Port Kembla Gas Terminal Proposed Modification

Environmental Assessment

November 2019

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Executive summary

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal. The project involves the development of a liquefied natural gas import terminal at Port Kembla, south of Wollongong in NSW. The project consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres.
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla.
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into an underground natural gas pipeline located on shore.
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

The project was declared Critical State Significant Infrastructure in accordance with section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). An environmental impact statement (EIS) was prepared for the project and the project subsequently received approval from the Minister for Planning and Public Spaces on the 24th of April 2019.

The EIS stated the project would have the capacity to deliver in excess of 100 petajoules (PJ) per annum and also indicated that the capacity of the project could be increased further to 140–150 PJ per annum in the future. The EIS assumed a relatively flat demand profile throughout the year based upon the predicted demands from a predominantly industrial customer base.

Further analysis of the market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. The rate of production will need to respond to this demand and will also be influenced by operational parameters such as the calorific content of LNG delivered to the project. This would also have implications for some other operating parameters of the project including the operation of LNG trains, booster pumps, seawater discharge, and scheduling and options for LNG carriers.

AIE is therefore seeking a modification of the Minister’s approval for the Port Kembla Gas Terminal under section 5.25 of the Environmental Planning and Assessment Act 1979.

An environmental assessment has been prepared to consider the potential environmental impacts arising from the operational changes proposed as part of the modification under Section 5.25 of the EP&A Act. The proposed modification will not significantly alter the construction footprint or methodology which have been previously assessed as part of the Port Kembla Gas Terminal EIS. The assessment has therefore focussed upon environmental consequences arising from the operation of the project. The environmental assessment was informed by an initial scoping exercise that determined the issues that would require further assessment.

The key issues that were found to be potentially affected by the proposed modification include hazard and risk, water resources, marine ecology, noise and vibration, air quality, port navigation, greenhouse gas, and social and economic matters.

Other matters that were considered, but were not considered likely to be materially affected by the proposed modification, included soils and contamination, terrestrial biodiversity, heritage, traffic and access, waste management, climate change risk and cumulative impacts.

The potential hazards and risks of the project with the proposed modification have been assessed in an updated hazard and risk assessment. The assessment accounts for potential variability in throughput of natural gas and schedules and options for deliveries by LNG carriers with the proposed modification — including an indicative low season and high season. The main risk identified was the extension of the risk contours for open space across a section of Seawall Road and the extension of risk contours for industrial areas into the offsite truck washing area for the adjoining coal terminal operation. The risk to both areas was found to be limited due to the limited and transitory use of Seawall Road and the offsite truck washing area and the potential for access restrictions to be put in place for Seawall Road in particular. Further assessment of the high season incorporating refined assumptions and fire and gas detection systems was found to mitigate the risk further.

Potential impacts of utilisation and release of seawater during the high season on water resources were modelled, including cold water discharge and residual sodium hypochlorite. The modelling indicated that cold water discharge plumes would generally comply with the ANZECC requirement to adhere to the 20^{th} percentile of ambient temperature. Some restricted areas at the base of the water column were found to be in the order of 0.5 degrees colder than the ANZECC guidance.

The modelling also indicated that high season discharge resulted in improved mixing characteristics with regard to residual sodium hypochlorite. The nearfield mixing zone was therefore not materially different to the base case assessed in the EIS, being 42.5 metres in the base case and 42.6 metres in the high season respectively. Given the relatively small extent and seasonality of impacts identified, the mitigation measures in the EIS were considered adequate and no further mitigation measures were considered necessary.

Given the limited change in impacts to water resources potential impacts to marine ecology were similarly limited. The small temperature differentials that were modelled were found to be within typical seasonal variations and levels of tolerance for the marine communities within the area of impact. Any toxicity risk from residual sodium hypochlorite was found to be restricted to the zone of impact which, as described above, was not materially different to the base case.

Potential noise and vibration and air quality impacts were consistent with the base case assessed in the EIS in the sense that no incremental or cumulative exceedances of noise and vibration or air quality criteria were predicted at the sensitive receptor locations.

The potential variability in the schedule and options for LNG carriers was assessed for potential impacts to port navigation with reference to the original assessment, which included a review of applicable navigational guidelines and port protocols and completion of navigation simulation study. It was found that vessels would be able to continue to navigate the safely within the port following the proposed increase in frequency and variability in the schedule for LNG Carriers introduced by the proposed modification. Further, AIE would continue to consult with NSW Ports and the Port Authority of NSW throughout operation to ensure the project integrates safely and efficiently with port operations.

An updated greenhouse gas emissions inventory was produced, which demonstrated that while the inventory would continue to comprise about 0.01 % of Australia's national greenhouse gas emissions, there would be a relatively modest increase of 19% in the annual greenhouse gas inventory driven by the indicative high season.

The project with the proposed modification would continue to generate economic benefits through direct job creation as well as supporting gas-reliant industrial users and jobs, be in the order of 15,000 jobs in the region and 300,000 jobs across NSW. The proposed modification would not only provide long-term contracts to industry users but would also provide long-term contracts to retailers and in turn a supply of gas to over 1.5 million mass market residential and commercial customers. It would also potentially increase the total gas throughput of the project to the market and users.

1. Introduction

1.1 Overview

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Port Kembla Gas Terminal consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres.
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla.
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into an underground natural gas pipeline located on shore.
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

LNG will be sourced from worldwide suppliers and transported by LNG carriers to the Port Kembla Gas Terminal. The LNG will then be re-gasified for input into the NSW gas transmission network. The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

The Project was declared Critical State Significant Infrastructure (CSSI) in accordance with section 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and received Infrastructure Approval from the Minister for Planning and Public Spaces on the 24th of April 2019.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

The EIS stated the project would have the capacity to deliver in excess of 100 petajoules (PJ) per annum and also indicated that the capacity of the project could be increased further to 140–150 PJ per annum in the future. The EIS assumed a relatively flat demand profile throughout the year based upon the predicted demands from a predominantly industrial customer base. The assessment presented in the EIS for operation of the gas terminal was therefore based upon a flat rate of production with two LNG trains operating within the FSRU.

