment model and sediment transport model were each re-run using the refined regional hydrodynamic model.

The re-run wastewater discharge model indicated that predicted temperature and chlorine discharge plumes from the discharge of the cooled FSRU wastewater following reuse in the refinery would be within guideline values and do not reach the Ramsar site. The predicted temperature and chlorine plumes from the alternative diffuser discharge were within guideline values and the predicted 20:1 dilution was verified by an independent modelling specialist.

The additional analysis of chlorine by-products in mussels was undertaken to further assess the potential impacts of the existing chlorine discharge on marine life in Corio Bay and at the Ramsar site. Mussels were deployed within the existing discharge plumes and then tested for chlorine by-products. The results reported concentrations below laboratory limits of detection. It is concluded that the existing chlorine discharges present a minimal risk to marine life in Corio Bay and at the Ramsar site.

The results of the entrainment modelling indicated that there would be no significant difference in the entrainment of plankton and fish eggs from the Ramsar site during operation of the FSRU in comparison to existing refinery operations. The overall entrainment rates are negligible in comparison to natural processes such as predation and starvation.

The predicted suspended solids plume from dredging activities would not impact the Ramsar site. There would be larger areas and higher concentrations of suspended solids on the seabed than on the surface, although the rate of sediment accretion would have negligible impact on seagrasses and the infauna or mobile marine communities that inhabit the muddy seabed. Seagrass would not be removed during dredging activities at Refinery Pier and seagrass in Corio Bay and the Ramsar site would receive enough available light, indicating that there is a low risk to seagrass growth during dredging. Dredging would not impact the Ramsar site.

3.1 Methodology

3.1.1 Minister's Directions

Table 1 of the Minister's Directions consolidates the recommendations for further work to inform the Supplementary Statement. The Minister's Directions relevant to the supplementary marine environment study are presented in **Table 3-1** below

Table 3-1 Minister's Direction relevant to the supplementary marine environment study

Recommendation	Description	Section addressed
Recommendation 1	Undertake further survey work to better establish the existing environment and the impacts of existing wastewater discharges from the refinery to enable better understanding of Project impacts. The survey work should: a. Cover intertidal, littoral and subtidal habitats that could potentially be affected by the project, including the Ramsar site. b. Update seagrass mapping to include the intertidal zone and information on the different seagrass species. c. Be carried out over a period of at least 12 months before construction or dredging starts, with a minimum of four sampling runs (one in each season) to address seasonal variability. d. Establish a better baseline for monitoring during and after the project to confirm predicted outcomes on shoreline and benthic communities, including seagrasses and macroalgae.	Section 3.3.1
Recommendation 2	Refine calibration of the regional hydrodynamic model so that it more accurately reproduces observed water levels, currents, tidal range and tidal exchange in Corio Bay. Consider: a. The selection of the most appropriate wind data. b. More detailed horizontal resolution to represent the Hopetoun and North Channels more accurately. c. More detailed vertical resolution to represent discharge plumes in shallow waters more accurately. d. The effects of the presence of the Floating Storage Regasification Unit (FSRU) on currents. e. Peer review of the model calibration.	Section 3.3.2
Recommendation 3	Re-run the wastewater discharge modelling with revised inputs based on the refined hydrodynamic model. Consider: a. Revising the nearfield modelling of discharges from the diffuser to address the matters raised by Dr McCowan in his written evidence (D75). b. The IAC's recommended default guideline values (DGV) for chlorine discharges (7.2 microgram per litre in Corio Bay generally, including the Project area; 2.2 microgram per litre at the Ramsar site).	Section 3.3.3

Recommendation	Description	Section addressed
Recommendation 4	Consider undertaking further targeted investigations into the effects of existing chlorine discharges from the refinery to confirm likely project impacts resulting from chlorination by-products, including measurement of chlorination by-product concentrations in: a. Seawater. b. Biota that have high susceptibility to contamination.	Section 3.3.4
Recommendation 5	Re-run the entrainment modelling with revised inputs based on the refined hydrodynamic model.	Section 3.3.5
Recommendation 6	Re-run the sediment transport modelling with revised inputs based on the refined hydrodynamic model. Consider including a 'worst-case' scenario for sediment fractions and settling rates which includes the largest expected proportions of fine and very fine materials that have the slowest expected settling velocities.	Section 3.3.6
Recommendation 7	Undertake further assessment of dredging impacts on seagrass based on: a. The revised sediment transport modelling. b. Revised light thresholds of 10 % to 20 % surface irradiance (20 % surface irradiance should be applied to any sediment plumes that extend to the Port Phillip Bay (western shoreline) and Bellarine Peninsular Ramsar Site). c. The updated seagrass mapping (Rec. 1b).	Section 3.3.7
Recommendation 8	Confirm the EES conclusion that dredging will not impact the Ramsar site after considering: a. The revised marine modelling. b. The revised assessment of impacts on seagrass.	Section 3.3.8

A summary of the tasks that were undertaken to address the items of further work is provided below:

- Methodology for Recommendation 1: To better understand the existing environment and the impacts of existing wastewater discharges from the refinery, comprehensive sampling of water temperature was conducted in the existing refinery discharge plumes to identify the extent of the plumes (when water temperature returned to ambient) and chlorine concentrations were inferred. Additionally, seagrass mapping in proximity to the refinery and at the Ramsar site was undertaken.
- Methodology for Recommendation 2: Refine the regional hydrodynamic model using the most appropriate wind data (Geelong or Avalon), more detailed horizontal resolution to represent the Hopetoun and North Channels more accurately, more detailed vertical resolution to represent discharge plumes in shallow waters more accurately and with the inclusion of the FSRU to observe its effect on currents.
- Methodology for Recommendation 3: The wastewater discharge modelling was repeated using the refined regional hydrodynamic model (Recommendation 2) and with consideration to the near-field modelling of discharges from the proposed diffuser located on Refinery Pier.
- Methodology for Recommendation 4: Seven sets of mussels were deployed along the existing refinery plumes for four weeks and analysed for a range of potential chlorine residuals to further investigate existing chlorine discharges from the refinery and the potential effects of the accumulation of chlorinated by-products in marine organisms.
- Methodology for Recommendation 5: The entrainment modelling was repeated using the refined regional hydrodynamic model (Recommendation 2) and with consideration to fish breeding sites in Corio Bay and the entrainment of particles from seagrass zones in Corio Bay.
- Methodology for Recommendation 6: The sediment transport modelling was repeated using the refined regional hydrodynamic model (Recommendation 2) and with consideration to the expected proportions of fine and very fine materials from various dredging areas and loss rates from the large bucket dredge.
- Methodology for Recommendation 7: The potential impacts on seagrass beds from dredging activities was assessed by determining the extent of seagrass that may have reduced light, calculating the frequency and duration of events with less than the minimum 10 % surface irradiance in Corio Bay and 20 % surface irradiance within the Ramsar site recommended by the IAC, and by comparing predicted dredging impacts with actual impacts observed from previous dredging programs in Corio Bay.
- Methodology for Recommendation 8: The sediment transport modelling (Recommendation 6) was updated and the further assessment of impacts of dredging on seagrass (Recommendation 7) was conducted to confirm that dredging will not impact the Ramsar site.
- Identify any additional mitigation measures, if necessary.
- Confirm significance level of construction and operational impacts on the marine environment.

3.1.2 Study area

Consistent with the original marine EES study, the study area for the supplementary marine environment study considered all of Corio Bay as well as the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (Ramsar site) with a focus on the marine environment surrounding the project site at Refinery Pier.

3.2 Summary of the original marine EES study impact assessment

A full assessment of the potential impacts on the marine environment from the project was conducted as part of the original marine EES study. In accordance with Recommendations 1 to 8 in Table 1 of the Minister's Directions, the focus of the supplementary marine environment study was to better establish the existing environment and the impacts of existing wastewater discharges from the refinery, refine the regional hydrodynamic model and re-run the wastewater discharge modelling, entrainment modelling and sediment transport modelling, and confirm the significance level of marine environment impacts associated with project construction and operation.

As part of the original marine EES study, field investigations were carried out over a 12-month period to understand the baseline conditions of the marine environment. Field investigations included current, temperature and water quality monitoring, assessment of bathymetry, surveys of the seabed habitat and plankton and larvae surveys. The seabed and shoreline of Corio Bay have been substantially modified over the last 170 years with shipping channels being dredged, the western shoreline being established for industrial uses, the Port of Geelong being developed, and seawalls, marinas and jetties constructed as part of Geelong's urbanisation. Despite these developments, field investigations indicated that Corio Bay has good water quality and a diverse range of marine life that has adapted to the existing conditions of the Bay. Corio Bay has a dynamic and self-sustaining ecosystem which includes approximately 1,000 species of plants and animals.

Construction

The original marine EES study concluded that potential impacts related to construction activities (i.e., localised dredging, excavation of a trench for installation of the seawater transfer pipe, construction of a temporary loadout facility at Lascelles Wharf and construction of the extension to Refinery Pier) such as turbidity, light attenuation, habitat modification and underwater noise would be temporary and localised and would not result in significant impacts to nearby populations and communities. Furthermore, it was considered likely that any altered conditions (e.g., turbidity, light availability) would return to original conditions within a short period of time after the construction activity ceases.

The original marine EES study proposed mitigation measures to manage these potential impacts such as avoiding dredging during spring when marine productivity is highest; installation of a silt curtain to minimise turbidity in the water column near seagrass beds and at the refinery seawater intake; and turbidity, seabed biota and plankton monitoring.

Operation

For 70 years, Viva Energy's Geelong Refinery has been using up to 350 megalitres (ML) per day of seawater from Corio Bay for cooling purposes. This seawater is then discharged to Corio Bay at temperatures warmer than the ambient seawater temperature and with residual levels of chlorine associated with biofouling control through four Environment Protection Authority (EPA) licensed discharge outlets. The project would also require the use of seawater for LNG heating purposes as part of operation of the FSRU.

The original marine EES study determined that the reuse of the cooled FSRU discharge water in the refinery during operation would result in no change to the total volume of seawater extracted from Corio Bay, no change to the volume of water discharged from the refinery, no change in residual chlorine levels and an improvement in the temperature of the discharge compared to the existing refinery discharge. As the refinery discharge has been occurring for 70 years, the original marine EES study was able to assess empirical evidence of potential effects of chlorine and temperature levels associated with these long-term discharges.

The field surveys undertaken for the original marine EES study did not identify evidence of negative impacts on marine ecology under the existing refinery discharge plumes which have been occurring over the past 70 years. Seagrass in the past 70 years vicinity of the plume was observed to be abundant and healthy; sea urchins, which are considered to be sensitive to chlorine, were abundant in the current discharge plumes; and tests on mussels from the vicinity showed no detectable residual chlorine. As such, this empirical evidence provided confidence that it would be highly unlikely that there would be adverse impacts on the marine environment from operation of the FSRU and reuse of the seawater in the refinery, as the proposed discharge is an overall improvement when compared within the quality of the existing discharges.

An alternative discharge arrangement for the project, also assessed in the original EES, would involve direct discharge of some, or all, of the cooled FSRU discharge water into Corio Bay via a diffuser located under the Refinery Pier extension. The diffuser could be used during refinery maintenance periods when the rate of FSRU discharge could exceed the refinery demand for seawater and would be used in the event that the refinery was decommissioned in the future and the option for reuse of the FSRU discharge water in the refinery was no longer available. Modelling undertaken for the original marine EES study showed that, due to high dilution, the resulting chlorine and temperature plumes on the seabed would be localised within the shipping channel and well below temperature and chlorine guideline limits.

Entrainment modelling in the original marine EES study showed that the project would result in a slight increase to the proportion of plankton entrained in the FSRU seawater intake from the Ramsar site and northern and southern Corio Bay compared to the current refinery intake. However, these entrainment rates were considered low to negligible in comparison to natural predation and other losses.

The original EES proposed monitoring for the rates and characteristics of all FSRU wastewater discharges, either from the refinery or directly into Corio Bay, to confirm that the discharge rate, temperature and chlorine concentration are within the values stipulated in the EPA licence conditions and, if not, provide the trigger for remedial action.

3.3 Outcomes of supplementary tasks

The following sections present the outcomes of the tasks undertaken in the supplementary marine impact assessment in response to Recommendations 1 to 8 of the Minister's Directions.

3.3.1 Existing environment and impacts of existing wastewater discharges

Undertake further survey work to better establish the existing environment and the impacts of existing wastewater discharges from the refinery to enable better understanding of Project impacts. The survey work should:

a. Cover intertidal, littoral, and subtidal habitats that could potentially be affected by the project, including the Ramsar site.Update seagrass mapping to include the intertidal zone and information on the different seagrass species.
b. Be carried out over a period of at least 12 months before construction or dredging starts, with a minimum of four sampling runs (one in each season) to address seasonal variability.
c. Establish a better baseline for monitoring during and after the project to confirm predicted outcomes on shoreline and benthic communities, including seagrasses and macroalgae.
d. Establish a better baseline for monitoring during and after the project to confirm predicted outcomes on shoreline and benthic communities, including seagrasses and macroalgae.

3.3.1.1 Extent and impact of existing refinery temperature and chlorine plumes

The usual regasification mode of the FSRU for this project is open loop. Further information on the FSRU and its modes of operation can be found in EES Chapter 4: *Project description*. Open loop regasification mode would involve transfer of the cooled discharge water from the FSRU via a seawater transfer pipe to the existing refinery seawater intake for reuse in the refinery as cooling water.

The refinery currently uses approximately 350 ML/day of seawater for cooling purposes. After use, the seawater is returned to Corio Bay via four discharge points (W1, W3, W4 and W5 from south to north) along the foreshore in front of the refinery (refer to **Figure 3-1**).

The discharge water can be up to 10 degrees Celsius (°C) above ambient temperature and can contain residual chlorine concentrations up to 40 micrograms per litre (µg/L) at the point of discharge.

Temperature rise was used as the primary indicator of the extent of the existing refinery discharge plumes because it can be measured directly in the field; chlorine decays quickly and cannot be measured in the field.

As part of this supplementary study, additional temperature monitoring around the area of the existing refinery discharge plumes was conducted to measure vertical temperature profiles and verify the accuracy of the temperature modelling predictions conducted for the marine studies. Temperatures in the existing plumes were measured monthly with 3000 to 5000 measurements recorded in each survey. Contour maps of temperature measurements confirm that the plumes flow to the north following the currents of the bay and also confirm that the actual temperatures in Corio Bay are consistent with the modelled results (further discussed in **Section 3.3.2**).

Design guideline values for temperature and chlorine

Updated Design Guideline Values (DGV) for temperature were determined with reference to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Based on the annual variation in seawater temperature in Corio Bay from 11°C to 22°C, the 50 to 80 percentile temperature range is 3.3°C. Therefore, the adopted DGV for temperature variation in Corio Bay is 3°C.

A more stringent temperature DGV of 2°C was adopted for the Ramsar site which at its closest point is 830m north-east of the W5 discharge although it is noted that natural temperature variations in the Ramsar site, particularly Limeburners Bay, are larger than in Corio Bay.

A less stringent temperature DGV of 5°C was defined for the intertidal zone based on the natural variations in atmospheric temperature that intertidal seagrass experiences.

The DGV for chlorine-producing oxidants (CPO) from the Environment Reference Standard (EPA 2021) as follows:

- 95% protection (Corio Bay) CPO = 10 µg/L.
- 99% protection (Ramsar site) CPO = 4.3 µg/L.

Extent of existing temperature plumes

Figure 3-1 presents the extent of the measured temperature plume for the existing refinery discharges. The temperature increase (i.e., temperature increase from ambient) is currently 5°C within 150 m of discharge W5. The +3°C contour extends approximately 560m to the north along the shore from W5. The +2°C contour extends a further 90 m north along the shore but does not reach the Ramsar site including Limeburners Bay. The temperature plumes from the current refinery operations do not extend to the Ramsar site or have any impact on ambient water temperature within the site.

Being warmer than the surrounding seawater, the plumes are buoyant and form a shallow surface layer (typically within the top 1m). The biota which could potentially be affected by the discharges are in the intertidal zone, on the seabed in the subtidal zone to a depth of 1 m below low tide, and the top of seagrass in the subtidal zone up to a depth of 2 m.

Figure 3-1 Envelope of extent of measured temperature plumes
(Note: The extent of plume envelopes in Figure 3-1 is not the outline of an instantaneous plume but the extent of all plumes in all directions based on six surveys of plume temperature.)

Extent of existing chlorine plumes

To establish chlorine concentrations in the existing refinery plumes it was necessary to develop a correlation between temperature and residual chlorine concentration and use it to convert the measured temperature contours into equivalent chlorine contours. This method was used as chlorine rapidly reaches non-detect levels in seawater and could not be measured even at short distances from the refinery discharge points. Using this method, the shape and extent of the chlorine plumes and 10 µg/L and 4.3 µg/L chlorine contours (corresponding to the DGV for chlorine in Corio Bay and the Ramsar site respectively) were determined.

The inferred chlorine plumes are shown in **Figure 3-2**. For all discharges, the inferred 10 µg/L chlorine contour is within the mixing zone defined in the refinery's current EPA operating licence. The inferred 4.3 µg/L chlorine contour extends approximately 200 m from W1 and approximately 60 m from W5. The chlorine level in the plume would be less than 4.3 µg/L well before the Ramsar site and the small extent of the measured plumes demonstrates that there is negligible risk of chlorine from the existing discharges reaching the Ramsar site and having any impact on biota.

Figure 3-2 Inferred chlorine contours in existing plumes. Current EPA operating licence mixing zones shown in yellow.

3.3.1.2 Seagrass distribution

Intertidal and subtidal seagrass distribution and density has been assessed throughout northern Corio Bay, along both the refinery shoreline and in the Ramsar site, in many surveys conducted in 2020-2021 (for the original marine EES study) and 2023-2024, using a towed underwater camera and composite low-level drone images. Seagrass was also inspected visually at low tide to ground-truth and classify the photographs that were collected.

The results of the surveys showed that the main seagrass species in Corio Bay are a combination of *Nanozostera muelleri* (Muelleri) in the intertidal zone and *Heterozostera nigricaulis* (H. nigricaulis), Halophila australis (Halophila) and *Althenia marina* (Althenia) in the subtidal zone. The results also showed an increase in seagrass cover in 2023 compared to 2021. Cover of medium and dense seagrass was about 60 % in 2021 and increased to about 75% in 2023.

