Chapter 10 D.4 RPS Marine Discharge Modelling Report

MAKING COMPLEX EASY

BROWSE TO NWS PROJECT - MARINE DISCHARGE MODELLING

Report

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Approval for issue

David Wright	27 November 2019

Prepared by:

RPS

Level 2, 27-31 Troode Street
West Perth WA 6005

T +61 8 9211 1111

Prepared for:

Woodside Energy Ltd

Mia Yellagonga, 11 Mount Street
Perth WA 6000

T +61 8 9348 4000

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EXECUTIVE SUMMARY

RPS was commissioned by Woodside Energy Ltd (Woodside) to undertake a marine dispersion modelling study of proposed water discharges from the proposed Browse Joint Venture (BJV) Floating Production Storage and Offloading (FPSO) facilities. The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs located approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline.

The BJV propose to develop the Browse resource using two FPSO facilities with up to 1,100 million standard cubic feet per day (MMscf/d) export capacity (annual daily average). The proposed FPSOs will be supplied by a subsea production system and will export gas to existing North West Shelf (NWS) Project infrastructure via a ~85 km spur line and a ~900 km Browse Trunkline (BTL), which will tie in near the North Rankin Complex (NRC).

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the BJV: Woodside Browse Pty Ltd, Shell Australia Pty Ltd (Shell), BP Developments Australia Pty Ltd (BP), Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI) and PetroChina International Investment (Australia) Pty Ltd (PetroChina).

The proposed Browse to NWS Project involves the processing of hydrocarbons and as a result will produce cooling water (CW) and produced water (PW). In situ hydrostatic pressure testing may be performed following installation of the BTL/inter-field spur line. If required, this will occur during commissioning. Hydrotesting will require hydrotest fluid to be introduced and left in situ to protect the infrastructure from corrosion. Hydrotest fluids will be directly discharged to sea from the Pipeline End Terminals (PLETs).

The principal aim of the study was to quantify the possible extents of the near-field and far-field mixing zones based on:

- The predicted dilution levels for chlorine in the CW discharge and the temperature differential between the discharge and the ambient receiving water;
- The predicted dilution levels for total oil (including benzene, toluene, ethylbenzene and xylene; BTEX), mercury and monoethylene glycol (MEG) in the PW discharge;
- The predicted dilution levels for biocide in the hydrotest discharge.

This will indicate the concentrations of these constituents and the temperature of the plume at the limits of the mixing zones (i.e. the predictions of dilution or cooling relative to the source characteristics).

To accurately determine the dilution of the discharges and the total potential area of influence, the effect of near-field mixing needs to be considered first, followed by an investigation of the far-field mixing performance. Different modelling approaches are required for calculating near-field and far-field dilutions due to the differing hydrodynamic scales.

To assess the rate of mixing of the chlorine in the CW stream from the Torosa FPSO, dispersion modelling was carried out for a flow rate of 720,000 m^3/d at a discharge depth of 12 m below the water surface.

To assess the rate of mixing of the total oil, mercury and MEG in the PW stream from the Torosa FPSO, dispersion modelling was carried out for flow rates of 5,723 m^3/d and 490 m^3/d at a discharge depth of 14 m below the water surface.

To assess the rate of mixing of the biocide in the hydrotest stream from each PLET, dispersion modelling was carried out for a flow rate of 25 m^3/min (36,000 m^3/d) at three discharge locations in water depths of 117 m, 461 m and 539 m.

The potential area that may be influenced by the discharge streams was assessed for three distinct seasons: (i) summer (December to February); (ii) the transitional periods (March and September to November); and (iii) winter (April to August). An annualised aggregation of outcomes was also assembled.

The main findings of the study are as follows:

Near-Field Modelling

Cooling Water Discharges

- The results show that due to the momentum of the discharge a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 12 m below the water surface (Case C). Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plume is predicted to rise in the water column.
- The plume is predicted to plunge up to 16 m below the sea surface in all seasons.
- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.
- The maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as 37.8 m.
- The maximum diameter of the plume at the end of the near-field zone is predicted as 15.2 m.
- For all seasons, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.
- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:13.5 for Case C. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:6.3 for Case C.
- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Produced Water Discharges

- The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 14 m below the water surface (Cases P and M). Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plumes are predicted to rise in the water column.
- For Cases P and M, the plume is predicted to rise towards the water surface after the momentum of the initial discharge is lost.
- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.
- For both discharges, the maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as 20.2 m.
- For both discharges, the maximum diameter of the plume at the end of the near-field zone is predicted as 11.7 m.
- For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.

- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:204 for Case P and 1:1,222 for Case M. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:70 for Case P and 1:323 for Case M.

- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Hydrotest Discharges

- The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge points, which are 117 m (Case H1), 461 m (Cases H2 and H3b) and 539 m (Case H3a) below the water surface. Following this initial mixing, the near neutrally buoyant plumes are predicted to travel laterally in the water column.

- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.

- For all discharges, the maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as being in the range 50-77 m.

- For all discharges, the maximum diameter of the plume at the end of the near-field zone is predicted as being in the range 16-24 m.

- For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.

- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:111 for Case H1, 1:166 for Case H2, 1:172 for Case H3a and 1:166 for Case H3b. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:41 for Case H1, 1:62 for Case H2, 1:65 for Case H3a and 1:62 for Case H3b.

- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Far-Field Modelling

Cooling Water Discharges

- Instantaneous concentrations (based on a 60-second model time step) are considered when calculating dilution contours.

- The minimum level of dilution achieved at or within the Scott Reef receptor at the 95^{th} percentile in any season is predicted to be 1:125 for Case C.

- For Case C, annualised results show dilution to reach an example level of 1:100 is achieved within an area of influence extending up to 4.2 km at the 95^{th} percentile. The discharged plumes are predicted to travel predominantly along a north-northwest/south-southeast axis throughout the year, which is broadly parallel to the Scott Reef receptor boundary.

- For Case C, annualised results show the area of exposure defined by the 1:100 dilution contour is predicted to reach a maximum value of 3.7 km^2 at the 95^{th} percentile.

- The maximum depth reached by the discharge across all seasons is predicted as 20 m for Case C.

- Considering the relative rates of acclimation of the plume characteristics with the ambient water, the limiting factor for the plume's area of influence is likely to be defined by its chlorine constituent rather than its temperature.
- An example 3 °C plume-ambient temperature differential is forecast to be met within 120 m at the 95th percentile across all seasons.

Produced Water Discharges

- Instantaneous concentrations (based on a 60-second model time step) are considered when calculating dilution contours.
- The minimum levels of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season are predicted to be 1:1,507 for Case P and 1:17,674 for Case M.
- For Case P, annualised results show dilution to reach an example level of 1:300 is achieved within an area of influence extending up to 0.9 km at the 95th percentile. The discharged plumes are predicted to travel predominantly along a north-northwest/south-southeast axis throughout the year, which is broadly parallel to the Scott Reef receptor boundary, with trajectories to the south-southeast forecast to be longer.
- For Case P, annualised results show the area of exposure defined by the 1:300 dilution contour is predicted to reach a maximum value of 0.7 km^2 at the 95th percentile.
- The maximum depth reached by the discharge across all seasons is predicted as 19 m for Case P.

Hydrotest Discharges

- Concentrations calculated following application of a rolling 48-hour median to the instantaneous data are considered when calculating dilution contours.
- The minimum levels of dilution achieved at or within the nearest receptor at the 95th percentile in any season are predicted to be >>1:20,000 for Case H1 (Rankin Bank), 1:4,440 for Case H2 (Scott Reef), >1:20,000 for Case H3a (Scott Reef) and 1:2,711 for Case H3b (Scott Reef).
- For Cases H1, H2, H3a and H3b, annualised results show dilution to reach an example level of 1:10,000 is achieved within an area of influence extended up to 16.1 km, 12.5 km, 23.4 km and 8.2 km, respectively, at the 95th percentile. The predominant plume travel directions throughout the year are forecast to be south-westerly (Case H1), along a north-northwest/south-southeast axis (Cases H2 and H3a) and along a north-east/south-west axis (Case H3a).
- For Cases H1, H2, H3a and H3b, annualised results show the area of exposure defined by the 1:10,000 dilution contour is predicted to reach a maximum of 79.2 km^2, 87.1 km^2, 89.4 km^2 and 40.8 km^2, respectively, at the 95th percentile.

Key Observations

Cooling Water Discharges

- The discharge will be initially positively buoyant and will rise in the water column, and may resurface in the vicinity of the discharge point prior to acclimation with ambient receiving water conditions.
- At the 95th percentile, plumes for Case C are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:125 in any season.
- At the 95th percentile, temperature acclimation of the plume with ambient waters is expected to occur within 120 m of the discharge point in any season and plume temperature will not be a relevant factor at the Scott Reef 3 nm State water boundary.

Produced Water Discharges

- At the 95th percentile, plumes are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:1,507 for Case P and 1:17,674 for Case M in any season.

Hydrotest Discharges

- Due to significant variations in the magnitude and directionality of the hindcast currents at each location where potential discharges will occur, predicted outcomes are markedly different.

- Transport patterns will reflect the predominant drift current trajectories at each location, with tidal movements a particularly important driver of dispersion for the deeper discharges. Greater variability in current trajectories is expected near the water surface due to the influence of wind, but, because the plumes are discharged at the seabed and are not positively buoyant, they will not experience these variations.

- At the 95th percentile, plumes are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:4,440 for Case H2, 1:20,000 for Case H3a and 1:2,711 for Case H3b in any season. For Case H1, the dilution level of any plumes that may reach Rankin Bank is expected to be significantly greater than 1:20,000.

1 INTRODUCTION

1.1 Background

RPS was commissioned by Woodside Energy Ltd (Woodside) to undertake a marine dispersion modelling study of proposed water discharges from the proposed Browse Joint Venture (BJV) Floating Production Storage and Offloading (FPSO) facilities. The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs located approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline.

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To accurately determine the dilution of the discharges and the total potential area of influence, the effect of near-field mixing needs to be considered first, followed by an investigation of the far-field mixing performance. Different modelling approaches are required for calculating near-field and far-field dilutions due to the differing hydrodynamic scales.

To assess the rate of mixing of the chlorine in the CW stream from the Torosa FPSO (location shown in Table 1.1 and Figure 1.1), dispersion modelling was carried out for a flow rate of 720,000 m^3/d at a discharge depth of 12 m below the water surface.

To assess the rate of mixing of the total oil, mercury and MEG in the PW stream from the Torosa FPSO, dispersion modelling was carried out for flow rates of 5,723 m^3/d and 490 m^3/d at a discharge depth of 14 m below the water surface.

To assess the rate of mixing of the biocide in the hydrotest stream from each PLET (locations shown in Table 1.1 and Figure 1.1), dispersion modelling was carried out for a flow rate of 25 m^3/min (36,000 m^3/d) at three discharge locations in water depths of 117 m, 461 m and 539 m.

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The potential area that may be influenced by the discharge streams was assessed for three distinct seasons: (i) summer (December to February); (ii) the transitional periods (March and September to November); and (iii) winter (April to August). An annualised aggregation of outcomes was also assembled.

All discharge characteristics used as input to the modelling are specified in the Model Input Form for this study (Woodside, 2019).

Table 1.1 Locations of the proposed Torosa FPSO and PLETs used as the release sites for the dispersion modelling assessment.

Release Site	Latitude (S)	Longitude (E)	Water Depth (m)
Torosa FPSO	13° 58' 15.06"	122° 01' 28.53"	481
Torosa PLET	13° 58' 41.70"	122° 01' 26.76"	461
Brecknock/Calliance PLET	14° 32' 21.92"	121° 37' 34.23"	539
NRC Tie-In PLET	19° 36' 41.37"	116° 10' 23.53"	117

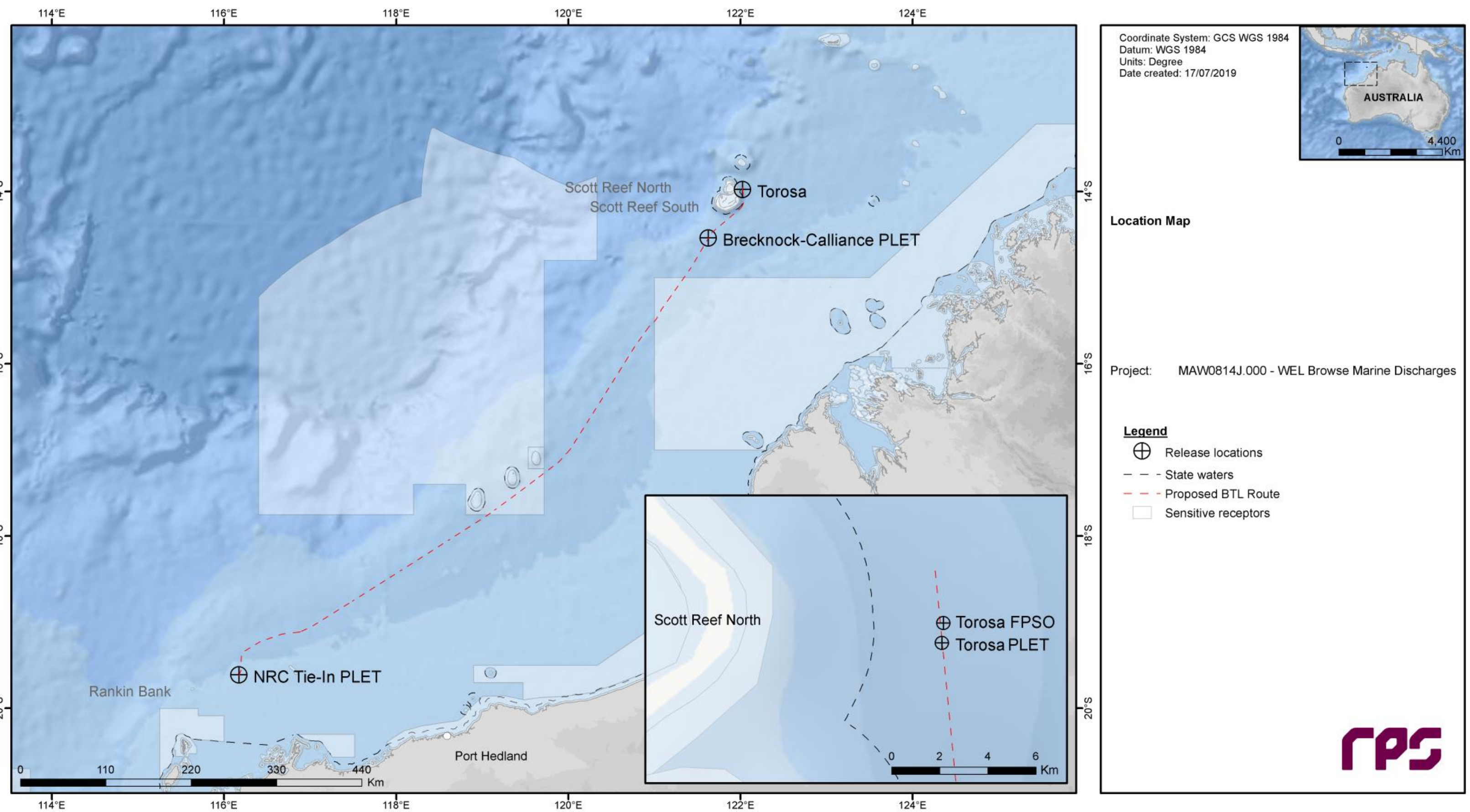

Figure 1.1 **Locations of the proposed Torosa FPSO and PLETs, on the North West Shelf and in proximity to Scott Reef, off the Kimberley Coast of Western Australia.**

1.2 Modelling Scope

The physical mixing of the CW, PW and hydrotest plumes was first investigated for the near-field mixing zone. The limits of the near-field mixing zone are defined by the area where the levels of mixing and dilution are controlled by a plume's initial jet momentum and the buoyancy flux, resulting from density differences between the plume and the receiving water. When the plume encounters a boundary such as the water surface, near-field mixing is complete. At this point, the plume is considered to enter the far-field mixing zone.

The scope of the modelling included the following components:

- Collation of a suitable three-dimensional, spatially-varying current data set surrounding the Torosa FPSO and NRC tie-in, Torosa and Brecknock/Calliance PLET locations for a ten-year (2006-2015) hindcast period. The current data set included the combined influence of drift and tidal currents and was suitably long as to be indicative of interannual variability in ocean currents. The current data set was validated against metocean data collected in the Browse project area, and also against independent tidal predictions at many locations within the model domain including the NRC area.
- Derivation of statistical distributions for the current speed and directions for use in the near-field modelling. Analyses included percentile distributions and development of current roses. This analysis was important to ensure that current data samples applied in the dispersion model were statistically representative.
- Collation of seasonally-varying vertical water density profiles at the Torosa FPSO and NRC tie-in, Torosa and Brecknock/Calliance PLET locations for use as input to the dispersion models.
- Near-field modelling conducted for each unique discharge to assess the initial mixing of the discharge due to turbulence and subsequent entrainment of ambient water. This modelling was conducted at high spatial and temporal resolution (scales of metres and seconds, respectively).
- Outcomes from the near-field modelling included estimates of the width, shape and orientation of the plumes, and resulting constituent concentrations and dilutions, for each discharge at a range of incident current speeds.
- Establishment of a far-field dispersion model to repeatedly assess discharge scenarios under different sample conditions, with each sample represented by a unique time sequence of current flow, chosen at random from the time series of current data.
- Analysis of the results of all simulations to quantify, by return frequency, the potential extent and shape of the mixing zone.

2 MODELLING METHODS

2.1 Near-Field Modelling

2.1.1 Overview

Numerical modelling was applied to quantify the area of influence of CW, PW and hydrotest water discharges, in terms of the distribution of the maximum constituent concentrations that might occur with distance from the source given defined discharge configurations, source concentrations, and the distribution of the metocean conditions affecting the discharge location.

The dispersion of the CW, PW and hydrotest discharges will depend, initially, on the geometry and hydrodynamics of the discharges themselves, where the induced momentum and buoyancy effects dominate over background processes. This region is generally referred to as the near-field zone and is characterised by variations over short time and space scales. As the discharges mix with the ambient waters, the momentum and buoyancy signatures are eroded, and the background – or ambient – processes become dominant.

The shape and orientation of the discharged water plumes, and hence the distribution and dilution rate of the plume, will vary significantly with natural variation in prevailing water currents. Therefore, to best calculate the likely outcomes of the discharges, it is necessary to simulate discharge under a statistically representative range of current speeds representative of the Torosa FPSO and NRC tie-in, Torosa and Brecknock/Calliance PLET locations.

2.1.2 Description of Near-Field Model: Updated Merge

The near-field mixing and dispersion of the water discharge was simulated using the Updated Merge (UM3) flow model. The UM3 model is a three-dimensional Lagrangian steady-state plume trajectory model designed for simulating single and multiple-port submerged discharges in a range of configurations, available within the Visual Plumes modelling package provided by the United States Environmental Protection Agency (Frick *et al.*, 2003). The UM3 model was selected because it has been extensively tested for various discharges and found to predict observed dilutions more accurately (Roberts & Tian, 2004) than other near-field models (i.e. RSB and CORMIX).

In the UM3 model, the equations for conservation of mass, momentum, and energy are solved at each time step, giving the dilution along the plume trajectory. To determine the change of each term, UM3 follows the shear (or Taylor) entrainment hypothesis and the projected-area-entrainment (PAE) hypothesis, which quantifies forced entrainment in the presence of a background ocean current. The flows begin as round buoyant jets and can merge to a plane buoyant jet (Carvalho *et al.*, 2002). Model output consists of plume characteristics including centreline dilution, rise-rate, width, centreline height and plume diameter. Dilution is reported as the “effective dilution”, the ratio of the initial concentration to the concentration of the plume at a given point, following Baumgartner *et al.* (1994).

The near-field zone ends where the discharged plume reaches a physical boundary or assumes the same density as the ambient water.

Figure 2.1 and Figure 2.2 show conceptual diagrams of the dispersion and fates of positively and negatively buoyant discharges, respectively, and the idealised representation of the discharge phases.

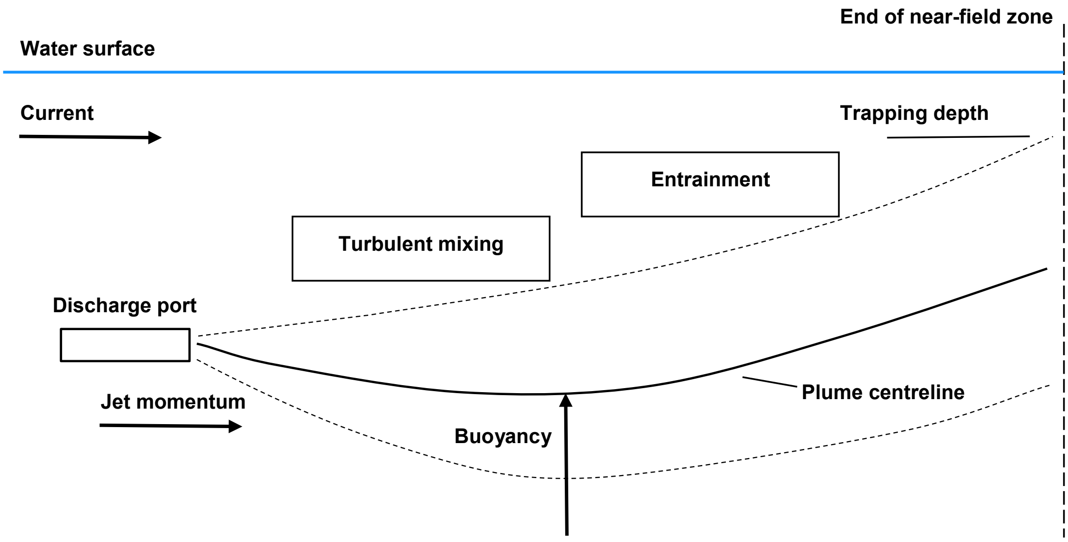

Figure 2.1 Conceptual diagram showing the general behaviour of a positively buoyant discharge.

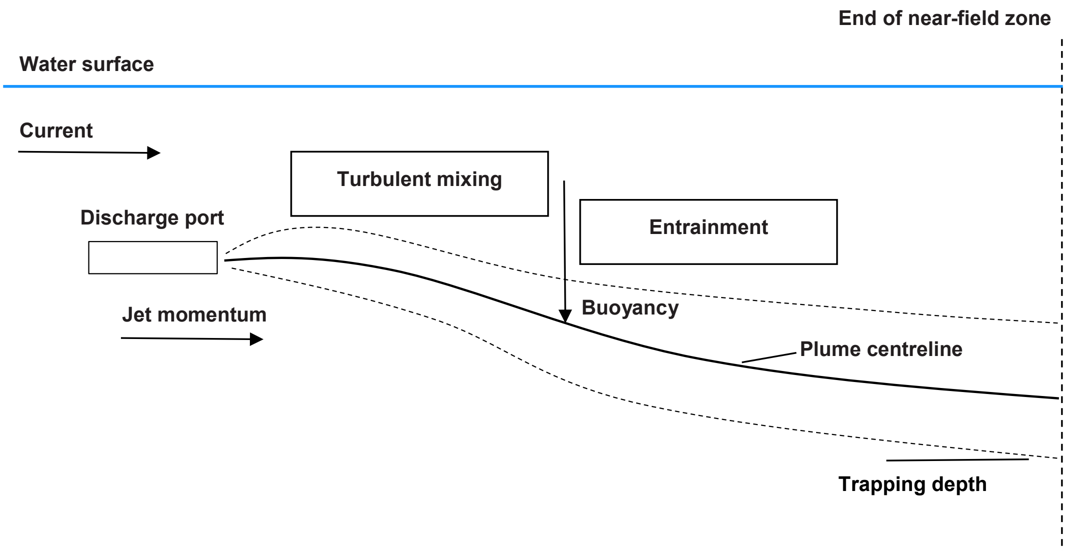

Figure 2.2 Conceptual diagram showing the general behaviour of a negatively buoyant discharge.

2.1.3 Setup of Near-Field Model

2.1.3.1 Discharge Characteristics

The CW discharge characteristics for Case C are summarised in Table 2.1. Case C represents the continuous discharge of CW at peak rates from the facility.

The PW discharge characteristics for Cases P and M are summarised in Table 2.2. Case P represents the continuous discharge of PW at peak rates from the facility. Case M represents an intermittent discharge of MEG as part of the PW stream during start-up and early operations. Note that the maximum MEG specification assumed for the purposes of modelling has since been updated, which is reflected in the Environmental Impact Statement (EIS)/Environmental Review Document (ERD).

The hydrotest discharge characteristics for Cases H1, H2, H3a and H3b are summarised in Table 2.3. These cases represent potential one-off discharges of hydrotest fluid from PLETs at the NRC tie-in, Torosa and Brecknock/Calliance locations following installation and commissioning of the BTL and inter-field spur line.

Indicative concentrations of the constituents of interest within the CW (chlorine), PW (total oil, mercury and MEG) and hydrotest (biocide) discharges are described in Table 2.4, Table 2.5 and Table 2.6, respectively. The indicated concentrations were based on the engineering definitions available at the time of commissioning the dispersion modelling study and should not be considered definitive.

Table 2.1 Summary of the CW discharge characteristics.

Parameter	Case C
Discharge location	Torosa FPSO
Discharge coordinates	13° 58' 15.06" S 122° 01' 28.53" E
Flow rate (m^3/d)	720,000
Outlet pipe internal diameter (m) [in]	2 x 0.91 [2 x 36]
Outlet pipe orientation	Horizontal
Depth of pipe below sea surface (m)	12
Discharge salinity (ppt)	35
Discharge temperature (°C)	50

Table 2.2 Summary of the PW discharge characteristics.

Parameter	Case P	Case M
Discharge location	Torosa FPSO	
Discharge coordinates	13° 58' 15.06" S 122° 01' 28.53" E	
Flow rate (m^3/d)	5,723	490
Outlet pipe internal diameter (m) [in]	0.15 [6]	
Outlet pipe orientation	Horizontal	
Depth of pipe below sea surface (m)	14	
Discharge salinity (ppt)	9.5	0.0
Discharge temperature (°C)	50	

Table 2.3 Summary of the hydrotest discharge characteristics.

Parameter	Case H1	Case H2	Case H3a	Case H3b
Discharge location	NRC Tie-In PLET	Torosa PLET	Breck./Cal. PLET	Torosa PLET
Discharge coordinates	19° 36' 41.37" S 116° 10' 23.53" E	13° 58' 41.70" S 122° 01' 26.76" E	14° 32' 21.92" S 121° 37' 34.23" E	13° 58' 41.70" S 122° 01' 26.76" E
Flow rate (m^3/min)	25			
Discharge volume (m^3)	736,000	846,000	790,000	56,000
Discharge duration (hours)	490	564	527	37
Outlet pipe internal diameter (m) [in]	0.2 [7.9]			
Outlet pipe orientation	Horizontal			
Depth of pipe below sea surface (m)	117	461	539	461
Discharge salinity (ppt)	Ambient (seabed)			
Discharge temperature (°C)	Ambient (seabed)			

Table 2.4 Constituent of interest within the CW discharge.

Constituent/Property	Indicative Source Concentration or Temperature
Chlorine	0.2 ppm
	0.5 ppm
Temperature	50 °C

Table 2.5 Constituents of interest within the PW discharges.

Constituent	Indicative Source Concentration (mg/L)
Total Oil (including BTEX)	30
Mercury	0.03
MEG	79,000

Table 2.6 Constituent of interest within the hydrotest discharges.

Constituent	Indicative Source Concentration (ppm)
Biocide	600

2.1.3.2 Ambient Environmental Conditions

Inputs of ambient environmental conditions to the UM3 model included a vertical profile of temperature and salinity, along with constant current speeds and general direction. The temperature and salinity profiles are required to accurately account for the buoyancy of the diluting plume, while the current speeds control the intensity of initial mixing and the deflection of the CW, PW and hydrotest plumes. These inputs are described in the following sections.

2.1.3.2.1 Ambient Temperature and Salinity

Temperature and salinity data applied to the near-field modelling was sourced from the World Ocean Atlas 2013 (WOA13) database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration, NOAA) and its co-located World Data Center for Oceanography (Levitus *et al.*, 2013).

Table 2.7, Table 2.8 and Table 2.9 show the average seasonal water temperature and salinity levels at varying depths from 0 m to 500 m (depending on the location). This data can be considered representative of seasonal conditions at the Torosa FPSO/PLET, Brecknock/Calliance PLET and NRC tie-in PLET locations, respectively.

The seasonal temperature profiles exhibit a reasonably consistent reduction in temperature with increasing depth. Salinity levels are generally more consistent and exhibit a vertically well-mixed water body (34.3-34.6 practical salinity unit, PSU), irrespective of season or depth.

Table 2.7 Average temperature and salinity levels adjacent to the proposed Torosa FPSO/PLET locations.

Season	Depth (m)	Temperature (°C)	Salinity (PSU)
Summer	0	29.7	34.6
	20	29.4	34.6
	50	28.0	34.5
	200	16.5	34.6
	500	8.7	34.6
Transitional	0	28.5	34.4
	20	28.1	34.4
	50	26.9	34.4
	200	16.1	34.6
	500	8.7	34.6
Winter	0	27.6	34.3
	20	27.6	34.3
	50	27.2	34.4
	200	17.1	34.6
	500	8.7	34.6
Annualised	0	28.4	34.4
	20	28.2	34.4
	50	27.3	34.4
	200	16.6	34.6
	500	8.7	34.6

Table 2.8 Average temperature and salinity levels adjacent to the proposed Brecknock/Calliance PLET location.

Season	Depth (m)	Temperature (°C)	Salinity (PSU)
Summer	0	29.7	34.6
	20	29.4	34.6
	50	28.0	34.5
	200	16.5	34.6
	500	8.7	34.6
Transitional	0	28.5	34.4
	20	28.1	34.4
	50	26.9	34.4
	200	16.1	34.6
	500	8.7	34.6
Winter	0	27.6	34.3
	20	27.6	34.3
	50	27.2	34.4
	200	17.1	34.6
	500	8.7	34.6
Annualised	0	28.4	34.4
	20	28.2	34.4
	50	27.3	34.4
	200	16.6	34.6
	500	8.7	34.6

Table 2.9 Average temperature and salinity levels adjacent to the proposed NRC tie-in PLET location.

Season	Depth (m)	Temperature (°C)	Salinity (PSU)
Summer	0	28.5	34.8
	20	28.3	34.8
	50	26.8	34.8
	200	20.6	34.9
Transitional	0	27.1	34.8
	20	26.8	34.8
	50	25.4	34.8
	200	20.9	35.0
Winter	0	27.0	34.9
	20	26.9	34.9
	50	26.4	34.9
	200	21.2	34.9
Annualised	0	27.4	34.8
	20	27.2	34.8
	50	26.2	34.8
	200	20.9	34.9

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2.1.3.2.2 Ambient Current

Ocean current data was sourced from a ten-year hindcast data set of combined large-scale ocean (BRAN) and tidal currents. The data was statistically analysed to determine the 5th, 50th and 95th percentile current speeds. These statistical current speeds can be considered representative of seasonal conditions at the Torosa FPSO/PLET, Brecknock/Calliance PLET and NRC tie-in PLET locations.

Table 2.10, Table 2.11 and Table 2.12 present the steady-state, unidirectional current speeds at varying depths used as input to the near-field model as forcing for each discharge case at the Torosa FPSO/PLET, Brecknock/Calliance PLET and NRC tie-in PLET locations, respectively:

- 5th percentile current speed: weak currents, low dilution and slow advection.
- 50th percentile (median) current speed: average currents, moderate dilution and advection.
- 95th percentile current speed: strong currents, high dilution and rapid advection to nearby areas.

The 5th, 50th and 95th percentile values are referenced as weak, medium and strong current speeds, respectively.

Table 2.10 Adopted ambient current conditions adjacent to the proposed Torosa FPSO/PLET locations.

Season	Depth (m)	5th Percentile (Weak) Current Speed (m/s)	50th Percentile (Medium) Current Speed (m/s)	95th Percentile (Strong) Current Speed (m/s)
Summer	2.5	0.038	0.145	0.316
	22.7	0.032	0.128	0.296
	56.7	0.027	0.118	0.281
	205.2	0.019	0.100	0.251
	545.5	0.013	0.095	0.221
Transitional	2.5	0.037	0.141	0.316
	22.7	0.033	0.132	0.299
	56.7	0.028	0.120	0.294
	205.2	0.019	0.104	0.269
	545.5	0.013	0.097	0.282
Winter	2.5	0.031	0.130	0.283
	22.7	0.027	0.124	0.275
	56.7	0.024	0.113	0.266
	205.2	0.019	0.100	0.247
	545.5	0.012	0.091	0.278
Annualised	2.5	0.034	0.137	0.303
	22.7	0.030	0.128	0.289
	56.7	0.026	0.116	0.280
	205.2	0.019	0.101	0.256
	545.5	0.012	0.094	0.267

Table 2.11 Adopted ambient current conditions adjacent to the proposed Brecknock/Calliance PLET location.

Season	Depth (m)	5th Percentile (Weak) Current Speed (m/s)	50th Percentile (Medium) Current Speed (m/s)	95th Percentile (Strong) Current Speed (m/s)
Summer	2.5	0.042	0.155	0.316
	22.7	0.043	0.151	0.306
	56.7	0.042	0.149	0.301
	205.2	0.041	0.146	0.297
	545.5	0.040	0.142	0.290
Transitional	2.5	0.044	0.163	0.327
	22.7	0.044	0.161	0.326
	56.7	0.044	0.159	0.323
	205.2	0.043	0.158	0.320
	545.5	0.042	0.154	0.313
Winter	2.5	0.039	0.144	0.300
	22.7	0.038	0.143	0.299
	56.7	0.038	0.143	0.299
	205.2	0.038	0.143	0.298
	545.5	0.038	0.143	0.295
Annualised	2.5	0.042	0.153	0.314
	22.7	0.041	0.151	0.311
	56.7	0.041	0.150	0.308
	205.2	0.040	0.149	0.306
	545.5	0.040	0.146	0.300

Table 2.12 Adopted ambient current conditions adjacent to the proposed NRC tie-in PLET location.

Season	Depth (m)	5th Percentile (Weak) Current Speed (m/s)	50th Percentile (Medium) Current Speed (m/s)	95th Percentile (Strong) Current Speed (m/s)
Summer	2.5	0.043	0.167	0.357
	22.7	0.043	0.165	0.345
	56.7	0.042	0.161	0.342
	130.0	0.042	0.161	0.342
Transitional	2.5	0.042	0.173	0.374
	22.7	0.046	0.170	0.366
	56.7	0.041	0.164	0.360
	130.0	0.041	0.164	0.360
Winter	2.5	0.050	0.183	0.365
	22.7	0.047	0.175	0.355
	56.7	0.043	0.164	0.350
	130.0	0.043	0.164	0.350
Annualised	2.5	0.045	0.176	0.366
	22.7	0.046	0.171	0.357
	56.7	0.042	0.163	0.352
	130.0	0.042	0.163	0.352

2.2 Far-Field Modelling

2.2.1 Overview

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included, and the potential for recirculation of the plume back to the discharge location to be assessed. In this case, concentrations near the discharge point can be increased due to the discharge plume mixing with the remnant plume from an earlier time. This may be a potential source of episodic increases in plume concentrations in the receiving waters.

2.2.2 Description of Far-Field Model: CHEMMAP

The mixing and dispersion of the CW discharges was predicted using the three-dimensional discharge and plume behaviour model, CHEMMAP (French-McCay & Isaji, 2004; French-McCay *et al.*, 2006).

CHEMMAP predicts the movement and fate of a wide variety of chemical products, including floating, sinking, soluble/insoluble chemicals and product mixtures (French-McCay & Isaji, 2004). CHEMMAP incorporates many important chemical modelling components, including: transport and spreading of floating chemicals; transport of dissolved or particulate chemicals in three dimensions; evaporation or volatilisation of chemicals at the surface; dissolution; re-suspension; sedimentation; and degradation of chemicals in air, water and sediments (French-McCay *et al.*, 2006).

The most important inputs associated with the chemical model are the physical properties relating to the released chemical. The properties used to predict the fate and transport of each chemical include density, vapour pressure, water solubility, environmental degradation rates, adsorbed/dissolved partitioning coefficients (K_{OW}, K_{OC}), viscosity and surface tension (French-McCay *et al.*, 2006). CHEMMAP contains its own chemical database and the information found within this database is compiled from published literature sources (French-McCay & Payne, 2008).

The transport algorithm within CHEMMAP depends heavily on the precision of the input current data (French-McCay & Whittier, 2004). The model uses a Lagrangian three-dimensional transport model to predict the movement of the chemical in the water column, on the surface and in the air (French-McCay & Whittier, 2004).

For each time step, the model calculates the phase transfer percentages and changes the state of particular proportions of the spilled chemical (French-McCay & Isaji, 2004). This may mean that a chemical changes from a substance floating on the surface to a gas, or is dissolved into the water column. The evaporation algorithm used in the CHEMMAP model has been tested by comparison to experimental data from Kawamura & Mackay (1987) and French-McCay & Whittier (2004).

2.2.3 Description of Far-Field Model: MUDMAP

The mixing and dispersion of the PW and hydrotest discharges was predicted using the three-dimensional discharge and plume behaviour model, MUDMAP (Koh & Chang, 1973; Khondaker, 2000).

The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. Any chemicals/constituents within the discharge stream are represented by a sample of Lagrangian particles. These particles are moved in three dimensions over each subsequent time step according to the prevailing local current data as well as horizontal and vertical mixing coefficients.

MUDMAP treats the Lagrangian particles as conservative tracers (i.e. they are not removed over time to account for chemical interactions, decay or precipitation). Predicted concentrations will therefore be conservative overestimates where these processes actually do occur. Each particle represents a proportion of the discharge, by mass, and particles are released at a given rate to represent the rate of the discharge (mass per unit time). Concentrations of constituents are predicted over time by counting the number of particles that occur within a given depth level and grid square and converting this value to mass per unit volume.

The system has been extensively validated and applied for discharge operations in Australian waters (e.g. Burns *et al.*, 1999; King & McAllister, 1997, 1998).

2.2.4 Stochastic Modelling

A stochastic modelling procedure was applied in the far-field modelling to sample a representative set of conditions that could affect the distribution of constituents. This approach involves multiple possible simulations of a given discharge scenario and season (50 for the CW and PW discharges; 25 for the hydrotest discharges), with each simulation being carried out under a randomly-selected period of currents. This methodology ensures that the calculated movement and fate of each discharge is representative of the range of prevailing currents at the discharge location. Once the stochastic modelling is complete, all simulations are statistically analysed to develop the distribution of outcomes based on time and event.

The stochastic simulations are jointly processed as an aggregated set for each season. This is done by building a time series of maximum constituent concentrations, at any depth in the water column within each model grid cell, for all time steps of all replicate simulations. The resultant time series at each grid cell is a representation of the stochastic outcomes, and this is statistically analysed to allow percentile data (representing the percentage of time that particular concentrations occur) to be generated. The resultant percentile concentration contours, and the initial source concentration of the discharge, are used to determine the dilution contours for each percentile.

To calculate the tabulated results of dilutions at particular distances from the source location, all grid cells at the specified radial distances (e.g. 100 m), including a buffer zone of 10 m either side (e.g. every grid cell in the 90-110 m range), are interrogated. The minimum dilution is calculated as the lowest value in any individual non-zero grid cell within the defined range, including the buffer zone. The average dilution is calculated as the average value across all non-zero grid cells within the defined range, including the buffer zone. This is done for all defined radial distances from the source location for each percentile.

The process is similar on the outer edge of the Scott Reef receptor, where there is a 10 m buffer zone, but on the inside the entire receptor area is considered in order to capture details of the plume characteristics at all points predicted to be affected. The analysis is therefore not restricted only to the receptor boundary line. The minimum dilution is calculated as the lowest value in any individual non-zero grid cell within the receptor area (plus the 10 m outer buffer), while the average dilution is calculated as the average value across all non-zero grid cells within the receptor area (plus the 10 m outer buffer). In practice, because the aggregated plume concentrations generally decrease as the plume penetrates further into the receptor (with dilution levels therefore increasing), the minimum dilutions identified by the analysis are usually found on or very close to the boundary line.

2.2.5 Setup of Far-Field Model

2.2.5.1 Discharge Characteristics

The CHEMMAP and MUDMAP models simulated the discharge into a time-varying current field with the initial dilution set by the near-field results described in Section 2.1.

The CW and PW discharge scenarios were modelled as a continuous discharge using 50 simulations for each season, while the hydrotest discharge scenarios were modelled as a one-off discharge using 25 simulations for each season. A reduced number of hydrotest simulations was justified in light of the significantly longer duration of most of these scenarios (>20 days in three of four cases) relative to the duration of all CW and PW scenarios (5 days). Even with fewer replicates, the range of environmental conditions sampled from the ten-year hindcast data set during the hydrotest simulations was similarly extensive to (or more extensive than) that sampled during the CW and PW simulations.

Once the simulations were complete, they were reported on a seasonal basis: (i) summer (December to February); (ii) transitional (March and September to November) and (iii) winter (April to August). The CW, PW and hydrotest discharge characteristics for all cases are summarised in Table 2.13, Table 2.14 and Table 2.15, respectively.

Table 2.13 Summary of far-field CW discharge modelling assumptions.

Parameter	Case C
Hindcast modelling period	2006-2015
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual
Flow rate (m^3/d)	720,000
Discharge depth (m)	12
Discharge salinity (ppt)	35
Discharge temperature (°C)	50
Number of simulations	150 (50 per season)
Simulated discharge type	Continuous
Simulated discharge period (days)	5

Table 2.14 Summary of far-field PW discharge modelling assumptions.

Parameter	Case P	Case M
Hindcast modelling period	2006-2015	
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual	
Flow rate (m^3/d)	5,723	490
Discharge depth (m)	14	
Discharge salinity (ppt)	9.5	0.0
Discharge temperature (°C)	50	
Number of simulations	150 (50 per season)	
Simulated discharge type	Continuous	
Simulated discharge period (days)	5	

Table 2.15 Summary of far-field hydrotest discharge modelling assumptions.

Parameter	Case H1	Case H2	Case H3a	Case H3b
Hindcast modelling period	2006-2015			
Seasons	Summer (December to February) Transitional (March and September to November) Winter (April to August) Annual			
Flow rate (m^3/min)	25			
Discharge volume (m^3)	736,000	846,000	790,000	56,000
Discharge duration (hours)	490	564	527	37
Discharge depth (m)	117	461	539	461
Discharge salinity (ppt)	Ambient (seabed)			
Discharge temperature (°C)	Ambient (seabed)			
Number of simulations	75 (25 per season)			
Simulated discharge type	One-off			
Simulated discharge period (days)	21	24	22	4

2.2.5.2 Mixing Parameters

The horizontal and vertical dispersion coefficients represent the mixing and diffusion caused by turbulence, both of which are sub-grid-scale processes. Both coefficients are expressed in units of rate of area change per second (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations faster. Increasing the vertical dispersion coefficient spreads the discharge across the vertical layers (or depths) faster.

Spatially constant, conservative dispersion coefficients of 0.25 m^2/s and 0.00001 m^2/s were used to control the spreading of the CW, PW and hydrotest plumes in the horizontal and vertical directions, respectively. Each of the mixing parameters was selected following extensive sensitivity testing to recreate the plume characteristics predicted by the near-field modelling. It would be expected that the in situ mixing dynamics would be greater under average and high energy conditions by a factor of 10 (King & McAllister, 1997, 1998) and thus the far-field model results are designed to produce a worst-case result for concentration extents.

2.2.5.3 Grid Configuration

CHEMMAP and MUDMAP each use a three-dimensional grid to represent the geographic region under study (water depth and bathymetric profiles). Due to the rapid mixing and small-scale effect of the effluent discharge, it was necessary to use a fine grid with a resolution of 40 m x 40 m (CW and hydrotest discharges) and 20 m x 20 m (PW discharges) to track the movement and fate of the discharge plume. The extent of the grid region measured approximately 40 km (longitude or x-axis) by 40 km (latitude or y-axis) for CW and hydrotest discharges, and approximately 20 km by 20 km for PW discharges, each of which was subdivided horizontally into 1,000 x 1,000 cells. The vertical resolution was set to 1 m (CW and PW discharges) and 2 m (hydrotest discharges).

2.2.1 Regional Ocean Currents

2.2.1.1 Background

The area of interest for this study is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf. While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in all directions. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. Further south of the project area, the Leeuwin Current becomes the dominant large-scale current system, flowing poleward down the pressure gradient along the Western Australian coastline and past Cape Leeuwin.

Offshore regions with water depths exceeding 100-200 m experience significant large-scale drift currents. These drift currents can be relatively strong (1-2 knots) and complex, manifesting as a series of eddies, meandering currents and connecting flows. These offshore drift currents also tend to persist longer (days to weeks) than tidal current flows (hours between reversals) and thus will have greater influence upon the net trajectory of plumes over time scales exceeding a few hours.

On the continental shelf, in shallower waters around Scott Reef and closer to the inshore region of the Kimberley Coast, surface winds and tidal dynamics dominate over the large scale current flows (Condie & Andrewartha, 2008). In comparison to drift currents, tidal currents generate only relatively short tidal migrations (distance travelled by a parcel of water over a tidal cycle) that follow an elliptical path with a period of about 12 hours in the study region. Hence, tidal currents add variability to the longer-term drift patterns of an entrained plume.

Wind shear on the water surface also generates local-scale currents that can persist for extended periods (hours to days) and result in long trajectories. Persistent winds along the mainland coast can induce Ekman transport, where surface waters move offshore and facilitate upwelling events in which cold nutrient-rich waters from the deep Indian Ocean are brought to the surface. However, due to the opposing transport of warm tropical waters by the Leeuwin Current, large-scale persistent upwelling along the Western Australian coast is suppressed. Therefore, upwelling events are sporadic, short-term and localised to areas of the coastline where the continental shelf narrows, including the area around the Capes and the Ningaloo coast (IMOS, 2015). This process is seasonal/transient and affected by the strength of the Leeuwin Current, with minimal upwelling in times with strong Leeuwin Current flow.

The current-induced transport of plumes can be variably affected by combinations of tidal, wind-induced and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given discharge location.

To appropriately allow for temporal and spatial variation in the current field, dispersion modelling requires the current speed and direction over a spatial grid covering the potential migration trajectories of plumes. As long-term measured current data is not available for simultaneous periods over a network of locations covering the offshore areas relevant to this study, the analysis relied upon hindcasts of the circulation generated through numerical modelling by internationally recognised organisations.

A composite modelled ocean current data product was derived by combining predictions of mesoscale circulation currents, available at daily resolution from global ocean models, with predictions of the hourly tidal currents generated by the RPS HYDROMAP model. By combining a drift current model with a tidal model, the influences of inter-annual and seasonal drift patterns, and the more regular variations in tide, were depicted, ensuring nearshore and offshore hydrodynamic processes were represented.

2.2.1.2 Mesoscale Circulation

2.2.1.2.1 Description of Mesoscale Model: BRAN

Two mesoscale ocean current data sets were considered for the study: the CSIRO (Commonwealth Scientific and Industrial Research Organisation) global ocean model, BRAN (Bluelink ReANalysis); and the HYCOM (Hybrid Coordinate Ocean Model) Consortium's global ocean model, HYCOM. Based on a hydrodynamic model validation conducted by RPS, the output of the BRAN (Oke *et al.*, 2008, 2009; Schiller *et al.*, 2008) ocean model, which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy and CSIRO, was chosen for representation of the drift currents that affect the area. BRAN is a data-assimilative, three-dimensional ocean model that has been run as a hindcast for many periods and is now used for ocean forecasting (Schiller *et al.*, 2008).

BRAN routinely assimilates sea level anomaly data, tide gauge data, sea surface temperature and in situ temperature and salinity measurements (Oke *et al.*, 2009). Comparisons of BRAN hindcast outputs to satellite and independent in situ observations found that BRAN was reliably representing the broad-scale ocean circulation, the mesoscale surface eddy field, and shelf circulation around Australia (Oke *et al.*, 2008; Schiller *et al.*, 2008). Additionally, reanalysis of past periods using the BRAN model has been shown to realistically represent upwelling events, in particular along the Bonney Coast of South Australia, a region of frequent wind-driven upwellings (Oke *et al.*, 2009).

The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 0.1° over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale. Drift currents that are represented over the inner shelf waters in the BRAN data are principally attributable to wind induced drift.

There are several versions of the BRAN database available. The latest BRAN simulation spans the period of January 1994 to August 2016. From this database, three-dimensional data representing horizontal water movement at discrete depths was extracted for all points in the model domain for the years 2006-2015 (inclusive). The data was assumed to be a suitably representative sample of the current conditions over the study area for future years.

Although this data should represent effects of upwelling and downwelling processes on horizontal transport at a given depth, the data does not explicitly represent vertical currents between horizontal layers. This was considered reasonable because vertical currents associated with episodic upwelling and downwelling events are relatively small in magnitude (3-30 cm/s; Kampf *et al.*, 2004) compared to horizontal currents represented in the tidal and non-tidal current data (0.5-2 m/s), and considering allowances for dispersion rates in the horizontal (0.1-50 m/s) and vertical (1-10 cm/s) planes.

2.2.1.2.2 Mesoscale Current Validation

The suitability of the BRAN ocean model product was evaluated by comparing the predicted currents to those measured within the Browse project area. The validation included both quantitative and qualitative comparisons between measured and modelled data at a range of depths through the water column, at three available measurement locations shown in Figure 2.3: Browse C1-1 (three depth layers), B2-1 (eight depth layers) and G2-1 (three depth layers).

Time series comparisons of modelled and measured current magnitude, direction, and U/V velocity components are presented for sites B2-1 (Figure 2.4 and Figure 2.5), C1-1 (Figure 2.6 and Figure 2.7) and G2-1 (Figure 2.8 and Figure 2.9). For the purposes of brevity and clarity, only a surface and mid-depth time series at each site was selected for presentation. The time series comparisons revealed that, at two of the sites (B2-1 and G2-1), the BRAN model offered a good match in magnitude and direction of the measured current velocity in the upper water column; however, the magnitudes of the peaks and troughs were often underpredicted at the deeper levels. At the C1-1 site, the BRAN model captured the range in current magnitude at each depth; however, the timing of peaks and troughs in the measured current velocity and direction was not well-matched. Given the location of this site in close proximity to Scott Reef, with steep gradients in the bathymetry and the relatively coarse resolution of the ocean model (relative to the tidal model), this was not unexpected.

A quantitative analysis of the BRAN model's skill at replicating the drift currents was conducted using the Index of Agreement (IOA), presented in Willmott (1981) and Willmott *et al.* (1985), and the Mean Absolute Error (MAE), discussed in Willmott (1982) and Willmott & Matsuura (2005). A perfect agreement can be said to exist between the model and field observations if the IOA gives a measure of one, and complete disagreement will produce an IOA measure of zero (Willmott, 1981). The MAE is simply the average of the absolute values of the differences between the observed and modelled values.

The IOA and MAE values derived from comparisons of the U/V velocity components over the full measurement period at sites B2-1, C1-1 and G2-1 for all available water depths are presented in Table 2.16. The results confirm the conclusions drawn from analysis of the comparison time series plots. The IOA for both velocity components is good at sites B2-1 and G2-1 in the upper water column but reduces at deeper layers. This reflects the generally good match in the range, magnitude and direction of the measured and modelled drift currents at these sites, particularly in the upper water column. The IOA for both velocity components at site C1-1 is low, suggesting a poor agreement, reflecting the poor match in the timing of peaks and troughs in velocity observed in the time series plots.

Overall, the BRAN model data offered a reasonable match to the field measurements within the Browse project area, particularly in the upper water column. Given the stochastic methodology applied in far-field modelling, the use of a ten-year hindcast of BRAN current data allowed a realistic spatial distribution of potential plume trajectories and extents to be captured in aggregate. The BRAN model was considered suitable for use in the marine dispersion modelling studies.

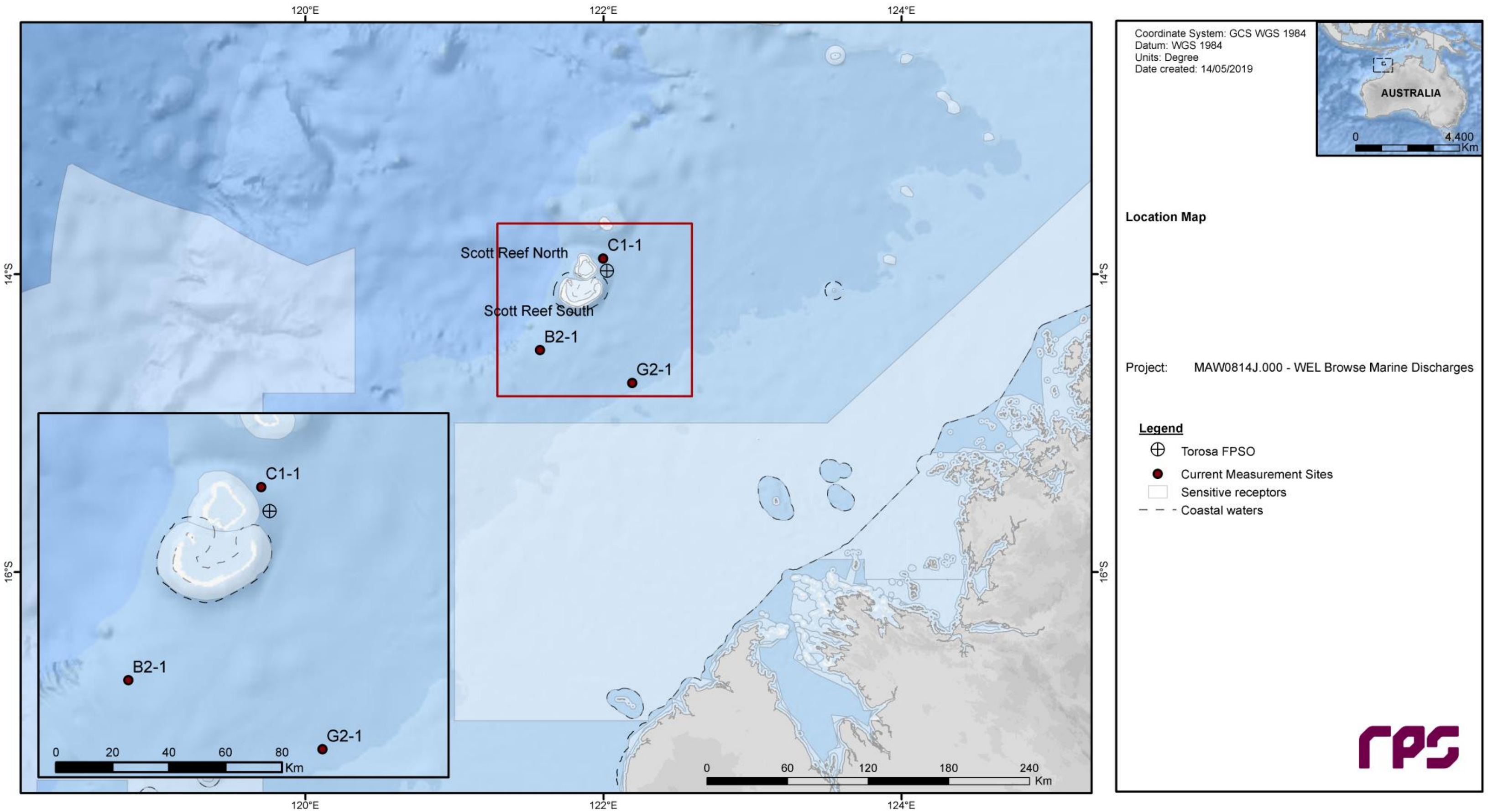

Figure 2.3 Locations of the proposed Torosa FPSO and the current measurement sites used for model validation, in proximity to Scott Reef, off the Kimberley Coast of Western Australia.

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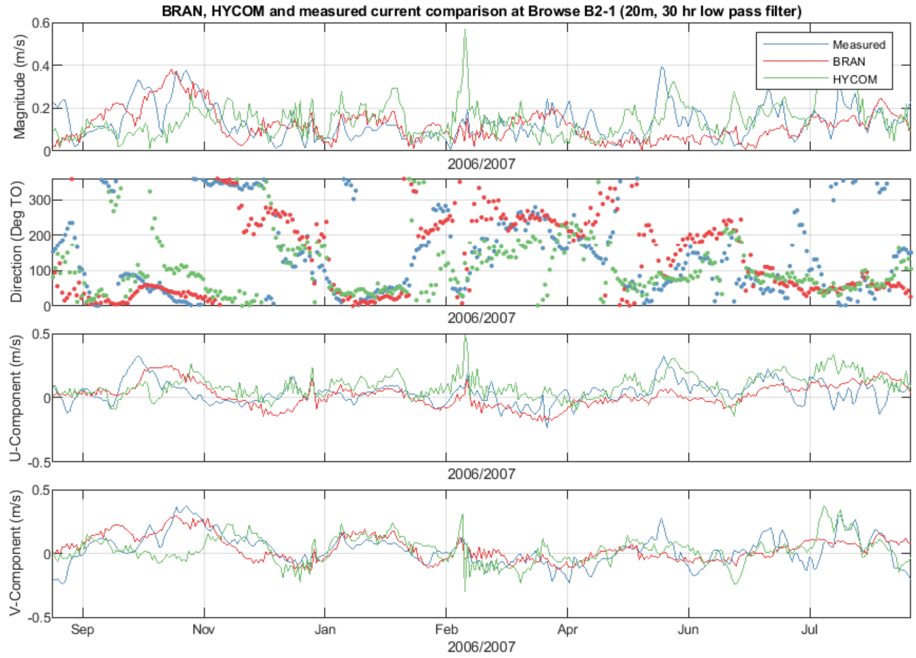

Figure 2.4 Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site B2-1, at a depth of approximately 20 m, for the period of August 2006 to July 2007.

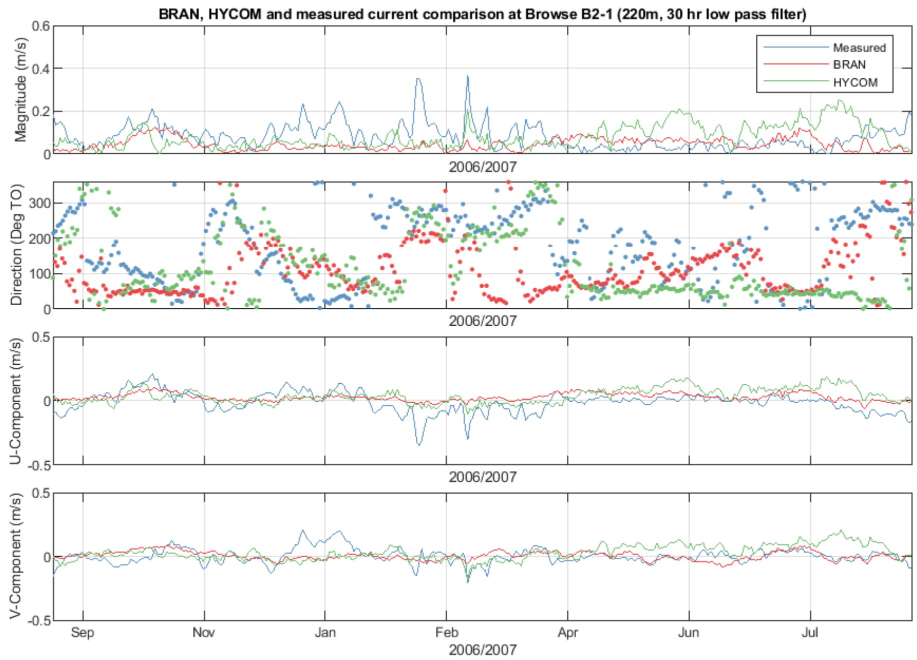

Figure 2.5 Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site B2-1, at a depth of approximately 220 m, for the period of August 2006 to July 2007.

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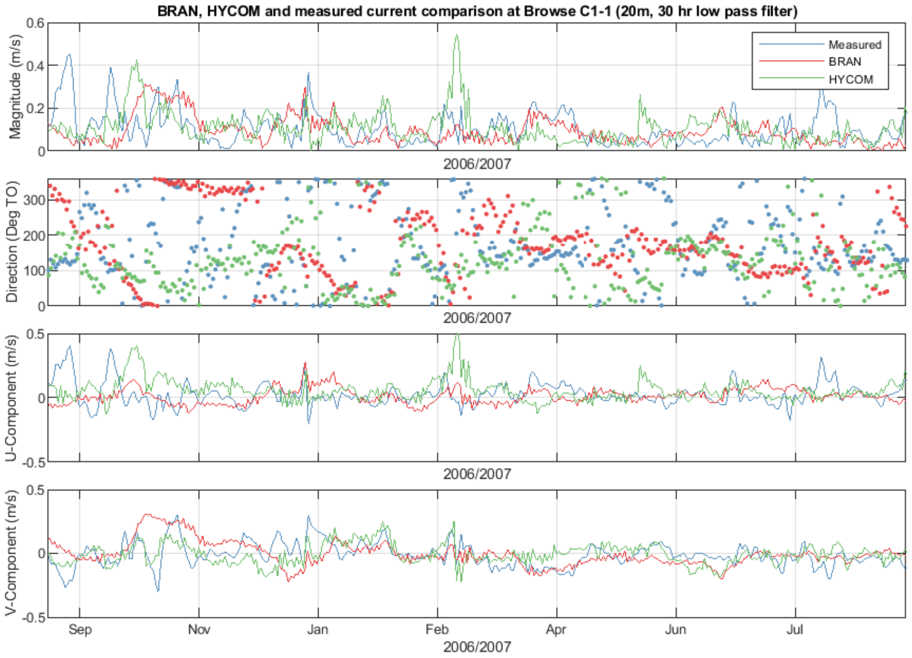

Figure 2.6 Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site C1-1, at a depth of approximately 20 m, for the period of August 2006 to July 2007.

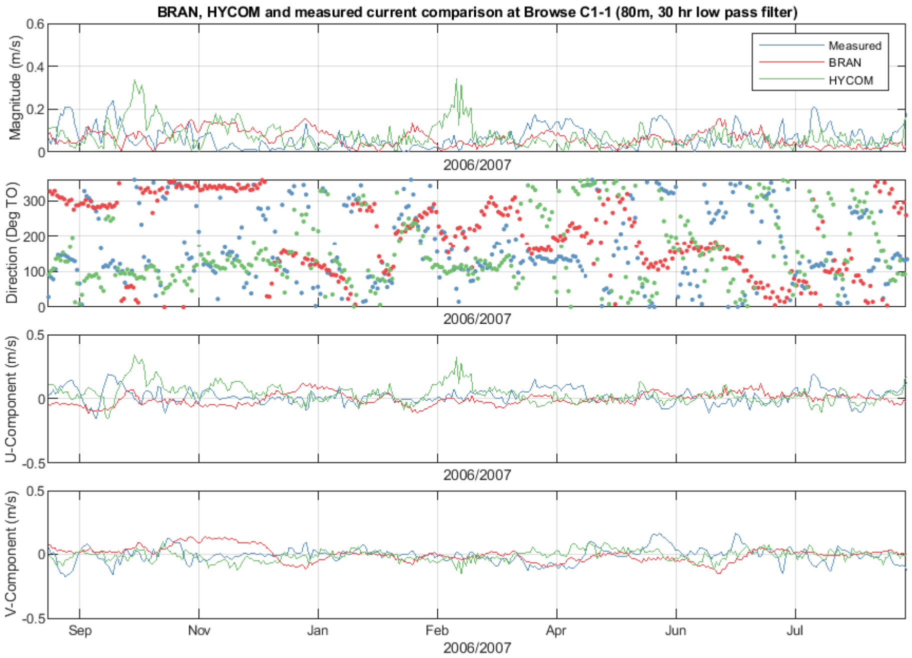

Figure 2.7 Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site C1-1, at a depth of approximately 80 m, for the period of August 2006 to July 2007.

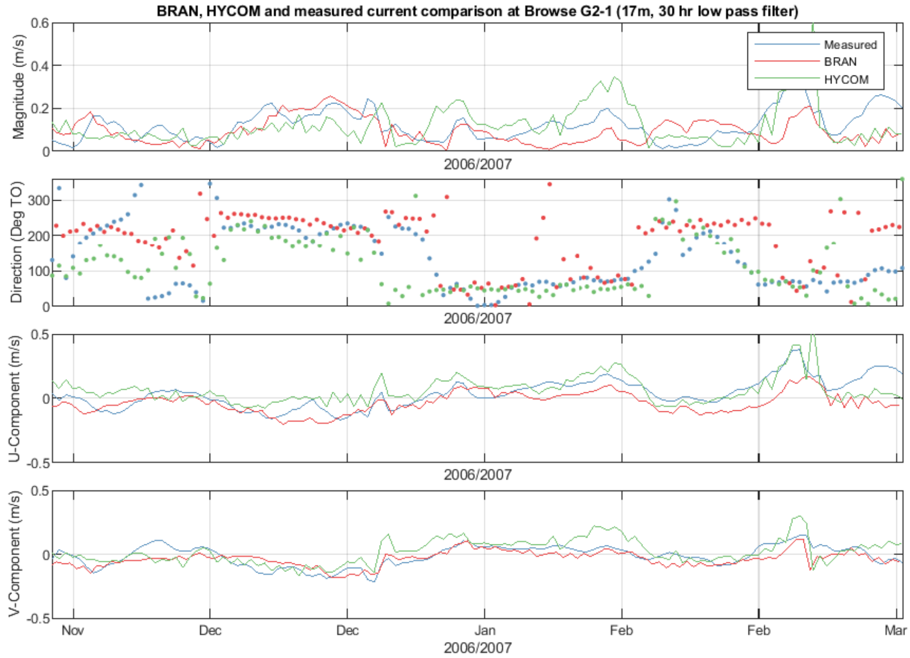

Figure 2.8 **Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site G2-1, at a depth of approximately 17 m, for the period of August 2006 to July 2007.**

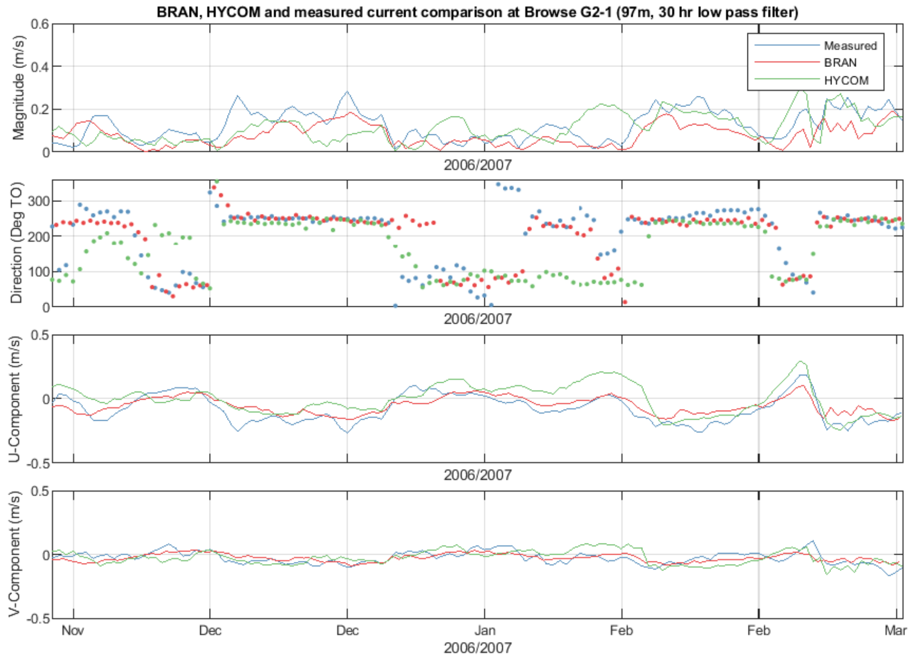

Figure 2.9 **Comparisons between BRAN-predicted (red line), HYCOM-predicted (green line) and measured (blue line) non-tidal current data at site G2-1, at a depth of approximately 97 m, for the period of August 2006 to July 2007.**

Table 2.16 Statistical comparison of BRAN-predicted and measured non-tidal current speeds along orthogonal component axes at the three measurement sites (2006-2007).

Site	Depth (m)	IOA		MAE (m/s)	
		U Component	V Component	U Component	V Component
B2-1	20.0	0.65	0.76	0.08	0.08
	60.0	0.68	0.77	0.06	0.06
	100.0	0.65	0.73	0.05	0.05
	160.0	0.70	0.63	0.05	0.05
	220.0	0.52	0.43	0.06	0.05
	300.0	0.47	0.52	0.04	0.04
	420.0	0.34	0.53	0.03	0.03
	547.4	0.46	0.40	0.02	0.02
C1-1	20.0	0.29	0.53	0.08	0.08
	80.0	0.28	0.32	0.06	0.06
	472.4	0.25	0.29	0.03	0.04
G2-1	17.0	0.71	0.81	0.08	0.05
	97.0	0.82	0.72	0.06	0.03
	192.0	0.45	0.17	0.06	0.06

2.2.1.2.3 Mesoscale Currents at the Discharge Locations

Figure 2.10, Figure 2.11 and Figure 2.12 show the seasonal distribution of current speeds and directions for the BRAN data points closest to the Torosa FPSO/PLET, Brecknock/Calliance PLET and NRC tie-in PLET locations, respectively. Note that the convention for defining current direction is the direction towards which the current flows.

The data near the Torosa locations (Figure 2.10) shows that current speeds and directions vary between seasons. In general, during summer (December to February) currents have the strongest average speed (0.13 m/s with a maximum of 0.42 m/s). Lower current speeds are typical of the transitional (March and September to November; 0.11 m/s with a maximum of 0.36 m/s) and winter (April to August; 0.10 m/s with a maximum of 0.28 m/s) seasons. Flow is expected to occur with a reasonably equitable distribution in all directions, but northerly and westerly flows are slightly more prevalent across the year.

The data near the Brecknock/Calliance location (Figure 2.11) shows that current speeds and directions are relatively consistent between seasons. In general, during summer currents have the strongest average speed (0.13 m/s with a maximum of 0.41 m/s). North-easterly flows are expected to be dominant across all seasons.

The data near the NRC tie-in location (Figure 2.12) shows that current speeds and directions are relatively consistent between seasons. In general, during the transitional season currents have the strongest average speed (0.10 m/s), with maximum current speeds of 0.40 m/s occurring during summer. South-westerly flows are expected to be dominant across all seasons.

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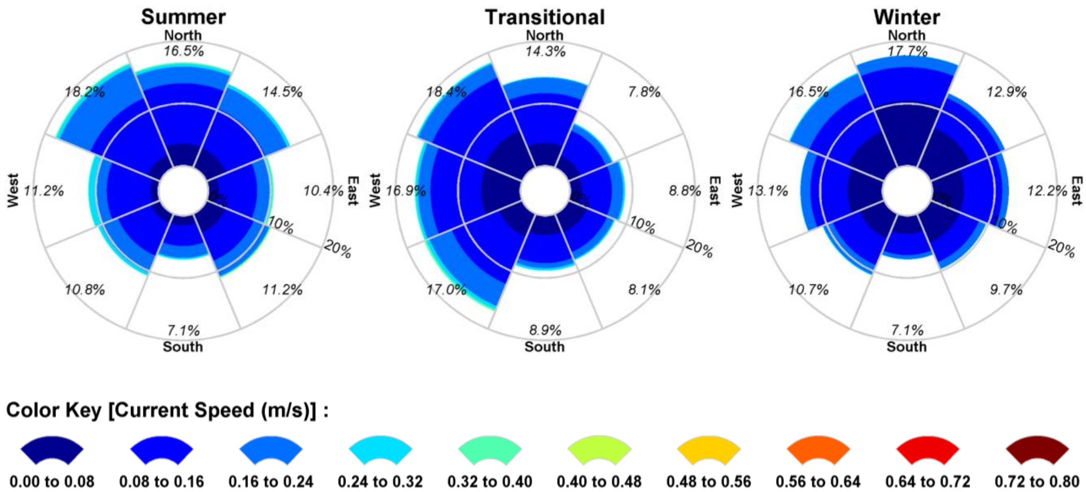

Figure 2.10 Seasonal current distribution (2006-2015, inclusive) derived from the BRAN database near to the proposed Torosa FPSO/PLET locations. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

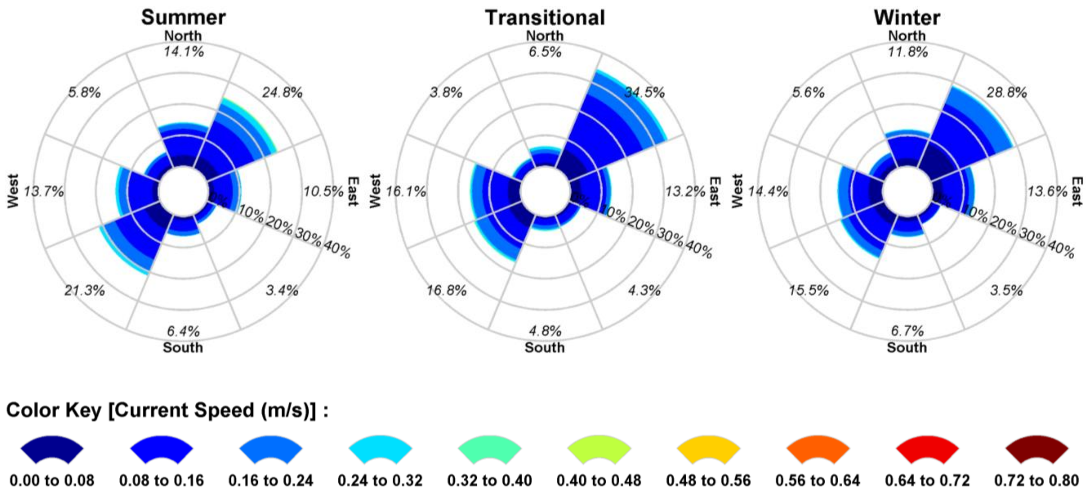

Figure 2.11 Seasonal current distribution (2006-2015, inclusive) derived from the BRAN database near to the proposed Brecknock/Calliance PLET location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

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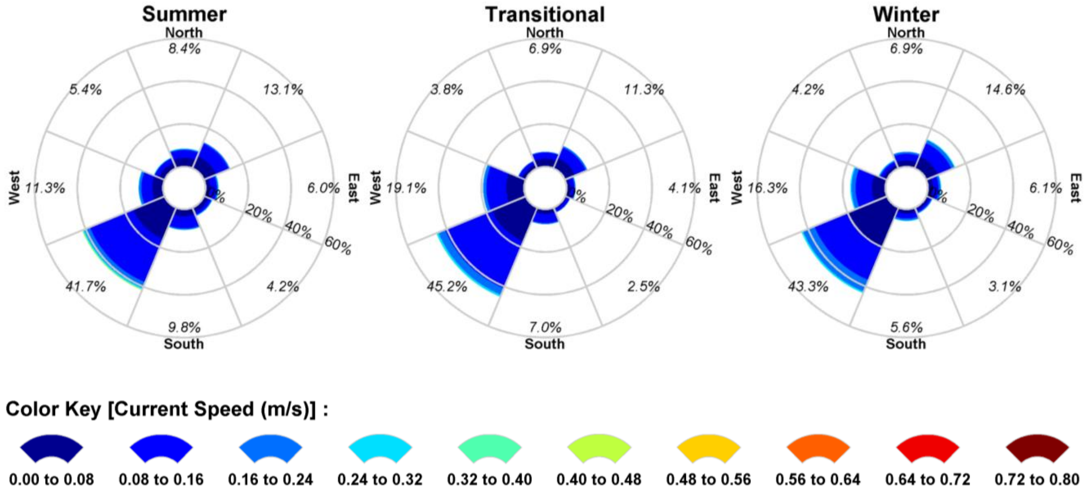

Figure 2.12 Seasonal current distribution (2006-2015, inclusive) derived from the BRAN database near to the proposed NRC tie-in PLET location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

2.2.1.3 Tidal Circulation

2.2.1.3.1 Description of Tidal Model: HYDROMAP

As the BRAN model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using RPS' three-dimensional hydrodynamic model, HYDROMAP.

The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 30 years (Isaji & Spaulding, 1984, 1986; Isaji *et al.*, 2001; Zigic *et al.*, 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan for the Australian Maritime Safety Authority (AMSA, 2002).