Further analysis of the market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. The rate of production will need to respond to this demand and will also be influenced by operational parameters such as the calorific content of LNG delivered to the project. Accordingly, the supply will likely vary from the assumed flat rate of around 300 Terajoules (TJ) per day for any given season or shipment of LNG.

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the *Environmental Planning and Assessment Act 1979*. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

The variation in demand between high season and low season is not as described in the EIS and the operations in high season are in excess of the intensity of operations considered as part of the environmental assessment process. Likewise, the low season impacts are considerably lower than those described in the EIS.

The modification will also require an increase to the overall number of LNG carrier deliveries per year to accommodate both the seasonality and the increase in capacity. The EIS anticipated the arrival of 24 consistently sized (170,000 cubic metre) vessels. However, with seasonality, incoming vessels may vary considerably in size from approximately 140,000 cubic metres to 180,000 cubic metres and up to 52 LNG Carriers per year may be required to support the project

Overall, the Port Kembla Gas Terminal will remain substantially the same development as approved under the original Infrastructure approval (SSI 9471). The proposed modification does not seek to significantly alter the nature or scale of the proposed development. Of the 64 conditions issued as part of the original development consent, it is expected that 3 will require some modification.

1.2 Purpose and structure

The purpose of this report is to provide environmental assessment of the proposed modification in support of a request for a Minister's approval under section 5.25 of the EP&A Act.

The structure and content of this report is as follows:

- Section 2 — Description of applicable legislation
- Section 3 —Project strategic context
- Section 4 — Description of proposed modification
- Section 5 — Environmental assessment of the proposed modification
- Section 6 — Consistency assessment of proposed modification with approval conditions
- Section 7 — Summary and conclusion.

2. Statutory context

2.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the principal law regulating development in NSW. It establishes a regime for the making of development applications, assessment of their environmental impacts, and development approval.

Part 5 Division 5.2 of the EP&A Act provides for declaration, assessment and approval of State significant infrastructure and critical State Significant Infrastructure (CSSI).

Port Kembla Gas Terminal has been declared to be CSSI. The CSSI application for Port Kembla Gas Terminal was submitted in July 2018. Secretary's environmental assessment requirements for the assessment of Port Kembla Gas Terminal were then issued in August 2018 and an EIS was then prepared in accordance with the environmental assessment requirements and was placed on public display in November and December of 2018. The RTS was prepared to respond to submissions from government agencies, organisations and individuals regarding the Port Kembla Gas Terminal. Development approval was subsequently given under section 5.19 of the EP&A Act on 24 April 2019.

Development approval for State significant infrastructure or critical State significant infrastructure may be modified under section 5.25 of the EP&A Act. The section states:

> *(2) The proponent may request the Minister to modify the Minister's approval for State significant infrastructure. The Minister's approval for a modification is not required if the infrastructure as modified will be consistent with the existing approval under this Division.*
>
> *(3) The request for the Minister's approval is to be lodged with the Planning Secretary. The Planning Secretary may notify the proponent of environmental assessment requirements with respect to the proposed modification that the proponent must comply with before the matter will be considered by the Minister.*
>
> *(4) The Minister may modify the approval (with or without conditions) or disapprove of the modification.*

The proposed design changes will not alter any aspect of the permissibility or regulatory framework for the project presented in Chapter 6 of the Port Kembla Gas Terminal EIS (2018).

2.2 Protection of the Environment Operations Act 1997

It is noted that following recent amendments to the *Protection of the Environment Operations Act 1997* (PoEO Act), the dredging required for construction of the berth would no longer constitute a scheduled activity requiring an Environment Protection Licence (EPL) as they are ancillary to the development of the project approved under the EP&A Act and the primary purpose of the dredging is not for the sale of extracted material.

An EPL will still be obtained for construction of the project to provide a defence against pollution of waters under Section 120 of the PoEO Act and the project will remain a scheduled activity during operations.

3. Strategic context

3.1 Overview

This chapter updates the strategic drivers of the project with regard to the NSW gas market, industrial users, predicted gas shortfalls, as well as key NSW government policies. It also notes the introduction of retail demand into the consumer demand profile for the project, which is the key driver for the proposed modification, to enable the project to be able to service both sectors.

NSW is the only mainland eastern state that does not have its own material local gas supplies and relies on Queensland, Victoria and South Australia for more than 95 per cent of its gas needs. This means NSW is widely exposed to supply and/or price disruptions from other states while the requirement to transport natural gas over large distances via on-shore transmission networks also puts NSW gas consumers at an immediate financial disadvantage. According to reports by the Australian Competition and Consumer Commission reports, NSW consumers may pay as much as an additional $3.50 per gigajoule (GJ) in gas transportation costs.

Forecasts from a range of market analysts and the Australian Energy Market Operator (AEMO) note the east coast gas market is becoming increasingly reliant on undeveloped, contingent or prospective sources of supply in order to meet forecast demand. These supplies may never be realised. In addition, gas producers in the north are expected to continue to focus on export markets while gas producers in the south continue to note declining production levels and increasing extraction costs.

Government policies such as the Australian Domestic Gas Security Mechanism have the potential to provide some relief to potential gas shortfalls, however gas forced to be supplied to NSW from interstate would likely remain expensive due to production and transportation costs.

The project will provide NSW with its own ‘virtual pipeline’ to natural gas production zones all around Australia and the world.