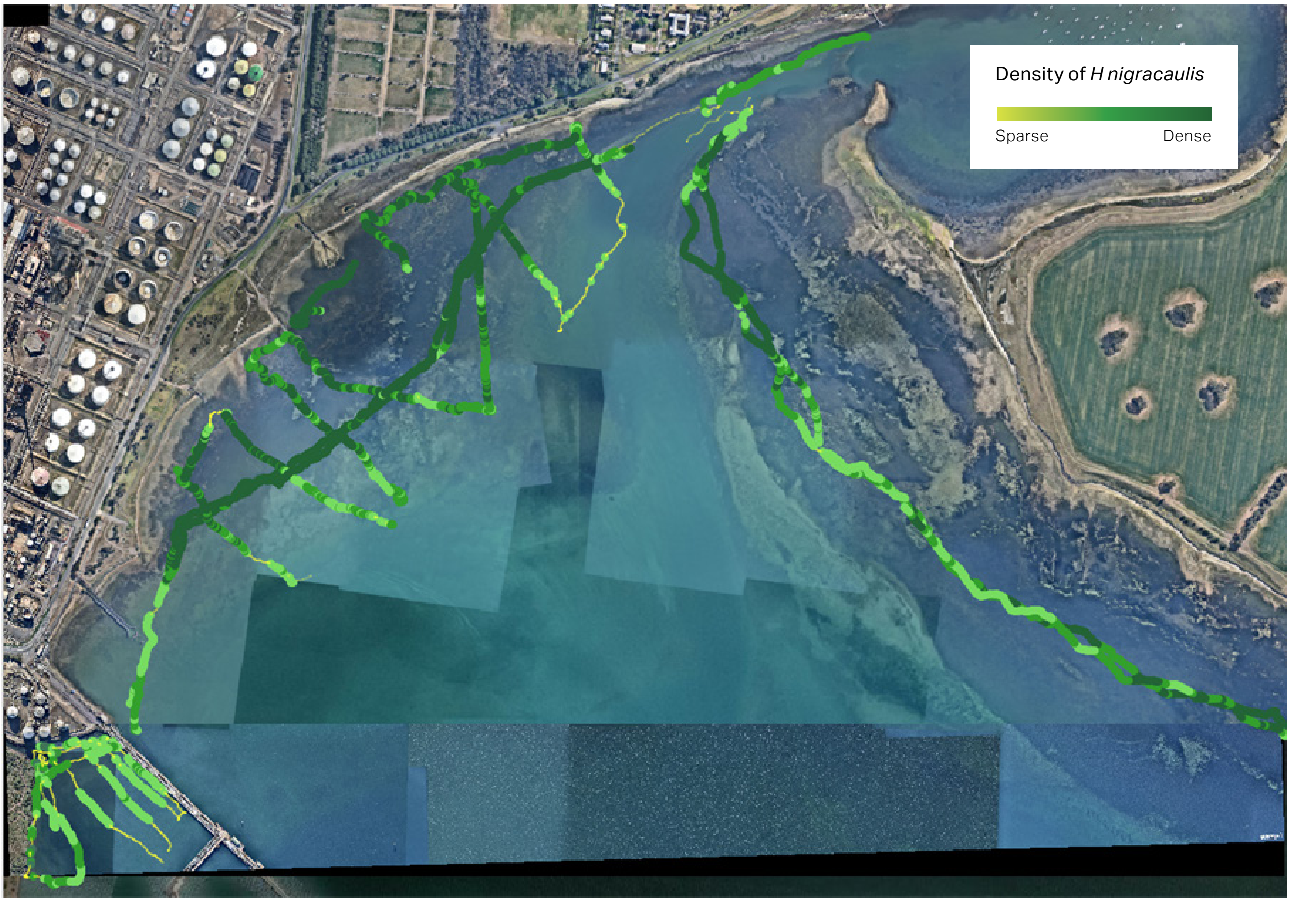


Figure 3-3 Results of seagrass mapping - density of H. nigricaulis

Figure 3-3 shows the results of the transect tows for H. nigricaulis. Light green to dark green circles represent sparse to dense seagrass cover. The map shows H. nigricaulis is the dominant species of seagrass in Corio Bay through all months and is found growing densely around the discharges and in the Ramsar site.

Figure 3-4 shows the results of the transect tows for Halophila. Light blue to dark blue circles represent sparse to dense seagrass cover. It was observed that Halophila typically grows in deeper water than the denser H. nigricaulis and is therefore found further offshore. No Halophila was observed close to the existing refinery discharges.

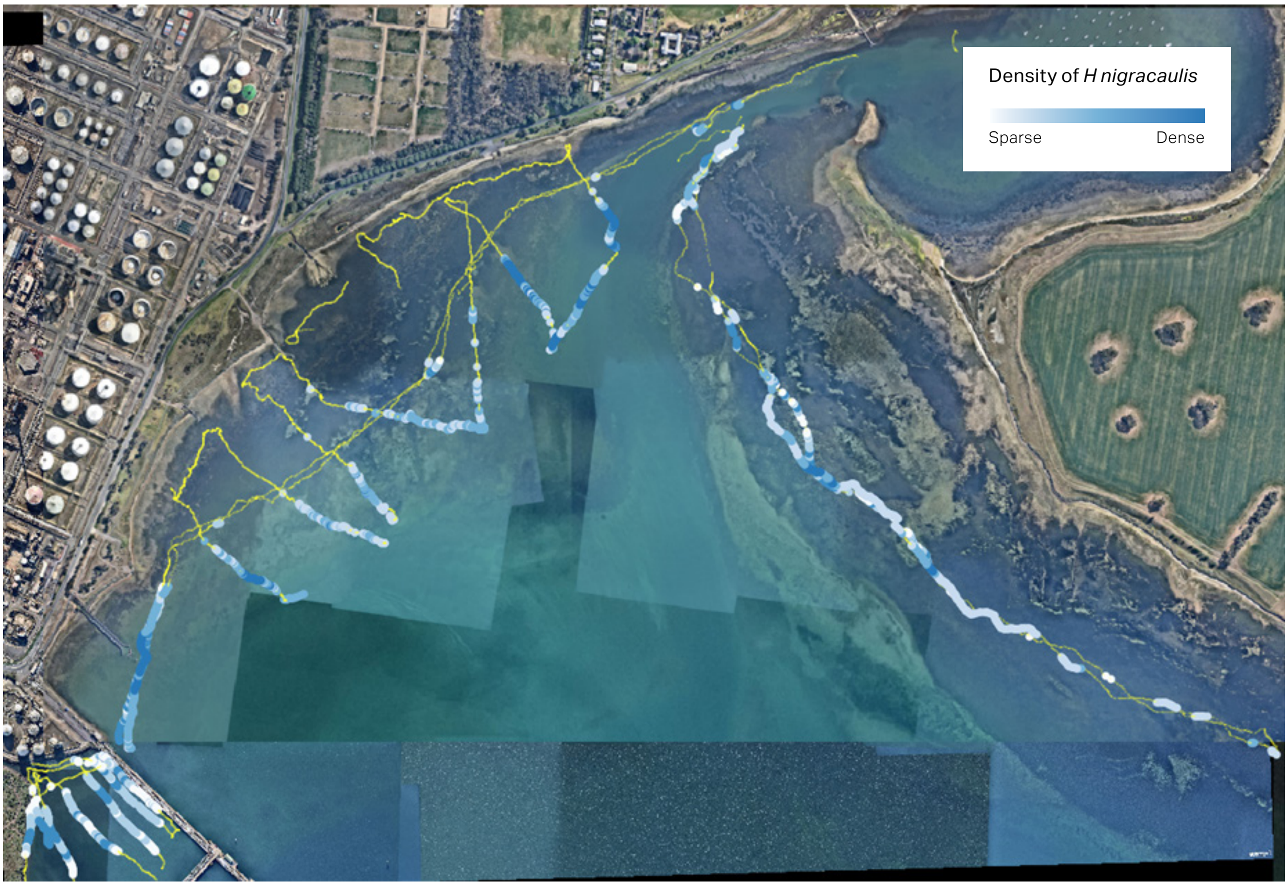
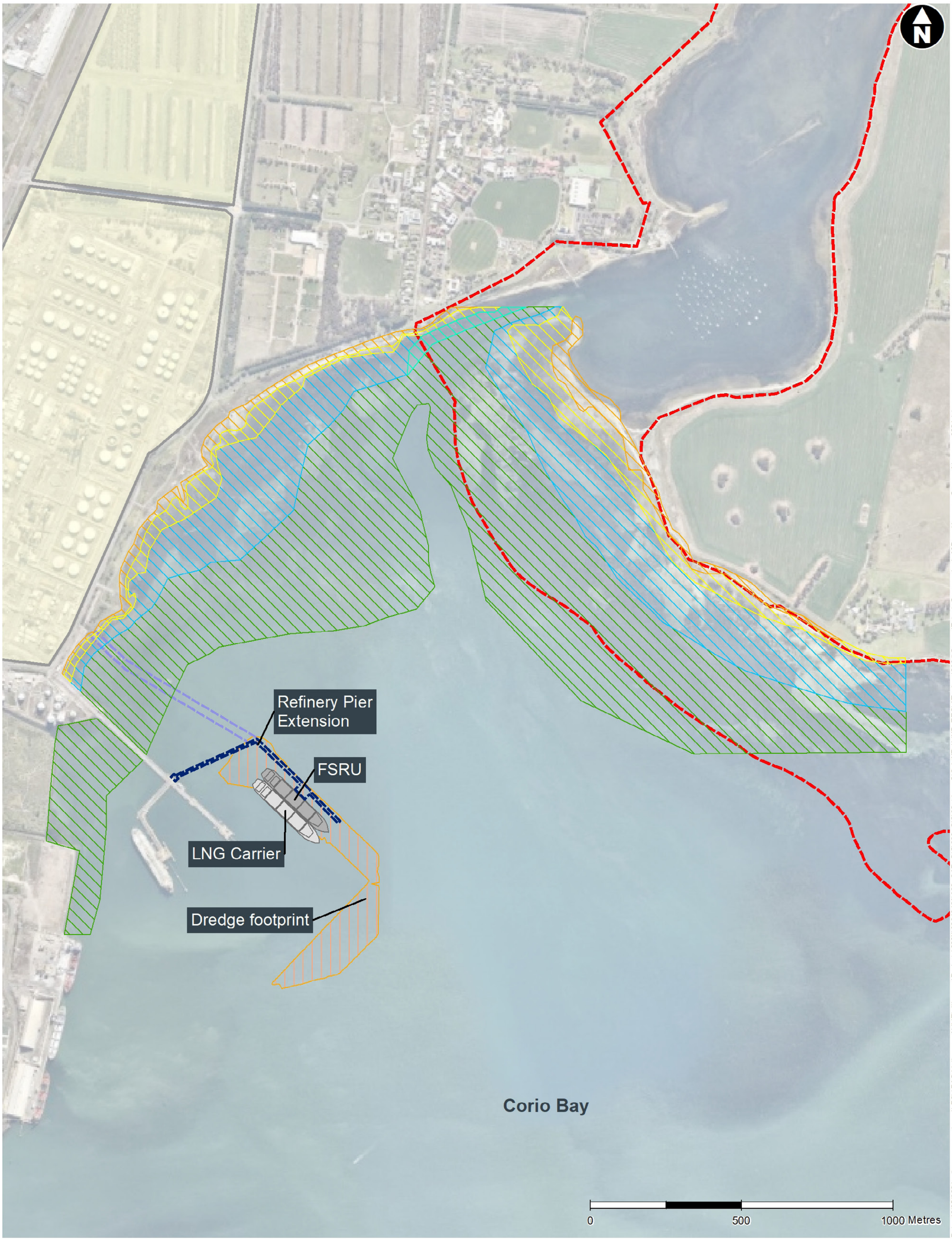


Figure 3-4 Results of seagrass mapping – density of Halophila

Figure 3-5 shows a map of intertidal and subtidal seagrass zones based on the species found in each zone. The orange zone shows the intertidal zone which is dominated by Muelleri as well as some green algae which can be observed at several points along the shoreline. The yellow zone represents the transition zone from intertidal seagrass to subtidal seagrass and includes a combination of Muelleri and H. nigricaulis. The darker blue zone represents the shallow subtidal area that contains a combination of H. nigricaulis and Althenia, although is dominated by H. nigricaulis. The lighter blue zone represents an area of broadleaf Muelleri in the entrance to Limeburners Bay, this seagrass is the same species as Muelleri however because it is found in the shallow subtidal zone has broader leaves. The green zone represents the deeper subtidal area with a combination of H. nigricaulis and the deeper Halophila. The shallower part of this zone is typically dominated by H. nigricaulis. At greater depth, Halophila is more dominant. At around 5 m below the surface there is insufficent available light to support seagrass growth and the seabed is bare sand and mud.

As described above, the refinery discharge plumes are buoyant and form a shallow surface layer. Muelleri in the intertidal and shallow subtidal zones in the vicinity of the W2 to W5 discharge points is routinely exposed to the discharges. H. nigricaulis and Althenia are also exposed to the discharges most of the time close to the discharge points and regularly in shallow water along the path of the plume. Seagrass that is more than 2 m below mean sea level is seldom exposed to the discharges as the plume occupies the layer of water above the seagrass. Halophila is a short plant and generally grows in waters too deep to be exposed to the discharge plumes



- Seawater Transfer Pipe
- Refinery Pier Extension
- Dredged Area
- Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site
- Viva Energy owned land
- Muelleri
- Short H. nigricaulis Mixed with Intertidal Seagrass
- H. nigricaulis Mixed with Broadleaf Muelleri
- H. nigricaulis with Scattered Althenia
- Halophilia Mixed H. nigricaulis

Figure 3-5 Seagrass distribution in northern Corio Bay

3.3.1.3 Impact of existing discharges on seagrass

Seagrass surveys as described above were conducted during the winter, spring and summer of 2023.

Figure 3-6, to assess impacts, four transect lines parallel to the coast, two in the intertidal zone and two in the subtidal zone were defined. As reference sites, two intertidal lines and two subtidal lines were defined at two sites in the Ramsar zone well away from the refinery discharges. Survey points were defined at 15 m intervals along each transect. Seagrass cover was assessed within a 2 m by 2 m area at each point using a four-level scale from dense to bare sediment and plotted to show the variation in cover with distance along each line.

The results are summarised in **Table 3-2** and **Figure 3-7** for intertidal seagrass cover and in **Table 3-3** and **Figure 3-8** for subtidal seagrass cover.

Figure 3-6 Location of intertidal and subtidal transects

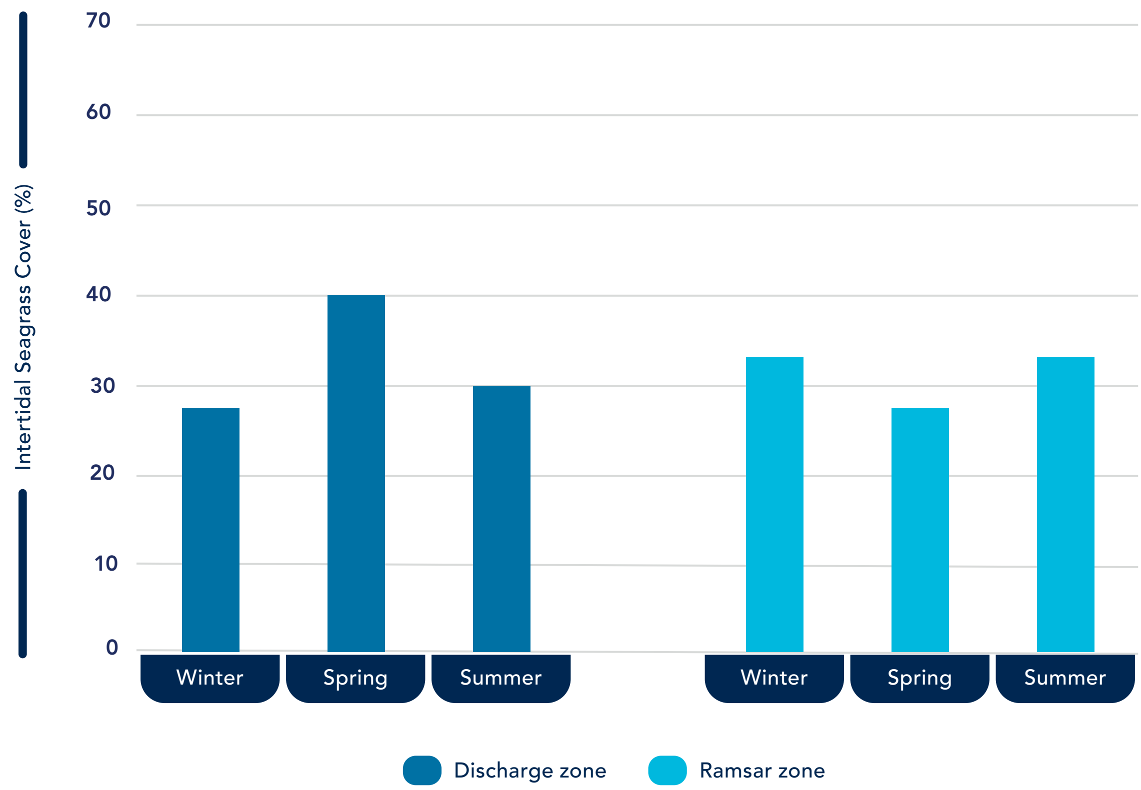


Figure 3-7 Average intertidal seagrass cover

Table 3-2 Average intertidal seagrass cover

Discharge zone				Ramsar Zone		
Winter						
Cover	**W3**	**W4-5**	**Average**	**Ref 1**	**Ref 2**	**Average**
Bare	33%	16%	25%	23%	7%	15%
Sparse	30%	35%	33%	28%	59%	43%
Moderate	23%	34%	29%	23%	15%	19%
Dense	7%	12%	9%	20%	19%	20%
Average	21%	32%	**27%**	33%	31%	**32%**
Spring						
Bare	43%	14%	29%	17%	54%	36%
Sparse	13%	38%	26%	39%	45%	28%
Moderate	22%	24%	23%	34%	29%	32%
Dense	22%	24%	23%	10%	2%	6%
Average	33%	39%	**36%**	31%	18%	**24%**
Summer						
Bare	23%	22%	23%	0%	52%	26%
Sparse	38%	44%	41%	30%	13%	22%
Moderate	15%	21%	18%	55%	30%	43%
Dense	23%	12%	18%	15%	5%	10%
Average	33%	26%	**30%**	45%	23%	**34%**

For the intertidal zone over all three seasons, there was an average 33% seagrass cover at the refinery

For the intertidal zone over all three seasons, there was an average 31% seagrass cover at the refinery discharge sites and an average 30% seagrass cover in the Ramsar reference sites.

For the subtidal zone over all three seasons, there was an average 72% seagrass cover at the refinery discharge sites and an average 69% seagrass cover at the Ramsar reference sites.

Statistical analysis using a T-test, a type of analysis which checks if there is a significant difference between two data sets, has shown there is no significant effect on seagrass cover in the discharge zone and the seagrass cover in the Ramsar zone for all three seasons.