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

2.2.1.3.2 Tidal Domain Setup

A HYDROMAP model was established over a domain that extended approximately 3,300 km east-west by 3,100 km north-south over the eastern Indian Ocean. The grid extends beyond Eucla in the south and beyond Bathurst Island in the north (Figure 2.13). Approximately 98,600 cells were used to define the region, with four layers of sub-gridding applied to provide variable resolution throughout the domain. The resolution at the primary level was 15 km. The finer levels were defined by subdividing these cells into 4, 16 and 64 cells, resulting in resolutions of 7.5 km, 3.75 km and 1.88 km.

The finer grids were allocated in a step-wise fashion to areas where higher resolution of circulation patterns was required to resolve flows through channels, around shorelines or over more complex bathymetry. Figure 2.14 shows a zoomed subset of the hydrodynamic model grid in the Scott Reef region, showing the finer resolution grids surrounding Scott Reef, the numerous shoals and islands, and complex areas of the mainland coastline.

Modelling of the tidal circulation at relatively fine scales in the topographically-complex area around Scott Reef was achieved using an additional model sub-domain with resolutions ranging down to <500 m. Major tidal channels that occur across the reef flats of North Scott Reef were represented in this model, with tidal current flows across the rest of the flats known to be minimal.

High-resolution (~50 m) bathymetric data covering Scott and Seringapatam Reefs and the Brecknock, Torosa and Calliance gas fields was supplied by Woodside. Beyond these areas, bathymetric data used to define the three-dimensional shape of the study domain was extracted from the Geoscience Australia 250 m resolution bathymetry database (GA, 2009) and the CMAP electronic chart database, supplemented where necessary with manual digitisation of chart data supplied by the Australian Hydrographic Office. Depths in the domain ranged from shallow intertidal areas through to approximately 7,200 m.

2.2.1.3.3 Tidal Boundary Conditions

Ocean boundary data for the HYDROMAP model was obtained from the TOPEX/Poseidon global tidal database (TPXO7.2) of satellite-measured altimetry data, which provided estimates of tidal amplitudes and phases for the eight dominant tidal constituents (designated as K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1) at a horizontal scale of approximately 0.25°. Using the tidal data, sea surface heights are firstly calculated along the open boundaries at each time step in the model.

The TOPEX/Poseidon satellite data is produced, and quality controlled by the US National Atmospheric and Space Agency (NASA). The satellites, equipped with two highly accurate altimeters capable of taking sea level measurements accurate to less than ±5 cm, measured oceanic surface elevations (and the resultant tides) for over 13 years (1992-2005). In total, these satellites carried out more than 62,000 orbits of the planet. The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being the subject of more than 2,100 research publications (e.g. Andersen, 1995; Ludicone *et al.*, 1998; Matsumoto *et al.*, 2000; Kostianoy *et al.*, 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen, 2010). As such, the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

2.2.1.3.4 Tidal Elevation Validation

For the purpose of verification of the tidal predictions, the model output was compared against independent predictions of tides using the XTide database (Flater, 1998). The XTide database contains harmonic tidal constituents derived from measured water level data at locations around the world. Overall, there are more than 120 tidal stations within the HYDROMAP model domain; however, some of these are located in areas that are not sufficiently resolved by this large-scale ocean model. More than 80 stations along the coastline were suitable for comparisons of the model performance with the observed data. These stations covered the mid-to-northwest regions of the Western Australian coastline, encompassing the locales of the marine discharges considered in this study (Figure 2.13 and Figure 2.14). For the purposes of brevity and clarity, a selected representative subset of the available tidal station validation data is presented here.

Water level time series for the selected subset of ten stations are shown in Figure 2.15 and Figure 2.16 for a one-month period (January 2018). All comparisons show that the model produces a very good match to the known tidal behaviour for a wide range of tidal amplitudes and clearly represents the varying diurnal and semi-diurnal nature of the tidal signal.

The model skill was further evaluated through a comparison of the predicted and observed tidal constituents, derived from an analysis of model-predicted time series at each of the tidal station locations. Scatter plots of the observed and modelled amplitude (top) and phase (bottom) of the five dominant tidal constituents (S_2, M_2, N_2, K_1 and O_1) for all relevant stations within the model domain (>80) are presented in Figure 2.17. The red line on each plot shows the 1:1 line, which would indicate a perfect match between the modelled and observed data. Note that the data is generally closely aligned to the 1:1 line demonstrating the high quality of the model performance.

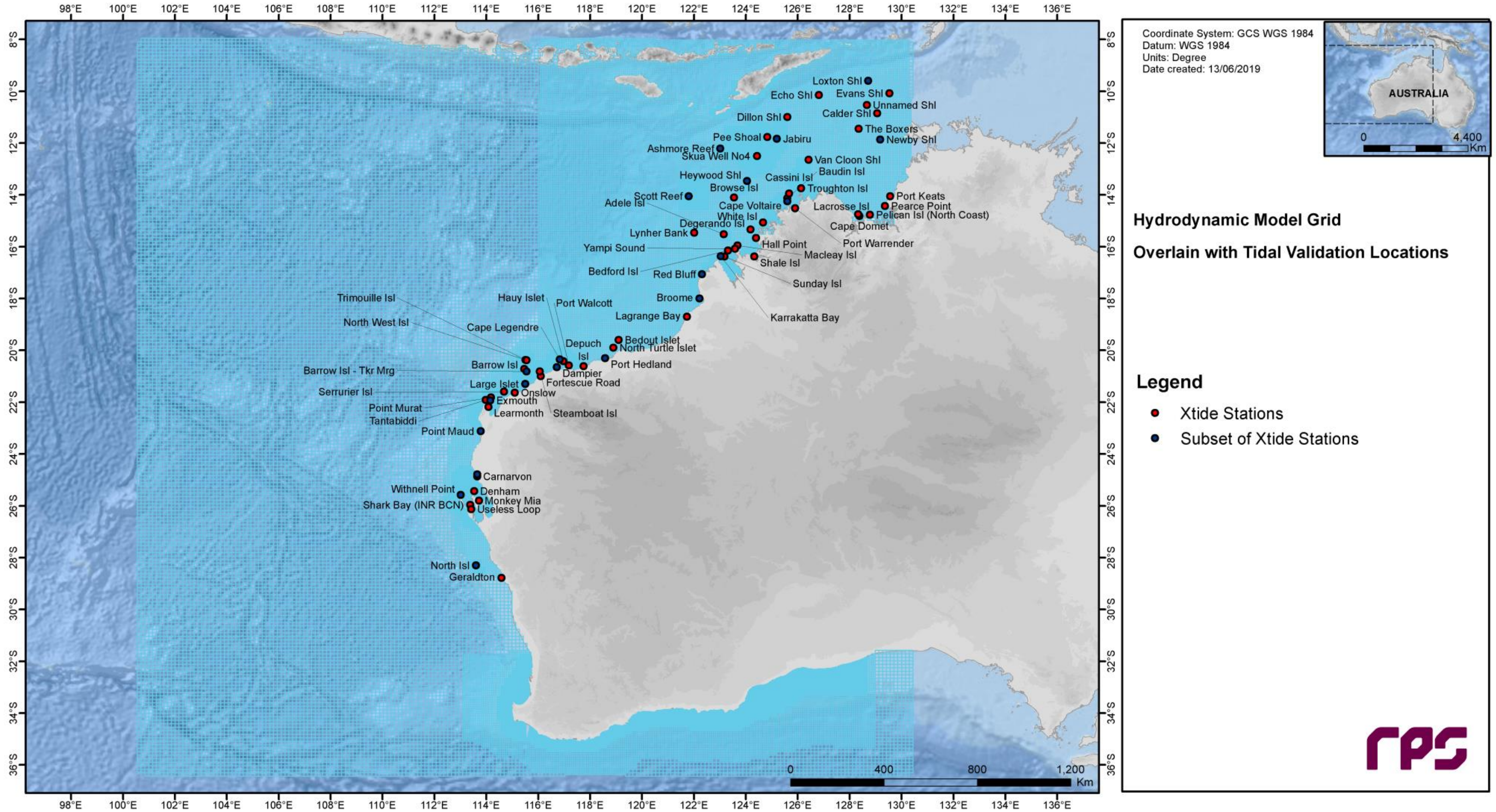

Figure 2.13 Hydrodynamic model grid (blue wire mesh) used to generate the tidal currents, showing the full domain in context with the continental land mass and the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.

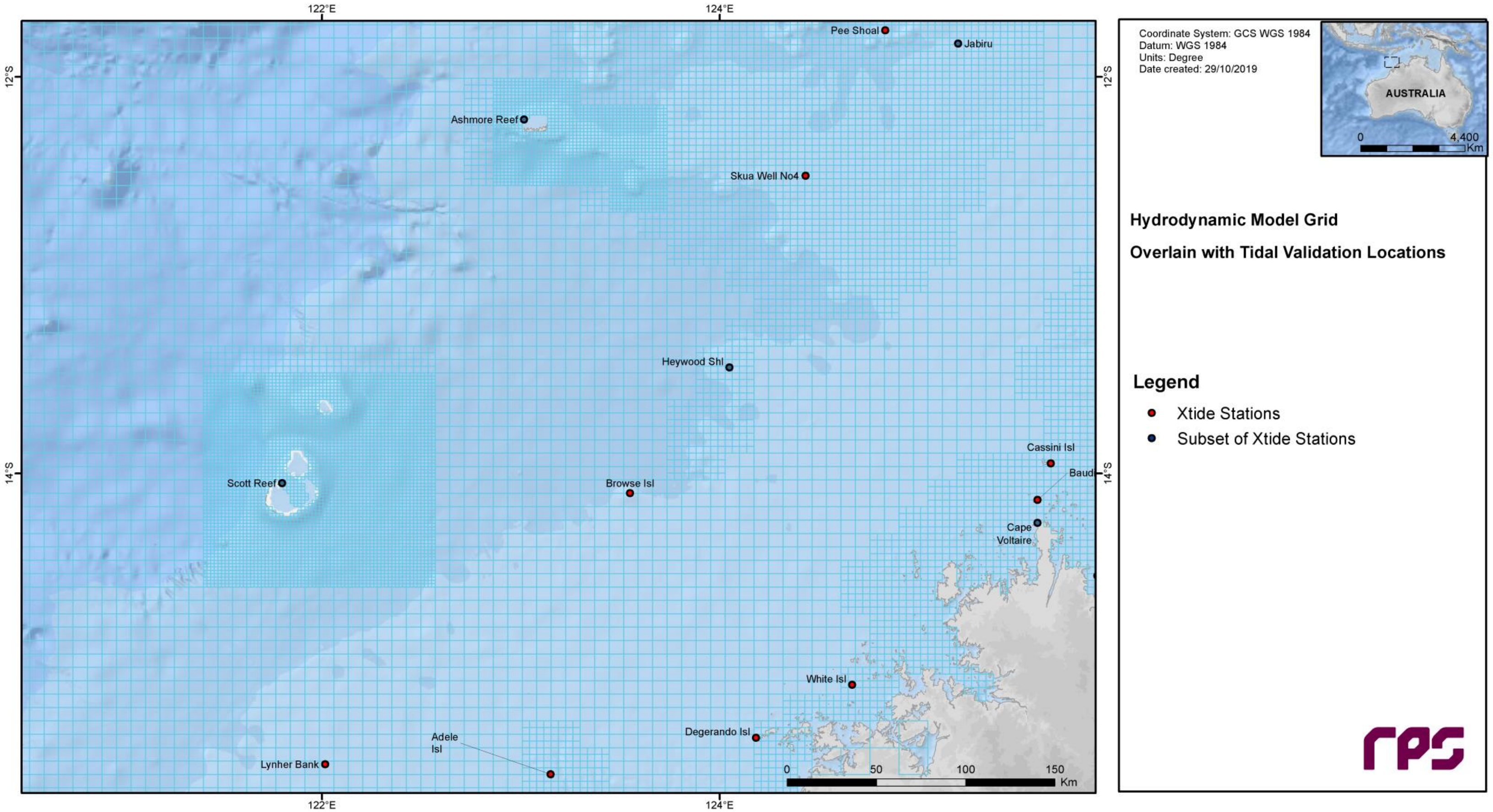

Figure 2.14 **Zoomed subset of the hydrodynamic model grid (blue wire mesh) for the Scott Reef area, showing the locations available for tidal comparisons (red and blue labelled dots). Higher-resolution areas are indicated by the denser mesh zones.**

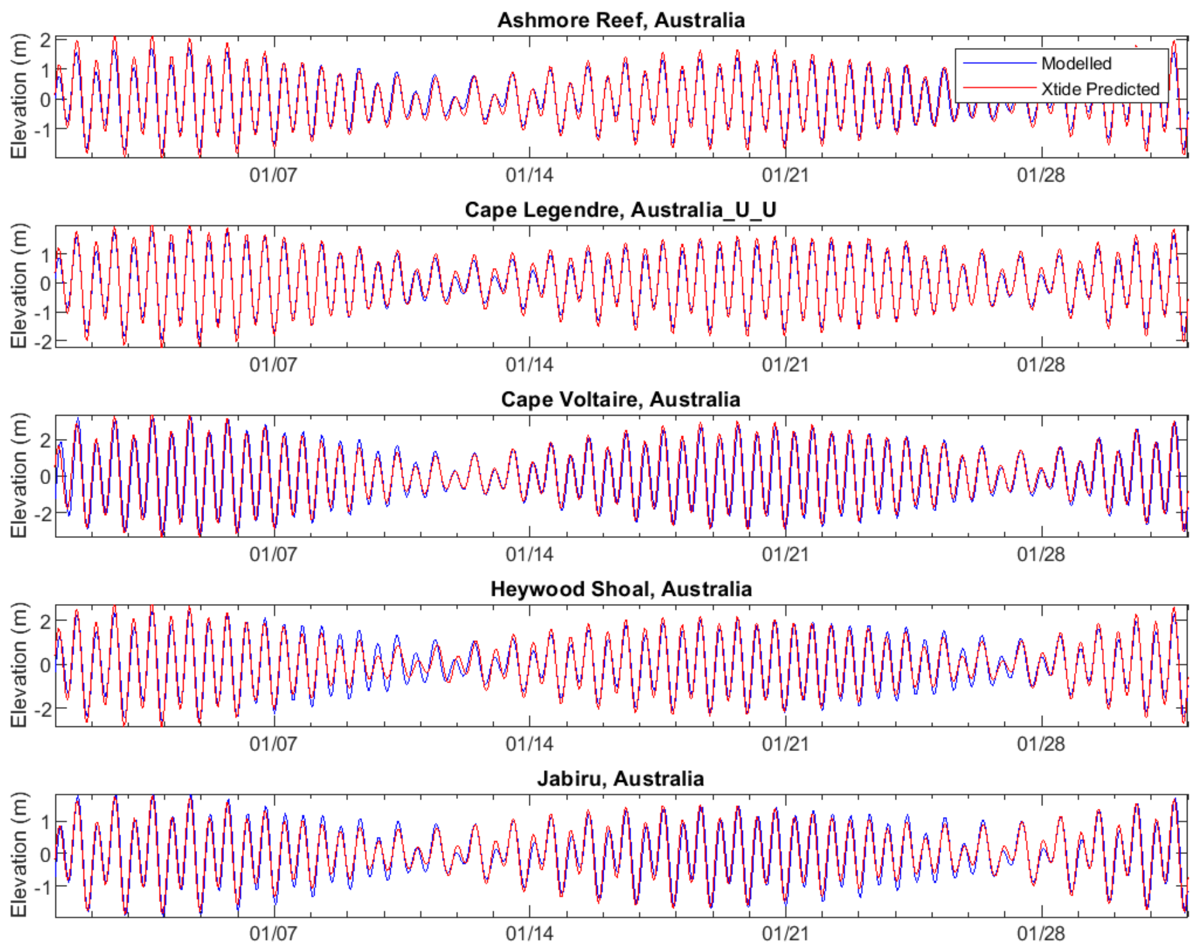

Figure 2.15 Comparisons between the predicted (blue line) and observed (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.

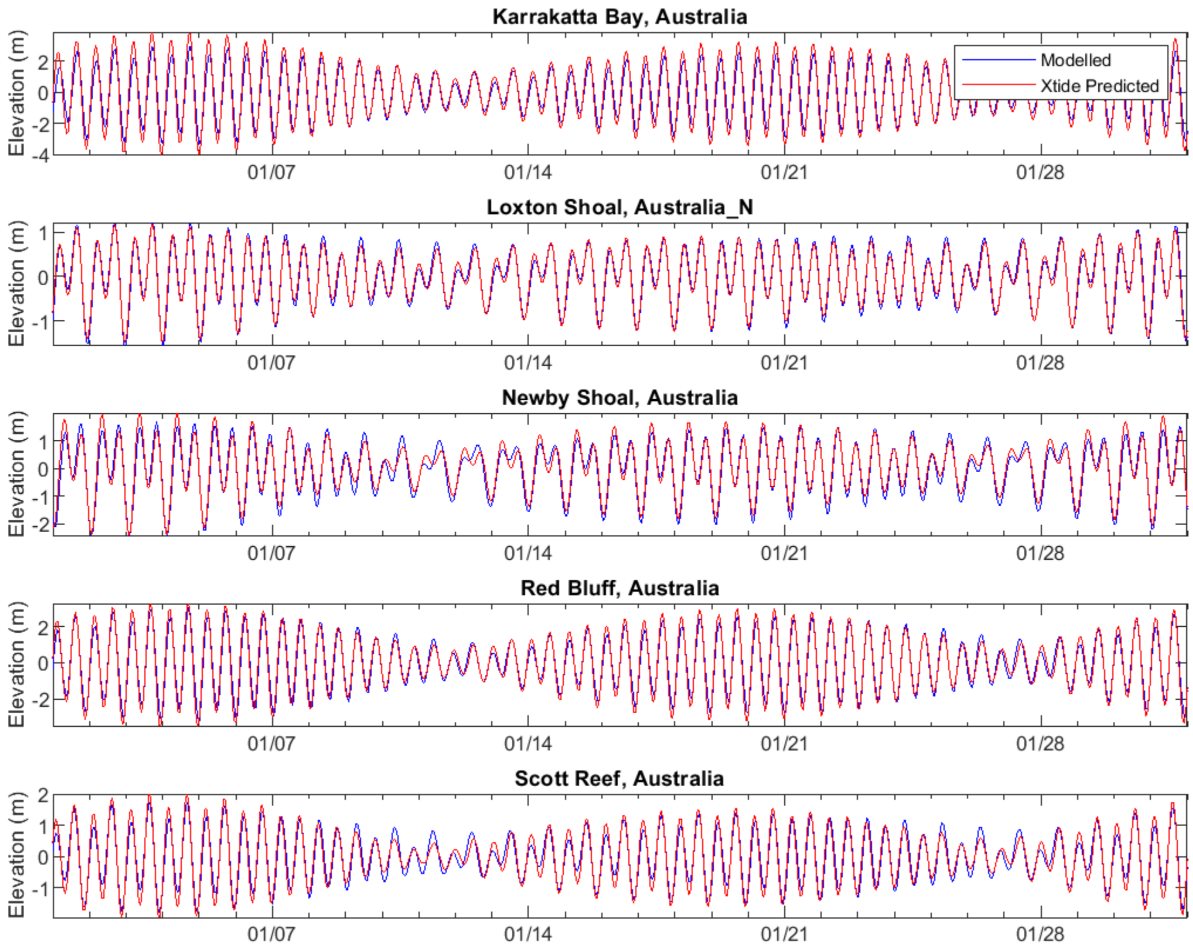

Figure 2.16 Comparisons between the predicted (blue line) and observed (red line) surface elevation variations at five locations in the north-east of the tidal model domain for January 2018.

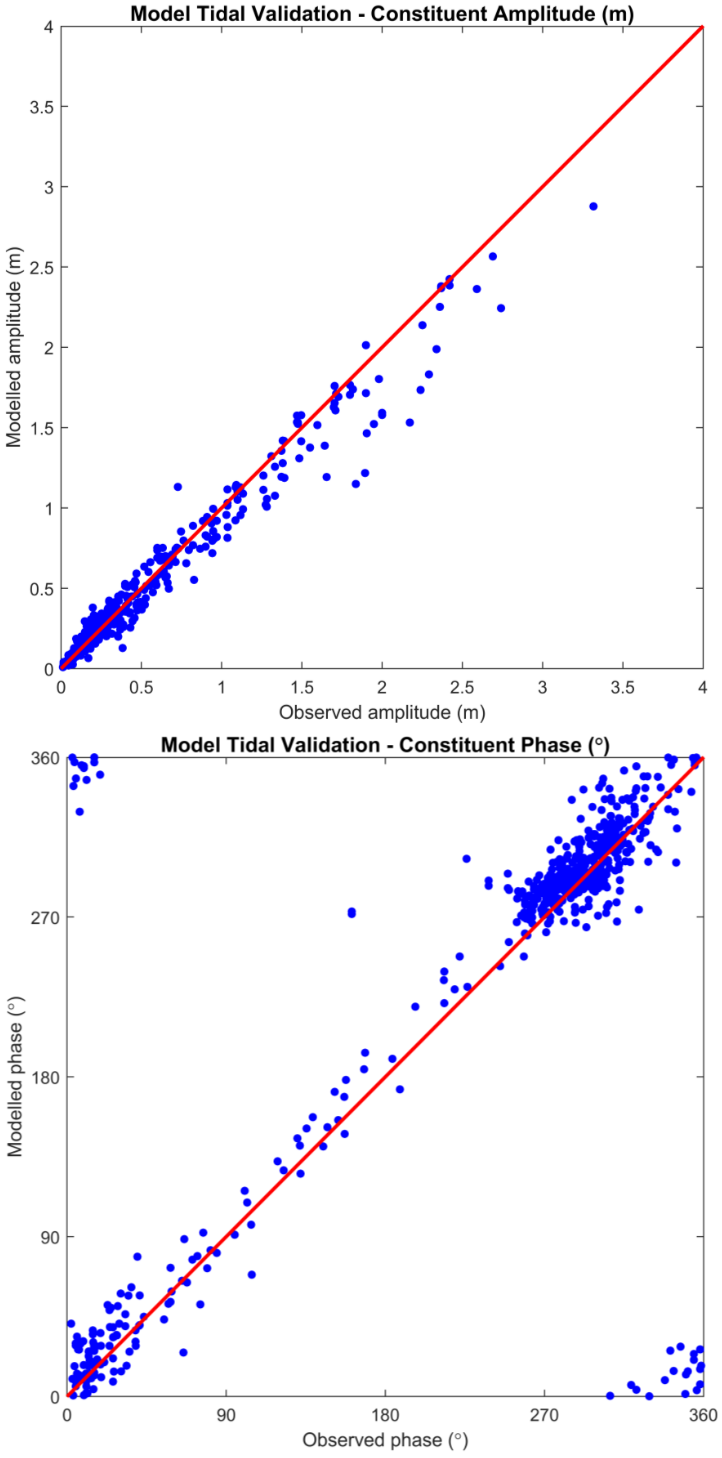

Figure 2.17 Comparisons between modelled and observed tidal constituent amplitudes (top) and phases (bottom) at all relevant stations (>80) in the HYDROMAP model domain. The red line indicates a 1:1 correlation between the modelled and observed data.

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2.2.1.3.5 Tidal Currents at the Discharge Locations

Figure 2.18, Figure 2.19 and Figure 2.20 show the seasonal distribution of current speeds and directions for the HYDROMAP data points closest to the Torosa FPSO/PLET, Brecknock/Calliance PLET and NRC tie-in PLET locations, respectively. Note that the convention for defining current direction is the direction towards which the current flows.

The current data indicates cyclical tidal flow directions along a northwest-southeast axis at all locations, with maximum speeds of around 0.35 m/s, 0.35 m/s and 0.45 m/s at the Torosa, Brecknock/Calliance and NRC tie-in locations, respectively.

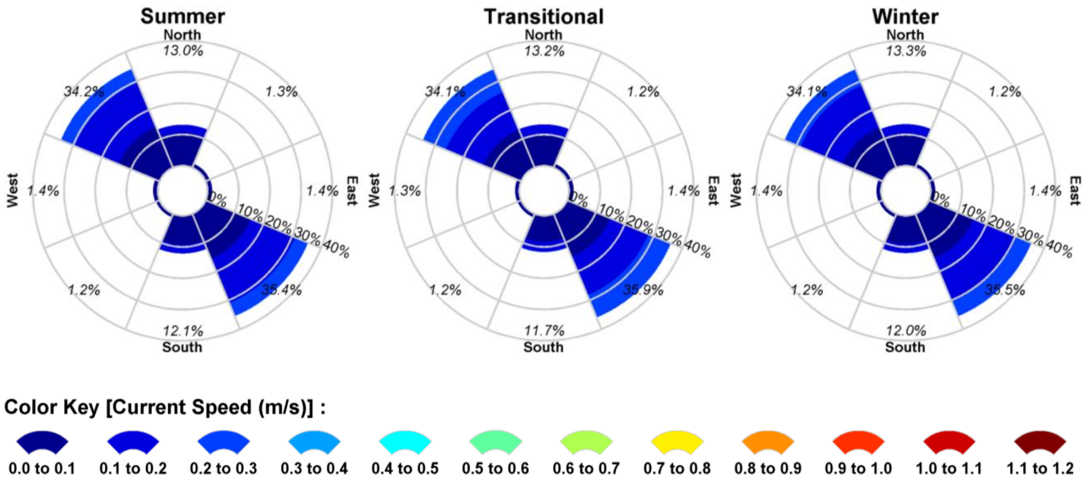

Figure 2.18 Seasonal current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the proposed Torosa FPSO/PLET locations. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.

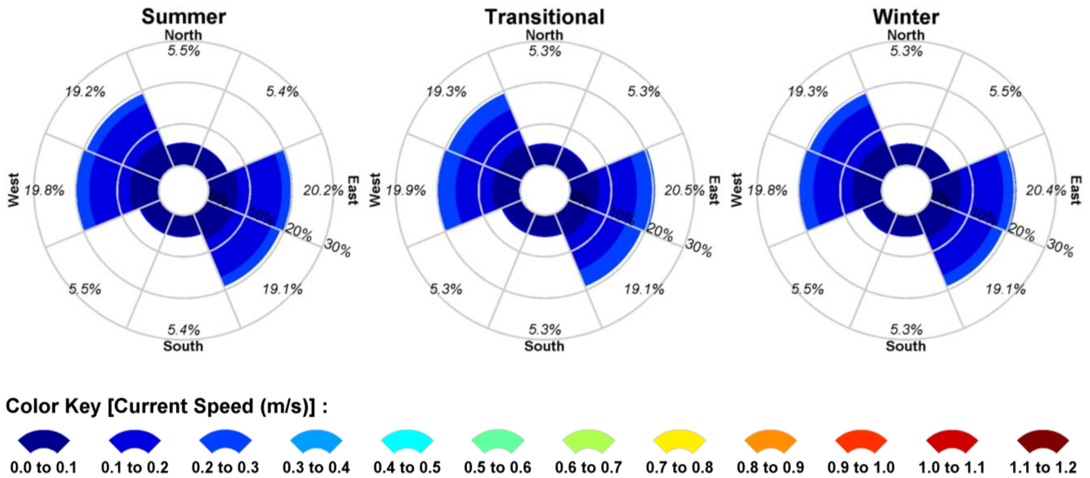

Figure 2.19 **Seasonal current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the proposed Brecknock/Calliance PLET location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

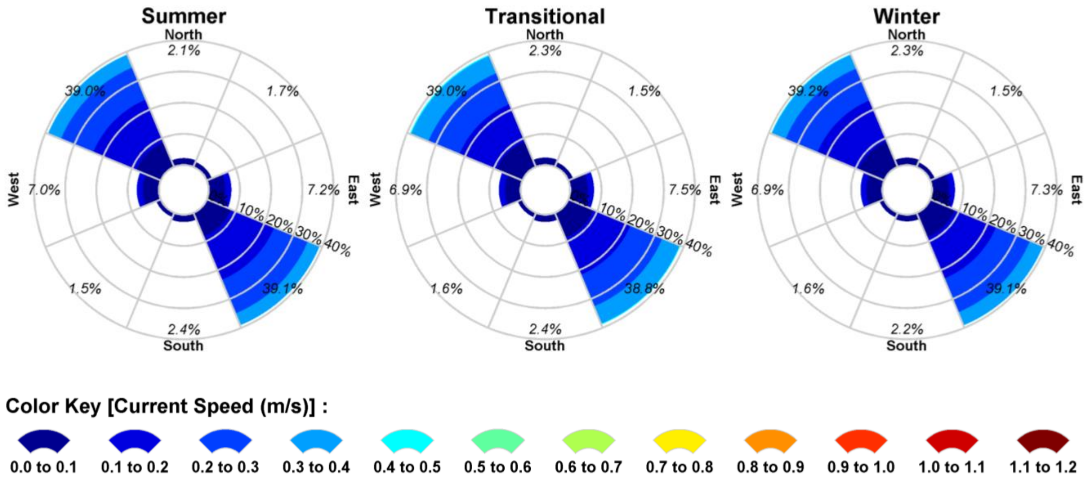

Figure 2.20 **Seasonal current distribution (2006-2015, inclusive) derived from the HYDROMAP database near to the proposed NRC tie-in PLET location. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record.**

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3 MODELLING RESULTS

3.1 Near-Field Modelling

3.1.1 Cooling Water Discharges

3.1.1.1 Overview

In the following sections, information for each of the modelled discharge cases is presented first in a table summarising the predicted plume characteristics in the near-field mixing zone under varying current speeds, and then in further tables summarising the concentrations of chlorine and the amount of dilution at the end of the near-field mixing zone for each season and for the annual period.

Figure 3.1 to Figure 3.4 (note the differing x-axis and y-axis aspect ratios) show the change in average dilution and temperature of the plume at a discharge rate of 720,000 m^3/d and depth of 12 m, under varying seasonal conditions (summer, transitional, winter and annual) and current speeds (weak, medium and strong). The figures show the predicted horizontal distance travelled by the plume before the trapping depth is reached (i.e. before the plume becomes neutrally buoyant).

The results show that due to the momentum of the discharge a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 12 m below the water surface. Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plume is predicted to rise in the water column. The plume is predicted to plunge up to 16 m below the sea surface in all seasons. Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.

Table 3.1 shows the predicted plume characteristics for the varying seasonal conditions and current speeds. High annualised currents push the plume to a maximum horizontal distance of 42.4 m for the Case C discharge. The annualised maximum diameter of the plume at the end of the near-field zone is forecast to be 15.2 m for the Case C discharge.

For all seasons, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth closer to the discharge point, which slows the rate of dilution (Table 3.1). The annualised average dilution levels of the plume upon reaching the trapping depth under medium currents are predicted to be 1:13.5 for Case C. Additionally, the annualised minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under medium currents are predicted to be 1:6.3 for Case C. Note that these predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

3.1.1.2 Results – Tables and Figures

3.1.1.2.1 Discharge Case C: Flow Rate of 720,000 m^3/day at 12 m Depth

Table 3.1 Predicted plume characteristics at the end of the near-field mixing zone for the 12 m depth discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.03)	15.1 [6.9]	29.84	1.62	6.3	12.5	35.5
	Medium (0.14)	15.1 [7.0]	29.70	1.48	6.3	13.5	37.8
	Strong (0.30)	15.2 [7.2]	29.86	1.25	6.4	15.6	42.4
Summer	Weak (0.04)	15.1 [7.0]	31.01	1.50	6.3	12.5	35.6
	Medium (0.16)	15.1 [7.2]	30.88	1.38	6.2	13.5	37.8
	Strong (0.32)	15.3 [7.2]	30.66	1.16	6.4	15.9	43.1
Transitional	Weak (0.04)	15.1 [6.9]	29.92	1.60	6.3	12.5	35.5
	Medium (0.14)	15.1 [7.1]	29.78	1.47	6.3	13.5	37.8
	Strong (0.32)	15.1 [7.3]	29.58	1.27	6.3	15.6	42.3
Winter	Weak (0.03)	15.1 [6.8]	29.12	1.68	6.3	12.4	35.4
	Medium (0.13)	15.2 [6.9]	28.87	1.54	6.3	13.5	37.8
	Strong (0.28)	15.1 [7.2]	28.78	1.36	6.4	15.2	41.6

Table 3.2 Concentrations of chlorine and plume-ambient temperature difference, and number of dilutions, at the end of the near-field stage for the annual period. Note from Table 3.1 that dilutions at the 5th, 50th and 95th percentile current speeds were 12.5, 13.5 and 15.6, respectively.

Constituent	Source Concentration or Temperature	End of Near-Field Concentration or ΔT		
		5th %ile 12.5x Dilution	50th %ile 13.5x Dilution	95th %ile 15.6x Dilution
Chlorine in Water (ppm)	0.2	0.016	0.015	0.013
	0.5	0.040	0.037	0.032
Δ Temperature (°C)	50	1.62	1.48	1.25

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Table 3.3 Concentrations of chlorine and plume-ambient temperature difference, and number of dilutions, at the end of the near-field stage for the summer season. Note from Table 3.1 that dilutions at the 5th, 50th and 95th percentile current speeds were 12.5, 13.5 and 15.9, respectively.

Constituent	Source Concentration or Temperature	End of Near-Field Concentration or ΔT		
		5th %ile 12.5x Dilution	50th %ile 13.5x Dilution	95th %ile 15.9x Dilution
Chlorine in Water (ppm)	0.2	0.016	0.015	0.013
	0.5	0.040	0.037	0.031
Δ Temperature (°C)	50	1.50	1.38	1.16

Table 3.4 Concentrations of chlorine and plume-ambient temperature difference, and number of dilutions, at the end of the near-field stage for the transitional season. Note from Table 3.1 that dilutions at the 5th, 50th and 95th percentile current speeds were 12.5, 13.5 and 15.6, respectively.

Constituent	Source Concentration or Temperature	End of Near-Field Concentration or ΔT		
		5th %ile 12.5x Dilution	50th %ile 13.5x Dilution	95th %ile 15.6x Dilution
Chlorine in Water (ppm)	0.2	0.016	0.015	0.013
	0.5	0.040	0.037	0.032
Δ Temperature (°C)	50	1.60	1.47	1.27

Table 3.5 Concentrations of chlorine and plume-ambient temperature difference, and number of dilutions, at the end of the near-field stage for the winter season. Note from Table 3.1 that dilutions at the 5th, 50th and 95th percentile current speeds were 12.4, 13.5 and 15.2, respectively.

Constituent	Source Concentration or Temperature	End of Near-Field Concentration or ΔT		
		5th %ile 12.4x Dilution	50th %ile 13.5x Dilution	95th %ile 15.2x Dilution
Chlorine in Water (ppm)	0.2	0.016	0.015	0.013
	0.5	0.040	0.037	0.033
Δ Temperature (°C)	50	1.68	1.54	1.36

3.1.1.2.1.1 Annualised

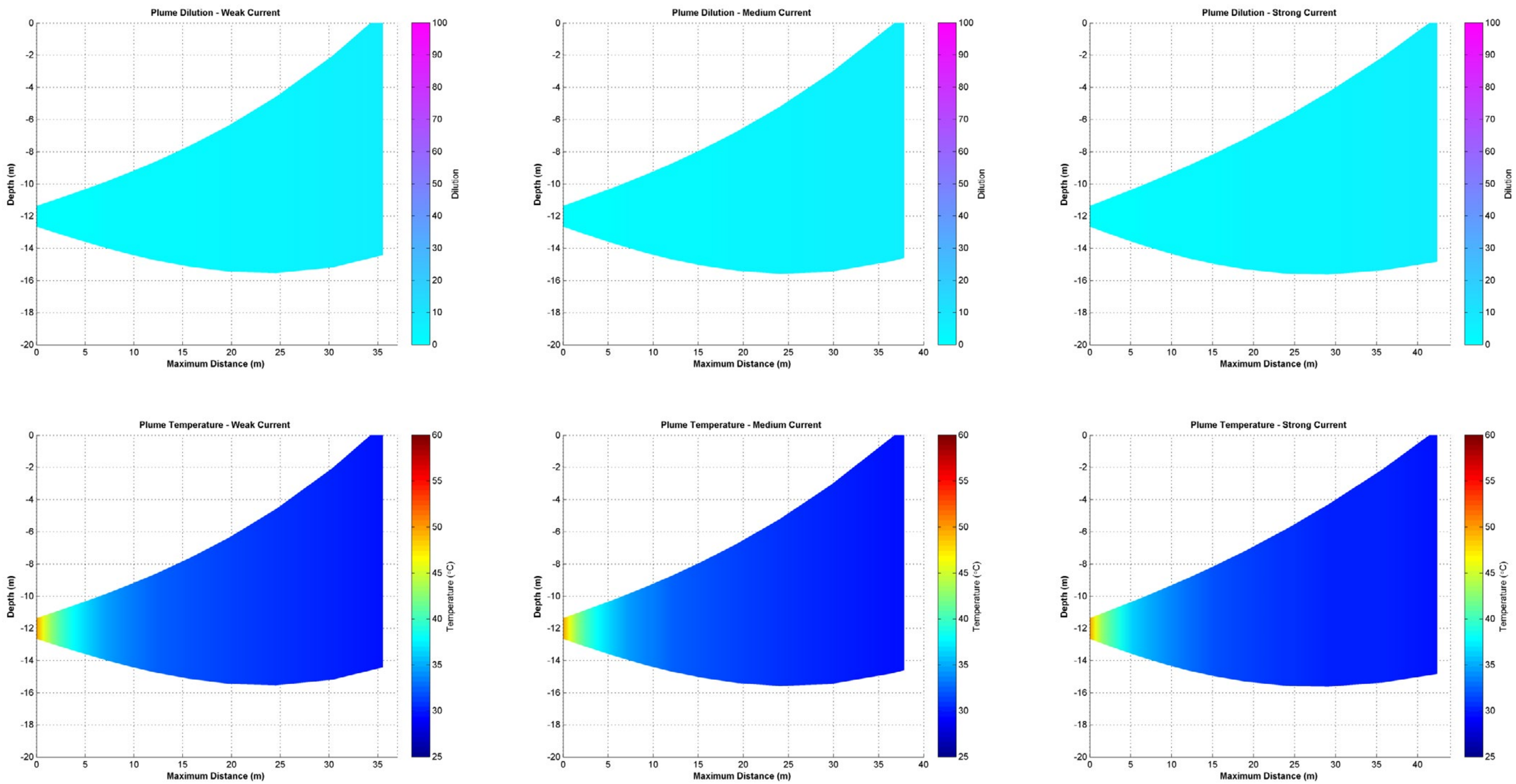

Figure 3.1 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (12 m depth discharge at 720,000 m^3/d flow rate).

3.1.1.2.1.2 Summer

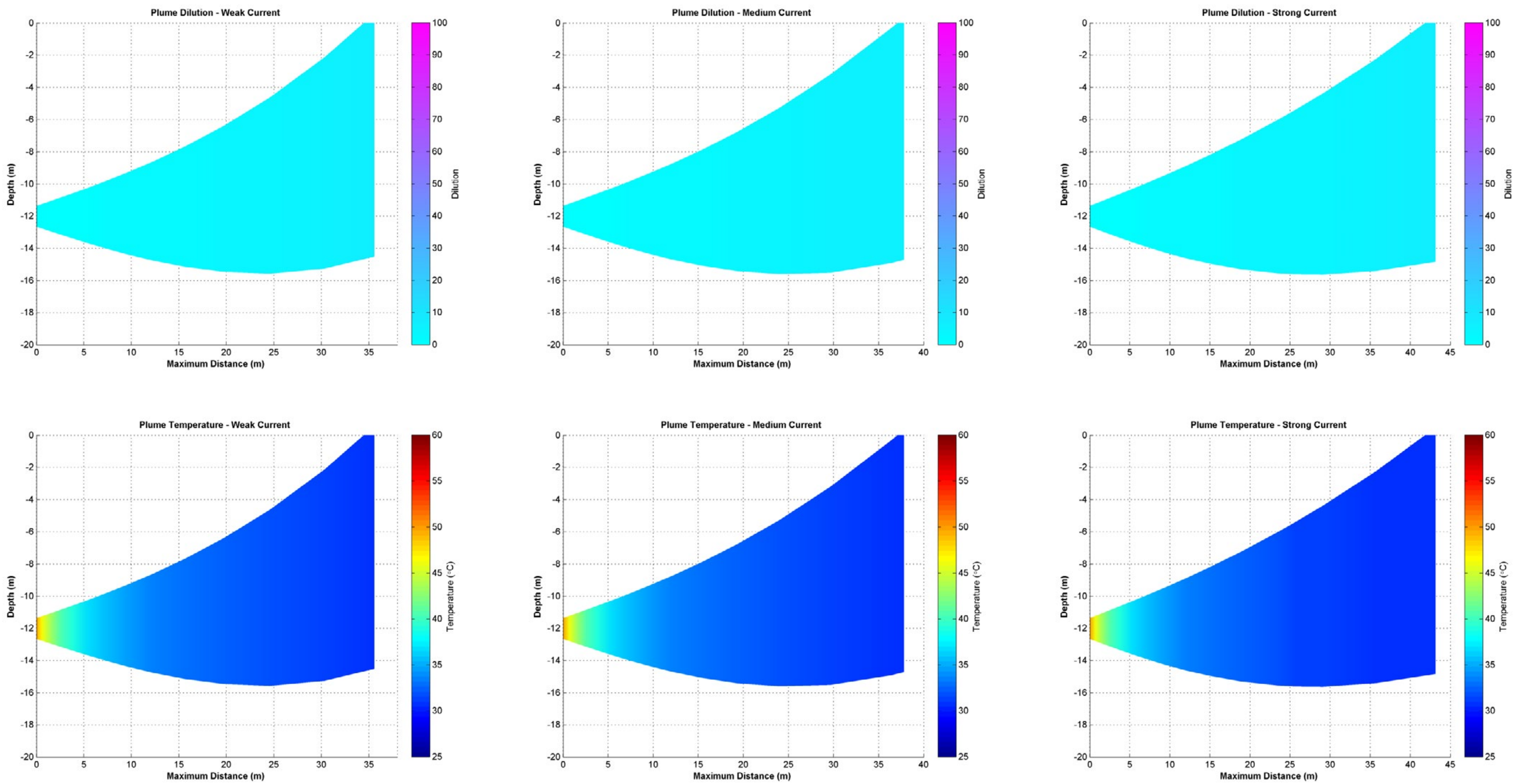

Figure 3.2 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (12 m depth discharge at 720,000 m^3/d flow rate).

3.1.1.2.1.3 Transitional

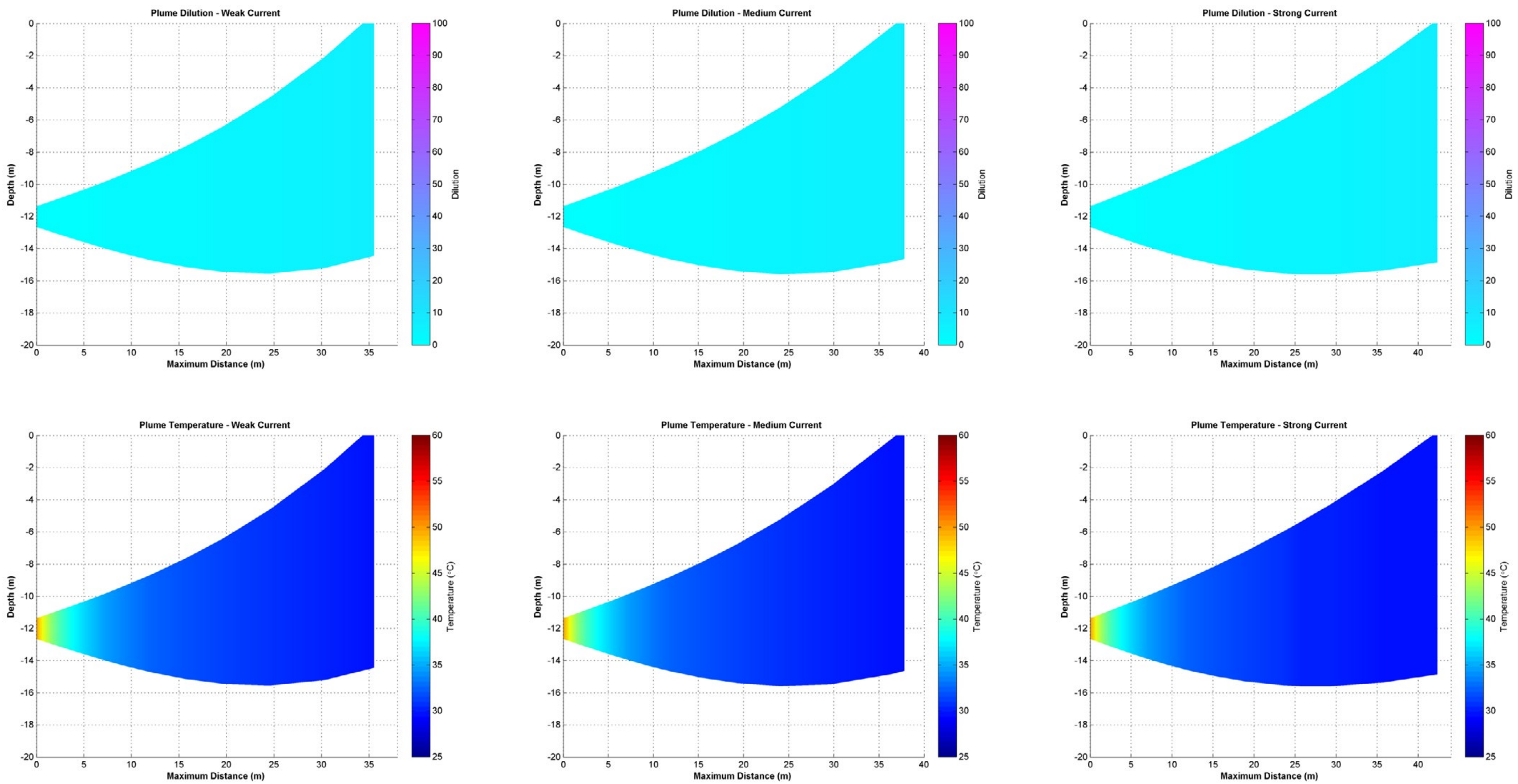

Figure 3.3 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (12 m depth discharge at 720,000 m³/d flow rate).

3.1.1.2.1.4 Winter

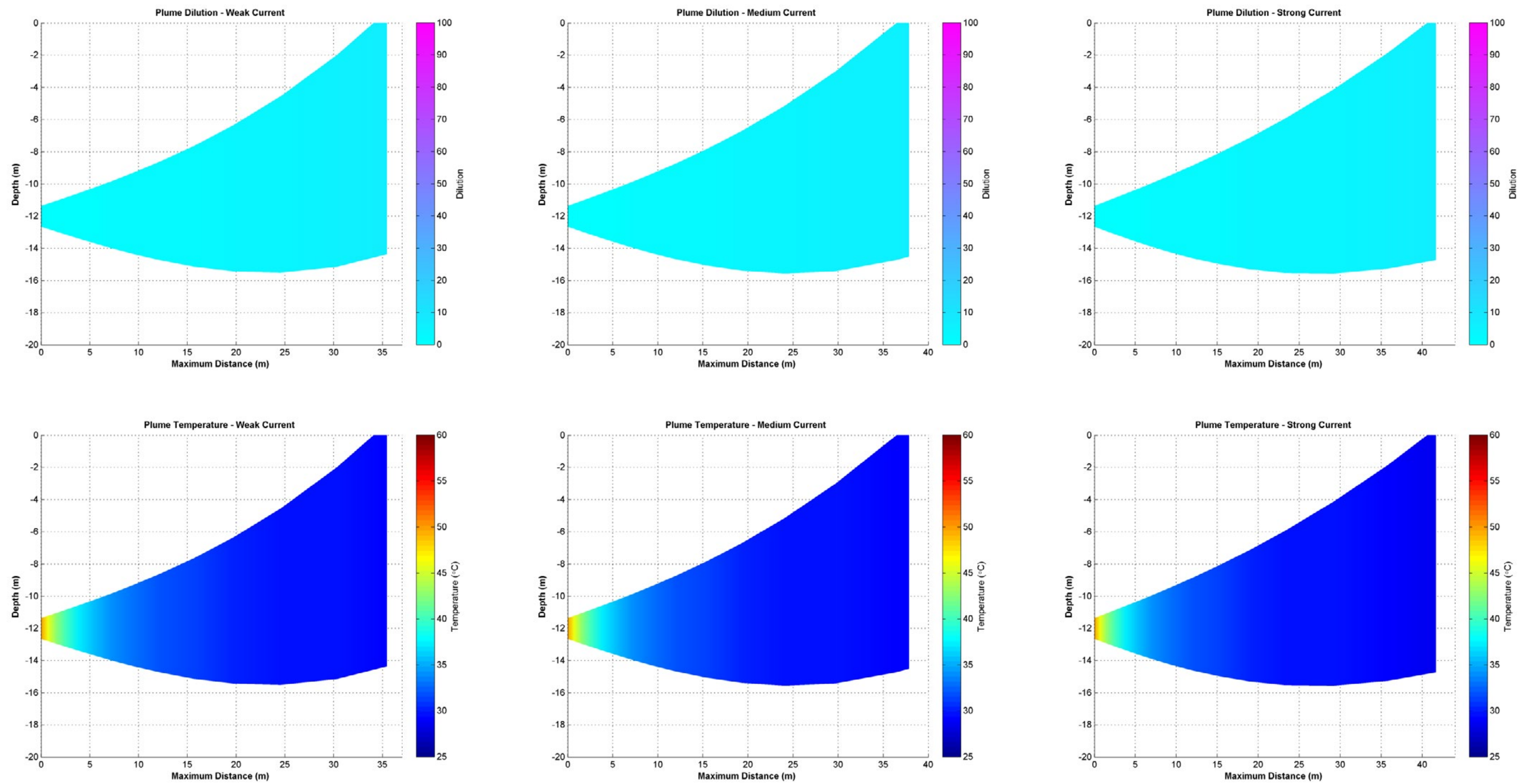

Figure 3.4 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (12 m depth discharge at 720,000 m^3/d flow rate).

3.1.2 Produced Water Discharges

3.1.2.1 Overview

In the following sections, information for each of the modelled discharge cases is presented first in a table summarising the predicted plume characteristics in the near-field mixing zone under varying current speeds, and then in further tables summarising the concentrations of total oil, mercury and MEG, and the amount of dilution, at the end of the near-field mixing zone for each season and for the annual period.

Figure 3.5 to Figure 3.12 (note the differing x-axis and y-axis aspect ratios) show the change in average dilution and temperature of the plume under varying discharge rates (5,723 m^3/d and 490 m^3/d), seasonal conditions (summer, transitional, winter and annual), and current speeds (weak, medium and strong). The figures show the predicted horizontal distance travelled by the plume before the trapping depth is reached (i.e. before the plume becomes neutrally buoyant).

The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 14 m (Cases P and M) below the water surface. Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plumes are predicted to rise in the water column. In each case, the plume is predicted to rise towards the water surface after the momentum of the initial discharge is lost. Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.

Table 3.6 and Table 3.11 show the predicted plume characteristics for the varying discharge rates, seasonal conditions, and current speeds. High annualised currents push the plume to a maximum horizontal distance of 43.8 m and 43.4 m for the Case P and M discharges, respectively. The annualised maximum diameter of the plume at the end of the near-field zone is forecast to be 11.7 m for Case P and 8.0 m for Case M.

For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth closer to the discharge point, which slows the rate of dilution (Table 3.6 and Table 3.11). The annualised average dilution levels of the plume upon reaching the trapping depth under medium currents are predicted to be 1:204 for Case P and 1:1,222 for Case M. Additionally, the annualised minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under medium currents are predicted to be 1:70 for Case P and 1:323 for Case M. Note that these predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

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3.1.2.2 Results – Tables and Figures

3.1.2.2.1 Discharge Case P: Flow Rate of 5,723 m³/day at 14 m Depth

Table 3.6 Predicted plume characteristics at the end of the near-field mixing zone for the 14 m depth discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.03)	5.6 [0.8]	28.46	0.06	40	79	12.6
	Medium (0.14)	9.9 [4.2]	28.29	0.00	70	204	19.6
	Strong (0.30)	11.7 [5.7]	28.59	0.00	136	508	43.8
Summer	Weak (0.04)	5.7 [1.0]	29.72	0.02	40	81	12.8
	Medium (0.15)	10.1 [4.5]	29.55	0.00	72	217	20.3
	Strong (0.32)	11.7 [5.7]	29.48	0.00	140	529	40.3
Transitional	Weak (0.04)	5.7 [0.9]	28.55	0.05	40	80	12.7
	Medium (0.14)	10.0 [4.3]	28.38	0.00	71	213	20.0
	Strong (0.32)	11.7 [5.7]	28.29	0.00	141	529	46.0
Winter	Weak (0.03)	5.5 [1.0]	27.68	0.08	38	76	12.3
	Medium (0.13)	9.7 [4.0]	27.51	0.00	68	193	18.9
	Strong (0.28)	11.6 [5.6]	27.42	0.00	127	469	39.6

Table 3.7 Concentrations of total oil and mercury, and number of dilutions, at the end of the near-field stage for the annual period. Note from Table 3.6 that dilutions at the 5th, 50th and 95th percentile current speeds were 79, 204 and 508, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		79x Dilution	204x Dilution	508x Dilution
Total Oil (including BTEX)	30	0.38	0.15	0.06
Mercury	0.03	$3.80*10^{-4}$	$1.47*10^{-4}$	$5.91*10^{-5}$

Table 3.8 Concentrations of total oil and mercury, and number of dilutions, at the end of the near-field stage for the summer season. Note from Table 3.6 that dilutions at the 5th, 50th and 95th percentile current speeds were 81, 217 and 529, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		81x Dilution	217x Dilution	529x Dilution
Total Oil (including BTEX)	30	0.37	0.14	0.06
Mercury	0.03	$3.70*10^{-4}$	$1.38*10^{-4}$	$5.67*10^{-5}$

Table 3.9 Concentrations of total oil and mercury, and number of dilutions, at the end of the near-field stage for the transitional season. Note from Table 3.6 that dilutions at the 5th, 50th and 95th percentile current speeds were 80, 213 and 529, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		80x Dilution	213x Dilution	529x Dilution
Total Oil (including BTEX)	30	0.38	0.14	0.06
Mercury	0.03	$3.75*10^{-5}$	$1.41*10^{-4}$	$5.67*10^{-5}$

Table 3.10 Concentrations of total oil and mercury, and number of dilutions, at the end of the near-field stage for the winter season. Note from Table 3.6 that dilutions at the 5th, 50th and 95th percentile current speeds were 76, 193 and 469, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		76x Dilution	193x Dilution	469x Dilution
Total Oil (including BTEX)	30	0.39	0.16	0.06
Mercury	0.03	$3.95*10^{-4}$	$1.55*10^{-4}$	$6.40*10^{-5}$

3.1.2.2.1.1 Annualised

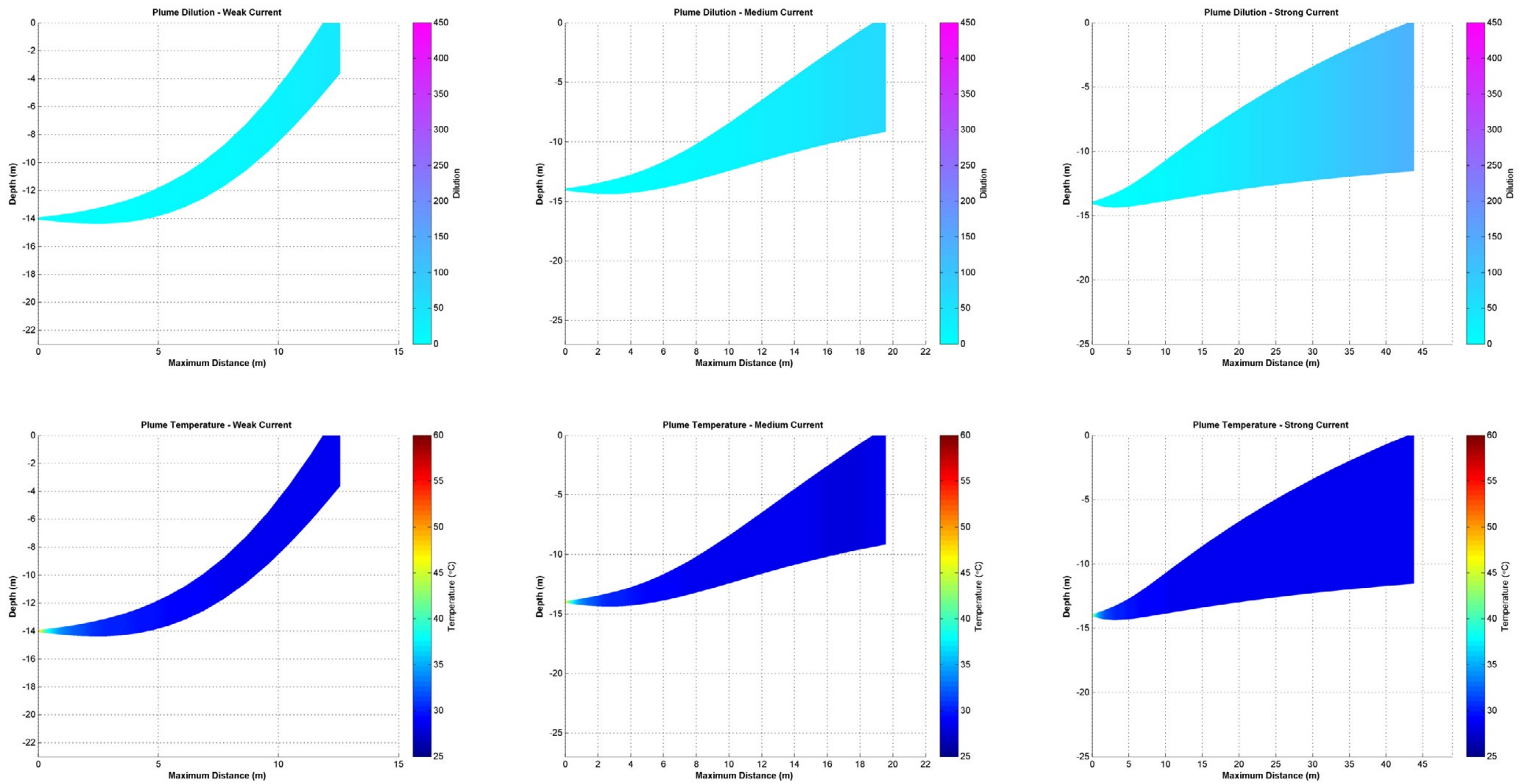

Figure 3.5 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (14 m depth discharge at 5,723 m^3/d flow rate).

3.1.2.2.1.2 Summer

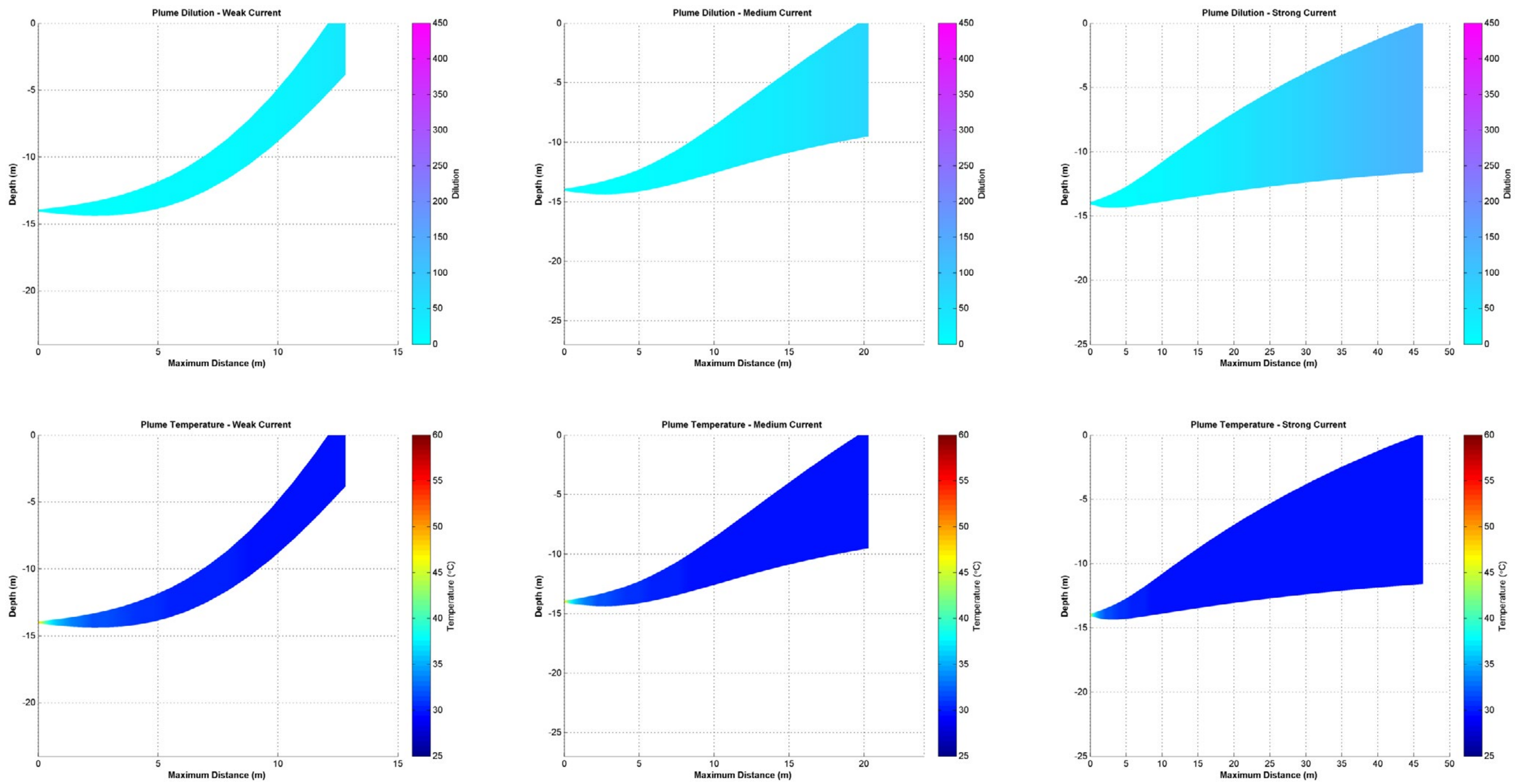

Figure 3.6 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (14 m depth discharge at 5,723 m^3/d flow rate).

3.1.2.2.1.3 Transitional

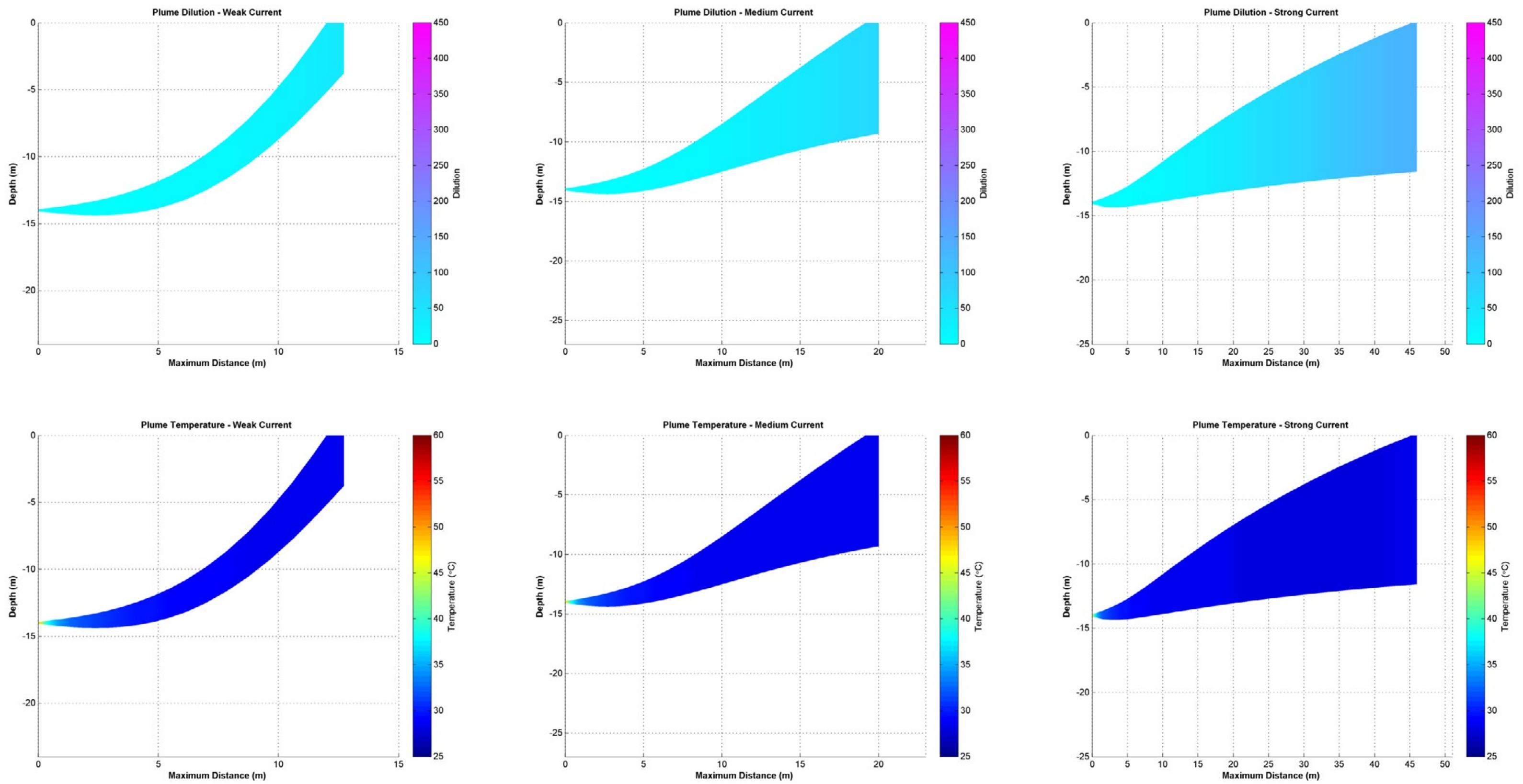

Figure 3.7 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (14 m depth discharge at 5,723 m^3/d flow rate).

3.1.2.2.1.4 Winter

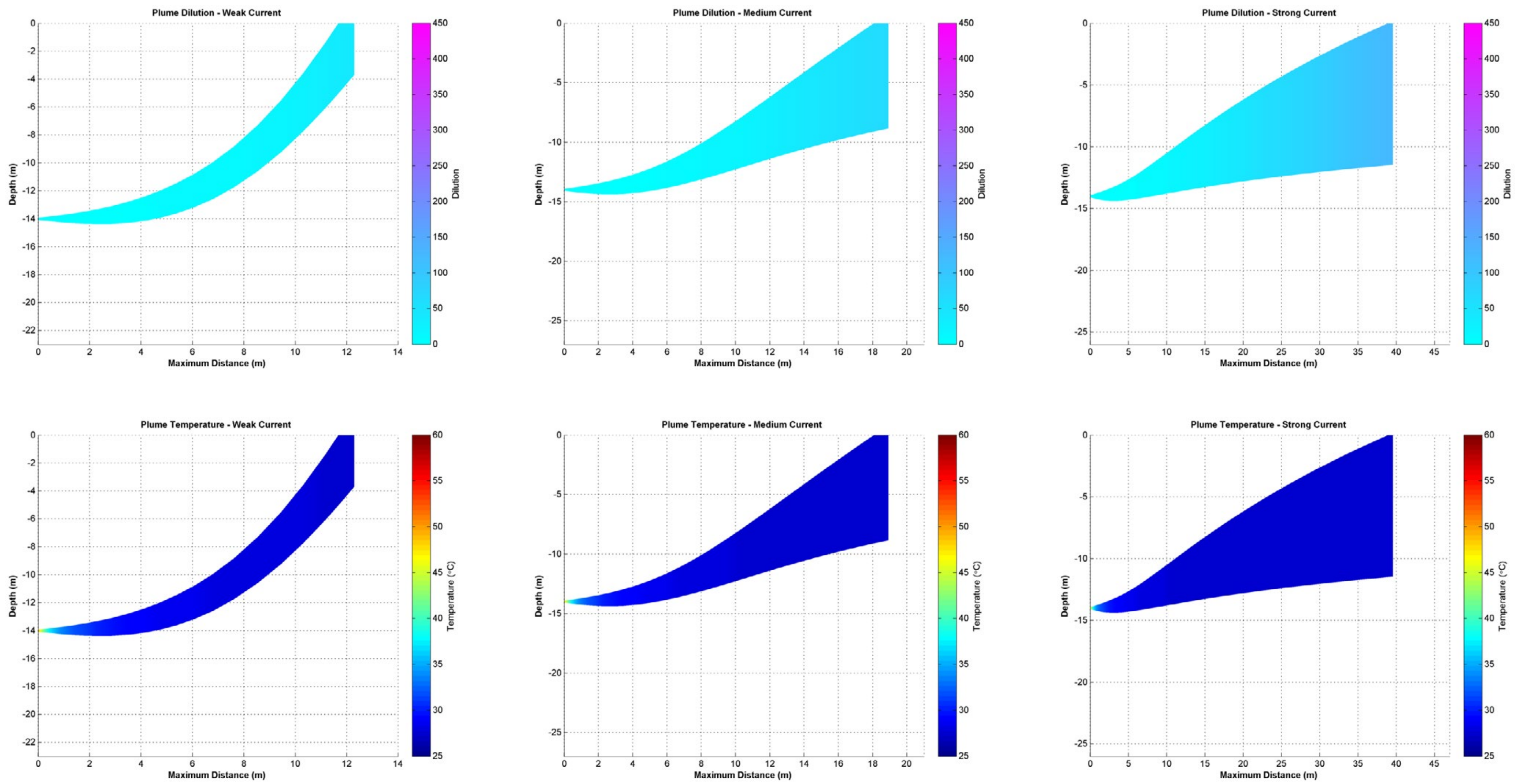

Figure 3.8 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (14 m depth discharge at 5,723 m³/d flow rate).

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3.1.2.2.2 Discharge Case M: Flow Rate of 490 m^3/day at 14 m Depth

Table 3.11 Predicted plume characteristics at the end of the near-field mixing zone for the 14 m depth discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.03)	4.8 [0.9]	28.35	0.00	143	295	4.3
	Medium (0.14)	8.0 [7.2]	28.16	0.00	323	1,222	20.2
	Strong (0.30)	6.2 [9.1]	28.49	0.00	410	1,592	43.4
Summer	Weak (0.04)	5.2 [1.1]	29.63	0.00	153	327	4.8
	Medium (0.15)	7.7 [7.5]	29.43	0.00	313	1,191	20.7
	Strong (0.32)	6.0 [7.4]	29.45	0.00	401	1,558	44.0
Transitional	Weak (0.04)	5.1 [1.1]	28.44	0.00	150	318	4.7
	Medium (0.14)	7.9 [7.3]	28.29	0.00	321	1,217	20.6
	Strong (0.32)	6.1 [7.5]	28.26	0.00	418	1,620	45.3
Winter	Weak (0.03)	4.6 [0.6]	27.56	0.00	137	280	4.0
	Medium (0.13)	8.2 [6.8]	27.38	0.00	327	1,233	19.7
	Strong (0.28)	6.5 [9.0]	27.32	0.00	427	1,655	42.5

Table 3.12 Concentrations of MEG and number of dilutions at the end of the near-field stage for the annual period. Note from Table 3.11 that dilutions at the 5th, 50th and 95th percentile current speeds were 295, 1,222 and 1,592, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		295x Dilution	1,222x Dilution	1,592x Dilution
MEG	79,000	267.80	64.65	49.62

Table 3.13 Concentrations of MEG and number of dilutions at the end of the near-field stage for the summer season. Note from Table 3.11 that dilutions at the 5th, 50th and 95th percentile current speeds were 327, 1,191 and 1,558, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		327x Dilution	1,191x Dilution	1,558x Dilution
MEG	79,000	241.59	66.33	50.71

Table 3.14 Concentrations of MEG and number of dilutions at the end of the near-field stage for the transitional season. Note from Table 3.11 that dilutions at the 5th, 50th and 95th percentile current speeds were 318, 1,217 and 1,620, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		318x Dilution	1,217x Dilution	1,620x Dilution
MEG	79,000	248.43	64.91	48.77

Table 3.15 Concentrations of MEG and number of dilutions at the end of the near-field stage for the winter season. Note from Table 3.11 that dilutions at the 5th, 50th and 95th percentile current speeds were 280, 1,233 and 1,655, respectively.

Constituent	Source Concentration (mg/L)	End of Near-Field Concentration (mg/L)		
		5th %ile	50th %ile	95th %ile
		280x Dilution	1,233x Dilution	1,655x Dilution
MEG	79,000	282.14	64.07	47.73

3.1.2.2.2.1 Annualised

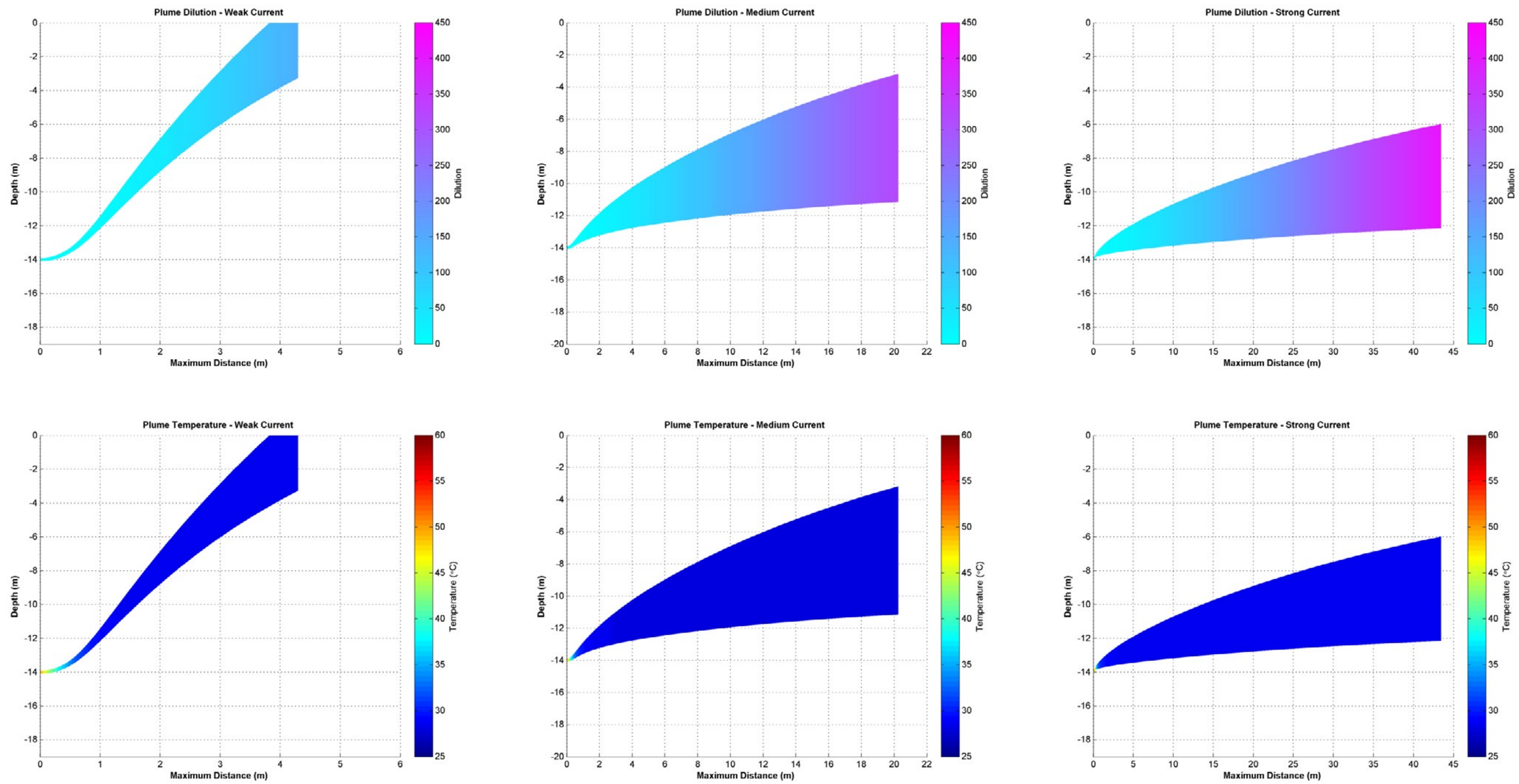

Figure 3.9 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (14 m depth discharge at 490 m^3/d flow rate).