The original concept for the project foresaw large industrial users in NSW keen to embrace a new source of secure natural gas. Whilst industrial users remain a key focus for the project, retailers have also come forward seeking a reliable supply of natural gas. Unlike industrial demand which tends to be lower but consistent over the entire year, retail demand varies greatly between peak and off-peak seasons. Therefore, in order to achieve sufficient off-take agreements and to meet the needs of both industrial and retail customers, the project requires greater operational flexibility than is currently achievable under its existing consent.

The FSRU is designed with the capacity to run three LNG processing trains. However, this level of production is not required by the market. Instead, highly variable customer demand is expected to see two trains operating during the 6 month peak season and one train operating the remainder of the year.

The FSRU also has an inherent storage capacity of up to 4 PJs. This is equivalent to 10–12 days of emergency supply for all of NSW, should there be a significant disruption to gas supplies from other sources.

The key objectives of the project now are to:

- Introduce a new source of competitively priced gas to meet predicted supply shortfalls and help put downward pressure on prices
- Provide gas security to NSW
- Provide long-term contracts to industrial users

- Provide long-term contracts to retailers which in turn provide over 1.5 million mass market residential and commercial customers throughout NSW (AER 2018)
- Help support the 300,000 jobs across NSW, and the 15,000 jobs in the Illawarra, which rely on a competitive, reliable supply of natural gas
- Provide critical peaking supply in periods of high demand, typically winter seasonal demand and summer heat waves
- Support the diversification and future growth of Port Kembla.

3.2 Need for gas

Gas is an important natural resource for households, businesses and industries. The *NSW Gas Plan* (NSW Government 2014) notes more than a million households use gas for everyday uses like cooking or heating. It also notes about 33,000 NSW businesses and 500 heavy industrial operations rely on natural gas for their operations. These businesses are estimated to support over 300,000 jobs across NSW. In addition, over 10% of NSW's current electricity generation capacity is gas powered, with a number of proposed expansions already approved or well advanced in the planning process.

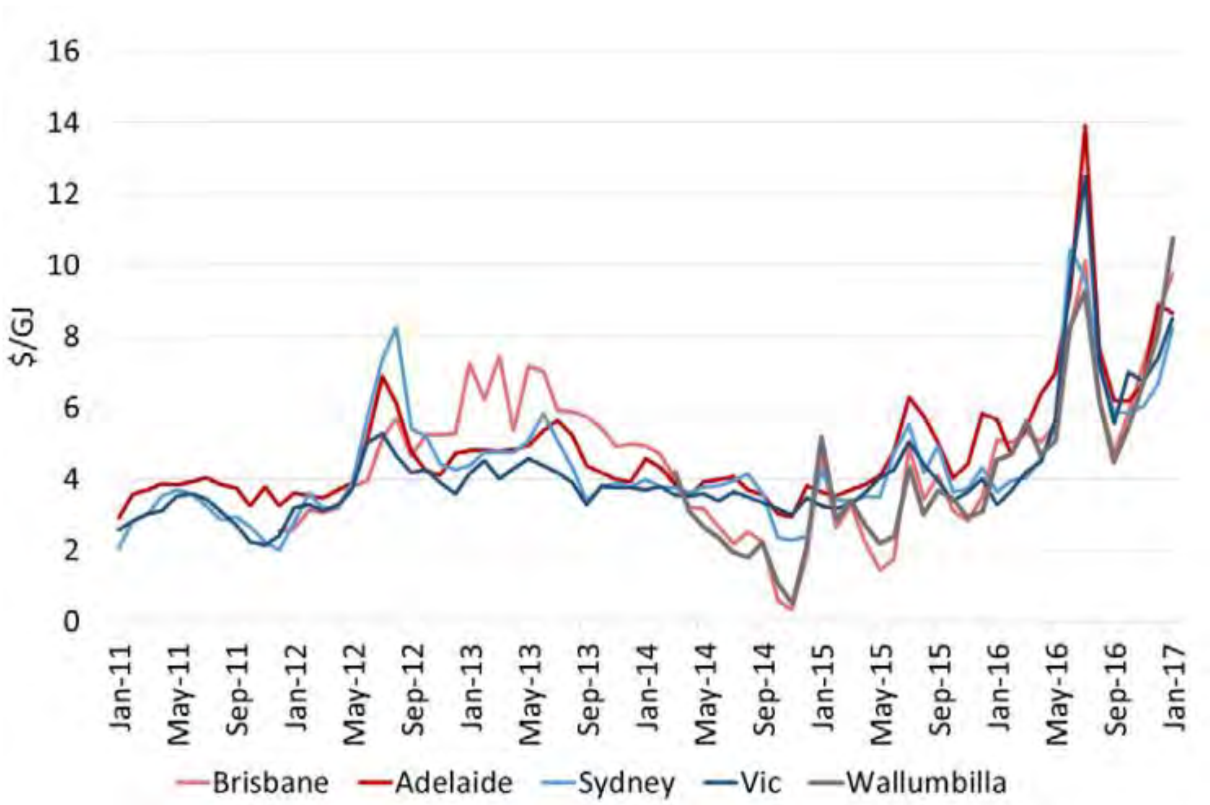
NSW has a heavier reliance on natural gas for use in its industrial sector than other east coast states. In NSW, industry accounts for 42% of demand, gas powered generation accounts for 21% of demand and residences accounting for the remaining 37% (AEMO 2018).

The AEMO is responsible for operating the gas markets across NSW, Victoria, Queensland and South Australia. Every year AEMO releases a Gas Statement of Opportunities (GSOO) to forecast the ability of Australian gas markets to meet demand. AEMO's latest GSOO (2019) states "the gas supply-demand balance remains tight, with gas production in southern Australia continuing to decline, and supplies from Queensland limited by pipeline constraints." It notes further that "from 2021 to 2023, [a] decline in production will reduce Victoria's ability to export surplus gas supplies to South Australia and NSW, placing more reliance on Queensland supplies in these States" (AEMO 2019).