Table 3-3 Average subtidal seagrass cover

Discharge zone				Ramsar Zone		
Winter						
Cover	**W3**	**W4-5**	**Average**	**Ref 1**	**Ref 2**	**Average**
Bare	3%	4%	4%	11%	4%	8%
Sparse	17%	6%	12%	11%	7%	9%
Moderate	27%	38%	32%	30%	19%	24%
Dense	53%	52%	52%	48%	70%	59%
Average	66%	69%	**67%**	62%	77%	**69%**
Spring						
Bare	3%	4%	4%	2%	5%	3%
Sparse	7%	10%	9%	17%	4%	10%
Moderate	30%	18%	24%	29%	19%	24%
Dense	60%	68%	64%	52%	72%	62%
Average	73%	75%	**74%**	66%	78%	**72%**
Summer						
Bare	0%	2%	1%	2%	6%	4%
Sparse	17%	9%	13%	21%	13%	17%
Moderate	24%	19%	22%	17%	25%	21%
Dense	59%	70%	64%	60%	56%	58%
Average	70%	77%	**73%**	68%	67%	**67%**

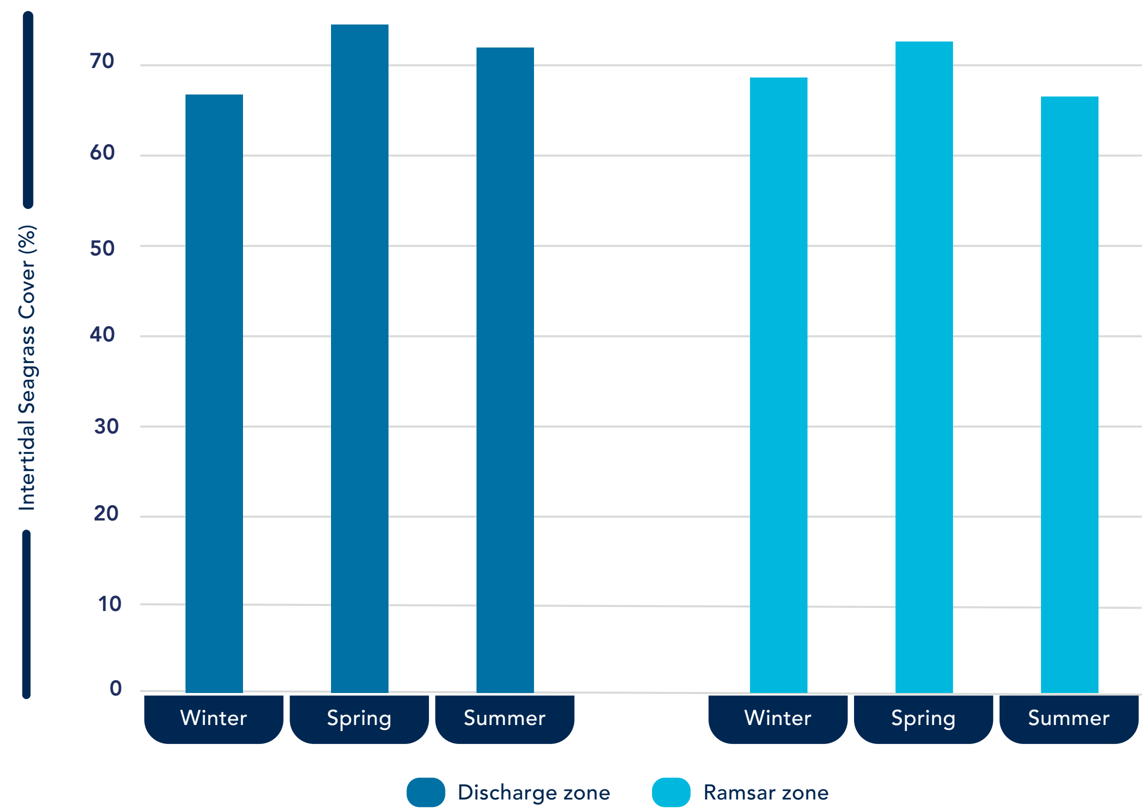


Figure 3-8 Average subtidal seagrass cover

Figure 3-9, Figure 3-10 and **Figure 3-11** show seagrass growing in the plumes from discharge points W3, W4 and W5. Seagrass was observed growing directly in the discharge plumes at the same density and health as elsewhere.

The analysis of temporal variations in seagrass cover at a local scale indicate that patches of seagrass in Corio Bay come and go with seasonal changes as well as other factors including sea urchins (which feed on seagrass), nutrient availability and seabed characteristics. **Figure 3-12** presents the variation in seagrass cover in Port Phillip Bay, beyond the study area for this assessment.

3.3.1.4 Proposed baseline surveys prior to dredging

The longer and more extensive survey required by this Recommendation will be carried out over the 12 month period before dredging commences, with a minimum of four sampling runs (one in each season). The supplementary marine study has shown that seagrass cover in Port Phillip Bay and Corio Bay varies from year to year. Therefore, the baseline studies need to be scheduled in the year just prior to dredging to appropriately define the seagrass baseline.

Figure 3-9 Muelleri growing in W3 plume

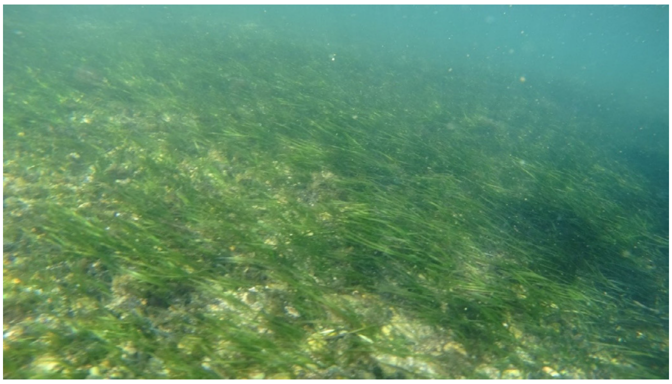


Figure 3-10 Dense H. nigricaullis growing in W4 plume

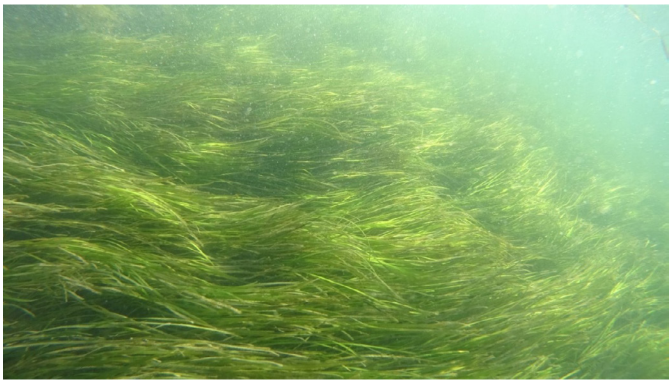


Figure 3-11 H. nigricaulis growing in W5 plume

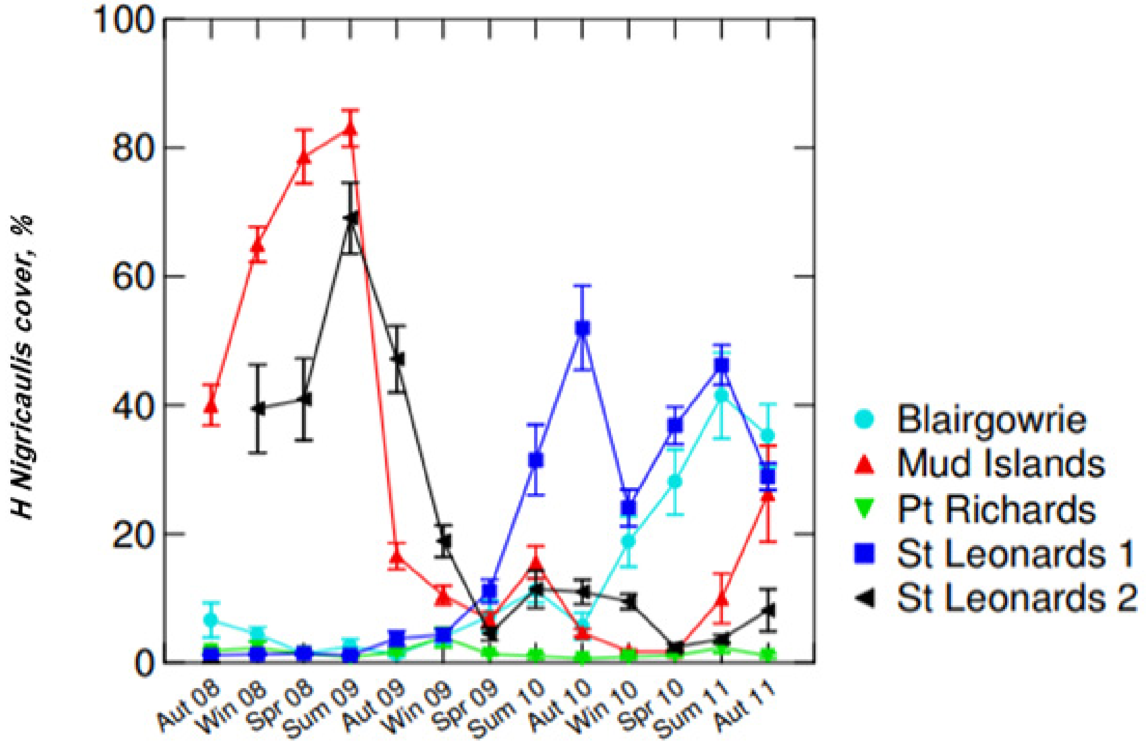


Figure 3-12 Variation in seagrass cover in Port Phillip Bay (Jenkins et al, 2015)

3.3.2 Refining the regional hydrodynamic model

Refine calibration of the regional hydrodynamic model so that it more accurately reproduces observed water levels, currents, tidal range, and tidal exchange in Corio Bay. Consider:

a. The selection of the most appropriate wind data.
b. More detailed horizontal resolution to represent the Hopetoun and North Channels more accurately.
c. More detailed vertical resolution to represent discharge plumes in shallow waters more accurately.
d. The effects of the presence of the Floating Storage Regasification Unit (FSRU) on currents
e. Peer review of the model calibration

Hydrodynamic modelling is the study of fluids, such as seawater, in motion. Near field and regional hydrodynamic models were developed for the project and used in the original EES to:

- Simulate the existing currents, temperatures, and salinities in Corio Bay.
- Predict the fate and transport of fine sediments (clay and silt) that are likely to be mobilised during dredging and dredge spoil disposal.
- Predict the path and dispersion of the discharge plumes, including cooled or warmed chlorinated discharges from the Geelong Refinery and the FSRU.
- Simulate the potential transport and dispersion of plankton and larvae from different regions of the bay and predict the entrainment of plankton in the seawater intakes during operation of the FSRU.

The near-field model was used to predict the The path, initial dilution and extent of the discharge plumes close to the point of discharges. The predictions from the near-field modelling were then incorporated into the regional model which was used to simulate the existing conditions of Corio Bay and predict potential impacts related to construction and operation of the project.

In summary, for the supplementary marine environment study, the following refinements were made to the regional hydrodynamic model:

- A new CALMET - a wind model which constructs three-dimensional wind and temperature fields from meteorological measurements, topography, and land use data - wind file was created. This wind file combines and interpolates between measured wind fields at Geelong Racecourse, Avalon Airport, Point Wilson and the Geelong Refinery. It was selected as the most appropriate for predicting potential impacts of the project and was used in the model. Noting that all wind files compared in this study predicted plumes similar in extent to the measured plumes (refer to **Section 3.3.1**) because tides and currents not wind are the major factors influencing movement and mixing of the plumes in Corio Bay.
- A more detailed horizontal grid of 20 m x 20 m resolution throughout Corio Bay, Hopetoun Channel and North Channel, and extending further into the western arm of Port Phillip Bay was used to improve representation of the Hopetoun Channel and North Channel which convey most of the tidal exchange.
- An additional vertical resolution of 0.5 m in the upper 4 m of water in Corio Bay was used to better represent warm surface layers at or near the refinery discharge points.
- An update to the tidal inputs on the eastern open boundary of the model.
- The FSRU was implemented as a solid barrier in the grid (height 10 m, length 300 m and width 40 m) to match the moored FSRU at the proposed Refinery Pier extension.

In order to calibrate the refined model, the predicted plumes for the existing refinery discharges were compared to data collected and observations made during field investigations (refer to **Section 3.3.1.1**). It was found that the refined model could reproduce sea level, tidal exchange, currents, and the temperature plumes satisfactorily.

Simulated sea levels in Corio Bay were consistent with the records at Geelong over the July 2019 to February 2020 period (obtained for the original marine EES study). The tidal phase and low and high tide levels were accurately reproduced by the refined model as shown in **Figure 3-13**, with an improvement in the reproduction of low tide levels compared to the model used in the original EES.

Currents were measured in Corio Bay in summer 2020 and winter 2021 during the 12-month marine monitoring program for the original EES. A comparison between current roses generated from the measured data and the model predictions showed that the refined model reproduced measured current speeds and directions well except for producing brief periods of stronger currents in winter (with direction consistent with observed). This is an improvement on the prediction of currents in the original EES.

Temperature plumes from the existing refinery discharge measured during surveys conducted between July 2023 and January 2024 (refer to **Section 3.3.1**). Comparing this data the simulated temperature plumes modelled under comparable tide and wind conditions shows, illustrates that the refined model reproduces plumes similar in shape, temperature difference and extent to those observed along the refinery shoreline.

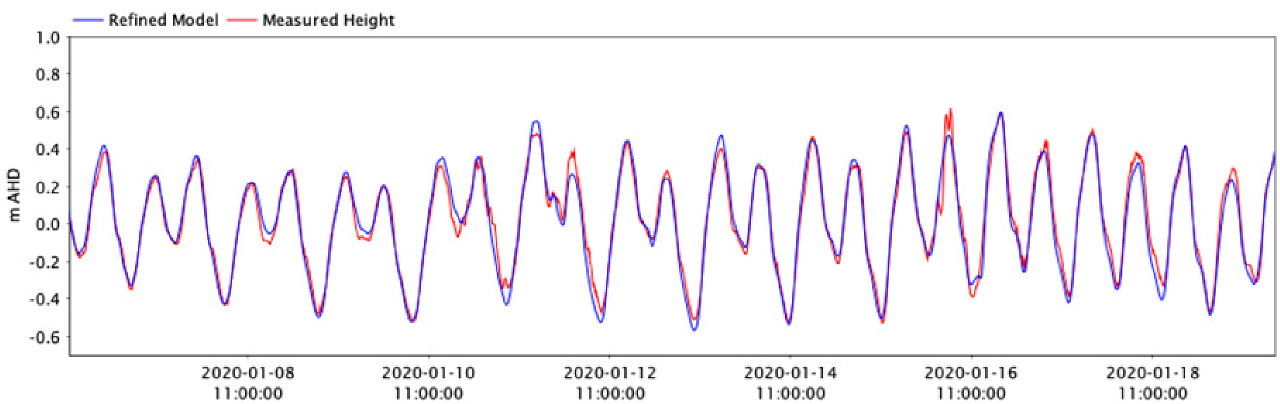


Figure 3-13 Comparison of observed and predicted tide level at Geelong

Table 3-4 below presents the average area of each of the temperature contours for the measured plumes and modelled plumes. The table shows that both the measured and modelled temperature plumes are similar in size, with the measured +2 degree and +3 degree plumes being slightly bigger in the measurements and the +5 degree contour being slightly bigger in the model.

Table 3-4 Average measured and modelled plume area

Plum Type	+2 degrees	+3 dregrees	+5 degrees
Measured	20 hectares	12 hectares	3 hectares
Modelled	18 hectares	10 hectares	5 hectares

Modelling was undertaken to illustrate the effect of the FSRU on the current pattern for northward and southward currents. Near the seabed, the FSRU and the flow from the diffuser increases the currents that flow south-west into the shipping channel during a northward surface flow, with additional fanning out of the currents around the hull of the FSRU and a very weak current flowing north-east away from the diffuser. This contrasts with the more quiescent existing conditions. During a southward surface flow, the currents in the shipping channel remain very weak for both the existing case and the project case. The FSRU increases the currents near the bed, which supports with the flow from the diffuser along the seabed.

The results of the revised modelling of the diffuser discharge using the refined model are presented in **Section 3.3.3**.

As required by the Minister's Directions an independent peer reviewer was engaged by the Department of Transport and Planning (DTP) to review the model calibration. The peer review concluded that the refined regional hydrodynamic model calibration was sound. It was recommended that additional comparisons were made between modelled and measured data to quantify the model's calibration metrics. The peer review report is provided in Attachment I of this Supplementary Statement.

The refined regional hydrodynamic model was subsequently used to re-run the wastewater discharge, entrainment and sediment transport modelling in accordance with the Minister's Directions (refer to **Section 3.3.3**, **Section 3.3.5** and **Section 3.3.6** respectively).

3.3.3 Re-running wastewater discharge modelling

Re-run the wastewater discharge modelling with revised inputs based on the refined hydrodynamic model. Consider:

a. Revising the nearfield modelling of discharges from the diffuser to address the matters raised by Dr McCowan in his written evidence (D75).
b. The IAC's recommended default guideline values (DGV) for chlorine discharges (7.2 microgram per litre in Corio Bay generally, including the Project area; 2.2 microgram per litre at the Ramsar site.

The following section discusses the wastewater discharge modelling, which has been re-run based on the refined regional hydrodynamic model. The wastewater discharge modelling relates to the discharge of seawater from the FSRU into Corio Bay, through the existing refinery discharge points, or alternatively, from the diffuser to be located under the new pier.

3.3.3.1 Predicted temperature and chlorine plumes – FSRU discharge through the refinery

This scenario would occur when the FSRU is operating in the preferred open loop operating mode. The modelled future peak flow case represents a seawater intake of 350ML/day and transferring all of the cooled discharge water from the FSRU (at approximately 7°C below ambient temperature) to the existing refinery seawater intake for reuse in the refinery as cooling water. The flow through the refinery would warm the seawater and it would be discharged to Corio Bay through the four existing discharge points (W1, W3, W4 and W5) at 7°C cooler than the existing refinery discharge temperatures (i.e., approximately 1°C to 3°C above ambient temperature).

Figure 3-14 to Figure 3-16 shows the predicted future extent of the temperature plume for the future peak flow case for summer and winter compared with existing extent of the temperature plume for the refinery discharge. With the project in operation, there would be a smaller temperature plume along the shoreline compared to the existing refinery discharges, and most of the plume would only be 1°C to 2°C above ambient seawater temperature as a result of the cooled water input from the FSRU. The project would result in a smaller plume, with lower temperatures in Corio Bay, which is considered to be an environmental improvement resulting from reuse of the FSRU discharge water. The temperature plume does not reach the Ramsar site including Limeburners Bay and returns to ambient temperatures at a substantial distance from the site.

Seawater used by the FSRU in summer would be approximately half of the seawater used in winter, given that less gas is produced in summer. As a consequence, the seawater transferred from the FSRU in winter has a greater temperature difference (close to 7°C below ambient) compared 3.5°C below ambient in summer. As the refinery increases the seawater temperature by 8°C to 9°C throughout the year, the winter discharge would be approximately 1.5°C above ambient and the summer discharge would be approximately 4°C above ambient. Therefore, the temperature plumes are small in winter and larger in summer.

Figure 3-17 shows the predicted extent of the chlorine plume for the future peak flow case. The pattern and concentrations are very similar to the existing refinery discharge plume as the same volume of seawater with the same concentration of residual chlorine would be discharged (50 μg/L). There are minor changes to the spatial extent of the plume as a result of reduced spreading due to the lower temperature of future discharge plumes resulting from the cooler discharge water from the FSRU. The chlorine plume would not extend to the Ramsar site including Limeburners Bay.