3.1.2.2.2.2 Summer

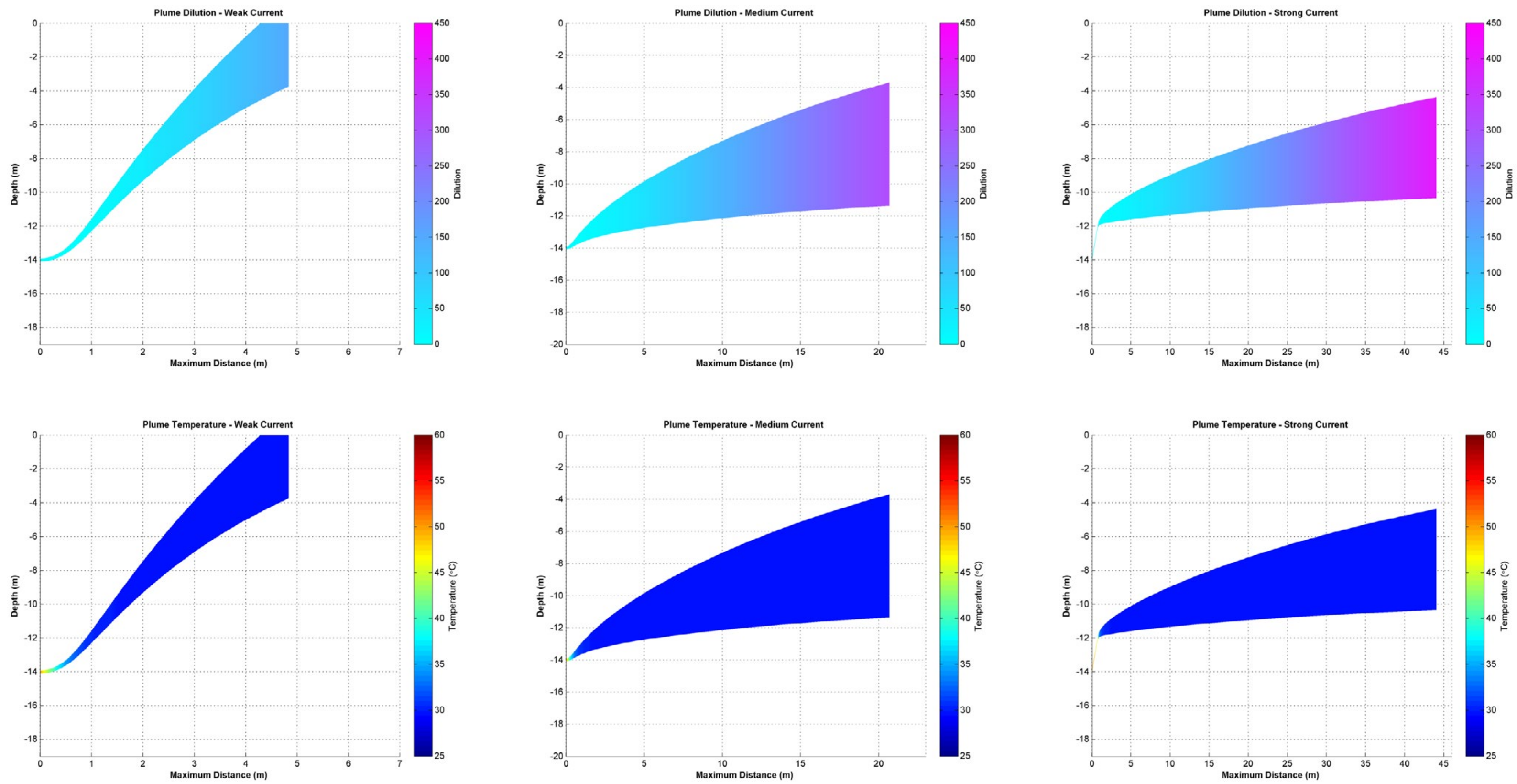

Figure 3.10 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (14 m depth discharge at 490 m^3/d flow rate).

3.1.2.2.2.3 Transitional

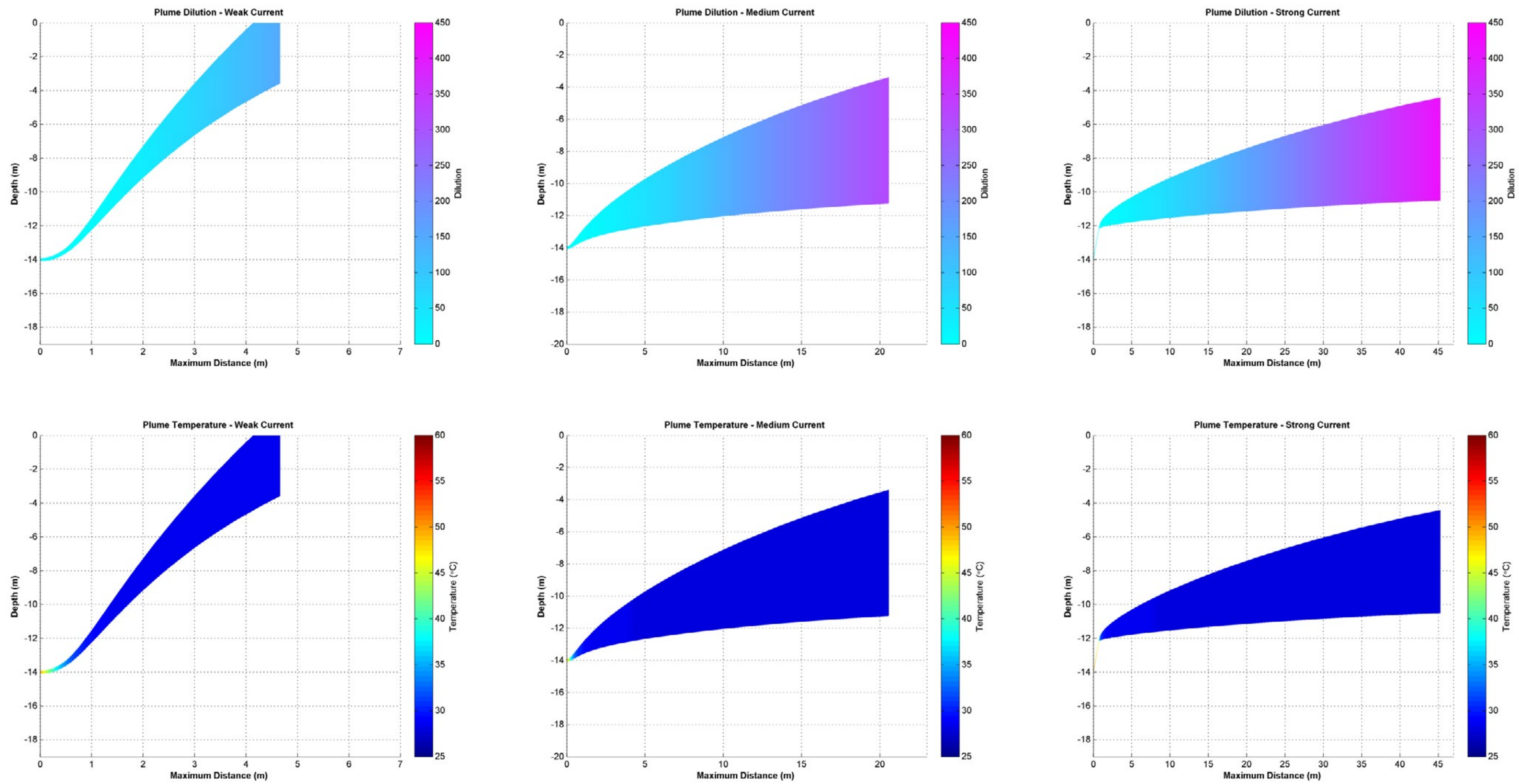

Figure 3.11 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (14 m depth discharge at 490 m^3/d flow rate).

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3.1.2.2.2.4 Winter

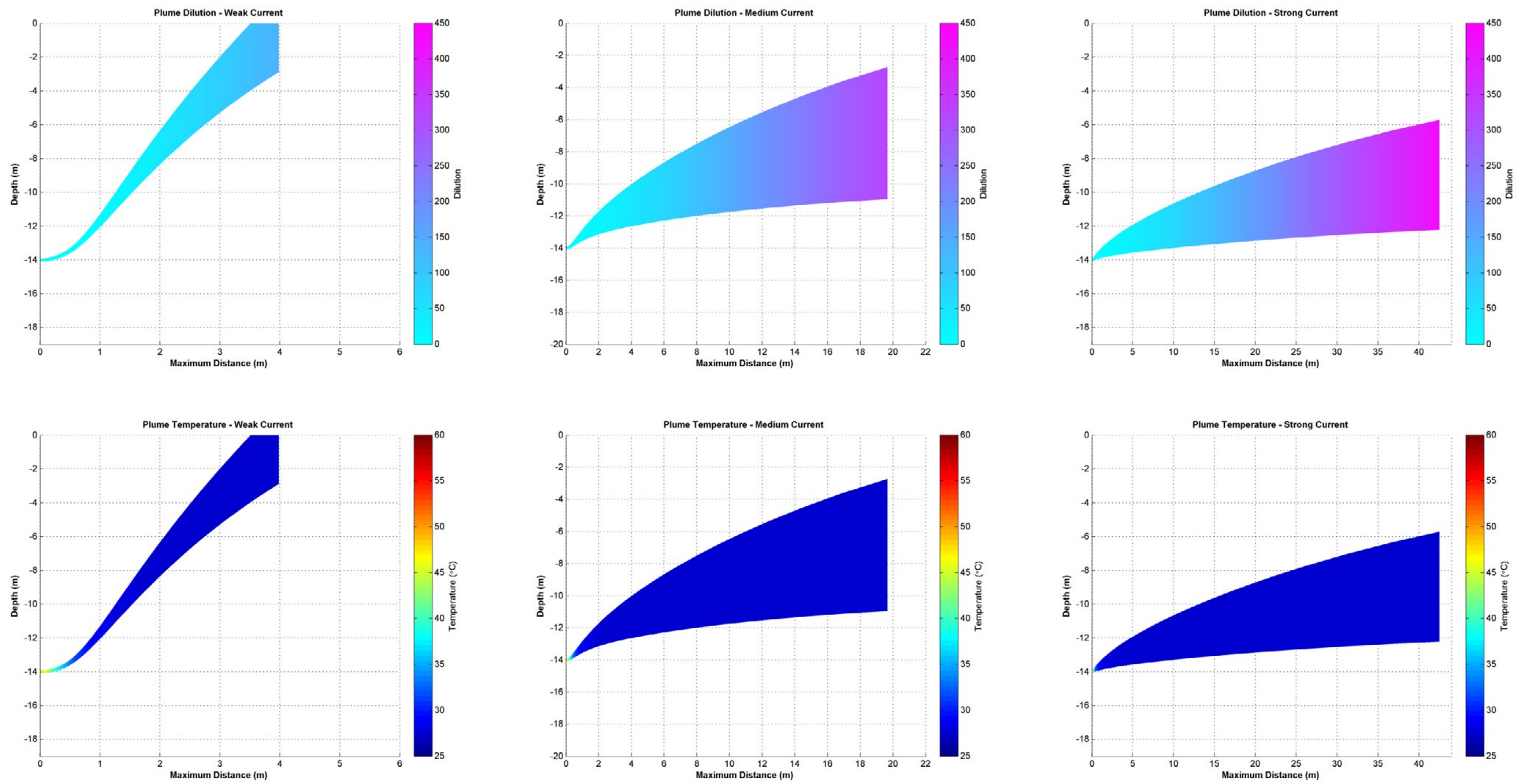

Figure 3.12 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (14 m depth discharge at 490 m^3/d flow rate).

3.1.3 Hydrotest Discharges

3.1.3.1 Overview

In the following sections, information for each of the modelled discharge cases is presented first in a table summarising the predicted plume characteristics in the near-field mixing zone under varying current speeds, and then in further tables summarising the concentrations of biocide and the amount of dilution at the end of the near-field mixing zone for each season and for the annual period.

Figure 3.13 to Figure 3.28 (note the differing x-axis and y-axis aspect ratios) show the change in average dilution and temperature of the plume at a discharge rate of 25 m^3/min, under varying discharge depths (117 m, 461 m and 539 m), seasonal conditions (summer, transitional, winter and annual) and current speeds (weak, medium and strong). The figures show the predicted horizontal distance travelled by the plume before the trapping depth is reached (i.e. before the plume becomes neutrally buoyant).

The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge points, which are 117 m (Case H1), 461 m (Cases H2 and H3b) and 539 m (Case H3a) below the water surface. Following this initial mixing, the near neutrally buoyant plumes are predicted to travel laterally in the water column. Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.

Table 3.16, Table 3.21, Table 3.26 and Table 3.31 show the predicted plume characteristics for the varying discharge depths, seasonal conditions and current speeds. High annualised currents push the plume to a maximum horizontal distance of 64.5 m, 101.2 m, 103.0 m and 101.2 m for the Case H1, H2, H3a and H3b discharges, respectively. The annualised maximum diameter of the plume at the end of the near-field zone is forecast to be 15.8 m for Case H1, 23.4 m for Case H2, 24.0 m for Case H3a and 23.4 m for Case H3b.

For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. The annualised average dilution levels of the plume upon reaching the trapping depth under medium currents are predicted to be 1:111 for Case H1, 1:166 for Case H2, 1:172 for Case H3a and 1:166 for Case H3b. Additionally, the annualised minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under medium currents are predicted to be 1:41 for Case H1, 1:62 for Case H2, 1:65 for Case H3a and 1:62 for Case H3b. Note that these predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

3.1.3.2 Results – Tables and Figures

3.1.3.2.1 Discharge Case H1: NRC Tie-In Hydrotest Discharge of 736,000 m³ at 117 m Depth

Table 3.16 Predicted plume characteristics at the end of the near-field mixing zone for the NRC tie-in 736,000 m³ hydrotest discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.04)	15.8 [116.0]	23.42	0.00	41	90	41.7
	Medium (0.16)	14.8 [116.0]	23.42	0.00	41	111	49.5
	Strong (0.35)	13.2 [116.0]	23.42	0.00	43	136	64.5
Summer	Weak (0.04)	13.4 [116.0]	23.61	0.00	42	125	57.6
	Medium (0.16)	14.5 [116.0]	23.61	0.00	41	109	48.5
	Strong (0.34)	13.2 [116.0]	23.61	0.00	43	133	62.8
Transitional	Weak (0.04)	15.5 [115.9]	22.78	0.00	41	88	40.9
	Medium (0.16)	14.7 [115.9]	22.78	0.00	41	111	49.5
	Strong (0.36)	13.0 [115.9]	22.77	0.00	43	136	64.8
Winter	Weak (0.04)	14.1 [116.1]	23.89	0.00	45	139	64.7
	Medium (0.16)	15.3 [116.2]	23.89	0.00	43	118	52.5
	Strong (0.35)	13.7 [116.1]	23.89	0.00	45	144	69.1

Table 3.17 Concentrations of biocide and number of dilutions at the end of the near-field stage for the annual period. Note from Table 3.16 that dilutions at the 5th, 50th and 95th percentile current speeds were 90, 111 and 136, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		90x Dilution	111x Dilution	136x Dilution
Biocide	600	6.7	5.4	4.4

Table 3.18 Concentrations of biocide and number of dilutions at the end of the near-field stage for the summer season. Note from Table 3.16 that dilutions at the 5th, 50th and 95th percentile current speeds were 125, 109 and 133, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 125x Dilution	50th %ile 109x Dilution	95th %ile 133x Dilution
Biocide	600	4.8	5.5	4.5

Table 3.19 Concentrations of biocide and number of dilutions at the end of the near-field stage for the transitional season. Note from Table 3.16 that dilutions at the 5th, 50th and 95th percentile current speeds were 88, 111 and 136, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 88x Dilution	50th %ile 111x Dilution	95th %ile 136x Dilution
Biocide	600	6.8	5.4	4.4

Table 3.20 Concentrations of biocide and number of dilutions at the end of the near-field stage for the winter season. Note from Table 3.16 that dilutions at the 5th, 50th and 95th percentile current speeds were 139, 118 and 144, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 139x Dilution	50th %ile 118x Dilution	95th %ile 144x Dilution
Biocide	600	4.3	5.1	4.2

3.1.3.2.1.1 Annualised

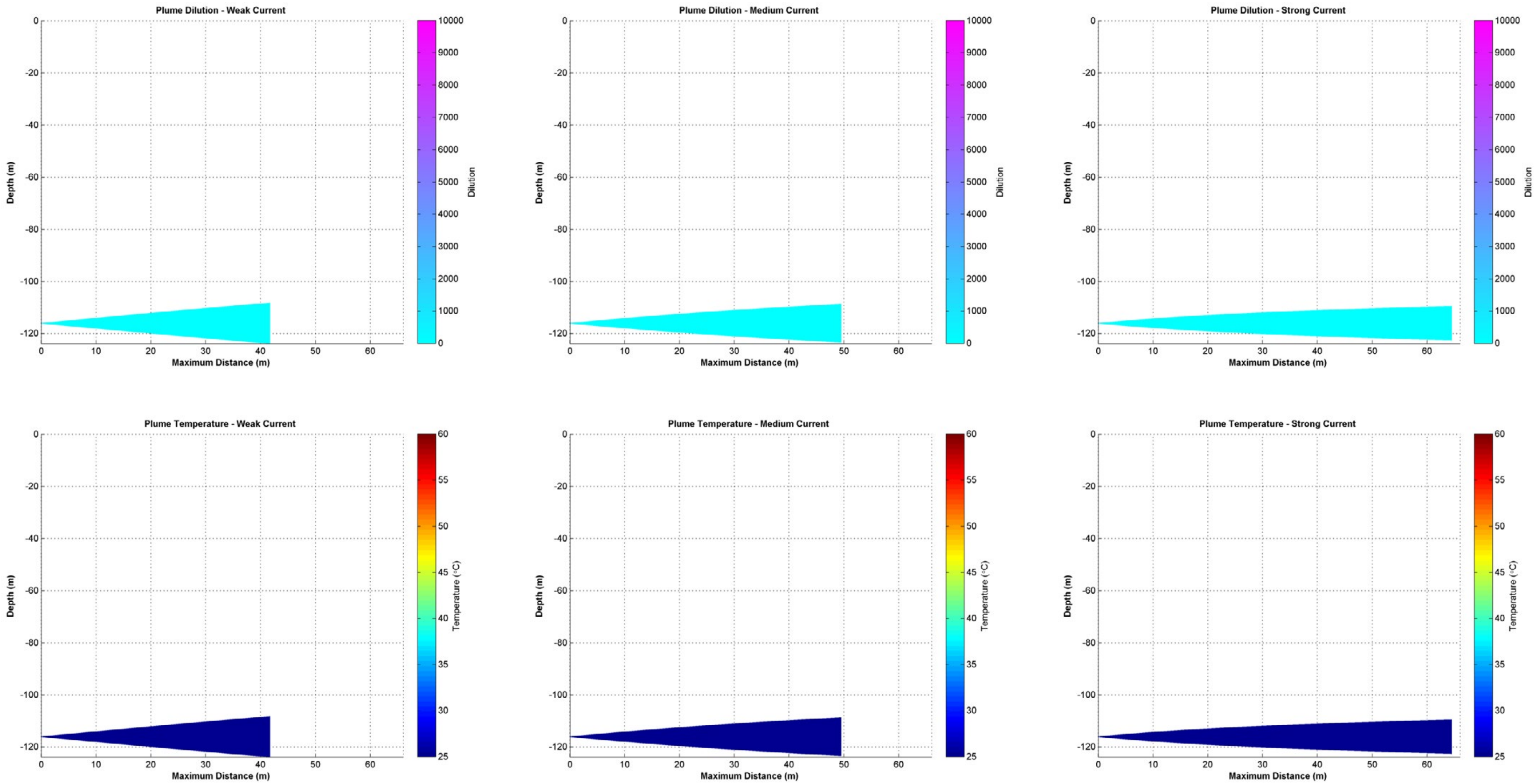

Figure 3.13 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (NRC tie-in 736,000 m³ hydrotest discharge).

3.1.3.2.1.2 Summer

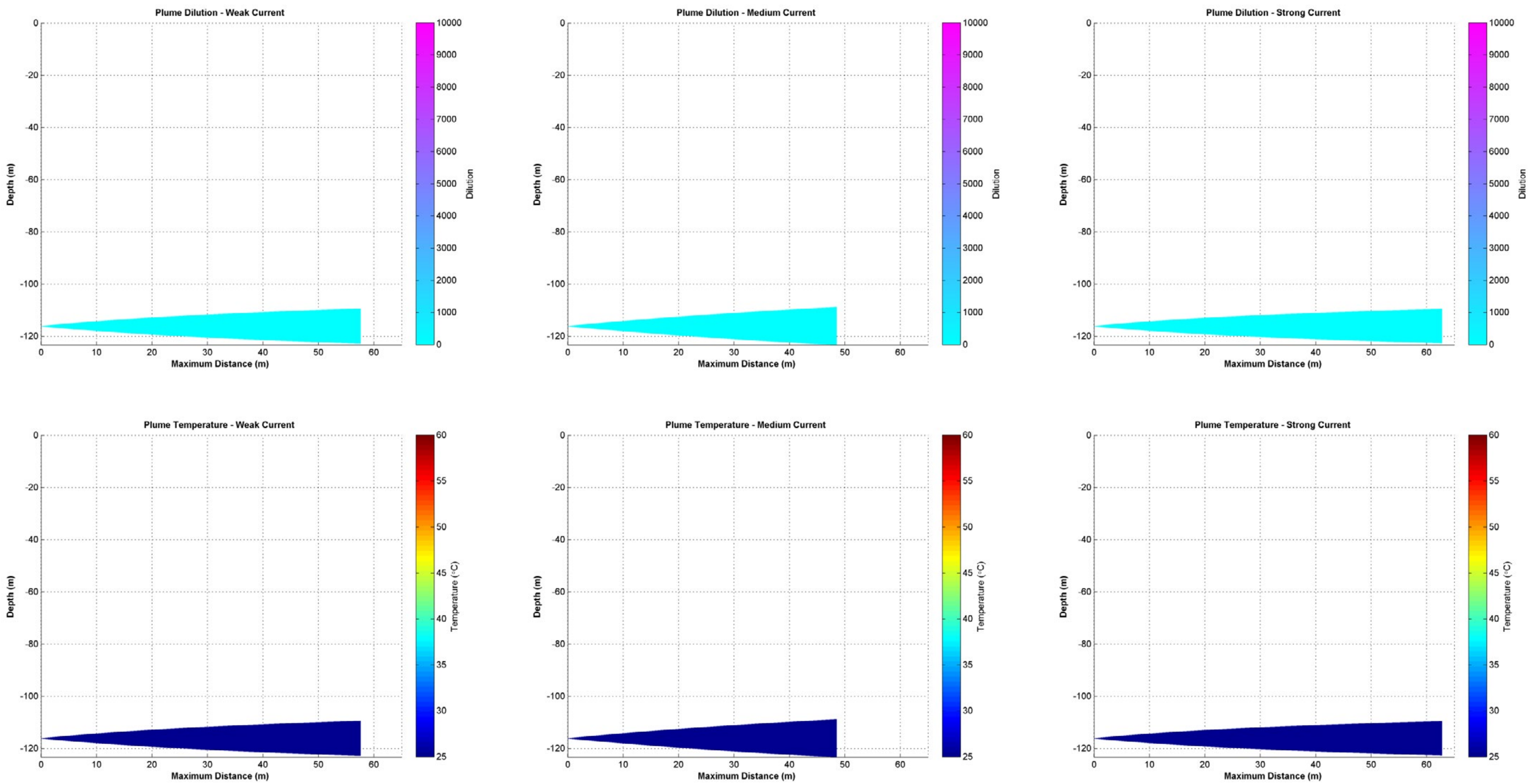

Figure 3.14 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (NRC tie-in 736,000 m³ hydrotest discharge).

3.1.3.2.1.3 Transitional

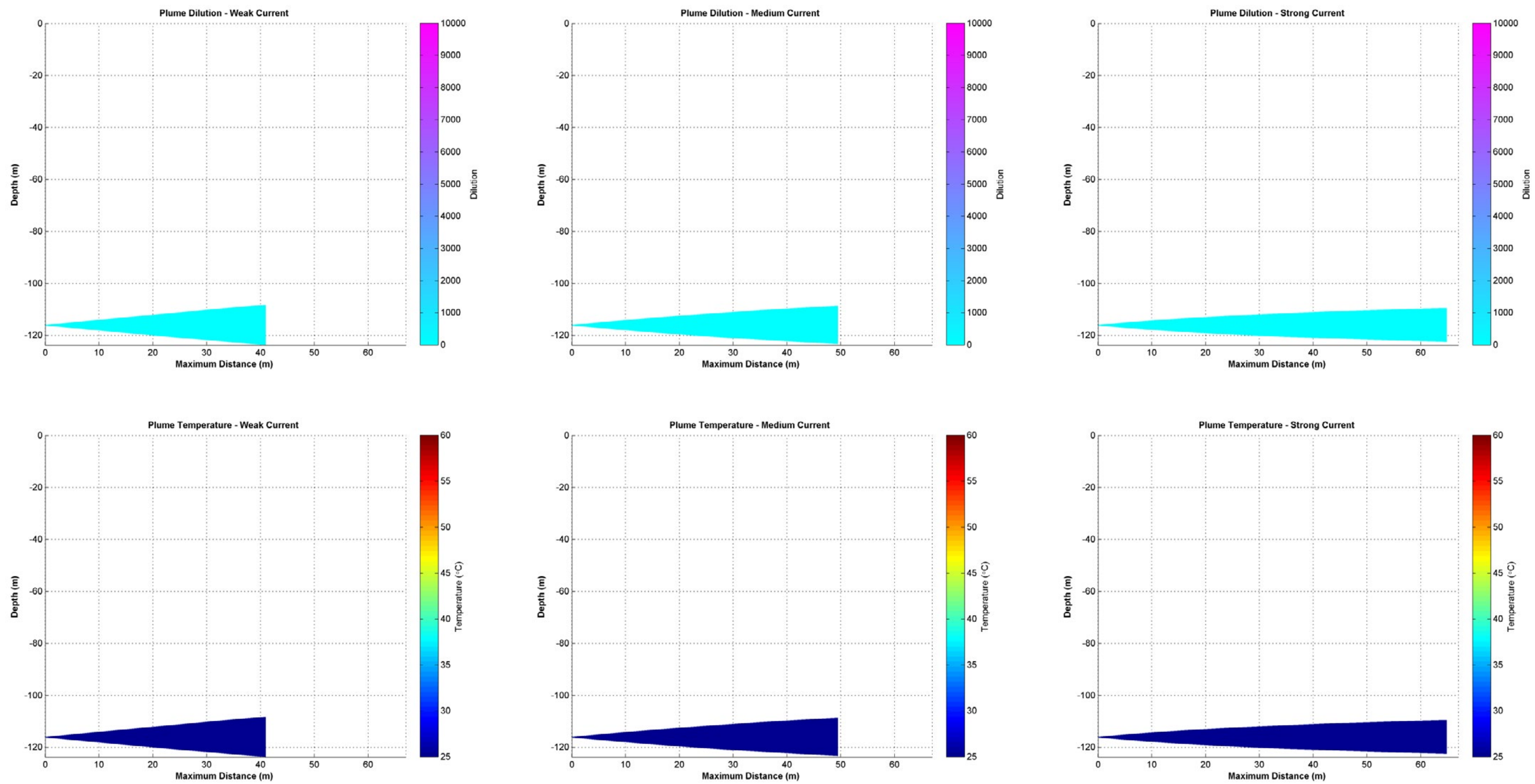

Figure 3.15 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (NRC tie-in 736,000 m³ hydrotest discharge).

3.1.3.2.1.4 Winter

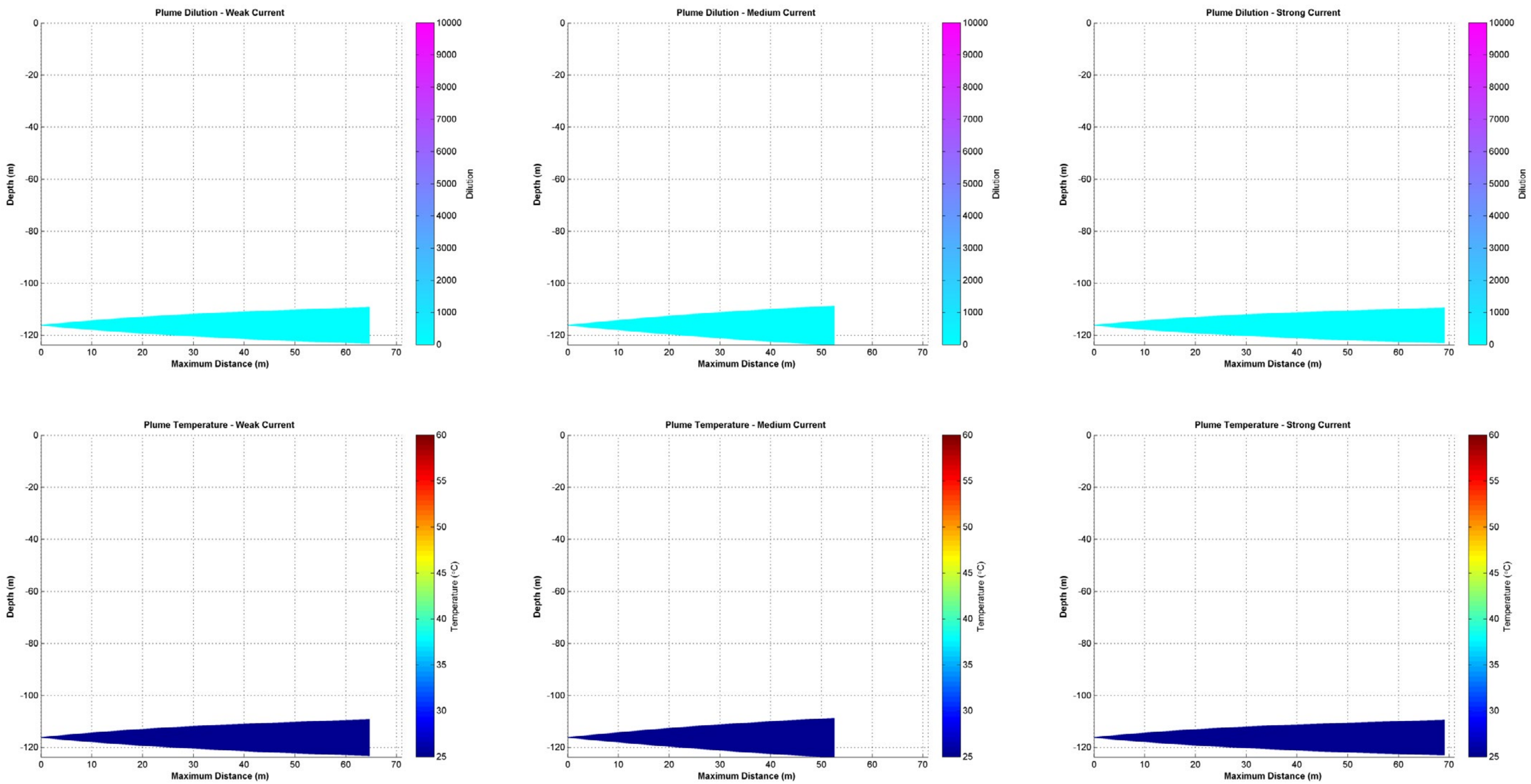

Figure 3.16 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (NRC tie-in 736,000 m^3 hydrotest discharge).

3.1.3.2.2 Discharge Case H2: Torosa Hydrotest Discharge of 846,000 m^3 at 461 m Depth

Table 3.21 Predicted plume characteristics at the end of the near-field mixing zone for the Torosa 846,000 m^3 hydrotest discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.02)	23.4 [460.5]	10.67	0.00	61	126	59.9
	Medium (0.10)	22.3 [460.4]	10.68	0.00	62	166	73.6
	Strong (0.26)	19.5 [460.3]	10.68	0.00	66	210	101.2
Summer	Weak (0.02)	23.7 [460.5]	10.65	0.00	62	136	63.3
	Medium (0.10)	22.3 [460.4]	10.65	0.00	62	166	73.6
	Strong (0.25)	19.5 [460.3]	10.65	0.00	66	210	101.1
Transitional	Weak (0.02)	23.8 [460.4]	10.55	0.00	62	128	61.0
	Medium (0.10)	22.7 [460.3]	10.55	0.00	64	172	76.6
	Strong (0.27)	19.8 [460.3]	10.55	0.00	68	218	106.5
Winter	Weak (0.02)	23.0 [460.5]	10.80	0.00	60	123	58.8
	Medium (0.10)	22.1 [460.4]	10.80	0.00	62	162	72.2
	Strong (0.25)	19.4 [460.3]	10.80	0.00	65	206	98.5

Table 3.22 Concentrations of biocide and number of dilutions at the end of the near-field stage for the annual period. Note from Table 3.21 that dilutions at the 5th, 50th and 95th percentile current speeds were 126, 166 and 210, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		126x Dilution	166x Dilution	210x Dilution
Biocide	600	4.8	3.6	2.9

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Table 3.23 Concentrations of biocide and number of dilutions at the end of the near-field stage for the summer season. Note from Table 3.21 that dilutions at the 5th, 50th and 95th percentile current speeds were 136, 166 and 210, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 136x Dilution	50th %ile 166x Dilution	95th %ile 210x Dilution
Biocide	600	4.4	3.6	2.9

Table 3.24 Concentrations of biocide and number of dilutions at the end of the near-field stage for the transitional season. Note from Table 3.21 that dilutions at the 5th, 50th and 95th percentile current speeds were 128, 172 and 218, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 128x Dilution	50th %ile 172x Dilution	95th %ile 218x Dilution
Biocide	600	4.7	3.5	2.8

Table 3.25 Concentrations of biocide and number of dilutions at the end of the near-field stage for the winter season. Note from Table 3.21 that dilutions at the 5th, 50th and 95th percentile current speeds were 123, 162 and 206, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 123x Dilution	50th %ile 162x Dilution	95th %ile 206x Dilution
Biocide	600	4.9	3.7	2.9

3.1.3.2.2.1 Annualised

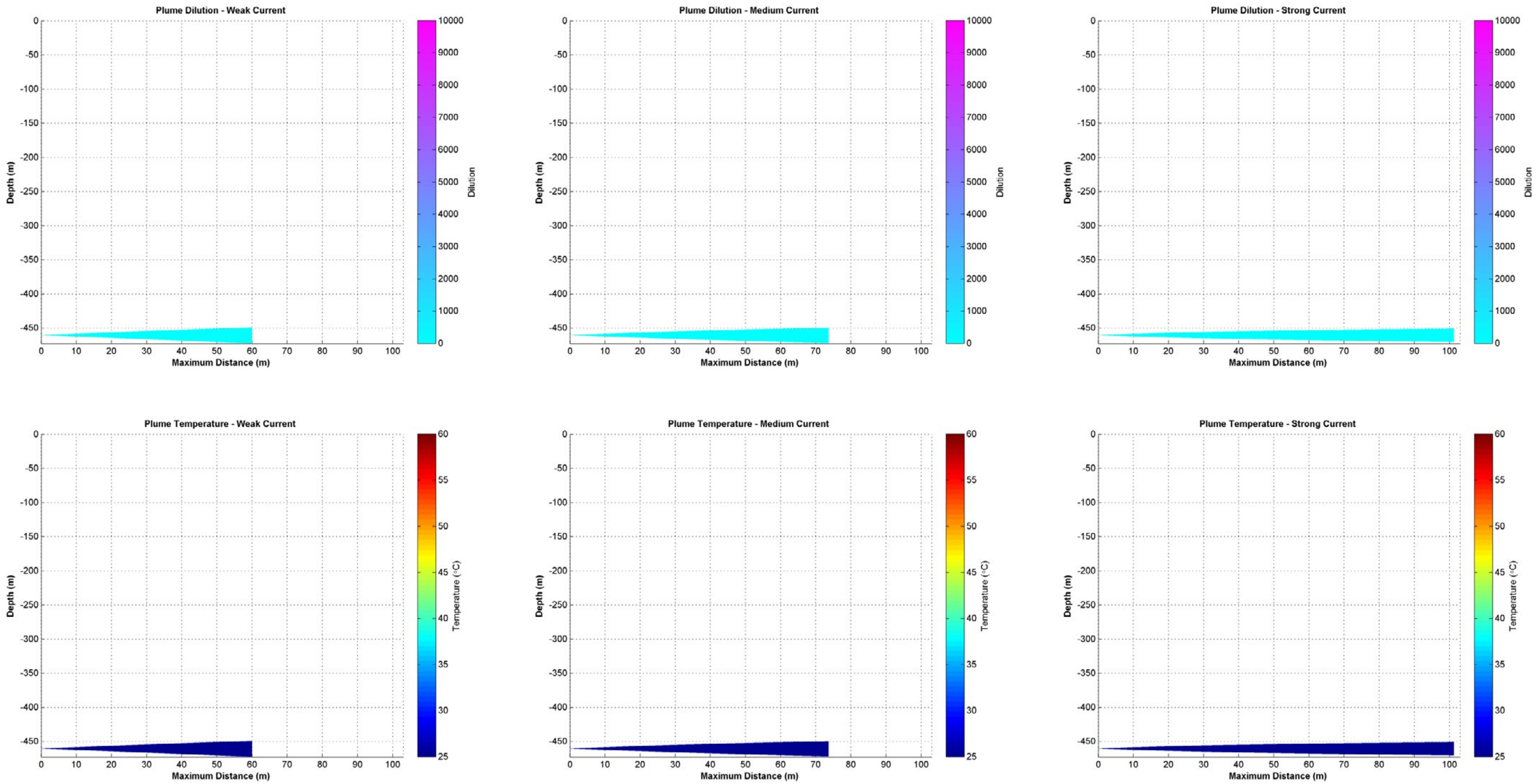

Figure 3.17 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (Torosa 846,000 m^3 hydrotest discharge).

3.1.3.2.2.2 Summer

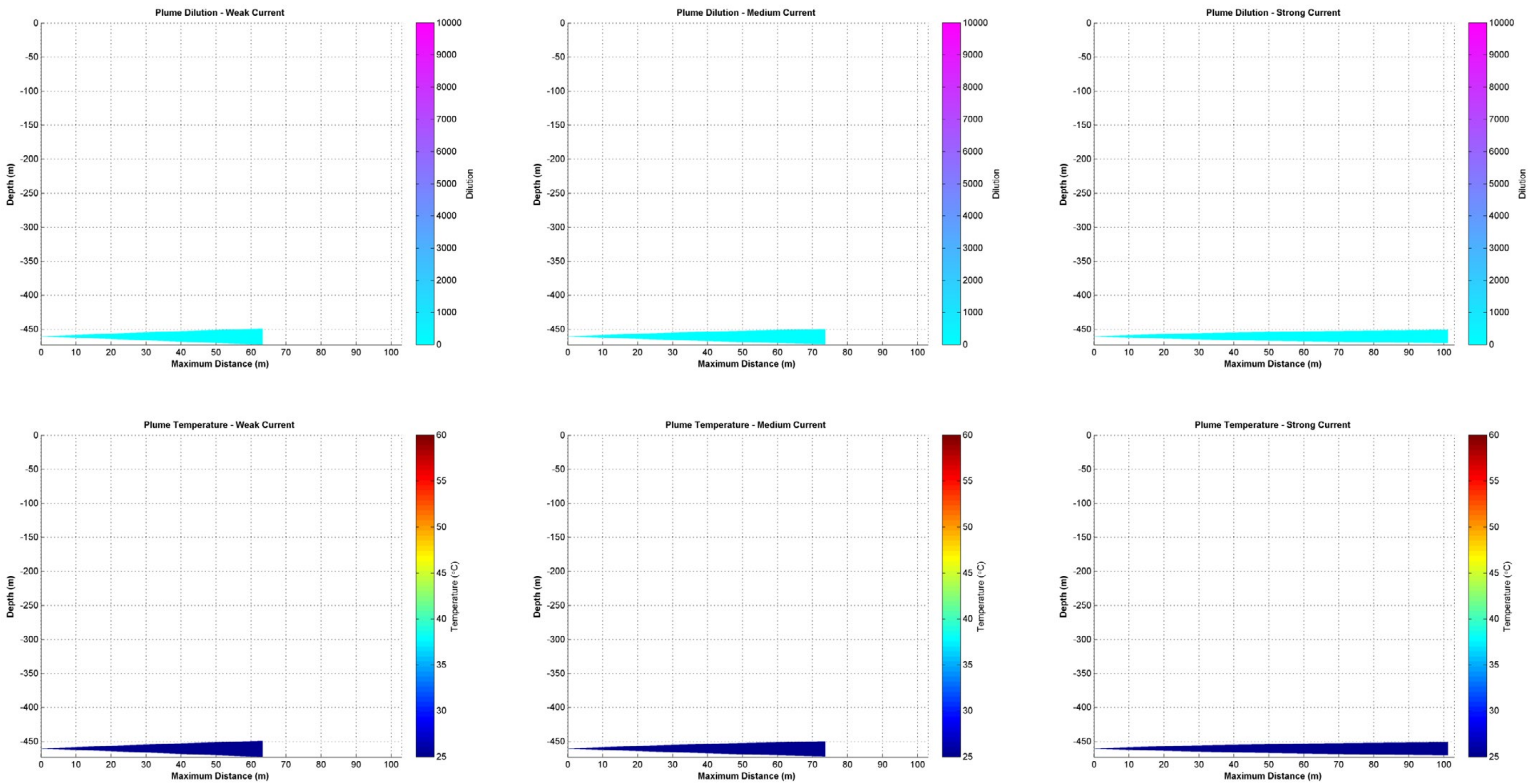

Figure 3.18 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (Torosa 846,000 m^3 hydrotest discharge).

3.1.3.2.2.3 Transitional

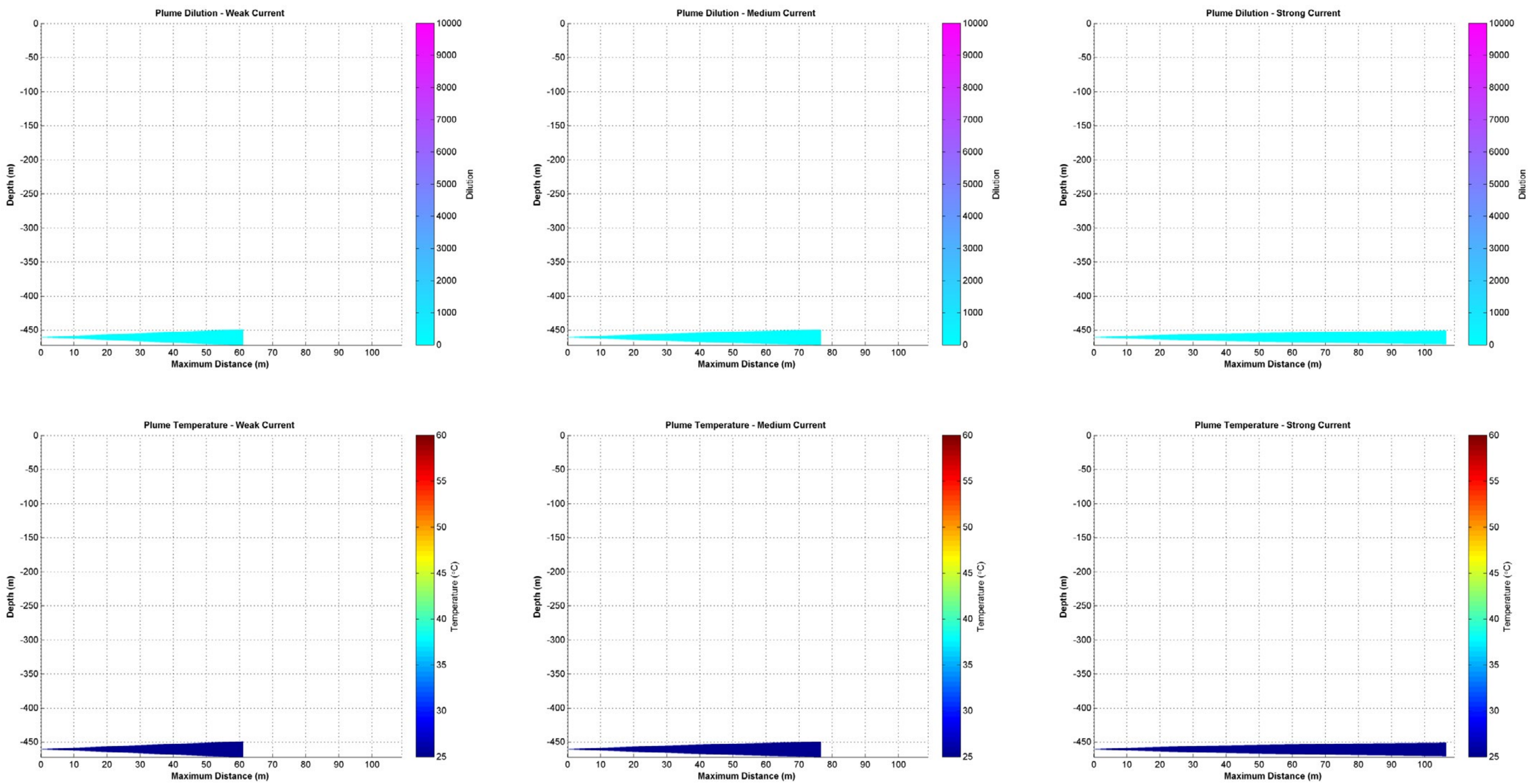

Figure 3.19 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (Torosa 846,000 m^3 hydrotest discharge).

3.1.3.2.2.4 Winter

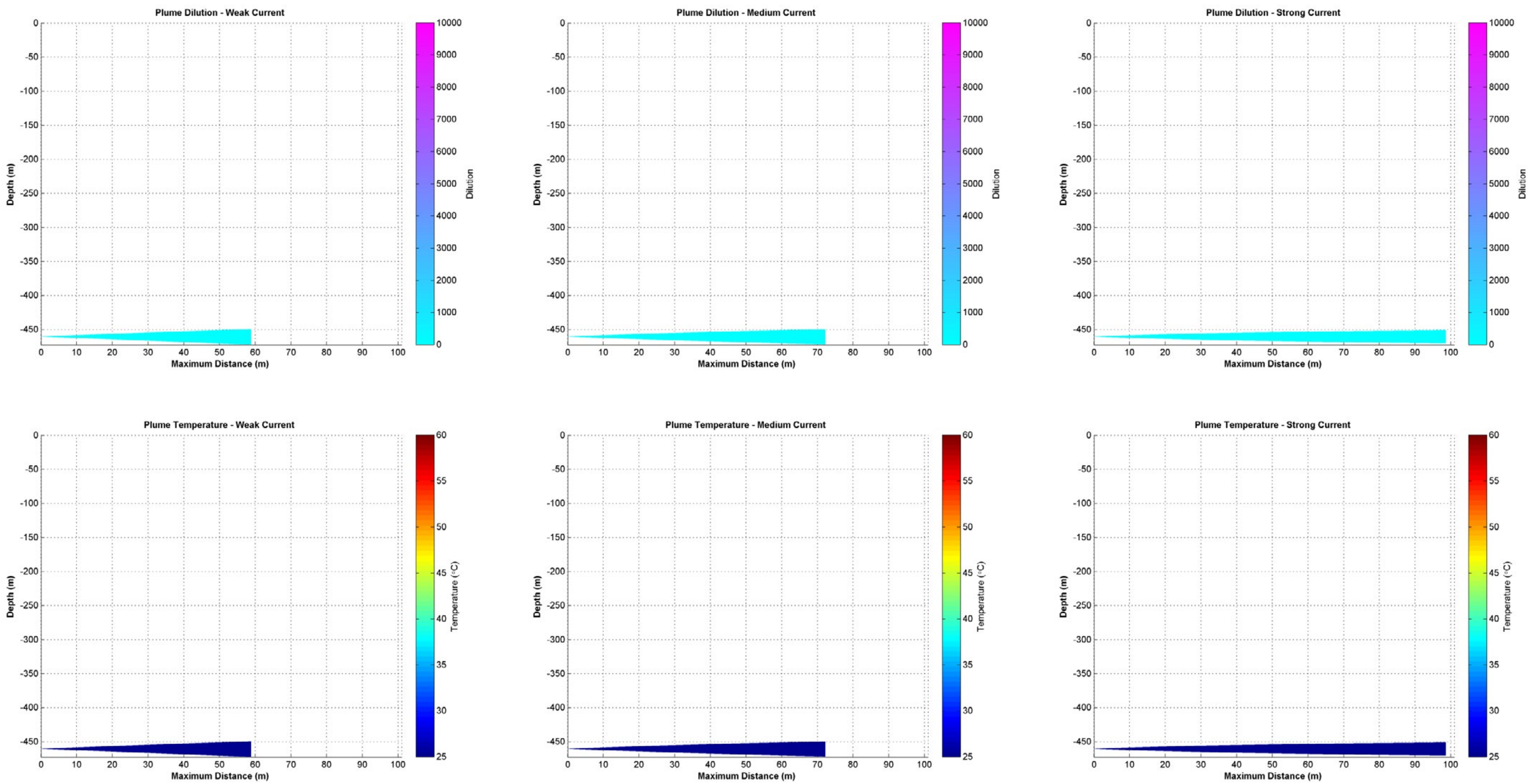

Figure 3.20 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (Torosa 846,000 m^3 hydrotest discharge).

3.1.3.2.3 Discharge Case H3a: Brecknock/Calliance Hydrotest Discharge of 790,000 m³ at 539 m Depth

Table 3.26 Predicted plume characteristics at the end of the near-field mixing zone for the Brecknock/Calliance 790,000 m³ hydrotest discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.02)	24.0 [538.1]	8.87	0.00	63	128	61.3
	Medium (0.10)	23.0 [538.1]	8.87	0.00	65	172	76.6
	Strong (0.26)	20.0 [538.1]	8.87	0.00	67	214	103.0
Summer	Weak (0.02)	24.3 [538.1]	8.87	0.00	64	141	65.5
	Medium (0.10)	23.0 [538.1]	8.87	0.00	64	172	76.6
	Strong (0.25)	20.3 [538.1]	8.87	0.00	68	218	105.3
Transitional	Weak (0.02)	24.8 [538.1]	8.86	0.00	65	133	63.6
	Medium (0.10)	23.2 [538.1]	8.86	0.00	65	176	78.1
	Strong (0.27)	20.3 [538.1]	8.86	0.00	69	223	108.1
Winter	Weak (0.02)	24.0 [538.1]	8.88	0.00	63	128	61.3
	Medium (0.10)	22.6 [538.1]	8.88	0.00	63	166	73.6
	Strong (0.25)	19.9 [538.1]	8.88	0.00	66	210	100.3

Table 3.27 Concentrations of biocide and number of dilutions at the end of the near-field stage for the annual period. Note from Table 3.26 that dilutions at the 5th, 50th and 95th percentile current speeds were 128, 172 and 214, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		128x Dilution	172x Dilution	214x Dilution
Biocide	600	4.7	3.5	2.8

Table 3.28 Concentrations of biocide and number of dilutions at the end of the near-field stage for the summer season. Note from Table 3.26 that dilutions at the 5th, 50th and 95th percentile current speeds were 141, 172 and 218, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 141x Dilution	50th %ile 172x Dilution	95th %ile 218x Dilution
Biocide	600	4.3	3.5	2.8

Table 3.29 Concentrations of biocide and number of dilutions at the end of the near-field stage for the transitional season. Note from Table 3.26 that dilutions at the 5th, 50th and 95th percentile current speeds were 133, 176 and 223, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 133x Dilution	50th %ile 176x Dilution	95th %ile 223x Dilution
Biocide	600	4.5	3.4	2.7

Table 3.30 Concentrations of biocide and number of dilutions at the end of the near-field stage for the winter season. Note from Table 3.26 that dilutions at the 5th, 50th and 95th percentile current speeds were 128, 166 and 210, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile 128x Dilution	50th %ile 166x Dilution	95th %ile 210x Dilution
Biocide	600	4.7	3.6	2.9

3.1.3.2.3.1 Annualised

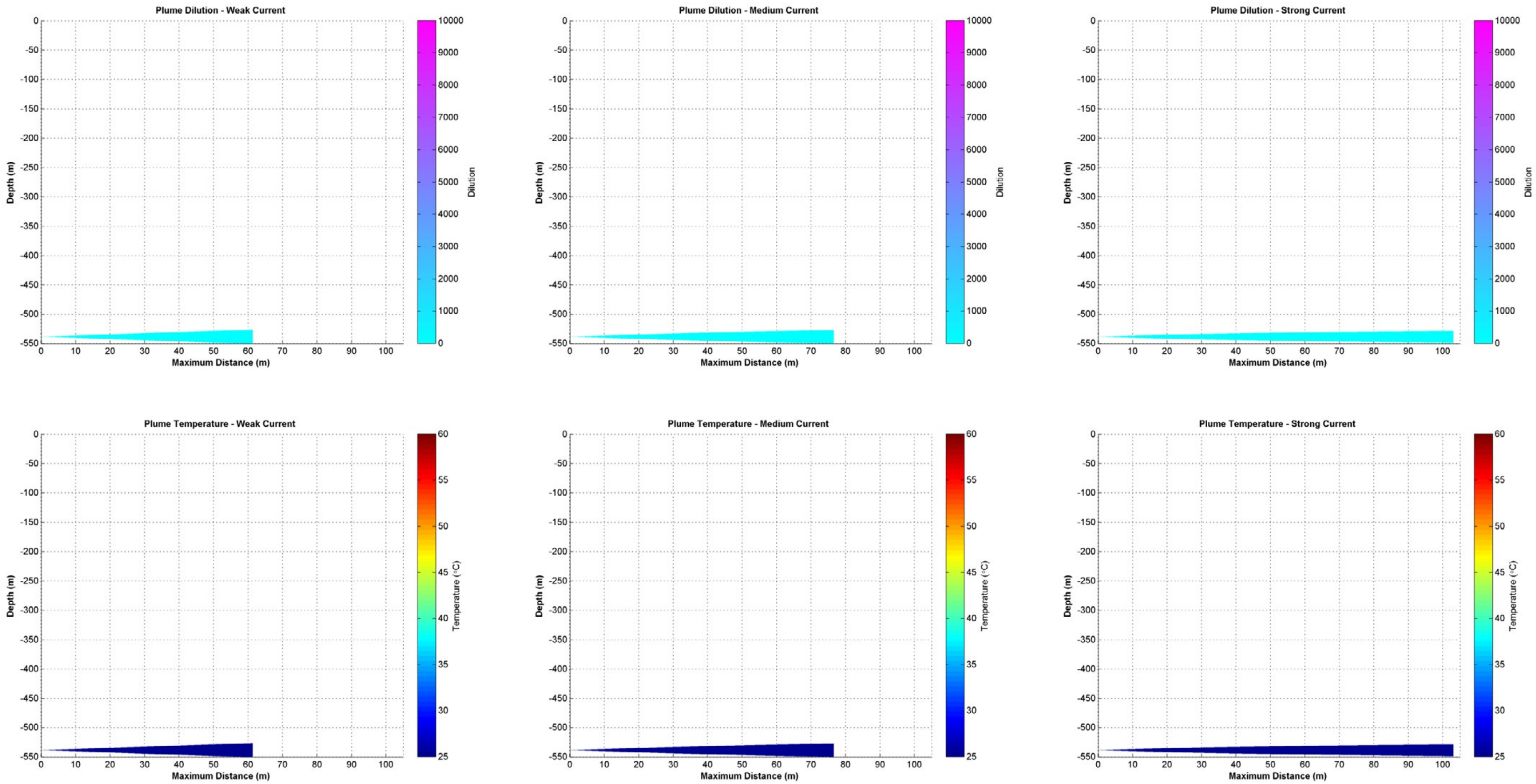

Figure 3.21 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (Brecknock/Calliance 790,000 m³ hydrotest discharge).

3.1.3.2.3.2 Summer

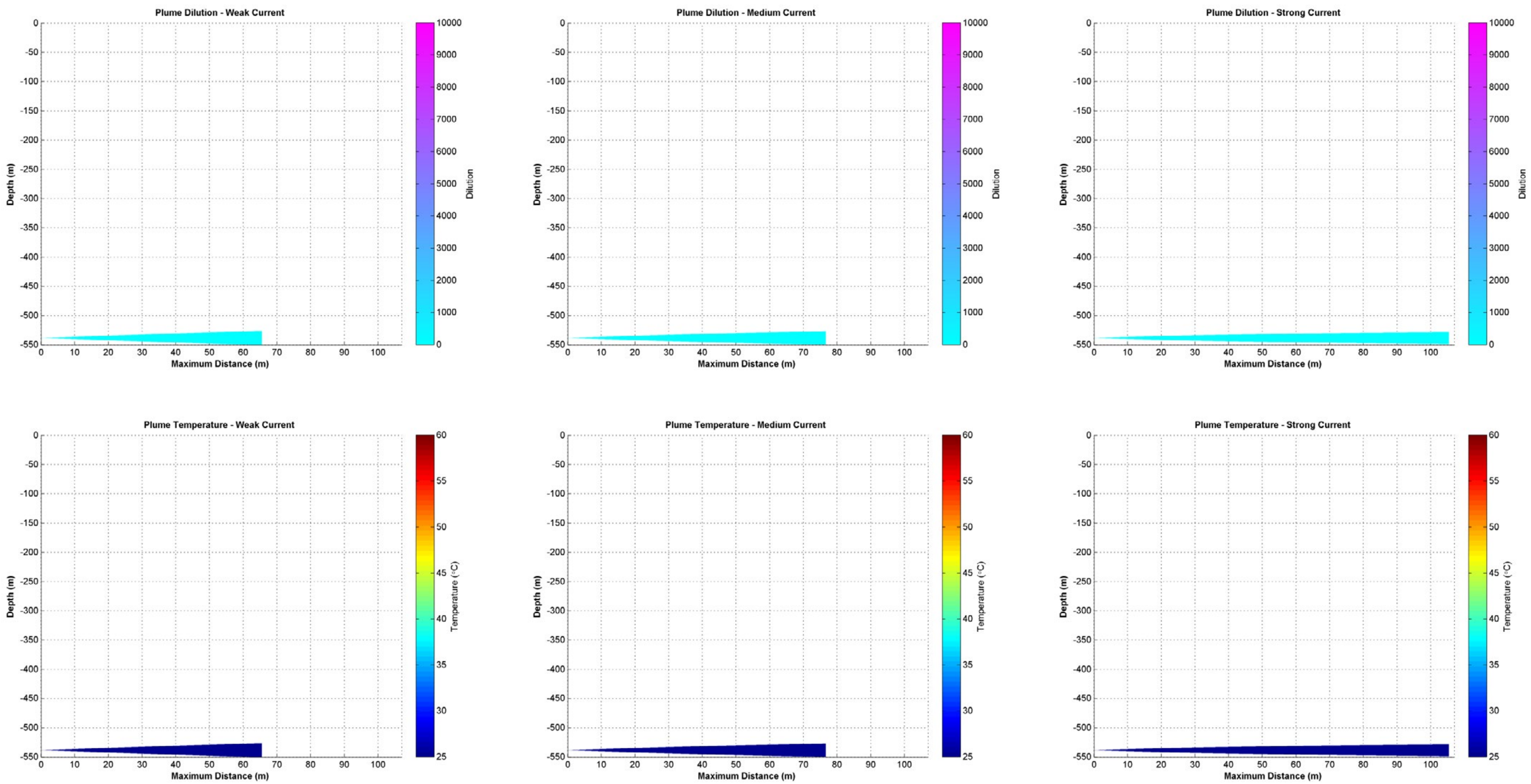

Figure 3.22 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (Brecknock/Calliance 790,000 m³ hydrotest discharge).

3.1.3.2.3.3 Transitional

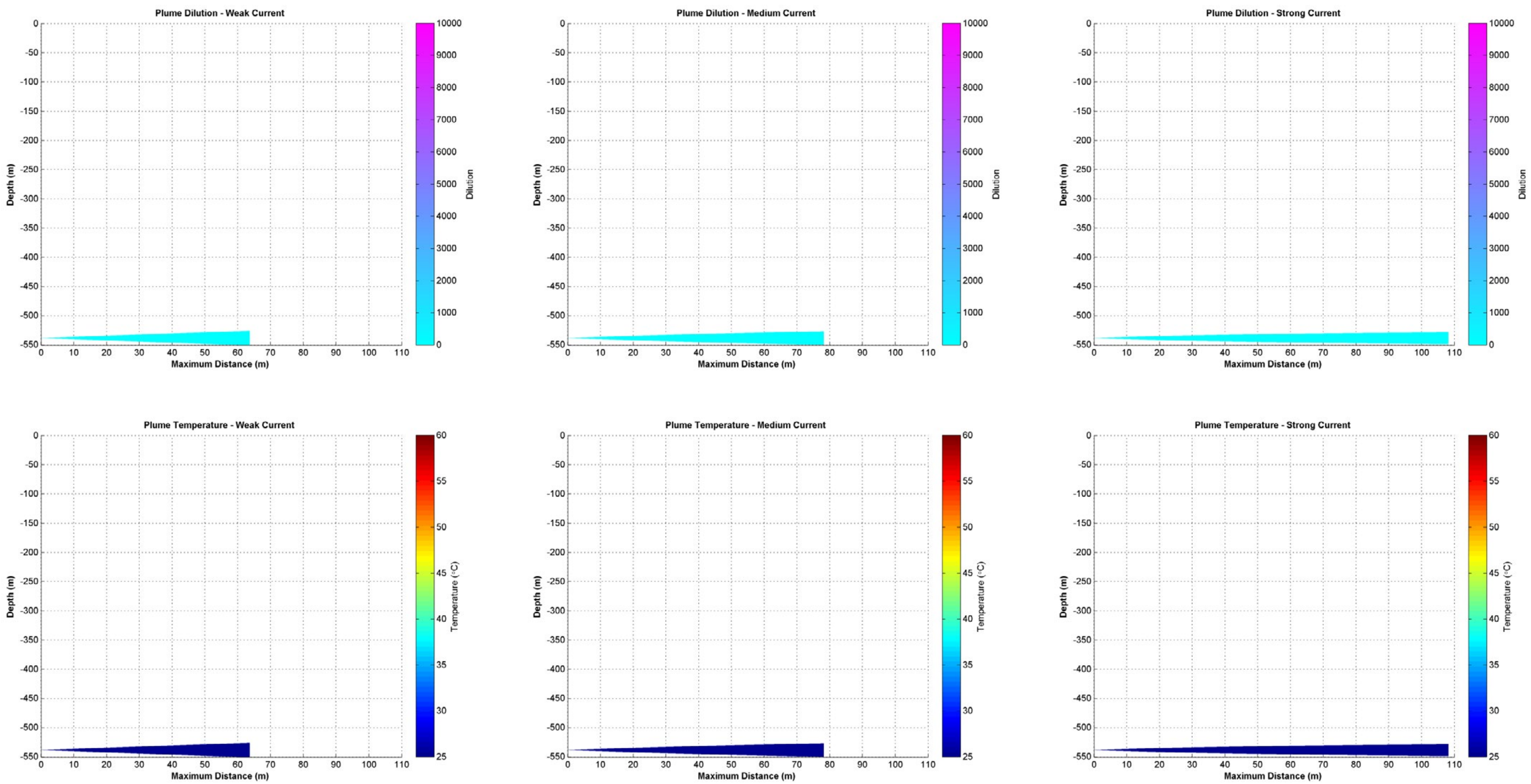

Figure 3.23 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (Brecknock/Calliance 790,000 m^3 hydrotest discharge).

3.1.3.2.3.4 Winter

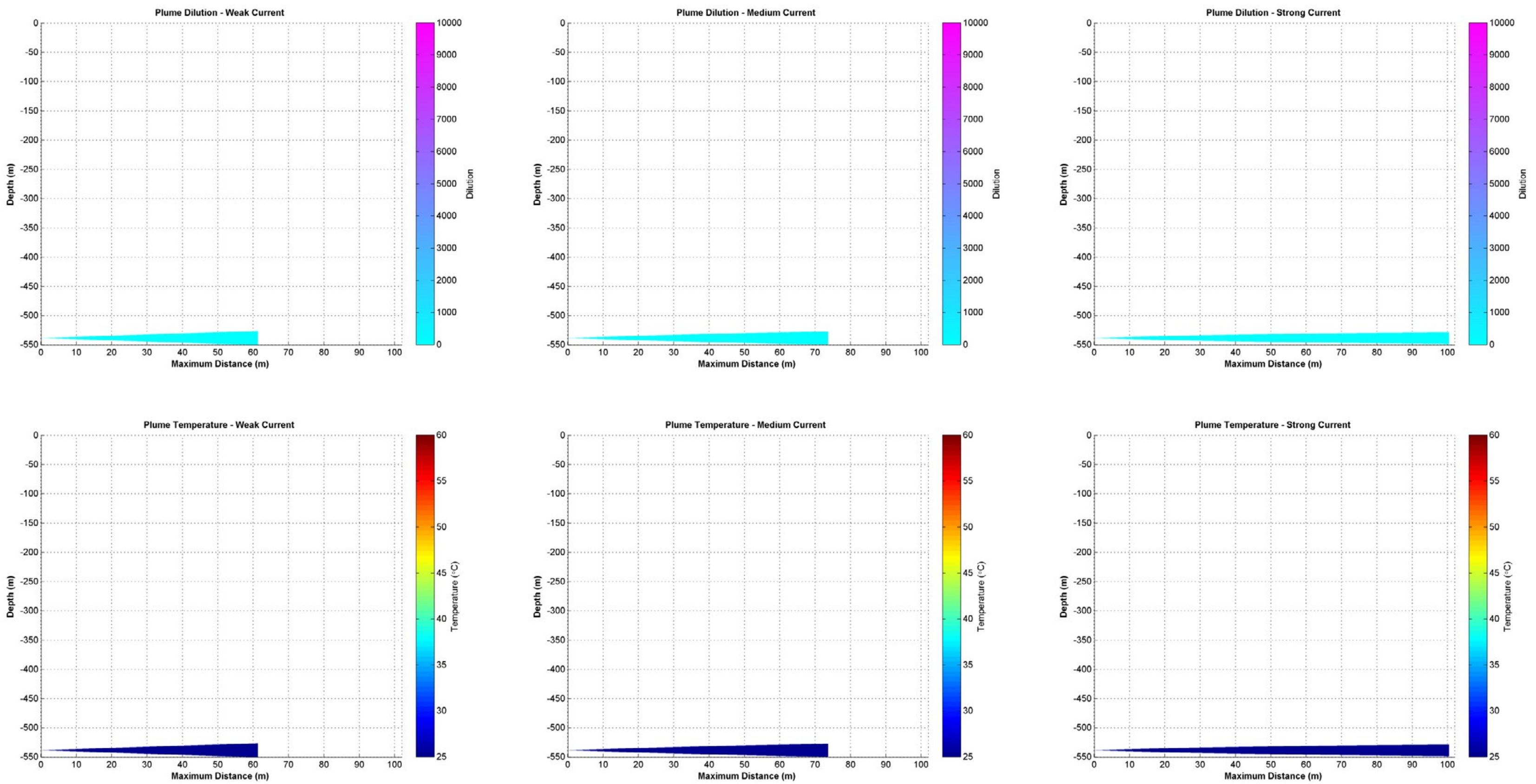

Figure 3.24 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (Brecknock/Calliance 790,000 m³ hydrotest discharge).

3.1.3.2.4 Discharge Case H3b: Torosa Hydrotest Discharge of 56,000 m^3 at 461 m Depth

Table 3.31 Predicted plume characteristics at the end of the near-field mixing zone for the Torosa 56,000 m^3 hydrotest discharge for each season and current speed.

Season	Surface Current Speed (m/s)	Plume Diameter (m) at Depth [m]	Plume Temperature (°C)	Plume-Ambient Temperature Difference (°C)	Plume Dilution (1:x)		Maximum Horizontal Distance (m)
					Minimum	Average	
Annual	Weak (0.02)	23.4 [460.5]	10.67	0.00	61	126	59.9
	Medium (0.10)	22.3 [460.4]	10.68	0.00	62	166	73.6
	Strong (0.26)	19.5 [460.3]	10.68	0.00	66	210	101.2
Summer	Weak (0.02)	23.7 [460.5]	10.65	0.00	62	136	63.3
	Medium (0.10)	22.3 [460.4]	10.65	0.00	62	166	73.6
	Strong (0.25)	19.5 [460.3]	10.65	0.00	66	210	101.1
Transitional	Weak (0.02)	23.8 [460.4]	10.55	0.00	62	128	61.0
	Medium (0.10)	22.7 [460.3]	10.55	0.00	64	172	76.6
	Strong (0.27)	19.8 [460.3]	10.55	0.00	68	218	106.5
Winter	Weak (0.02)	23.0 [460.5]	10.80	0.00	60	123	58.8
	Medium (0.10)	22.1 [460.4]	10.80	0.00	62	162	72.2
	Strong (0.25)	19.4 [460.3]	10.80	0.00	65	206	98.5

Table 3.32 Concentrations of biocide and number of dilutions at the end of the near-field stage for the annual period. Note from Table 3.31 that dilutions at the 5th, 50th and 95th percentile current speeds were 126, 166 and 210, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		126x Dilution	166x Dilution	210x Dilution
Biocide	600	4.8	3.6	2.9

Table 3.33 Concentrations of biocide and number of dilutions at the end of the near-field stage for the summer season. Note from Table 3.31 that dilutions at the 5th, 50th and 95th percentile current speeds were 136, 166 and 210, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		136x Dilution	166x Dilution	210x Dilution
Biocide	600	4.4	3.6	2.9

Table 3.34 Concentrations of biocide and number of dilutions at the end of the near-field stage for the transitional season. Note from Table 3.31 that dilutions at the 5th, 50th and 95th percentile current speeds were 128, 172 and 218, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		128x Dilution	172x Dilution	218x Dilution
Biocide	600	4.7	3.5	2.8

Table 3.35 Concentrations of biocide and number of dilutions at the end of the near-field stage for the winter season. Note from Table 3.31 that dilutions at the 5th, 50th and 95th percentile current speeds were 123, 162 and 206, respectively.

Constituent	Source Concentration (ppm)	End of Near-Field Concentration (ppm)		
		5th %ile	50th %ile	95th %ile
		123x Dilution	162x Dilution	206x Dilution
Biocide	600	4.9	3.7	2.9

3.1.3.2.4.1 Annualised

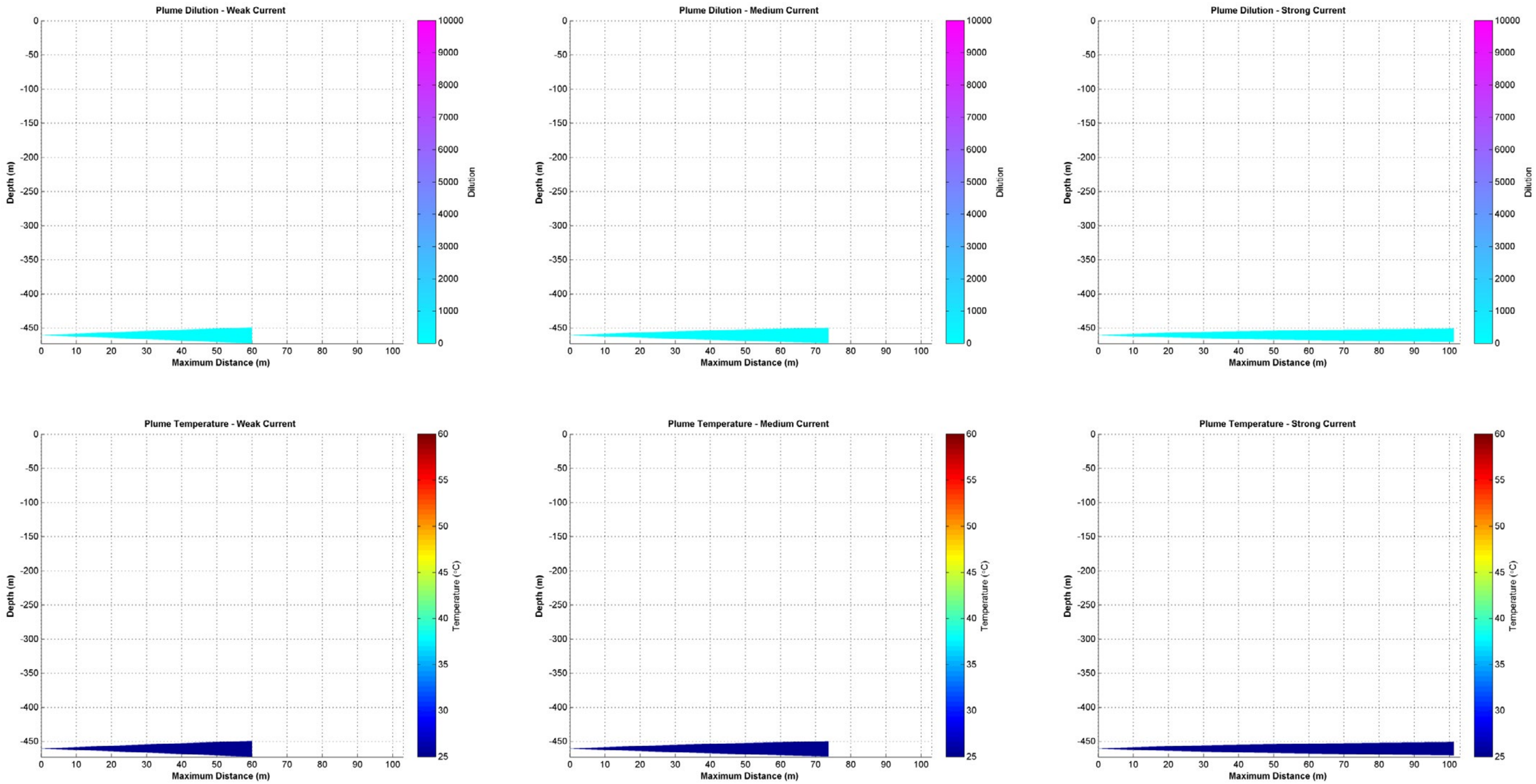

Figure 3.25 Near-field average dilution and temperature results for constant weak, medium and strong annualised currents (Torosa 56,000 m^3 hydrotest discharge).

3.1.3.2.4.2 Summer

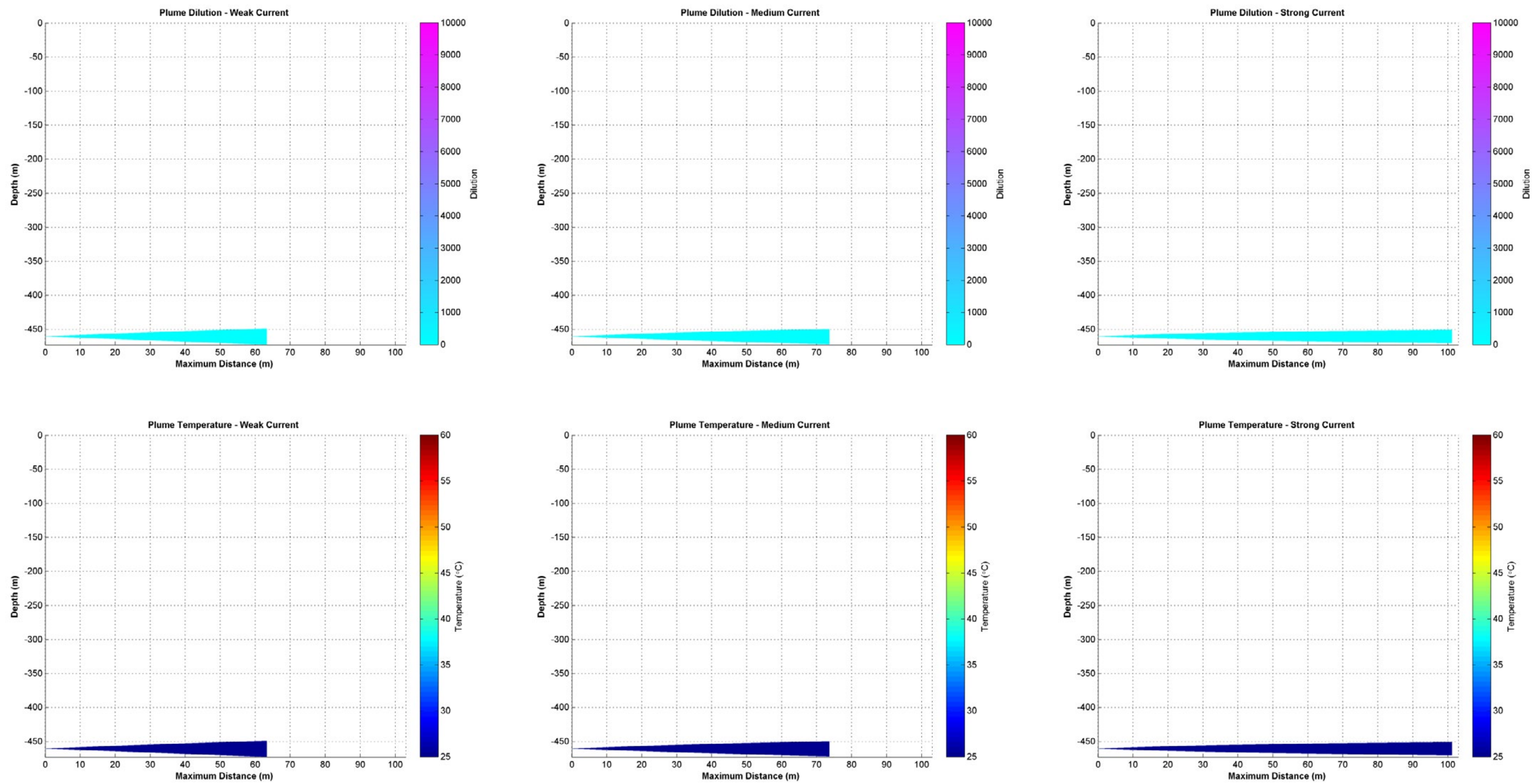

Figure 3.26 Near-field average dilution and temperature results for constant weak, medium and strong summer currents (Torosa 56,000 m^3 hydrotest discharge).