An import terminal in the heart of the Illawarra provides NSW with the opportunity to secure its own gas supplies and reduce its vulnerability to supply and price shocks from its traditional sources of supply.

3.3 Gas pricing

The Gas Price Trends Review Report 2017 found substantial increases in wholesale gas prices on the east coast gas market. Between 2015 and 2017 wholesale gas prices for large industrial users were found to have risen by 21% in NSW, 78% in Victoria and 60% in Tasmania (Department of the Environment and Energy 2018). The volatility of gas prices and potential for sharp increases is demonstrated in the wholesale spot gas price trends over the longer term between 2011 and 2017 as shown in Figure 3-1.



Source: AEMO (2017)

Figure 3-1 Monthly average wholesale gas prices

Global gas prices respond to both production and transportation costs, as well as demand and supply balances. Typically, this means that eastern Australia is increasing its need for gas supplies while the northern hemisphere is reducing its demand. By opening the NSW market up to global gas supplies, the project ensures NSW gas users can potentially take advantage of counter-seasonal price advantages. In many instances, given the high costs of on-shore unconventional gas production and the large overland pipeline distances involved, an import terminal can provide both supply security and downward pressure on prices.

3.4 Gas supply

The most recent GSOO (AEMO 2019) has a specific section on supply infrastructure adequacy. In that section, AEMO notes, “Victoria has supplied, on average, 150 PJ per year to Tasmania, New South Wales, and South Australia from production surplus to Victorian gas consumption requirements over the last five years. Without new reserves and resources being developed in Victoria, this production surplus is projected to erode to 23 PJ in 2023. As a result, New South Wales and South Australia will need to source more gas from Queensland. Pipeline infrastructure constraints (particularly the Moomba to Sydney Pipeline, Moomba to Adelaide Pipeline, and later the South West Queensland Pipeline if Moomba production is reduced) start limiting the amount of gas able to be transported from the north to meet southern domestic demand or refill storages.

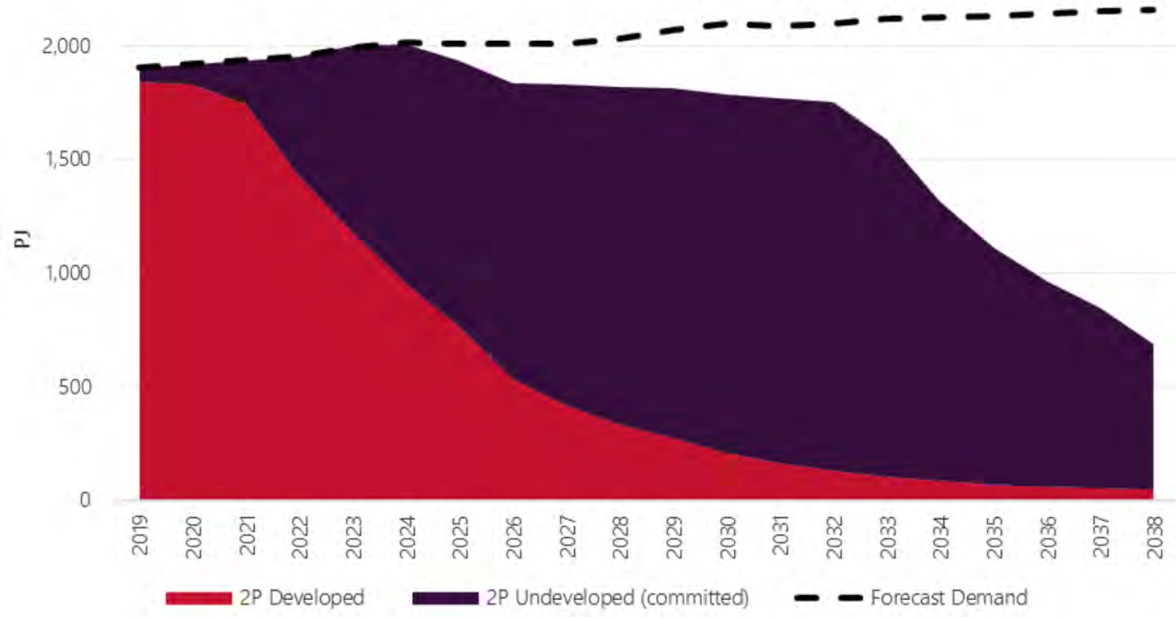
The GSOO goes on to also note “*within the next five years, domestic gas demand, particularly in the southern states, will be difficult to meet in its entirety without either:*

- Exploration and development of new southern resources, or
- New gas supplies delivered via LNG import terminal, or

- Major pipeline infrastructure expansions to deliver Queensland and Northern Territory gas southwards, or
- A combination of all three." (AEMO 2019).