The reuse of discharge from the FSRU in the refinery for cooling water purposes would be maximised to ensure that the residual chlorine discharge to Corio Bay is minimised as far as reasonably practicable and there is a reduction in temperature plume from existing refinery discharge (refer to MM-ME01).

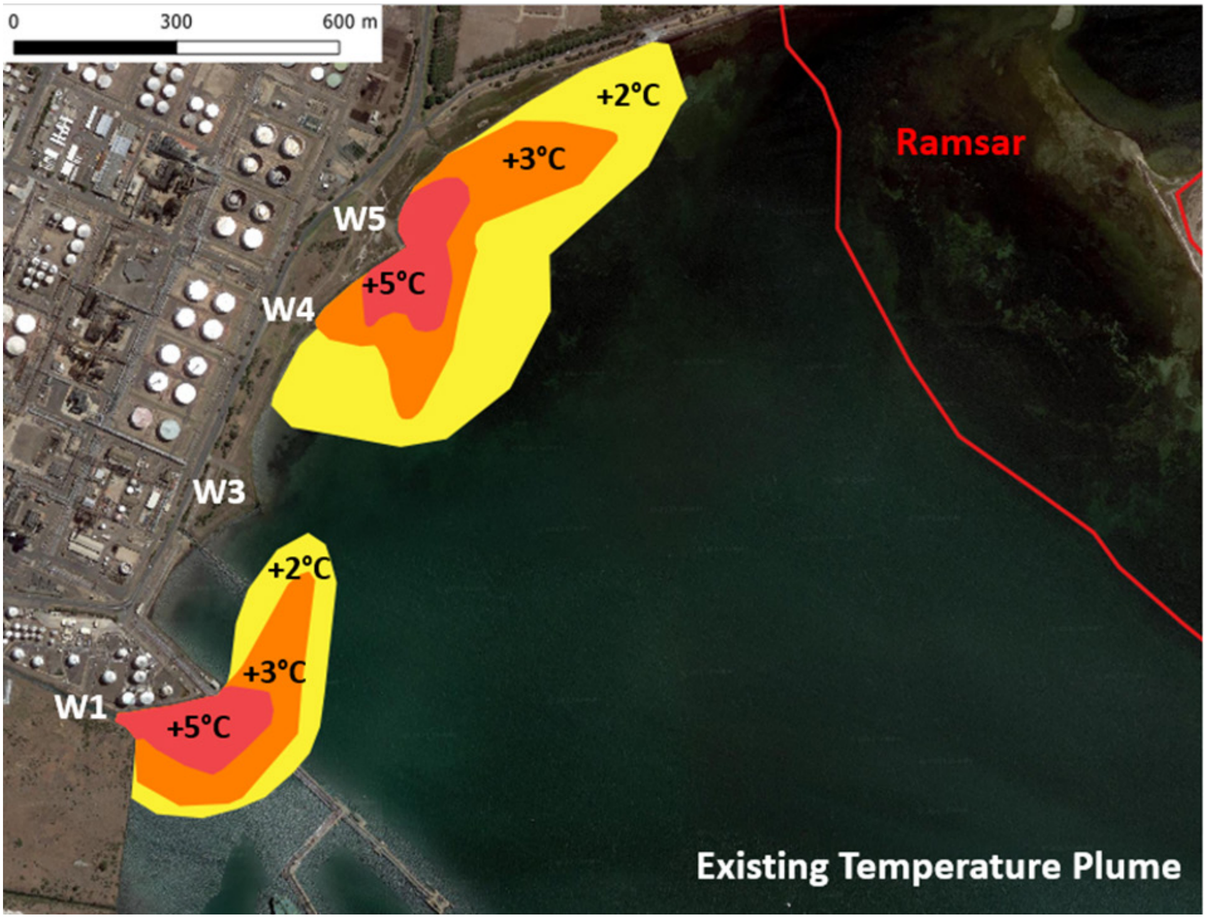


Figure 3-14 Existing temperature plume from the refinery discharge points

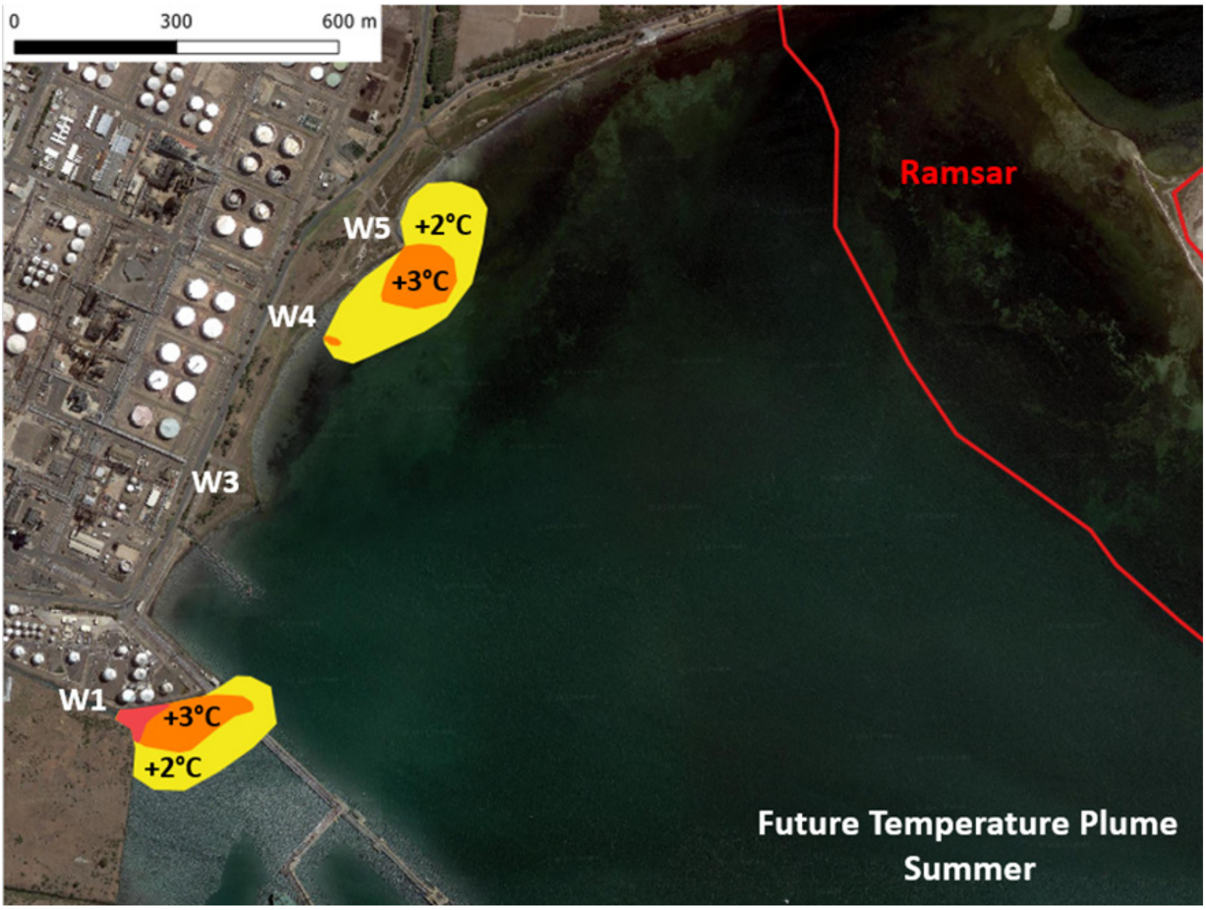


Figure 3-15 Future temperature plume with the project in operation – summer

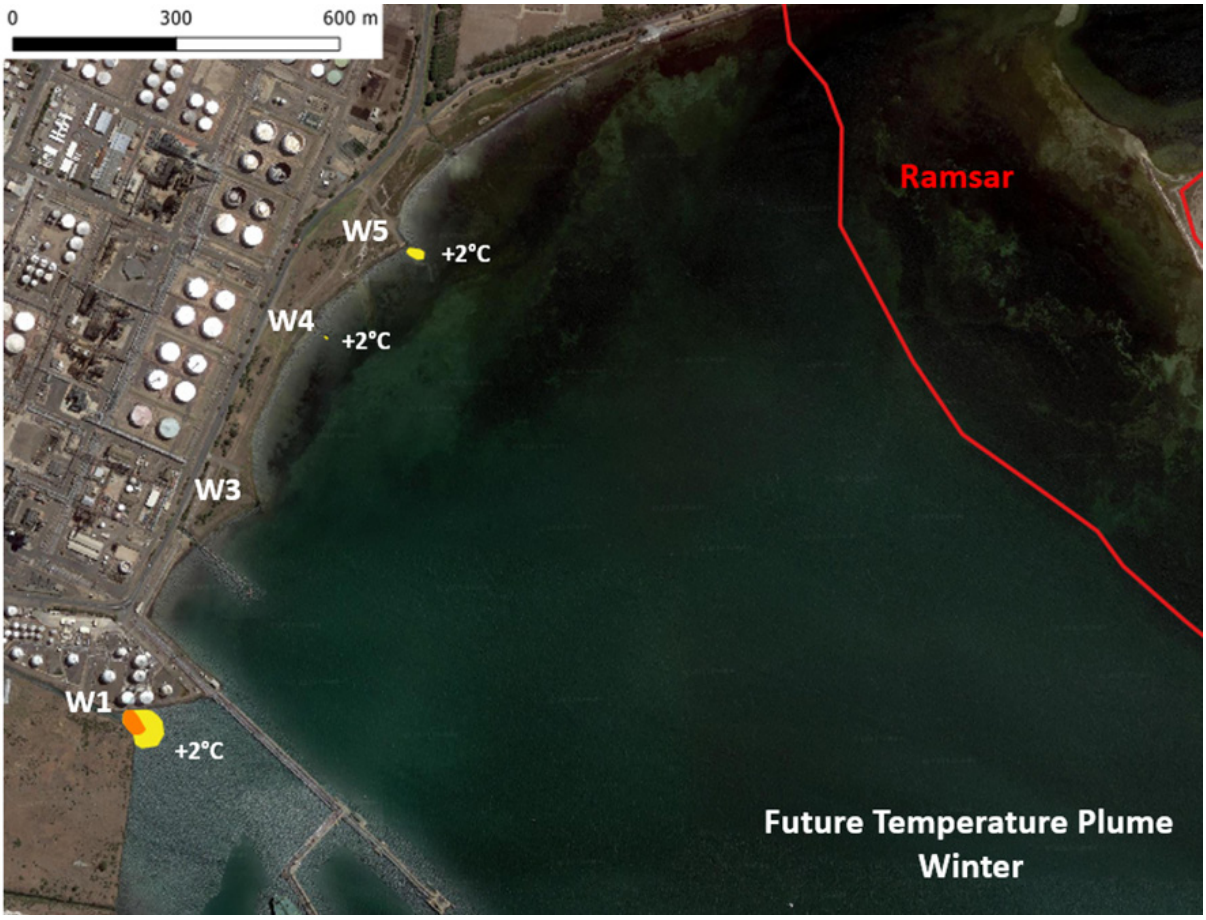


Figure 3-16 Future temperature plume with the project in operation – winter

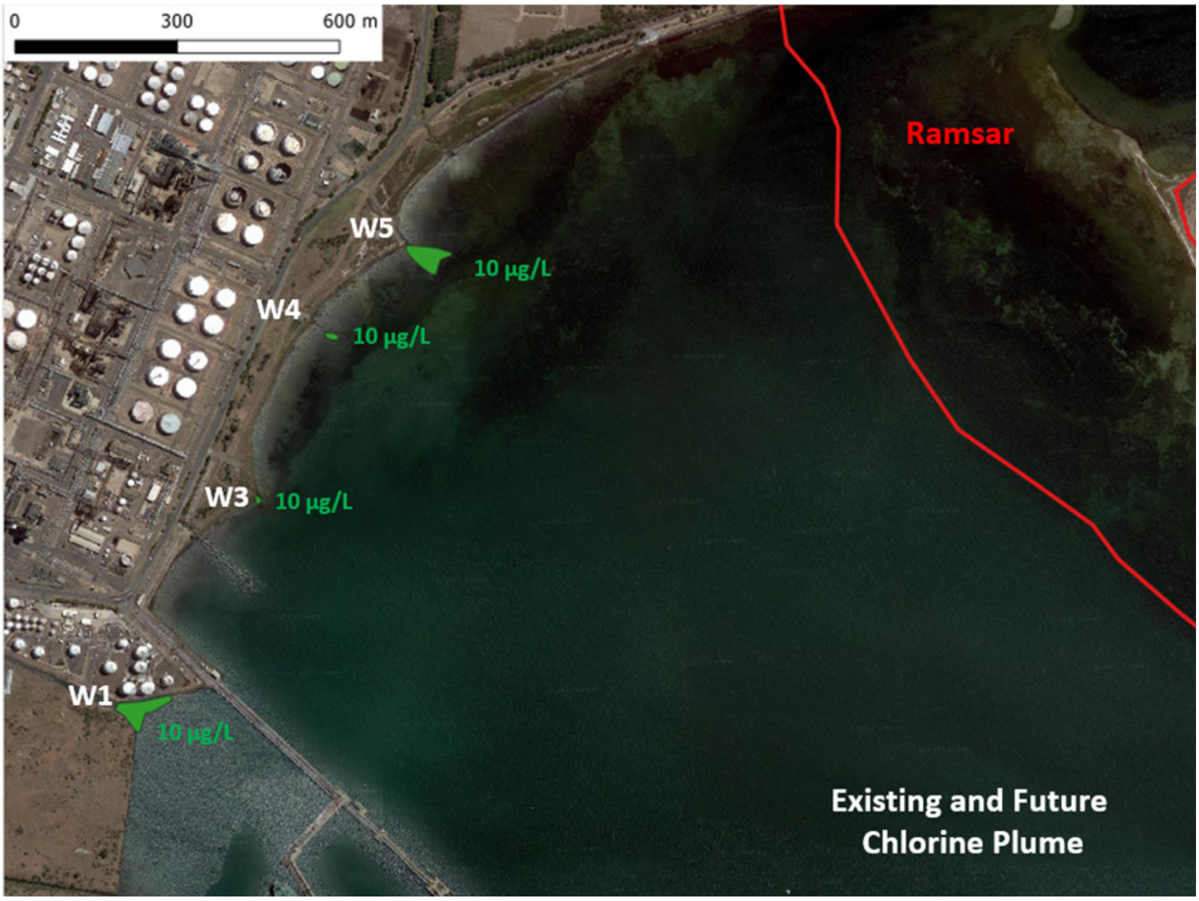


Figure 3-17 Existing and future chlorine plumes)

3.3.3.2 Predicted temperature and chlorine plumes – FSRU discharge through the diffuser

This alternative FSRU discharge scenario would only occur during refinery maintenance periods when the rate of FSRU discharge could exceed the refinery demand for seawater and would be used in the event that the refinery was decommissioned in the future and the option for reuse of the FSRU discharge water in the refinery was no longer available.

Near-field hydrodynamic model

The IAC recommended that matters raised by Dr McCowan in evidence to the IAC inquiry be addressed. During the EES IAC hearing, evidence submitted by Dr McCowan raised concern over chlorine plumes associated with diffuser discharges and stated that the modelling conducted in the original EES overestimated the dilution of chlorine following discharge via diffusers.

To address the matters raised by Dr McCowan relating to the dilution of the discharge from the diffuser, an independent modelling specialist, Professor Lee, Director of the Croucher Laboratory of Environmental Hydraulics from the University of Hong Kong was engaged to assess the dilution calculation in the original EES. Professor Lee assessed the dilution calculation using his near-field hydrodynamic model (Visjet) and verified the accuracy of the original EES calculation (refer to Section 5.3.3 of Technical Report A: Supplementary marine environment impact assessment for further information). Professor Lee reported that the plumes from the diffuser ports reached the seabed at approximately 10 m from the discharge ports before merging and predicted an initial dilution of 20:1, that is 20 parts of seawater for every 1 part of discharge. This is consistent with the initial dilution of 20:1 predicted using the INTIDIL near-field hydrodynamic model in the original marine EES study and two further models, Cederwall and VPPLUMES, in this supplementary study.

Professor Lee also undertook sensitivity testing in higher and lower ambient seawater temperatures and concluded that the predicted dilution would be the same during summer and winter.

The predicted chlorine dilution of 20:1 would reduce the expected chlorine level in the FSRU discharge from 50 µg/L to 2.5 µg/L, which is well below the DGV for chlorine in Corio Bay of 10 µg/L. It is noted that in the original EES, a conservative chlorine concentration of 100 µg/L was assumed to discharge from the FSRU. This has been revised to 50 µg/L in the Supplementary Statement, as the refinery does not exceed chlorine discharges of 50 µg/L.

Figure 3-18 shows the plume path as predicted by Professor Lee's near-field model. The FSRU is situated 50 m from the diffuser well beyond the zone of near-field dilution. Friction on the seabed slows the plume and there is a transition from supercritical flow (in the individual jets) to subcritical flow (on the seabed) through a local undular hydraulic jump (UHJ) which produces waves on the top surface of the jet flow and some further dilution. The location of the UHJ is shown in **Figure 3-18** where the individual jets reach the seabed and merge together. Noting that the flow pattern associated with the UHJ occurs at depth and does not produce significant waves on the surface of Corio Bay.

The worst-case for flow under the FSRU would be when all the LNG has been transferred to the FSRU from the LNG carrier and it is at maximum draft of 11.9 m below sea level. The LNG carrier is not shown in **Figure 3-18** because the FSRU and LNG carrier cannot be at maximum draft simultaneously because when one is fully loaded the other is not. The space between the bottom of the hull and the seabed would be 1.45 m at lowest tide when fully loaded and the velocity of the flow through this space would be 0.16 m/s. The super-elevation due to this velocity would be less than 2 mm which is significantly less than the 2 m super-elevation presented by Dr McCowan. A vessel moored in port across tidal currents can have a small super-elevation - of about a millimetre - on the side facing the current. Generally, the super-elevation is negligible in comparison with the effect of waves reaching the vessel.

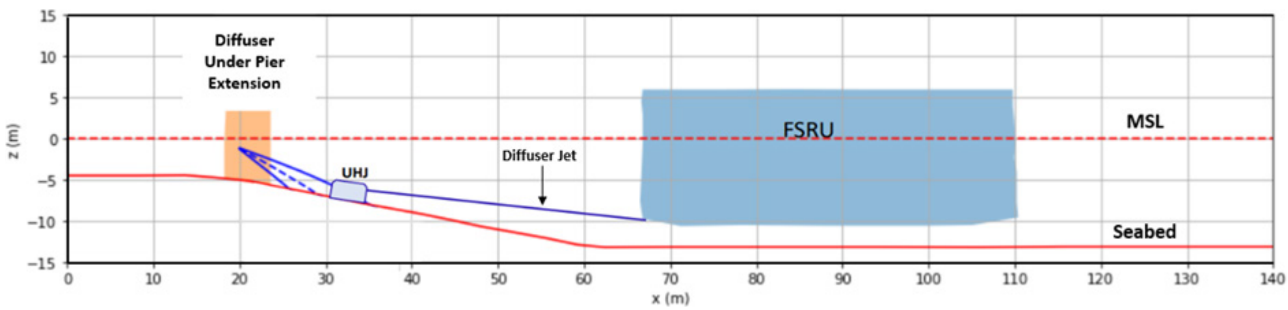


Figure 3-18 Predicted plume path from near-field model (Professor Lee, Visjet Output and Interpretation, 2023)

Regional hydrodynamic model

The connection from the near-field model described above to the refined regional hydrodynamic model described in **Section 3.3.2** was made at 19 m along the path of the plume, where the plume is on the seabed at a dilution of 20:1. **Figure 3-19** shows the predicted temperature plume on the seabed (flowing under the FSRU) from the diffuser discharge. The maximum predicted temperature contour of 0.5°C below ambient seawater temperature is well below the DGV of 3°C for temperature variations in Corio Bay.