3.1.3.2.4.3 Transitional

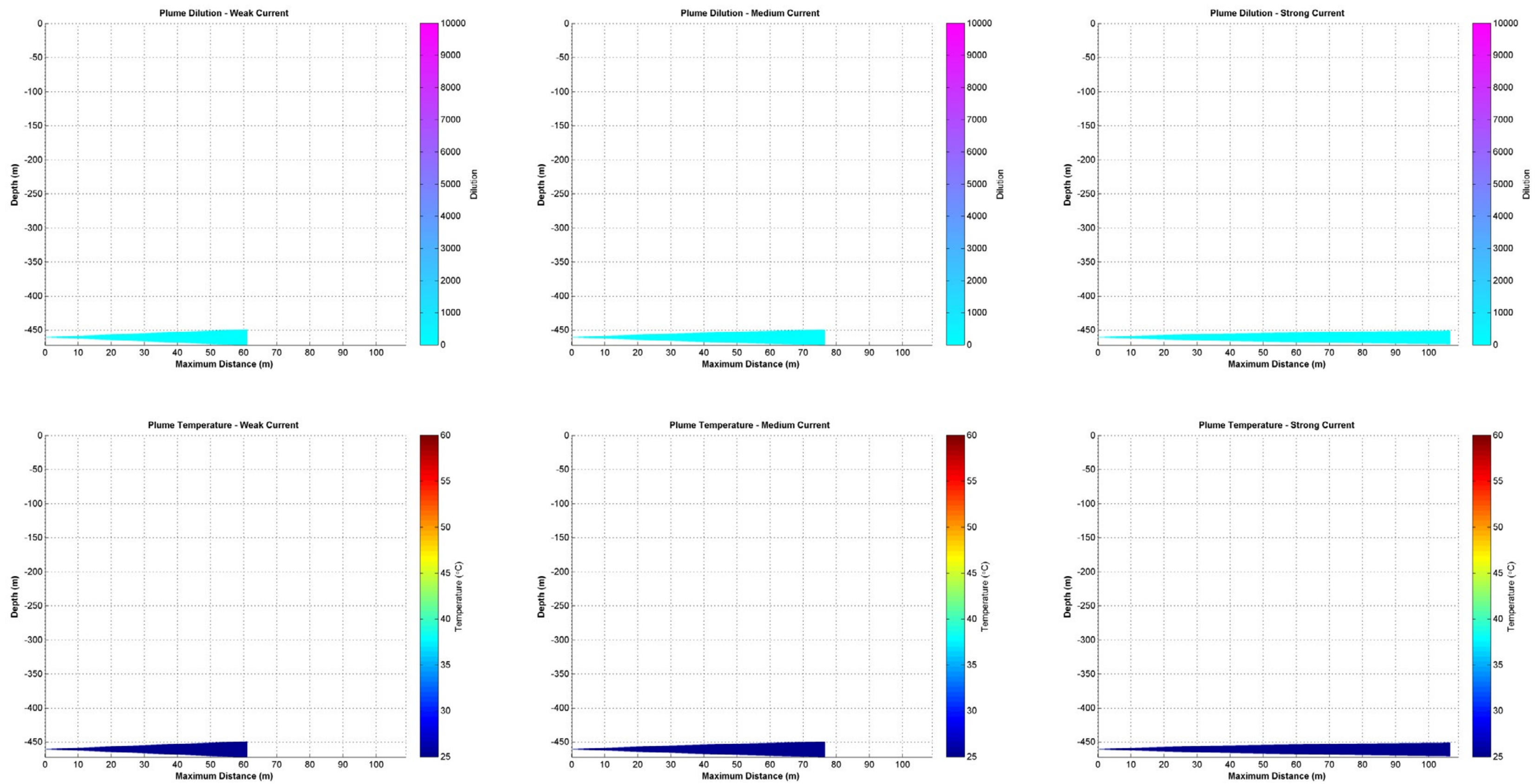

Figure 3.27 Near-field average dilution and temperature results for constant weak, medium and strong transitional currents (Torosa 56,000 m³ hydrotest discharge).

3.1.3.2.4.4 Winter

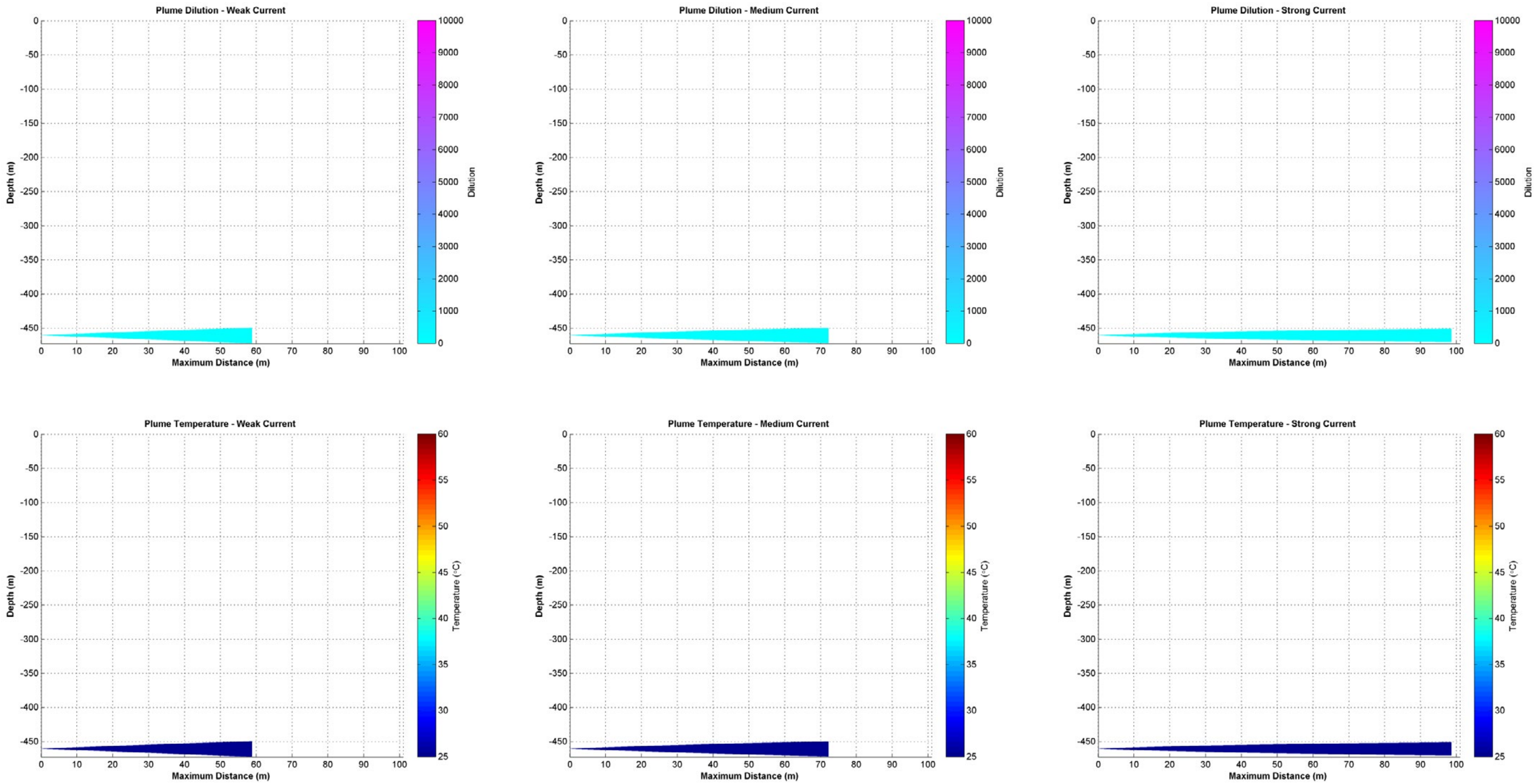

Figure 3.28 Near-field average dilution and temperature results for constant weak, medium and strong winter currents (Torosa 56,000 m³ hydrotest discharge).

3.2 Far-Field Modelling

3.2.1 Overview

It is important to note that near-field and far-field modelling are used to describe different processes and scales of effect, and therefore the far-field modelling results will not necessarily correspond to the outcomes at the end of the near-field mixing zone for any given discharge scenario. The far-field results included episodes of pooling of the discharge plume under weak currents, which caused lower dilutions (higher concentrations) further from the discharge location when the pooled plume was advected away. Episodes of recirculation – where the plume moved back under the discharge at some later time due to the oscillatory nature of the tide – were also observed, compounding the pooling effect and further lowering the dilution values.

3.2.2 Interpretation of Percentile Dilution Contours

For each of the modelled discharge cases, the results for all simulations were combined and a statistical analysis performed to produce percentile contours of dilution. In the following sections, outcomes based on 95th percentile dilution contours are presented.

Calculation of 95th percentile statistics is a common approach to assessing the impact of dispersing plumes and captures the variability in outcomes, for all but the most ephemeral and extreme forcing conditions, in the data set under consideration. Impact assessment criteria for water quality are often defined using similar statistical indicators.

Note that the percentile figures do not represent the location of a plume at any point in time; they are a statistical and spatial summary of the percentage of time that particular dilution values occur across all replicate simulations and time steps. For example, if the 95th percentile minimum dilution at a particular location in the model domain is predicted as a value of 100, this means that for 95% of the time the dilution level will be higher than 100 and for only 5% of the time the dilution level will be lower than 100. A comparison of instantaneous plume extent snapshots, as shown in Figure 3.29 (CW discharges), Figure 3.41 (PW discharges) and Figure 3.56 (hydrotest discharges), with the percentile images for the corresponding discharge demonstrates the significant difference between an instantaneous snapshot and a cumulative estimate of coverage over several days and many individual simulations.

Dilution contours are calculated from the ratios of dispersing constituent concentrations in the receiving waters to the initial concentration of the constituent in the discharge. Note that this assumes the background concentration of the constituent in the receiving waters is zero and there is no significant biodegradation of the discharged constituent over the short duration of the dispersion process.

Table 3.36 summarises the initial concentrations of chlorine, as specified, and the equivalent dispersed concentrations required to yield particular dilution levels (1:100, 1:200 and 1:400).

Table 3.36 Initial concentrations of chlorine and equivalent concentrations at example dilution levels.

Parameter	Chlorine Concentration (ppm)	
Initial concentration in discharge	0.2	0.5
Initial concentration in receiving waters	0.0	
Concentration at 1:100 dilution	0.002	0.005
Concentration at 1:200 dilution	0.001	0.0025
Concentration at 1:400 dilution	0.0005	0.00125

Table 3.37 summarises the initial concentrations of total oil (including BTEX), mercury and MEG, as specified, and the equivalent dispersed concentrations required to yield particular dilution levels (1:100, 1:200 and 1:400).

Table 3.37 Initial concentrations of total oil, mercury and MEG, and equivalent concentrations at example dilution levels.

Parameter	Total Oil Concentration (mg/L)	Mercury Concentration (mg/L)	MEG Concentration (mg/L)
Initial concentration in discharge	30.0	0.03	79,000.0
Initial concentration in receiving waters	0.0	0.00	0.0
Concentration at 1:100 dilution	0.3	0.0003	790.0
Concentration at 1:200 dilution	0.15	0.00015	395.0
Concentration at 1:400 dilution	0.075	0.000075	197.5

Table 3.38 summarises the initial concentrations of biocide, as specified, and the equivalent dispersed concentrations required to yield particular dilution levels (1:100, 1:200, 1:400 and 1:10,000).

Table 3.38 Initial concentrations of biocide and equivalent concentrations at example dilution levels.

Parameter	Biocide Concentration (ppm)
Initial concentration in discharge	600.0
Initial concentration in receiving waters	0.0
Concentration at 1:100 dilution	6.0
Concentration at 1:200 dilution	3.0
Concentration at 1:400 dilution	1.5
Concentration at 1:10,000 dilution	0.06

These concentrations may be useful to consider when interpreting the contour plots of percentile dilutions.

3.2.3 Cooling Water Discharges

3.2.3.1 General Observations

Figure 3.29 shows example time series snapshots of predicted dilutions during a single simulation at 3-hour intervals from 01:00 to 16:00 on 20th January 2013. This simulation – selected merely to be representative of typical conditions – considers the Case C discharge at 12 m BMSL. The spatially-varying orientation of the plume with the currents and the rapidly-varying nature of the concentrations around the source can be observed. The snapshots also show the combined effect of the tide and the drift currents, with a clear tidal oscillation.

These snapshots illustrate that the dilutions (and in turn concentrations) become more variable over time because of changes in current speed and direction. Higher dilutions (lower concentrations) are predicted during periods of increased current speed, whereas patches of lower dilutions (higher concentrations) tend to accumulate during the turning of the tide or during periods of weak drift currents. During prolonged periods of lowered current speed, the plume has a more continuous appearance, with higher-concentration patches moving as a unified group.

The snapshots in Figure 3.29 show a clear separation between a contiguous plume emanating from the source and a more distant detached plume. The detached plume contains higher constituent concentrations than the surrounding waters, which is the result of a recirculation episode at an earlier time in the discharge where the existing plume passed over the source once more. Within the main plume, another sub-plume likely to break off in the future can be seen.

These findings agree with the research of King & McAllister (1997, 1998) who noted that concentrations within effluent plumes generated by an offshore platform were patchy and likely to peak around the reversal of the tides.

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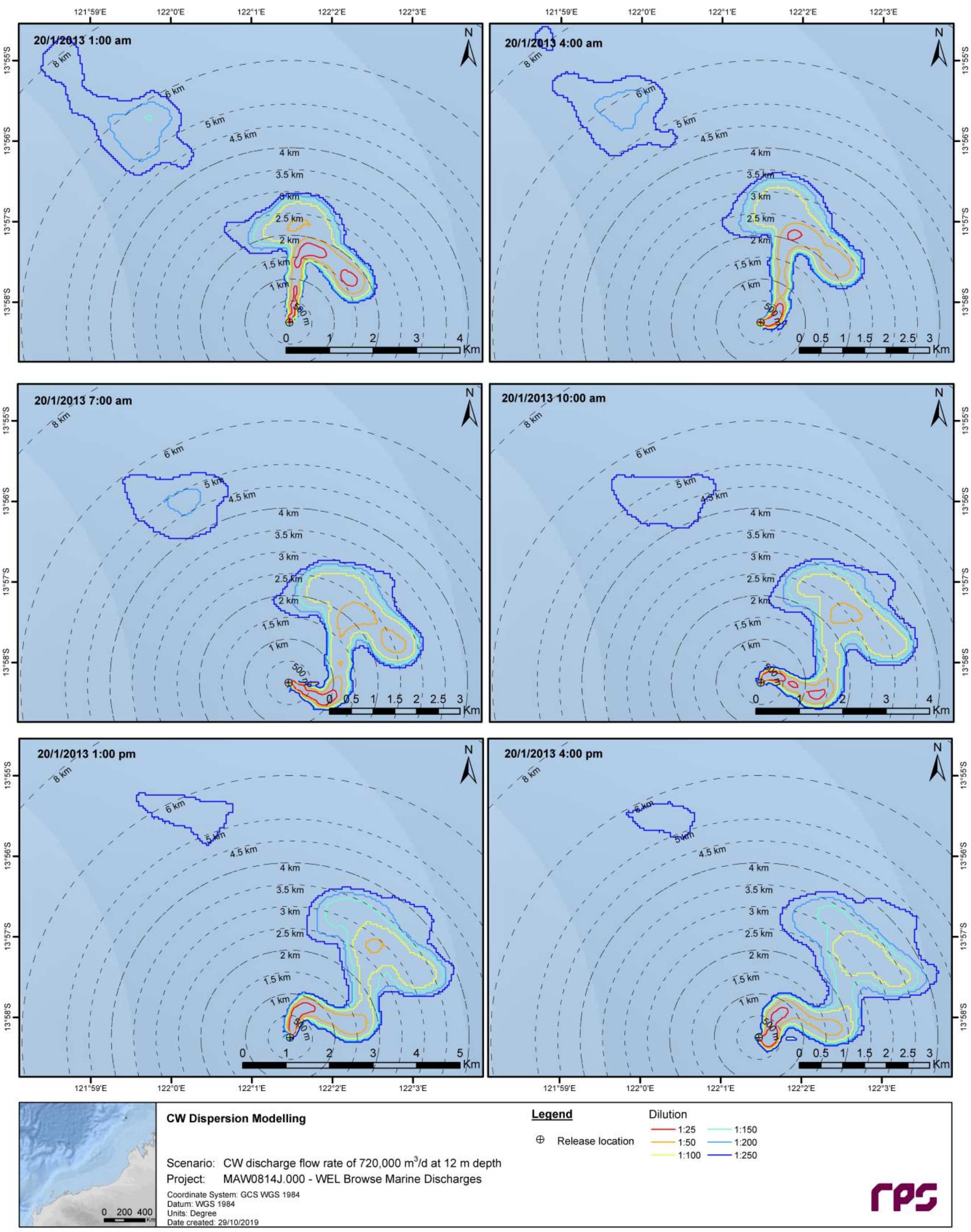

Figure 3.29 Snapshots of predicted dilution levels, at 3-hour intervals from 01:00 to 16:00 on 20th January 2013, for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

3.2.3.2 Seasonal Analysis

3.2.3.2.1 Summary

The model outputs over the ten-year hindcast period (2006-2015) were combined and analysed on a seasonal basis (summer, transitional and winter). This approach assists with identifying the potential exposure to surrounding sensitive receptors whilst considering inter-annual variability in ocean current conditions.

Table 3.39 summarises for Case C the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the Scott Reef area defined by the 3 nm State water boundary – for each season and percentile.

Table 3.40 provides for Case C a summary of the maximum distances from the discharge location to achieve an example dilution level of 1:100 for each season and percentile. The results indicate that the release of effluent under all seasonal conditions results in slow dispersion within the ambient environment. A 1:100 dilution is achieved within an area of influence ranging from 3.7-4.2 km at the 95th percentile.

Table 3.41 provides for Case C a summary of the total areas of coverage for the 1:100 dilution contour for each season and percentile. The area of exposure defined by the relevant dilution contour is predicted to reach a maximum value of 1.9-2.3 km^2 at the 95th percentile.

Table 3.42 provides for Case C a summary of the maximum depths from the discharge location to achieve 1:100 dilution for each season and percentile. The maximum depth is observed in summer and winter, with a prediction of 20 m.

Table 3.43 provides a summary of the maximum distances from the discharge location and total areas of coverage to achieve an example 3 °C plume-ambient temperature differential for each season and percentile. This differential is forecast to be met within 120 m at the 95th percentile.

For Case C, the aggregated spatial extents of the minimum dilutions for each season at the 95th percentile are presented in Figure 3.30 to Figure 3.32. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration. The discharged plumes are predicted to travel in predominantly northerly directions during summer and transitional months, and south-easterly directions during winter.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

For Case C, Figure 3.33 to Figure 3.35 show the aggregated spatial extents of the maximum plume-ambient temperature differential for each season at the 95th percentile.

Seasonal water column cross-section figures of 95th percentile dilution, extracted along perpendicular transects running through the origin point of the discharge (one of which is broadly aligned with the principal travel direction of the plume), are presented in Figure 3.36 to Figure 3.38. Although initially slightly positively buoyant due to its elevated temperature, the discharged plume is predicted to achieve density equilibrium with the receiving waters relatively quickly. The plume centreline – where highest concentrations and lowest dilutions are found – will tend to remain entrained more than 10 m below the water surface.

3.2.3.2.2 Discharge Case C: Flow Rate of 720,000 m^3/day at 12 m Depth

Table 3.39 Average and minimum dilutions (1:x) achieved at specific radial distances from the CW discharge location in each season for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	559	357	471	69	288	24	573	250	394	50	202	23	527	125	409	50	230	8
20	3	2	1	1	1	1	2	2	1	1	1	1	2	2	1	1	0	0
50	8	7	3	1	1	1	6	5	3	1	1	1	4	4	2	1	1	1
100	14	5	5	3	2	1	8	5	5	3	2	1	7	5	4	3	1	1
200	22	9	8	5	3	2	15	9	7	4	3	2	15	8	7	4	3	2
300	42	13	13	6	6	3	25	12	10	6	5	3	21	11	10	6	4	2
400	38	16	14	8	5	3	28	13	11	7	5	2	30	13	13	7	6	3
500	63	18	21	9	8	4	44	15	15	8	7	3	34	15	15	8	7	4
600	60	20	20	10	8	4	46	18	16	8	8	4	47	17	20	8	8	3
700	88	23	28	11	11	4	67	22	20	11	9	4	49	19	20	9	9	3
800	82	25	27	12	11	5	66	24	21	11	10	3	67	18	24	11	11	4
900	118	27	34	15	14	5	99	26	25	12	12	5	65	20	25	10	12	6
1,000	102	29	33	14	14	5	95	30	26	14	12	6	84	24	30	11	13	5
1,100	146	31	42	15	17	6	144	32	32	15	14	5	81	24	30	12	13	5
1,200	145	31	41	14	16	5	141	34	32	16	14	4	111	25	37	11	15	4
1,300	176	34	51	16	19	6	182	37	38	15	15	5	112	28	38	11	16	4
1,400	173	38	49	18	18	6	169	38	37	15	16	5	148	31	46	11	18	4
1,500	224	39	58	17	19	7	229	42	42	17	18	7	149	32	45	13	19	5
1,600	220	41	57	19	20	7	209	45	43	17	18	6	197	36	50	13	21	6
1,700	262	45	65	21	24	7	204	45	48	19	20	6	182	37	50	12	21	7
1,800	251	45	65	19	24	7	204	50	48	20	21	8	231	41	55	13	23	6
1,900	302	50	72	21	26	7	250	50	55	19	21	7	208	39	53	15	22	6
2,000	300	48	77	22	28	7	231	54	58	20	22	7	258	45	62	15	25	5
2,100	290	48	75	22	28	8	226	50	65	24	23	7	239	45	61	17	24	5
2,200	339	50	81	21	31	10	251	56	75	22	23	8	304	46	70	19	27	7
2,300	301	50	80	25	32	10	247	63	76	21	25	9	265	50	71	21	28	8
2,400	331	56	88	24	33	9	285	59	71	22	28	8	299	55	83	22	32	7
2,500	322	56	91	28	34	8	293	63	76	24	32	9	292	60	87	23	31	7
2,600	349	63	100	32	35	10	323	71	79	26	32	8	318	62	95	22	33	7
2,700	331	69	101	33	34	11	322	73	83	33	35	9	312	63	95	20	33	7
2,800	369	71	107	32	37	10	364	82	86	36	36	11	346	63	103	20	35	6
2,900	348	71	113	31	37	11	328	83	98	34	41	11	334	63	100	23	35	6
3,000	365	74	115	31	40	12	362	71	90	35	37	10	339	71	111	23	37	9
3,100	375	76	118	29	42	12	341	71	104	34	42	11	352	71	111	23	40	8
3,200	390	83	115	32	46	14	356	83	95	30	44	11	371	71	124	22	43	9
3,300	389	83	120	31	50	14	357	83	116	30	47	11	368	76	117	25	41	9
3,400	394	83	123	33	53	14	380	86	107	33	46	13	353	79	133	24	43	7
3,500	405	83	134	34	55	15	362	97	122	34	47	15	369	83	127	21	43	7

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,600	410	79	135	36	55	16	398	97	115	33	47	13	387	83	145	20	44	7
3,700	429	83	150	31	60	17	391	100	131	34	51	15	422	83	131	20	45	10
3,800	409	83	149	32	65	14	366	100	137	40	51	14	370	83	143	23	44	8
3,900	416	83	166	35	73	13	369	100	154	45	51	14	395	92	143	27	45	8
4,000	412	86	166	39	76	13	362	100	155	46	54	12	378	100	160	28	48	8
4,100	419	98	179	40	80	15	379	100	168	43	53	12	396	100	158	29	50	9
4,200	429	100	196	42	79	16	361	100	186	42	60	12	425	100	181	28	53	11
4,300	427	100	210	38	82	18	377	100	183	38	58	14	417	125	175	29	56	10
4,400	445	100	219	40	84	18	402	114	208	45	63	18	396	125	196	33	59	10
4,500	460	100	236	42	91	16	422	116	200	45	64	15	422	125	192	34	61	11
4,600	436	100	239	42	90	14	401	125	219	46	69	14	435	125	208	36	69	11
4,700	446	118	252	42	95	16	408	125	207	46	70	17	430	129	196	41	69	13
4,800	445	125	240	40	92	19	397	132	223	50	70	18	451	129	213	40	74	13
4,900	489	125	260	45	101	18	429	130	213	52	74	16	452	134	200	46	69	14
5,000	488	125	251	45	91	17	429	167	225	56	77	14	442	136	220	45	73	14
5,500	461	125	277	58	113	24	425	167	226	63	127	17	481	167	233	57	83	17
6,000	461	167	300	62	113	24	424	250	224	69	147	25	482	250	242	71	99	22
6,500	478	167	329	50	108	27	472	250	256	83	149	22	488	250	262	85	125	25
7,000	542	230	337	72	115	26	506	250	269	100	145	28	484	250	281	71	132	25
7,500	568	250	370	86	139	31	585	500	290	100	161	36	495	250	289	71	141	29
8,000	541	250	382	101	157	29	523	483	302	125	172	42	497	250	332	84	145	11
8,500	508	250	408	125	169	36	540	500	300	83	173	40	520	250	353	100	162	28
9,000	527	285	405	100	175	41	522	500	307	83	175	42	559	250	383	100	181	31
9,500	511	500	431	100	188	38	522	500	322	100	173	55	515	387	381	100	196	33
10,000	536	500	431	125	195	42	528	500	334	100	175	38	577	500	391	100	203	42
10,500	531	500	447	136	225	45	515	500	346	100	188	42	568	500	403	125	211	45
11,000	530	500	424	125	224	50	520	500	349	100	197	46	633	500	408	125	205	45
11,500	533	500	432	125	236	56	543	500	364	125	201	48	538	500	410	125	216	50
12,000	521	500	435	167	251	42	535	500	369	125	217	56	530	500	418	125	217	50
12,500	513	500	463	167	262	45	543	500	393	130	228	51	556	500	403	125	233	56
13,000	500	500	458	167	267	56	507	500	398	167	234	56	548	500	411	157	237	56
13,500	500	500	469	250	277	56	508	500	409	167	247	56	575	500	412	167	229	56
14,000	567	500	469	250	279	59	531	500	411	126	244	57	566	500	430	167	247	50
14,500	515	500	478	250	296	61	569	500	410	125	261	63	500	500	443	125	257	56
15,000	514	500	479	250	293	64	564	500	441	167	257	61	500	500	461	167	266	65
15,500	516	500	496	250	300	61	618	500	446	130	266	63	500	500	453	176	283	71
16,000	500	500	487	250	298	60	582	500	458	167	268	63	526	500	450	214	278	64
16,500	561	500	496	250	317	57	523	500	465	167	260	70	500	500	459	250	296	71
17,000	500	500	491	250	323	55	525	500	470	167	274	60	524	500	466	250	297	71
17,500	548	500	501	462	334	53	659	500	467	167	276	64	500	500	466	250	313	71
18,000	545	500	501	500	331	24	500	500	474	167	275	81	527	500	461	250	314	71
18,500	533	500	503	491	332	50	944	500	474	167	280	58	525	500	470	197	315	71
19,000	618	500	506	500	338	24	1,500	500	474	125	296	56	700	500	476	250	320	63
19,500	-	-	499	250	354	23	-	-	478	176	282	63	500	500	476	250	328	63

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
20,000	-	-	505	500	357	39	-	-	482	250	272	50	500	500	480	176	312	63

Table 3.40 Maximum distance from the CW discharge location to achieve 1:100 dilution in each season for Case C (12 m depth discharge at 720,000 m³/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	4,158
	Transitional	3,734
	Winter	3,975
99th	Summer	7,601
	Transitional	9,445
	Winter	10,011
100th	Summer	21,497
	Transitional	22,675
	Winter	20,947

Table 3.41 Total area of coverage for 1:100 dilution in each season for Case C (12 m depth discharge at 720,000 m³/d flow rate).

Percentile	Season	Total area (km²) of coverage for given dilution
95th	Summer	1.88
	Transitional	2.09
	Winter	2.27
99th	Summer	9.39
	Transitional	11.52
	Winter	10.78
100th	Summer	47.50
	Transitional	51.31
	Winter	64.18

Table 3.42 Maximum depth from the CW discharge location to achieve 1:100 dilution in each season for Case C (12 m depth discharge at 720,000 m³/d flow rate).

Season	Maximum depth (m) from discharge location to achieve given dilution
Summer	20
Transitional	19
Winter	20

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Table 3.43 Maximum distance from the CW discharge location, and corresponding total area of coverage, to achieve 3 °C plume-ambient ΔT in each season for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given ΔT	Total area (km^2) of coverage for given ΔT
95th	Summer	107	0.004
	Transitional	114	0.006
	Winter	120	0.008
99th	Summer	264	0.024
	Transitional	293	0.029
	Winter	318	0.038
100th	Summer	1242	0.217
	Transitional	1,708	0.311
	Winter	2,914	0.377

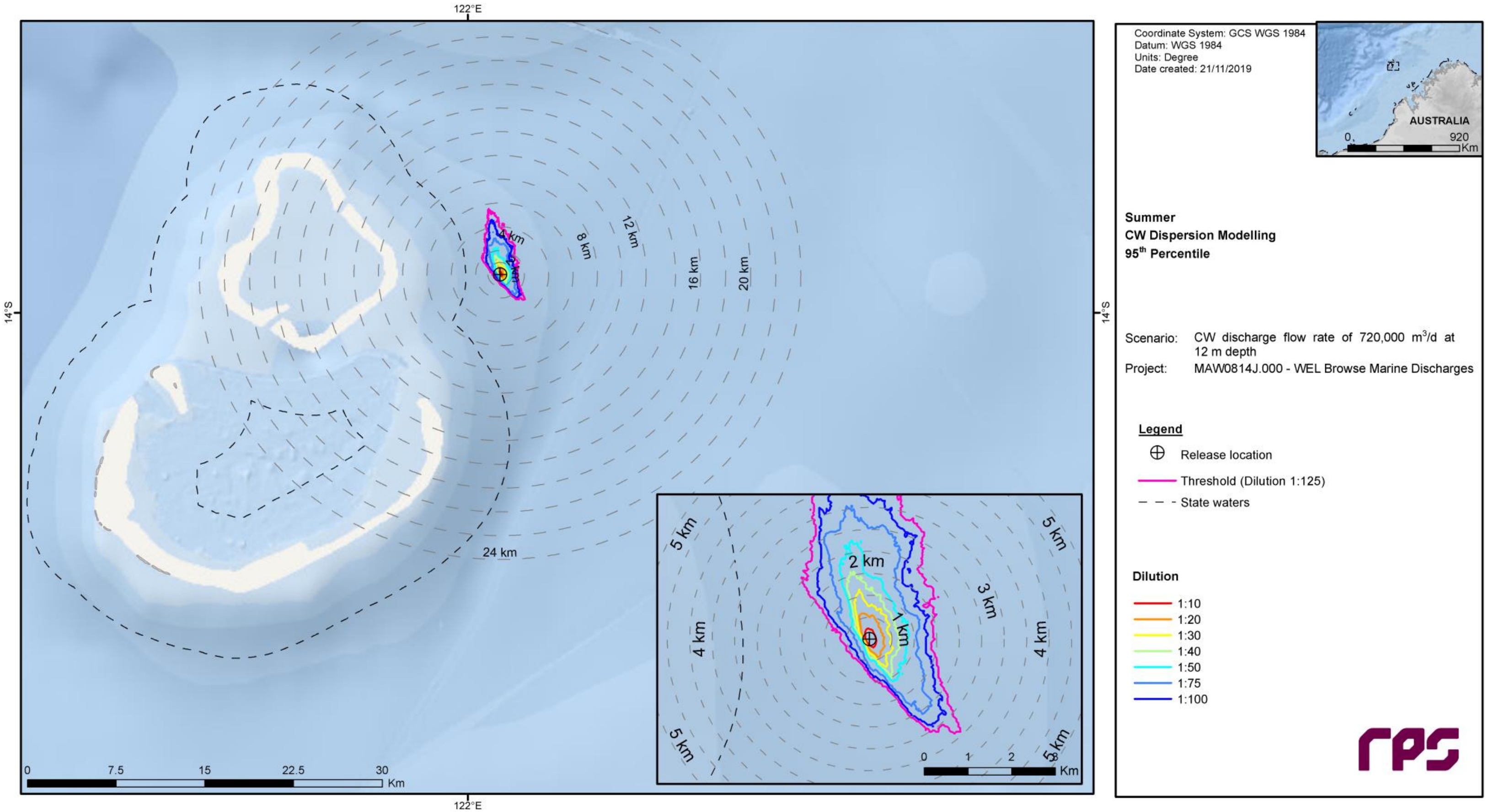

Figure 3.30 Predicted minimum dilutions at the 95th percentile under summer conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

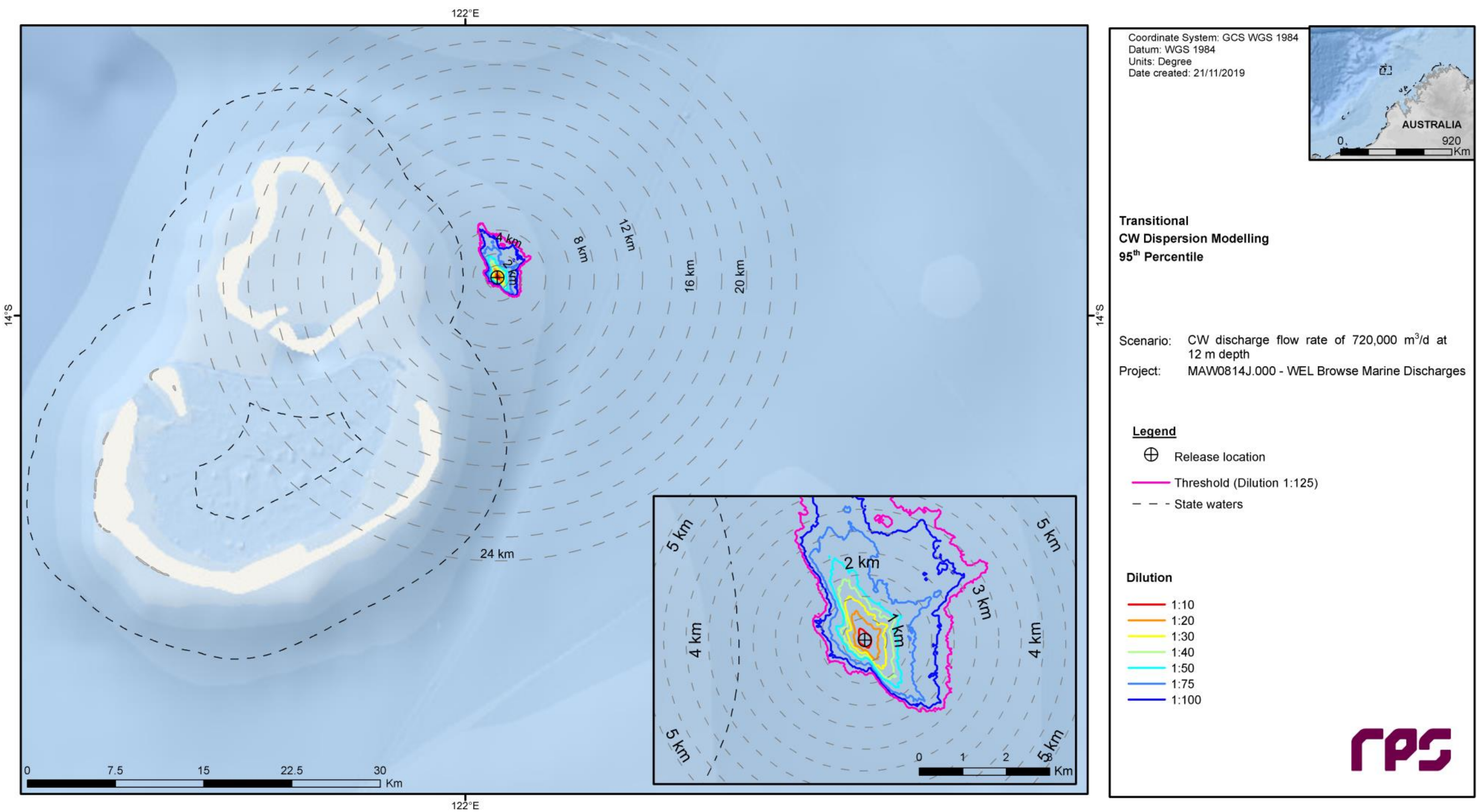

Figure 3.31 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

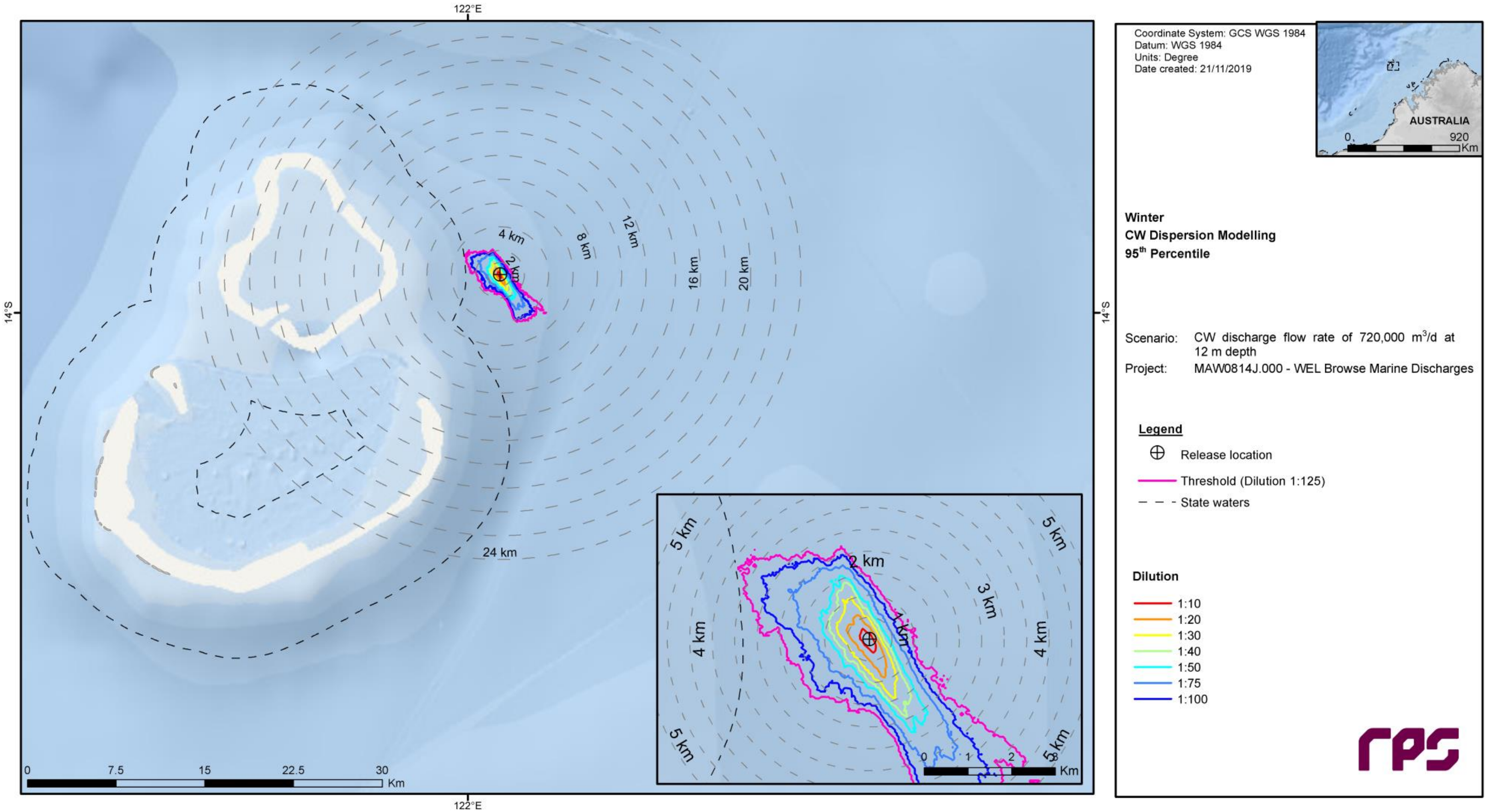

Figure 3.32 Predicted minimum dilutions at the 95th percentile under winter conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

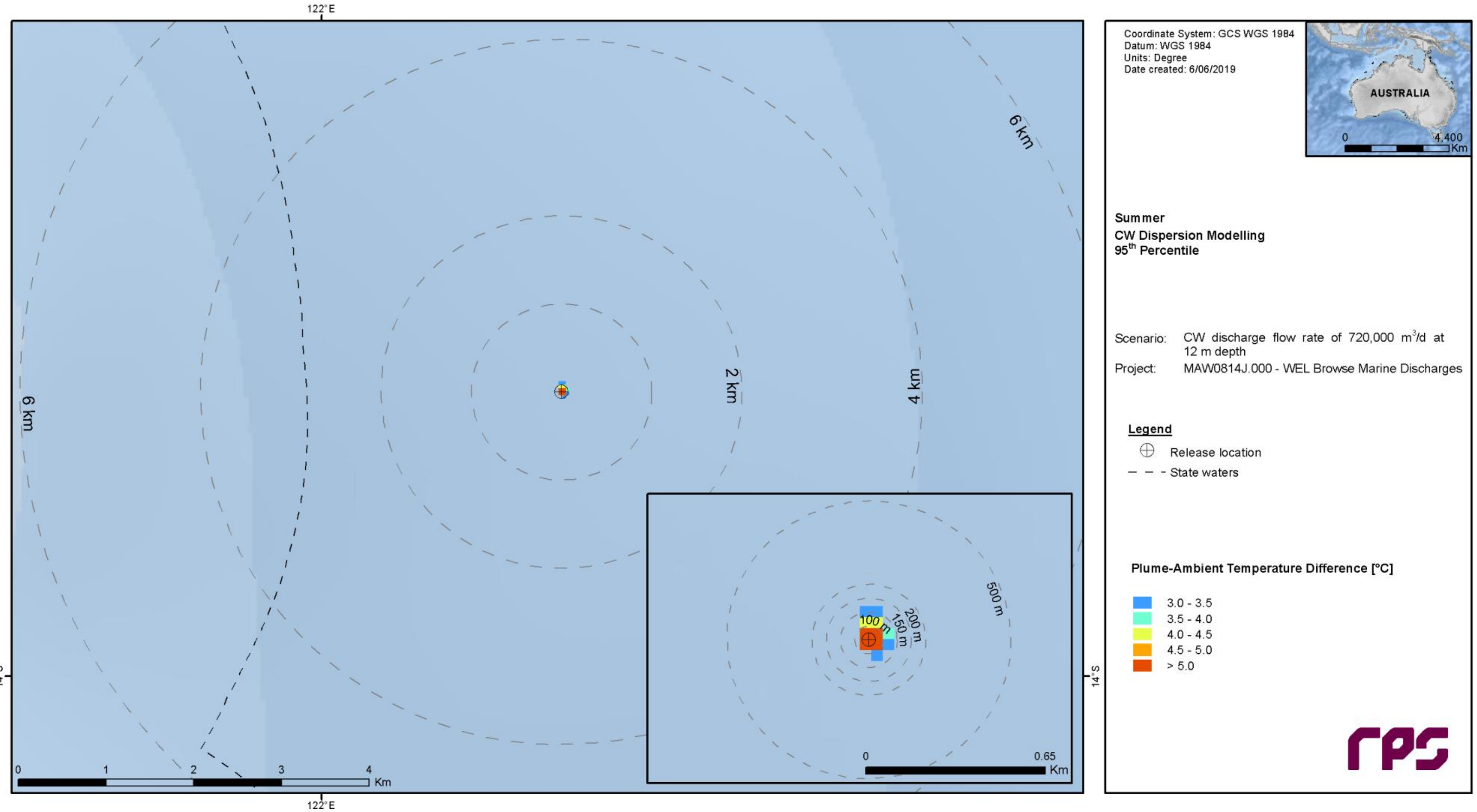

Figure 3.33 Predicted maximum plume-ambient ΔT at the 95th percentile under summer conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

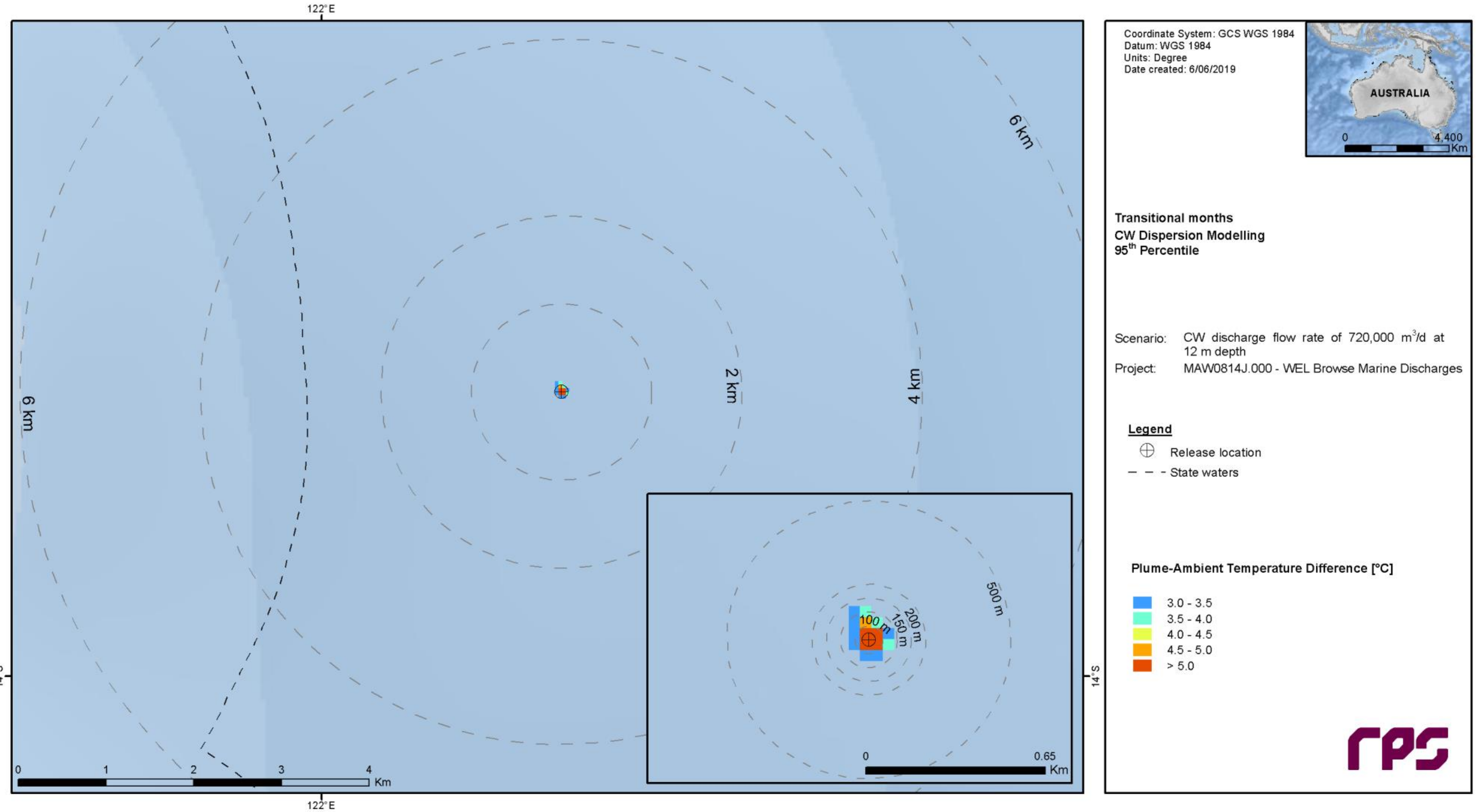

Figure 3.34 Predicted maximum plume-ambient ΔT at the 95th percentile under transitional conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

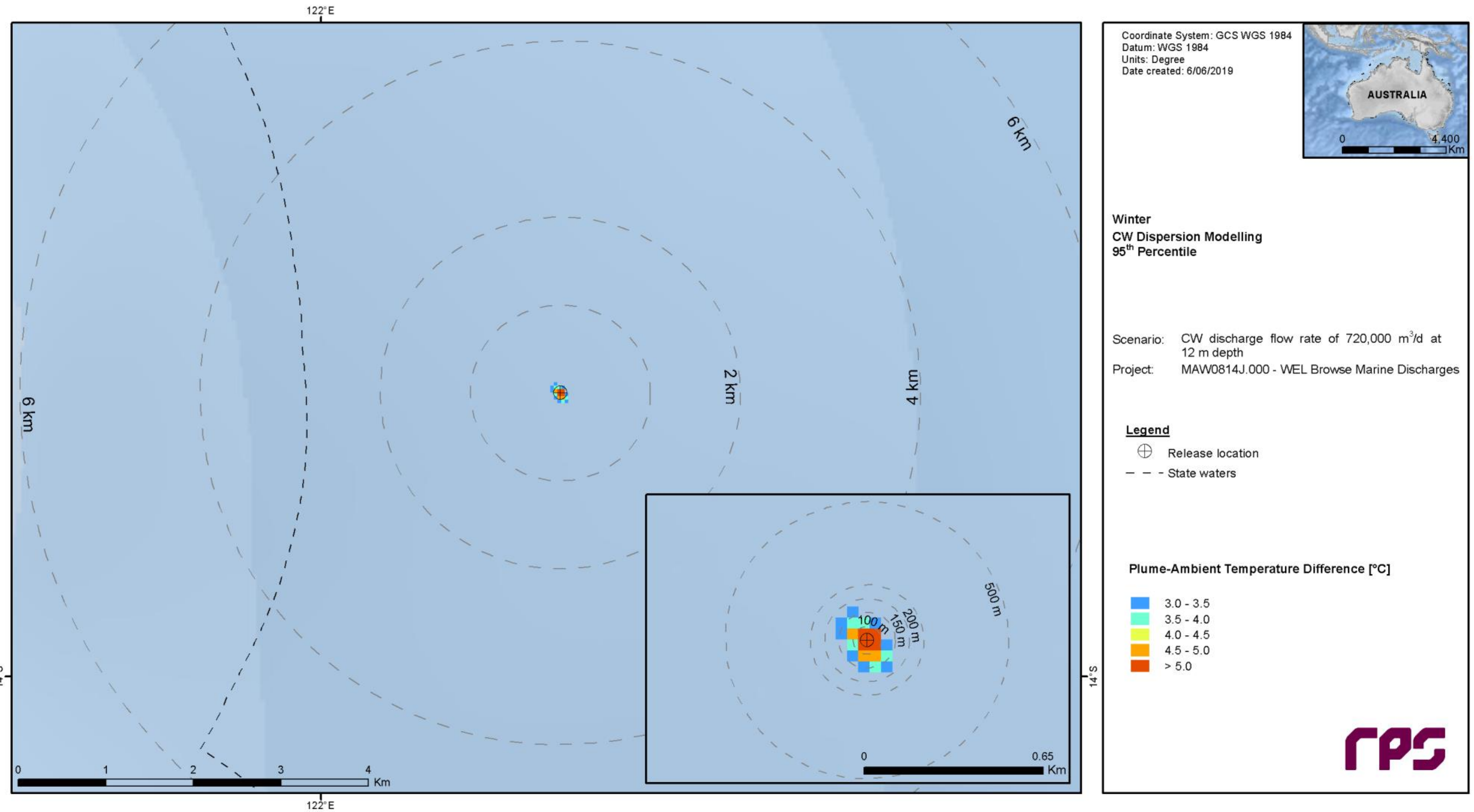

Figure 3.35 Predicted maximum plume-ambient ΔT at the 95th percentile under winter conditions for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

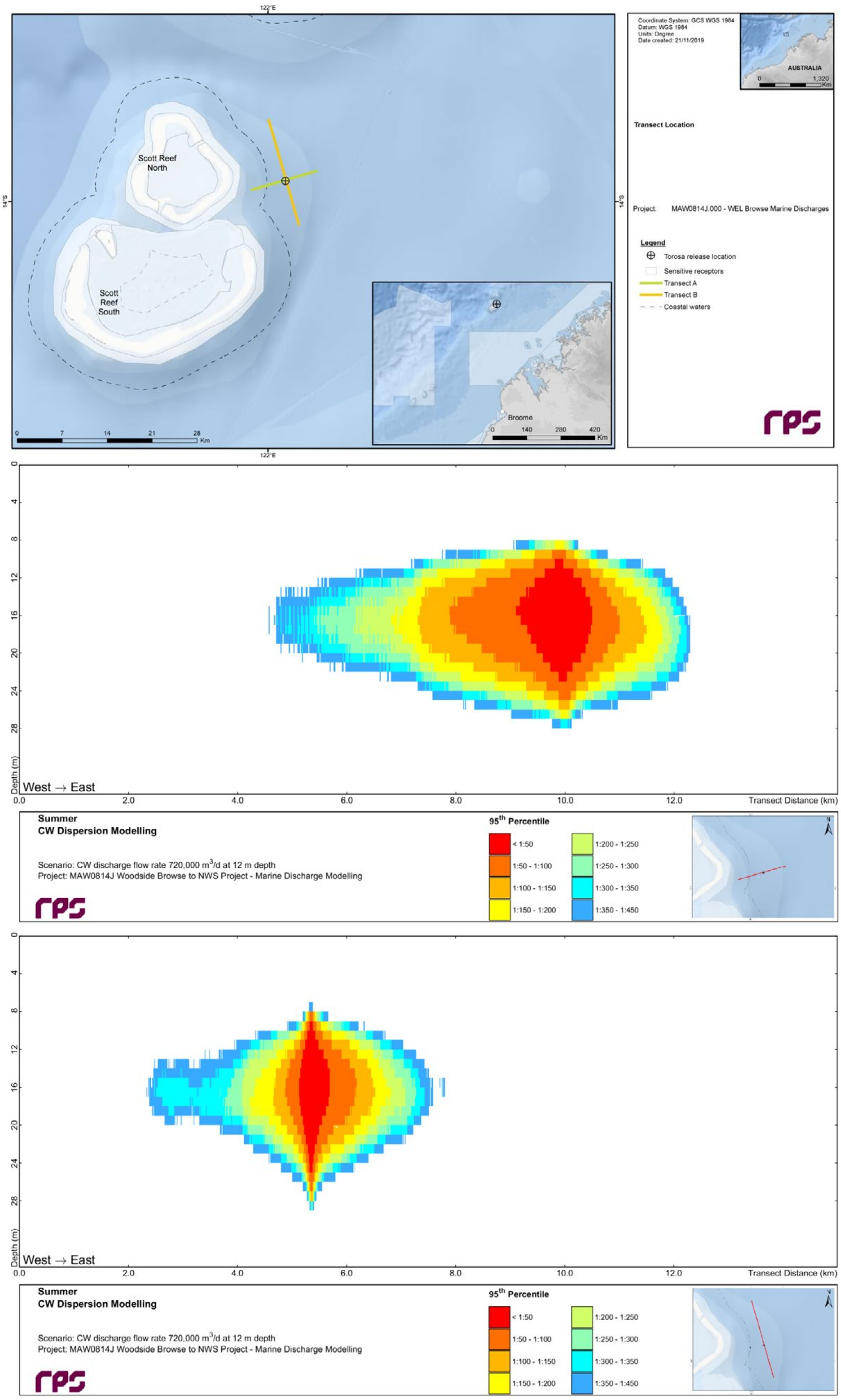

Figure 3.36 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case C (12 m depth discharge at 720,000 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.30.

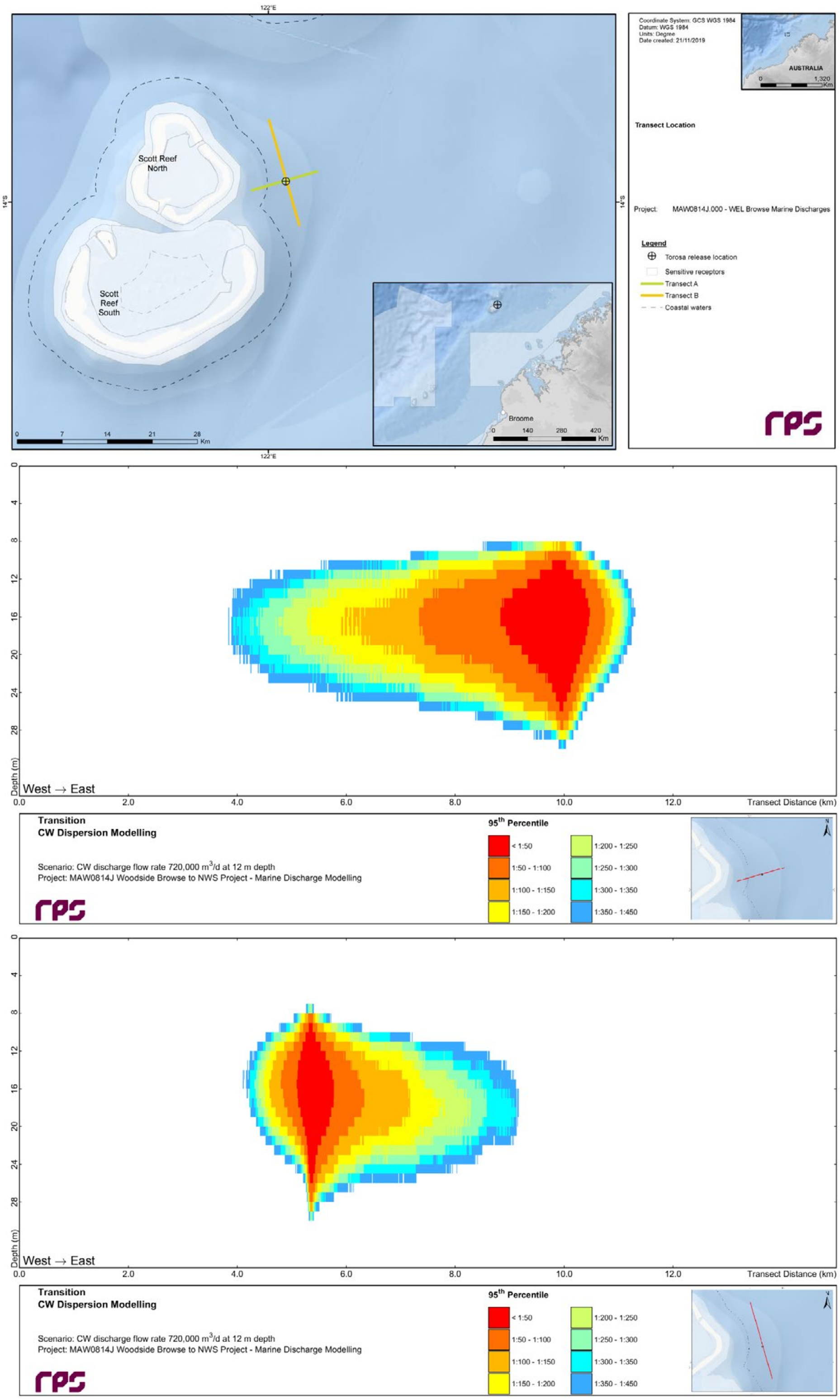

Figure 3.37 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case C (12 m depth discharge at 720,000 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.31.**

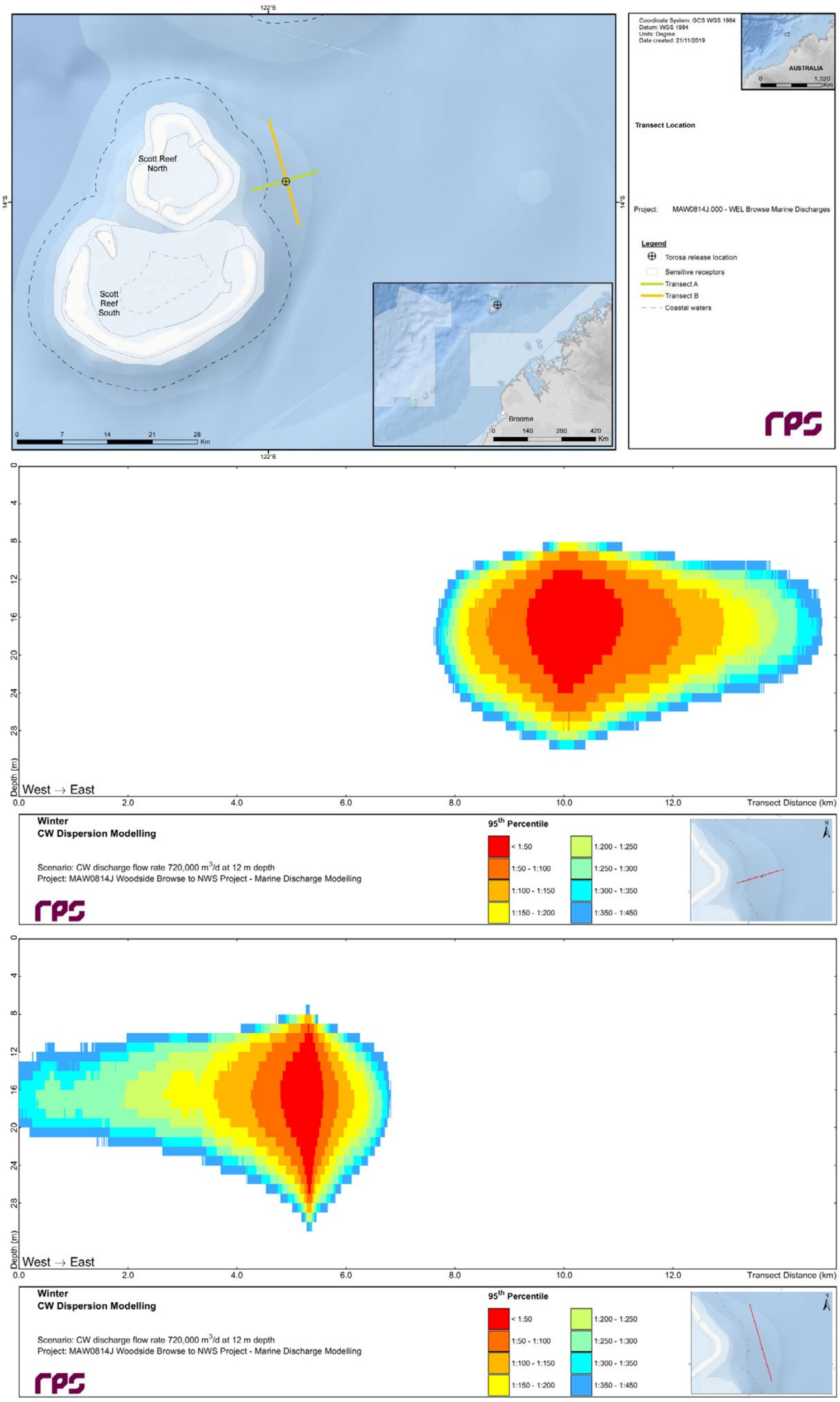

Figure 3.38 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case C (12 m depth discharge at 720,000 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.32.**

3.2.3.3 Annualised Analysis

3.2.3.3.1 Summary

The model outputs for each season (summer, transitional and winter) over the ten-year hindcast period (2006-2015) were combined and analysed on an annualised basis.

Table 3.44 summarises for Case C the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the Scott Reef area defined by the 3 nm State water boundary – for each percentile over the annual period.

The minimum level of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season is predicted to be 1:125 for Case C.

Table 3.45 provides for Case C a summary of the annualised maximum distances from the discharge location to achieve an example dilution level of 1:100 for each percentile. The results indicate that the release of effluent under all seasonal conditions results in slow dispersion within the ambient environment. Dilution to reach the 1:100 level at the 95th percentile – this being the maximum spatial extent of the relevant dilution contour from the discharge location in any season – is achieved within a maximum area of influence of 4.2 km.

Table 3.46 provides for Case C a summary of the annualised total areas of coverage for the 1:100 dilution contour for each percentile. The area of exposure defined by the relevant dilution contour is predicted to reach a maximum value of 3.7 km^2 at the 95th percentile across all seasons.

Table 3.47 provides a summary of the annualised maximum distances from the discharge location and total areas of coverage to achieve an example 3 °C plume-ambient temperature differential for each percentile. This differential is forecast to be met within 120 m at the 95th percentile across all seasons.

For Case C, the aggregated spatial extents of the minimum dilutions at the 95th percentile are presented in Figure 3.39. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

For Case C, Figure 3.40 shows the aggregated spatial extents of the maximum plume-ambient temperature differential at the 95th percentile.

3.2.3.3.2 Discharge Case C: Flow Rate of 720,000 m³/day at 12 m Depth

Table 3.44 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the CW discharge location for Case C (12 m depth discharge at 720,000 m³/d flow rate).

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	530	125	393	50	188	8
20	2	2	1	1	0	0
50	4	4	2	1	1	1
100	6	5	3	3	1	1
200	11	8	5	4	2	2
300	16	11	8	6	3	2
400	20	13	10	7	4	2
500	25	15	12	8	6	3
600	30	17	14	8	6	3
700	34	19	16	9	7	3
800	40	18	18	11	8	3
900	45	20	21	10	10	5
1,000	51	24	22	11	10	5
1,100	57	24	24	12	11	5
1,200	63	25	25	11	11	4
1,300	70	28	29	11	13	4
1,400	75	31	30	11	13	4
1,500	82	32	33	13	15	5
1,600	87	36	34	13	15	6
1,700	96	37	36	12	17	6
1,800	102	41	36	13	17	6
1,900	110	39	39	15	17	6
2,000	121	45	40	15	18	5
2,100	126	45	42	17	18	5
2,200	140	46	43	19	19	7
2,300	151	50	47	21	21	8
2,400	191	55	49	22	21	7
2,500	188	56	51	23	22	7
2,600	221	62	54	22	23	7
2,700	213	63	57	20	25	7
2,800	237	63	60	20	25	6
2,900	231	63	62	23	26	6
3,000	251	71	65	23	27	9
3,100	249	71	65	23	28	8
3,200	266	71	67	22	29	9
3,300	264	76	66	25	30	9
3,400	284	79	71	24	31	7
3,500	291	83	71	21	32	7

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,600	313	79	76	20	33	7
3,700	315	83	76	20	35	10
3,800	312	83	83	23	35	8
3,900	339	83	85	27	37	8
4,000	314	86	92	28	37	8
4,100	359	98	92	29	38	9
4,200	323	100	103	28	40	11
4,300	341	100	105	29	40	10
4,400	340	100	114	33	42	10
4,500	357	100	113	34	43	11
4,600	359	100	123	36	44	11
4,700	378	118	124	41	45	13
4,800	379	125	126	40	45	13
4,900	596	125	128	45	46	14
5,000	398	125	134	45	47	14
5,500	448	125	159	57	56	17
6,000	431	167	180	62	63	22
6,500	447	167	198	50	71	22
7,000	478	230	206	71	73	25
7,500	495	250	229	71	85	29
8,000	494	250	254	84	88	11
8,500	489	250	276	83	99	28
9,000	496	250	303	83	103	31
9,500	499	387	305	100	112	33
10,000	500	500	319	100	120	38
10,500	500	500	344	100	133	42
11,000	500	500	336	100	146	45
11,500	500	500	352	125	152	48
12,000	505	500	360	125	162	42
12,500	500	500	360	125	165	45
13,000	500	500	370	157	171	56
13,500	500	500	376	167	183	56
14,000	500	500	391	126	182	50
14,500	500	500	405	125	197	56
15,000	507	500	426	167	208	61
15,500	500	500	440	130	209	61
16,000	500	500	439	167	195	60
16,500	510	500	456	167	242	57
17,000	500	500	464	167	216	55
17,500	511	500	465	167	228	53
18,000	527	500	473	167	356	24
18,500	517	500	481	167	232	50
19,000	554	500	477	125	232	24
19,500	500	500	478	176	249	23

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
20,000	500	500	483	176	232	39

Table 3.45 Annualised maximum distance from the CW discharge location to achieve 1:100 dilution for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	4,158
99th		10,011
100th		22,675

Table 3.46 Annualised total area of coverage for 1:100 dilution for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Annual	3.73
99th		17.52
100th		93.42

Table 3.47 Annualised maximum distance from the CW discharge location, and corresponding total area of coverage, to achieve 3 °C plume-ambient ΔT in each season for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given ΔT	Total area (km^2) of coverage for given ΔT
95th	Annual	120	0.009
99th		318	0.046
100th		2,914	0.499

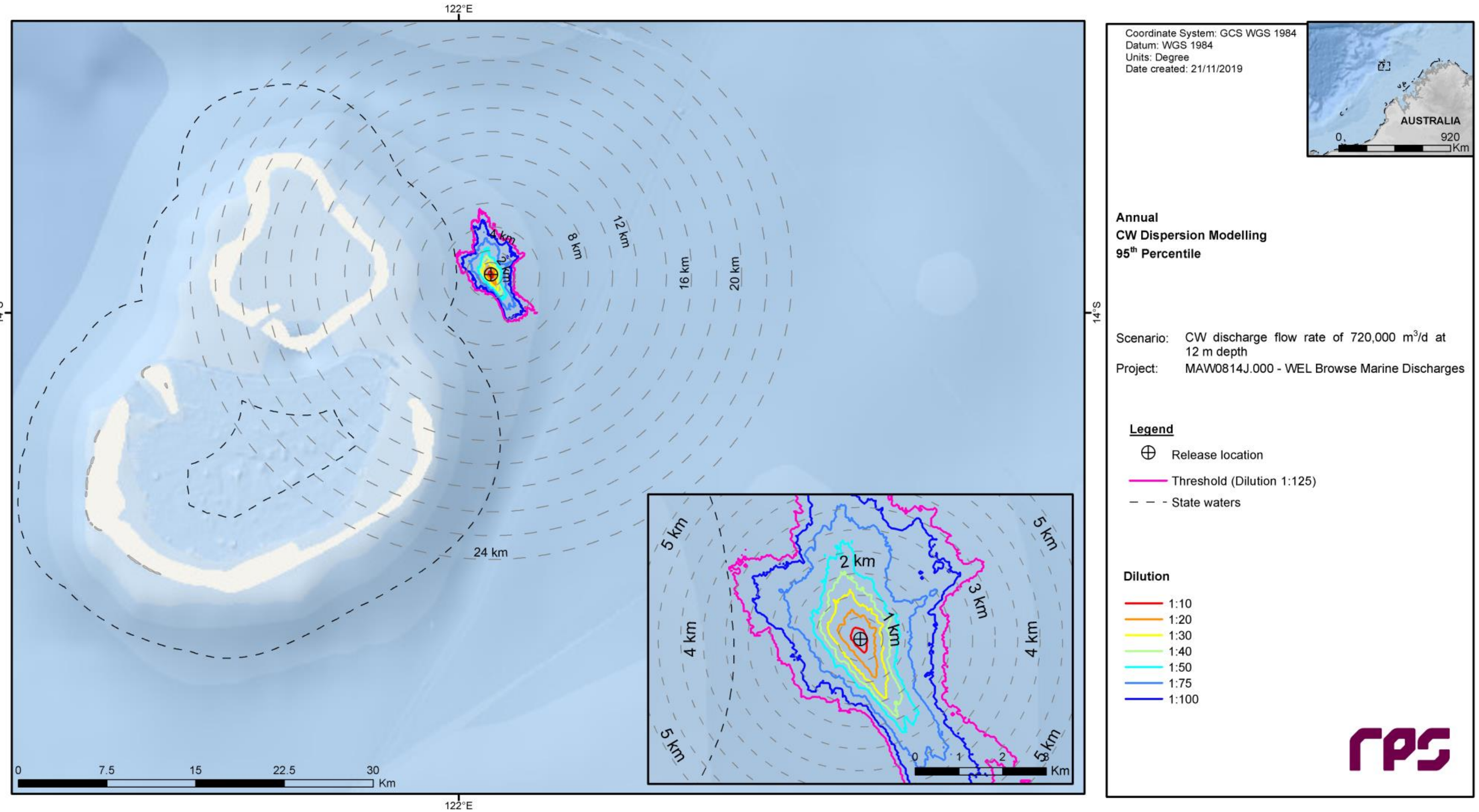

Figure 3.39 Predicted annualised minimum dilutions at the 95th percentile for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

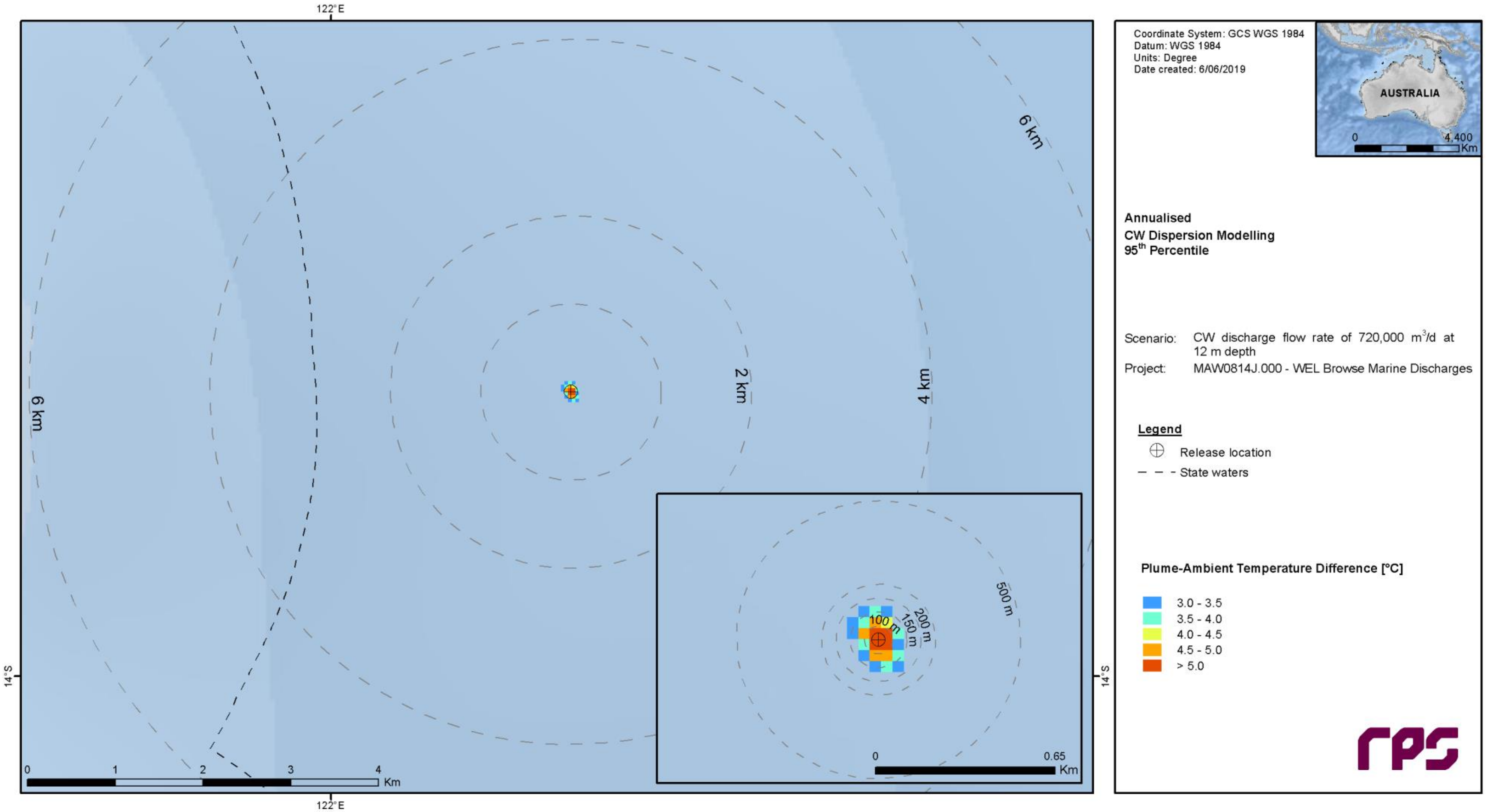

Figure 3.40 Predicted annualised maximum plume-ambient ΔT at the 95th percentile for Case C (12 m depth discharge at 720,000 m^3/d flow rate).