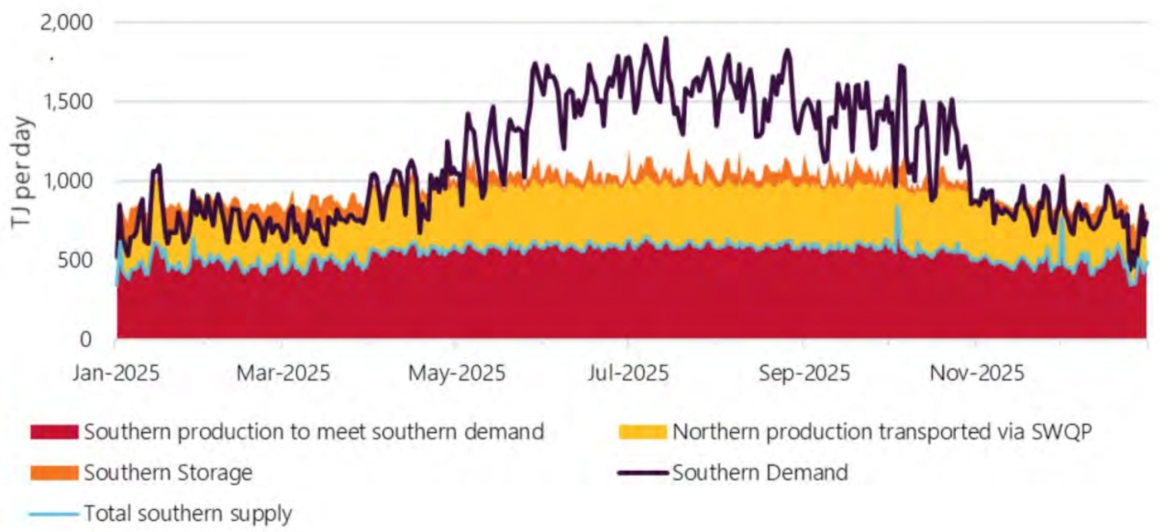
AEMO forecasts a supply gap from 2024, assuming all existing and committed projects proceed, as shown in Figure 3-2. However, this shortfall in demand is not a steady line. As Figure 3-3 shows, supply shortfalls are particularly obvious in winter months when gas consumption is heavily utilised for heating.

This seasonality in demand requires an ability for the market to ramp up supply quickly and easily for 6 months of the year. Many traditional supply sources are unable to dial-up / dial-down easily to respond to these market characteristics.



Source: AEMO (2019)

Figure 3-2 Projected eastern and south-eastern gas production (export LNG and domestic) from existing and committed projects (2019–38)



Source: AEMO (2019)

Figure 3-3 Forecast daily supply and demand balance in southern states including existing and commitment projects (2025)

Import terminals have been and are being used around the world to provide fast, economical access to global gas supplies for markets seeking to increase their independence from traditional suppliers, deliver seasonal flexibility, fast security of supply, increased pricing competition and support for decarbonisation plans in the electricity, marine transportation and other industries, all for a considerably lower infrastructure capital cost than might otherwise be required. The project would provide the same benefits to NSW in the face of a tightening eastern gas market.

3.5 Delivery to market

Approval of the Port Kembla Gas Terminal was based upon the development of short pipeline connection between the FSRU and the existing gas transmission network. The gas pipeline is proposed to comprise a DN450 carbon steel pipeline about 45 centimetres (18 inches) in diameter and about 6.3 kilometres in length and connect to an existing lateral extending from the Eastern Gas Pipeline (EGP) at Cringila.

The EGP is a key gas supply artery between the Gippsland Basin in Victoria and NSW and is owned and operated by Jemena. The pipeline delivers natural gas supplies to demand centres in Sydney, Canberra and Wollongong and passes through Kembla Grange to the west of Port Kembla.

An existing EGP lateral extends approximately 6.5 kilometres from Kembla Grange to a metering station at Cringila and services industrial customers at Port Kembla. The lateral spur line has a diameter of 200 mm (8 inches) and can be utilised for the project subject to upgrades to meet the projected demands for the project.

It is understood that Jemena are initiating an approval process to provide duplication and looping of the existing Kembla Grange to Cringila spurline. This is necessary to provide the required high season capacity to service the project and provide bi-directional flow of gas along the spurline to deliver gas to market whilst continuing to service existing customers at Port Kembla.

APA Group (APA) have also recently announced a proposal to develop a gas transmission solution that will provide a new pipeline connection between the Port Kembla Gas Terminal and the existing Moomba to Sydney pipeline network. The proposal would comprise a buried, steel, high pressure gas pipeline approximately 37 kilometres in length from Port Kembla to the existing gas transmission network located east of the town of Wilton on the south-western fringe of the Sydney metropolitan area.

The Moomba to Sydney Pipeline network is owned and operated by APA and comprises a 1,300 kilometre bi-directional mainline between Moomba in South Australia and Sydney. The pipeline system also includes a number of laterals connecting regional NSW, ACT and Victoria and will provide for flexibility of supply to Sydney, regional NSW and interstate markets.

Having two pipeline operators servicing the local area, as well as the wider NSW and interstate gas markets should result in significant benefits to gas buyers in the form of greater capacity, service delivery flexibility, enhanced geographic reach and stronger price competition.

The ultimate decision as to which pipeline is utilised to transport gas from the Port Kembla Gas Terminal to market will be based upon commercial agreements between gas retailers and pipeline operators. It is feasible that either gas transmission network, or a combination of the two alternatives, may potentially be used to deliver gas to market.

3.6 Policy setting

The policy setting of the project remains largely the same as described in the EIS. NSW remains vulnerable to supply constraints and the resulting economic hardship that a lack of supply or a lack of competitively priced supply can deliver to households, small businesses and manufacturers. As such, only key policy highlights are repeated below.

3.6.1 NSW Gas Plan

NSW Government gas policy is put forward in the *NSW Gas Plan* (NSW Government 2014). The plan outlined a strategic framework to secure “vital gas supplies for the state”. The plan recognised that “without affordable and reliable gas supplies our manufacturers will struggle to compete and our households will pay higher prices”. The plan identified five priority pathways, including a pathway dedicated to “securing NSW gas supply needs” which includes a range of measures to diversify supply sources and keep downward pressure on prices.

The project is consistent with the *NSW Gas Plan* (NSW Government 2014) as it contributes to a diversification of gas supply and increases competition in both the wholesale gas and the pipeline transmission markets. It also avoids some of the associated concerns over potential impacts of on-shore gas field development on prime agricultural land, or land valued for its environmental, social or cultural heritage values.

3.6.2 Australian Domestic Gas Security Mechanism

The Australian Domestic Gas Security Mechanism was established to enable the Australian Government to place export controls on uncontracted LNG exports to shore up domestic supply.