Figure 3-20 shows the predicted chlorine plume on the seabed. The maximum predicted chlorine contour of 3 μg/L is well below the DGV of 10 μg/L for chlorine in Corio Bay.

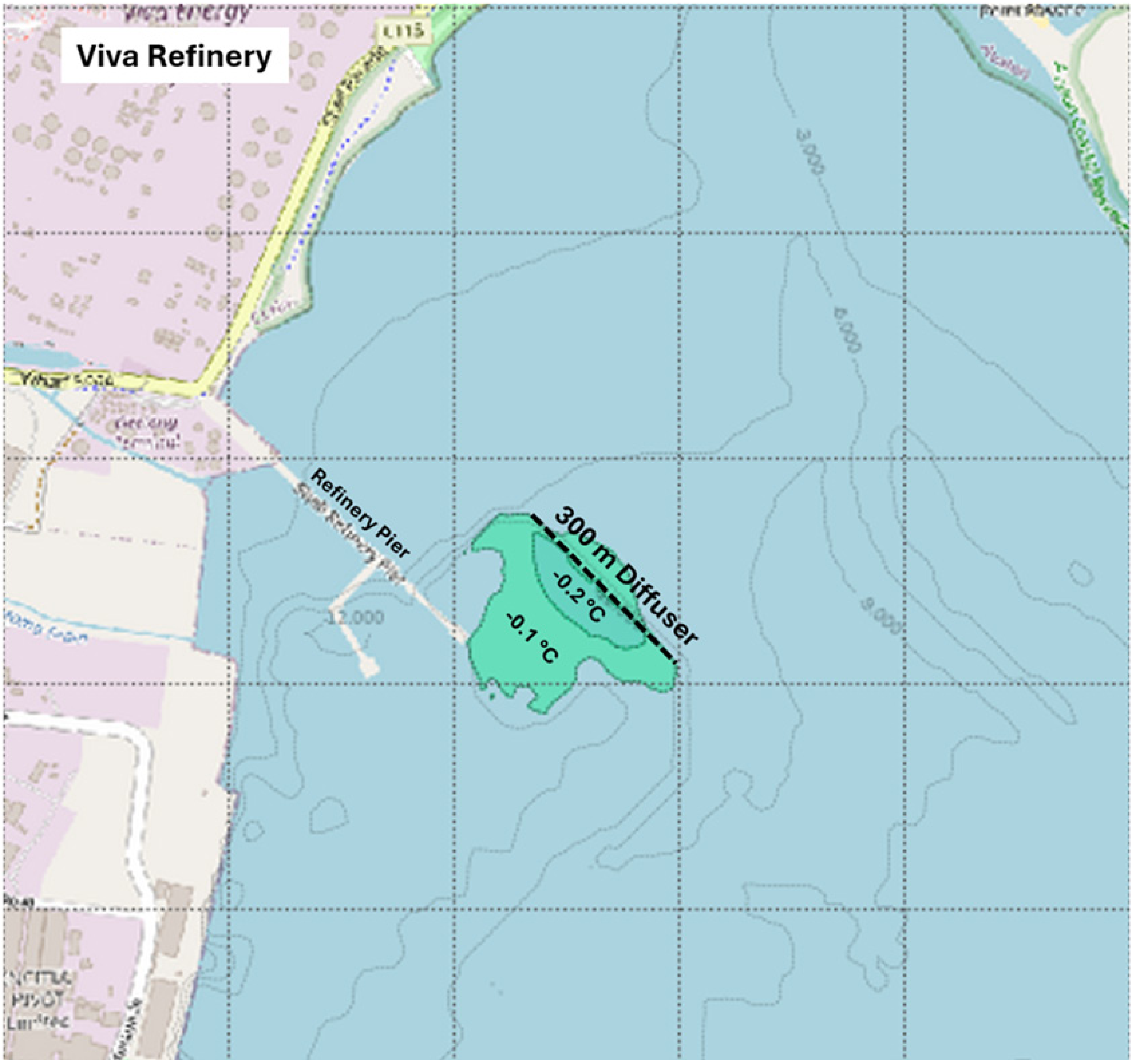


Figure 3-19 Predicted temperature plume - FSRU discharge through the diffuser.

Figure 3-20 Predicted chlorine plume – FSRU discharge through the diffuser

3.3.4 Further investigations into the effects of existing chlorine discharges

Consider undertaking further targeted investigations into the effects of existing chlorine discharges from the refinery to confirm likely project impacts resulting from chlorination by-products, including measurement of chlorination by-product concentrations in:

a. Seawater.

b. Biota that have high susceptibility to contamination.

As stated in the original marine EES study, direct measurement of chlorine or chlorine by-product concentrations in seawater is not considered feasible. Furthermore, there is no laboratory in Australia able to measure chlorine or chlorine by-products concentrations due to rapid decay to non-detect levels soon after discharge. The IAC noted this advice in its findings (IAC Report 1, section 7.4 (iii)).

For this reason, the investigations in both the original marine EES study and this supplementary study focused on whether the existing chlorine discharge from the refinery was producing significant levels of residual chemicals in marine life (i.e., mussels).

Mussels are filter-feeding marine organisms known to accumulate contaminants and are routinely used internationally in similar studies to monitor contaminant levels. In the United States, the National Centre for Coastal Ocean Science has been conducting the 'Mussel Watch' program since 1986 at 300 sites nationwide monitoring for metals and organic contaminants such as pesticides.

Seven sets of 12 mussels from Portarlington mussel farm were deployed at seven sites within the mapped extent of the existing refinery plume as shown in **Figure 3-21**. After four weeks the mussels were collected from six of the seven sites (noting the mussels from site 3 had been removed) and analysed for a wide range of chlorine residuals including trihalomethanes (THMs), haloacetic acids and bromophenols. Mussel samples were collected from Corio Bay on 19 October 2023 and were delivered to the laboratory within two hours of retrieval. The analysis was conducted on 24 November 2023. **Figure 3-21** also shows the locations from which mussels were collected for the original marine EES study.

The results for mussels from all six sites showed no detectible levels of THMs, haloacetic acids and bromophenols, The results indicate that the chlorine discharged from the refinery either decays or is volatilised in a short period, and there is no accumulation of toxic by-products in mussels or, by inference, other marine life in Corio Bay.

Figure 3-21 Locations from which mussels were obtained (2021) and locations of mussel deployment (2023) in Corio Bay

3.3.5 Refining entrainment predictions

Re-run the entrainment modelling with revised inputs based on the refined hydrodynamic model.

Entrainment is the unwanted passage of fish or small marine organisms through a water intake. The existing refinery seawater intake, which has been in place for 70 years, has resulted in a small volume of marine biota being entrained over this period.

Operation of the FSRU would also result in some entrainment of plankton, larvae and other small organisms as a result of seawater being drawn into the FSRU which has the potential to result in adverse effects on populations and productivity in Corio Bay including the Ramsar site.

To minimise the potential for entrapment, the seawater intake would be designed to keep the intake velocity in the horizontal plane at a speed below 0.15 m/s at the intake screen (a generally accepted US EPA guideline) to minimise capture of small and large fish and other free-swimming biota and to provide the same level of protection as the existing refinery intake. The intake would also be provided with a screen with apertures less than 100mm to prevent large objects and seagrass from being carried into the FSRU systems (refer to MM-ME08). The movement and dispersion of ichthyoplankton (i.e., fish eggs and larvae) in Corio Bay and Port Phillip Bay was assessed by incorporating the data collected during the 12-month original marine EES study monitoring program into the refined regional hydrodynamic model and tracking particles (as a proxy for the ichthyoplankton) using the model.

Figure 3-22 shows the ichthyoplankton abundance for the peak months of November and December 2020 expressed as larval fish units per cubic metre (m^3) of seawater. There was a large variability from month to month, but typically there were from 3 to 25 larval fish units per m^3, with an average of about 15 larval fish units per m^3 in north Corio Bay.

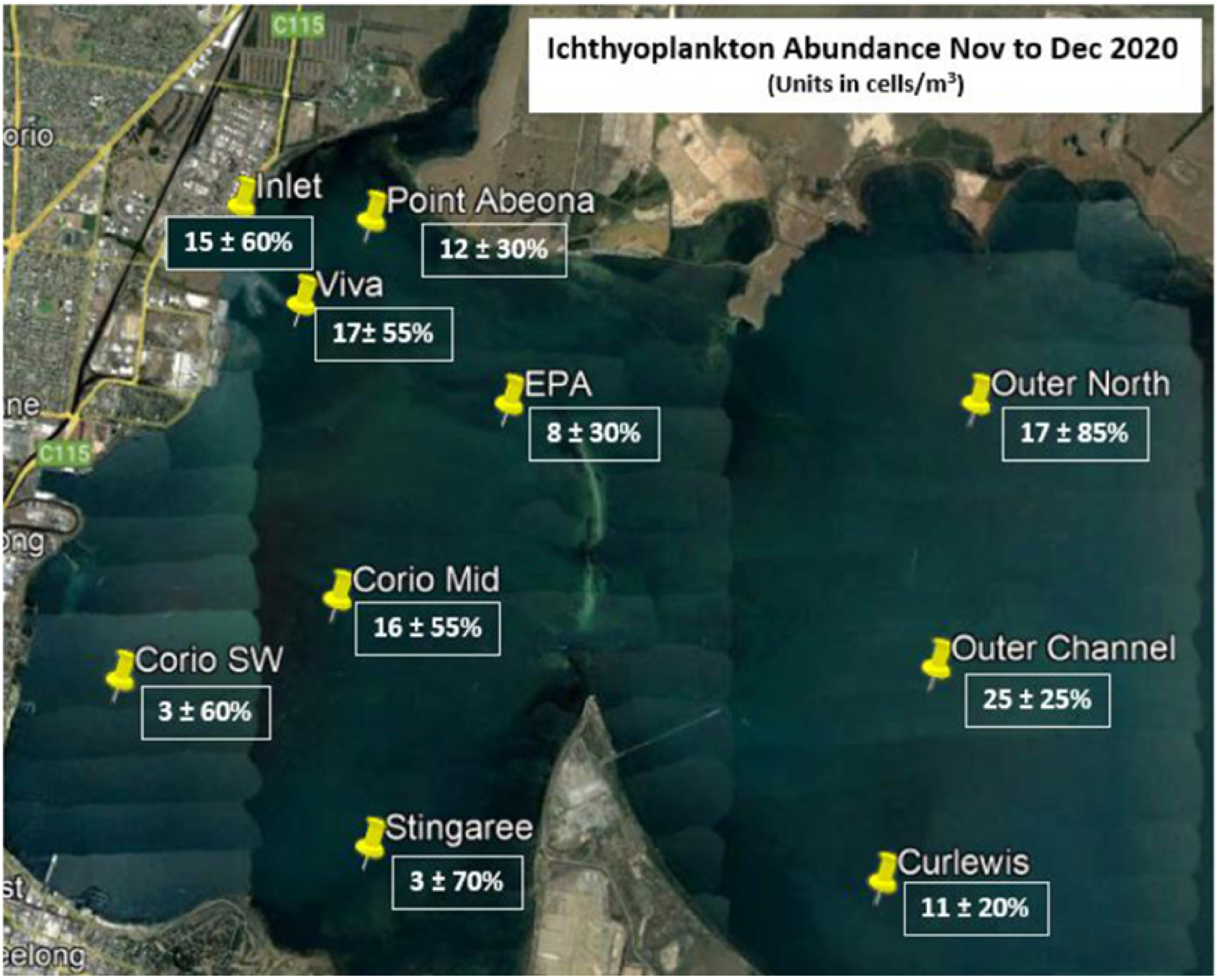


Figure 3-22 Ichthyoplankton abundance

The dispersion of ichthyoplankton was simulated from various starting points in Corio Bay and the potential for entrainment into the existing refinery intake and the proposed FSRU intake was predicted.

Following consultation with Professor Jenkins, Professorial Fellow in Fish Ecology at the University of Melbourne, regarding species and sources of fish eggs in Corio Bay, two locations were selected as starting points for the particle dispersion simulations:

- Ramsar site along the north coast of Corio Bay.
- All seagrass in Corio Bay.

The movement of the ichthyoplankton on the day of release from the Ramsar site and 7, 14 and 28 days later is illustrated in **Figure 3-23**. The results show that the particles disperse widely after their initial release from the Ramsar site.

After seven days, the particles have moved mostly eastward into Port Phillip Bay, with a smaller proportion moving down into the south-east part of Corio Bay. Only 42% of the particles remain in Corio Bay, of which 39% are in northern Corio Bay and 3% are in southern Corio Bay (an east-west line divides Corio Bay in half). This indicates that approximately half of all the particles in the Ramsar site move east out of Corio Bay.

This pattern of particle movement matches the observed current patterns, where there is a net northerly current near the western shore of Corio Bay and a slow clockwise circulation in Corio Bay.

At 14 days from release, there is an even wider distribution of particles. Only 25% remain in Corio Bay, with 51% moving into Port Phillip Bay. The particles that remain in Corio Bay after 14 days are more evenly spread between northern Corio Bay (14%) and southern Corio Bay (11%). Also, after 14 days, the particles are more evenly spread over Port Phillip Bay.

At 28 days from release, there are more particles in Port Phillip Bay than in Corio Bay, and a small percentage (2%) of particles have reached southern Corio Bay after travelling back into Corio Bay from Port Phillip Bay. After 28 days, there are more particles from the Ramsar site release in southern Corio Bay (17%) than in northern Corio Bay (9%).

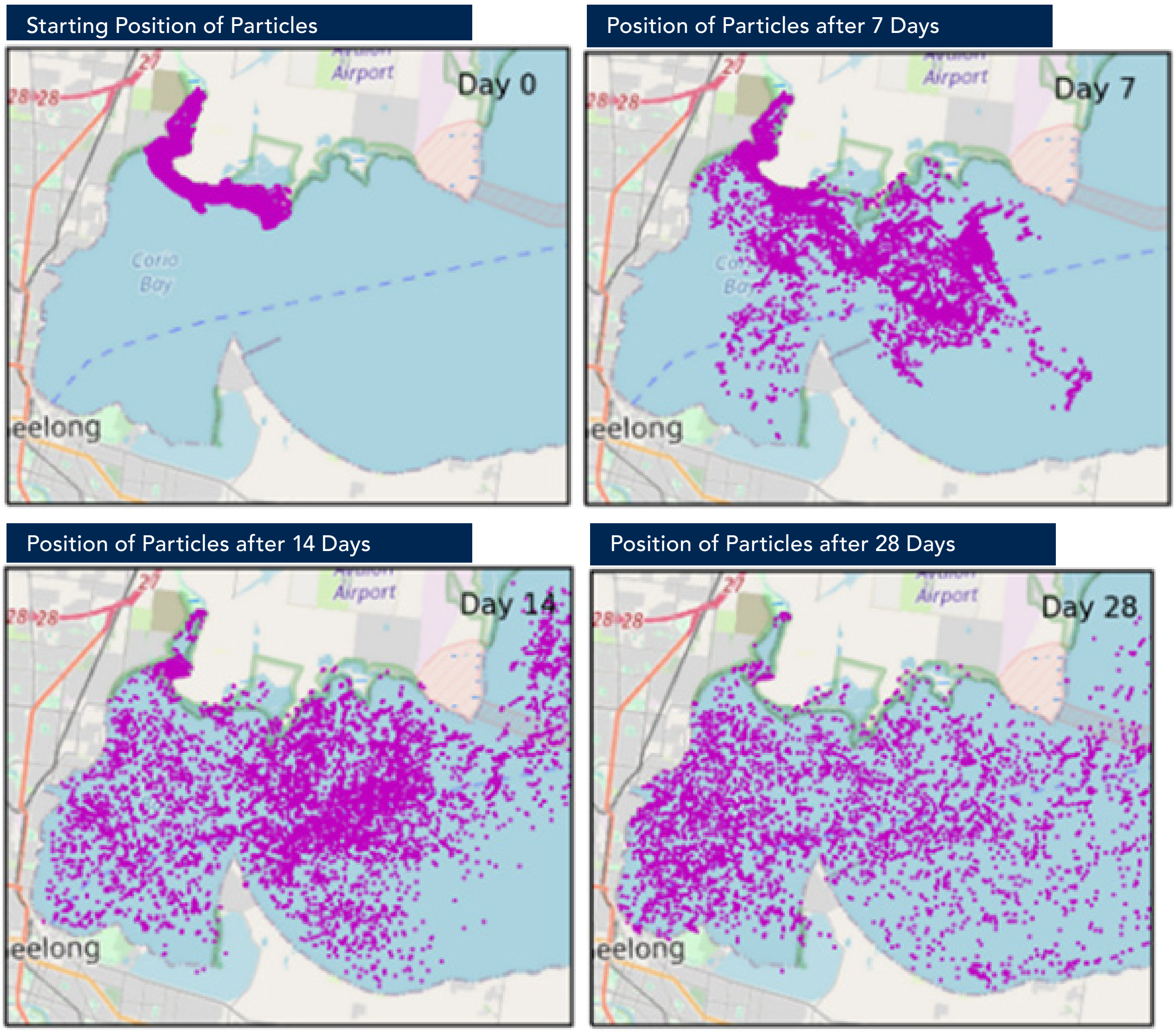


Figure 3-23 Distribution of particles released from the Ramsar site after 0, 7, 14 and 28 days

Table 3-5 lists the percentage of the particles from the Ramsar site captured in the existing refinery seawater intake and the future FSRU seawater intake.

The results using the refined regional hydrodynamic model show that the same percentage of particles from the Ramsar site would be entrained in the future FSRU seawater intake as are currently entrained in the refinery seawater intake.

An additional simulation was made of entrainment for particles released from all the seagrass areas in Corio Bay shown in **Figure 3-24**.

Table 3-5 shows the percentage of particles from each of the release sites entrained in the refinery or FSRU seawater intakes over periods of 7, 14 or 28 days, noting that the entrainment percentages are based on the maximum FSRU flow rate of 350 ML/day but in the warmer months of November and December, the FSRU seawater intake rate would be expected to average less than half the maximum flow rate with half the flow rate being via the refinery seawater intake.