3.2.4 Produced Water Discharges

3.2.4.1 General Observations

Figure 3.41 shows example time series snapshots of predicted dilutions during a single simulation at 3-hour intervals from 22:00 on 9th December 2007 to 13:00 on 10th December 2007. This simulation – selected merely to be representative of typical conditions – considers the Case P discharge at 14 m BMSL. The spatially-varying orientation of the plume with the currents and the rapidly-varying nature of the concentrations around the source can be observed. The snapshots also show the combined effect of the tide and the drift currents, with a clear tidal oscillation.

These snapshots illustrate that the dilutions (and in turn concentrations) become more variable over time because of changes in current speed and direction. Higher dilutions (lower concentrations) are predicted during periods of increased current speed, whereas patches of lower dilutions (higher concentrations) tend to accumulate during the turning of the tide or during periods of weak drift currents. During prolonged periods of lowered current speed, the plume has a more continuous appearance, with higher-concentration patches moving as a unified group.

The snapshots in Figure 3.41 show a clear “string of pearls” pattern, where a relatively thin plume emanating from the source is punctuated with higher-concentration plume patches which separate over time from the contiguous plume. This pattern is attributable to periodic tide reversals which cause the existing plume to repeatedly pass over the source.

These findings agree with the research of King & McAllister (1997, 1998) who noted that concentrations within effluent plumes generated by an offshore platform were patchy and likely to peak around the reversal of the tides.

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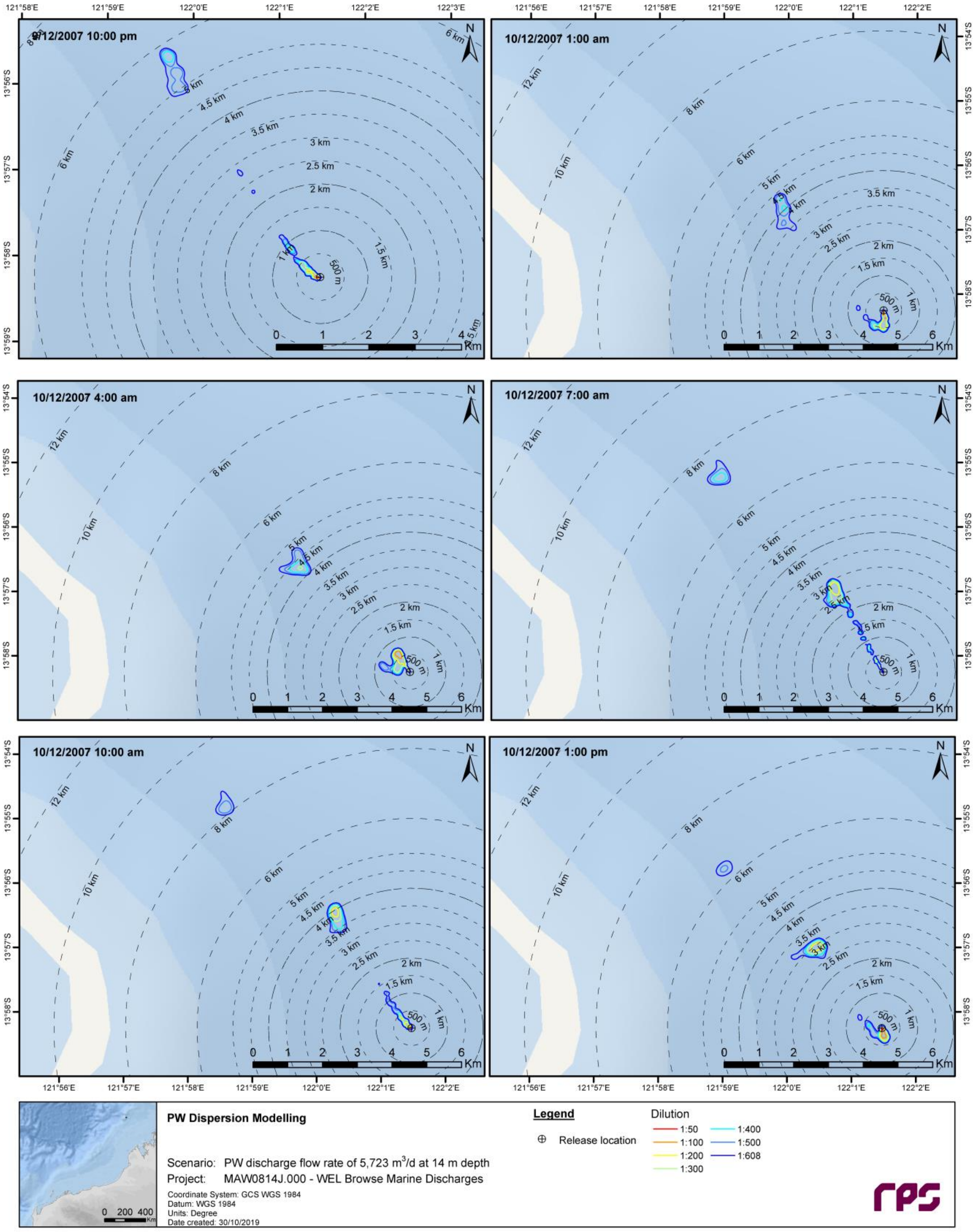

Figure 3.41 Snapshots of predicted dilution levels, at 3-hour intervals from 22:00 on 9th December 2007 to 13:00 on 10th December 2007, for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

3.2.4.2 Seasonal Analysis

3.2.4.2.1 Summary

The model outputs over the ten-year hindcast period (2006-2015) were combined and analysed on a seasonal basis (summer, transitional and winter). This approach assists with identifying the potential exposure to surrounding sensitive receptors whilst considering inter-annual variability in ocean current conditions.

Table 3.48 and Table 3.52 summarise, for Cases P and M respectively, the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the Scott Reef area defined by the 3 nm State water boundary – for each season and percentile.

Table 3.49 provides for Case P a summary of the maximum distances from the discharge location to achieve an example dilution level of 1:300 for each season and percentile. The results indicate that the release of effluent under all seasonal conditions results in rapid dispersion within the ambient environment. A 1:300 dilution is achieved within an area of influence ranging from 0.6-0.9 km at the 95th percentile.

Table 3.50 provides for Case P a summary of the total areas of coverage for the 1:300 dilution contour for each season and percentile. The area of exposure defined by the relevant dilution contour is predicted to reach a maximum value of 0.4-0.6 km^2 at the 95th percentile.

Table 3.51 provides for Case P a summary of the maximum depths from the discharge location to achieve 1:300 dilution for each season and percentile. The maximum depth is observed in winter, with a prediction of 19 m.

For Cases P and M, the aggregated spatial extents of the minimum dilutions for each season at the 95th percentile are presented in Figure 3.42 to Figure 3.44 and Figure 3.48 to Figure 3.50, respectively. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration. The discharged plumes are predicted to travel in predominantly northerly directions during summer and transitional months, and south-easterly directions during winter.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

Seasonal water column cross-section figures of 95th percentile dilution, extracted along perpendicular transects running through the origin point of the discharge (one of which is broadly aligned with the principal travel direction of the plume), are presented in Figure 3.45 to Figure 3.47 (Case P) and Figure 3.51 to Figure 3.53 (Case M). Although initially buoyant due to elevated temperature, the discharged plumes are predicted to quickly achieve density equilibrium with the receiving waters and rapidly dilute. This is particularly evident for the Case M discharge. The Case P plume centreline – where highest concentrations and lowest dilutions are found – will tend to remain entrained in a thin layer around 15 m below the water surface.

3.2.4.2.2 Discharge Case P: Flow Rate of 5,723 m³/day at 14 m Depth

Table 3.48 Average and minimum dilutions (1:x) achieved at specific radial distances from the PW discharge location in each season for Case P (14 m depth discharge at 5,723 m³/d flow rate).

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary	>20,000	1,658	>20,000	582	>20,000	159	>20,000	1,507	12,321	588	1,287	224	>20,000	3,897	>20,000	747	1,593	211
20	46	27	29	18	21	13	46	27	29	18	20	12	43	24	28	17	19	12
50	64	27	39	18	26	13	64	30	39	20	25	13	61	25	37	18	23	13
100	102	67	57	37	36	24	105	73	57	42	33	24	96	59	52	35	32	22
200	181	118	91	63	51	33	199	133	92	67	48	32	176	100	82	54	47	29
300	266	163	121	79	63	36	315	185	126	86	64	42	271	135	117	65	62	32
400	348	200	151	92	77	45	424	217	155	98	75	36	354	155	153	71	74	37
500	432	234	182	99	93	46	522	266	181	108	85	43	432	181	182	82	89	39
600	525	263	208	109	105	47	624	309	210	126	98	49	510	217	212	92	101	45
700	601	296	235	134	112	54	731	359	232	144	103	48	575	253	235	109	111	47
800	688	339	258	138	125	58	869	410	256	152	113	48	651	270	261	111	122	52
900	785	378	281	138	142	63	1,030	462	281	162	125	50	732	288	287	116	131	55
1,000	876	405	305	148	148	59	1,243	527	307	176	133	59	816	306	316	120	144	57
1,100	972	451	327	150	152	65	1,482	583	334	202	146	60	896	319	338	131	153	53
1,200	1,078	480	353	156	163	63	1,897	635	366	230	155	61	982	333	364	144	164	54
1,300	1,206	525	379	164	179	70	2,276	687	392	232	165	59	1,076	358	392	149	168	62
1,400	1,393	573	402	185	190	64	2,929	740	420	241	175	76	1,185	376	415	152	177	65
1,500	1,594	591	431	202	194	79	3,910	761	449	260	185	66	1,289	376	436	149	192	67
1,600	1,845	640	463	215	207	77	5,611	818	476	268	192	67	1,390	379	459	161	200	61
1,700	2,144	699	488	215	209	76	7,355	872	505	273	195	70	1,481	378	479	173	206	65
1,800	2,575	756	522	203	217	71	9,598	887	536	289	203	83	1,619	382	504	180	218	67
1,900	3,260	806	559	214	231	87	13,470	963	567	307	220	79	1,814	390	528	176	228	81
2,000	4,255	872	599	219	241	79	>20,000	1,042	597	312	231	85	2,014	393	557	174	233	82
2,100	5,610	936	638	231	253	73	>20,000	1,057	631	317	243	79	2,225	410	585	172	243	78
2,200	7,701	939	670	261	268	85	>20,000	1,059	672	337	253	94	2,494	414	613	176	257	77
2,300	11,595	1,035	697	278	276	98	>20,000	1,050	702	353	261	106	2,725	419	635	187	265	78
2,400	18,757	1,032	733	280	279	89	>20,000	1,106	738	355	269	94	3,043	419	662	185	275	88
2,500	>20,000	1,082	764	284	294	77	>20,000	1,158	773	360	275	92	3,522	434	696	181	282	85
2,600	>20,000	1,110	792	306	309	101	>20,000	1,259	808	361	292	98	4,184	452	724	186	285	85
2,700	>20,000	1,170	825	313	320	89	>20,000	1,370	847	429	305	112	4,964	487	758	189	293	95
2,800	>20,000	1,173	863	325	322	85	>20,000	1,482	889	476	310	95	5,915	525	794	197	302	102
2,900	>20,000	1,264	897	351	324	115	>20,000	1,516	926	530	313	105	7,368	551	821	213	305	93
3,000	>20,000	1,304	940	370	338	133	>20,000	1,558	966	519	312	101	9,837	617	858	229	316	96
3,100	>20,000	1,306	984	373	346	115	>20,000	1,554	1,013	539	312	104	14,201	674	887	259	335	112
3,200	>20,000	1,363	1,031	402	356	112	>20,000	1,547	1,059	558	318	129	>20,000	693	923	268	347	107
3,300	>20,000	1,400	1,092	415	364	100	>20,000	1,541	1,112	571	331	145	>20,000	736	964	290	355	108
3,400	>20,000	1,514	1,157	437	366	115	>20,000	1,586	1,171	663	350	161	>20,000	785	1,005	277	366	114
3,500	>20,000	1,621	1,212	465	371	130	>20,000	1,641	1,227	688	357	145	>20,000	814	1,053	293	369	105

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,600	>20,000	1,723	1,310	479	388	115	>20,000	1,758	1,306	710	371	118	>20,000	827	1,115	297	370	107
3,700	>20,000	1,933	1,413	494	402	122	>20,000	1,836	1,378	707	387	113	>20,000	872	1,186	342	370	128
3,800	>20,000	1,918	1,527	485	407	128	>20,000	1,906	1,474	722	396	132	>20,000	939	1,263	383	378	120
3,900	>20,000	2,007	1,757	507	417	105	>20,000	1,930	1,606	743	402	155	>20,000	959	1,350	420	395	123
4,000	>20,000	2,007	2,175	479	441	124	>20,000	2,008	1,771	712	412	131	>20,000	1,027	1,446	431	415	98
4,100	>20,000	2,035	2,797	512	464	128	>20,000	2,043	1,965	759	427	135	>20,000	1,057	1,540	436	443	133
4,200	>20,000	2,119	4,229	503	497	140	>20,000	2,119	2,259	770	435	138	>20,000	1,079	1,629	440	470	123
4,300	>20,000	2,270	6,721	523	528	145	>20,000	2,190	2,716	778	442	129	>20,000	1,086	1,723	441	479	128
4,400	>20,000	2,327	11,948	508	548	138	>20,000	2,221	3,282	768	453	152	>20,000	1,113	1,836	452	481	155
4,500	>20,000	2,390	>20,000	541	565	138	>20,000	2,260	4,092	801	469	167	>20,000	1,132	1,963	468	490	190
4,600	>20,000	2,388	>20,000	594	578	148	>20,000	2,365	4,794	807	477	171	>20,000	1,145	2,080	451	502	167
4,700	>20,000	2,493	>20,000	588	595	175	>20,000	2,328	6,113	894	484	151	>20,000	1,173	2,199	437	513	160
4,800	>20,000	2,528	>20,000	583	611	173	>20,000	2,416	8,130	888	495	123	>20,000	1,281	2,314	443	521	154
4,900	>20,000	2,770	>20,000	622	624	165	>20,000	2,473	11,170	885	506	168	>20,000	1,341	2,466	452	538	144
5,000	>20,000	2,890	>20,000	702	622	178	>20,000	2,699	14,522	928	519	160	>20,000	1,411	2,617	522	554	154
5,500	>20,000	3,689	>20,000	829	693	135	>20,000	3,414	>20,000	1,044	585	202	>20,000	1,817	4,076	663	616	172
6,000	>20,000	4,963	>20,000	868	831	184	>20,000	3,935	>20,000	1,140	629	218	>20,000	1,770	6,329	656	669	216
6,500	>20,000	5,730	>20,000	1,041	1,340	180	>20,000	4,256	>20,000	1,264	695	211	>20,000	1,948	11,642	713	742	136
7,000	>20,000	7,581	>20,000	1,408	8,610	193	>20,000	5,134	>20,000	1,529	780	279	>20,000	2,339	>20,000	810	805	228
7,500	>20,000	9,188	>20,000	1,544	14,106	196	>20,000	5,873	>20,000	1,602	843	246	>20,000	2,559	>20,000	886	869	212
8,000	>20,000	10,325	>20,000	1,691	8,039	175	>20,000	7,291	>20,000	1,738	928	258	>20,000	3,119	>20,000	935	996	169
8,500	>20,000	11,510	>20,000	1,547	8,882	302	>20,000	9,959	>20,000	1,870	1,333	205	>20,000	4,023	>20,000	1,161	1,050	205
9,000	>20,000	14,088	>20,000	1,799	12,035	259	>20,000	>20,000	>20,000	2,065	4,552	237	>20,000	3,950	>20,000	1,193	1,104	263
9,500	>20,000	18,786	>20,000	1,970	14,365	313	>20,000	>20,000	>20,000	1,963	9,189	176	>20,000	3,474	>20,000	1,190	1,211	290
10,000	>20,000	18,697	>20,000	1,913	10,858	345	>20,000	>20,000	>20,000	1,951	11,644	404	>20,000	4,721	>20,000	1,309	1,313	374

Table 3.49 Maximum distance from the PW discharge location to achieve 1:300 dilution in each season for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	699
	Transitional	584
	Winter	948
99th	Summer	2,576
	Transitional	1,883
	Winter	3,607
100th	Summer	9,349
	Transitional	10,493
	Winter	10,493

Table 3.50 Total area of coverage for 1:300 dilution in each season for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Summer	0.47
	Transitional	0.40
	Winter	0.62
99th	Summer	4.36
	Transitional	3.57
	Winter	5.50
100th	Summer	37.52
	Transitional	54.79
	Winter	36.23

Table 3.51 Maximum depth from the PW discharge location to achieve 1:300 dilution in each season for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

Season	Maximum depth (m) from discharge location to achieve given dilution
Summer	18
Transitional	18
Winter	19

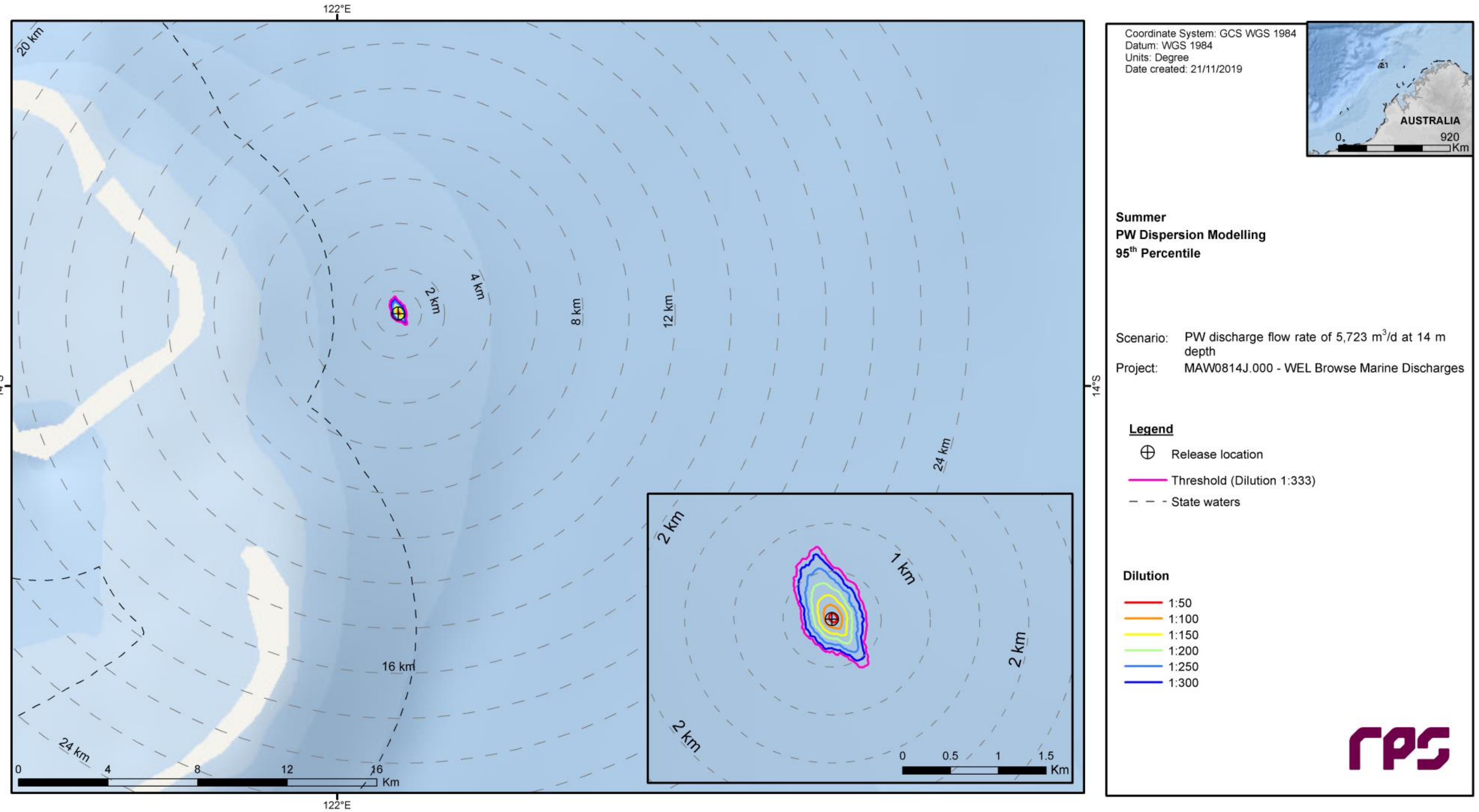

Figure 3.42 Predicted minimum dilutions at the 95th percentile under summer conditions for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

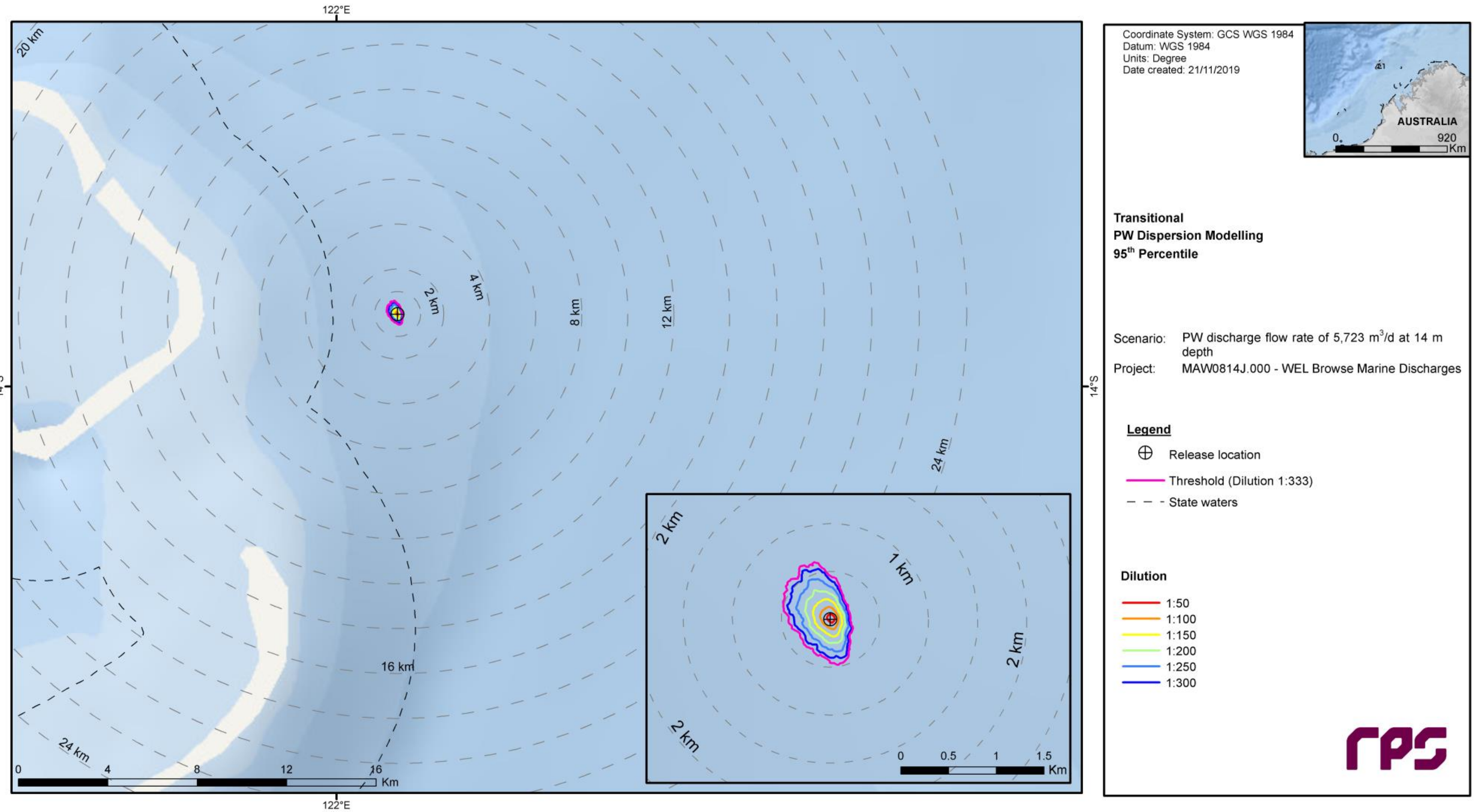

Figure 3.43 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

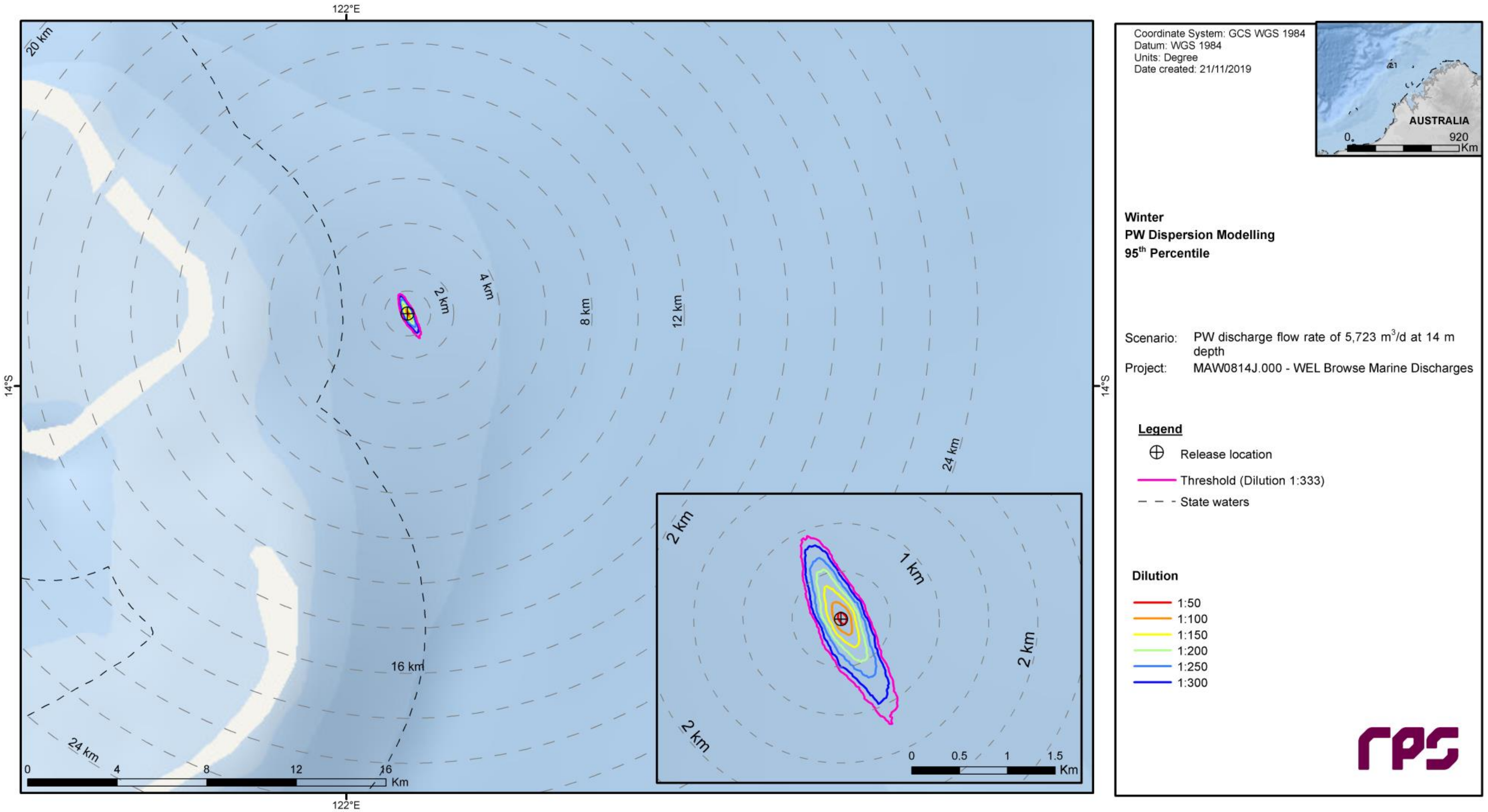

Figure 3.44 Predicted minimum dilutions at the 95th percentile under winter conditions for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

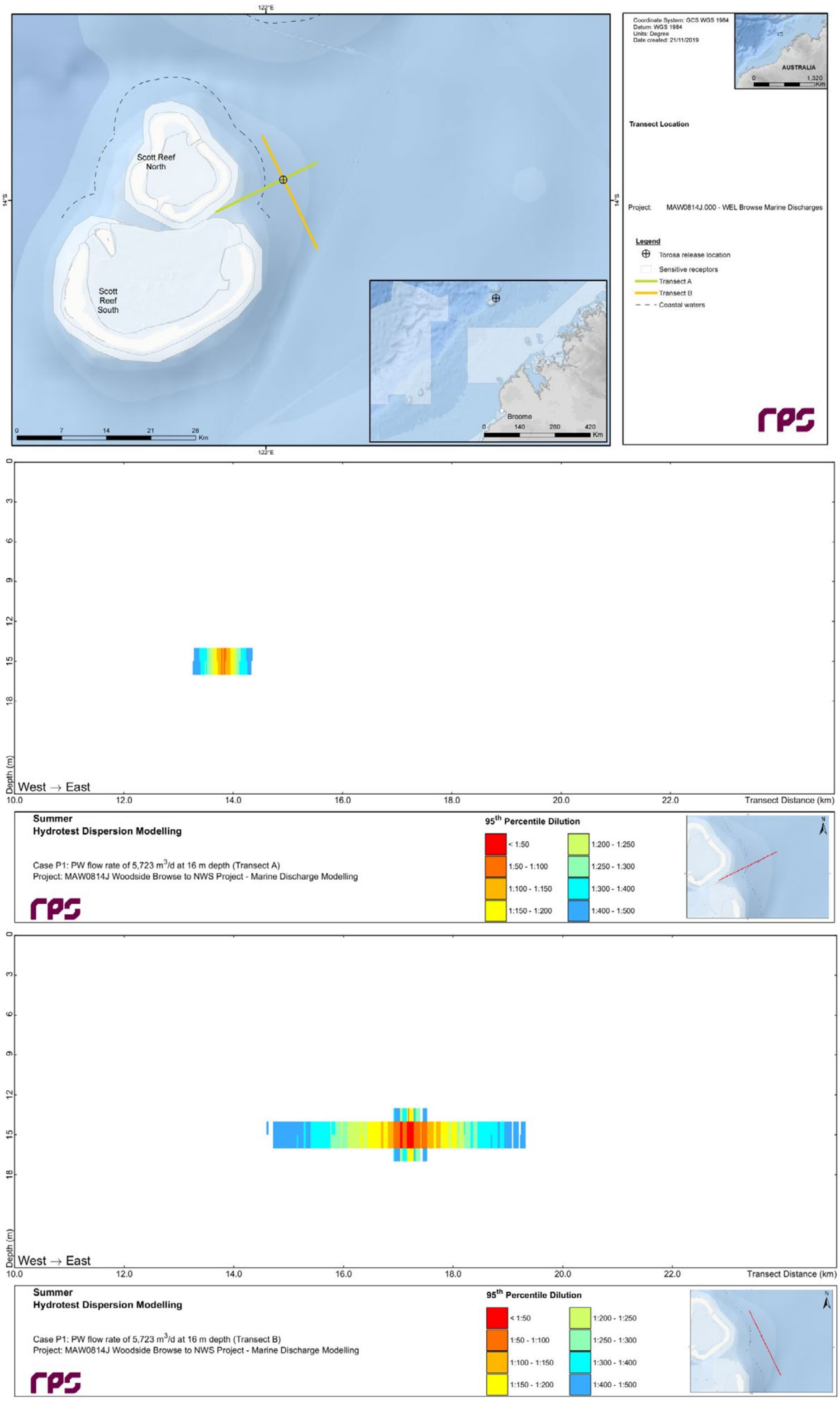

Figure 3.45 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case P (14 m depth discharge at 5,723 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.42.

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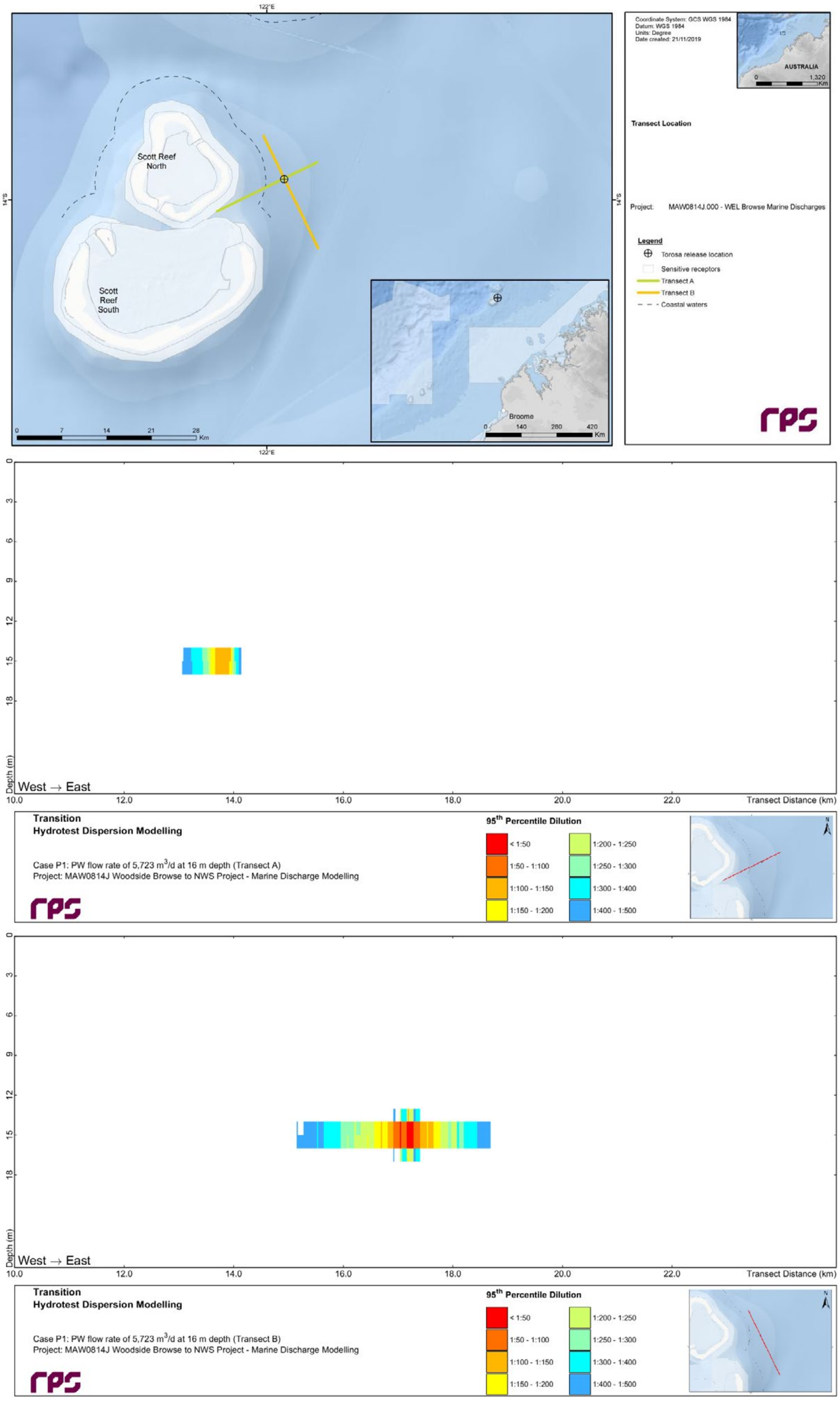

Figure 3.46 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case P (14 m depth discharge at 5,723 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.43.

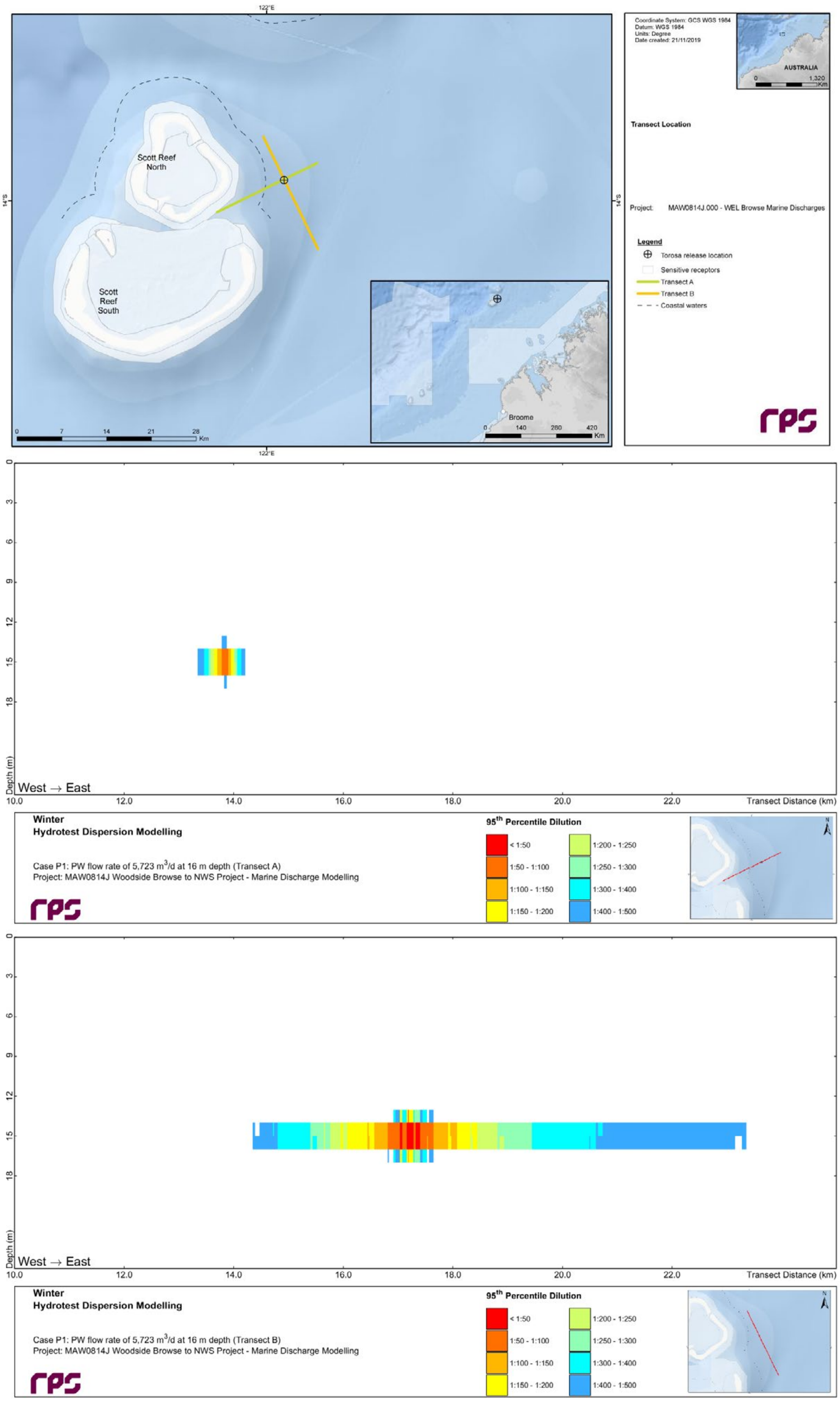

Figure 3.47 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case P (14 m depth discharge at 5,723 m^3/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.44.**

3.2.4.2.3 Discharge Case M: Flow Rate of 490 m^3/day at 14 m Depth

Table 3.52 Average and minimum dilutions (1:x) achieved at specific radial distances from the PW discharge location in each season for Case M (14 m depth discharge at 490 m^3/d flow rate).

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary	>20,000	19,974	>20,000	6,594	>20,000	1,949	>20,000	17,674	>20,000	6,758	13,838	2,219	>20,000	>20,000	>20,000	9,259	>20,000	3,138
20	509	283	314	189	200	138	492	274	304	189	198	130	598	321	333	199	211	127
50	710	289	421	195	277	120	696	319	408	208	254	123	913	396	446	220	244	126
100	1,166	675	625	409	364	221	1,182	763	620	457	354	271	1,766	906	691	463	347	211
200	2,091	1,320	1,001	665	548	344	2,283	1,474	1,004	735	541	335	3,615	1,538	1,205	744	554	316
300	3,101	1,830	1,368	915	668	442	3,676	2,014	1,402	939	716	446	5,563	2,069	1,834	866	760	382
400	4,089	2,187	1,705	1,068	839	463	5,007	2,471	1,741	1,046	810	420	7,054	2,742	2,442	1,056	926	418
500	5,092	2,597	2,040	1,148	1,004	523	6,132	3,006	2,053	1,209	942	427	8,716	3,344	2,907	1,202	1,083	444
600	6,127	2,946	2,373	1,300	1,153	580	7,400	3,435	2,375	1,410	1,061	486	10,413	3,983	3,364	1,379	1,284	472
700	7,096	3,505	2,650	1,508	1,220	579	8,665	4,205	2,651	1,636	1,154	548	12,381	4,648	3,647	1,513	1,383	549
800	8,133	3,777	2,897	1,542	1,373	640	10,500	4,744	2,921	1,779	1,315	626	14,941	5,074	4,064	1,746	1,526	573
900	9,274	4,252	3,206	1,659	1,521	732	12,345	5,393	3,212	1,819	1,438	675	18,297	5,654	4,488	1,872	1,643	599
1,000	10,357	4,751	3,492	1,698	1,623	735	15,026	5,777	3,526	1,937	1,507	555	>20,000	5,940	4,899	1,914	1,818	667
1,100	11,434	5,126	3,756	1,875	1,703	648	18,287	6,659	3,823	2,293	1,668	653	>20,000	6,247	5,254	2,011	1,914	657
1,200	12,815	5,500	4,029	1,910	1,750	710	>20,000	7,432	4,189	2,544	1,789	769	>20,000	6,763	5,696	2,371	2,019	712
1,300	14,475	5,997	4,322	1,964	1,982	755	>20,000	8,005	4,527	2,765	1,901	724	>20,000	7,151	6,043	2,394	2,198	728
1,400	16,690	6,517	4,664	2,208	2,060	709	>20,000	8,465	4,890	2,764	1,985	788	>20,000	7,468	6,388	2,531	2,330	793
1,500	19,484	6,983	4,996	2,332	2,153	851	>20,000	8,708	5,213	2,870	2,036	691	>20,000	7,504	6,731	2,575	2,504	749
1,600	>20,000	7,427	5,336	2,584	2,255	756	>20,000	9,388	5,545	3,024	2,138	768	>20,000	8,039	7,052	2,810	2,703	705
1,700	>20,000	7,984	5,633	2,434	2,279	909	>20,000	9,403	5,911	2,980	2,244	919	>20,000	8,500	7,296	2,850	2,741	907
1,800	>20,000	8,728	5,994	2,511	2,404	866	>20,000	10,478	6,254	3,091	2,293	821	>20,000	9,023	7,658	2,940	2,851	920
1,900	>20,000	9,122	6,442	2,483	2,554	979	>20,000	11,278	6,599	3,450	2,410	945	>20,000	9,318	8,023	3,133	2,901	983
2,000	>20,000	9,650	6,876	2,453	2,631	953	>20,000	11,970	6,923	3,533	2,544	896	>20,000	10,351	8,507	3,118	3,061	1,117
2,100	>20,000	10,333	7,365	2,628	2,783	928	>20,000	12,262	7,350	3,480	2,702	878	>20,000	11,045	9,020	3,190	3,214	1,039
2,200	>20,000	10,743	7,781	2,784	2,878	965	>20,000	12,369	7,759	3,665	2,789	1,136	>20,000	12,082	9,671	3,387	3,427	1,139
2,300	>20,000	12,654	8,126	3,000	2,985	1,010	>20,000	12,284	8,147	3,808	2,902	1,240	>20,000	13,142	10,464	3,360	3,500	1,022
2,400	>20,000	12,675	8,443	3,295	3,116	937	>20,000	13,449	8,563	4,081	2,976	1,050	>20,000	14,592	11,201	3,585	3,657	1,287
2,500	>20,000	12,901	8,801	3,468	3,285	873	>20,000	14,581	8,910	4,269	3,067	995	>20,000	15,153	12,057	3,861	3,917	1,158
2,600	>20,000	13,820	9,159	3,356	3,348	1,126	>20,000	15,120	9,273	4,399	3,185	934	>20,000	16,879	13,111	4,030	4,018	1,292
2,700	>20,000	13,842	9,644	3,533	3,509	1,068	>20,000	16,296	9,738	4,978	3,328	1,199	>20,000	>20,000	14,359	4,181	4,100	1,298
2,800	>20,000	14,320	10,081	3,805	3,621	1,064	>20,000	17,107	10,273	5,265	3,394	1,145	>20,000	>20,000	15,507	4,417	4,296	1,063
2,900	>20,000	14,523	10,458	3,653	3,631	1,373	>20,000	18,364	10,820	6,055	3,410	1,142	>20,000	>20,000	16,567	4,980	4,426	1,275
3,000	>20,000	15,357	10,961	4,226	3,750	1,205	>20,000	18,296	11,258	6,005	3,505	1,118	>20,000	>20,000	17,843	5,324	4,845	1,476
3,100	>20,000	15,803	11,404	4,380	3,854	1,270	>20,000	17,922	11,758	6,404	3,541	1,012	>20,000	>20,000	19,165	5,483	5,048	1,570
3,200	>20,000	15,758	12,036	4,444	3,990	1,152	>20,000	18,464	12,202	6,172	3,594	1,283	>20,000	>20,000	>20,000	6,254	5,172	1,421
3,300	>20,000	16,259	12,761	4,863	4,070	1,223	>20,000	18,295	12,817	6,407	3,716	1,672	>20,000	>20,000	>20,000	6,894	5,256	1,396
3,400	>20,000	17,437	13,541	5,216	4,090	1,338	>20,000	18,922	13,495	7,212	3,890	1,554	>20,000	>20,000	>20,000	6,736	5,468	1,380
3,500	>20,000	18,712	14,510	5,240	4,173	1,392	>20,000	>20,000	14,132	7,873	4,048	1,592	>20,000	>20,000	>20,000	7,139	5,618	1,275

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,600	>20,000	>20,000	15,485	5,498	4,292	1,356	>20,000	>20,000	15,111	8,006	4,214	1,340	>20,000	>20,000	>20,000	7,502	5,814	1,725
3,700	>20,000	>20,000	16,732	5,636	4,471	1,498	>20,000	>20,000	16,150	8,120	4,348	1,360	>20,000	>20,000	>20,000	7,664	6,079	1,791
3,800	>20,000	>20,000	18,163	5,451	4,561	1,277	>20,000	>20,000	17,200	8,196	4,481	1,519	>20,000	>20,000	>20,000	8,112	6,157	1,320
3,900	>20,000	>20,000	>20,000	5,874	4,699	1,033	>20,000	>20,000	18,503	8,574	4,597	1,782	>20,000	>20,000	>20,000	8,367	6,404	1,394
4,000	>20,000	>20,000	>20,000	5,663	4,883	1,408	>20,000	>20,000	>20,000	8,463	4,637	1,822	>20,000	>20,000	>20,000	8,956	6,663	2,004
4,100	>20,000	>20,000	>20,000	5,551	5,235	1,373	>20,000	>20,000	>20,000	8,289	4,753	1,585	>20,000	>20,000	>20,000	9,121	6,897	1,569
4,200	>20,000	>20,000	>20,000	5,777	5,670	1,498	>20,000	>20,000	>20,000	8,409	4,905	1,650	>20,000	>20,000	>20,000	9,074	7,140	1,533
4,300	>20,000	>20,000	>20,000	5,794	6,046	1,720	>20,000	>20,000	>20,000	8,805	5,021	1,331	>20,000	>20,000	>20,000	9,517	7,379	1,669
4,400	>20,000	>20,000	>20,000	5,899	6,258	1,634	>20,000	>20,000	>20,000	9,279	5,127	1,520	>20,000	>20,000	>20,000	9,709	7,626	1,935
4,500	>20,000	>20,000	>20,000	6,269	6,492	1,512	>20,000	>20,000	>20,000	9,278	5,276	2,117	>20,000	>20,000	>20,000	9,966	7,880	2,091
4,600	>20,000	>20,000	>20,000	6,649	6,751	1,718	>20,000	>20,000	>20,000	9,345	5,477	2,145	>20,000	>20,000	>20,000	10,450	8,126	1,973
4,700	>20,000	>20,000	>20,000	6,135	6,824	1,769	>20,000	>20,000	>20,000	9,423	5,584	1,778	>20,000	>20,000	>20,000	10,746	8,099	1,503
4,800	>20,000	>20,000	>20,000	6,857	7,007	1,897	>20,000	>20,000	>20,000	10,111	5,694	1,304	>20,000	>20,000	>20,000	10,966	8,353	1,715
4,900	>20,000	>20,000	>20,000	7,617	7,110	1,777	>20,000	>20,000	>20,000	10,406	5,731	1,484	>20,000	>20,000	>20,000	11,181	8,949	2,010
5,000	>20,000	>20,000	>20,000	8,483	6,983	1,627	>20,000	>20,000	>20,000	10,595	5,862	1,867	>20,000	>20,000	>20,000	11,720	10,203	2,061
5,500	>20,000	>20,000	>20,000	10,137	7,735	1,554	>20,000	>20,000	>20,000	12,207	6,514	1,995	>20,000	>20,000	>20,000	14,353	>20,000	1,986
6,000	>20,000	>20,000	>20,000	10,198	9,343	2,268	>20,000	>20,000	>20,000	13,468	7,230	2,663	>20,000	>20,000	>20,000	16,626	>20,000	2,544
6,500	>20,000	>20,000	>20,000	12,938	16,210	2,033	>20,000	>20,000	>20,000	14,729	7,999	2,580	>20,000	>20,000	>20,000	19,532	>20,000	3,381
7,000	>20,000	>20,000	>20,000	15,857	>20,000	2,032	>20,000	>20,000	>20,000	16,846	8,739	2,871	>20,000	>20,000	>20,000	>20,000	>20,000	3,138
7,500	>20,000	>20,000	>20,000	18,105	>20,000	2,215	>20,000	>20,000	>20,000	17,839	9,655	3,121	>20,000	>20,000	>20,000	>20,000	>20,000	4,803
8,000	>20,000	>20,000	>20,000	19,378	>20,000	2,241	>20,000	>20,000	>20,000	19,821	10,262	3,510	>20,000	>20,000	>20,000	>20,000	>20,000	3,366
8,500	>20,000	>20,000	>20,000	18,180	>20,000	2,646	>20,000	>20,000	>20,000	>20,000	13,784	1,918	>20,000	>20,000	>20,000	>20,000	>20,000	3,778
9,000	>20,000	>20,000	>20,000	>20,000	>20,000	2,230	>20,000	>20,000	>20,000	>20,000	>20,000	2,652	>20,000	>20,000	>20,000	>20,000	>20,000	3,583
9,500	>20,000	>20,000	>20,000	>20,000	>20,000	4,418	>20,000	>20,000	>20,000	>20,000	>20,000	1,986	>20,000	>20,000	>20,000	>20,000	>20,000	4,627
10,000	>20,000	>20,000	>20,000	>20,000	>20,000	3,464	>20,000	>20,000	>20,000	>20,000	>20,000	3,440	>20,000	>20,000	>20,000	>20,000	>20,000	4,007

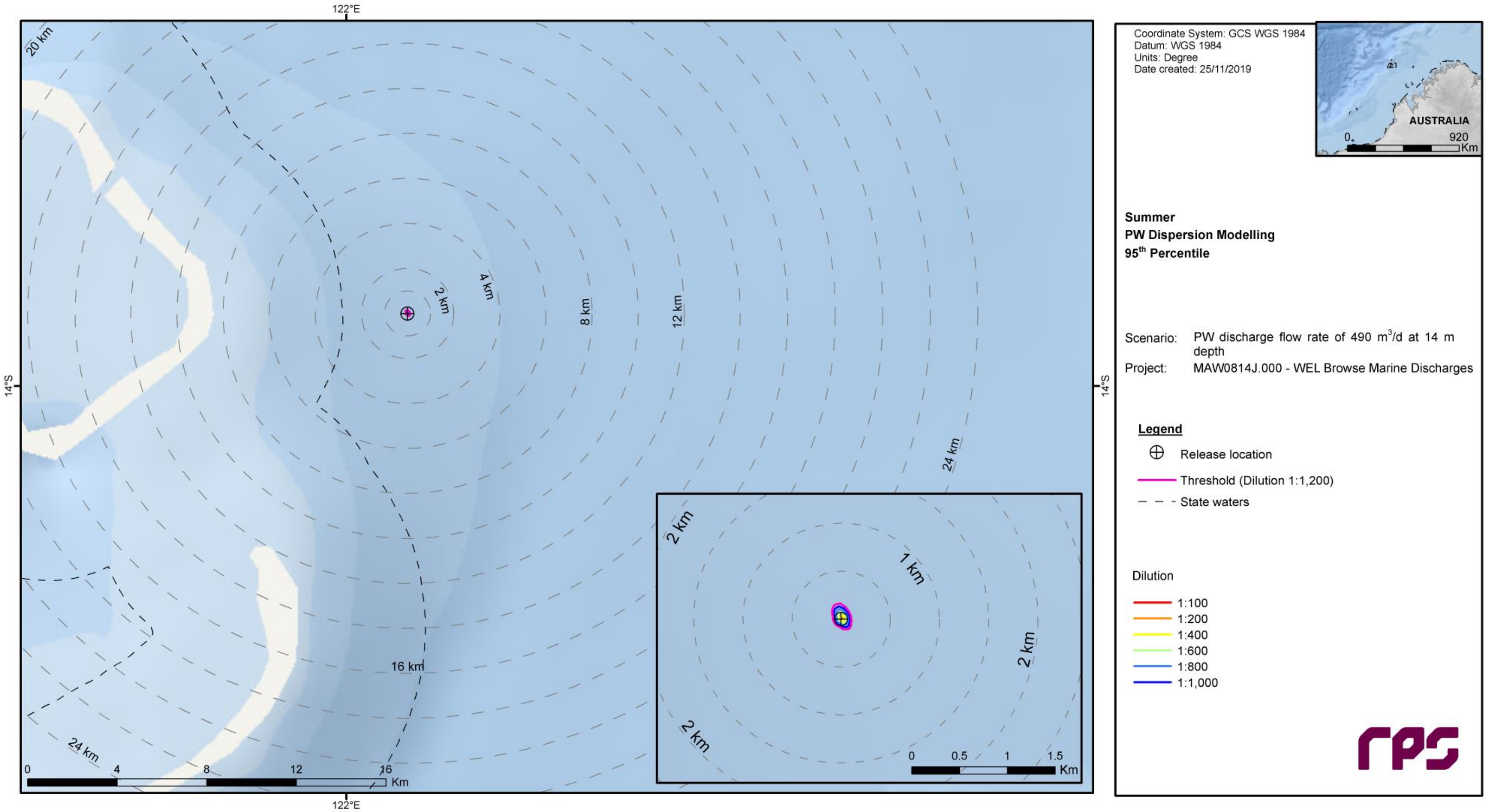

Figure 3.48 Predicted minimum dilutions at the 95th percentile under summer conditions for Case M (14 m depth discharge at 490 m^3/d flow rate).

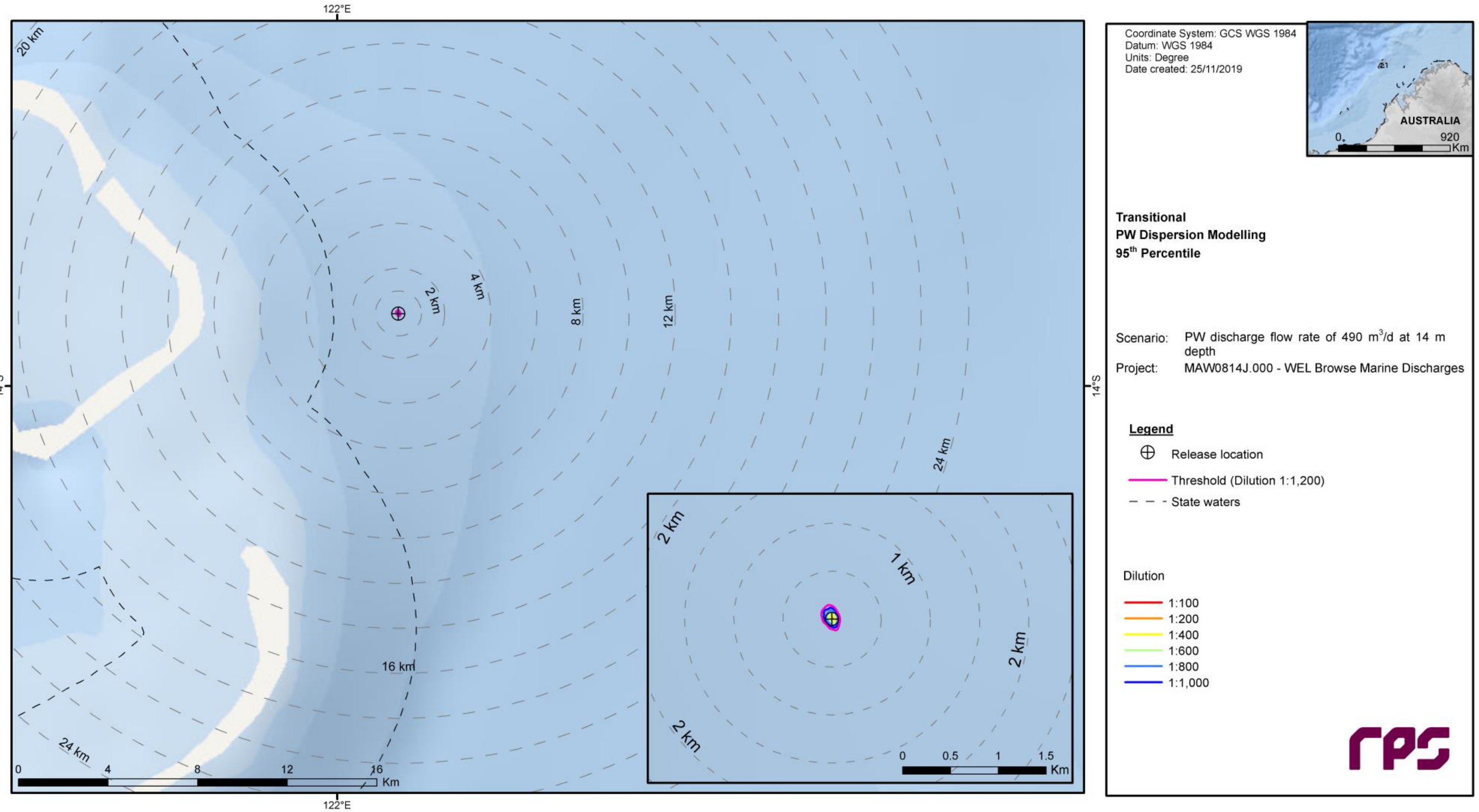

Figure 3.49 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case M (14 m depth discharge at 490 m^3/d flow rate).

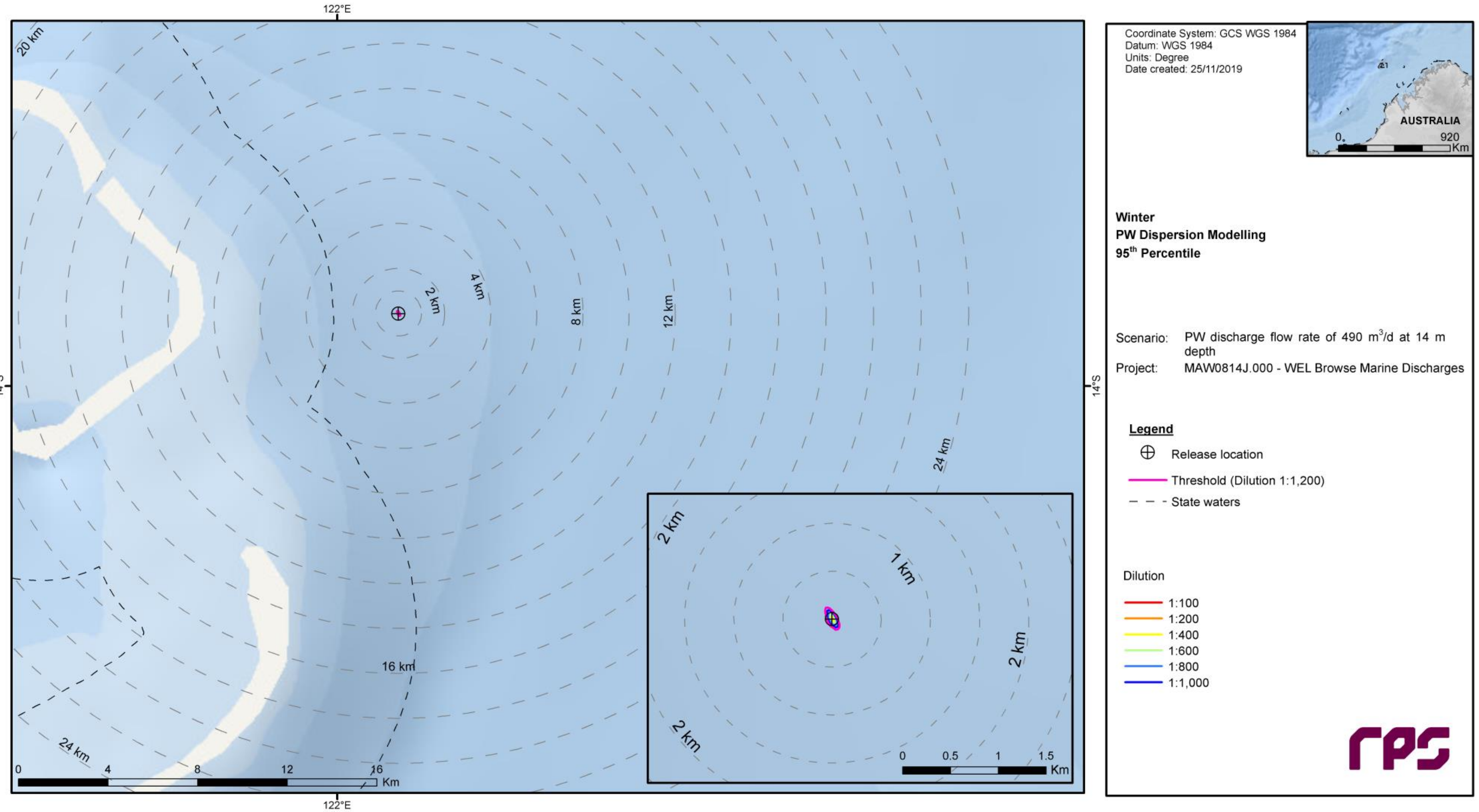

Figure 3.50 Predicted minimum dilutions at the 95th percentile under winter conditions for Case M (14 m depth discharge at 490 m^3/d flow rate).

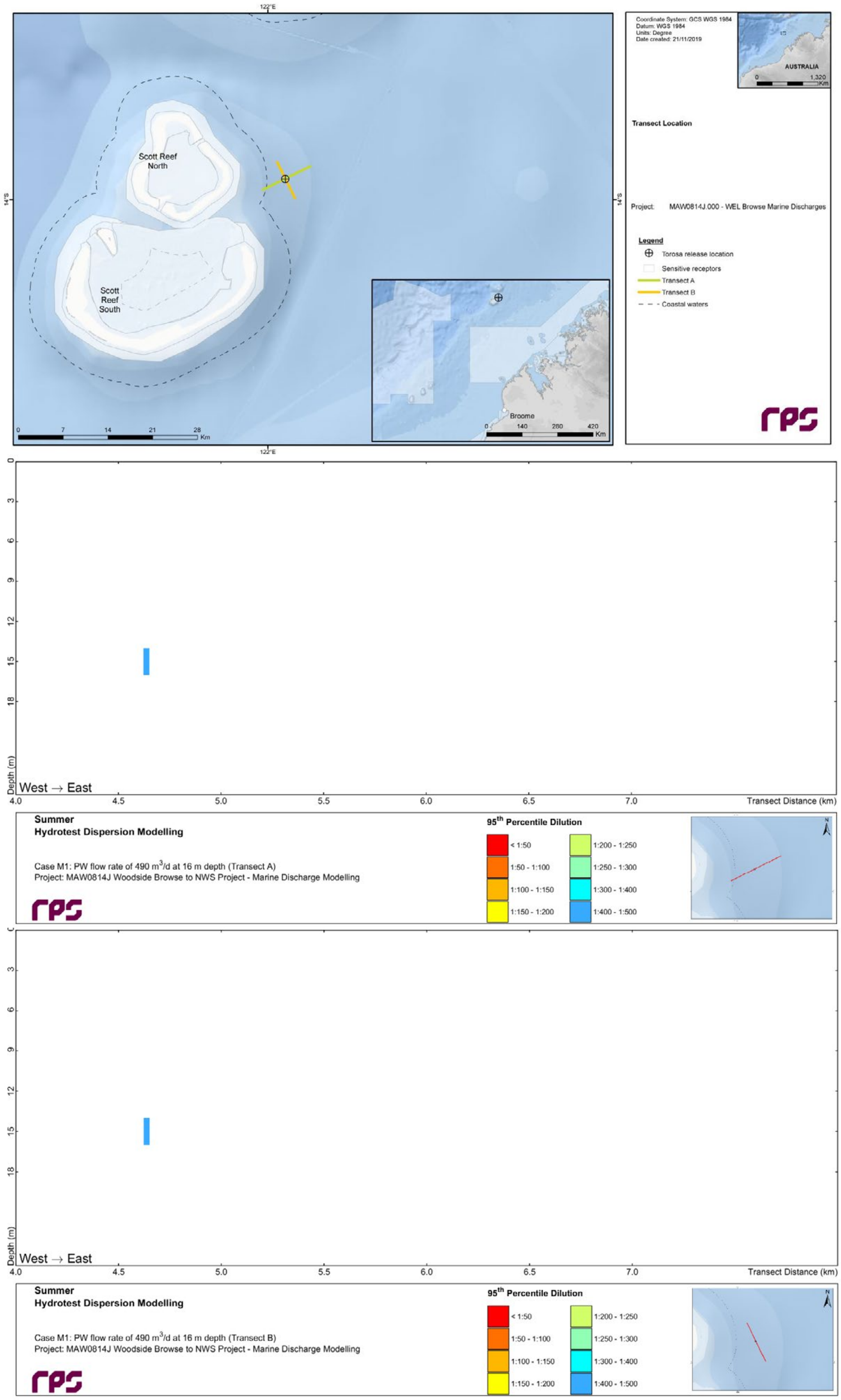

Figure 3.51 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case M (14 m depth discharge at 490 m^3/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.48.

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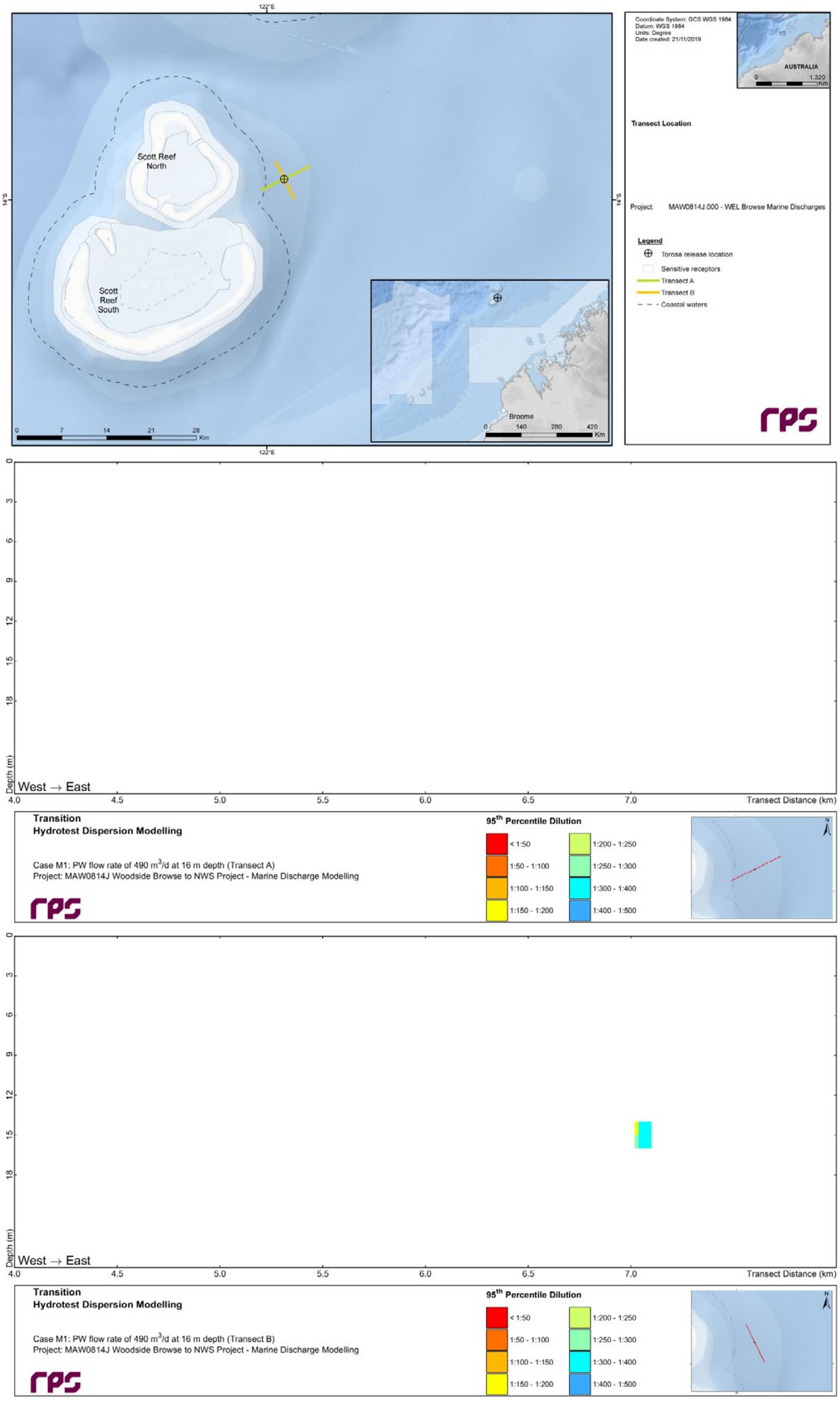

Figure 3.52 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case M (14 m depth discharge at 490 m^3/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.49.

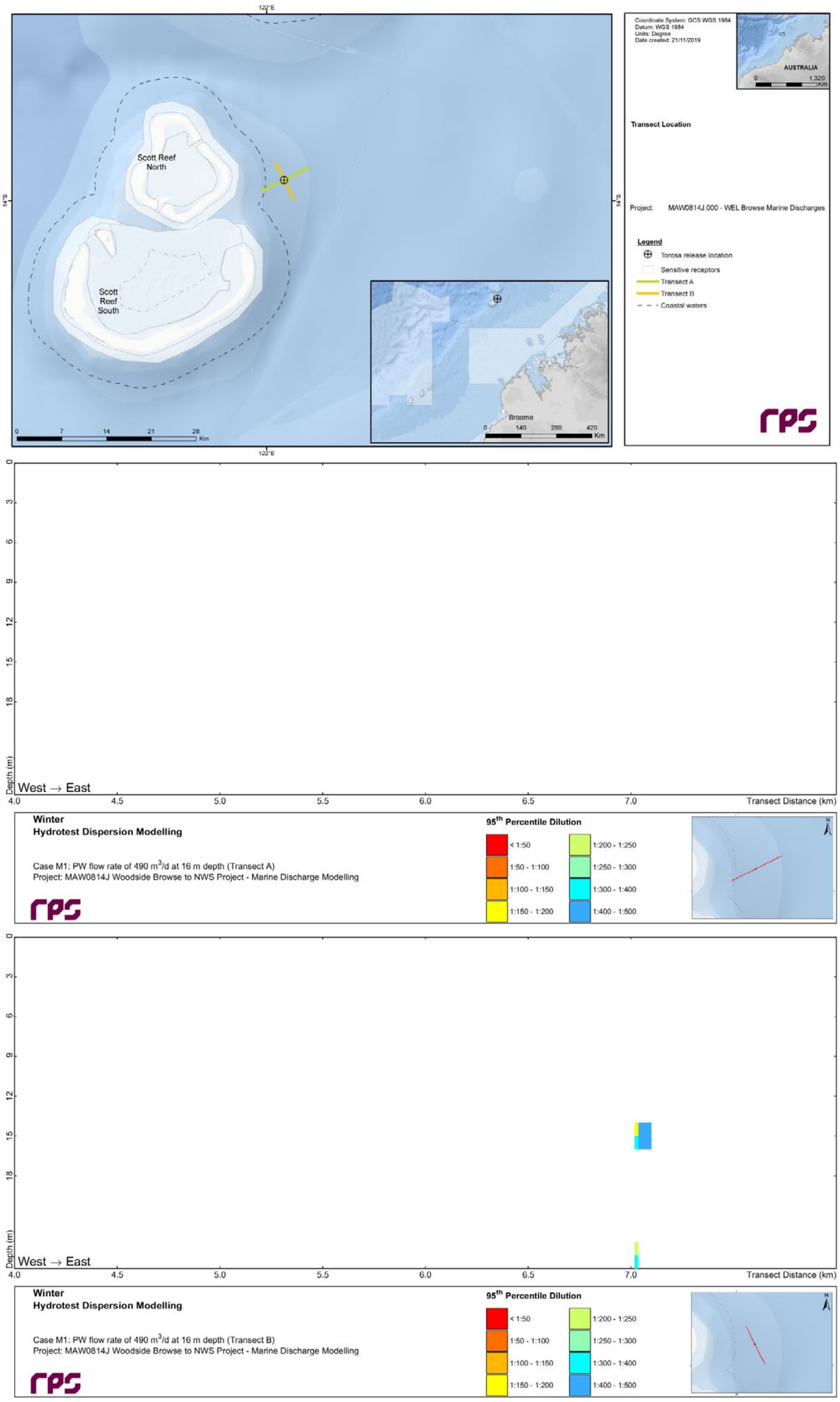

Figure 3.53 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case M (14 m depth discharge at 490 m³/d flow rate). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.50.**

3.2.4.3 Annualised Analysis

3.2.4.3.1 Summary

The model outputs for each season (summer, transitional and winter) over the ten-year hindcast period (2006-2015) were combined and analysed on an annualised basis.

Table 3.53 and Table 3.56 summarise, for Cases P and M respectively, the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the Scott Reef area defined by the 3 nm State water boundary – for each percentile over the annual period.

The minimum levels of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season are predicted to be 1:1,507 for Case P and 1:17,674 for Case M.

Table 3.54 provides for Case P a summary of the annualised maximum distances from the discharge location to achieve an example dilution level of 1:300 for each percentile. The results indicate that the release of effluent under all seasonal conditions results in rapid dispersion within the ambient environment. Dilution to reach the 1:300 level at the 95th percentile – this being the maximum spatial extent of the relevant dilution contour from the discharge location in any season – is achieved within a maximum area of influence of 0.9 km.

Table 3.55 provides for Case P a summary of the annualised total areas of coverage for the 1:300 dilution contour for each percentile. The area of exposure defined by the relevant dilution contour is predicted to reach a maximum value of 0.7 km^2 at the 95th percentile across all seasons.

For Cases P and M, the aggregated spatial extents of the minimum dilutions at the 95th percentile are presented in Figure 3.54 and Figure 3.55, respectively. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

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3.2.4.3.2 Discharge Case P: Flow Rate of 5,723 m³/day at 14 m Depth

Table 3.53 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the PW discharge location for Case P (14 m depth discharge at 5,723 m³/d flow rate).