The mechanism has not yet been triggered, as under the Australian East Coast Gas Domestic Gas Supply Commitment some east coast LNG exporters have agreed to “offer sufficient gas to meet [expected shortfalls] through the good faith offering of gas to the domestic market on reasonable terms” (Department of Industry, Innovation and Science 2019).

While the mechanism and associated commitments may provide additional domestic supply, it is reasonable to expect these supplies would remain at relatively high prices due to production and transportation costs, especially for users in NSW.

The mechanism is currently under review by the Commonwealth Government.

3.6.3 Illawarra Shoalhaven Regional Plan

The Illawarra Shoalhaven Regional Plan is an overarching regional plan applying to the local government areas of Kiama, Shellharbour, Shoalhaven and Wollongong.

The regional plan identifies Port Kembla as a major economic asset that directly and indirectly supports over 3,500 jobs and contributes $418 million to the regional economy each year. It makes a number of specific directions in relation to Port Kembla including to grow the capacity of the port as an international trade gateway. The project is considered to be consistent with this direction given operations would involve international trade and the disposal of dredged and excavated material would support the development of the Outer Harbour.

3.6.4 NSW Ports 30 Year Master Plan

The NSW Ports *30 Year Master Plan* (2015) provides the long-term strategy for ports and other assets operated by NSW Ports including Port Kembla, Port Botany and intermodal facilities.

The plan states that Port Kembla is an economic asset of national significance and will be required to cater for growing trade volumes over the next 30 years. It anticipates containers could more than triple from 2.3 million to 8.4 million in total, bulk liquids more than double from 5.1 million kilolitres to 10.8 million kilolitres; motor vehicles more than double from 390,000 to 850,000 and dry bulk products grow from 20.3 million to 30 million tonnes over that time. The project is considered to be consistent with the NSW Ports 30 Year Master Plan.

3.7 Other project benefits

The project is expected to involve a capital investment of about $250 million and employ about 150 workers at its peak. Once fully operational, the project is expected to employ about 40–50 workers. The project is also expected to contribute to the realisation of a number of other NSW state and local government policy and program commitments:

- NSW's commitments to the Council of Australian Governments Energy Council — including the Australian Gas Market Vision and Gas Market Reform Package — which note the critical need to increase the volume of gas available domestically, the number of competitors in wholesale supply and pipeline transmission, and the level of pricing transparency.
- NSW Energy Security Taskforce Final Report — which recommends the NSW Government be more proactive in managing risks to NSW's energy security, including disruption from other states and fuel supplies, albeit primarily for electricity.
- NSW Renewable Energy Plan — designed to increase the participation of renewable energy in a stable, safe electricity grid and reduce carbon emissions. A local supply of natural gas not only supports existing firming solutions but also potentially provides a reliable fuel supply for any additional combined cycle gas turbine power stations needed to support NSW's stable transition to a more decarbonised electricity sector.
- NSW Climate Change Policy Framework — which aims to achieve net-zero emissions by 2050.
- NSW Government Regional Development Framework — which in part notes the importance of "fast tracking infrastructure projects that support business confidence, private sector investment and job creation in regional areas".
- Wollongong Economic Development Strategy 2013–2023 — which outlines a desire to support the diversification of the economy and port operations, including new industrial investment, especially around the surplus industrial landholdings located near the Port.
- NSW Government Industry Action Plan — which outlines a vision for manufacturing in NSW to 2021 and includes a "parallel objective of sustaining the existing manufacturing capability".

The consultation process for the project also identified a number of additional benefits of possible interest to the local region:

- Possible use of the facilities for open tolling
- Possible use of the facilities to support new value-add capabilities in port, such as LNG bunkering (refuelling marine vessels in port). This is also relevant given that international regulations governing emissions of the marine transportation sector are set to change in 2020. As such, an increasing number of marine vessels, including cruise ships are moving to use LNG in place of other marine fuels. Ports that cannot provide LNG re-fuelling facilities may well become marginalised over time.
- Possible optionality for a new combined cycle gas turbine power station in the Illawarra region. Such power stations can provide both baseload and dispatchable load, keeping downward pressure on prices and delivering greater grid stability.

- Possible additional investment appeal for new industrial manufacturers seeking to move to the region due to the availability of a local source of gas supply, with the corresponding avoidance of unnecessary inter-state transportation costs for securing those gas supplies
- AIE's proposal for an 800 MW combined cycle gas turbine power station is one of twelve projects shortlisted as part of the Commonwealth Government's Underwriting New Generation Investments program.

4. Proposed modification

4.1 Overview of the approved development

Port Kembla Gas Terminal consists of four key components:

- LNG carrier vessels — there are hundreds of these in operation worldwide transporting LNG from production facilities all around the world to demand centres.
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla.
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into an underground natural gas pipeline located on shore.
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

The layout of the Port Kembla Gas Terminal is reproduced in Figure 4-1. The EIS described that the project would have the capacity to deliver in excess of 100 PJ of natural gas per annum, which could be increased further to around 140–150 PJ of natural gas per annum through a slight increase in scheduled deliveries and pipeline upgrades. For the purpose of assessing potential impacts the EIS assumed a flat rate of production at 300 TJ per day to deliver 100 PJ per annum.

In order to achieve the assessed rate of production it was anticipated that 24 LNG carrier vessels of uniform size would visit Port Kembla in any one year during project operations. This would equate to an LNG carrier vessel arriving every two to three weeks, or around two LNG carrier vessels on average per month. When an LNG carrier vessel arrived it would tether alongside the FSRU for around 24–36 hours while the cargo was transferred from the carrier to the FSRU. These LNG carrier movements would be low in proportion to the vessel movements anticipated from other operational arrangements at the port (1,680 to 2,380 vessel movements per year) and would not be expected to significantly increase vessel movements or restrict navigability within the port.