Figure 3-24 Release zone from all the seagrass areas in Corio Bay

Table 3-5 Results of entrainment modelling

Time after Release	Ramsar Site Release		Seagrass Zone Release		
	Refinery Intake	FSRU Intake	Refinery Intake	FSRU Intake	Refinery and FSRU Intakes (summer)
7 days	0.03 %	0.03 %	0.07 %	0.04 %	0.05%
14 days	0.07 %	0.07 %	0.14 %	0.16 %	0.15%
28 days	0.12 %	0.12 %	0.25 %	0.34 %	0.29%

The results using the refined regional hydrodynamic model show that a similar percentage of particles from all seagrass areas would be entrained in the future FSRU seawater intake as are currently entrained in the refinery seawater intake. Slightly more would be entrained in the future FSRU seawater intake because it is further offshore. In summer approximately the same percentage of particles from all seagrass areas would be entrained in total as are currently entrained in the refinery seawater intake.

To provide a perspective on these entrainment rates, of an initial 20,000 eggs laid in a batch by a female goby, only 2 (0.01%) survive into maturity and can breed, and the remining 99.99% are lost naturally to starvation and predation. The entrainment of eggs in the existing or proposed seawater intake has negligible effect in comparison to natural losses.

Modelling results using the refined regional hydrodynamic model show that the proportion of fish eggs entrained is very small in relation to the natural processes of starvation and predation. Considering the results of the field sampling and counting of fish eggs and the two simulations of the entrainment of fish eggs from different zones within Corio Bay, it can be concluded that there would not be a significant change in the proportion of fish eggs entrained with the FSRU in operation compared to current entrainment in the existing refinery seawater intake.

The refinery seawater intake has been capturing a very small proportion of ichthyoplankton in Corio Bay for the last 70 years. Transfer of the seawater intake to the FSRU is predicted to not change the proportion of fish eggs that are entrained. The very small number of ichthyoplankton captured has negligible effect on plankton and fish populations in Corio Bay, or on the availability of ichthyoplankton as food in the Ramsar site.

3.3.6 Re-running the sediment transport modelling with revised inputs

Re-run the sediment transport modelling with revised inputs based on the refined hydrodynamic model. Consider including a 'worst-case' scenario for sediment fractions and settling rates which includes the largest expected proportions of fine and very fine materials that have the slowest expected settling velocities.

Corio Bay has been extensively modified by dredging of channels to allow access by sea-going vessels, development of the Port of Geelong and development of marinas for recreational boats. The 12 ha of proposed localised dredging would increase the area dredged in the Port of Geelong, including the channels, from 310 ha to 322 ha. In the context of Corio Bay, the 12 ha to be dredged constitutes less than 0.3% of the 4,300 ha of Corio Bay.

Dredging is required to remove 490,000 m^3 of material adjacent to the existing shipping channel to provide sufficient water depth at the new berth and within the swing basin for visiting LNG carriers to turn.

The refined regional hydrodynamic model was used to simulate the dispersion and settling of fine sediments released by dredging. The model was reconfigured to simulate five different sediment sizes, each with a density of 2,600 kg/m^3 including:

- Organics and clay which makes up 2% of dredged material, settling velocity of 0.01 mm/s.
- Clay which makes up 44% of the dredged material, settling velocity of 0.063 mm/s.
- Fine Silt which makes up 11% of the dredged material, settling velocity of 0.026 mm/s.

- Medium silt which makes up 11% of the dredged material, settling velocity of 0.08 mm/s.
- Fine sand which makes up 32% of the dredged material, settling velocity of 1 mm/s.

Settling rates were calculated based on the type of material that was being modelled and it was found that clay particles settle at a slow rate and experience coagulation while settling. Sediment dispersion was simulated based on a rate of loss of 6.0 kg/s of material during dredging.

3.3.6.1 Suspended solids and turbidity

The dispersion of fine sediments is measured by suspended solids (in milligrams per litre (mg/L) SS) or as turbidity. Water samples were collected at a depth of 0.2 m at five sites in the Ramsar site as part of the Supplementary Statement and analysed for suspended solids concentration. The range of suspended solids was 1.2 mg/L to 2.3 mg/L and the average suspended solids concentration from all samples was 1.8 mg/L. This is considered to represent the average background suspended solids concentration for the Ramsar site.

Figure 3-25 shows the predicted increase in median suspended solids concentration in north Corio Bay due to dredging over the simulated 8 week dredging period during the months of August – September. There is a small area of 5 ha adjacent to the dredging area where the suspended solids concentration would be 5 mg/L above ambient and a large area of approximately 200 ha where the suspended solids concentration would be 2 mg/L above ambient over the 8-week dredging period.

Figure 3-25 Median increase in suspended solids concentration above ambient at surface during dredging.

Figure 3-26 Median increase in suspended solids concentration above ambient at seabed during dredging

Figure 3-26 shows that there would be larger areas and higher concentrations at the seabed with the area of 5 mg/L SS above ambient covering 40 ha and the area of 2 mg/L SS above ambient covering 265 ha. This means that the seabed would experience higher levels of suspended solids concentrations over larger areas compared to the surface.

A time series of surface suspended solids concentration above ambient was modelled at four sites over the 8-week dredging period (if conducted in August – September). A summary of the average suspended solids increment over the eight weeks of dredging for each site is as follows:

- At Site 1, the average SS increment over the eight weeks of dredging is 1.3 mg/L with a peak of 10 mg/L. The average including background SS is 3.1 mg/L.
- At Site 2, the average SS increment over the 8 weeks of dredging is 2.4 mg/L with a peak of 15 mg/L. The average including background SS is 4.2 mg/L.
- At Site 3, the average SS increment over the 8 weeks of dredging is 3.0 mg/L with a peak of 25 mg/L. The average including background SS is 4.8 mg/L.
- At Site 4, the average SS increment over the 8 weeks of dredging is 3.2 mg/L with a peak of 23 mg/L. The average including background SS is 5.0 mg/L.

Variations in the settling rate arise because the sediment characteristics vary from site to site. The 'worst case' reduction in the clay settling velocity from 0.063 mm/s to 0.04 mm/s results in an increase in the predicted average suspended solids concentration at site 3 from 3.0 mg/L to 4.9 mg/L

Turbidity experienced at the Ramsar site as a result of the dredging would be considerably lower than would be experienced in a strong wind or storm event in Corio Bay. Potential impacts of the predicted temporary increase in turbidity on light availability are further discussed in **Section 3.3.7**.

As a comparison, the 1996 – 1997 Corio Bay Channel Improvement Program excavated the same sediment from the same and similar areas of Corio Bay over a 14- month dredging program. Monitoring by Lawson and Treloar (1998) showed an average turbidity during dredging of 0.5 to 2.5 NTU. 2.5 NTU is equivalent to 2.1 mg/L SS which closely matches the extended area of 2 mg/L predicted in this supplementary study. A sediment dispersion model produced by Lawson and Treloar (1997) showed accurate reproduction of the measured turbidity levels.

To enable a comparison with the proposed dredging, the Lawson and Treloar model parameters were also used to model sediment mobilisation for this project.

At Site 3, the average suspended solids increment over the 8 weeks of dredging using the Lawson and Treloar parameters is 3.0 mg/L, which is the same as that predicted by the project model. At Site 4, the average suspended solids increment is 3.1 mg/L. This is very similar to the average suspended solids concentration of 3.2 mg/L predicted using the project model. The comparison shows little difference between the predicted average concentrations, however, the project model predicts higher peak concentrations. This indicates that while the project model is slightly more conservative, it is still appropriate to predict sediment transport during dredging.

3.3.6.2 Accretion of solids on the seabed

The suspended solids resulting from the proposed dredging would eventually settle and accrete (accumulate) on the seabed.

The increment in seabed elevation due to sedimentation if dredging was conducted during the months of August and September was modelled. The highest accretion of 20 mm occurs on the seabed in the area to be dredged and deepened. Lower accretion rates of 2 mm to 10 mm would occur over a larger area surrounding the dredging zone. The rate of accretion (0.04 mm/day to 0.2 mm/day) would have negligible impact on the muddy seabed and the infauna or mobile marine communities that inhabit muddy seabed. The accretion rate on seagrass beds, none of which are in the dredged area, is predicted to be from zero to 2 mm in the Ramsar site, which is expected to have negligible to very minor impact as seagrass naturally traps and accumulates sediment and studies show healthy seagrass beds with sedimentation rates of up to 20 mm/year (Cabaco et al., 2008) and 31 mm/year (Potouroglou et al., 2017).

The potential impacts of these accretion rates on seagrass in Corio Bay is further discussed in **Section 3.3.7**.

3.3.7 Further assessment of dredging impacts

Undertake further assessment of dredging impacts on seagrass based on:

a. The revised sediment transport modelling.
b. Revised light thresholds of 10 % to 20 % surface irradiance (20 % surface irradiance should be applied to any sediment plumes that extend to the Port Phillip Bay (western shoreline) and Bellarine Peninsular Ramsar Site).
c. The updated seagrass mapping (Rec. 1b).

The Port of Geelong shipping channels have been progressively modified and enlarged over a period of approximately 150 years to allow for safe access to the port (Worley Parsons, 2011) with approximately 20 million m^3 of material dredged to create and maintain the channels. The proposed localised dredging as part of this project is 490,000 m^3. Light attenuation would increase in the areas where elevated suspended solids concentrations and increased turbidity are predicted to occur during the 8-week dredging program. To enable assessment of the potential impact on seagrass of light attenuation due to dredging, the available light thresholds specified in Recommendation 7b were converted into suspended solids thresholds in accordance with the Victorian Dredging Guidelines (EPA, 2001). In summary:

- The recommended 20 % available light threshold for the Ramsar Site is equivalent to 11.7 mg/L suspended solids.
- The recommended 10 % available light threshold for Corio Bay is equivalent to 19 mg/L suspended solids.

Figure 3-25 in **Section 3.3.6** shows the predicted increase in median suspended solids concentration in the surface layer due to dredging over 8 weeks using the refined regional hydrodynamic model (refer to **Section 3.3.6** for more detail on sediment transport modelling). **Figure 3-27** illustrates that dredging at Refinery Pier would not remove any seagrass and the 5mg/L suspended solids plume would not reach the Ramsar site.

- 5 mg/L suspended solids plume
- 2 mg/L suspended solids plume
- Seawater Transfer Pipe
- Refinery Pier Extension
- Dredged Area
- Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site
- Viva Energy owned land
- Muelleri
- Short H. nigricaulis Mixed with Intertidal Seagrass
- H. nigricaulis Mixed with Broadleaf Muelleri
- H. nigricaulis with Scattered Althenia
- Halophilia Mixed H. nigricaulis

Figure 3-27 Predicted median increase in suspended solids concentration above ambient at surface and seagrass distribution zones

Figure 3-26 in **Section 3.3.6** shows the predicted increase in median suspended solids concentration at the seabed due to dredging over eight weeks using the refined regional hydrodynamic model.

The predicted suspended solids concentrations from **Section 3.3.6** were converted to a reduction in light using the equations listed in Appendix 5 of the Victorian Dredging Guidelines (EPA, 2001). The sequence involves converting suspended solids to turbidity as NTU, converting turbidity to a light extinction coefficient and calculating available light at the depth that seagrass is growing.

McMahon et al (WAMSI Dredging Science Node, 2017) and Chartrand et al. 2012 suggest an appropriate time scale for monitoring and detecting impacts on seagrass is two weeks. Therefore, 14-day average suspended solids concentrations, including background, have been extracted for the four nominated sites and are listed in **Table 3-6**.

Table 3-6 Summary of 14-day average suspended solids concentrations (mg/L)

Suspended solids	Background	Week 1-2	Week 3-4	Week 5-6	Week 7-8	Peak
Site 1	1.8	3.6	3.2	2.8	2.9	3.6
Site 2	1.8	4.8	4.4	3.8	3.7	4.8
Site 3	1.8	5.9	4.9	4.1	4.3	5.9
Site 4	1.8	6.7	5.2	4.2	4.0	6.7

Site 3, which is in the Ramsar site, has a highest 14-day average suspended solids concentration of 5.9 mg/L including background. Site 4, which is outside the Ramsar site, has a highest 14-day average suspended solids concentration of 6.7 mg/L, including background.

The peak 14-day average suspended solids concentration of 5.9mg/L corresponds to 22 % light availability for seagrass growing in the Ramsar site, meeting the recommended threshold of 20 % available light. For Site 4, the peak average suspended solids concentration of 6.7 mg/L corresponds to 14 % light availability for seagrass growing in Corio Bay. This meets the recommended threshold of 10 % available light for Corio Bay.

In summary, the assessment of light availability for seagrass shows that:

- All seagrass in the Ramsar site would receive more than the specified minimum 20 % of available light during the dredging program.
- Almost all seagrass in Corio Bay would receive more than the specified minimum 10 % of available light during the dredging program. However, there are sparse plants near 5 m depth that are close to the threshold of light required for growth. There might be some reduction in growth rate for these plants during the 8-week period of dredging, however the duration of reduced light is too short to cause a major setback.
- The light transmission would recover quickly to the original conditions after dredging ceases i.e., within one or two days.
- Any seagrass growth slowed by turbidity would recover soon after completion of the dredging program.

Noting that the duration of the high suspended solids concentrations are only a few hours, this is similar in effect to the natural day-night variation in available light. In order to minimise impact, the 8-week dredging program would avoid the spring season (September, October and November) as this is the period of the year where there is a high growth of seagrass and phytoplankton (refer to MM-ME02). Furthermore, the use of a temporary silt curtain during the dredging program would reduce the suspended solids concentration over seagrass patches along the shoreline (refer to MM-ME04).

3.3.8 Confirming EES conclusions regarding impacts of dredging

Confirm the EES conclusion that dredging will not impact the Ramsar site after considering:

a. The revised marine modelling.

b. The revised assessment of impacts on seagrass.

The area predicted to be impacted by the dredging is shown in **Figure 3-25** and **Figure 3-26**. The yellow indicates the area predicted to be affected by 2 mg/L median suspended solids which is approximately 200 ha, and the brown indicates the area affected by 5 mg/L median suspended solids which is approximately 5 ha. The median 5 mg/L suspended solids contour would not extend into the Ramsar site.

Over the 8-week dredging program, the highest average suspended solids concentration predicted at the outer edge of the Ramsar site is approximately 3 mg/L above ambient. The regional hydrodynamic modelling indicates that the area affected by dredging would not extend into Limeburners Bay. The Ramsar site would have only a minor increase in turbidity, similar to the increase in turbidity recorded in the 1996-1997 Corio Bay Channel Improvement Program.

There would be no reduction in the area of seagrass in the Ramsar site. The predicted increases in turbidity would occur for short periods within the limited 8-week dredging period. This could have a minor effect in slowing seagrass growth and productivity for a day or two, but the impact would be too small to be measured and of no ecological consequence.

Calculations of available light in the Ramsar site show that, for the highest 14-day suspended solids level, seagrass in the Ramsar site will receive more than 20 % of available light during the dredging program. This meets the light threshold recommended by the IAC and indicates very low risk to seagrass growth.

While it is considered that dredging would not impact fish populations present in seagrass habitat in the Ramsar site, as a precautionary approach, the dredging would be scheduled to avoid spring (September to November) where key fish species are potentially in a more vulnerable stage of development (early in their lifecycle) (refer to MM-ME02). Furthermore, avoidance of dredging in spring means early seasonal growth of H. nigricaulis, the most extensive seagrass in the Ramsar site, would not be impacted by potential increases in turbidity and greater risks associated with the mobilisation of nutrients from sediments in the water column during spring (i.e algal blooms).

In addition, a silt curtain is proposed to be installed during dredging to reduce the opportunity for sediment to reach the intertidal zone of the western shoreline of Corio Bay adjacent to the refinery (refer to MM-ME04).

Table 3-7 is based on the original EES Chapter 8 – *Marine environment* and provides a summary of the impacts to the Ramsar site. Following this supplementary marine study, there have been no changes required to the conclusions in this table with the further work conducted confirming the findings of the original EES.

In summary, the additional assessments conducted for the supplementary marine study confirm the conclusions in the EES that dredging would not impact the Ramsar site.

Table 3-7 Summary of impact assessment on Ramsar site

Components processes and services	Conclusion of assessment	Mitigation and monitoring
Wetland bathymetry	No change in intertidal mudflat area	No mitigation needed
Geomorphology	No significant change in sedimentation patterns	No mitigation needed
Marine invertebrates	Chlorine and temperature plumes below guideline limits well before they reach the Ramsar site, so no effect in Ramsar site	No mitigation needed Note: Infauna monitoring recommended close to dredging site
Seagrass	No loss of seagrass in Ramsar site	No mitigation needed Note: Turbidity monitoring recommended for boundary of Ramsar site
Mangroves	No loss of mangroves	No mitigation needed
Saltmarsh	No loss of saltmarsh	No mitigation needed
Fish	Minor change in entrainment of fish eggs and larvae, no effects on adults	No mitigation needed
Water bird abundance and diversity	No effect due to dredging or operation of FSRU	No mitigation needed
Water bird breeding	No effect due to dredging or operation of FSRU	No mitigation needed
Threatened bird species	Addressed in EES Chapter 10: Land environment; no significant impact pathway from marine operations. Addressed in SEES Technical Report B: Supplementary *threatened and migratory bird impact assessment*	No mitigation needed
Migratory birds	Addressed in EES Chapter 10: *Land environment*; no significant impact pathway from marine operations. No change in zooplankton availability. Addressed in SEES Technical Report B: Supplementary *threatened and migratory bird impact assessment*	No mitigation needed
Threatened fish species	No effect	No mitigation needed

3.4 Integrated assessment

The purpose of this section is to integrate the outcomes of the supplementary marine environment study with the original marine EES study.

The findings of the supplementary marine environment study and the findings of the marine EES impact assessment are consistent with respect to dredging impacts and marine discharges from the project discharges.

A summary of key findings from the EES and Supplementary Statement, as related to the Minister's Directions, is presented in Table 3-8 below. This demonstrates that the findings of the Supplementary Statement are similar to the findings of the EES and that no significant impacts to the marine environment have been identified.

Table 3-8 Summary of EES and Supplementary Statement findings

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 1:	
Method • In the original EES, the regional hydrodynamic model was used to predict the future temperature and chlorine plumes during operation of the project. • Different scenarios were modelled to understand the existing refinery temperature and chlorine plumes, and to predict the extent of the temperature and chlorine plumes once the FSRU was in operation. • Scenarios included existing discharge conditions, FSRU discharge to Corio Bay via the refinery and the direct discharge of the FSRU to Corio Bay via a diffuser under refinery pier. • Surveys of seagrass in Corio Bay were undertaken to assess the potential impacts of historical temperature and chlorine discharges from the refinery. • The cover and extent of Corio Bay was assessed in the original EES to identify variability in seagrass extent over time. • To obtain a more detailed understanding of the seabed characteristics in north Corio Bay near the project area, benthic habitat was surveyed along 49 transects in north Corio Bay using a towed underwater camera. • The surveys focused on habitats including seagrasses with macroalgae on shallow soft seabed, and microalgae (microphytobenthos) and burrowing invertebrates (bioturbation) on deeper soft seabed. • Data from the seagrass surveys was then used to map seagrass in the vicinity of Corio Bay.	**Method** • In the Supplementary Statement, the existing plumes were defined from extensive temperature measurements in the four existing four refinery discharge points and within the discharge plumes. Measurements were taken monthly between July 2023 and January 2024, at hundreds of locations within the discharge points, on a range of tide conditions using a highly sensitive temperature probe. • This allowed for the accurate measurement of temperature contours in the existing refinery discharges on a more extensive basis than conducted for the original EES. • As the chlorine levels in the existing refinery discharge plumes are below the level of detection, chlorine levels in the plumes were calculated using the measured temperature rise relative to ambient seawater, the known ratio of chlorine to temperature in the discharges and the known decay rates of chlorine and temperature with time. • Guideline values (DGV) to protect environmental values were established for temperature and chlorine for the Ramsar site and Corio Bay. • To further understand the spatial distribution of seagrass in Corio Bay, towed underwater camera transects were run throughout northern Corio Bay with a total of around 11,300 images analysed which built further on the data collected for the original EES. • To establish the potential impact on seagrass from the existing refinery discharges, a comparison was made of seagrass cover along transects parallel to the shoreline around the existing discharges and at the Ramsar site. • These surveys were undertaken in winter, spring and summer.