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary	>20,000	1,507	6,405	582	967	159
20	43	24	28	17	20	12
50	58	25	37	18	25	13
100	90	59	51	35	33	24
200	158	100	79	54	48	32
300	231	135	109	65	64	42
400	296	155	134	71	75	36
500	359	181	158	82	85	43
600	429	217	182	92	98	49
700	486	253	204	109	103	48
800	552	270	225	111	113	48
900	622	288	245	116	125	50
1,000	679	306	266	120	133	59
1,100	735	319	286	131	146	60
1,200	796	333	307	144	155	61
1,300	856	358	330	149	165	59
1,400	941	376	350	152	175	76
1,500	1,008	376	373	149	185	66
1,600	1,067	379	394	161	192	67
1,700	1,112	378	413	173	195	70
1,800	1,185	382	434	180	203	83
1,900	1,279	390	455	176	220	79
2,000	1,381	393	481	174	231	85
2,100	1,490	410	504	172	243	79
2,200	1,627	414	529	176	253	94
2,300	1,728	419	551	187	261	106
2,400	1,852	419	576	185	269	94
2,500	2,013	434	605	181	275	92
2,600	2,179	452	628	186	292	98
2,700	2,378	487	652	189	305	112
2,800	2,564	525	678	197	310	95
2,900	2,758	551	695	213	313	105
3,000	3,052	617	721	229	312	101
3,100	3,364	674	744	259	266	104
3,200	3,789	693	770	268	276	107
3,300	4,315	736	791	290	288	100
3,400	5,055	785	822	277	297	114
3,500	6,029	814	841	293	302	105

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,600	7,404	827	880	297	306	107
3,700	9,229	872	915	342	308	113
3,800	12,085	939	952	383	312	120
3,900	16,678	959	998	420	326	105
4,000	>20,000	1,027	1,042	431	340	98
4,100	>20,000	1,057	1,080	436	354	128
4,200	>20,000	1,079	1,123	440	361	123
4,300	>20,000	1,086	1,170	441	368	128
4,400	>20,000	1,113	1,207	452	373	138
4,500	>20,000	1,132	1,247	468	382	138
4,600	>20,000	1,145	1,283	451	391	148
4,700	>20,000	1,173	1,309	437	398	151
4,800	>20,000	1,281	1,336	443	403	123
4,900	>20,000	1,341	1,371	452	411	144
5,000	>20,000	1,411	1,396	522	420	154
5,500	>20,000	1,817	1,627	663	473	135
6,000	>20,000	1,770	1,984	656	520	184
6,500	>20,000	1,948	2,388	713	554	136
7,000	>20,000	2,339	2,698	810	596	193
7,500	>20,000	2,559	3,023	886	651	196
8,000	>20,000	3,119	3,587	935	716	169
8,500	>20,000	4,023	4,546	1,161	763	205
9,000	>20,000	3,950	7,741	1,193	824	237
9,500	>20,000	3,474	18,674	1,190	890	176
10,000	>20,000	4,721	>20,000	1,309	940	345

Table 3.54 Annualised maximum distance from the PW discharge location to achieve 1:300 dilution for Case P (14 m depth discharge at 5,723 m³/d flow rate).

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	948
99th		3,607
100th		10,493

Table 3.55 Annualised total area of coverage for 1:300 dilution for Case P (14 m depth discharge at 5,723 m³/d flow rate).

Percentile	Season	Total area (km²) of coverage for given dilution
95th	Annual	0.73
99th		6.77
100th		54.79

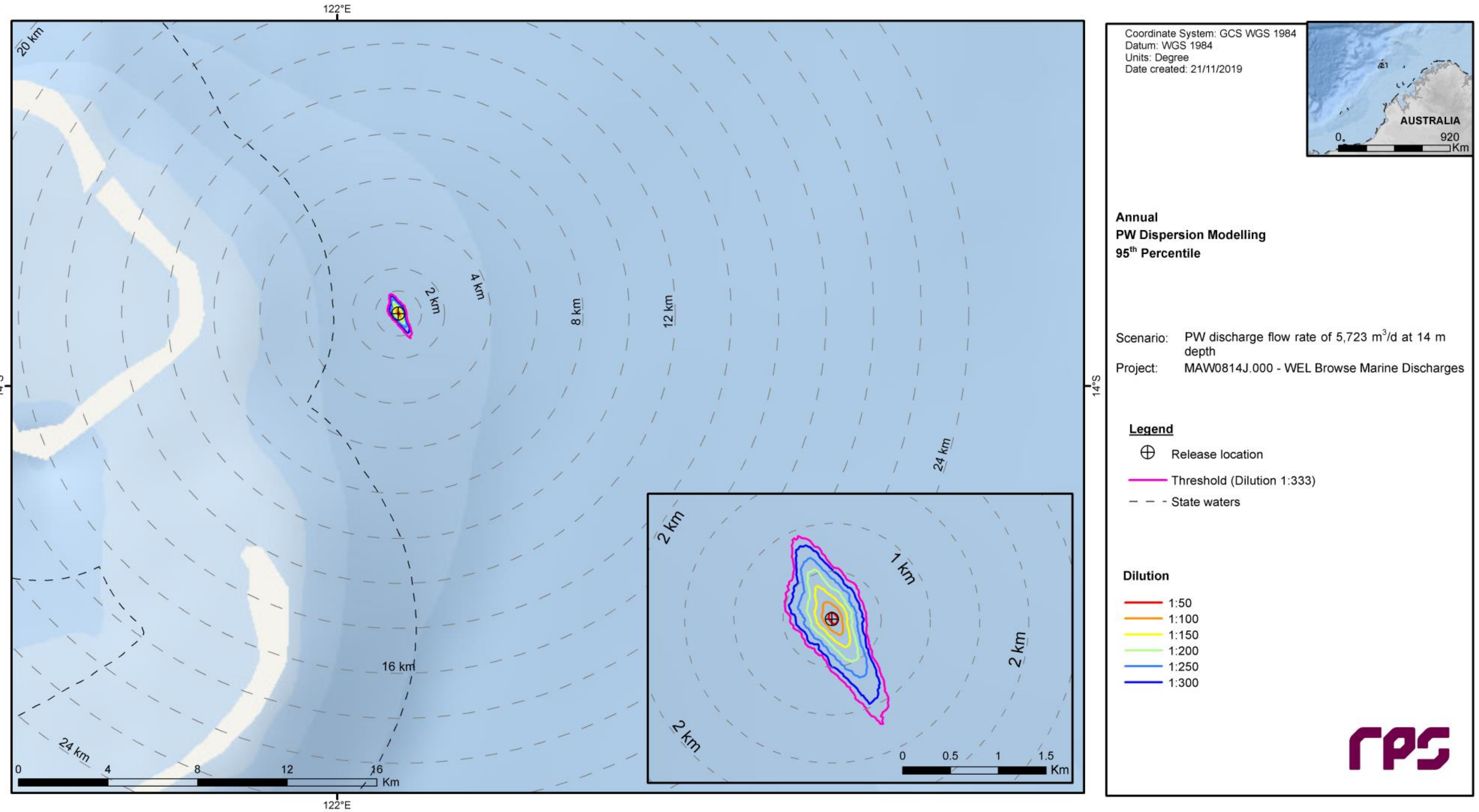

Figure 3.54 Predicted annualised minimum dilutions at the 95th percentile for Case P (14 m depth discharge at 5,723 m^3/d flow rate).

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3.2.4.3.3 Discharge Case M: Flow Rate of 490 m³/day at 14 m Depth

Table 3.56 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the PW discharge location for Case M (14 m depth discharge at 490 m³/d flow rate).

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary	>20,000	17,674	>20,000	6,594	10,796	1,949
20	489	274	303	189	184	127
50	675	289	401	195	235	120
100	1,092	675	597	409	323	211
200	1,929	1,320	941	665	484	316
300	2,826	1,830	1,282	866	596	382
400	3,655	2,187	1,598	1,046	707	418
500	4,429	2,597	1,880	1,148	823	427
600	5,319	2,946	2,161	1,300	962	472
700	6,100	3,505	2,399	1,508	1,036	548
800	6,989	3,777	2,625	1,542	1,189	573
900	7,820	4,252	2,904	1,659	1,275	599
1,000	8,577	4,751	3,155	1,698	1,386	555
1,100	9,387	5,126	3,404	1,875	1,465	648
1,200	10,247	5,500	3,624	1,910	1,537	710
1,300	11,177	5,997	3,866	1,964	1,702	724
1,400	12,486	6,517	4,156	2,208	1,754	709
1,500	13,951	6,983	4,458	2,332	1,871	691
1,600	15,337	7,427	4,761	2,584	1,988	705
1,700	17,059	7,984	4,976	2,434	2,005	907
1,800	19,271	8,728	5,263	2,511	2,075	821
1,900	>20,000	9,122	5,598	2,483	2,196	945
2,000	>20,000	9,650	5,902	2,453	2,276	896
2,100	>20,000	10,333	6,258	2,628	2,404	878
2,200	>20,000	10,743	6,602	2,784	2,515	965
2,300	>20,000	12,284	6,850	3,000	2,639	1,010
2,400	>20,000	12,675	7,119	3,295	2,706	937
2,500	>20,000	12,901	7,475	3,468	2,789	873
2,600	>20,000	13,820	7,800	3,356	2,890	934
2,700	>20,000	13,842	8,154	3,533	2,989	1,068
2,800	>20,000	14,320	8,479	3,805	3,053	1,063
2,900	>20,000	14,523	8,768	3,653	3,048	1,142
3,000	>20,000	15,357	9,173	4,226	3,116	1,118
3,100	>20,000	15,803	9,528	4,380	3,134	1,012
3,200	>20,000	15,758	9,987	4,444	3,246	1,152
3,300	>20,000	16,259	10,430	4,863	3,363	1,223
3,400	>20,000	17,437	10,945	5,216	3,441	1,338
3,500	>20,000	18,712	11,430	5,240	3,536	1,275

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,600	>20,000	>20,000	11,987	5,498	3,651	1,340
3,700	>20,000	>20,000	12,429	5,636	3,788	1,360
3,800	>20,000	>20,000	12,958	5,451	3,833	1,277
3,900	>20,000	>20,000	13,681	5,874	3,977	1,033
4,000	>20,000	>20,000	14,318	5,663	4,098	1,408
4,100	>20,000	>20,000	14,977	5,551	4,206	1,373
4,200	>20,000	>20,000	15,707	5,777	4,299	1,498
4,300	>20,000	>20,000	16,479	5,794	4,360	1,331
4,400	>20,000	>20,000	17,102	5,899	4,459	1,520
4,500	>20,000	>20,000	17,786	6,269	4,602	1,512
4,600	>20,000	>20,000	18,369	6,649	4,715	1,718
4,700	>20,000	>20,000	19,029	6,135	4,765	1,503
4,800	>20,000	>20,000	19,895	6,857	4,831	1,304
4,900	>20,000	>20,000	>20,000	7,617	4,892	1,484
5,000	>20,000	>20,000	>20,000	8,483	5,021	1,627
5,500	>20,000	>20,000	>20,000	10,137	5,726	1,554
6,000	>20,000	>20,000	>20,000	10,198	6,298	2,268
6,500	>20,000	>20,000	>20,000	12,938	6,979	2,033
7,000	>20,000	>20,000	>20,000	15,857	7,497	2,032
7,500	>20,000	>20,000	>20,000	17,839	8,263	2,215
8,000	>20,000	>20,000	>20,000	19,378	8,753	2,241
8,500	>20,000	>20,000	>20,000	18,180	9,328	1,918
9,000	>20,000	>20,000	>20,000	>20,000	9,904	2,230
9,500	>20,000	>20,000	>20,000	>20,000	10,805	1,986
10,000	>20,000	>20,000	>20,000	>20,000	11,991	3,440

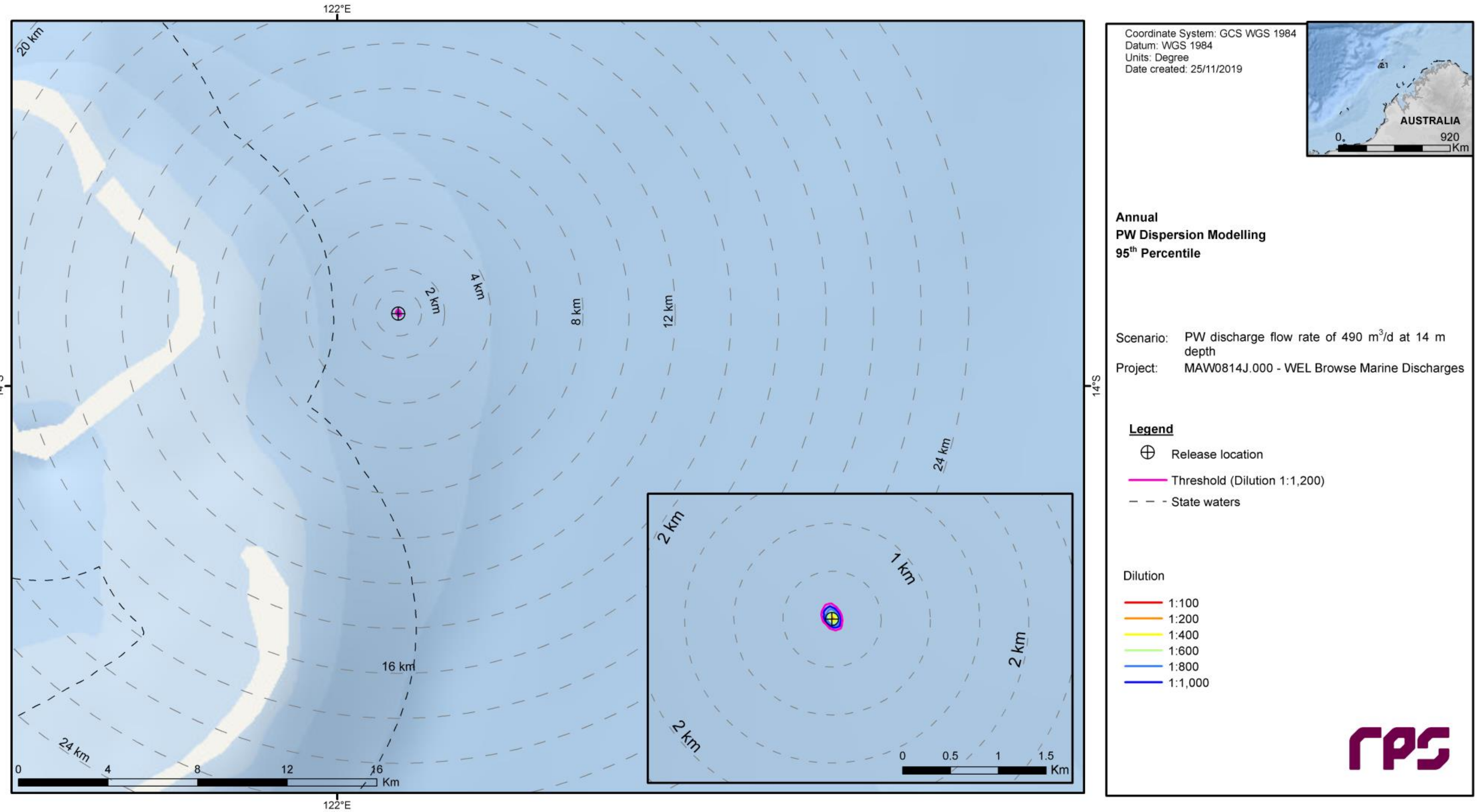

Figure 3.55 Predicted annualised minimum dilutions at the 95th percentile for Case M (14 m depth discharge at 490 m^3/d flow rate).

3.2.5 Hydrotest Discharges

3.2.5.1 General Observations

Figure 3.56 shows example time series snapshots of predicted dilutions during a single simulation at 4-hour intervals from 00:00 to 20:00 on 12th January 2010. This simulation – selected merely to be representative of typical conditions – considers the Case H1 discharge of 736,000 m^3 at 117 m BMSL at the PLET near the NRC. The spatially-varying orientation of the plume with the currents and the rapidly-varying nature of the concentrations around the source can be observed. The snapshots also show the combined effect of the tide and the drift currents, with a clear tidal oscillation.

These snapshots illustrate that the dilutions (and in turn concentrations) become more variable over time because of changes in current speed and direction. Higher dilutions (lower concentrations) are predicted during periods of increased current speed, whereas patches of lower dilutions (higher concentrations) tend to accumulate during the turning of the tide or during periods of weak drift currents. During prolonged periods of lowered current speed, the plume has a more continuous appearance, with higher-concentration patches moving as a unified group.

The snapshots in Figure 3.56 show a contiguous plume emanating from the source. Within this plume, higher-concentration patches – attributable to periodic tide reversals which cause the existing plume to repeatedly pass over the source – are most evident closer to the source, while towards the outermost extents a highly-diluted sub-plume has begun to detach from the main plume.

These findings agree with the research of King & McAllister (1997, 1998) who noted that concentrations within effluent plumes generated by an offshore platform were patchy and likely to peak around the reversal of the tides.

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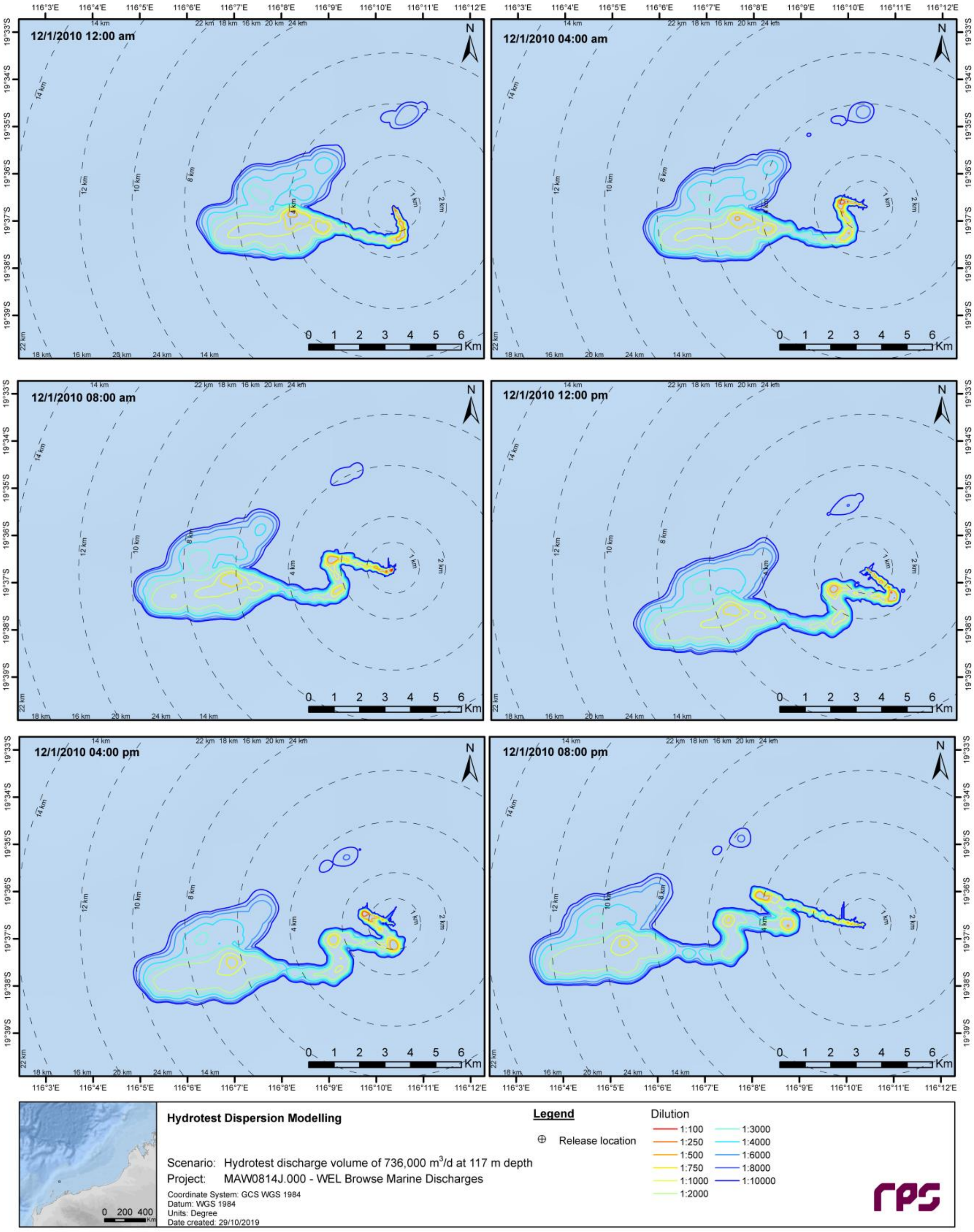

Figure 3.56 Snapshots of predicted dilution levels, at 4-hour intervals from 00:00 to 20:00 on 12th January 2010, for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge).

3.2.5.2 Seasonal Analysis

3.2.5.2.1 Summary

The model outputs over the ten-year hindcast period (2006-2015) were combined and analysed on a seasonal basis (summer, transitional and winter). This approach assists with identifying the potential exposure to surrounding sensitive receptors whilst considering inter-annual variability in ocean current conditions.

Table 3.57, Table 3.61, Table 3.65 and Table 3.69 summarise, for Cases H1, H2, H3a and H3b respectively, the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the boundary of the nearest sensitive receptor – for each season and percentile, with the application of a rolling 48-hour median to the data. The discharge location for Case H1 is distant from Scott Reef and the nearest receptor is Rankin Bank, while for Cases H2, H3a and H3b the nearest receptor is Scott Reef (defined by the 3 nm State water boundary).

Table 3.58, Table 3.62, Table 3.66 and Table 3.70 provide, for Cases H1, H2, H3a and H3b respectively, summaries of the maximum distances from the discharge location to achieve an example dilution level of 1:10,000 for each season and percentile. The results indicate that the release of effluent under all seasonal conditions results in slow dispersion within the ambient environment. For Case H1, a 1:10,000 dilution is achieved within an area of influence ranging from 9.0-16.1 km at the 95th percentile (Table 3.58), with the predominant plume travel direction being south-westerly throughout the year (Figure 3.57 to Figure 3.59). For Case H2, the maximum spatial extent of the relevant dilution contour varies from 8.0-12.5 km at the 95th percentile (Table 3.62), with the predominant axis of plume movement being north-northwest/south-southeast throughout the year (Figure 3.63 to Figure 3.65). For Case H3a, the maximum spatial extent of the relevant dilution contour is in the range 15.5-23.4 km at the 95th percentile (Table 3.66), with plumes travelling mostly to the north-east during transitional months, the south-west during winter, and both the north-east and south-west during summer (Figure 3.69 to Figure 3.71). For Case H3b, dilution to reach the 1:10,000 level is achieved within a distance of 7.3-8.2 km at the 95th percentile (Table 3.70), with plumes moving along a north-northwest/south-southeast axis throughout the year (Figure 3.75 to Figure 3.77).

Table 3.59, Table 3.63, Table 3.67 and Table 3.71 provide, for Cases H1, H2, H3a and H3b respectively, summaries of the total areas of coverage for the 1:10,000 dilution contour for each season and percentile. For Case H1, the area of exposure defined by the relevant dilution contour is predicted to reach a maximum value of 36.2-44.3 km^2 at the 95th percentile (Table 3.59). For Case H2, the corresponding maximum area of exposure is 30.7-74.6 km^2 at the 95th percentile (Table 3.63). For Case H3a, the maximum area of exposure is predicted to be 38.3-57.3 km^2 at the 95th percentile (Table 3.67). For Case H3b, the maximum area of exposure is forecast as 18.2-22.2 km^2 at the 95th percentile (Table 3.71).

Table 3.60, Table 3.64, Table 3.68 and Table 3.72 provide, for Cases H1, H2, H3a and H3b respectively, summaries of the maximum depths from the discharge location to achieve 1:10,000 dilution for each season and percentile. Given the near-seabed depths of each discharge and the near neutrally buoyant nature of the plumes, maximum depths are predicted as equivalent to the seabed depth in each case.

For Cases H1, H2, H3a and H3b, the aggregated spatial extents of the minimum dilutions for each season at the 95th percentile are presented in Figure 3.57 to Figure 3.59, Figure 3.63 to Figure 3.65, Figure 3.69 to Figure 3.71 and Figure 3.75 to Figure 3.77, respectively. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

Seasonal water column cross-section figures of 95th percentile dilution, extracted along perpendicular transects running through the origin points of the discharge (one of which is broadly aligned with the principal travel direction of the plume at each location), are presented in Figure 3.60 to Figure 3.62 (Case H1), Figure 3.66 to Figure 3.68 (Case H2), Figure 3.72 to Figure 3.74 (Case H3a) and Figure 3.78 to Figure 3.80 (Case H3b). In each case, the neutrally buoyant plumes are predicted to remain relatively close to the seabed as they disperse. It is evident that the plumes will be heavily influenced by local bathymetry features and may travel up slopes if currents in the lower water column are conducive to this effect. For the Case H1 discharge, the plume centreline will remain at a depth of more than 100 m below the water surface. For Cases H2, H3a and H3b, the plume centrelines will remain at depths of more than 450 m.

It should be noted that the bathymetry slopes shown in the water column cross-section figures are exaggerated due to the spatial scales used; the vertical axis is presented in units of metres, while the horizontal axis is presented in units of kilometres.

3.2.5.2.2 Discharge Case H1: NRC Tie-In PLET Hydrotest Discharge of 736,000 m^3 at 117 m Depth

Table 3.57 Average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location in each season for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Rankin Bank †	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000
20	553	230	235	172	230	163	676	288	429	183	386	178	1,093	537	566	391	441	377
50	392	183	168	115	149	109	582	287	215	131	197	130	712	350	452	289	315	215
100	1,815	540	975	377	809	313	1,425	524	932	300	793	297	2,085	499	590	323	499	298
200	2,810	1,339	1,664	709	1,481	510	2,395	1,108	1,507	969	1,264	655	3,584	1,146	919	644	804	616
300	3,514	1,447	2,139	719	1,590	663	3,192	1,502	1,910	1,052	1,693	988	5,106	1,529	1,189	684	988	624
400	3,995	1,609	2,344	1,053	1,889	867	3,551	1,605	2,110	975	1,957	967	5,819	1,787	1,511	697	1,145	680
500	4,684	1,845	2,481	1,109	1,933	1,092	5,343	1,941	2,641	1,115	2,080	1,053	8,225	2,353	1,926	791	1,566	699
600	5,009	1,956	2,761	1,478	2,230	1,178	6,156	1,973	2,867	1,218	2,280	1,086	7,532	2,284	2,606	904	1,931	801
700	5,747	2,259	2,846	1,684	2,238	1,289	10,815	1,927	3,230	1,249	2,722	1,135	9,427	2,278	3,051	1,067	2,435	984
800	6,069	2,271	3,190	1,546	2,689	1,341	12,742	2,074	3,702	1,399	2,895	1,182	9,588	2,699	2,987	1,071	2,427	1,063
900	6,329	2,040	3,256	1,516	2,763	1,386	>20,000	2,375	4,539	1,433	3,535	1,226	10,594	2,496	3,197	1,258	2,731	998
1,000	6,770	1,941	3,483	1,449	3,052	1,430	18,831	2,329	3,883	1,453	3,280	1,205	13,772	2,680	3,395	1,359	2,824	989
1,100	6,775	2,170	3,522	1,354	2,956	1,344	>20,000	2,550	6,732	1,480	4,997	1,360	15,439	2,854	3,625	1,298	3,012	1,184
1,200	7,212	2,284	3,788	1,400	3,265	1,379	19,634	2,607	4,605	1,586	3,180	1,392	19,550	2,978	4,707	1,428	3,885	1,338
1,300	7,035	2,002	3,849	1,254	3,103	1,243	>20,000	2,723	12,484	1,769	6,443	1,450	18,632	2,715	4,169	1,444	3,313	1,378
1,400	7,477	2,000	3,825	1,265	3,173	1,159	>20,000	2,689	6,550	1,780	4,090	1,573	>20,000	2,436	5,107	1,475	3,873	1,407
1,500	7,760	2,049	3,875	1,236	3,241	1,143	>20,000	2,869	17,886	1,791	9,591	1,651	>20,000	2,458	5,618	1,618	4,430	1,544
1,600	8,162	1,783	3,782	1,315	3,241	1,280	>20,000	2,967	9,061	1,793	5,313	1,626	>20,000	2,748	5,698	1,634	4,260	1,620
1,700	9,047	1,912	3,969	1,306	3,335	1,259	>20,000	2,762	>20,000	1,966	14,352	1,831	>20,000	2,801	7,826	1,594	5,194	1,547
1,800	9,473	1,851	4,154	1,313	3,543	1,224	>20,000	2,740	>20,000	1,847	>20,000	1,741	>20,000	2,870	8,758	1,645	5,585	1,497
1,900	10,691	2,119	4,192	1,248	3,651	1,224	>20,000	2,463	>20,000	1,729	13,737	1,672	>20,000	2,821	11,536	1,662	6,575	1,623
2,000	11,831	2,068	4,303	1,370	3,792	1,281	>20,000	2,428	>20,000	1,526	12,445	1,494	>20,000	2,914	12,260	1,884	7,428	1,676
2,100	15,635	2,200	4,777	1,472	4,070	1,342	>20,000	2,825	>20,000	1,347	>20,000	1,323	>20,000	2,945	16,569	1,883	11,504	1,772
2,200	19,535	2,106	5,016	1,419	4,439	1,380	>20,000	2,641	>20,000	1,230	>20,000	1,230	>20,000	3,106	>20,000	2,069	13,942	1,625
2,300	>20,000	2,362	5,477	1,620	4,526	1,463	>20,000	2,791	>20,000	1,273	>20,000	1,243	>20,000	3,169	>20,000	1,965	15,895	1,694
2,400	>20,000	2,259	6,036	1,577	5,067	1,508	>20,000	2,857	>20,000	1,301	>20,000	1,301	>20,000	3,284	>20,000	2,010	>20,000	1,930
2,500	>20,000	2,326	6,817	1,721	5,835	1,511	>20,000	2,952	>20,000	1,356	>20,000	1,324	>20,000	3,445	>20,000	1,974	>20,000	1,885
2,600	>20,000	2,407	7,464	1,748	6,478	1,648	>20,000	3,028	>20,000	1,543	>20,000	1,356	>20,000	3,469	>20,000	2,295	>20,000	1,936
2,700	>20,000	2,485	8,558	1,622	7,421	1,578	>20,000	2,949	>20,000	1,574	>20,000	1,433	>20,000	3,478	>20,000	2,505	>20,000	2,191
2,800	>20,000	2,782	10,105	1,586	8,523	1,515	>20,000	2,762	>20,000	1,676	>20,000	1,522	>20,000	3,579	>20,000	2,724	>20,000	2,429
2,900	>20,000	2,806	12,737	1,729	10,612	1,508	>20,000	2,930	>20,000	1,692	>20,000	1,566	>20,000	3,643	>20,000	2,781	>20,000	2,494
3,000	>20,000	2,974	14,934	1,940	12,290	1,596	>20,000	3,014	>20,000	1,807	>20,000	1,733	>20,000	3,681	>20,000	2,753	>20,000	2,323
3,100	>20,000	3,156	19,321	1,914	15,551	1,675	>20,000	3,048	>20,000	1,923	>20,000	1,841	>20,000	3,665	>20,000	2,934	>20,000	2,658
3,200	>20,000	3,218	>20,000	1,713	>20,000	1,588	>20,000	3,205	>20,000	2,145	>20,000	1,977	>20,000	3,763	>20,000	2,865	>20,000	2,487
3,300	>20,000	2,775	>20,000	1,524	>20,000	1,406	>20,000	3,228	>20,000	2,242	>20,000	1,871	>20,000	3,801	>20,000	2,943	>20,000	2,505
3,400	>20,000	3,181	>20,000	1,459	>20,000	1,378	>20,000	3,156	>20,000	2,285	>20,000	2,015	>20,000	3,895	>20,000	3,103	>20,000	2,371
3,500	>20,000	3,397	>20,000	1,717	>20,000	1,537	>20,000	3,299	>20,000	2,280	>20,000	2,029	>20,000	4,003	>20,000	3,114	>20,000	2,653

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,600	>20,000	3,173	>20,000	1,897	>20,000	1,540	>20,000	3,126	>20,000	2,172	>20,000	2,006	>20,000	3,911	>20,000	3,095	>20,000	2,865
3,700	>20,000	3,296	>20,000	1,892	>20,000	1,592	>20,000	3,196	>20,000	2,142	>20,000	1,962	>20,000	4,005	>20,000	3,100	>20,000	3,015
3,800	>20,000	3,389	>20,000	1,895	>20,000	1,750	>20,000	3,410	>20,000	2,013	>20,000	1,990	>20,000	3,913	>20,000	3,136	>20,000	2,951
3,900	>20,000	3,301	>20,000	2,199	>20,000	1,782	>20,000	3,598	>20,000	1,966	>20,000	1,896	>20,000	4,072	>20,000	3,116	>20,000	2,969
4,000	>20,000	3,011	>20,000	2,110	>20,000	1,893	>20,000	3,664	>20,000	1,855	>20,000	1,828	>20,000	4,118	>20,000	3,061	>20,000	2,963
4,100	>20,000	3,353	>20,000	2,281	>20,000	2,105	>20,000	3,755	>20,000	1,712	>20,000	1,712	>20,000	3,984	>20,000	3,114	>20,000	3,003
4,200	>20,000	3,288	>20,000	2,301	>20,000	2,180	>20,000	4,225	>20,000	1,745	>20,000	1,745	>20,000	4,127	>20,000	3,253	>20,000	3,157
4,300	>20,000	3,045	>20,000	2,327	>20,000	2,135	>20,000	4,499	>20,000	1,751	>20,000	1,739	>20,000	4,330	>20,000	3,382	>20,000	3,250
4,400	>20,000	3,134	>20,000	2,216	>20,000	2,110	>20,000	4,401	>20,000	1,857	>20,000	1,823	>20,000	4,485	>20,000	3,435	>20,000	3,234
4,500	>20,000	3,362	>20,000	2,133	>20,000	2,073	>20,000	4,428	>20,000	1,941	>20,000	1,887	>20,000	4,594	>20,000	3,345	>20,000	3,280
4,600	>20,000	3,214	>20,000	2,505	>20,000	2,334	>20,000	4,851	>20,000	1,952	>20,000	1,919	>20,000	4,709	>20,000	3,492	>20,000	3,034
4,700	>20,000	3,567	>20,000	2,412	>20,000	2,326	>20,000	4,927	>20,000	2,105	>20,000	2,087	>20,000	4,693	>20,000	3,570	>20,000	3,100
4,800	>20,000	3,655	>20,000	2,364	>20,000	2,246	>20,000	4,742	>20,000	2,208	>20,000	2,208	>20,000	4,744	>20,000	3,442	>20,000	2,961
4,900	>20,000	4,243	>20,000	2,105	>20,000	1,977	>20,000	4,791	>20,000	2,353	>20,000	2,353	>20,000	4,711	>20,000	3,210	>20,000	3,182
5,000	>20,000	4,165	>20,000	2,239	>20,000	2,147	>20,000	4,529	>20,000	2,697	>20,000	2,614	>20,000	4,781	>20,000	3,185	>20,000	3,141
5,500	>20,000	4,347	>20,000	3,192	>20,000	2,966	>20,000	5,158	>20,000	3,325	>20,000	3,325	>20,000	4,680	>20,000	3,374	>20,000	3,308
6,000	>20,000	4,982	>20,000	3,145	>20,000	2,925	>20,000	6,005	>20,000	3,770	>20,000	3,749	>20,000	4,591	>20,000	3,452	>20,000	3,428
6,500	>20,000	5,131	>20,000	3,254	>20,000	3,154	>20,000	6,397	>20,000	4,493	>20,000	3,830	>20,000	4,546	>20,000	3,452	>20,000	3,435
7,000	>20,000	5,251	>20,000	3,341	>20,000	3,288	>20,000	6,860	>20,000	5,276	>20,000	4,567	>20,000	4,493	>20,000	3,406	>20,000	3,357
7,500	>20,000	5,634	>20,000	2,761	>20,000	2,744	>20,000	8,130	>20,000	5,337	>20,000	5,312	>20,000	4,458	>20,000	3,367	>20,000	3,367
8,000	>20,000	5,963	>20,000	2,733	>20,000	2,733	>20,000	8,957	>20,000	6,364	>20,000	5,198	>20,000	4,460	>20,000	3,326	>20,000	3,273
8,500	>20,000	5,565	>20,000	2,884	>20,000	2,855	>20,000	9,353	>20,000	6,112	>20,000	5,415	>20,000	4,543	>20,000	3,403	>20,000	3,390
9,000	>20,000	6,359	>20,000	3,302	>20,000	3,139	>20,000	9,972	>20,000	5,969	>20,000	5,425	>20,000	4,572	>20,000	3,428	>20,000	3,428
9,500	>20,000	7,226	>20,000	3,632	>20,000	3,354	>20,000	9,814	>20,000	6,077	>20,000	5,683	>20,000	4,578	>20,000	3,435	>20,000	3,380
10,000	>20,000	7,581	>20,000	4,687	>20,000	3,937	>20,000	11,125	>20,000	6,481	>20,000	5,760	>20,000	4,568	>20,000	3,541	>20,000	3,474
10,500	>20,000	7,442	>20,000	4,364	>20,000	4,333	>20,000	11,990	>20,000	7,268	>20,000	5,664	>20,000	4,769	>20,000	3,592	>20,000	3,535
11,000	>20,000	8,052	>20,000	4,673	>20,000	4,435	>20,000	13,816	>20,000	8,001	>20,000	5,101	>20,000	5,428	>20,000	3,723	>20,000	3,613
11,500	>20,000	9,539	>20,000	4,513	>20,000	4,198	>20,000	13,941	>20,000	8,196	>20,000	6,015	>20,000	6,091	>20,000	3,736	>20,000	3,583
12,000	>20,000	8,899	>20,000	5,294	>20,000	4,619	>20,000	15,768	>20,000	8,313	>20,000	6,896	>20,000	6,543	>20,000	3,705	>20,000	3,600
12,500	>20,000	9,118	>20,000	5,135	>20,000	5,135	>20,000	14,843	>20,000	7,992	>20,000	6,614	>20,000	7,314	>20,000	3,684	>20,000	3,618
13,000	>20,000	9,205	>20,000	5,283	>20,000	5,154	>20,000	17,184	>20,000	8,782	>20,000	6,609	>20,000	8,300	>20,000	3,579	>20,000	3,510
13,500	>20,000	8,498	>20,000	5,203	>20,000	5,054	>20,000	16,561	>20,000	8,403	>20,000	6,260	>20,000	8,594	>20,000	3,642	>20,000	3,510
14,000	>20,000	9,434	>20,000	5,569	>20,000	5,557	>20,000	18,060	>20,000	8,989	>20,000	6,575	>20,000	8,792	>20,000	3,589	>20,000	3,449
14,500	>20,000	10,651	>20,000	6,548	>20,000	6,548	>20,000	18,839	>20,000	9,169	>20,000	7,484	>20,000	9,113	>20,000	3,557	>20,000	3,533
15,000	>20,000	9,083	>20,000	5,776	>20,000	5,158	>20,000	17,544	>20,000	9,209	>20,000	7,009	>20,000	9,565	>20,000	3,552	>20,000	3,541
15,500	>20,000	8,200	>20,000	6,099	>20,000	5,644	>20,000	17,479	>20,000	10,989	>20,000	8,041	>20,000	10,215	>20,000	3,487	>20,000	3,487
16,000	>20,000	10,216	>20,000	6,871	>20,000	6,393	>20,000	18,161	>20,000	12,295	>20,000	8,962	>20,000	10,548	>20,000	3,439	>20,000	3,431
16,500	>20,000	11,229	>20,000	7,298	>20,000	6,337	>20,000	19,711	>20,000	11,482	>20,000	9,618	>20,000	10,280	>20,000	3,429	>20,000	3,421
17,000	>20,000	12,207	>20,000	5,353	>20,000	5,067	>20,000	20,911	>20,000	12,773	>20,000	10,466	>20,000	11,325	>20,000	3,502	>20,000	3,470
17,500	>20,000	12,542	>20,000	6,492	>20,000	5,554	>20,000	19,018	>20,000	14,177	>20,000	12,157	>20,000	10,275	>20,000	3,511	>20,000	3,472
18,000	>20,000	14,165	>20,000	7,919	>20,000	7,443	>20,000	>20,000	>20,000	16,524	>20,000	13,079	>20,000	11,163	>20,000	3,480	>20,000	3,431
18,500	>20,000	13,062	>20,000	7,783	>20,000	6,989	>20,000	>20,000	>20,000	16,917	>20,000	13,834	>20,000	10,508	>20,000	3,464	>20,000	3,405
19,000	>20,000	14,856	>20,000	7,712	>20,000	7,413	>20,000	>20,000	>20,000	16,572	>20,000	15,453	>20,000	9,756	>20,000	3,439	>20,000	3,399
19,500	>20,000	14,621	>20,000	8,526	>20,000	7,629	>20,000	>20,000	>20,000	16,159	>20,000	15,368	>20,000	9,634	>20,000	3,432	>20,000	3,428

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
20,000	>20,000	15,117	>20,000	8,581	>20,000	7,833	>20,000	>20,000	>20,000	17,067	>20,000	14,802	>20,000	9,854	>20,000	3,447	>20,000	3,447

† This receptor is outside the model domain and predictions of dilution are unavailable at or within its boundaries. Given the high levels of dilution predicted within the extent of the model domain (20 km) in the direction of Rankin Bank, and the remaining distance (~40 km) from the edge of the model domain to the receptor, it can be assumed that a minimum dilution level of >>20,000 will occur at or within the receptor boundaries at all percentiles.

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Table 3.58 Maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	16,137
	Transitional	9,829
	Winter	8,965
99th	Summer	22,551
	Transitional	15,322
	Winter	16,158
100th	Summer	22,925
	Transitional	16,685
	Winter	17,989

Table 3.59 Total area of coverage for 1:10,000 dilution in each season for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km²) of coverage for given dilution
95th	Summer	44.30
	Transitional	40.70
	Winter	36.20
99th	Summer	150.90
	Transitional	107.30
	Winter	90.50
100th	Summer	182.70
	Transitional	141.00
	Winter	109.80

Table 3.60 Maximum depth from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge).

Season	Maximum depth (m) from sea surface to achieve given dilution
Summer	117 (seabed)
Transitional	117 (seabed)
Winter	117 (seabed)

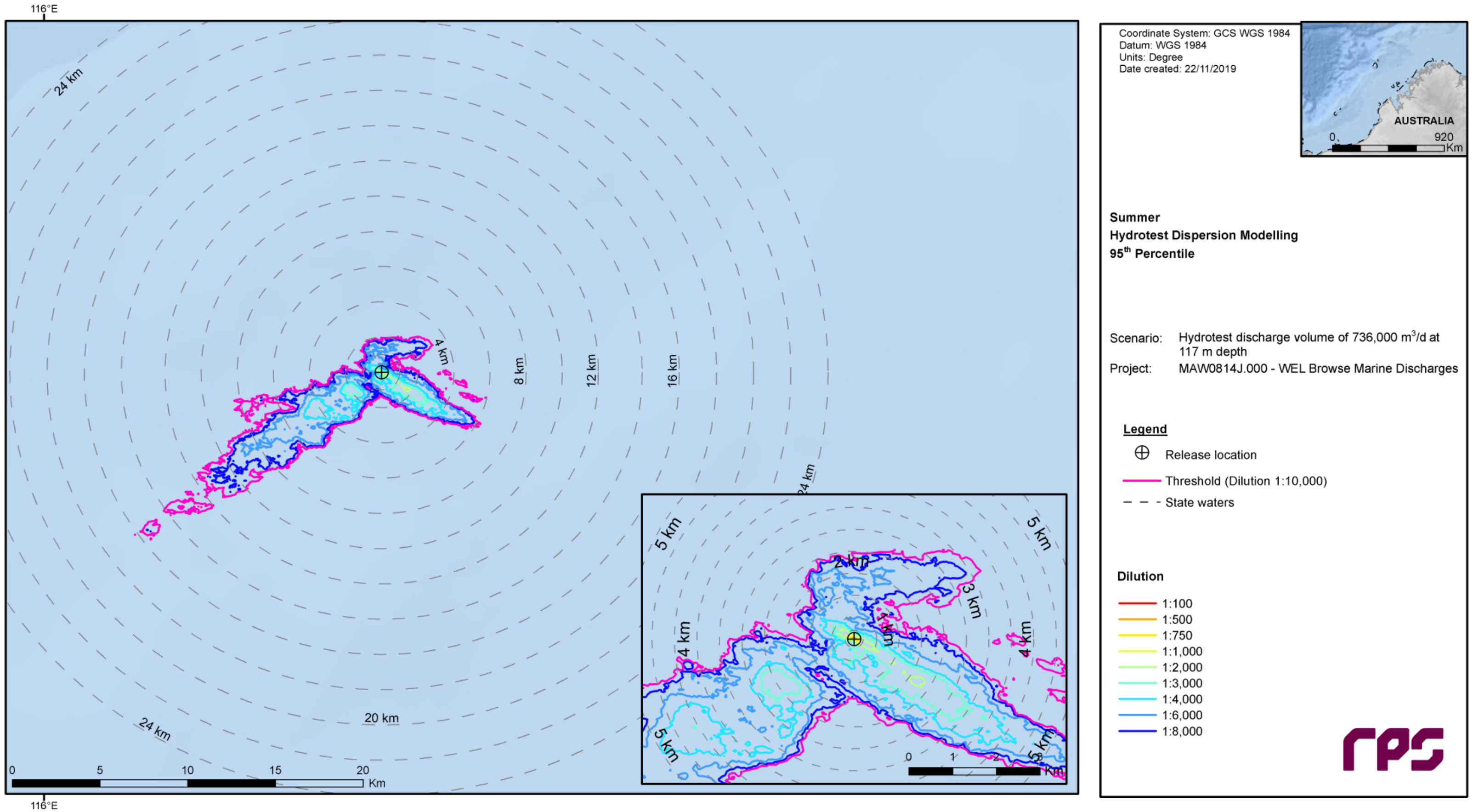

Figure 3.57 Predicted minimum dilutions at the 95th percentile under summer conditions for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

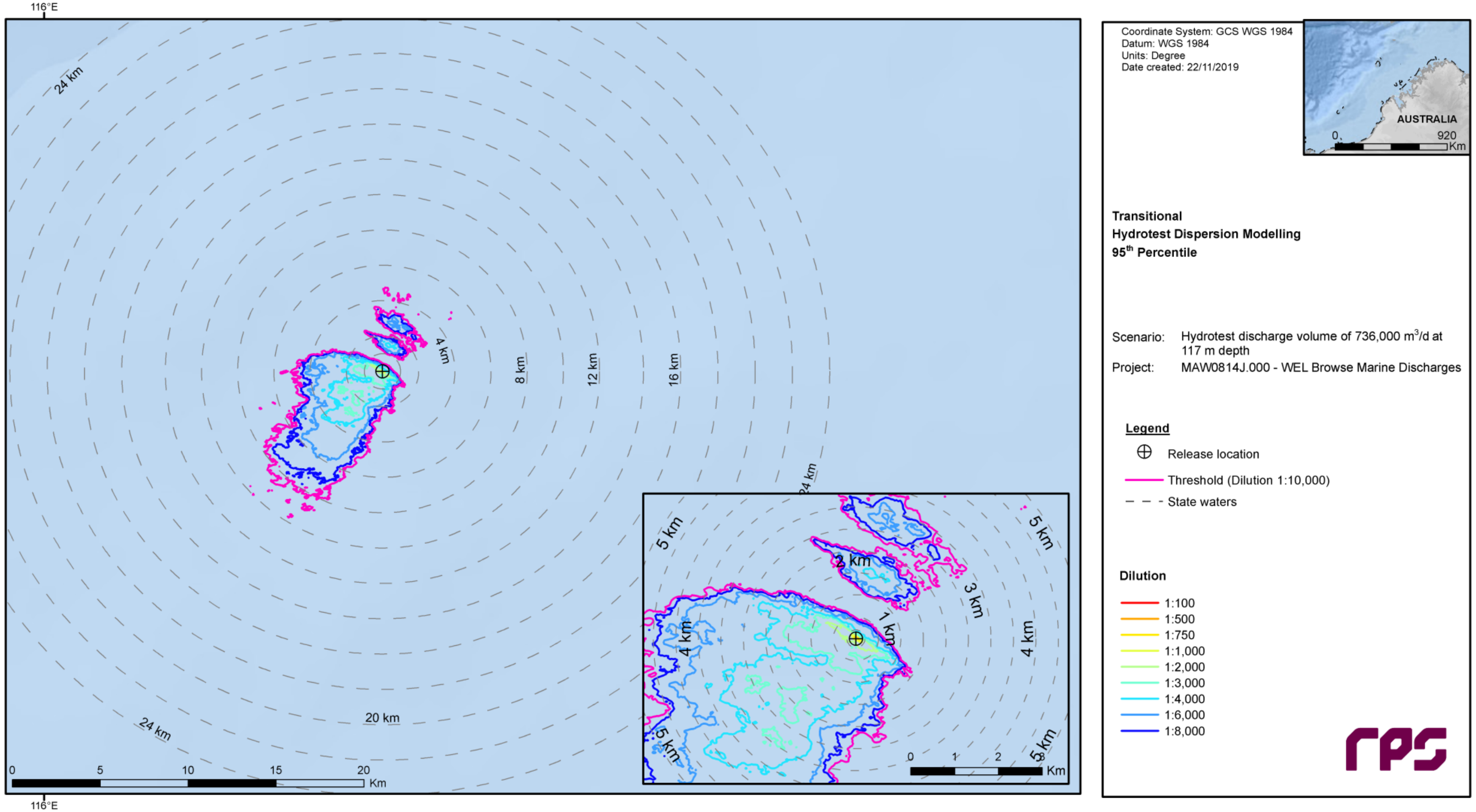

Figure 3.58 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

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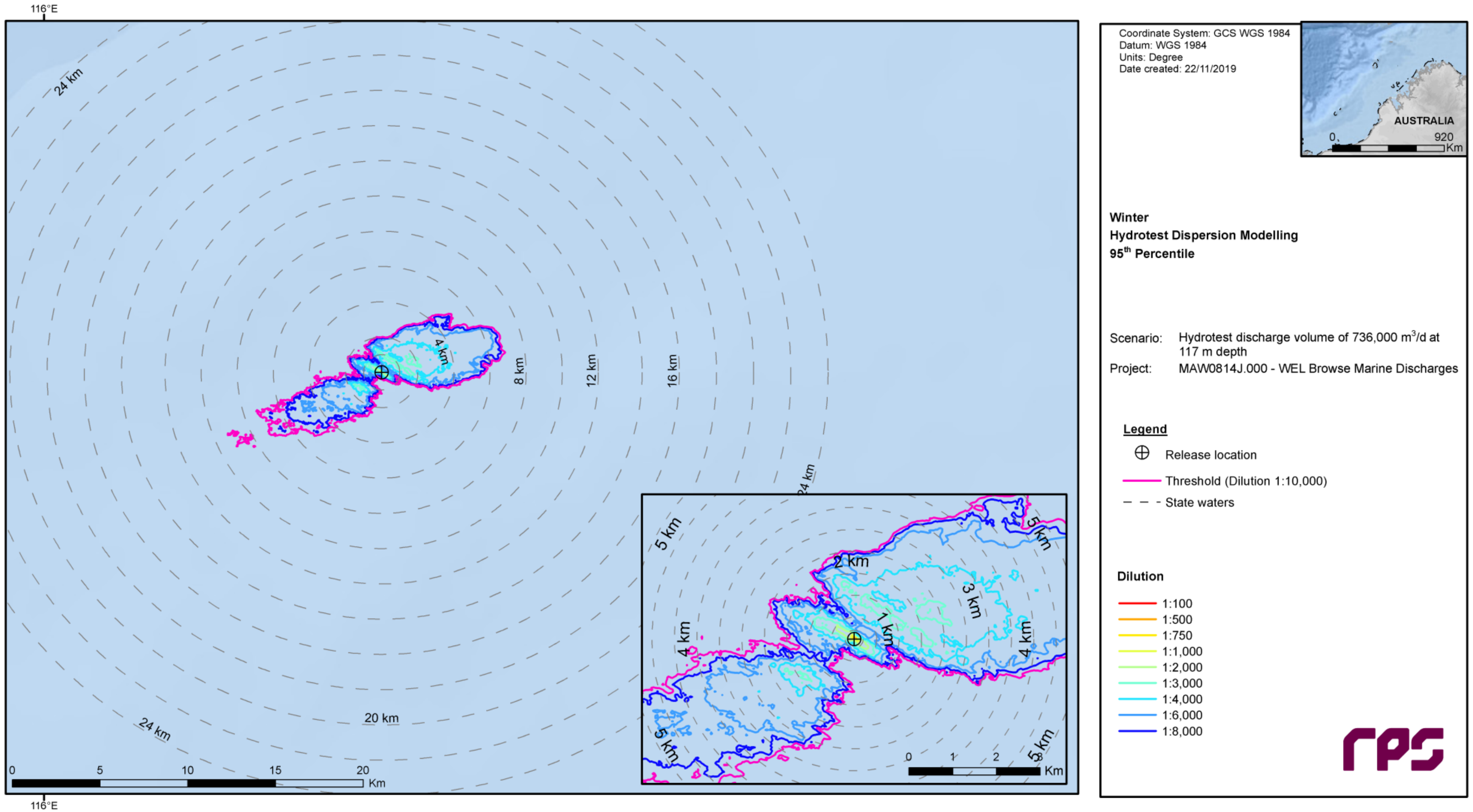

Figure 3.59 Predicted minimum dilutions at the 95th percentile under winter conditions for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

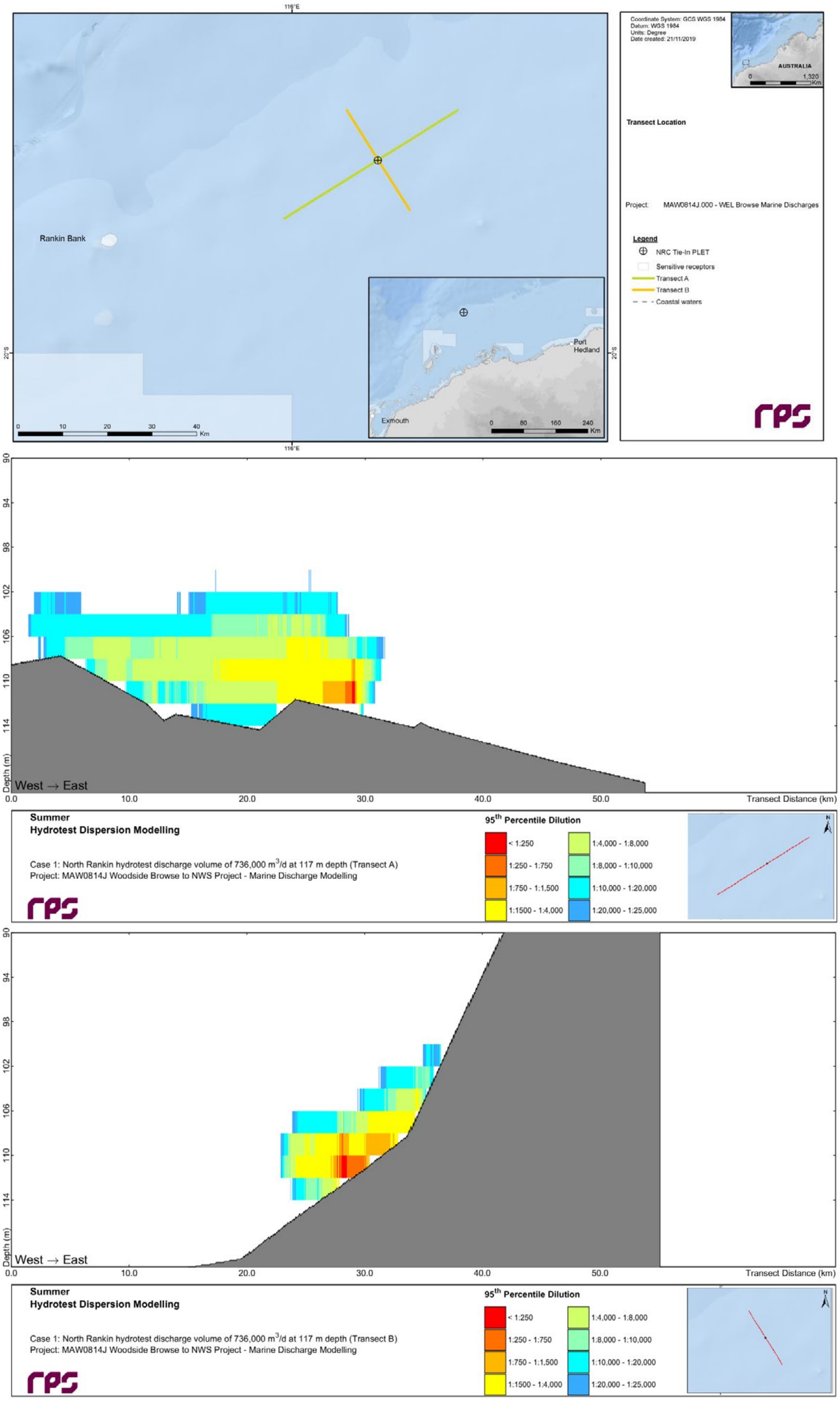

Figure 3.60 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.57.

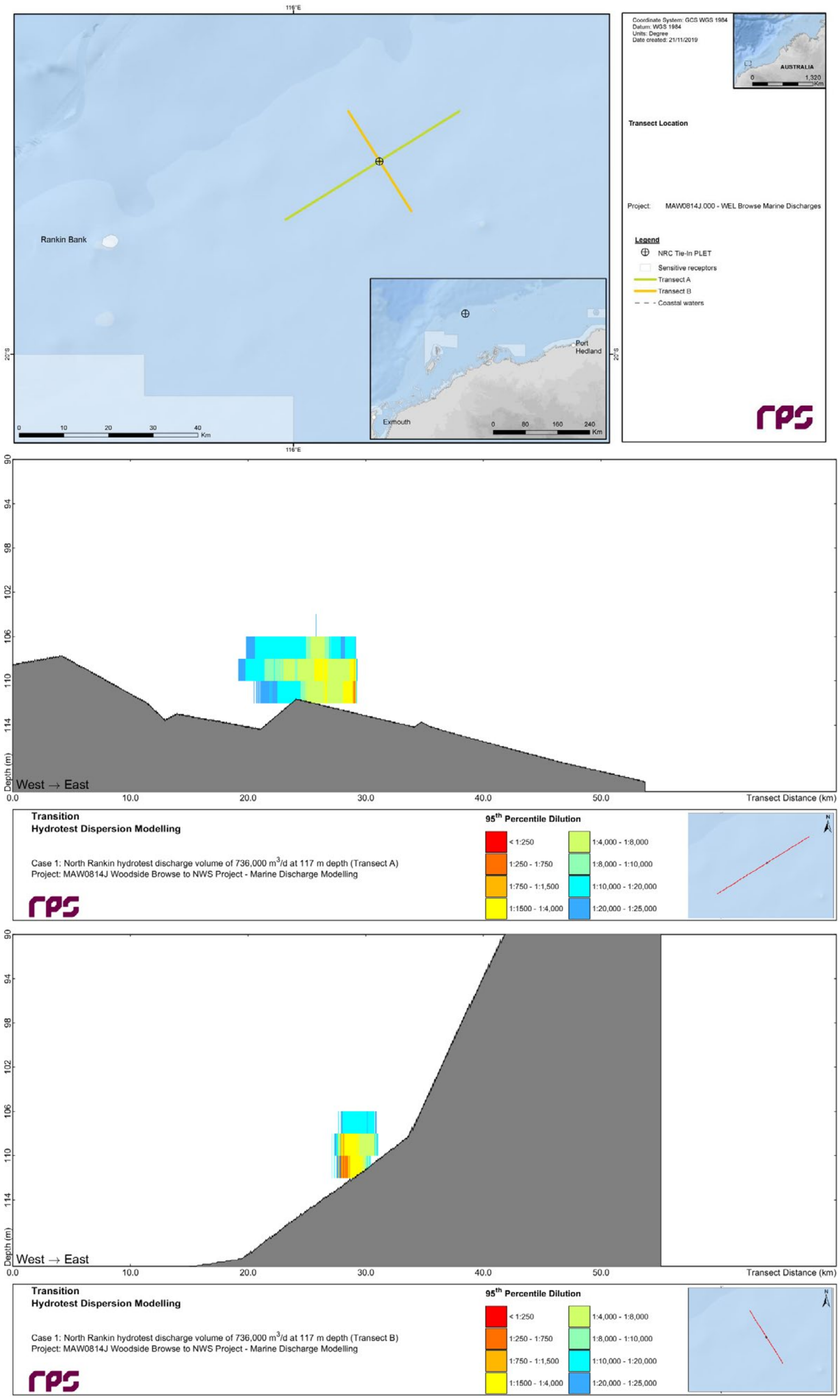

Figure 3.61 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.58.

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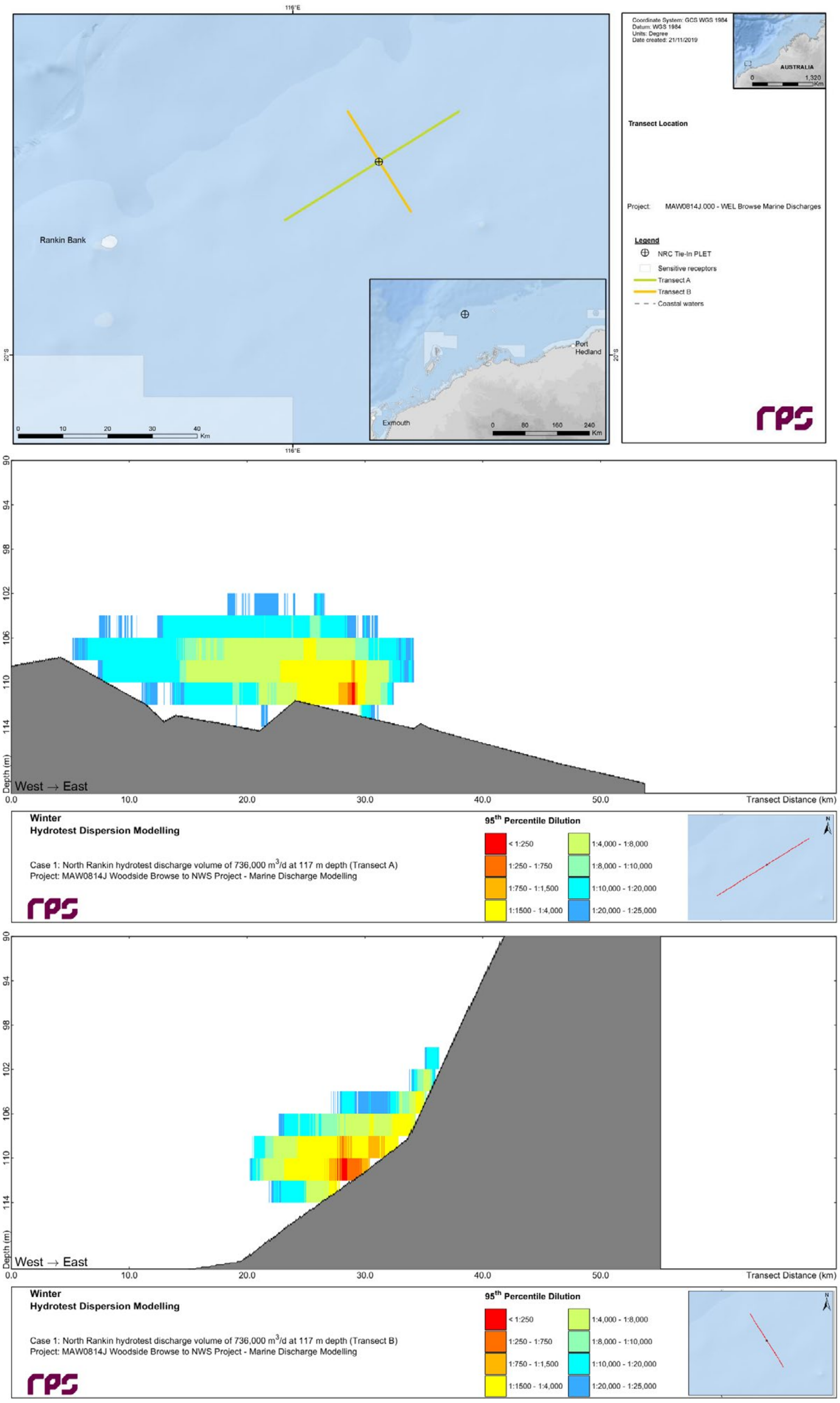

Figure 3.62 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.59.**

3.2.5.2.3 Discharge Case H2: Torosa PLET Hydrotest Discharge of 846,000 m³ at 461 m Depth

Table 3.61 Average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location in each season for Case H2 (Torosa PLET 846,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	>20,000	5,458	>20,000	3,635	>20,000	3,631	>20,000	4,440	>20,000	1,805	>20,000	1,633	>20,000	>20,000	>20,000	17,049	>20,000	13,688
20	1,155	1,078	724	692	618	571	785	743	573	546	545	523	1,627	1,606	1,395	1,349	1,352	1,324
50	1,108	896	697	602	583	532	753	626	556	516	527	491	1,629	1,553	1,371	1,224	1,293	1,098
100	1,049	800	660	540	584	469	723	560	549	458	514	426	1,636	1,380	1,197	899	1,134	861
200	1,114	661	646	484	551	415	806	433	575	322	530	297	1,731	1,094	1,434	626	1,279	612
300	1,075	618	642	396	593	354	840	382	583	253	528	245	1,571	825	1,248	525	1,142	486
400	1,052	507	700	389	654	371	855	388	642	262	559	243	1,593	822	1,272	551	1,219	498
500	1,149	434	786	311	735	303	935	364	712	239	606	230	1,584	822	1,281	527	1,225	527
600	1,264	271	825	232	780	205	1,074	289	771	232	650	214	1,777	648	1,494	532	1,414	468
700	1,477	299	920	249	859	240	1,265	453	892	236	737	230	2,024	933	1,520	631	1,442	631
800	1,457	91	941	74	864	69	1,311	117	958	95	775	91	2,344	338	1,510	260	1,443	248
900	1,776	441	1,046	341	986	295	1,489	561	1,079	356	920	332	3,398	1,039	1,644	846	1,595	835
1,000	1,711	292	1,108	272	1,024	256	1,662	608	1,161	250	975	238	6,568	1,085	1,694	901	1,627	810
1,100	2,103	340	1,139	293	1,093	280	1,832	735	1,260	379	1,069	340	9,996	1,188	1,755	919	1,695	783
1,200	1,893	410	1,161	275	1,081	264	1,995	725	1,388	599	1,180	528	>20,000	1,231	1,906	975	1,825	952
1,300	2,378	385	1,272	322	1,190	310	2,399	766	1,491	645	1,291	562	>20,000	1,466	2,163	1,080	2,057	1,003
1,400	2,369	466	1,318	274	1,170	272	2,985	800	1,588	666	1,387	590	>20,000	1,760	2,363	997	2,220	961
1,500	3,658	505	1,599	288	1,444	274	4,542	758	1,733	654	1,548	582	>20,000	2,099	2,681	1,076	2,557	1,036
1,600	3,820	484	1,508	317	1,268	310	6,851	797	1,818	648	1,594	627	>20,000	2,302	3,003	1,026	2,890	999
1,700	6,518	503	1,967	333	1,684	309	7,362	837	1,955	624	1,702	596	>20,000	2,350	3,506	1,050	3,384	1,004
1,800	7,709	536	1,798	341	1,510	336	16,707	920	2,075	615	1,844	567	>20,000	2,250	5,049	1,097	4,882	1,016
1,900	18,884	561	2,794	334	2,442	326	>20,000	960	2,261	619	1,998	586	>20,000	2,418	6,982	1,118	6,784	1,073
2,000	15,848	619	2,186	358	2,035	348	>20,000	1,012	2,419	740	2,132	654	>20,000	2,590	13,315	1,199	13,015	1,141
2,100	>20,000	654	2,835	369	2,622	366	>20,000	973	2,599	741	2,248	664	>20,000	2,579	>20,000	1,227	>20,000	1,142
2,200	>20,000	701	2,516	391	2,283	391	>20,000	972	2,734	802	2,382	636	>20,000	2,535	>20,000	1,249	>20,000	1,232
2,300	>20,000	734	3,543	422	3,189	422	>20,000	1,061	3,086	776	2,624	694	>20,000	2,642	>20,000	1,230	>20,000	1,211
2,400	>20,000	764	3,448	443	3,106	440	>20,000	1,083	3,343	790	2,838	750	>20,000	2,657	>20,000	1,316	>20,000	1,223
2,500	>20,000	811	5,856	490	5,286	484	>20,000	1,132	3,693	902	3,000	820	>20,000	2,845	>20,000	1,356	>20,000	1,263
2,600	>20,000	838	6,669	478	6,099	470	>20,000	1,153	4,007	965	3,228	920	>20,000	2,872	>20,000	1,431	>20,000	1,330
2,700	>20,000	827	>20,000	517	>20,000	508	>20,000	1,281	4,086	979	3,411	898	>20,000	3,122	>20,000	1,475	>20,000	1,406
2,800	>20,000	801	19,007	495	11,108	495	>20,000	1,415	4,150	1,062	3,496	1,006	>20,000	3,158	>20,000	1,534	>20,000	1,409
2,900	>20,000	825	>20,000	592	>20,000	592	>20,000	1,479	4,484	1,095	3,786	992	>20,000	3,108	>20,000	1,653	>20,000	1,502
3,000	>20,000	827	>20,000	610	>20,000	610	>20,000	1,563	4,524	1,113	3,785	989	>20,000	2,843	>20,000	1,849	>20,000	1,671
3,100	>20,000	877	>20,000	667	>20,000	653	>20,000	1,586	5,025	1,209	4,168	1,075	>20,000	3,038	>20,000	1,833	>20,000	1,733
3,200	>20,000	898	>20,000	676	>20,000	661	>20,000	1,703	5,134	1,135	4,255	946	>20,000	3,261	>20,000	2,018	>20,000	1,852
3,300	>20,000	919	>20,000	680	>20,000	651	>20,000	1,768	5,586	1,059	4,595	1,006	>20,000	3,225	>20,000	2,238	>20,000	1,899
3,400	>20,000	936	>20,000	723	>20,000	670	>20,000	1,833	5,721	1,032	4,763	1,032	>20,000	3,318	>20,000	2,179	>20,000	1,919

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	961	>20,000	749	>20,000	726	>20,000	1,918	6,472	1,092	5,443	1,092	>20,000	3,467	>20,000	1,931	>20,000	1,797
3,600	>20,000	973	>20,000	769	>20,000	744	>20,000	1,930	6,428	1,244	5,588	1,170	>20,000	3,417	>20,000	1,938	>20,000	1,672
3,700	>20,000	971	>20,000	844	>20,000	815	>20,000	2,042	6,820	1,270	5,810	1,154	>20,000	3,733	>20,000	2,433	>20,000	1,947
3,800	>20,000	1,035	>20,000	882	>20,000	833	>20,000	2,077	7,159	1,281	5,958	1,153	>20,000	4,326	>20,000	2,650	>20,000	2,435
3,900	>20,000	1,095	>20,000	883	>20,000	834	>20,000	2,069	7,789	1,340	6,631	1,129	>20,000	4,993	>20,000	2,779	>20,000	2,662
4,000	>20,000	1,092	>20,000	904	>20,000	863	>20,000	2,162	9,795	1,538	7,253	1,304	>20,000	4,866	>20,000	2,812	>20,000	2,338
4,100	>20,000	1,127	>20,000	909	>20,000	861	>20,000	2,273	16,720	1,622	7,871	1,350	>20,000	5,320	>20,000	3,137	>20,000	2,790
4,200	>20,000	1,187	>20,000	927	>20,000	917	>20,000	2,420	>20,000	1,534	9,750	1,417	>20,000	5,487	>20,000	2,933	>20,000	2,443
4,300	>20,000	1,157	>20,000	940	>20,000	903	>20,000	2,592	>20,000	1,653	13,429	1,392	>20,000	6,131	>20,000	3,229	>20,000	2,996
4,400	>20,000	1,177	>20,000	942	>20,000	899	>20,000	2,776	>20,000	1,641	19,452	1,508	>20,000	5,974	>20,000	3,163	>20,000	2,712
4,500	>20,000	1,232	>20,000	975	>20,000	971	>20,000	2,948	>20,000	1,704	>20,000	1,460	>20,000	6,572	>20,000	3,540	>20,000	3,061
4,600	>20,000	1,266	>20,000	990	>20,000	983	>20,000	2,941	19,797	1,736	>20,000	1,503	>20,000	6,772	>20,000	3,209	>20,000	2,836
4,700	>20,000	1,312	>20,000	1,000	>20,000	966	>20,000	2,973	>20,000	1,756	>20,000	1,552	>20,000	6,878	>20,000	3,824	>20,000	3,147
4,800	>20,000	1,367	>20,000	1,062	>20,000	990	>20,000	2,983	>20,000	1,666	>20,000	1,578	>20,000	6,533	>20,000	3,627	>20,000	3,085
4,900	>20,000	1,356	>20,000	1,166	>20,000	1,040	>20,000	3,089	>20,000	1,692	>20,000	1,569	>20,000	6,649	>20,000	4,278	>20,000	3,430
5,000	>20,000	1,433	>20,000	1,147	>20,000	1,126	>20,000	3,263	>20,000	1,744	>20,000	1,542	>20,000	7,169	>20,000	4,174	>20,000	3,407
5,500	>20,000	1,709	>20,000	1,099	>20,000	1,053	>20,000	2,824	>20,000	2,044	>20,000	1,816	>20,000	6,251	>20,000	4,433	>20,000	3,581
6,000	>20,000	2,499	>20,000	1,267	>20,000	1,253	>20,000	3,563	>20,000	2,264	>20,000	1,788	>20,000	5,487	>20,000	3,452	>20,000	3,154
6,500	>20,000	3,378	>20,000	1,318	>20,000	1,279	>20,000	4,575	>20,000	2,490	>20,000	2,233	>20,000	6,558	>20,000	3,153	>20,000	3,028
7,000	>20,000	3,415	>20,000	1,375	>20,000	1,364	>20,000	4,705	>20,000	2,943	>20,000	2,897	>20,000	8,080	>20,000	3,708	>20,000	3,708
7,500	>20,000	4,097	>20,000	1,603	>20,000	1,343	>20,000	5,401	>20,000	2,921	>20,000	2,832	>20,000	9,916	>20,000	3,262	>20,000	3,262
8,000	>20,000	4,260	>20,000	1,838	>20,000	1,357	>20,000	6,053	>20,000	2,898	>20,000	2,850	>20,000	10,340	>20,000	2,824	>20,000	2,824
8,500	>20,000	5,139	>20,000	1,992	>20,000	1,778	>20,000	5,583	>20,000	2,865	>20,000	2,591	>20,000	10,489	>20,000	2,446	>20,000	2,446
9,000	>20,000	5,771	>20,000	2,228	>20,000	2,040	>20,000	6,144	>20,000	2,582	>20,000	2,582	>20,000	14,289	>20,000	2,196	>20,000	2,196
9,500	>20,000	5,848	>20,000	2,646	>20,000	2,500	>20,000	6,882	>20,000	2,614	>20,000	2,614	>20,000	14,114	>20,000	2,080	>20,000	1,997
10,000	>20,000	7,837	>20,000	2,543	>20,000	2,506	>20,000	7,382	>20,000	2,763	>20,000	2,763	>20,000	13,940	>20,000	2,396	>20,000	2,150
10,500	>20,000	7,331	>20,000	2,618	>20,000	2,618	>20,000	7,757	>20,000	2,751	>20,000	2,751	>20,000	12,248	>20,000	3,044	>20,000	2,332
11,000	>20,000	9,182	>20,000	2,611	>20,000	2,611	>20,000	8,233	>20,000	2,611	>20,000	2,611	>20,000	11,943	>20,000	4,979	>20,000	2,382
11,500	>20,000	9,742	>20,000	3,389	>20,000	2,946	>20,000	8,606	>20,000	2,700	>20,000	2,700	>20,000	14,753	>20,000	7,075	>20,000	2,971
12,000	>20,000	12,750	>20,000	3,287	>20,000	3,287	>20,000	10,586	>20,000	3,220	>20,000	3,220	>20,000	>20,000	>20,000	9,657	>20,000	4,603
12,500	>20,000	9,813	>20,000	3,039	>20,000	3,039	>20,000	13,141	>20,000	3,506	>20,000	3,506	>20,000	>20,000	>20,000	11,476	>20,000	6,736
13,000	>20,000	14,773	>20,000	3,218	>20,000	2,645	>20,000	13,043	>20,000	3,873	>20,000	3,873	>20,000	>20,000	>20,000	11,570	>20,000	10,298
13,500	>20,000	16,076	>20,000	3,558	>20,000	2,954	>20,000	17,355	>20,000	3,681	>20,000	3,681	>20,000	>20,000	>20,000	14,334	>20,000	13,501
14,000	>20,000	17,912	>20,000	4,504	>20,000	4,102	>20,000	>20,000	>20,000	3,852	>20,000	3,852	>20,000	>20,000	>20,000	16,087	>20,000	14,850
14,500	>20,000	>20,000	>20,000	4,824	>20,000	3,729	>20,000	>20,000	>20,000	4,087	>20,000	4,087	>20,000	>20,000	>20,000	16,118	>20,000	14,576
15,000	>20,000	>20,000	>20,000	5,529	>20,000	3,814	>20,000	>20,000	>20,000	4,011	>20,000	4,011	>20,000	>20,000	>20,000	15,242	>20,000	14,677
15,500	>20,000	>20,000	>20,000	6,176	>20,000	5,318	>20,000	>20,000	>20,000	3,617	>20,000	3,617	>20,000	>20,000	>20,000	15,483	>20,000	14,598
16,000	>20,000	19,435	>20,000	9,973	>20,000	4,574	>20,000	>20,000	>20,000	4,011	>20,000	4,011	>20,000	>20,000	>20,000	18,962	>20,000	16,699
16,500	>20,000	19,642	>20,000	9,086	>20,000	4,014	>20,000	>20,000	>20,000	4,190	>20,000	4,190	>20,000	>20,000	>20,000	>20,000	>20,000	17,591
17,000	>20,000	>20,000	>20,000	8,607	>20,000	5,338	>20,000	>20,000	>20,000	4,605	>20,000	4,605	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
17,500	>20,000	16,380	>20,000	9,961	>20,000	4,674	>20,000	>20,000	>20,000	5,229	>20,000	5,132	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,000	>20,000	15,789	>20,000	11,302	>20,000	5,614	>20,000	>20,000	>20,000	5,435	>20,000	5,265	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,500	>20,000	17,692	>20,000	10,869	>20,000	7,902	>20,000	>20,000	>20,000	4,904	>20,000	4,904	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
19,000	>20,000	>20,000	>20,000	12,354	>20,000	10,458	>20,000	>20,000	>20,000	5,183	>20,000	5,143	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	>20,000	>20,000	14,338	>20,000	11,667	>20,000	>20,000	>20,000	6,873	>20,000	6,648	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
20,000	>20,000	>20,000	>20,000	13,964	>20,000	13,515	>20,000	>20,000	>20,000	6,826	>20,000	6,787	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

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Table 3.62 Maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H2 (Torosa PLET 846,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	12,496
	Transitional	11,855
	Winter	7,983
99th	Summer	17,703
	Transitional	20,555
	Winter	12,184
100th	Summer	18,920
	Transitional	20,723
	Winter	12,958

Table 3.63 Total area of coverage for 1:10,000 dilution in each season for Case H2 (Torosa PLET 846,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km²) of coverage for given dilution
95th	Summer	74.60
	Transitional	42.70
	Winter	30.70
99th	Summer	140.60
	Transitional	194.40
	Winter	70.00
100th	Summer	164.80
	Transitional	224.60
	Winter	84.90

Table 3.64 Maximum depth from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H2 (Torosa PLET 846,000 m³ hydrotest discharge).