The FSRU would receive the gas from the LNG carrier vessels, convert the LNG to high pressure gas onboard, and then transfer the gas to the gas pipeline for delivery to the existing gas transmission network. In order to convert the LNG to high-pressure gas the FSRU would warm the LNG from very low temperatures in the order of −161°C to temperatures in the order of 5°C. The FSRU would utilise seawater in this LNG regasification process and for a number of other purposes including cooling of engines and other machinery, ballast systems and a water curtain. It was expected that about 10.5 ML per hour would be utilised in the LNG regasification process, about 2.4 ML per hour for cooling of engines and other machinery, about 5.2 ML per hour for ballast systems and about 0.16 ML per hour for a water curtain. The seawater would usually be released back into Port Kembla harbour at a maximum temperature differential of 7°C.

Paper Size ISO A4

0 50100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

Project No. 21-27477
Revision No. A
Date 19 Feb 2019

Project layout

Figure 4-1

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Data source: Aerial imagery - nearmap 2018 (image date 16/04/2018, date extracted 01/08/2018); General topo - NSW LPI DTDB 2017, 2015 & 2015; Berth footprint - Australian Industrial Energy. Created by: afoddy

4.2 Proposed modification

4.2.1 Seasonality

Market analysis carried out since submission of the EIS has identified that demand for gas would be seasonally dependant. Retail customers in particular have a higher demand profile during the winter months in comparison the more steady state demand profile of industrial customers.

The FSRU operates with a series of three LNG regasification units or trains. Each LNG train comprises the necessary pumps, motors, heat exchangers, instrumentation, control and emergency shutdown systems. Each LNG train operates on either duty or standby mode and at least one LNG train is maintained in standby mode to provide redundancy to the overall FSRU operations. The operational scenario in the EIS included the operation of two LNG units, plus one on standby, with three LNG booster pumps running throughout the year. The output from each regasification unit can also be varied based upon the number of booster pumps and operating pressure. The regasification units involve LNG being pumped up from the cargo tanks into a suction drum. The LNG is then pumped through a series of heat exchanges, which utilise seawater as a source of natural heat differential to warm up the LNG. Once in a gaseous form, the gas is exported, under pressure, through the marine loading arms into the onshore gas pipeline.

Seasonal demand scenarios have been developed to support the modification assessment to allow for predicted variations in output throughout the year as shown in Table 4-1 and Figure 4-2.

The seasonal demand and associated variability of throughput on the FSRU would not require additional infrastructure or construction methodologies compared to the EIS.

Table 4-1 Proposed modification

Parameter	EIS	Modification scenarios	
	Base case	Low Season (approx. 6 months)	High Season (approx. 6 months)
LNG Trains	2	1	2
LNG booster pumps	3	1	4
Seawater discharge m^3/hr	10,500	3,250	13,000
Approximate TJ/day	300	120	500
Approximate PJ/year	100	115	

The high demand scenario will likely operate for up to six months from April through to September and will continue to operate with two LNG trains in accordance with the EIS. The high demand scenario will operate with one additional LNG booster pump to achieve higher gas output. Seawater discharges will also increase slightly from 10,500 m3/hr in the EIS to 13,000 m3/hr and have a maximum temperature differential of 7°C consistent with the EIS.

The low demand scenario will likely operate for up to six months from October through to March and will only operate with a single LNG train and LNG Booster pump based upon the lower gas output. Seawater discharges will decrease from 10,500 m3/hr in the EIS to 3,250 m3/hr and have a maximum temperature differential of 7°C, consistent with the EIS.

Figure 4-2 Seasonal demand scenario

In interpreting Table 4-1 and Figure 4-2, it is important to note actual daily customer demand and FSRU output will be influenced by operating conditions (rate of consumption) as well as the calorific content of the LNG delivered to the project. Supply of a relatively lean cargo vs a relatively rich cargo could result in variations in total derived units of energy (e.g. TJs) from the same volume of LNG. The demand and output projections (TJ/day) are therefore considered estimates for assessment purposes and to facilitate comparison with the original approved project. Similarly the size and number of LNG deliveries required per annum will depend on the LNG level in the FSRU, the calorific content of the shipment and the season. Essentially, with more variability in customer demand profiles, the project also requires more flexibility in the delivery schedule and options of its LNG cargoes.

NSW Ports has separately proposed the removal of shipment limits on port tenants, enabling NSW Ports to manage the overall capacity of the port for all port users. Additional movements of LNG carriers are not predicted to impact upon vessel movements or navigation within the port. Therefore, as discussed in section 6, removal or modification of Condition 6, which limits the project to 26 LNG cargoes per annum, is requested, providing this is acceptable to the NSW Government and NSW Ports.

4.2.2 Air emissions

Modern LNG carriers and FSRUs are typically powered by natural gas instead of marine diesel or other fossil fuels and consequently emit significantly lower levels of carbon dioxide, nitrogen oxides and particulates, and almost no sulphur oxides. While the FSRU would typically run on natural gas, it would also have the capability to run on marine diesel oil for maintenance purposes and/or in highly unusual/emergency type situations, in which there is no natural gas available for the engine. As described in the RTS, under these operating conditions there would be the potential for exhaust concentrations to exceed the NOx emissions limit in the Protection of the Environment Operations (Clean Air) Regulation 2010.

Increasingly, international and national air emissions standards are reducing the levels of permissible NOx emissions from marine transportation vessels. AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations and reducing greenhouse emissions wherever possible. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on marine diesel oil (MDO mode) to a level below the Protection of the Environment Operations (Clean Air)

Regulation 2010 limit. As discussed in section 6, Hoegh LNG has requested that Condition 8, limiting marine diesel oil use to 72 hours per year, be adjusted to note that the condition could be removed subject to the vessel being able to show compliance with Protection of the Environment Operations (Clean Air) Regulation 2010. This would remove the need for a further modification should technology be identified which can improve the environmental performance of the vessel in MDO mode.