Original Marine EES Study	Supplementary Statement Marine Study
Results • The existing +3°C temperature contour extends approximately 200 m offshore from the existing refinery discharge points W4 and W5, and 700 m to the north along the shore. • The plume of warmer water from the existing refinery discharges is below the DGV at the Ramsar site. • The extent of the chlorine plumes, measured at contours of 7.2 µg/L, 5.4 µg/L and 3.6 µg/L are confined to an area within 200 m of the shoreline. • The existing chlorine plume does not extend to the Ramsar site or to Limeburners Bay. • The northern shore of Corio Bay has extensive seagrass in intertidal and shallow subtidal waters • In front of the refinery, there is a mixture of sparse to dense seagrass. • Halophila seagrass is typically found in deeper water compared to H. nigricaulis and is normally patchy with sparse sediments between plants.	**Results** • The extensive additional temperature measurements conducted for the Supplementary Statement built on historical Viva Energy data and measurements taken for the original EES. The measurements provided comprehensive data on the extent of existing discharge plumes and where the plumes met the DGV. • The detailed measurements showed that the existing +5°C temperature contour from the refinery extends only 150 m from discharge point W5. • The +3°C contour extends approximately 560 m to the north along the shore from W5. • The +2°C contour, representing the guideline value for protection of the Ramsar site values, extends a further 90 m north along the shore but does not reach the Ramsar site. • For all existing discharges, the inferred 10 µg/L chlorine contour for protection of environmental values within Corio Bay is reached within the mixing zone defined in the refinery's current EPA operating licence. • The inferred 4.3 µg/L chlorine contour which reflects the guideline value for protection of the Ramsar site values extends approximately 200 m from the W1 discharge point and approximately 60 m from W5 and reaches the guideline level well before the Ramsar site. • The more extensive seagrass surveys conducted to build on those done for the original EES confirmed that the three main species of seagrass in northern Corio Bay – Muelleri in the intertidal zone and H. nigricaulis and Halophila in the subtidal zone. • Seagrass species are mixed in Corio Bay and the proportion of different species varies over time. An updated map showing the extent of the different seagrass species in Corio Bay was prepared (please refer to the 'Seagrass' section below for an updated assessment of potential direct impacts) • The supplementary studies included a comparison of seagrass cover in the vicinity of the existing refinery discharges and at the Ramsar site and concluded that the existing discharges have no measurable effect on seagrass cover as there was very little difference in cover in areas within and outside the discharge plumes. It was concluded that the three key services provided by seagrass – for primary productivity, as habitat and as food supply were at the same levels in the Ramsar site not influenced by the refinery discharges, and within the existing plumes.

Original Marine EES Study	Supplementary Statement Marine Study
	Results • The more detailed seagrass surveys conducted for the Supplementary Statement provided a more comprehensive overview of seagrass in Corio Bay and confirmed the findings of the original EES. Both the original EES and the supplementary studies concluded that seagrass coverage varies considerably over time due to a variety of factors but there is no evidence that seagrass is adversely affected by temperature and chlorine within the existing refinery plumes or will be affected by the project discharges.
Recommendation 2:	
Method • In the original EES, the regional hydrodynamic model was developed to underpin the assessment of temperature and chlorine impacts on the marine environment in Corio Bay. • Key model inputs included wind data from Geelong Racecourse, a 1 metre vertical grid, a 20 m by 20 m horizontal grid within the project area, a 400 m by 400 m horizontal grid in the outer regions of the model domain and a 400 m by 20-50 m horizontal grid In the Hopetoun Channel. • The regional hydrodynamic model did not include the potential influence of the FSRU on currents and discharges. **Results** • The regional hydrodynamic model was used to: – Simulate the existing currents, temperatures, and salinities in Corio Bay. – Predict the fate and transport of fine sediments (clay and silt) that are likely to be mobilised during dredging and dredge spoil disposal. – Predict the path and dispersion of the discharge plumes under two scenarios, namely the FSRU discharging into the refinery for use as cooling water and direct discharge of chilled water from the FSRU through a diffuser into Corio Bay. – Simulate the potential transport and dispersion of plankton and larvae (key elements of the marine ecosystem) from different regions of Corio Bay and predict the amount of entrainment of plankton during operation of the FSRU.	**Method** • In the Supplementary Statement, the regional hydrodynamic model was refined with a horizontal grid of 20 m by 20 m cells; a vertical grid of 0.5 m layers to 4 m depth, improving the resolution of tides and other sea level variations at the model boundary in Port Phillip Bay and by representing a fully loaded FSRU as a blockage to current flow. • A new CALMET wind file, which combines and interpolates between measured wind fields at Geelong Racecourse, Avalon Airport, Point Wilson and the Geelong Refinery, was created and adopted. **Results** • The refined regional hydrodynamic model more accurately reproduces observed water levels, currents, tidal range, and tidal exchange in Corio Bay. • The refined regional hydrodynamic model was used to re-run the wastewater discharge model, entrainment model and sediment transport model. • Temperature plumes predicted by the refined regional hydrodynamic model were compared with the measured plume temperatures made as part of the supplementary studies. • The comparison showed that the refined regional hydrodynamic model predicted plumes with the same shape, temperature and extent as the measured plumes. • An expert and independent peer review conducted on the refined regional hydrodynamic model concluded that it was appropriate and fit for purpose to model the existing environment in Corio Bay and predict relevant project impacts.

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 3:	
Method • In the original EES, the near-field model, together with the regional hydrodynamic model, was used to predict the path, initial dilution and extent of the discharge plumes close to the point of the existing refinery discharges. • Modelling was used to simulate existing and future discharges. • A Computational Fluid Dynamics (CFD) field model was used to model temperature and chlorine discharge plumes close to the four existing refinery discharge outlets. • The CEE INITDIL near-field model was used to simulate the cold water discharge plume within 50 m of the proposed diffuser on Refinery Pier. **Results** • With the project in operation and the FSRU discharging cooled water into the refinery prior to discharge through the existing refinery outlets, the area of the modelling showed that the temperature plume along the shoreline would be smaller, and most of the plume would only be 1°C to 2°C above ambient seawater temperature, as a result of the cooled water input from the FSRU. • The temperature plume would return to ambient temperature well before the Ramsar site. • Future chlorine discharges would be the same as existing discharges as the same volume and same concentration of residual chlorine would be discharged with the project in operation. • The diffuser would achieve a 20:1 dilution and to ensure that the discharge had a temperature change of less than 0.4°C from ambient to minimise the impact of the plume. • The diluted plume is slightly more dense than ambient seawater and would form a plume approximately 1 m thick on the seabed in the dredged shipping channel. • The predicted chlorine concentration with the diffuser would be 5.4 µg/L, which is well below the (then) 7.2 µg/L guideline value for chlorine in marine waters.	**Method** • As part of the Supplementary Statement, the near-field model was re-run using the refined regional hydrodynamic model. • An independent analysis of the near-field modelling was undertaken by Prof Lee, Director of the Croucher Laboratory of Environmental Hydraulics at the University of Hong Kong (an independent specialist modeller) using Visjet, a different near-field model. • The assertions made during the hearing on superelevation and other matters were assessed. **Results** • The independent specialist modeller predicted the same dilution of 20:1 from the diffuser, matching the dilution predictions in the original EES and confirming the original findings. • Consistent with the original EES modelled findings, the temperature and chlorine levels in the plume from the diffuser would meet the DGV with a large factor of safety. • The predicted chlorine dilution of 20:1 would reduce the expected chlorine discharge concentrations from 50 µg/L to 2.5 µg/L, which is well below the guideline value of 10 µg/L. It is noted that in the original EES, a conservative chlorine concentration of 100 µg/L was assumed to discharge from the FSRU. This has been revised to 50 µg/L in the Supplementary Statement, as the refinery does not exceed chlorine discharges of 50 µg/L. • Modelling using the refined hydrodynamic model confirmed the original EES finding that there would be a smaller temperature plume along the shoreline as a result of FSRU cooling water being used in the refinery when compared to the current situation and that the plume would not reach the Ramsar site or have impacts in the site. • Consistent with the original EES modelled findings, future chlorine discharges were modelled with the refined hydrodynamic model arriving at the same conclusion that chlorine levels would be the same as at present from the refinery.

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 4:	

Original Marine EES Study

Method

- In the original EES, mussels were collected from six sites in northern Corio Bay and analysed for a wide range of chlorine residuals including trihalomethanes (THMs), haloacetic acids and bromophenols.
- Mussels accumulate contaminants in the water with little metabolic transformation and the contaminant levels in their tissue are multiple times the concentrations in the water. As such, they are an appropriate species to assess for bioaccumulation of contaminants.
- The six survey sites included Refinery Pier and locations directly within the dispersing refinery plumes from the discharge points, as well as samples from navigational markers around the dredged channel and two reference sites further out in Corio Bay.

Results

- The laboratory analysis from mussels from each location, including the reference sites, found no detectible levels of THMs, haloacetic acids and bromophenols in the mussels.
- It was concluded that the chlorine discharged from the refinery either decays or is volatilised in a short period, and there is no accumulation of toxic by-products in mussels or, by inference, other marine life in Corio Bay as a result of existing refinery discharges. Of interest, marine surveys conducted during the original EES studies found an abundance of sea urchins present directly in the refinery plumes. Sea urchins are considered to be highly sensitive to chlorine and anecdotally suggested that chlorine in the discharges was at levels not adversely affecting this sensitive species.

Supplementary Statement Marine Study

Method

- To provide a further data in relation to bioaccumulation of chlorine in biota, the IAC recommended that the mussel bioaccumulation study conducted for the original EES was repeated for the supplementary studies.
- Fresh mussels were collected from the Portarlington mussel farm and deployed at seven sites within the existing refinery discharge zone.
- The mussels were collected after four weeks and analysed for a wide range of chlorinated compounds, including four trihalomethanes, six haloacetic acids and two bromophenols (all potential chlorine by-products).

Results

- In the repeat mussel investigation, all compounds analysed in the mussels were below the level of laboratory detection, and therefore well below Australian water quality guideline limits.
- This additional testing of mussels as part of the supplementary studies confirmed and supported the findings of the original EES that chlorinated compounds were not bioaccumulating in this species and were decaying or volatilising in a short period over short distances.

Original Marine EES Study	Supplementary Statement Marine Study

Recommendation 5:

Original Marine EES Study

Method

- The original EES assessed the potential for entrainment of plankton and fish larvae into the intake of the FSRU.
- A detailed survey of plankton (phytoplankton, zooplankton and ichthyoplankton (fish eggs and fish larvae)) in Corio Bay was conducted from November 2020 to November 2021. The survey assessed the type and spatial distribution of plankton and larvae In Corio Bay.
- The sampling included collection and identification of phytoplankton, zooplankton and ichthyoplankton at ten sites in Corio Bay, including the existing refinery seawater inlet, other sites around Corio Bay and the Geelong Arm of Port Phillip Bay.
- An analysis of the results showed that the plankton have similar composition and abundance throughout the bay with no significant difference detected between plankton in North Corio, South Corio and the Geelong Arm.
- Entrainment modelling was undertaken to simulate the potential transport and dispersion of plankton and larvae from different regions of the bay.
- Particles that entered the intake zone were counted and assumed to be entrained. The counts were made for 7, 14 and 28-day periods after release and repeated for release at high tide and low tide.

Results

- The original EES concluded that the majority of fish larvae originating from the Ramsar site are dispersed into Port Phillip Bay as a result of currents and other physical processes.
- The proportion of plankton and larvae originating from the Ramsar site that would be entrained in the existing refinery seawater intake and the proposed FSRU intake would be no more than 0.13 % and 0.27 % respectively.
- This was considered inconsequential when compared with natural attrition rates and the EES concluded that operation of the FSRU would have negligible impact on plankton and larvae populations.

Supplementary Statement Marine Study

Method

- During the supplementary statement, an eDNA survey was undertaken expand the list of fish species in Corio Bay, particularly smaller species.
- The IAC determined that re-running the plankton and larvae modelling using the refined hydrodynamic model would be prudent to assess whether the refined model resulted in any material impacts to entrainment of plankton and larvae.
- Additional information on fish species in Corio Bay was obtained from Professor Jenkins (Professorial Fellow in Fish Ecology at Melbourne University).
- The entrainment modelling from the original EES was re-run using the refined regional hydrodynamic model and further understanding of fish species present in Corio Bay.

Results

- The results from running the refined hydrodynamic model indicated that for the proportion of plankton and larvae originating from the Ramsar site, approximately the same percentage (0.12 %) of particles (used as a proxy for plankton and larvae in the model) would be entrained in the existing refinery inlet and at a future FSRU intake. This correlates closely with the 0.13 % entrainment predicted for the refinery intake in the original EES modelling and is slightly lower than the 0.27 % predicted for the FSRU intake in the original modelling.
- Overall, it is concluded that there would not be a significant change in the proportion of fish eggs entrained with the FSRU in operation compared to the current entrainment in the existing refinery intake and that the proportion of fish eggs entrained is very small in relation to the natural processes of starvation and predation.
- The supplementary modelling concluded that the project would have negligible impact on plankton and larvae populations and productivity, the food chain and in turn the ecological character of the Ramsar site and food availability for migratory shorebirds.

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 6:	

Original Marine EES Study

Method

- The original EES marine studies modelled the likely movement and settlement of sediments released during the proposed 8-week dredging in and around Refinery Pier.
- The regional hydrodynamic model was used to simulate the dispersion and settling of fine sediments released by the project dredging and from disposal of dredge spoil from a barge at the dredged material ground in Port Phillip Bay.
- The model was configured to simulate four different sediment sizes including:
  - Clay with a particle size of 2 micron which makes up 46 % of the dredged material.
  - Silt with a particle size of 30 micron which makes up 17 % of the dredged material.
  - Fine sand with a particle size of 125 micron which makes up 12 % of the dredged material.
  - Sand with a diameter of 250 microns for the remaining 25 % of the dredged material.

Results

- Suspended solids modelling predicted that there would be a small 7 ha patch of 5 mg/L suspended solids above ambient and a large 210 ha patch of 2 mg/L suspended solids above ambient at the surface during dredging.
- There would be larger patches and higher concentrations on the seabed
- Modelling indicated the highest sediment accretion of 20 mm occurs on the seabed in the area to be dredged and deepened. Lower accretion rates of 2 to 10mm would occur over a larger area surrounding the dredging zone.
- The rate of accretion (0.04 mm/day to 0.2 mm/day) would have negligible impact on the muddy seabed and the infauna or mobile marine communities.
- The implications of these sedimentation results from the modelling on marina biota is discussed under Recommendation 7.

Supplementary Statement Marine Study

Method

- The IAC recommended that the modelling of sediment transport and settlement associated with the proposed project dredging be rerun with the refined hydrodynamic model and adopting a 'worst case' scenario which assumed fine and very fine sediments with the slowest settlement times.
- The spill rates and settling velocity were refined using additional borehole data collected after the EES.
- The sediment transport model was updated to include:
  - Organic fines, with a settling velocity of 0.01 mm/s, making up 2 % of the dredged material.
  - Clay, with a settling velocity of 0.063 mm/s, making up 44 % of the dredged material.
  - Fine silt, with a settling velocity of 0.26 mm/s, making up 11 % of the dredged material.
  - Medium silt, with a settling velocity of 0.8 mm/s, making up 11 % of the dredged material.
  - Sand, with a settling velocity of 1 mm/s, making up 32 % of the dredged material.
- To verify the model, parameters from an independent sediment transport model completed following the Corio Bay Channel Improvement Program were used as a comparison.

Results

- The refined modelling indicates that there is a small area of 5 ha adjacent to the dredging area where the suspended solids concentration would be 5 mg/L above ambient and a large area of approximately 200 ha where the suspended solids concentration would be 2 mg/L above ambient.
- The comparison of the project model with an independent model previously used for modelling dredging in Corio Bay showed little difference between the predicted average concentrations.
- The rate of accretion results were much the same as in the EES.
- Both modelling programs predicted similar results.
- The predicted suspended solids levels are expected to cause minimal impacts.

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 7:	
Method • The method for predicting the increase in suspended solids in the original EES is described in more detail in Recommendation 6 in this report (and summarised above). The method involved using the original hydrodynamic model to predict the transport and settlement of sediments based on the various sediment particle sizes adopted. **Results** • The results of the modelling for the original EES indicated that suspended solids and turbidity would be limited to the proposed dredging area and immediate surrounds with the Ramsar site and central Corio Bay experiencing only a minor increase in turbidity. • The area of predicted 5 mg/L suspended solids modelled in the original EES does not extend over any seagrass. • The increase in turbidity and light attenuation could result in a temporary loss in productivity of a small area of deeper seagrass around the area to be dredged but within the tolerance range of seagrass as outlined in the Victorian Dredging Guidelines. • The increase in turbidity and light attenuation could result in a minor loss in productivity of seagrass in deeper waters. • The original EES concluded that while there could be minor losses of seagrass productivity over the 8-week dredging period, the levels of light attenuation and settlement of sediments predicted are well within the ranges experienced by seagrass and impacts would be minimal.	**Method** • The IAC recommended that a minimum surface irradiance light threshold was applied to seagrass in the Ramsar site (20%) and Corio Bay (10%) to assess potential impacts of reduced light during dredging. • The predicted suspended solids concentrations from Recommendation 6 were converted to a reduction in light using the equations listed in Appendix 5 of the Victorian Dredging Guidelines (EPA, 2001). • WAMSI Dredging Science Node suggest an appropriate time scale for detecting impacts on seagrass is two weeks. **Results** • The highest average 14-day suspended solids concentration in the Ramsar site was 5.9 mg/L, including background. • This corresponds to 22 % light availability for seagrass in the Ramsar site meaning that all seagrass in the Ramsar site would receive more than the specified minimum 20 % of available light during the dredging program and meets the IAC recommended threshold. • In summary, all seagrass in the Ramsar site (zero to 2 m depth) will receive sufficient light for growth during the proposed dredging program. • The highest average 14-day suspended solids concentration in Corio Bay seagrass at 4 m depth is 6.7 mg/L. • This corresponds to 14 % light availability for seagrass in Corio Bay meaning that seagrass in Corio Bay would receive more than the specified minimum 10 % of available light during the dredging program as recommended by the IAC. • Deep sparse seagrass near the dredging area may experience a minor setback in growth rates during the 8-week period of dredging. • Any seagrass growth slowed by turbidity would recover soon after completion of the dredging program. • The modelling for a 'worst case' sediment scenario indicated that there would be no unacceptable impacts on seagrass from light attenuation both in the Ramsar site and Corio Bay and supports the original EES findings.