Season	Maximum depth (m) from sea surface to achieve given dilution
Summer	461 (seabed)
Transitional	461 (seabed)
Winter	461 (seabed)

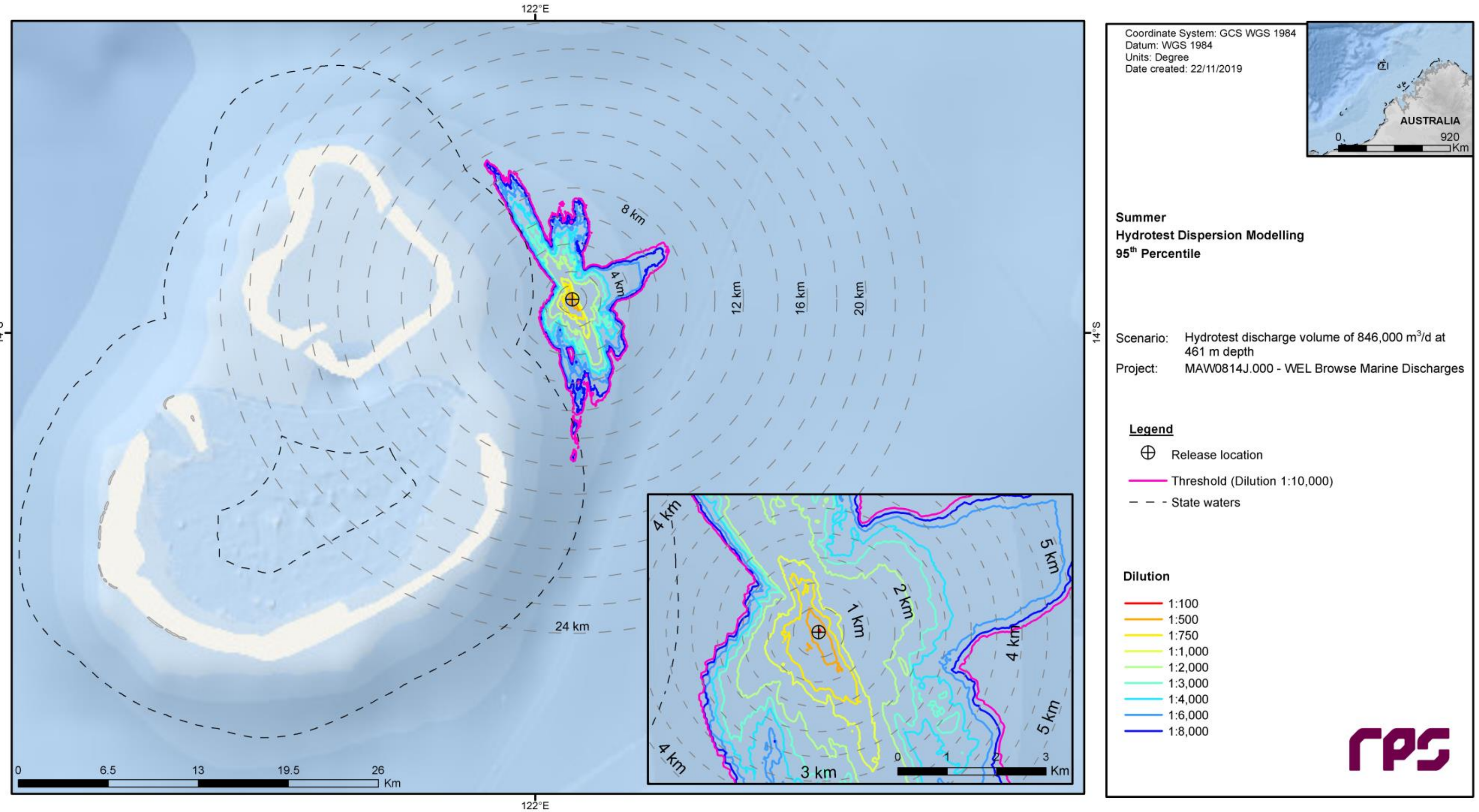

Figure 3.63 Predicted minimum dilutions at the 95th percentile under summer conditions for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

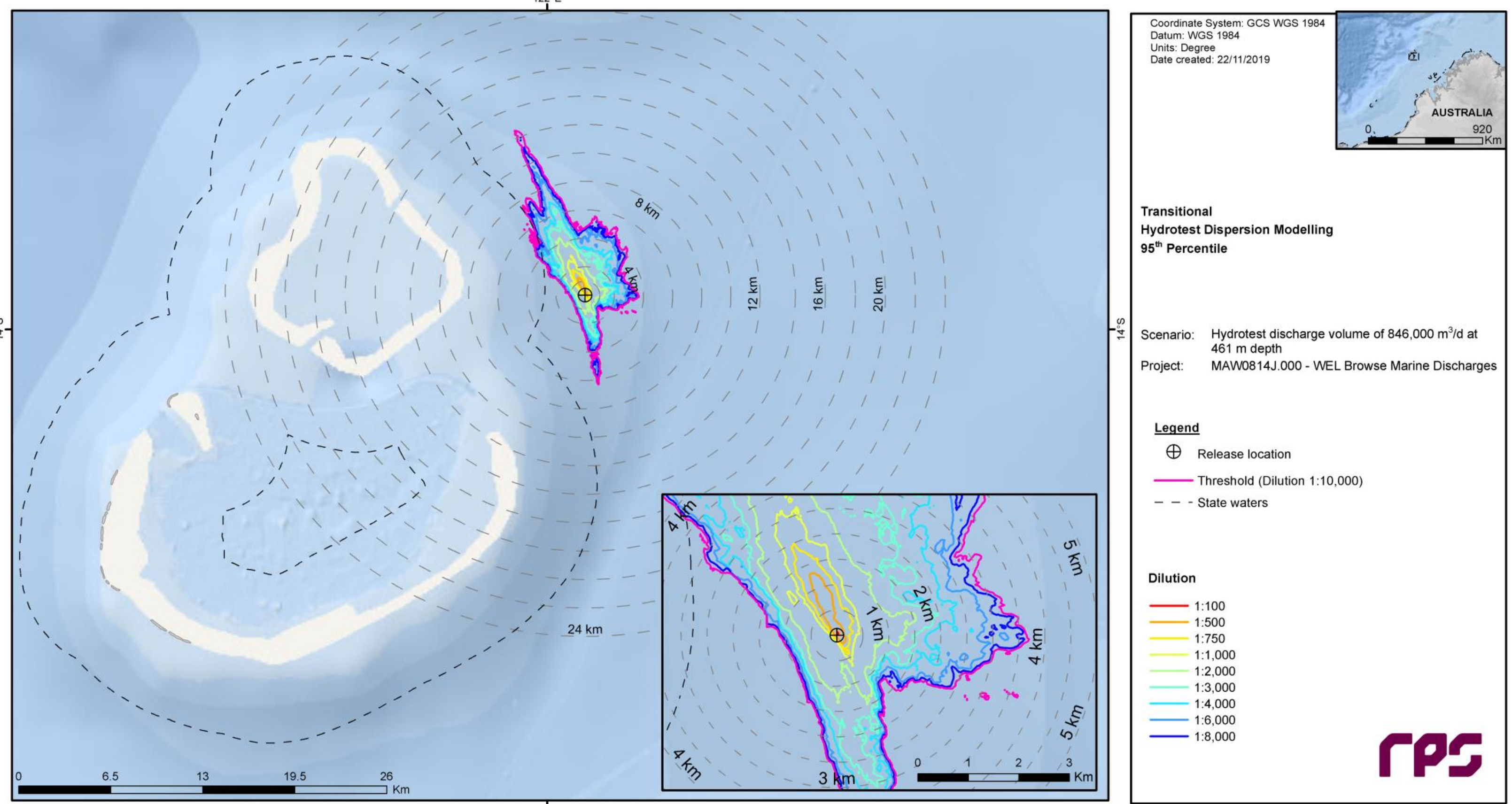

Figure 3.64 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

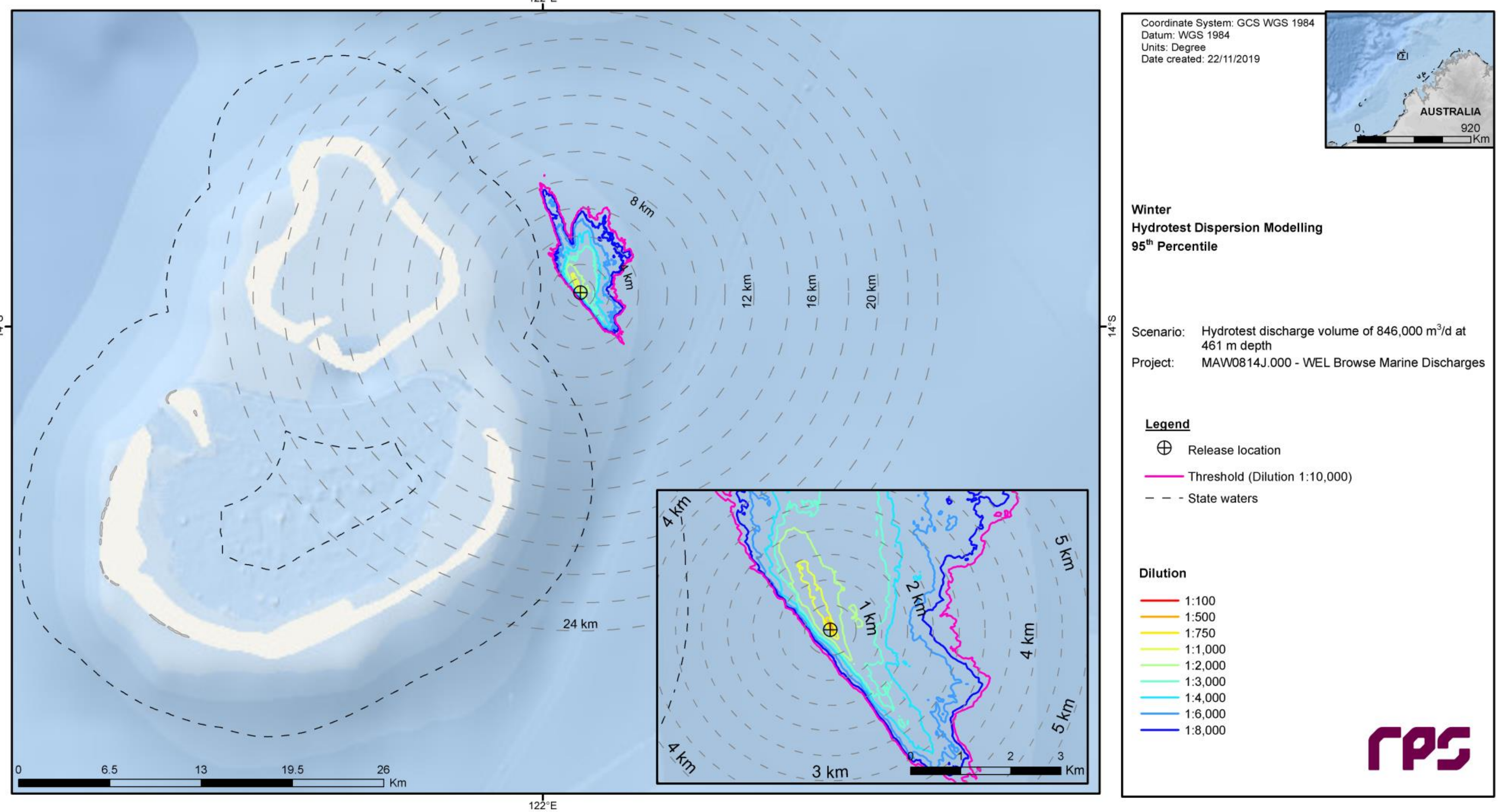

Figure 3.65 Predicted minimum dilutions at the 95th percentile under winter conditions for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

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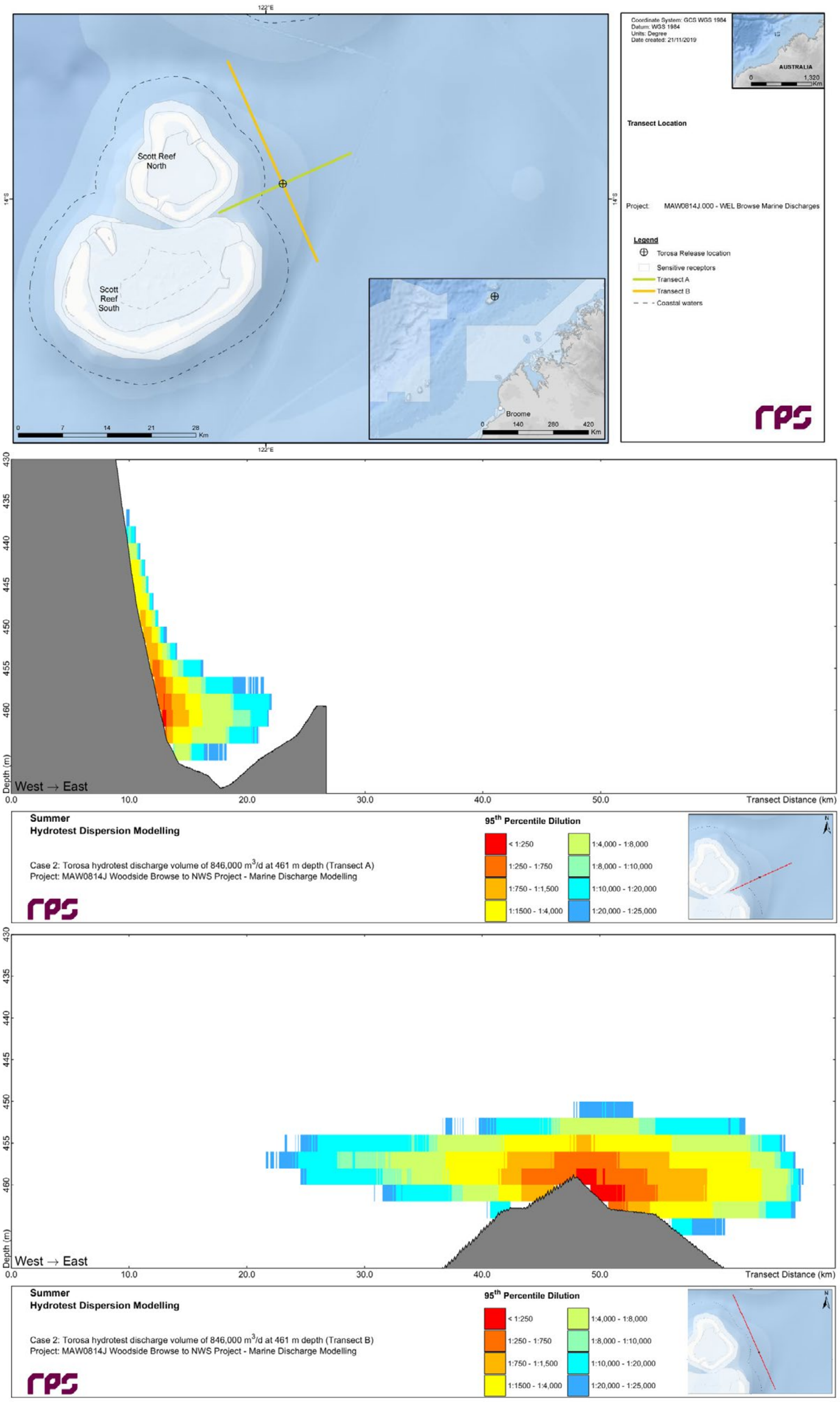

Figure 3.66 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case H2 (Torosa PLET 846,000 m³ hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.63.

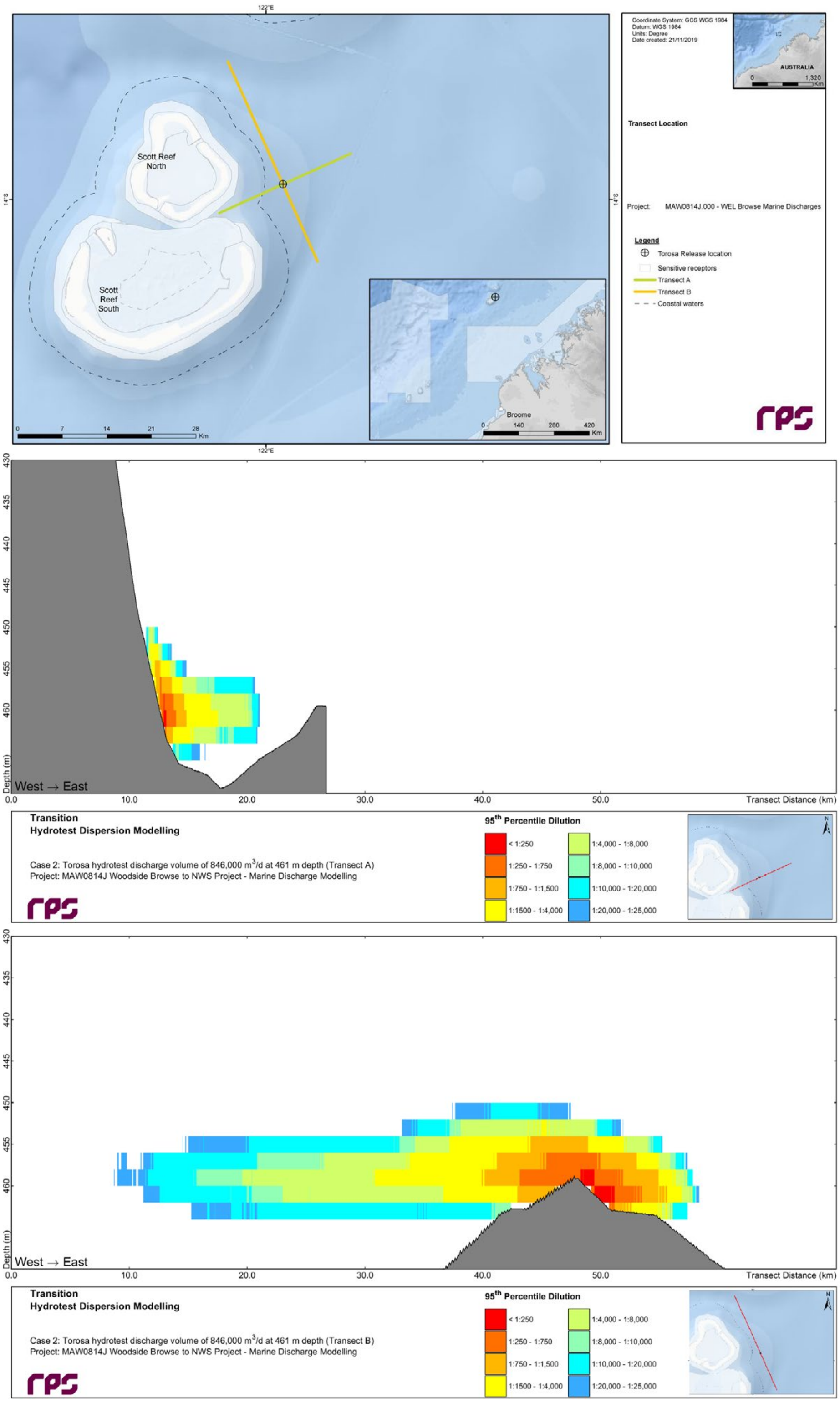

Figure 3.67 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.64.

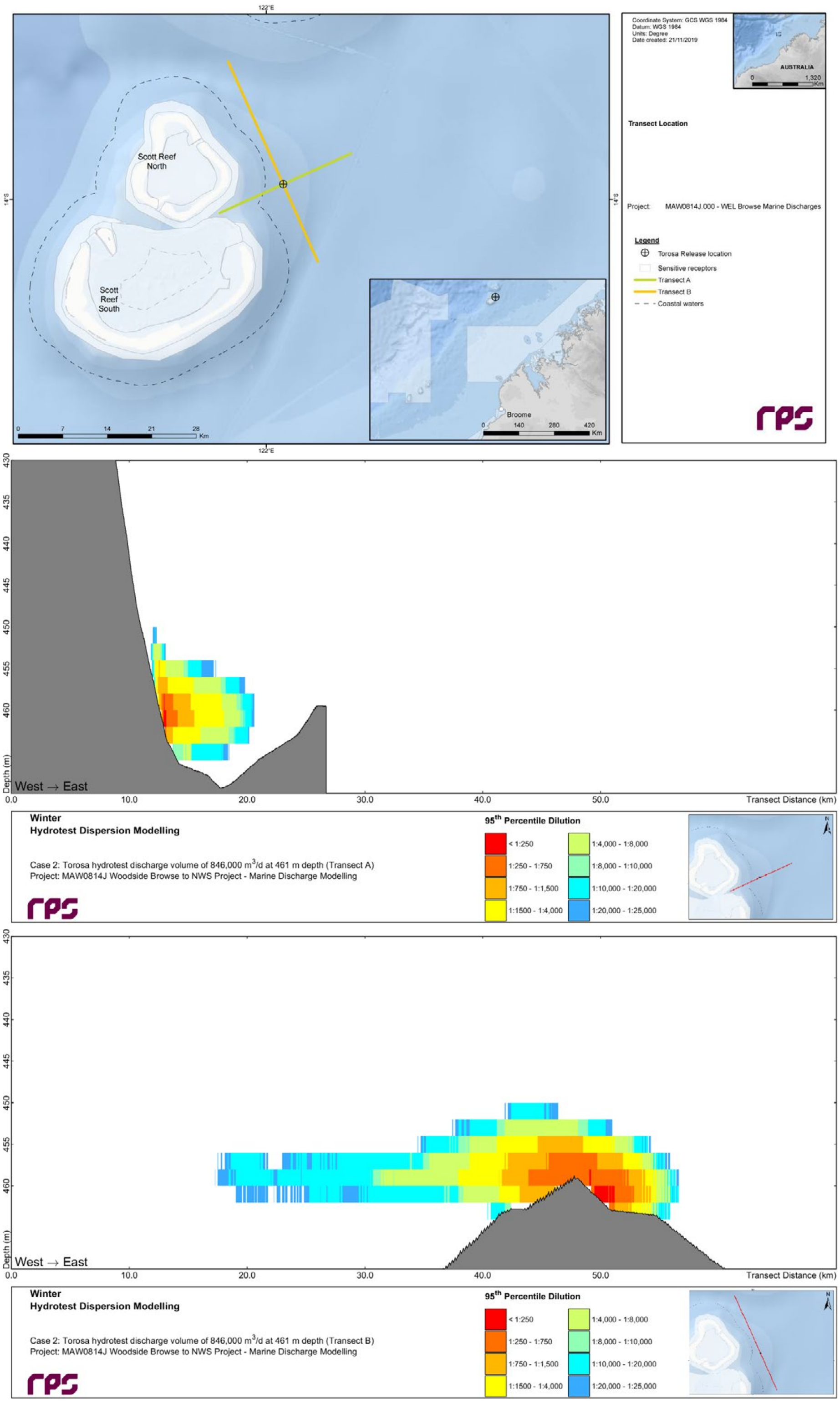

Figure 3.68 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.65.

3.2.5.2.4 Discharge Case H3a: Brecknock/Calliance PLET Hydrotest Discharge of 790,000 m³ at 539 m Depth

Table 3.65 Average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location in each season for Case H3a (Brecknock/Calliance PLET 790,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary) †	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000
20	508	508	353	353	324	324	1,066	1,066	366	366	318	318	1,520	1,520	1,014	1,014	522	522
50	826	74	465	72	398	71	1,342	87	831	74	629	73	1,797	90	1,443	80	1,130	79
100	1,611	334	1,072	165	838	139	1,954	411	1,217	157	986	145	2,856	1,412	2,019	440	1,796	296
200	2,285	1,513	1,396	412	1,141	371	2,024	1,291	1,313	321	1,026	267	3,825	1,616	2,420	1,179	2,302	1,001
300	3,081	1,780	2,049	663	1,709	634	2,356	1,371	1,747	703	1,511	593	4,927	2,140	3,330	1,620	3,016	1,450
400	3,085	1,874	1,899	646	1,596	622	2,302	1,445	1,572	1,014	1,316	781	4,878	2,246	3,460	1,871	3,168	1,592
500	3,475	2,192	2,176	776	1,855	709	2,712	1,562	1,695	1,020	1,500	912	5,428	2,531	3,820	1,788	3,356	1,747
600	3,508	2,210	2,229	910	1,966	860	2,652	1,580	1,613	877	1,384	778	5,873	2,885	3,786	1,981	3,446	1,823
700	3,868	2,298	2,376	1,014	2,022	780	3,070	1,847	1,955	985	1,672	972	6,567	2,644	3,828	1,979	3,418	1,841
800	3,743	2,167	2,428	1,162	2,119	840	3,128	1,559	1,962	862	1,579	840	8,172	2,592	4,021	1,936	3,540	1,629
900	3,993	2,277	2,631	1,281	2,294	866	3,569	1,850	2,301	1,041	1,912	1,041	9,493	2,356	4,126	1,674	3,674	1,517
1,000	4,041	2,363	2,710	1,130	2,436	942	3,766	1,609	2,374	1,051	1,887	992	10,720	2,269	3,924	1,806	3,506	1,517
1,100	4,276	2,189	2,905	1,197	2,649	959	4,133	1,979	2,676	931	2,197	864	14,246	2,208	3,941	1,612	3,541	1,416
1,200	4,248	2,128	2,992	922	2,732	881	4,395	1,856	2,793	1,006	2,215	921	>20,000	2,304	3,836	1,578	3,422	1,355
1,300	4,621	2,081	3,016	1,091	2,759	993	4,876	1,924	3,044	1,003	2,628	1,003	>20,000	2,342	4,105	1,536	3,610	1,283
1,400	4,886	1,960	3,086	953	2,827	888	5,012	1,913	3,129	1,383	2,715	1,232	>20,000	2,188	4,059	1,456	3,499	1,109
1,500	5,561	2,235	3,173	874	2,861	822	6,099	2,084	3,506	1,309	3,001	1,258	>20,000	2,145	4,473	1,541	3,810	1,167
1,600	5,507	2,188	3,084	820	2,822	753	6,602	2,230	3,765	1,304	3,238	1,304	>20,000	2,083	4,336	1,424	3,804	1,204
1,700	6,407	2,327	3,371	772	3,063	726	10,432	2,296	4,069	1,250	3,476	1,159	>20,000	2,163	5,201	1,300	4,185	1,163
1,800	6,067	2,168	3,358	787	3,066	726	11,269	2,409	4,543	1,213	3,882	1,033	>20,000	2,375	5,598	1,363	4,393	1,197
1,900	6,939	2,121	3,762	811	3,344	772	>20,000	2,558	4,830	1,199	4,126	1,107	>20,000	2,011	7,887	1,321	5,363	1,161
2,000	6,825	2,088	3,634	783	3,332	783	>20,000	2,429	5,013	1,185	4,307	921	>20,000	2,172	9,393	1,215	6,307	1,150
2,100	7,987	2,169	4,179	862	3,758	862	>20,000	2,461	5,610	1,265	4,562	1,010	>20,000	2,198	14,586	1,262	10,058	1,155
2,200	8,132	2,057	4,138	971	3,749	971	>20,000	2,563	5,340	1,257	4,381	976	>20,000	2,128	19,283	1,367	11,468	1,237
2,300	9,429	2,166	4,578	1,117	4,119	1,071	>20,000	2,601	6,462	1,448	4,944	1,116	>20,000	2,279	>20,000	1,407	17,353	1,307
2,400	9,949	2,382	4,508	1,085	4,035	1,058	>20,000	2,750	6,175	1,330	4,936	1,225	>20,000	2,247	>20,000	1,474	>20,000	1,324
2,500	11,729	2,567	4,985	1,232	4,370	1,159	>20,000	2,682	8,091	1,485	5,299	1,310	>20,000	2,513	>20,000	1,525	>20,000	1,327
2,600	12,902	2,590	4,967	1,372	4,422	1,272	>20,000	2,943	7,807	1,391	5,408	1,264	>20,000	2,265	>20,000	1,636	>20,000	1,472
2,700	14,779	2,683	5,544	1,654	4,818	1,498	>20,000	3,040	11,029	1,625	5,732	1,393	>20,000	2,570	>20,000	1,700	>20,000	1,501
2,800	17,003	2,854	5,623	1,833	4,913	1,643	>20,000	3,445	10,830	1,766	6,024	1,584	>20,000	2,724	>20,000	1,653	>20,000	1,626
2,900	18,629	2,889	5,880	1,726	5,036	1,588	>20,000	3,283	>20,000	1,641	6,587	1,565	>20,000	2,563	>20,000	1,664	>20,000	1,630
3,000	>20,000	2,837	6,011	1,810	5,169	1,629	>20,000	3,470	15,471	1,964	6,961	1,705	>20,000	2,660	>20,000	1,707	>20,000	1,643
3,100	>20,000	2,910	6,083	1,753	5,255	1,638	>20,000	4,532	>20,000	1,993	7,447	1,719	>20,000	2,744	>20,000	1,665	>20,000	1,568
3,200	>20,000	2,988	6,368	1,709	5,531	1,549	>20,000	4,433	>20,000	1,868	7,602	1,575	>20,000	2,905	>20,000	1,776	>20,000	1,688
3,300	>20,000	2,941	6,538	1,784	5,592	1,514	>20,000	4,457	>20,000	1,844	8,648	1,582	>20,000	3,022	>20,000	1,805	>20,000	1,637
3,400	>20,000	3,048	7,261	1,853	6,093	1,754	>20,000	4,343	>20,000	1,867	8,886	1,473	>20,000	3,306	>20,000	1,877	>20,000	1,776

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	3,059	7,582	1,737	6,234	1,723	>20,000	4,568	>20,000	1,832	10,689	1,428	>20,000	3,210	>20,000	1,865	>20,000	1,687
3,600	>20,000	3,092	8,550	1,636	6,797	1,578	>20,000	4,677	>20,000	2,188	11,249	1,422	>20,000	3,392	>20,000	1,868	>20,000	1,799
3,700	>20,000	3,138	9,211	1,593	6,975	1,512	>20,000	4,946	>20,000	2,346	15,034	1,803	>20,000	3,407	>20,000	1,868	>20,000	1,796
3,800	>20,000	3,205	10,248	1,671	7,798	1,644	>20,000	5,268	>20,000	2,309	17,936	1,924	>20,000	3,548	>20,000	1,799	>20,000	1,741
3,900	>20,000	3,196	11,207	1,685	8,073	1,672	>20,000	5,244	>20,000	2,274	>20,000	2,023	>20,000	3,766	>20,000	1,738	>20,000	1,665
4,000	>20,000	3,134	12,363	1,758	8,948	1,749	>20,000	5,305	>20,000	2,309	>20,000	2,058	>20,000	3,589	>20,000	1,799	>20,000	1,717
4,100	>20,000	3,150	13,381	1,788	10,118	1,786	>20,000	5,739	>20,000	2,247	>20,000	2,071	>20,000	4,034	>20,000	1,729	>20,000	1,676
4,200	>20,000	3,089	14,306	1,995	11,234	1,954	>20,000	5,299	>20,000	2,194	>20,000	2,040	>20,000	4,173	>20,000	1,766	>20,000	1,720
4,300	>20,000	3,164	15,387	2,093	11,927	1,989	>20,000	4,824	>20,000	2,052	>20,000	1,965	>20,000	4,156	>20,000	1,893	>20,000	1,739
4,400	>20,000	3,028	16,818	2,375	12,763	2,261	>20,000	5,121	>20,000	2,056	>20,000	1,954	>20,000	4,195	>20,000	1,867	>20,000	1,744
4,500	>20,000	3,225	>20,000	2,382	15,095	2,294	>20,000	5,077	>20,000	2,132	>20,000	2,042	>20,000	4,335	>20,000	1,949	>20,000	1,711
4,600	>20,000	3,185	>20,000	2,678	15,482	2,414	>20,000	5,028	>20,000	2,095	>20,000	2,046	>20,000	4,343	>20,000	1,930	>20,000	1,724
4,700	>20,000	3,287	>20,000	2,671	18,224	2,660	>20,000	5,548	>20,000	1,993	>20,000	1,930	>20,000	4,510	>20,000	2,010	>20,000	1,833
4,800	>20,000	3,303	>20,000	2,752	18,952	2,749	>20,000	5,752	>20,000	2,028	>20,000	1,964	>20,000	4,561	>20,000	2,137	>20,000	1,869
4,900	>20,000	3,642	>20,000	2,552	>20,000	2,552	>20,000	4,988	>20,000	2,273	>20,000	1,977	>20,000	4,639	>20,000	2,122	>20,000	1,924
5,000	>20,000	3,924	>20,000	2,392	>20,000	2,392	>20,000	4,912	>20,000	2,360	>20,000	2,240	>20,000	4,717	>20,000	2,132	>20,000	1,981
5,500	>20,000	4,260	>20,000	2,917	>20,000	2,917	>20,000	5,473	>20,000	2,994	>20,000	2,218	>20,000	5,440	>20,000	2,119	>20,000	1,921
6,000	>20,000	4,650	>20,000	3,295	>20,000	3,009	>20,000	8,198	>20,000	3,130	>20,000	3,002	>20,000	6,786	>20,000	2,321	>20,000	2,028
6,500	>20,000	4,880	>20,000	4,189	>20,000	4,008	>20,000	7,996	>20,000	3,624	>20,000	2,808	>20,000	6,708	>20,000	2,475	>20,000	2,134
7,000	>20,000	5,429	>20,000	4,610	>20,000	4,462	>20,000	8,123	>20,000	3,579	>20,000	2,326	>20,000	6,180	>20,000	2,742	>20,000	2,182
7,500	>20,000	5,848	>20,000	4,692	>20,000	4,565	>20,000	9,851	>20,000	4,266	>20,000	2,714	>20,000	5,819	>20,000	2,577	>20,000	2,412
8,000	>20,000	7,250	>20,000	4,762	>20,000	4,747	>20,000	9,519	>20,000	4,639	>20,000	3,482	>20,000	7,374	>20,000	2,256	>20,000	2,256
8,500	>20,000	6,268	>20,000	3,842	>20,000	3,768	>20,000	8,986	>20,000	4,787	>20,000	4,087	>20,000	9,036	>20,000	2,732	>20,000	2,684
9,000	>20,000	5,187	>20,000	3,351	>20,000	3,263	>20,000	10,263	>20,000	4,974	>20,000	4,214	>20,000	8,925	>20,000	3,348	>20,000	2,904
9,500	>20,000	4,857	>20,000	3,147	>20,000	3,065	>20,000	9,153	>20,000	4,552	>20,000	3,475	>20,000	9,394	>20,000	4,337	>20,000	3,207
10,000	>20,000	5,514	>20,000	3,992	>20,000	3,772	>20,000	8,754	>20,000	4,303	>20,000	2,591	>20,000	10,090	>20,000	4,554	>20,000	3,509
10,500	>20,000	8,244	>20,000	5,100	>20,000	4,523	>20,000	10,008	>20,000	5,131	>20,000	2,738	>20,000	9,122	>20,000	4,535	>20,000	3,805
11,000	>20,000	9,735	>20,000	5,875	>20,000	5,143	>20,000	12,903	>20,000	5,212	>20,000	5,091	>20,000	8,851	>20,000	4,932	>20,000	4,199
11,500	>20,000	9,050	>20,000	5,300	>20,000	4,536	>20,000	10,941	>20,000	4,826	>20,000	4,590	>20,000	10,174	>20,000	5,261	>20,000	4,367
12,000	>20,000	6,800	>20,000	4,318	>20,000	4,227	>20,000	12,968	>20,000	5,444	>20,000	5,188	>20,000	10,983	>20,000	4,622	>20,000	4,501
12,500	>20,000	5,854	>20,000	4,223	>20,000	4,009	>20,000	13,397	>20,000	5,736	>20,000	5,332	>20,000	13,818	>20,000	6,506	>20,000	5,614
13,000	>20,000	5,567	>20,000	4,395	>20,000	4,312	>20,000	12,972	>20,000	5,402	>20,000	5,198	>20,000	14,801	>20,000	6,558	>20,000	6,219
13,500	>20,000	5,689	>20,000	4,654	>20,000	4,467	>20,000	12,555	>20,000	6,278	>20,000	6,008	>20,000	11,572	>20,000	6,132	>20,000	5,891
14,000	>20,000	7,012	>20,000	6,096	>20,000	5,359	>20,000	11,853	>20,000	5,756	>20,000	5,348	>20,000	10,221	>20,000	6,033	>20,000	5,677
14,500	>20,000	8,689	>20,000	5,214	>20,000	5,080	>20,000	11,228	>20,000	5,366	>20,000	5,167	>20,000	9,560	>20,000	6,417	>20,000	5,899
15,000	>20,000	6,872	>20,000	5,372	>20,000	5,120	>20,000	9,472	>20,000	5,369	>20,000	5,038	>20,000	12,124	>20,000	7,067	>20,000	6,542
15,500	>20,000	7,539	>20,000	4,633	>20,000	4,487	>20,000	10,728	>20,000	5,119	>20,000	4,967	>20,000	14,879	>20,000	7,288	>20,000	6,154
16,000	>20,000	5,381	>20,000	4,293	>20,000	4,274	>20,000	13,673	>20,000	5,914	>20,000	5,739	>20,000	12,373	>20,000	6,079	>20,000	5,578
16,500	>20,000	6,935	>20,000	4,584	>20,000	4,470	>20,000	16,705	>20,000	6,383	>20,000	5,895	>20,000	10,093	>20,000	7,637	>20,000	6,673
17,000	>20,000	7,454	>20,000	4,686	>20,000	4,458	>20,000	19,614	>20,000	7,292	>20,000	6,657	>20,000	8,925	>20,000	7,429	>20,000	6,996
17,500	>20,000	11,966	>20,000	7,090	>20,000	6,090	>20,000	16,612	>20,000	6,742	>20,000	6,629	>20,000	9,676	>20,000	6,955	>20,000	6,351
18,000	>20,000	16,895	>20,000	8,070	>20,000	7,853	>20,000	17,274	>20,000	6,442	>20,000	6,040	>20,000	9,502	>20,000	6,863	>20,000	6,625
18,500	>20,000	12,999	>20,000	7,638	>20,000	7,272	>20,000	13,545	>20,000	5,598	>20,000	5,371	>20,000	10,774	>20,000	7,293	>20,000	6,714
19,000	>20,000	11,331	>20,000	6,491	>20,000	6,321	>20,000	13,205	>20,000	5,650	>20,000	5,650	>20,000	12,959	>20,000	7,498	>20,000	6,792

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	9,513	>20,000	5,379	>20,000	4,960	>20,000	15,452	>20,000	6,640	>20,000	6,547	>20,000	13,913	>20,000	6,707	>20,000	6,342
20,000	>20,000	8,823	>20,000	5,738	>20,000	5,589	>20,000	14,091	>20,000	7,962	>20,000	7,292	>20,000	11,724	>20,000	6,888	>20,000	5,927

† This receptor is outside the model domain and predictions of dilution are unavailable at or within its boundaries. Given the high levels of dilution predicted within the extent of the model domain (20 km) in the direction of Scott Reef, and the remaining distance (~12 km) from the edge of the model domain to the receptor, it can be assumed that a minimum dilution level of >20,000 will occur at or within the receptor boundaries at all percentiles.

Table 3.66 Maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	23,421
	Transitional	15,474
	Winter	18,032
99th	Summer	26,400
	Transitional	22,836
	Winter	24,340
100th	Summer	26,502
	Transitional	22,923
	Winter	24,556

Table 3.67 Total area of coverage for 1:10,000 dilution in each season for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Summer	57.30
	Transitional	42.20
	Winter	38.30
99th	Summer	160.80
	Transitional	172.00
	Winter	175.80
100th	Summer	189.00
	Transitional	222.50
	Winter	213.60

Table 3.68 Maximum depth from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge).

Season	Maximum depth (m) from sea surface to achieve given dilution
Summer	539 (seabed)
Transitional	539 (seabed)
Winter	539 (seabed)

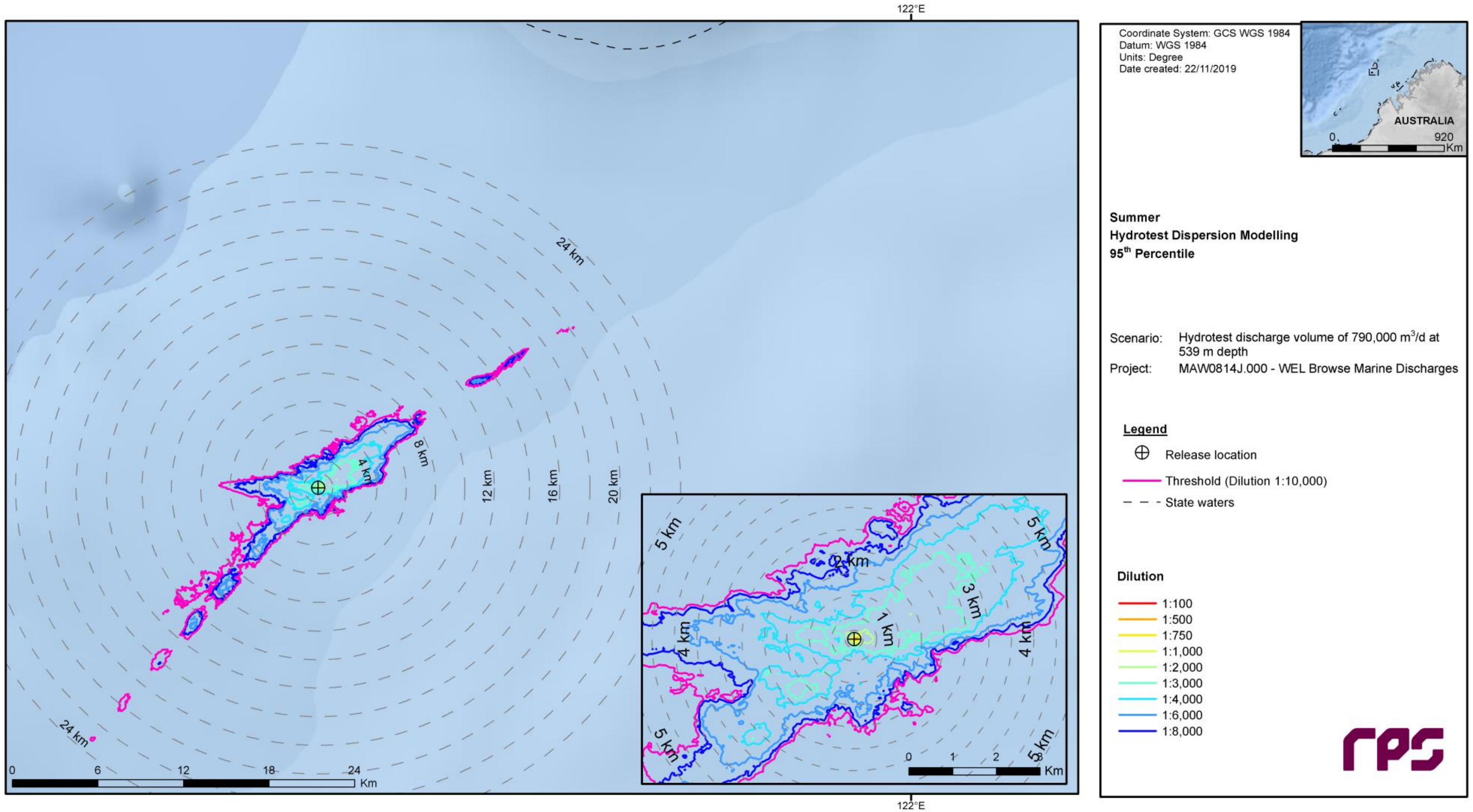

Figure 3.69 Predicted minimum dilutions at the 95th percentile under summer conditions for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

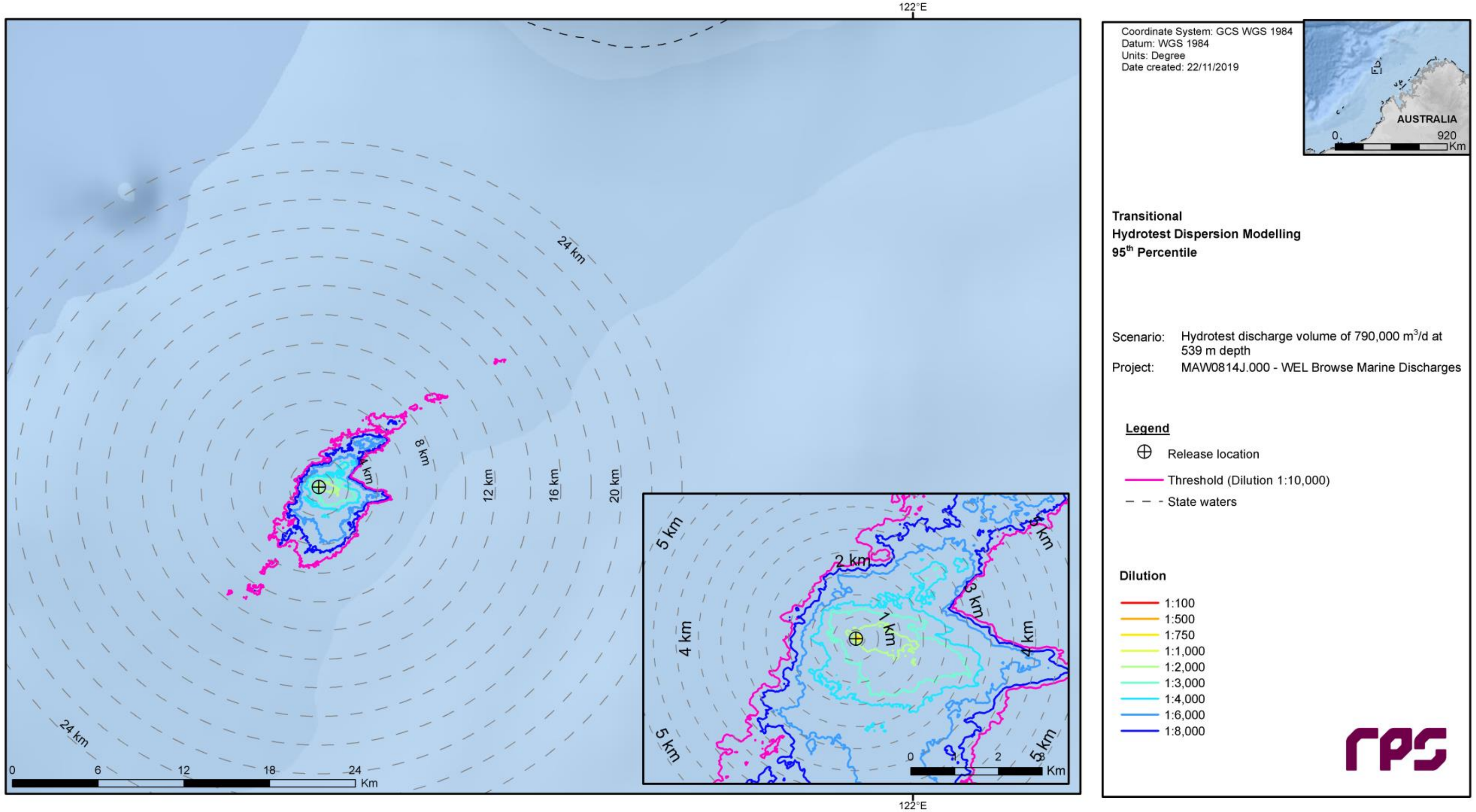

Figure 3.70 **Predicted minimum dilutions at the 95th percentile under transitional conditions for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.**

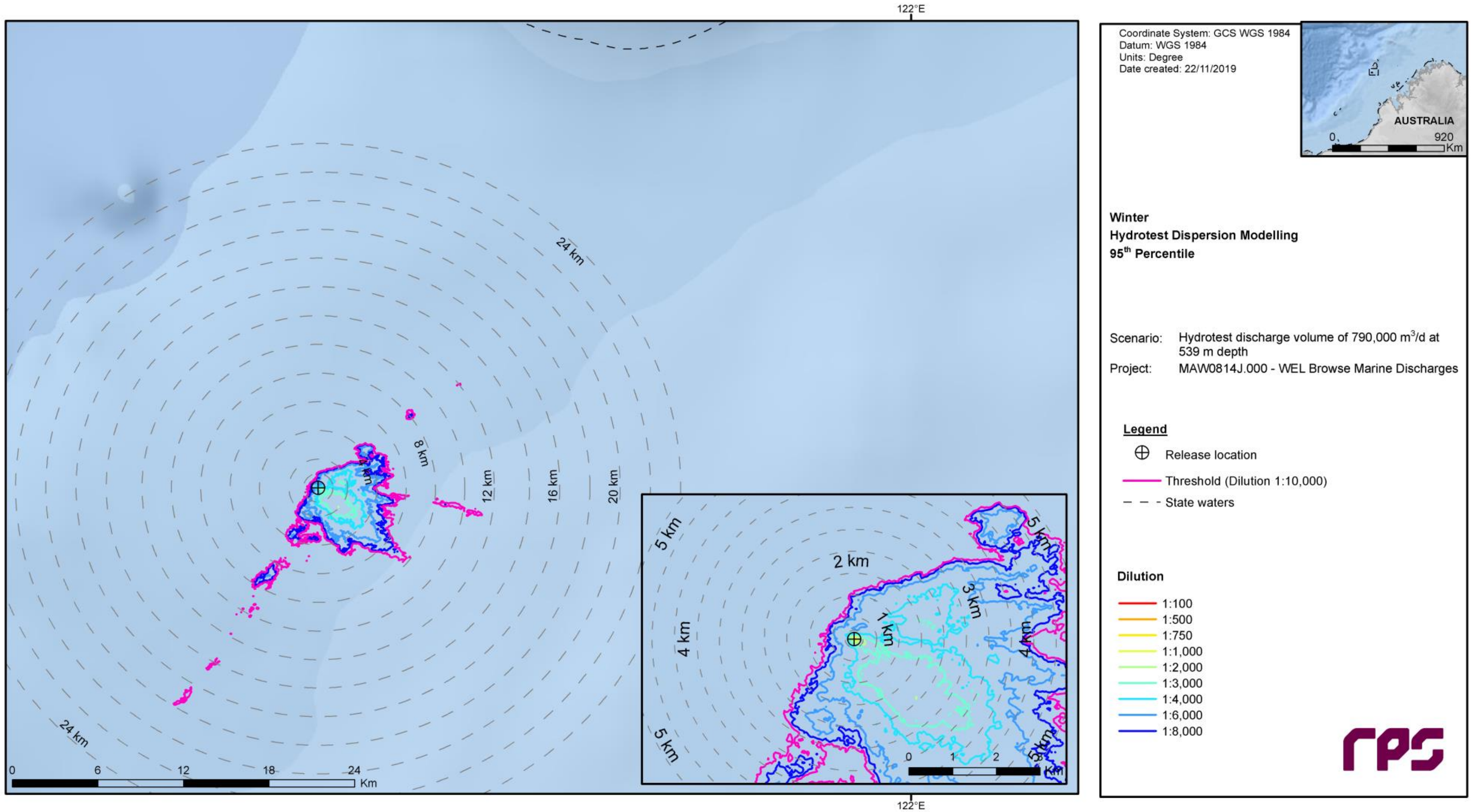

Figure 3.71 Predicted minimum dilutions at the 95th percentile under winter conditions for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

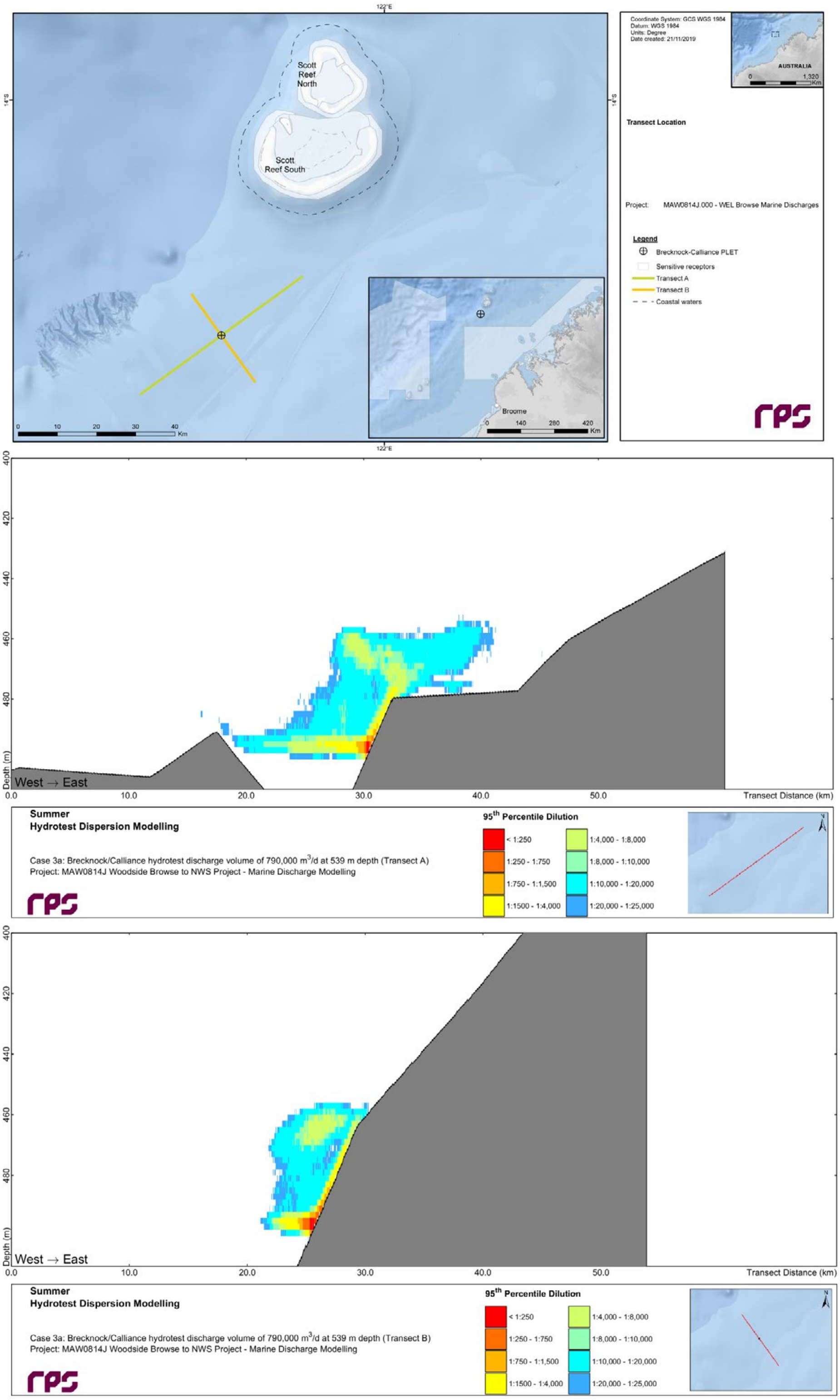

Figure 3.72 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.69.

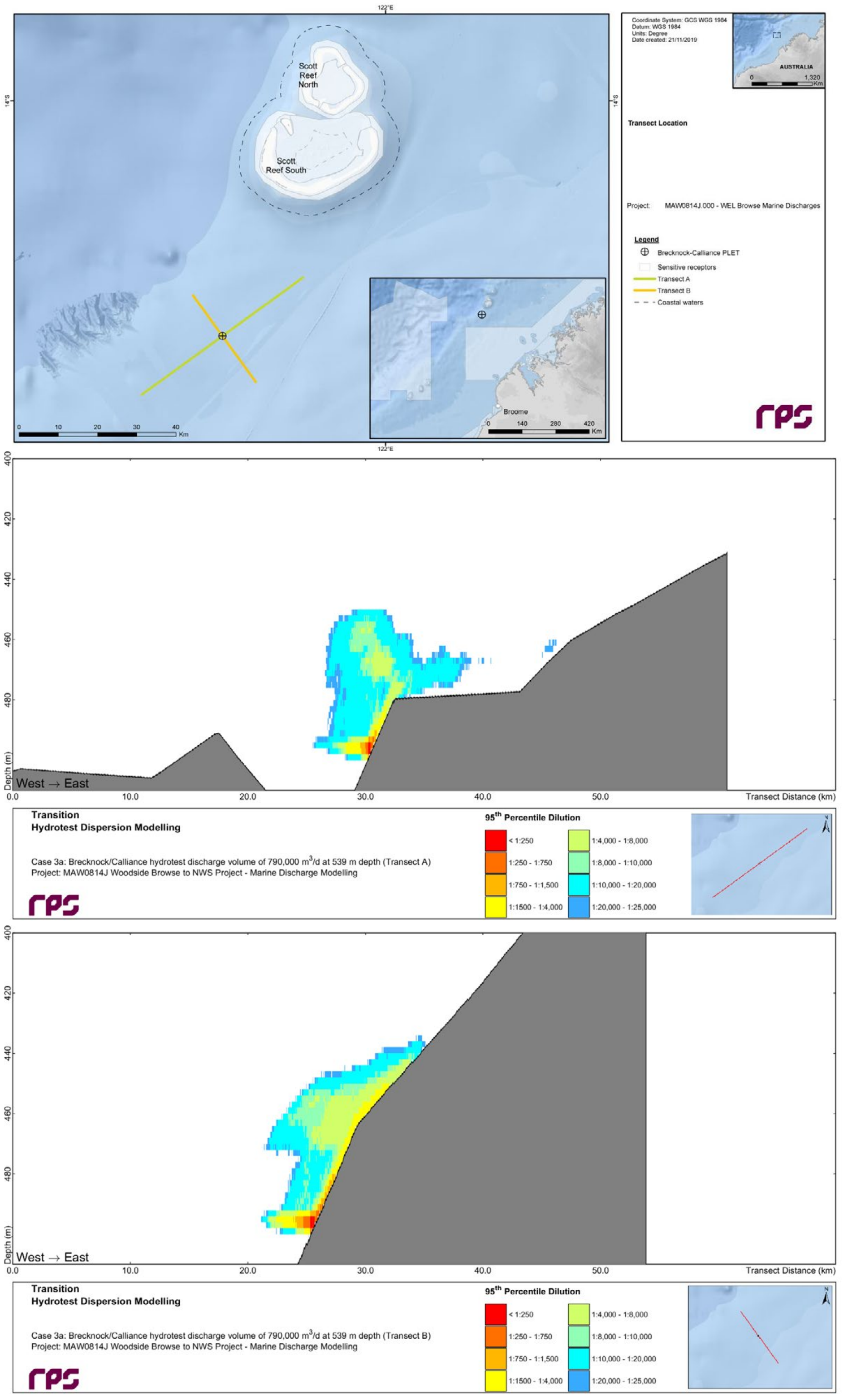

Figure 3.73 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case H3a (Brecknock/Calliance PLET 790,000 m³ hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.70.

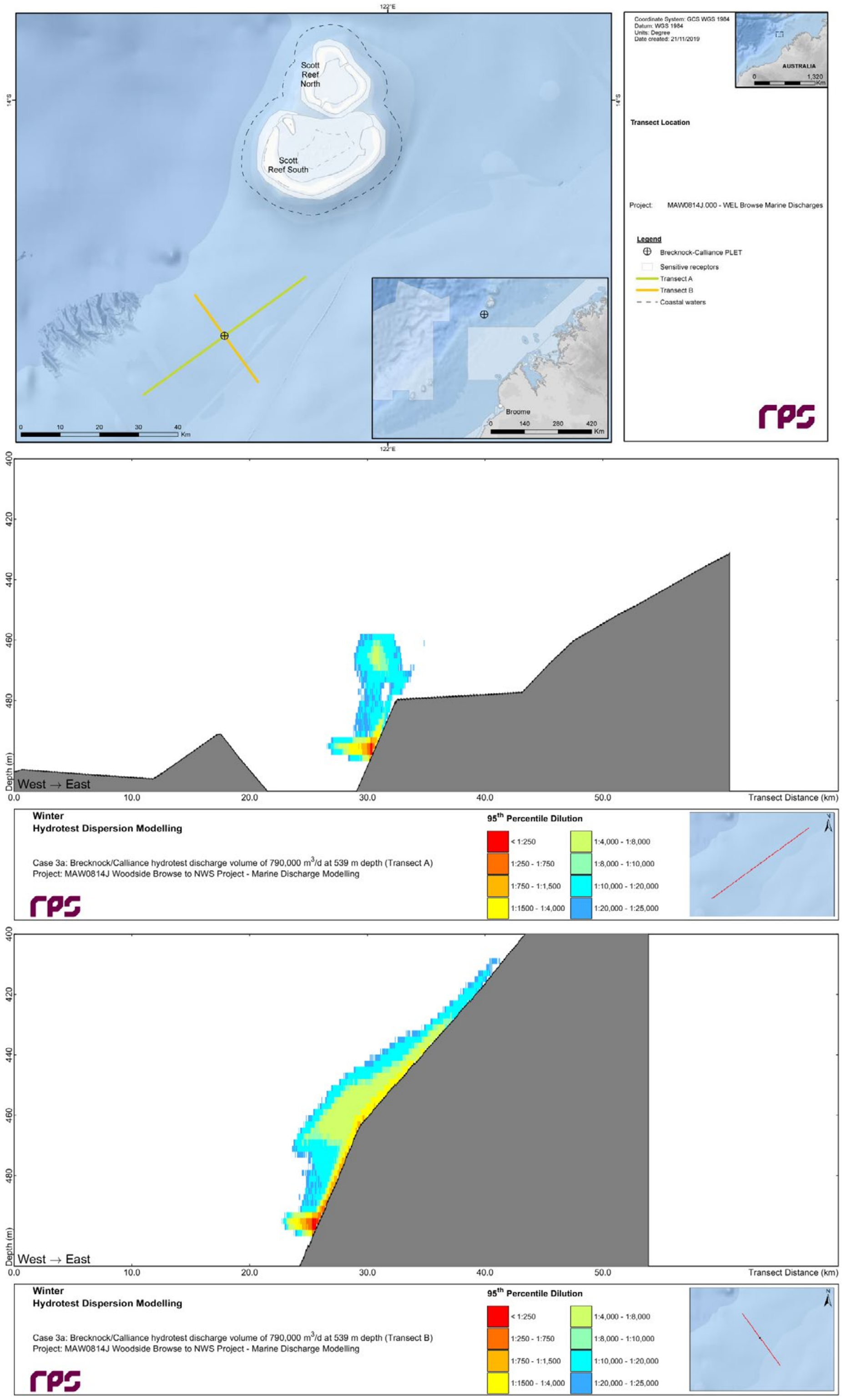

Figure 3.74 **Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case H3a (Brecknock/Calliance PLET 790,000 m³ hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.71.**

3.2.5.2.5 Discharge Case H3b: Torosa PLET Hydrotest Discharge of 56,000 m³ at 461 m Depth

Table 3.69 Average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location in each season for Case H3b (Torosa PLET 56,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	>20,000	>20,000	>20,000	3,610	>20,000	3,428	>20,000	2,711	>20,000	1,531	>20,000	1,530	>20,000	10,480	>20,000	2,400	>20,000	2,326
20	1,058	1,030	273	258	149	145	1,688	1,677	1,089	980	1,089	980	779	730	608	584	590	578
50	1,039	945	277	250	160	145	1,612	1,482	1,026	859	1,026	859	746	691	619	598	594	577
100	975	766	300	241	162	131	1,568	1,264	1,055	737	1,046	737	779	663	589	488	559	485
200	972	553	347	236	188	123	1,693	868	1,174	529	1,164	517	940	642	608	374	549	348
300	907	415	325	157	187	96	1,683	626	1,161	422	1,128	367	1,015	675	574	300	507	297
400	935	337	317	115	184	76	1,923	572	1,242	340	1,201	306	1,148	593	614	302	550	302
500	1,028	234	334	104	194	64	1,859	440	1,198	274	1,157	262	1,224	570	724	294	658	291
600	1,149	164	363	76	215	53	2,240	445	1,492	326	1,443	320	1,378	517	822	317	755	315
700	1,268	226	413	96	229	65	2,533	652	1,527	272	1,474	268	1,543	685	1,014	460	937	422
800	1,318	58	416	37	223	28	2,762	346	1,742	133	1,665	87	1,709	379	1,095	208	1,023	132
900	1,600	290	480	104	260	84	3,309	663	2,092	341	1,964	330	2,061	810	1,296	475	1,260	475
1,000	1,847	228	536	109	314	61	4,258	1,048	2,198	424	2,058	289	2,440	689	1,438	512	1,408	512
1,100	2,239	284	584	133	339	78	5,666	1,376	2,269	764	2,167	641	3,461	741	1,690	504	1,656	493
1,200	2,688	403	602	148	328	91	12,214	1,282	2,291	839	2,206	689	6,846	951	1,858	579	1,808	579
1,300	3,999	477	636	179	342	82	>20,000	1,272	2,540	872	2,420	823	>20,000	749	2,346	578	2,167	578
1,400	4,980	600	651	182	354	103	>20,000	1,342	2,705	983	2,542	931	>20,000	1,004	2,725	595	2,426	585
1,500	9,013	781	709	197	378	113	>20,000	1,643	3,021	968	2,883	929	>20,000	1,078	3,618	628	2,724	618
1,600	11,297	793	738	195	385	86	>20,000	1,636	3,228	1,119	3,079	1,049	>20,000	1,168	5,316	689	3,520	672
1,700	17,879	1,228	820	209	406	96	>20,000	1,722	3,756	1,159	3,475	1,076	>20,000	1,170	7,188	747	3,684	734
1,800	>20,000	1,176	895	258	433	114	>20,000	1,659	4,671	1,101	4,011	1,023	>20,000	1,245	>20,000	783	6,682	772
1,900	>20,000	1,126	962	315	441	110	>20,000	1,499	5,411	1,206	4,286	1,167	>20,000	1,453	>20,000	878	9,002	869
2,000	>20,000	1,134	1,051	317	480	145	>20,000	1,448	7,412	1,178	5,146	1,129	>20,000	1,726	>20,000	1,280	>20,000	1,208
2,100	>20,000	1,129	1,125	427	485	129	>20,000	1,454	9,542	1,146	6,089	1,136	>20,000	1,770	>20,000	1,328	>20,000	1,279
2,200	>20,000	1,179	1,266	445	520	163	>20,000	1,439	13,951	1,217	7,948	1,129	>20,000	1,930	>20,000	1,305	>20,000	1,267
2,300	>20,000	1,269	1,339	498	542	201	>20,000	1,591	>20,000	1,126	14,396	1,126	>20,000	1,818	>20,000	1,337	>20,000	1,212
2,400	>20,000	1,295	1,547	473	580	205	>20,000	1,723	>20,000	1,221	>20,000	1,135	>20,000	2,206	>20,000	1,331	>20,000	1,298
2,500	>20,000	1,505	1,819	582	599	199	>20,000	1,547	>20,000	1,229	>20,000	913	>20,000	3,776	>20,000	1,319	>20,000	1,319
2,600	>20,000	1,479	2,053	569	655	168	>20,000	1,735	>20,000	1,156	>20,000	1,026	>20,000	3,319	>20,000	1,134	>20,000	1,134
2,700	>20,000	1,824	2,312	509	661	189	>20,000	2,012	>20,000	1,096	>20,000	1,032	>20,000	3,474	>20,000	1,209	>20,000	1,209
2,800	>20,000	1,689	2,755	589	721	199	>20,000	1,987	>20,000	1,192	>20,000	1,168	>20,000	3,643	>20,000	1,166	>20,000	1,166
2,900	>20,000	1,997	3,316	590	792	209	>20,000	2,160	>20,000	1,362	>20,000	1,297	>20,000	3,947	>20,000	1,188	>20,000	1,188
3,000	>20,000	1,746	3,579	596	871	190	>20,000	2,603	>20,000	1,294	>20,000	1,294	>20,000	3,426	>20,000	1,209	>20,000	1,209
3,100	>20,000	1,847	4,018	735	901	175	>20,000	1,996	>20,000	1,263	>20,000	1,263	>20,000	3,150	>20,000	1,444	>20,000	1,444
3,200	>20,000	1,746	4,642	631	934	168	>20,000	2,839	>20,000	1,308	>20,000	1,308	>20,000	3,147	>20,000	1,443	>20,000	1,443
3,300	>20,000	1,779	7,138	579	917	171	>20,000	1,870	>20,000	1,305	>20,000	1,305	>20,000	3,261	>20,000	1,504	>20,000	1,504
3,400	>20,000	1,725	11,699	564	946	188	>20,000	2,570	>20,000	1,300	>20,000	1,300	>20,000	3,469	>20,000	1,475	>20,000	1,475

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	1,793	>20,000	617	1,064	201	>20,000	2,192	>20,000	1,285	>20,000	1,285	>20,000	3,148	>20,000	1,513	>20,000	1,513
3,600	>20,000	1,762	>20,000	684	1,275	217	>20,000	2,828	>20,000	1,438	>20,000	1,428	>20,000	2,681	>20,000	1,547	>20,000	1,547
3,700	>20,000	1,833	>20,000	728	1,646	230	>20,000	2,635	>20,000	1,481	>20,000	1,481	>20,000	2,572	>20,000	1,623	>20,000	1,623
3,800	>20,000	1,839	>20,000	763	>20,000	214	>20,000	3,103	>20,000	1,494	>20,000	1,494	>20,000	2,624	>20,000	1,653	>20,000	1,653
3,900	>20,000	1,822	>20,000	801	14,756	204	>20,000	3,322	>20,000	1,569	>20,000	1,569	>20,000	2,742	>20,000	1,680	>20,000	1,680
4,000	>20,000	1,712	13,226	857	>20,000	193	>20,000	3,230	>20,000	1,663	>20,000	1,663	>20,000	2,552	>20,000	1,536	>20,000	1,536
4,100	>20,000	1,793	>20,000	883	>20,000	199	>20,000	3,222	>20,000	1,603	>20,000	1,603	>20,000	2,794	>20,000	1,492	>20,000	1,492
4,200	>20,000	1,804	>20,000	887	>20,000	221	>20,000	3,016	>20,000	1,611	>20,000	1,611	>20,000	2,684	>20,000	1,526	>20,000	1,526
4,300	>20,000	1,919	>20,000	885	14,453	244	>20,000	3,621	>20,000	1,585	>20,000	1,585	>20,000	2,718	>20,000	1,291	>20,000	1,291
4,400	>20,000	2,019	>20,000	925	>20,000	263	>20,000	3,042	>20,000	1,727	>20,000	1,727	>20,000	2,769	>20,000	1,178	>20,000	1,178
4,500	>20,000	2,221	>20,000	947	>20,000	274	>20,000	4,809	>20,000	1,698	>20,000	1,698	>20,000	2,603	>20,000	1,297	>20,000	1,297
4,600	>20,000	2,263	>20,000	908	>20,000	332	>20,000	3,322	>20,000	1,753	>20,000	1,690	>20,000	2,371	>20,000	1,173	>20,000	1,173
4,700	>20,000	2,342	>20,000	943	>20,000	353	>20,000	5,107	>20,000	1,815	>20,000	1,815	>20,000	2,204	>20,000	1,135	>20,000	1,135
4,800	>20,000	2,358	>20,000	1,031	>20,000	352	>20,000	3,242	>20,000	1,783	>20,000	1,769	>20,000	2,475	>20,000	1,198	>20,000	1,192
4,900	>20,000	2,662	>20,000	945	>20,000	341	>20,000	3,829	>20,000	1,970	>20,000	1,912	>20,000	2,109	>20,000	1,315	>20,000	1,298
5,000	>20,000	2,563	>20,000	991	>20,000	340	>20,000	3,450	>20,000	2,034	>20,000	1,988	>20,000	1,840	>20,000	1,324	>20,000	1,290
5,500	>20,000	3,487	>20,000	1,361	>20,000	403	>20,000	2,919	>20,000	2,351	>20,000	2,351	>20,000	2,365	>20,000	1,253	>20,000	1,246
6,000	>20,000	3,776	>20,000	1,337	>20,000	448	>20,000	3,386	>20,000	1,962	>20,000	1,962	>20,000	6,688	>20,000	1,689	>20,000	1,644
6,500	>20,000	5,042	>20,000	1,547	>20,000	459	>20,000	3,423	>20,000	2,371	>20,000	2,371	>20,000	9,115	>20,000	1,612	>20,000	1,461
7,000	>20,000	7,561	>20,000	1,611	>20,000	483	>20,000	6,039	>20,000	3,549	>20,000	3,113	>20,000	10,226	>20,000	1,542	>20,000	1,458
7,500	>20,000	8,350	>20,000	2,002	>20,000	507	>20,000	4,503	>20,000	3,390	>20,000	3,390	>20,000	15,276	>20,000	1,801	>20,000	1,513
8,000	>20,000	14,430	>20,000	2,032	>20,000	563	>20,000	7,494	>20,000	3,847	>20,000	3,847	>20,000	>20,000	>20,000	3,542	>20,000	2,187
8,500	>20,000	>20,000	>20,000	2,236	>20,000	568	>20,000	13,983	>20,000	3,068	>20,000	3,068	>20,000	>20,000	>20,000	6,469	>20,000	5,723
9,000	>20,000	>20,000	>20,000	2,757	>20,000	830	>20,000	>20,000	>20,000	4,611	>20,000	3,839	>20,000	>20,000	>20,000	8,769	>20,000	7,591
9,500	>20,000	>20,000	>20,000	2,741	>20,000	763	>20,000	>20,000	>20,000	5,610	>20,000	5,111	>20,000	>20,000	>20,000	10,876	>20,000	9,512
10,000	>20,000	>20,000	>20,000	2,519	>20,000	649	>20,000	>20,000	>20,000	6,567	>20,000	5,777	>20,000	>20,000	>20,000	9,320	>20,000	7,556
10,500	>20,000	>20,000	>20,000	1,938	>20,000	672	>20,000	>20,000	>20,000	6,425	>20,000	6,425	>20,000	>20,000	>20,000	9,876	>20,000	6,540
11,000	>20,000	>20,000	>20,000	2,234	>20,000	689	>20,000	>20,000	>20,000	5,956	>20,000	5,956	>20,000	>20,000	>20,000	10,693	>20,000	5,653
11,500	>20,000	>20,000	>20,000	2,907	>20,000	770	>20,000	>20,000	>20,000	8,539	>20,000	8,539	>20,000	>20,000	>20,000	16,627	>20,000	8,898
12,000	>20,000	>20,000	>20,000	4,288	>20,000	802	>20,000	>20,000	>20,000	13,055	>20,000	11,702	>20,000	>20,000	>20,000	>20,000	>20,000	11,939
12,500	>20,000	>20,000	>20,000	3,636	>20,000	875	>20,000	>20,000	>20,000	17,960	>20,000	17,960	>20,000	>20,000	>20,000	>20,000	>20,000	18,065
13,000	>20,000	>20,000	>20,000	3,075	>20,000	1,080	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
13,500	>20,000	>20,000	>20,000	3,342	>20,000	942	>20,000	>20,000	>20,000	>20,000	>20,000	14,415	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
14,000	>20,000	>20,000	>20,000	3,301	>20,000	1,381	>20,000	>20,000	>20,000	>20,000	>20,000	12,962	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
14,500	>20,000	>20,000	>20,000	3,650	>20,000	1,641	>20,000	>20,000	>20,000	>20,000	>20,000	18,419	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
15,000	>20,000	>20,000	>20,000	5,180	>20,000	1,486	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
15,500	>20,000	>20,000	>20,000	5,433	>20,000	1,727	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
16,000	>20,000	>20,000	>20,000	5,818	>20,000	1,605	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
16,500	>20,000	>20,000	>20,000	4,291	>20,000	1,299	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
17,000	>20,000	>20,000	>20,000	4,952	>20,000	1,539	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
17,500	>20,000	>20,000	>20,000	8,096	>20,000	1,557	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,000	>20,000	>20,000	>20,000	11,854	>20,000	1,710	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,500	>20,000	>20,000	>20,000	14,403	>20,000	2,416	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
19,000	>20,000	>20,000	>20,000	15,606	>20,000	2,273	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

Distance (m)	Summer						Transitional						Winter					
	95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile		95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	>20,000	>20,000	15,981	>20,000	2,249	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
20,000	>20,000	>20,000	>20,000	>20,000	>20,000	2,213	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

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Table 3.70 Maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Summer	7,822
	Transitional	8,230
	Winter	7,303
99th	Summer	13,845
	Transitional	11,639
	Winter	10,492
100th	Summer	13,845
	Transitional	11,639
	Winter	11,570

Table 3.71 Total area of coverage for 1:10,000 dilution in each season for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Summer	19.79
	Transitional	22.16
	Winter	18.24
99th	Summer	46.39
	Transitional	57.31
	Winter	40.47
100th	Summer	54.24
	Transitional	63.87
	Winter	45.76

Table 3.72 Maximum depth from the hydrotest discharge location to achieve 1:10,000 dilution in each season for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge).