Original Marine EES Study	Supplementary Statement Marine Study
Recommendation 8:	

Original Marine EES Study

Method

- The original EES determined that the pathways for an impact of dredging on the Ramsar site would be direct removal of seagrass, impacts associated with temperature and chlorine discharges for the project or an increase in turbidity and light attenuation over the seagrass beds within the Ramsar site boundary.
- The methods used to assess seagrass impacts in the Ramsar site in the original EES are described below and involved an assessment of temperature and chlorine plumes from discharges, sediment transport and accretion and light attenuation associated with dredging.
- The proposed dredging at Refinery Pier would not involve any removal of seagrass (please refer to 'Seagrass' section below for an updated assessment of potential direct impacts to seagrass in the seawater transfer pipe alignment).
- The assessment of whether temperature and chlorine impact would potentially impact on seagrass in the Ramsar site is described in the response to Recommendation 1 in this supplementary report and summarised in this table above.
- The assessment of whether sedimentation from dredging would impact the Ramsar site is described as part of Recommendation 1 (seagrass surveys and mapping), Recommendation 6 (Sediment transport modelling) and Recommendation 7 (Further assessment of dredging on seagrass).

Results

- The original EES modelling indicated that the median 5 mg/L suspended solids contour would not extend into the Ramsar site.
- The original EES findings showed that the level of sedimentation expected in the Ramsar site are well within the tolerance ranges of by seagrass and there would be no material impacts on the Ramsar seagrass beds or to the Ramsar values.
- There would be no reduction in the area of seagrass or seagrass health in the Ramsar site. The predicted increases in turbidity would occur for short periods within the limited 8-week dredging period and impacts would recover quickly post dredging.

Supplementary Statement Marine Study

Method

- The methods used to conduct the additional assessments in the Supplementary Statement involve use of a refined regional hydrodynamic model and conservative parameters for sediment sizing and light attenuation thresholds.

Results

- The area predicted to have 5 mg/L median suspended solids is approximately 5 ha.
- The 5 mg/L suspended solids contour would not extend into the Ramsar site and would not have any impact on seagrass in the site.
- The highest average suspended solids concentration predicted at the outer edge of the Ramsar site is approximately 3 mg/L which is well within the tolerance ranges experienced by seagrass and there would be no material impacts on the Ramsar seagrass beds or to the Ramsar values.
- There would be no reduction in the area of seagrass or seagrass health in the Ramsar site.
- The predicted increases in turbidity would occur for short periods within the limited 8-week dredging period.
- This could have a minor effect in slowing the growth of seagrass in deeper waters near the dredging but the impact would be too small to be measured and of no ecological consequence.
- There is no change to the conclusion in the original EES that dredging would not impact the Ramsar site.

Original Marine EES Study	Supplementary Statement Marine Study
Native Vegetation Removal – marine (seagrass) and terrestrial	
The original marine EES study did not identify any direct impacts to marine native vegetation (seagrass) through removal. The original EES identified the total likely maximum loss of approximately 0.1 ha of terrestrial native vegetation. Approximately 0.1 ha of EVC 132 Plains Grassland (synonymous with FFG Act listed Western (Basalt) Plains Grassland Community) would be removed (subject to the finalisation of the design) as a result of construction of the gas pipeline. The original EES discussed measures taken to minimise terrestrial native vegetation loss. Under the Pipelines Act, a permit (under Clause 52.17 of the Greater Geelong Planning Scheme(GGPS)) is not required for the removal of native vegetation for the gas pipeline. The licence under the Pipelines Act for the gas pipeline will provide the mechanism for regulation of terrestrial native vegetation removal and offset obligations through the imposition of conditions on the licence.	Seagrass mapping undertaken for the supplementary study has identified the potential removal/disturbance of approximately 0.5 ha of seagrass as a result of excavation of a shallow trench for installation of the seawater transfer pipe. The trench would extend about 550 m from the proposed extension to Refinery Pier to the existing refinery seawater intake channel. Approximately 0.3 ha of seagrass would be removed from the inshore 230 m of the proposed alignment, and a further 0.2 ha would be smothered when the excavated sediment is placed on the seabed adjacent to the trench (prior to being replaced after pipe lay). Mapping indicates that the seagrass which would be potentially disturbed/removed would be a mixture of H. nigricaulis (endangered under the *Flora and Fauna Guarantee Act 1988* (FFG Act)) and Halophila. Of the total potentially impacted area of seagrass only 10% is likely to be *H. nigricaulis* (i.e., an area of 0.05 ha) and 90% is likely to be Halophila (i.e., an area of 0.45 ha). Seagrass would regrow from rhizomes present in the excavated sediment near the surface and from the disturbed area adjacent to the trench following replacement of the sediment when installation is complete. The loss of seagrass would be localised and temporary and three years after installation, seagrass cover on the alignment is expected to be the same as elsewhere in Corio Bay. Corio Bay has an estimated 1,050 ha of seagrass (excluding the seagrass in Outer Harbour, which is counted under Port Phillip Bay) and there would be no regional effect of removing 0.5 ha of seagrass on the ecological services or seagrass meadows in Corio Bay. Secondary approval requirements for the removal of seagrass relate to Victoria's Native Vegetation Removal Regulations and protected flora controls under the FFG Act. Seagrass is considered as native vegetation under the Victorian Native Vegetation Removal Regulations where local council areas extend over lakes, estuaries or the sea (DELWP 2018). The GGPS covers the area of the seawater transfer pipe therefore removal of seagrass in that area will be considered as a removal of a patch of native vegetation in accordance with the *Guidelines for the removal, destruction or lopping of native vegetation* (DELWP 2017) under Clause 52.17 of the GGPS.

Original Marine EES Study	Supplementary Statement Marine Study
Native Vegetation Removal – marine (seagrass) and terrestrial	
	The area of seagrass to be removed is comprised of a mixture of species that includes Australian Grass-wrack *H. nigricaulis* which is listed as endangered under the FFG Act. As all land from the high tide line is public land, a protected flora permit will be required for *H. nigricaulis* under the FFG Act. This permit will be in addition to a threatened community permit to remove FFG Act listed Western (Basalt) Plains Grassland Community, required where the community is removed from public land for construction of the gas pipeline. Removal of native vegetation will be offset in accordance with Victoria's *guidelines for the removal, destruction or lopping of native vegetation*. The project triggers general offsets owing to the proposed removal of approximately 0.5 ha of seagrass during installation of the seawater transfer pipe and approximately 0.1 ha of Plains Grassland during construction of the gas pipeline. The list of secondary approvals required for the project is outlined in Chapter 9: *Environmental Management Framework*.

3.5 Mitigation measures

The findings of the of the supplementary marine environment study and the findings of the original marine EES study are consistent and confirm the conclusions reached in the EES in relation to negligible to low impact from dredging, and current and future wastewater discharges.

The mitigation measures proposed in the original EES are still considered appropriate to manage project impacts noting that changes to MM-ME04, MM-ME05, MM-ME06, MM-ME07 and MM-ME08 and the addition of mitigation measure MM-ME19 recommended by the IAC (Report No. 2 Appendix G) have also been adopted. Mitigation measure MM-ME11 has been updated to reference the May 2023 version of the National Light Pollution Guidelines for Wildlife.

To minimise the potential impact of the removal of seagrass during installation of the seawater transfer pipe, the following mitigation measure MM-ME20 has been added to the marine ecology and water quality mitigation measures.

Refer to Chapter 9: *Environmental Management Framework* for a list of the mitigation measures relevant to the areas of further work covered by the Supplementary Statement.

Table 3-9 Marine environment and water quality mitigation measure

MM-ID	Mitigation measure	Statutory implementation	Project timing
MM-ME20	**Minimise direct impacts to seagrass during installation of the seawater transfer pipe.** A seagrass survey of the seawater transfer pipe alignment will be undertaken prior to installation of the seawater transfer pipe.The seawater transfer pipe installation method will minimise the area of seagrass disturbed during excavation as far as practicable and require excavated sediment to be replaced on top of the installed pipe as soon as possible following pipelay. Seagrass will be planted along the centreline of the seawater transfer pipe alignment to facilitate seagrass rehabilitation following the completion of construction. Transplantation of seagrass will be undertaken in accordance with the published Western Australian seagrass transplantation manual. (Transplanting Posidonia Seagrass in Temperate Western Australian Waters: A Practical 'How To' Guide, BMT Oceanica, July 2013).	Incorporated Document Consent under the *Marine and Coastal Act 2018*	Construction

3.6 Conclusion

Overall, the original marine EES study concluded that construction and operation of the project is not considered to have significant impacts on the marine environment.

The original marine EES study concluded that potential impacts related to localised dredging, such as turbidity, light attenuation, habitat modification and underwater noise would be temporary and localised and would not result in significant impacts to nearby populations and communities. It is likely that any altered conditions (e.g., turbidity, light availability) would return to original conditions within a short period of time after the construction activity ceases.

With the reuse of FSRU discharge water for cooling in the refinery, there would be no change to the maximum volume of water drawn from and discharged into Corio Bay (350 ML/day) except when refinery maintenance occurs every second year. There would be a reduction in temperature in the refinery discharge compared to existing discharges and the residual chlorine concentrations in the discharge would remain the same. The existing refinery discharges have been operating for years, and while Corio Bay is a modified environment, the ecological surveys conducted for the original EES and the Supplementary Statement have indicated that there is a healthy marine environment in both Corio Bay and the Ramsar site suggesting that the refinery discharges are not having significant impacts. On this basis, it was concluded that the project discharge would not have adverse impacts on marine ecology and water quality and the reduction in the temperature of the proposed discharge from the project would be an environmental improvement.

Potential impacts from use of the diffuser on the pier extension for discharge of water into Corio Bay were also assessed. The diffuser would be used infrequently to discharge excess FSRU seawater during refinery maintenance periods in the event that the rate of FSRU discharge exceeded the refinery demand for seawater or in the event that the refinery was decommissioned in the future and the option for reuse of the FSRU discharge water was no longer available. As the diffuser would be designed to achieve high dilution, EES modelling demonstrated that the resulting chlorine and temperature plumes on the seabed would be localised and contained within the shipping channel and well below temperature and chlorine guideline limits.

With respect to entrainment of plankton and larvae, the original marine EES study concluded that there would be a slight increase to the number of plankton entrained from the Ramsar site and northern and southern Corio Bay as a result of the project, however, the entrainment rates of less than 0.66 % are considered low to negligible in comparison to natural predation and other losses.

With consideration to the Supplementary Statement, to address Recommendation 1 of the Minister's Directions, additional temperature monitoring was undertaken at the existing refinery discharges and in the discharge plumes to provide empirical data on the extent of elevated temperature and chlorine in the plumes. The empirical data also indicated a high level of correlation with the outcomes of the marine modelling undertaken for both the original EES and the supplementary studies. A number of seagrass surveys were undertaken to update the seagrass mapping adjacent to the refinery and at the Ramsar site. The following findings were made:

- The existing refinery discharge plumes are within the guideline values for temperature change and chlorine for Corio Bay and do not reach the Ramsar site.
- The existing discharges have had no measurable effect on seagrass when compared with seagrass condition at reference sites in the Ramsar site.
- As the project involves recycling the cooled FSRU discharge water through the refinery for use as cooling water, the refinery discharge with the project operational will have the same chlorine concentrations and be at the same discharge volumes as have occurred historically. On the basis that the refinery discharges (which have been in place for 70 years) have had no discernible impact on seagrass over time, it is considered that the discharges with the project operational will not have adverse impacts on seagrass. The discharges with the project operational will also reduce the temperature of the current discharge and bring it closer to the ambient water temperatures in Corio Bay which is an environmental enhancement.

To address Recommendation 2 of the Minister's Directions, updates were made to refine the regional hydrodynamic model used in the initial EES. These updates included the use of a CALMET wind file (which combines and interpolates between measured wind fields at Geelong Racecourse, Avalon Airport, Point Wilson and the Geelong Refinery), a more detailed horizontal grid (20 m x 20 m resolution) within the model, a more detailed vertical resolution (0.5 m) and the implementation of the FSRU as a solid barrier in the grid. In order to calibrate the modified model, the predicted plumes were compared to actual data collected and observations made during field investigations. It was found that the refined model could reproduce sea level, tidal exchange, currents, and the temperature plumes accurately. A refined, calibrated, and peer reviewed regional hydrodynamic model was used for the tasks that were undertaken to address Recommendations 3, 5 and 6 of the Minister's Directions.

To address Recommendation 3 of the Minister's Directions, the wastewater discharge modelling was re-run and demonstrated that with the project in operation, there would be a smaller temperature plume along the shoreline compared to the existing situation. Chlorine concentrations would be similar to the existing refinery discharge plume.

Additionally, an independent review conducted by a recognised expert was undertaken to assess the chlorine dilution calculations presented in the original EES resulting from a discharge from the proposed diffusers beneath Refinery Pier. It was found that there was no basis to the assertion made during the IAC hearing that the dilution would be less than 20:1 which was the finding in the original EES. The regional plume modelling was repeated using the refined, calibrated, and peer reviewed regional hydrodynamic model as required by the Minister's Recommendation 3 and the outcomes were consistent with the original EES chlorine dilution of 20:1, and validated the original findings.

To address Recommendation 4 of the Minister's Directions, further targeted investigations were undertaken to establish the effects of existing chlorine discharges from the refinery to confirm likely impacts resulting from CBP. Measurement of chlorination by-product concentrations in seawater is not considered feasible as it reaches non-detect levels very soon after discharge. Hence, the supplementary studies of chlorine by-products in Corio Bay focused on measurement of chlorine by-products in mussels which are filter-feeding marine organisms known to accumulate contaminants and therefore with a high susceptibility to contamination. All compounds analysed in mussels deployed for the study were reported below the limit of laboratory detection and therefore at very low levels. This confirmed the original EES findings that chlorine impacts on biota due to the existing discharges or proposed discharges of low concentrations of chlorine into Corio Bay would be negligible.

To address Recommendation 5 of the Minister's Directions, the entrainment modelling for plankton and larvae in Corio Bay was repeated using the refined hydrodynamic model. Modelling results showed that the proportion of fish eggs entrained is very small in relation to the natural processes of starvation and predation. It was concluded that there would not be a significant change in the proportion of fish eggs entrained with the FSRU in operation when compared to the current entrainment as a result of the existing refinery intake. The results were found to be very similar to the previous entrainment predictions presented in the original EES.

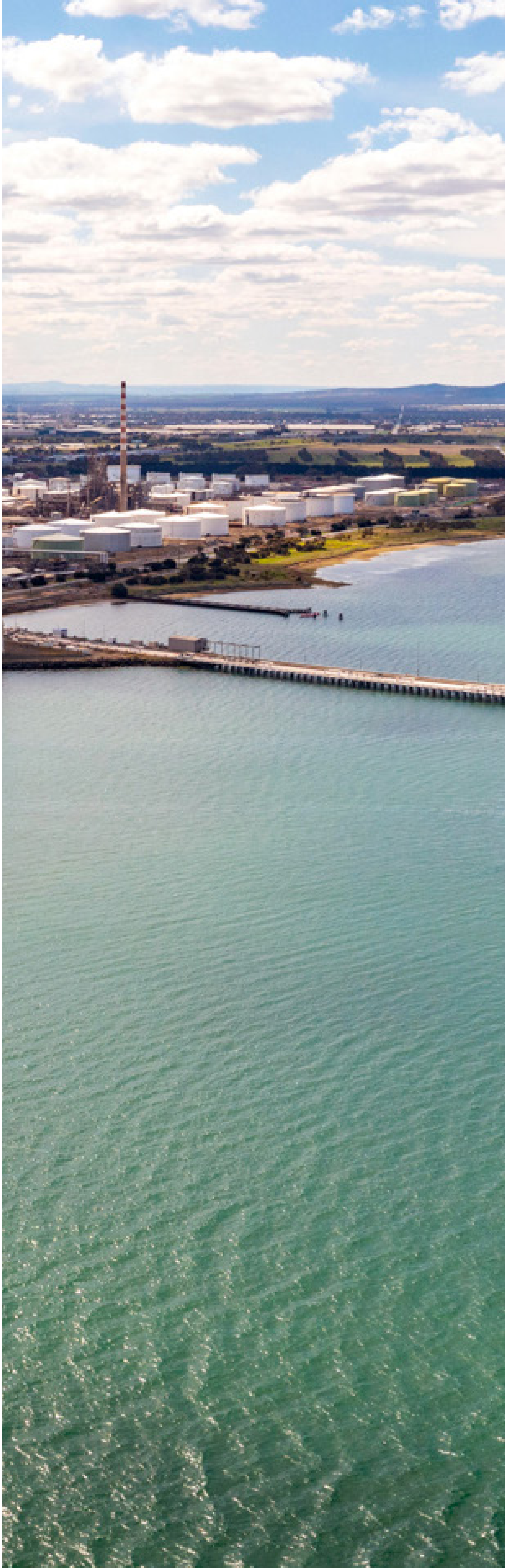
To address Recommendation 6 of the Minister's Directions, the sediment transport modelling was repeated using the refined hydrodynamic model and revised input parameters. The updated sediment transport modelling showed only minor changes from the results reported in the original EES. The extent of increased suspended sediment concentration from dredging covered much the same area in north Corio Bay as shown in the EES, with low concentrations of suspended solids at the edge of the Ramsar site.

To address Recommendation 7 of the Minister's Directions, further assessment of the potential impacts of dredging on seagrass using the refined sediment transport modelling and minimum light thresholds of 20 % surface irradiance for the Ramsar Site and 10 % surface irradiance for the rest of Corio Bay recommended by the IAC was undertaken. The results of the updated modelling were similar to the predictions presented in the original EES, which found that turbidity would cause only a small reduction in light reaching seagrass and all seagrass in the Ramsar site (zero to 2 m depth) would receive sufficient available light for growth. The dredging is not expected to have any impact on intertidal seagrass, as that seagrass is exposed to high light intensity every low tide (during daylight hours). The predictions show the Ramsar site would experience only a minor increase in turbidity over the 8-week dredging program. The change is too small to cause an adverse impact on seagrass productivity.

To address Recommendation 8 of the Minister's Directions, it was confirmed that dredging would not impact the Ramsar site.

Seagrass mapping undertaken for the supplementary study identified the potential removal/disturbance of approximately 0.5 ha of seagrass as a result of excavation of a shallow trench for installation of the seawater transfer pipe. However, it was concluded that there would be no regional effect on the ecological services or seagrass meadows in Corio Bay.

Overall, the findings of the supplementary study were found to be consistent with the findings of the marine environment impact assessment completed as part of the original EES and confirmed the initial conclusion that construction and operation of the project would not have significant environmental impacts with the proposed mitigation measures in place.



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