Season	Maximum depth (m) from sea surface to achieve given dilution
Summer	461 (seabed)
Transitional	461 (seabed)
Winter	461 (seabed)

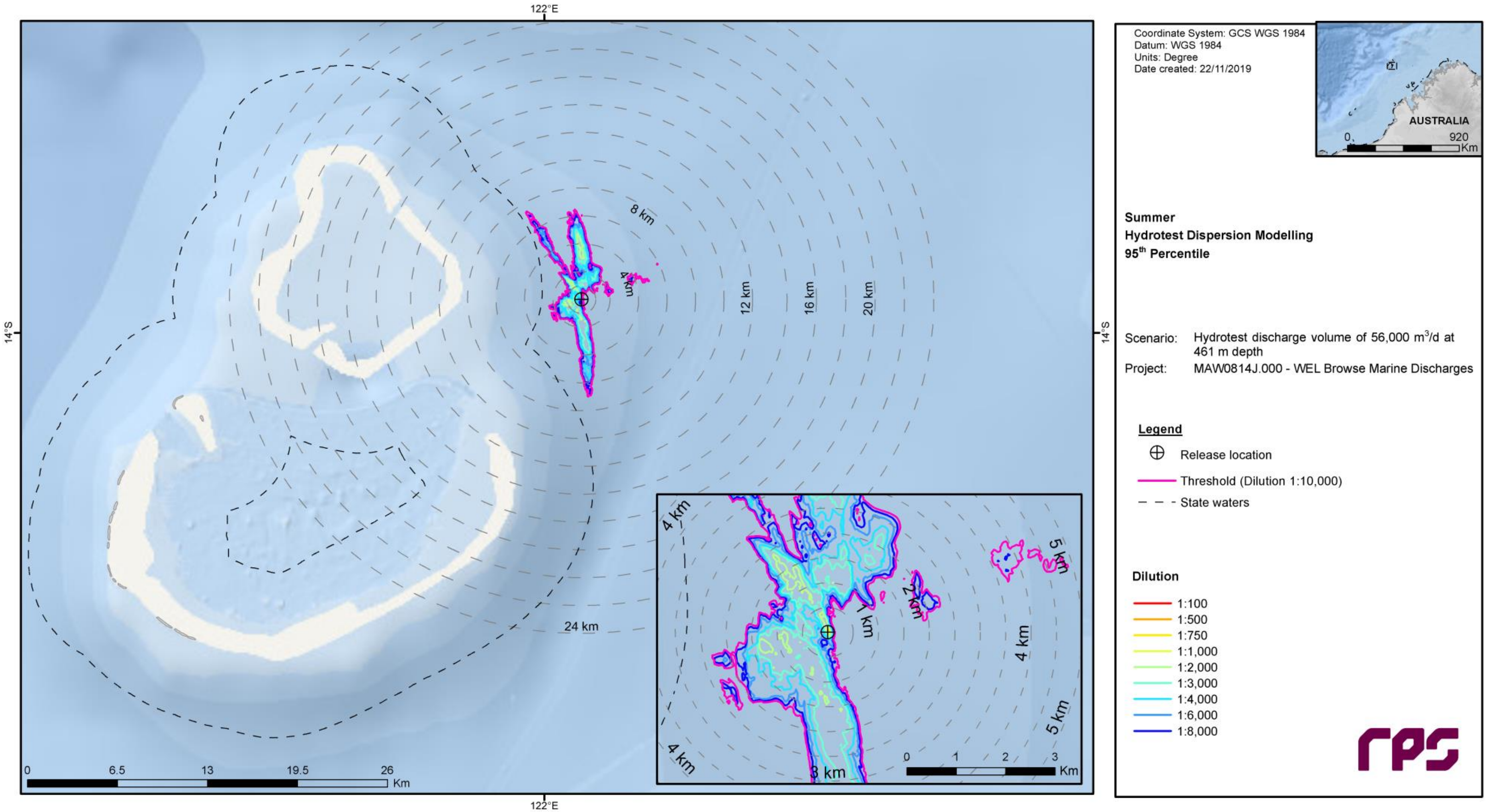

Figure 3.75 Predicted minimum dilutions at the 95th percentile under summer conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

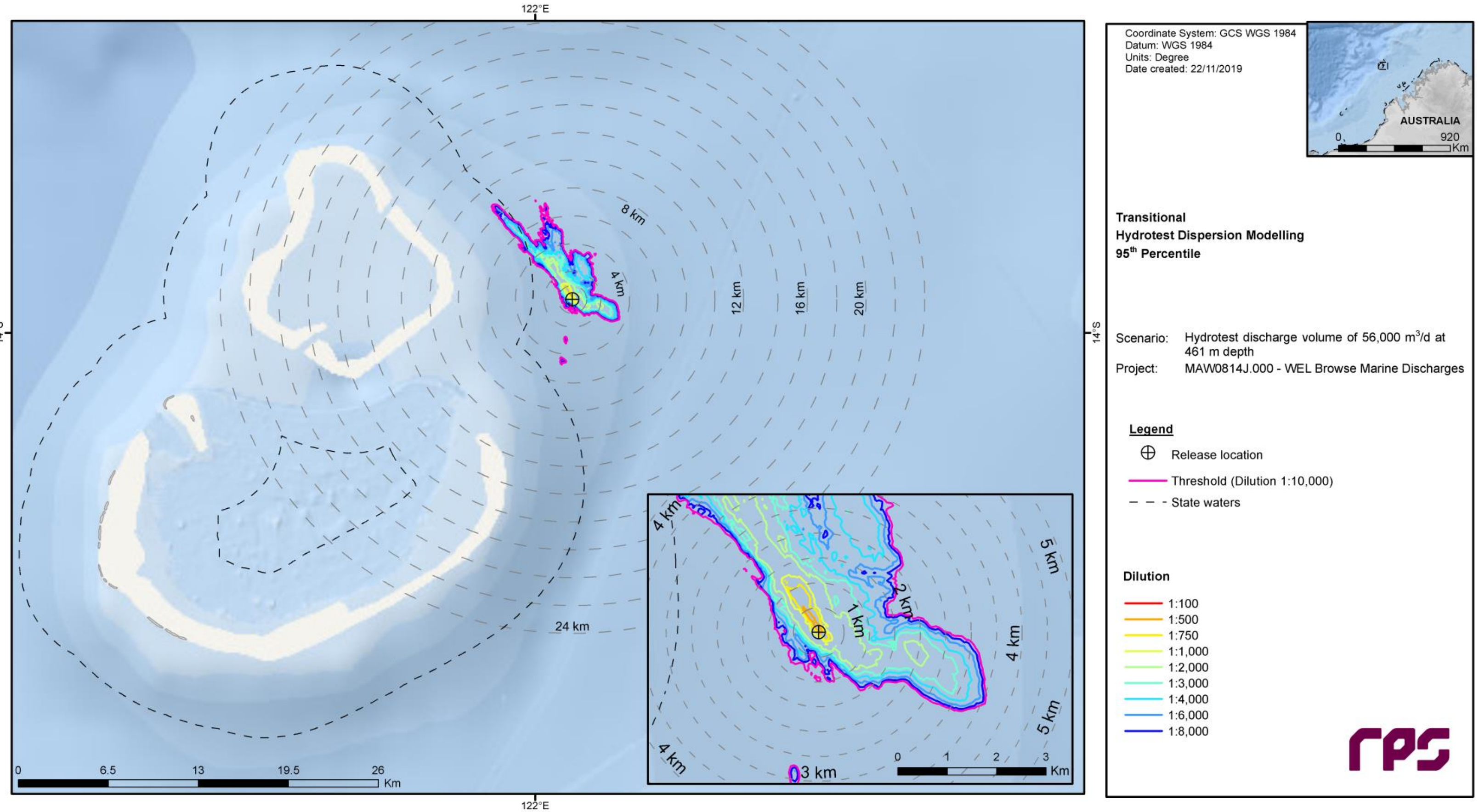

Figure 3.76 Predicted minimum dilutions at the 95th percentile under transitional conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

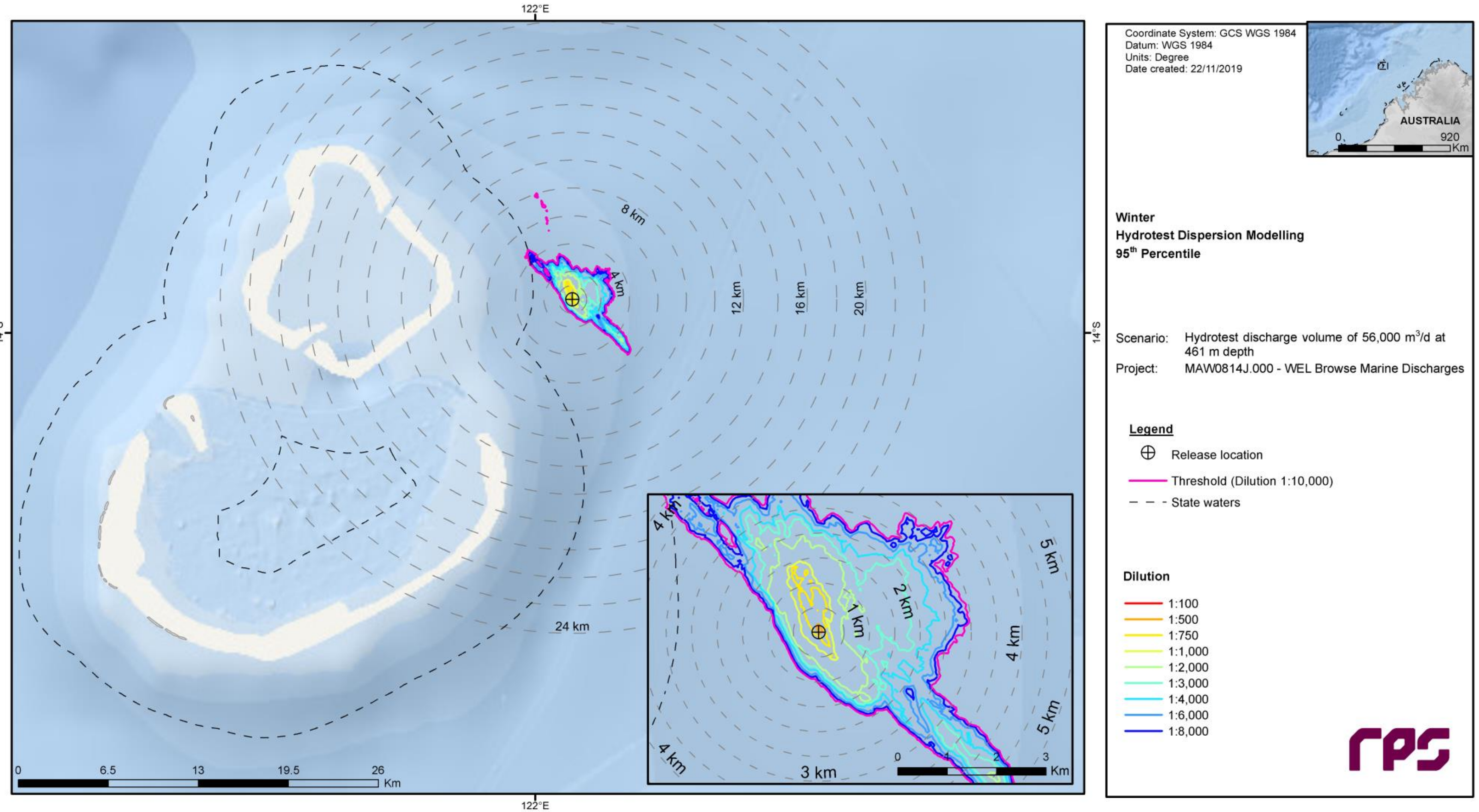

Figure 3.77 Predicted minimum dilutions at the 95th percentile under winter conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

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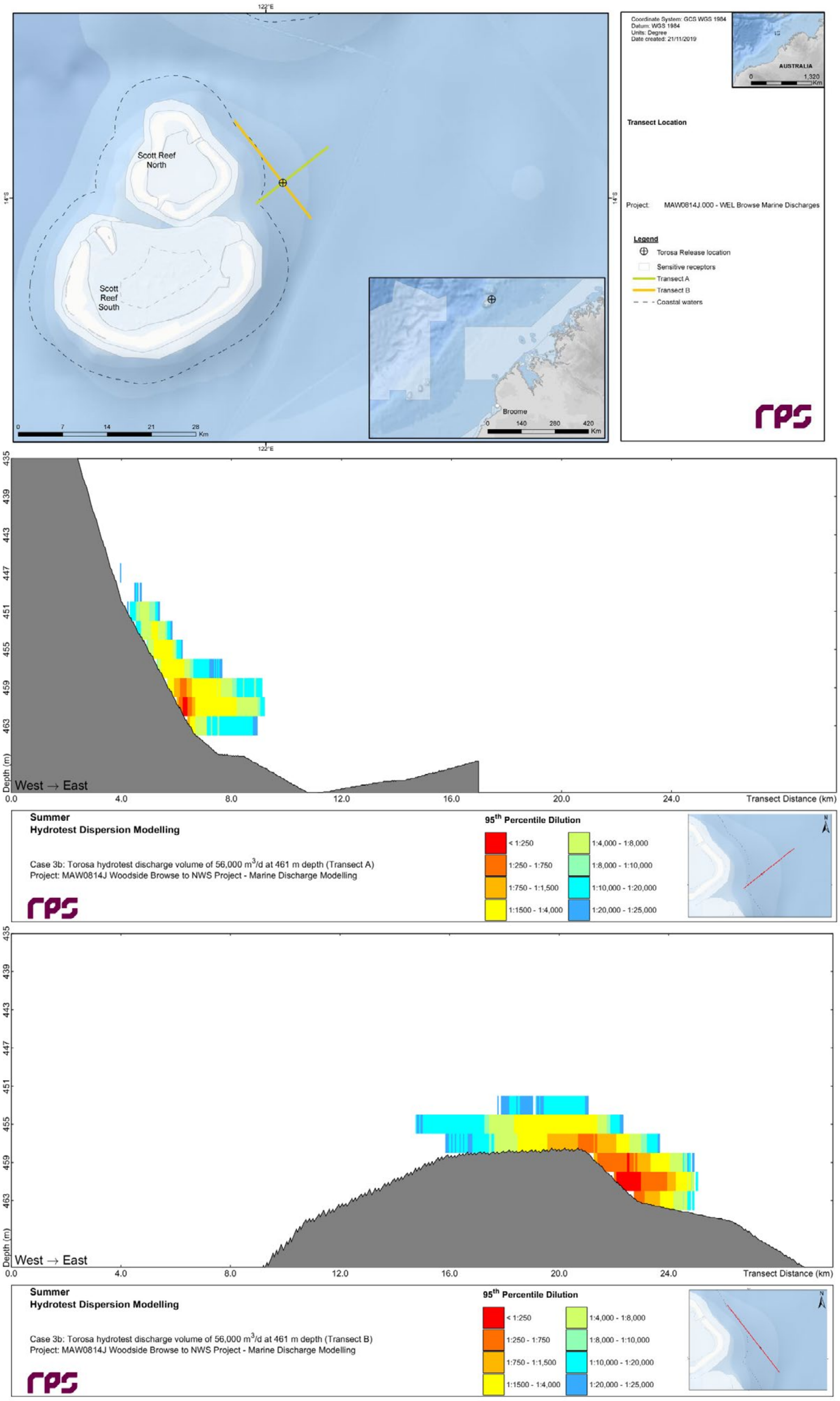

Figure 3.78 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under summer conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.75.

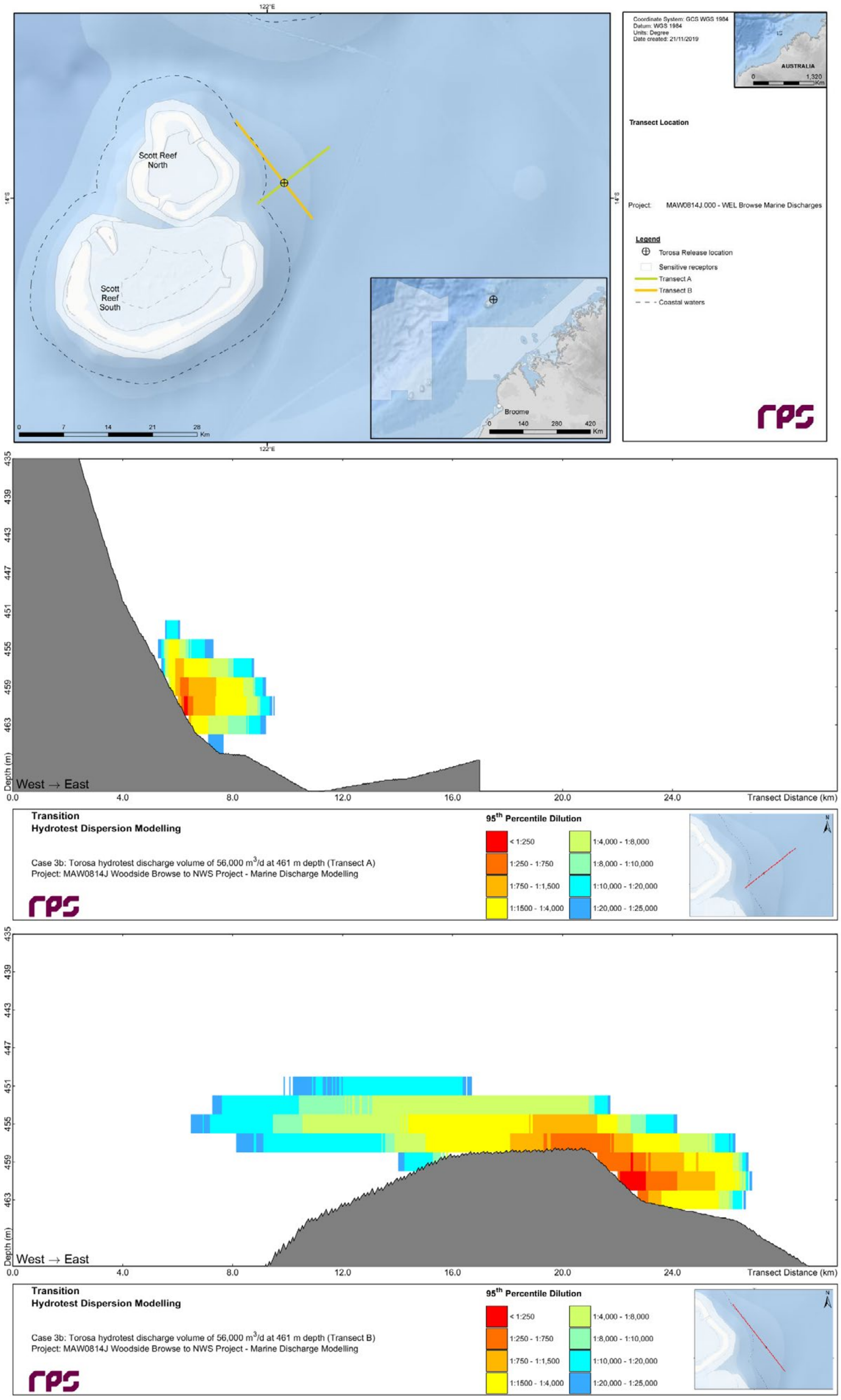

Figure 3.79 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under transitional conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.76.

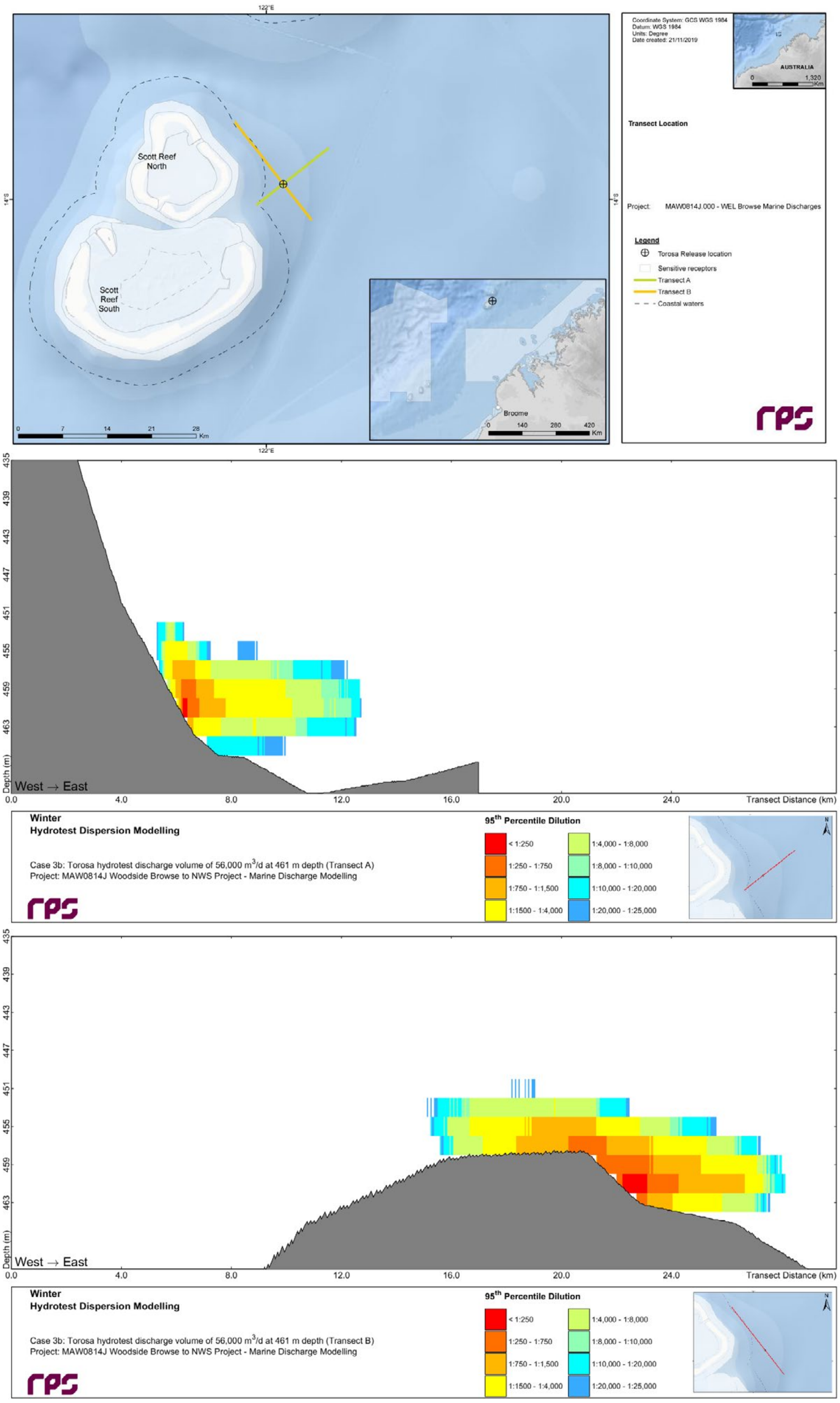

Figure 3.80 Vertical cross-section plots of predicted minimum dilutions at the 95th percentile under winter conditions for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge). Transect locations are shown in the top panel, with transect A shown in the middle panel and transect B shown in the bottom panel. Spatial representation of this data is shown in Figure 3.77.

3.2.5.3 Annualised Analysis

3.2.5.3.1 Summary

The model outputs for each season (summer, transitional and winter) over the ten-year hindcast period (2006-2015) were combined and analysed on an annualised basis.

Table 3.73, Table 3.76, Table 3.79 and Table 3.82 summarise, for Cases H1, H2, H3a and H3b respectively, the average and minimum dilution achieved at specific radial distances from the discharge location – as well as at or within the boundary of the nearest sensitive receptor – for each percentile over the annual period, with the application of a rolling 48-hour median to the data. The discharge location for Case H1 is distant from Scott Reef and the nearest receptor is Rankin Bank, while for Cases H2, H3a and H3b the nearest receptor is Scott Reef (defined by the 3 nm State water boundary).

The minimum levels of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season are predicted to be 1:4,440 for Case H2 and 1:2,711 for Case H3b. For Cases H1 and H3a, the discharge locations are sufficiently distant from the nearest receptors – Rankin Bank and Scott Reef, respectively – that the model domains could not encompass the receptors. The expected number of dilutions at the receptors has been inferred from the outcomes at the limits of the model domains. The minimum levels of dilution achieved at the 95th percentile in any season are predicted to be in excess of 1:20,000 at Scott Reef in Case H3a and significantly in excess of 1:20,000 at Rankin Bank in Case H1.

Table 3.74, Table 3.77, Table 3.80 and Table 3.83 provide, for Cases H1, H2, H3a and H3b respectively, summaries of the annualised maximum distances from the discharge location to achieve an example dilution level of 1:10,000 for each percentile. The results indicate that the release of effluent under all seasonal conditions results in slow dispersion within the ambient environment. Dilution to reach the 1:10,000 level at the 95th percentile – this being the maximum spatial extent of the relevant dilution contour from the discharge location in any season – is achieved within a maximum area of influence of: 16.1 km (Case H1), with the maximum extent found to the south-west (Figure 3.81); 12.5 km (Case H2), with the maximum extent found to the north-west (Figure 3.82); 23.4 km (Case H3a), with the maximum extent found to the south-west (Figure 3.83); and 8.2 km (Case H3b), with the maximum extent found to the north-west (Figure 3.84).

Table 3.75, Table 3.78, Table 3.81 and Table 3.84 provide, for Cases H1, H2, H3a and H3b respectively, summaries of the annualised total areas of coverage for the 1:10,000 dilution contour for each percentile. The area of exposure defined by the relevant dilution contour, at the 95th percentile across all seasons, is predicted to reach maximum values of 79.2 km^2 (Case H1), 87.1 km^2 (Case H2), 89.4 km^2 (Case H3a) and 40.8 km^2 (Case H3b).

For Cases H1, H2, H3a and H3b, the aggregated spatial extents of the minimum dilutions at the 95th percentile are presented in Figure 3.81, Figure 3.82, Figure 3.83 and Figure 3.84, respectively. Note that the contours represent the lowest predicted dilution (highest concentration) at any given time step through the water column and do not consider frequency or duration.

The results presented assume that no processes other than dilution would reduce the source concentrations over time, and therefore can be considered as conservative outcomes.

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3.2.5.3.2 Discharge Case H1: NRC Tie-In PLET Hydrotest Discharge of 736,000 m³ at 117 m Depth

Table 3.73 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location for Case H1 (NRC tie-in PLET 736,000 m³ hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Rankin Bank †	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000	>>20,000
20	553	230	235	172	230	163
50	392	183	168	115	149	109
100	1,301	499	576	300	482	297
200	2,189	1,108	906	644	783	510
300	2,950	1,447	1,147	684	982	624
400	3,268	1,605	1,407	697	1,138	680
500	3,634	1,845	1,480	791	1,334	699
600	3,212	1,956	1,624	904	1,448	801
700	3,546	1,927	1,689	1,067	1,558	984
800	3,361	2,074	1,891	1,071	1,709	1,063
900	3,599	2,040	1,909	1,258	1,753	998
1,000	3,505	1,941	1,986	1,359	1,787	989
1,100	3,640	2,170	2,013	1,298	1,847	1,184
1,200	3,861	2,284	2,148	1,400	1,931	1,338
1,300	3,825	2,002	2,245	1,254	1,974	1,243
1,400	4,133	2,000	2,405	1,265	2,084	1,159
1,500	4,181	2,049	2,477	1,236	2,204	1,143
1,600	4,410	1,783	2,525	1,315	2,235	1,280
1,700	4,553	1,912	2,664	1,306	2,332	1,259
1,800	5,002	1,851	2,787	1,313	2,429	1,224
1,900	5,725	2,119	2,814	1,248	2,534	1,224
2,000	6,422	2,068	2,828	1,370	2,581	1,281
2,100	8,673	2,200	3,015	1,347	2,723	1,323
2,200	9,836	2,106	3,230	1,230	2,959	1,230
2,300	13,270	2,362	3,387	1,273	3,022	1,243
2,400	11,465	2,259	3,618	1,301	3,230	1,301
2,500	14,318	2,326	3,756	1,356	3,431	1,324
2,600	12,872	2,407	4,124	1,543	3,713	1,356
2,700	19,660	2,485	4,473	1,574	4,048	1,433
2,800	>20,000	2,762	4,885	1,586	4,346	1,515
2,900	>20,000	2,806	5,790	1,692	5,078	1,508
3,000	>20,000	2,974	6,425	1,807	5,607	1,596
3,100	>20,000	3,048	8,928	1,914	7,533	1,675
3,200	>20,000	3,205	11,514	1,713	9,239	1,588
3,300	>20,000	2,775	12,956	1,524	10,400	1,406
3,400	>20,000	3,156	15,831	1,459	11,688	1,378

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	3,299	17,820	1,717	11,929	1,537
3,600	>20,000	3,126	>20,000	1,897	13,100	1,540
3,700	>20,000	3,196	>20,000	1,892	12,950	1,592
3,800	>20,000	3,389	>20,000	1,895	18,687	1,750
3,900	>20,000	3,301	>20,000	1,966	14,990	1,782
4,000	>20,000	3,011	>20,000	1,855	17,570	1,828
4,100	>20,000	3,353	>20,000	1,712	>20,000	1,712
4,200	>20,000	3,288	>20,000	1,745	>20,000	1,745
4,300	>20,000	3,045	>20,000	1,751	>20,000	1,739
4,400	>20,000	3,134	>20,000	1,857	>20,000	1,823
4,500	>20,000	3,362	>20,000	1,941	>20,000	1,887
4,600	>20,000	3,214	>20,000	1,952	>20,000	1,919
4,700	>20,000	3,567	>20,000	2,105	>20,000	2,087
4,800	>20,000	3,655	>20,000	2,208	>20,000	2,208
4,900	>20,000	4,243	>20,000	2,105	>20,000	1,977
5,000	>20,000	4,165	>20,000	2,239	>20,000	2,147
5,500	>20,000	4,347	>20,000	3,192	>20,000	2,966
6,000	>20,000	4,568	>20,000	3,145	>20,000	2,925
6,500	>20,000	5,131	>20,000	3,254	>20,000	3,154
7,000	>20,000	5,251	>20,000	3,341	>20,000	3,288
7,500	>20,000	5,634	>20,000	2,761	>20,000	2,744
8,000	>20,000	5,963	>20,000	2,733	>20,000	2,733
8,500	>20,000	5,565	>20,000	2,884	>20,000	2,855
9,000	>20,000	6,359	>20,000	3,302	>20,000	3,139
9,500	>20,000	7,226	>20,000	3,632	>20,000	3,354
10,000	>20,000	7,581	>20,000	4,339	>20,000	3,937
10,500	>20,000	7,442	>20,000	4,364	>20,000	4,333
11,000	>20,000	8,052	>20,000	4,673	>20,000	4,435
11,500	>20,000	9,539	>20,000	4,513	>20,000	4,198
12,000	>20,000	8,899	>20,000	5,294	>20,000	4,619
12,500	>20,000	9,118	>20,000	5,135	>20,000	5,135
13,000	>20,000	9,205	>20,000	5,283	>20,000	5,154
13,500	>20,000	8,498	>20,000	5,203	>20,000	5,054
14,000	>20,000	9,434	>20,000	5,569	>20,000	5,557
14,500	>20,000	10,651	>20,000	6,548	>20,000	6,548
15,000	>20,000	9,083	>20,000	5,776	>20,000	5,158
15,500	>20,000	8,200	>20,000	6,099	>20,000	5,644
16,000	>20,000	10,216	>20,000	6,871	>20,000	6,393
16,500	>20,000	11,229	>20,000	7,298	>20,000	6,337
17,000	>20,000	12,207	>20,000	5,353	>20,000	5,067
17,500	>20,000	12,542	>20,000	6,492	>20,000	5,554
18,000	>20,000	14,165	>20,000	7,919	>20,000	7,443
18,500	>20,000	13,062	>20,000	7,783	>20,000	6,989
19,000	>20,000	14,856	>20,000	7,712	>20,000	7,413

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	14,621	>20,000	8,526	>20,000	7,629
20,000	>20,000	15,117	>20,000	8,581	>20,000	7,833

† This receptor is outside the model domain and predictions of dilution are unavailable at or within its boundaries. Given the high levels of dilution predicted within the extent of the model domain (20 km) in the direction of Rankin Bank, and the remaining distance (~40 km) from the edge of the model domain to the receptor, it can be assumed that a minimum dilution level of >>20,000 will occur at or within the receptor boundaries at all percentiles.

Table 3.74 Annualised maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	16,137
99th		22,551
100th		22,925

Table 3.75 Annualised total area of coverage for 1:10,000 dilution for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Annual	79.20
99th		217.20
100th		270.40

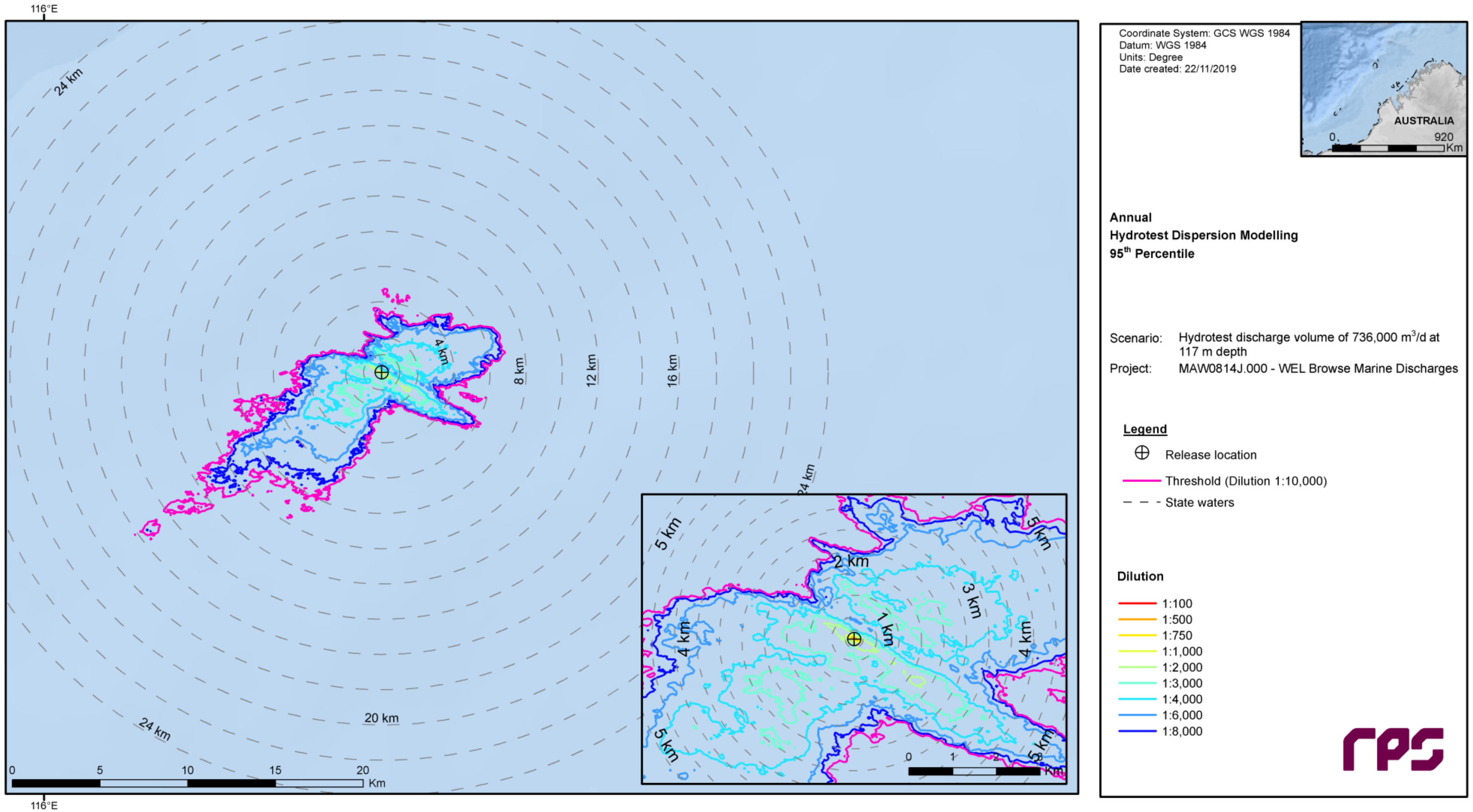

Figure 3.81 Predicted annualised minimum dilutions at the 95th percentile for Case H1 (NRC tie-in PLET 736,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

REPORT

3.2.5.3.3 Discharge Case H2: Torosa PLET Hydrotest Discharge of 846,000 m^3 at 461 m Depth

Table 3.76 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	>20,000	4,440	>20,000	1,805	>20,000	1,633
20	785	743	573	546	545	523
50	753	626	556	516	527	491
100	723	560	549	458	514	426
200	806	433	571	322	512	297
300	839	382	559	253	511	245
400	855	388	600	262	522	243
500	933	364	641	239	539	230
600	1,032	271	715	232	605	205
700	1,168	299	789	236	679	230
800	1,150	91	845	74	715	69
900	1,245	441	956	341	848	295
1,000	1,269	292	989	250	868	238
1,100	1,382	340	1,045	293	942	280
1,200	1,420	410	1,061	275	962	264
1,300	1,648	385	1,142	322	1,059	310
1,400	1,685	466	1,156	274	1,076	272
1,500	2,275	505	1,298	288	1,222	274
1,600	2,267	484	1,265	317	1,162	310
1,700	3,340	503	1,397	333	1,277	309
1,800	3,121	536	1,448	341	1,337	336
1,900	4,959	561	1,599	334	1,443	326
2,000	3,952	619	1,581	358	1,478	348
2,100	5,589	654	1,716	369	1,561	366
2,200	5,267	701	1,691	391	1,549	391
2,300	8,435	734	1,827	422	1,660	422
2,400	6,670	764	1,830	443	1,689	440
2,500	10,251	811	1,959	490	1,821	484
2,600	9,727	838	2,046	478	1,891	470
2,700	14,682	827	2,189	517	2,030	508
2,800	14,079	801	2,276	495	2,052	495
2,900	>20,000	825	2,561	592	2,271	592
3,000	>20,000	827	2,748	610	2,380	610
3,100	>20,000	877	2,901	667	2,566	653
3,200	>20,000	898	3,010	676	2,644	661
3,300	>20,000	919	3,388	680	2,903	651
3,400	>20,000	936	3,445	723	2,952	670

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	961	3,620	749	3,177	726
3,600	>20,000	973	3,771	769	3,285	744
3,700	>20,000	971	3,994	844	3,488	815
3,800	>20,000	1,035	4,081	882	3,484	833
3,900	>20,000	1,095	4,603	883	3,968	834
4,000	>20,000	1,092	4,652	904	56,220	863
4,100	>20,000	1,127	4,970	909	4,244	861
4,200	>20,000	1,187	294,350	927	4,315	917
4,300	>20,000	1,157	5,720	940	4,794	903
4,400	>20,000	1,177	5,962	942	5,044	899
4,500	>20,000	1,232	7,254	975	6,123	971
4,600	>20,000	1,266	7,461	990	6,237	983
4,700	>20,000	1,312	9,728	1,000	8,112	966
4,800	>20,000	1,367	10,372	1,062	8,925	990
4,900	>20,000	1,356	13,333	1,166	11,551	1,040
5,000	>20,000	1,433	13,752	1,147	12,196	1,126
5,500	>20,000	1,709	>20,000	1,099	>20,000	1,053
6,000	>20,000	2,499	>20,000	1,267	>20,000	1,253
6,500	>20,000	3,378	>20,000	1,318	>20,000	1,279
7,000	>20,000	3,415	>20,000	1,375	>20,000	1,364
7,500	>20,000	4,097	>20,000	1,603	>20,000	1,343
8,000	>20,000	4,260	>20,000	1,838	>20,000	1,357
8,500	>20,000	5,139	>20,000	1,992	>20,000	1,778
9,000	>20,000	5,771	>20,000	2,196	>20,000	2,040
9,500	>20,000	5,848	>20,000	2,080	>20,000	1,997
10,000	>20,000	7,382	>20,000	2,396	>20,000	2,150
10,500	>20,000	7,331	>20,000	2,618	>20,000	2,332
11,000	>20,000	8,233	>20,000	2,611	>20,000	2,382
11,500	>20,000	8,606	>20,000	2,700	>20,000	2,700
12,000	>20,000	10,586	>20,000	3,220	>20,000	3,220
12,500	>20,000	9,813	>20,000	3,039	>20,000	3,039
13,000	>20,000	13,043	>20,000	3,218	>20,000	2,645
13,500	>20,000	16,076	>20,000	3,558	>20,000	2,954
14,000	>20,000	17,912	>20,000	3,852	>20,000	3,852
14,500	>20,000	>20,000	>20,000	4,087	>20,000	3,729
15,000	>20,000	>20,000	>20,000	4,011	>20,000	3,814
15,500	>20,000	>20,000	>20,000	3,617	>20,000	3,617
16,000	>20,000	19,435	>20,000	4,011	>20,000	4,011
16,500	>20,000	19,642	>20,000	4,190	>20,000	4,014
17,000	>20,000	>20,000	>20,000	4,605	>20,000	4,605
17,500	>20,000	16,380	>20,000	5,229	>20,000	4,674
18,000	>20,000	15,789	>20,000	5,435	>20,000	5,265
18,500	>20,000	17,692	>20,000	4,904	>20,000	4,904
19,000	>20,000	>20,000	>20,000	5,183	>20,000	5,143

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	>20,000	>20,000	6,873	>20,000	6,648
20,000	>20,000	>20,000	>20,000	6,826	>20,000	6,787

Table 3.77 Annualised maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	12,496
99th		20,555
100th		20,723

Table 3.78 Annualised total area of coverage for 1:10,000 dilution for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Annual	87.10
99th		252.90
100th		292.70

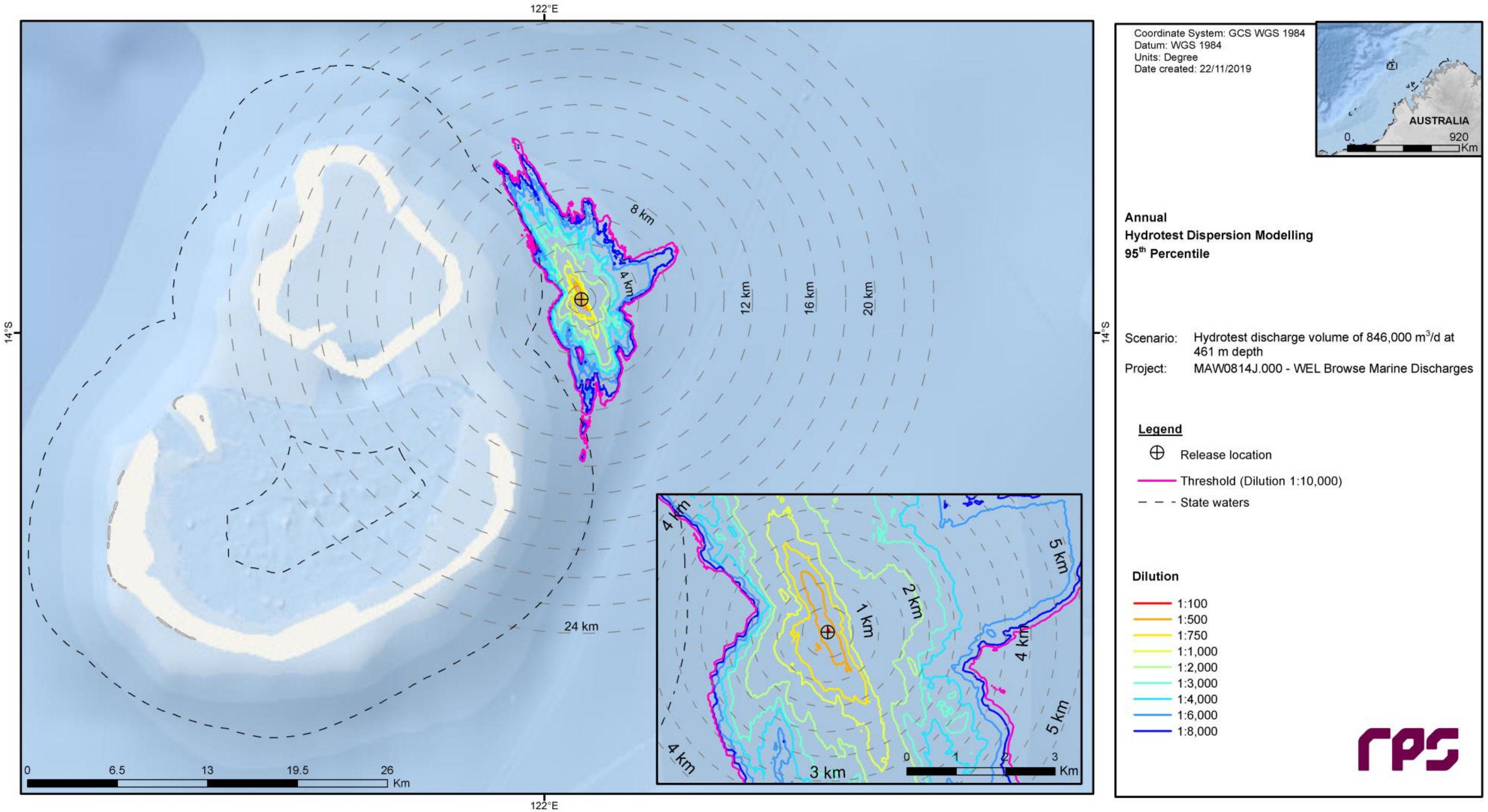

Figure 3.82 Predicted annualised minimum dilutions at the 95th percentile for Case H2 (Torosa PLET 846,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

REPORT

3.2.5.3.4 Discharge Case H3a: Brecknock/Calliance PLET Hydrotest Discharge of 790,000 m^3 at 539 m Depth

Table 3.79 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary) †	>>20,000	>20,000	>>20,000	>20,000	>>20,000	>20,000
20	508	508	353	353	318	318
50	826	74	465	72	398	71
100	1,611	334	1,070	157	817	139
200	2,007	1,291	1,167	321	923	267
300	2,351	1,371	1,695	663	1,476	593
400	2,286	1,445	1,486	646	1,245	622
500	2,608	1,562	1,642	776	1,462	709
600	2,599	1,580	1,542	877	1,352	778
700	2,959	1,847	1,833	985	1,586	780
800	2,959	1,559	1,823	862	1,514	840
900	3,199	1,850	2,101	1,041	1,740	866
1,000	3,271	1,609	2,151	1,051	1,740	942
1,100	3,412	1,979	2,291	931	1,924	864
1,200	3,504	1,856	2,402	922	1,948	881
1,300	3,685	1,924	2,494	1,003	2,165	993
1,400	3,844	1,913	2,542	953	2,284	888
1,500	3,993	2,084	2,623	874	2,337	822
1,600	4,175	2,083	2,581	820	2,353	753
1,700	>20,000	2,163	2,701	772	2,406	726
1,800	>20,000	2,168	2,736	787	2,435	726
1,900	4,517	2,011	2,767	811	2,441	772
2,000	4,760	2,088	2,923	783	2,587	783
2,100	4,945	2,169	3,130	862	2,703	862
2,200	5,331	2,057	3,251	971	2,819	971
2,300	5,567	2,166	3,466	1,117	2,896	1,071
2,400	6,068	2,247	3,598	1,085	3,087	1,058
2,500	>20,000	2,513	3,722	1,232	3,110	1,159
2,600	6,842	2,265	3,950	1,372	3,401	1,264
2,700	6,751	2,570	3,957	1,625	3,436	1,393
2,800	7,438	2,724	4,270	1,653	3,760	1,584
2,900	>20,000	2,563	4,241	1,641	3,804	1,565
3,000	8,966	2,660	4,519	1,707	4,108	1,629
3,100	8,906	2,744	>20,000	1,665	4,123	1,568
3,200	10,312	2,905	4,870	1,709	4,428	1,549
3,300	>20,000	2,941	4,930	1,784	4,412	1,514
3,400	13,559	3,048	5,502	1,853	4,899	1,473

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,500	14,586	3,059	5,597	1,737	4,854	1,428
3,600	>20,000	3,092	6,490	1,636	5,394	1,422
3,700	>20,000	3,138	7,114	1,593	5,483	1,512
3,800	>20,000	3,205	8,050	1,671	6,142	1,644
3,900	>20,000	3,196	8,682	1,685	6,200	1,665
4,000	>20,000	3,134	9,520	1,758	7,055	1,717
4,100	>20,000	3,150	10,208	1,729	7,994	1,676
4,200	>20,000	3,089	10,079	1,766	8,739	1,720
4,300	>20,000	3,164	10,326	1,893	8,843	1,739
4,400	>20,000	3,028	10,529	1,867	8,993	1,744
4,500	>20,000	3,225	12,226	1,949	9,976	1,711
4,600	>20,000	3,185	14,096	1,930	9,690	1,724
4,700	>20,000	3,287	18,124	1,993	9,962	1,833
4,800	>20,000	3,303	19,313	2,028	9,207	1,869
4,900	>20,000	3,642	>20,000	2,122	9,535	1,924
5,000	>20,000	3,924	>20,000	2,132	8,527	1,981
5,500	>20,000	4,260	>20,000	2,119	8,314	1,921
6,000	>20,000	4,650	>20,000	2,321	8,286	2,028
6,500	>20,000	4,880	>20,000	2,475	9,838	2,134
7,000	>20,000	5,429	>20,000	2,742	18,503	2,182
7,500	>20,000	5,819	>20,000	2,577	>20,000	2,412
8,000	>20,000	7,250	>20,000	2,256	>20,000	2,256
8,500	>20,000	6,268	>20,000	2,732	>20,000	2,684
9,000	>20,000	5,187	>20,000	3,348	>20,000	2,904
9,500	>20,000	4,857	>20,000	3,147	>20,000	3,065
10,000	>20,000	5,514	>20,000	3,992	>20,000	2,591
10,500	>20,000	8,244	>20,000	4,535	>20,000	2,738
11,000	>20,000	8,851	>20,000	4,932	>20,000	4,199
11,500	>20,000	9,050	>20,000	4,826	>20,000	4,367
12,000	>20,000	6,800	>20,000	4,318	>20,000	4,227
12,500	>20,000	5,854	>20,000	4,223	>20,000	4,009
13,000	>20,000	5,567	>20,000	4,395	>20,000	4,312
13,500	>20,000	5,689	>20,000	4,654	>20,000	4,467
14,000	>20,000	7,012	>20,000	5,756	>20,000	5,348
14,500	>20,000	8,689	>20,000	5,214	>20,000	5,080
15,000	>20,000	6,872	>20,000	5,369	>20,000	5,038
15,500	>20,000	7,539	>20,000	4,633	>20,000	4,487
16,000	>20,000	5,381	>20,000	4,293	>20,000	4,274
16,500	>20,000	6,935	>20,000	4,584	>20,000	4,470
17,000	>20,000	7,454	>20,000	4,686	>20,000	4,458
17,500	>20,000	9,676	>20,000	6,742	>20,000	6,090
18,000	>20,000	9,502	>20,000	6,442	>20,000	6,040
18,500	>20,000	10,774	>20,000	5,598	>20,000	5,371
19,000	>20,000	11,331	>20,000	5,650	>20,000	5,650

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	9,513	>20,000	5,379	>20,000	4,960
20,000	>20,000	8,823	>20,000	5,738	>20,000	5,589

† This receptor is outside the model domain and predictions of dilution are unavailable at or within its boundaries. Given the high levels of dilution predicted within the extent of the model domain (20 km) in the direction of Scott Reef, and the remaining distance (~12 km) from the edge of the model domain to the receptor, it can be assumed that a minimum dilution level of >20,000 will occur at or within the receptor boundaries at all percentiles.

Table 3.80 Annualised maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	23,421
99th		26,400
100th		26,502

Table 3.81 Annualised total area of coverage for 1:10,000 dilution for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Annual	89.40
99th		324.30
100th		390.50

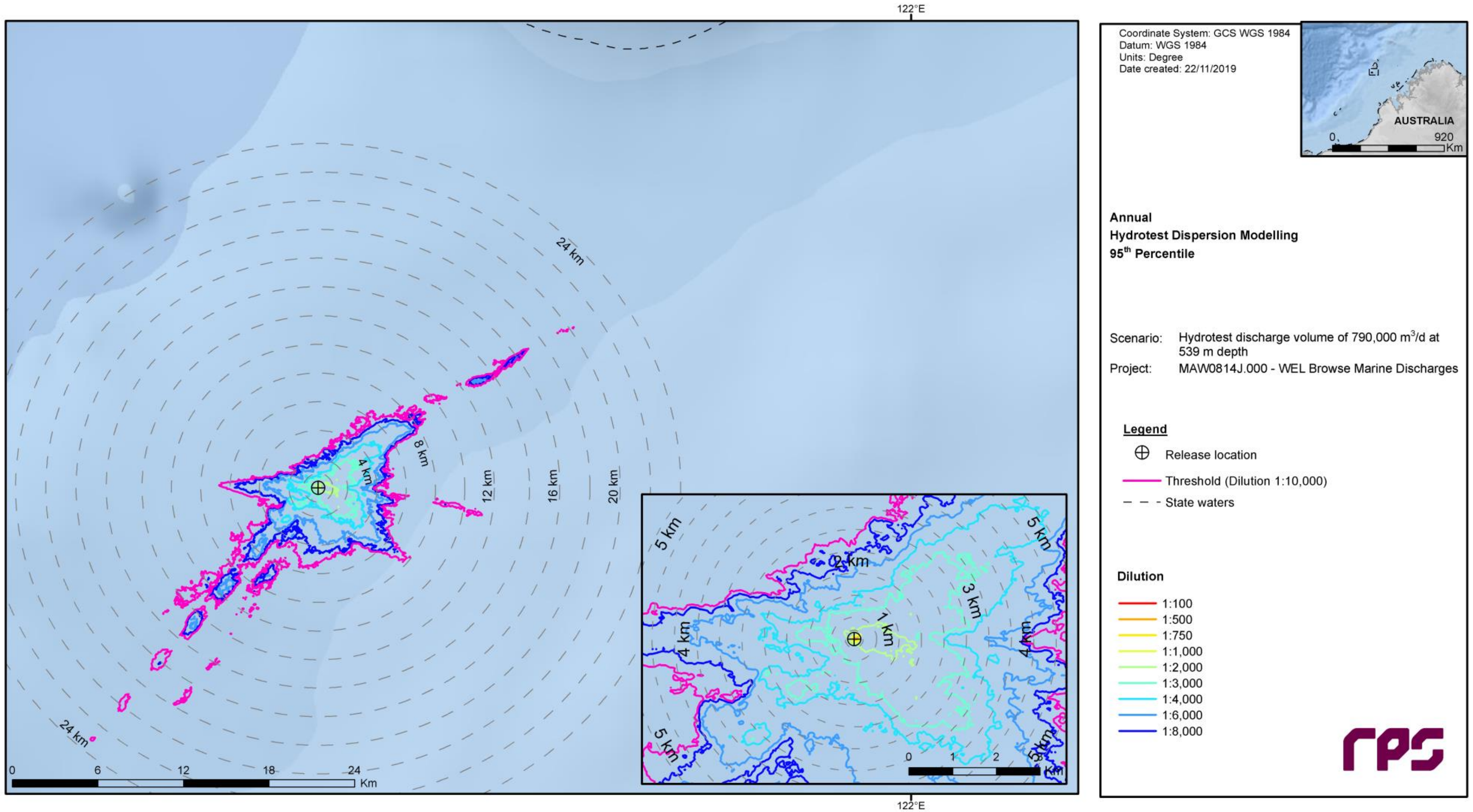

Figure 3.83 Predicted annualised minimum dilutions at the 95th percentile for Case H3a (Brecknock/Calliance PLET 790,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

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3.2.5.3.5 Discharge Case H3b: Torosa PLET Hydrotest Discharge of 56,000 m^3 at 461 m Depth

Table 3.82 Annualised average and minimum dilutions (1:x) achieved at specific radial distances from the hydrotest discharge location for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
Scott Reef (3 nm State Water Boundary)	>20,000	2,711	>20,000	1,531	>20,000	1,530
20	779	730	608	584	590	578
50	746	691	619	598	594	577
100	779	663	589	488	559	485
200	940	642	608	374	549	348
300	1,000	626	574	300	507	297
400	1,135	572	590	302	530	302
500	1,162	440	602	231	545	231
600	1,356	445	706	159	649	159
700	1,516	652	838	148	781	148
800	1,664	346	895	97	851	70
900	1,995	663	1,113	341	1,085	330
1,000	2,334	689	1,201	416	1,173	289
1,100	2,946	741	1,373	399	1,350	399
1,200	3,312	951	1,490	402	1,459	402
1,300	4,265	749	1,711	447	1,642	447
1,400	3,741	1,004	1,642	481	1,571	481
1,500	6,178	1,078	1,914	559	1,710	559
1,600	5,580	1,168	1,791	689	1,723	672
1,700	11,774	1,170	2,136	747	1,903	734
1,800	14,208	1,245	2,293	783	2,157	772
1,900	>20,000	1,453	2,755	878	2,586	869
2,000	>20,000	1,448	2,832	1,178	2,565	1,129
2,100	>20,000	1,454	3,165	1,146	2,831	1,136
2,200	>20,000	1,439	3,051	1,217	2,765	1,129
2,300	>20,000	1,591	3,358	1,126	>20,000	1,126
2,400	>20,000	1,722	3,262	1,221	3,063	1,135
2,500	>20,000	1,547	4,221	1,229	>20,000	913
2,600	>20,000	1,578	>20,000	1,134	>20,000	1,026
2,700	>20,000	2,012	7,335	1,096	6,036	1,032
2,800	>20,000	1,712	13,266	1,166	6,751	1,166
2,900	>20,000	2,160	>20,000	1,188	14,070	1,188
3,000	>20,000	1,779	>20,000	1,209	16,907	1,209
3,100	>20,000	1,949	>20,000	1,263	>20,000	1,263
3,200	>20,000	1,720	>20,000	1,308	>20,000	1,308
3,300	>20,000	1,750	>20,000	1,305	>20,000	1,305
3,400	>20,000	1,852	>20,000	1,300	>20,000	1,300

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Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
3,500	>20,000	1,815	>20,000	1,285	>20,000	1,285
3,600	>20,000	1,726	16,669	1,438	14,106	1,428
3,700	>20,000	1,776	>20,000	1,481	>20,000	1,481
3,800	>20,000	2,117	18,415	1,494	13,545	1,494
3,900	>20,000	2,014	>20,000	1,569	>20,000	1,569
4,000	>20,000	2,538	>20,000	1,536	>20,000	1,536
4,100	>20,000	2,255	>20,000	1,492	>20,000	1,492
4,200	>20,000	2,400	>20,000	1,526	>20,000	1,526
4,300	>20,000	2,115	>20,000	1,291	>20,000	1,291
4,400	>20,000	2,453	>20,000	1,178	>20,000	1,178
4,500	>20,000	2,376	>20,000	1,297	>20,000	1,297
4,600	>20,000	2,371	>20,000	1,173	>20,000	1,173
4,700	>20,000	2,204	>20,000	1,135	>20,000	1,135
4,800	>20,000	2,475	>20,000	1,198	>20,000	1,192
4,900	>20,000	2,109	>20,000	1,315	>20,000	1,298
5,000	>20,000	1,840	>20,000	1,324	>20,000	1,290
5,500	>20,000	2,365	>20,000	1,253	>20,000	1,246
6,000	>20,000	3,386	>20,000	1,689	>20,000	1,644
6,500	>20,000	3,423	>20,000	1,612	>20,000	1,461
7,000	>20,000	6,039	>20,000	1,542	>20,000	1,458
7,500	>20,000	4,503	>20,000	1,801	>20,000	1,513
8,000	>20,000	7,494	>20,000	3,542	>20,000	2,187
8,500	>20,000	13,983	>20,000	3,068	>20,000	3,068
9,000	>20,000	>20,000	>20,000	4,611	>20,000	3,839
9,500	>20,000	>20,000	>20,000	5,610	>20,000	5,111
10,000	>20,000	>20,000	>20,000	6,567	>20,000	5,777
10,500	>20,000	>20,000	>20,000	6,425	>20,000	5,381
11,000	>20,000	>20,000	>20,000	5,529	>20,000	5,529
11,500	>20,000	>20,000	>20,000	8,539	>20,000	8,539
12,000	>20,000	>20,000	>20,000	12,075	>20,000	11,702
12,500	>20,000	>20,000	>20,000	17,960	>20,000	17,960
13,000	>20,000	>20,000	>20,000	18,800	>20,000	18,800
13,500	>20,000	>20,000	>20,000	9,105	>20,000	9,105
14,000	>20,000	>20,000	>20,000	13,245	>20,000	12,962
14,500	>20,000	>20,000	>20,000	16,575	>20,000	14,560
15,000	>20,000	>20,000	>20,000	14,604	>20,000	12,981
15,500	>20,000	>20,000	>20,000	18,969	>20,000	17,076
16,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
16,500	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
17,000	>20,000	>20,000	>20,000	>20,000	>20,000	19,356
17,500	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
18,500	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
19,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

Distance (m)	95th Percentile		99th Percentile		100th Percentile	
	Average	Minimum	Average	Minimum	Average	Minimum
19,500	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000
20,000	>20,000	>20,000	>20,000	>20,000	>20,000	>20,000

Table 3.83 Annualised maximum distance from the hydrotest discharge location to achieve 1:10,000 dilution for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Maximum distance (m) from discharge location to achieve given dilution
95th	Annual	8,230
99th		13,845
100th		13,845

Table 3.84 Annualised total area of coverage for 1:10,000 dilution for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with application of a rolling 48-hour median to the dilution data.

Percentile	Season	Total area (km^2) of coverage for given dilution
95th	Annual	40.80
99th		92.70
100th		105.80

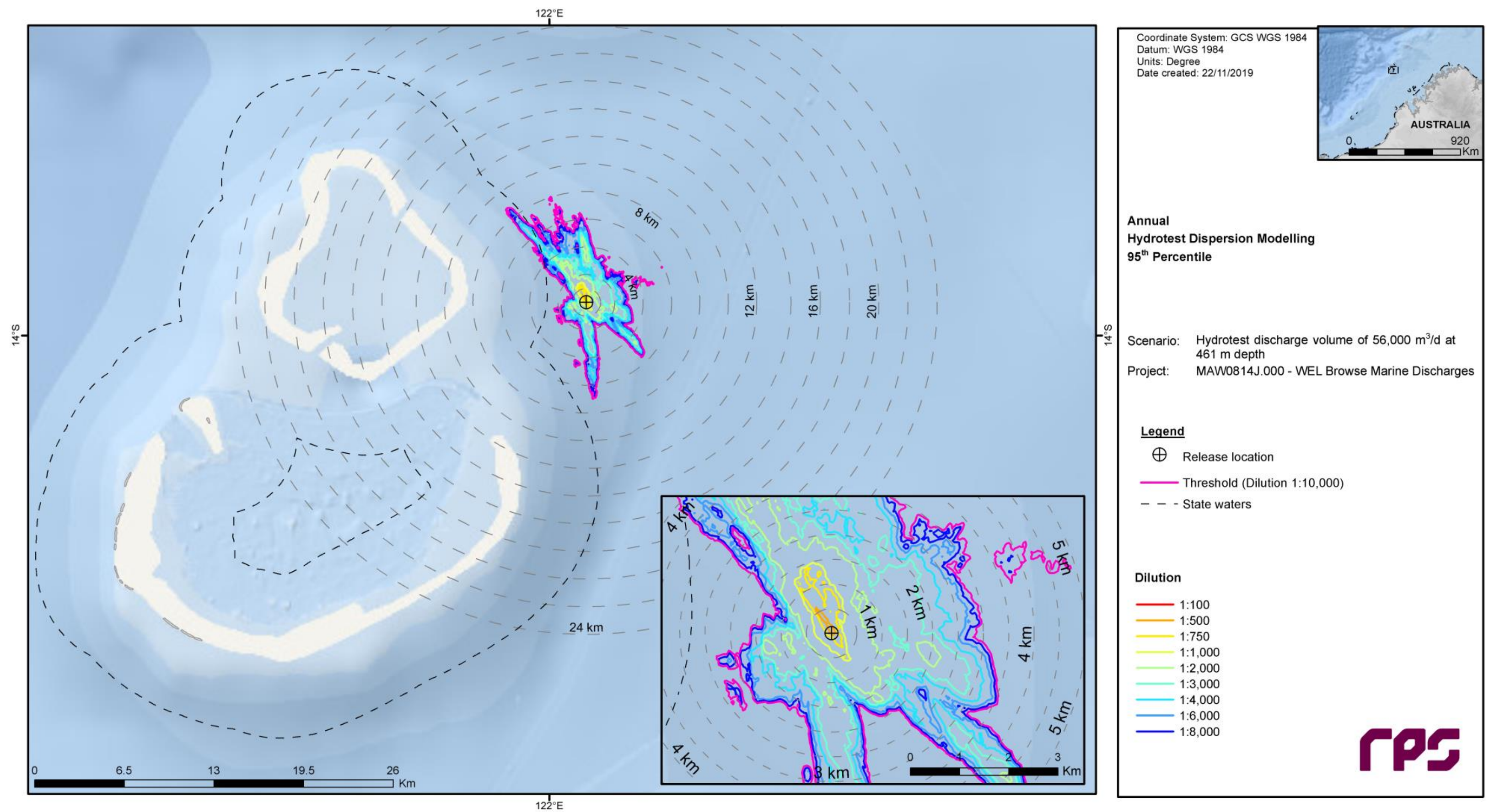

Figure 3.84 Predicted annualised minimum dilutions at the 95th percentile for Case H3b (Torosa PLET 56,000 m^3 hydrotest discharge), with a rolling 48-hour median of the dilution data.

4 CONCLUSIONS

The main findings of the study are as follows:

Near-Field Modelling

Cooling Water Discharges

- The results show that due to the momentum of the discharge a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 12 m below the water surface (Case C). Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plume is predicted to rise in the water column.
- The plume is predicted to plunge up to 16 m below the sea surface in all seasons.
- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.
- The maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as 37.8 m.
- The maximum diameter of the plume at the end of the near-field zone is predicted as 15.2 m.
- For all seasons, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.
- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:13.5 for Case C. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:6.3 for Case C.
- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Produced Water Discharges

- The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge point, which is 14 m below the water surface (Cases P and M). Medium and strong currents are shown to increase the extent of the turbulent mixing zone. Following this initial mixing, the positively buoyant plumes are predicted to rise in the water column.
- For Cases P and M, the plume is predicted to rise towards the water surface after the momentum of the initial discharge is lost.
- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.
- For both discharges, the maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as 20.2 m.
- For both discharges, the maximum diameter of the plume at the end of the near-field zone is predicted as 11.7 m.
- For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the

predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.

- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:204 for Case P and 1:1,222 for Case M. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:70 for Case P and 1:323 for Case M.

- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Hydrotest Discharges

- The results show that due to the momentum of the discharges a turbulent mixing zone is created in the immediate vicinity of the discharge points, which are 117 m (Case H1), 461 m (Cases H2 and H3b) and 539 m (Case H3a) below the water surface. Following this initial mixing, the near neutrally buoyant plumes are predicted to travel laterally in the water column.

- Increased ambient current strengths are shown to increase the horizontal distance travelled by the plume from the discharge point.

- For all discharges, the maximum horizontal distance travelled by the plume under annualised average current speeds is predicted as being in the range 50-77 m.

- For all discharges, the maximum diameter of the plume at the end of the near-field zone is predicted as being in the range 16-24 m.

- For all combinations of discharge case and season, the primary factor influencing dilution of the plume is the strength of the ambient current. Weak currents allow the plume to reach the trapping depth (at which the predictions of dispersion are halted due to the plume reaching equilibrium with the ambient receiving water) closer to the discharge point, which slows the rate of dilution.

- The average dilution levels of the plume upon reaching the trapping depth under annualised average current speeds are predicted to be 1:111 for Case H1, 1:166 for Case H2, 1:172 for Case H3a and 1:166 for Case H3b. Additionally, the minimum dilution levels of the plume (i.e. dilution of the plume centreline) upon encountering the trapping depth under annualised average current speeds are predicted to be 1:41 for Case H1, 1:62 for Case H2, 1:65 for Case H3a and 1:62 for Case H3b.

- The predictions of dilution rely on the persistence of current speed and direction over time and do not account for any build-up of plume concentrations due to slack currents or current reversals.

Far-Field Modelling

Cooling Water Discharges

- Instantaneous concentrations (based on a 60-second model time step) are considered when calculating dilution contours.

- The minimum level of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season is predicted to be 1:125 for Case C.

- For Case C, annualised results show dilution to reach an example level of 1:100 is achieved within an area of influence extending up to 4.2 km at the 95th percentile. The discharged plumes are predicted to travel predominantly along a north-northwest/south-southeast axis throughout the year, which is broadly parallel to the Scott Reef receptor boundary.

- For Case C, annualised results show the area of exposure defined by the 1:100 dilution contour is predicted to reach a maximum value of 3.7 km^2 at the 95th percentile.

- The maximum depth reached by the discharge across all seasons is predicted as 20 m for Case C.
- Considering the relative rates of acclimation of the plume characteristics with the ambient water, the limiting factor for the plume's area of influence is likely to be defined by its chlorine constituent rather than its temperature.
- An example 3 °C plume-ambient temperature differential is forecast to be met within 120 m at the 95th percentile across all seasons.

Produced Water Discharges

- Instantaneous concentrations (based on a 60-second model time step) are considered when calculating dilution contours.
- The minimum levels of dilution achieved at or within the Scott Reef receptor at the 95th percentile in any season are predicted to be 1:1,507 for Case P and 1:17,674 for Case M.
- For Case P, annualised results show dilution to reach an example level of 1:300 is achieved within an area of influence extending up to 0.9 km at the 95th percentile. The discharged plumes are predicted to travel predominantly along a north-northwest/south-southeast axis throughout the year, which is broadly parallel to the Scott Reef receptor boundary, with trajectories to the south-southeast forecast to be longer.
- For Case P, annualised results show the area of exposure defined by the 1:300 dilution contour is predicted to reach a maximum value of 0.7 km^2 at the 95th percentile.
- The maximum depth reached by the discharge across all seasons is predicted as 19 m for Case P.

Hydrotest Discharges

- Concentrations calculated following application of a rolling 48-hour median to the instantaneous data are considered when calculating dilution contours.
- The minimum levels of dilution achieved at or within the nearest receptor at the 95th percentile in any season are predicted to be >>1:20,000 for Case H1 (Rankin Bank), 1:4,440 for Case H2 (Scott Reef), >1:20,000 for Case H3a (Scott Reef) and 1:2,711 for Case H3b (Scott Reef).
- For Cases H1, H2, H3a and H3b, annualised results show dilution to reach an example level of 1:10,000 is achieved within an area of influence extended up to 16.1 km, 12.5 km, 23.4 km and 8.2 km, respectively, at the 95th percentile. The predominant plume travel directions throughout the year are forecast to be south-westerly (Case H1), along a north-northwest/south-southeast axis (Cases H2 and H3a) and along a north-east/south-west axis (Case H3a).
- For Cases H1, H2, H3a and H3b, annualised results show the area of exposure defined by the 1:10,000 dilution contour is predicted to reach a maximum of 79.2 km^2, 87.1 km^2, 89.4 km^2 and 40.8 km^2, respectively, at the 95th percentile.

Key Observations

Cooling Water Discharges

- The discharge will be initially positively buoyant and will rise in the water column, and may resurface in the vicinity of the discharge point prior to acclimation with ambient receiving water conditions.
- At the 95th percentile, plumes for Case C are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:125 in any season.

- At the 95th percentile, temperature acclimation of the plume with ambient waters is expected to occur within 120 m of the discharge point in any season and plume temperature will not be a relevant factor at the Scott Reef 3 nm State water boundary.

Produced Water Discharges

- At the 95th percentile, plumes are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:1,507 for Case P and 1:17,674 for Case M in any season.

Hydrotest Discharges

- Due to significant variations in the magnitude and directionality of the hindcast currents at each location where potential discharges will occur, predicted outcomes are markedly different.

- Transport patterns will reflect the predominant drift current trajectories at each location, with tidal movements a particularly important driver of dispersion for the deeper discharges. Greater variability in current trajectories is expected near the water surface due to the influence of wind, but, because the plumes are discharged at the seabed and are not positively buoyant, they will not experience these variations.

- At the 95th percentile, plumes are not expected to reach the Scott Reef 3 nm State water boundary at dilution levels less than 1:4,440 for Case H2, 1:20,000 for Case H3a and 1:2,711 for Case H3b in any season. For Case H1, the dilution level of any plumes that may reach Rankin Bank is expected to be significantly greater than 1:20,000.

REPORT

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