5. Environmental assessment

5.1 Overview

This environmental assessment has been prepared to consider the potential environmental impacts arising from the operational changes proposed as part of the modification under Section 5.25 of the EP&A Act. The proposed modification will not significantly alter the construction footprint or methodology which have been previously assessed as part of the Port Kembla Gas Terminal EIS. The assessment has therefore focussed upon environmental consequences arising from the operation of the project. The environmental assessment was informed by an initial scoping exercise that determined the issues that would require further assessment. The key issues that were found to be potentially affected by the proposed modification include:

Key assessments undertaken as part of the environmental assessment include:

- Hazard and Risk — revision to the Preliminary Hazard Analysis completed for the project in accordance with the requirements of *State and Environmental Planning Policy No 33 – Hazardous and Offensive Development* (SEPP 33) and HIPAP 4: Risk Criteria for Land Use Safety Planning.
- Water Resources — Updated water quality modelling to determine potential impacts associated with release of seawater used in the regasification process back into Port Kembla's Inner Harbour. The results compared to criteria established during determination of the project with reference to Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2018), US EPA standards and NSW Environment Protection Authority (EPA) guidance.
- Marine Ecology — consideration of the potential impacts associated with the modified operations to marine values of Port Kembla with reference to Matters of National Environmental Significance under the *Environment Protection Biodiversity Conservation Act 1999*, and threatened marine fauna species listed under the NSW Fisheries Management Act, and the NSW Biodiversity Conservation Act 2016.
- Noise and vibration — updated noise assessment in accordance with the NSW *Noise Policy for Industry* (EPA 2017)
- Air quality — updated air quality assessment in accordance with *The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2016) (the Approved Methods) and reference to the Protection of the Environment Operations (Clean Air) Regulation 2010.
- Port Navigation — An updated assessment based on the existing navigation studies and ongoing consultation with NSW Ports and the Port Kembla Harbour Master is proposed throughout operations to ensure any increase in visiting vessels is integrated safely and efficiently into port operations.
- Greenhouse gas – updated greenhouse gas assessment undertaken in accordance with the *National Greenhouse and Energy Reporting Act 2007* and *National Greenhouse and Energy Reporting (Measurement) Determination 2008* and supplementary documentation in line with good accounting practice
- Social and economic — with regard to potential increased gas production and diversification of delivery to industrial, residential and commercial customers

Other matters that were considered, but were not considered likely to be materially affected by the proposed modification, included soils and contamination, terrestrial biodiversity, heritage, traffic and access, waste management, climate change risk and cumulative impacts.

5.2 Hazard and risk

5.2.1 Introduction

The potential hazards and risks arising from the project were originally assessed in the hazard and risk assessment in the Port Kembla Gas Terminal EIS. The assessment describes the potential hazards arising from the project, the consequences of those hazards, the likelihood of hazard events occurring and the level of risk in relation to the relevant risk criteria. The hazards identified include a loss of containment of LNG from the FSRU and/or LNG carrier, marine loading arms, berth pipeline and gas pipeline. The consequences arising from those hazards included jet fire, flash fire, pool fire or explosion.

The assessment found that risks to sensitive, residential and commercial areas were well within the relevant hazard criteria for these areas. The risks were generally contained to industrial and open areas adjacent to the Berth 101, including parts of the coal terminal, inner harbour and a section of Seawall Road about 150 metres to the east. The presence of people, vehicles or vessels in these areas would be expected to be transitory and consequently subject to a very low level of risk in the order of 50 chances in a million per annum or fewer. The assessment committed to further hazard analysis including a safety case, hazard identification and design assurance processes and a comprehensive safety management system to minimise risk.

The assessment of potential hazards and risks has been updated to account for the proposed modification, including the potential variability in throughput of natural gas and the schedule and options for deliveries by LNG carriers as discussed in section 4. The updated assessment is provided as Appendix A while the findings of the assessment are summarised below.

5.2.2 Risk criteria

The risk criteria applied in the updated assessment of potential hazards and risks is consistent with the EIS and as per *Hazardous Industry Planning Advisory Paper No 4 Risk Criteria for Land Use Safety Planning*. The relevant risk criteria are reproduced in Table 5-1.

The assessment also incorporates a number of worst case assumptions, including that the mitigating effect of fire and gas detection, isolation and depressuring systems on the FSRU and LNG carriers are not taken into account, and that all leak scenarios are modelled based on an infinite volume of LNG. As such the hazard and risk assessment may represent a worst case.

Table 5-1 Risk criteria

Risk (per annum)	Land use
Fatality	
0.5 in 1 million (5E-07)	Sensitive land uses such as hospitals, care facilities or schools
1 in 1 million (1E-06)	Residential areas including hotels and motels
5 in 1 million (5E-06)	Commercial areas including shops and offices
10 in 1 million (1E-05)	Active open space including sport complexes
50 in 1 million (5E-05)	Industrial areas
Injury	
50 in 1 million (5E-05)	Sensitive land uses and residential areas
Propagation	
50 in 1 million (5E-05)	Industrial operations

5.2.3 Risk assessment

Low season

The indicative low season throughput of 120 TJ/day was assessed and resulting risk contours shown below in Figure 5-1. Other than throughput, all other model inputs were retained as per the hazard and risk assessment in the EIS. The results indicate the contour for industrial areas (5E-05) is contained within the site boundary. The results also indicate the contour for open space (1E-05) extend beyond the site boundary and across a small section of Seawall Road at a similar extent to the contour assessed in the EIS, although slightly reduced. Potential impacts at Seawall Road are discussed further below in relation to the high season.

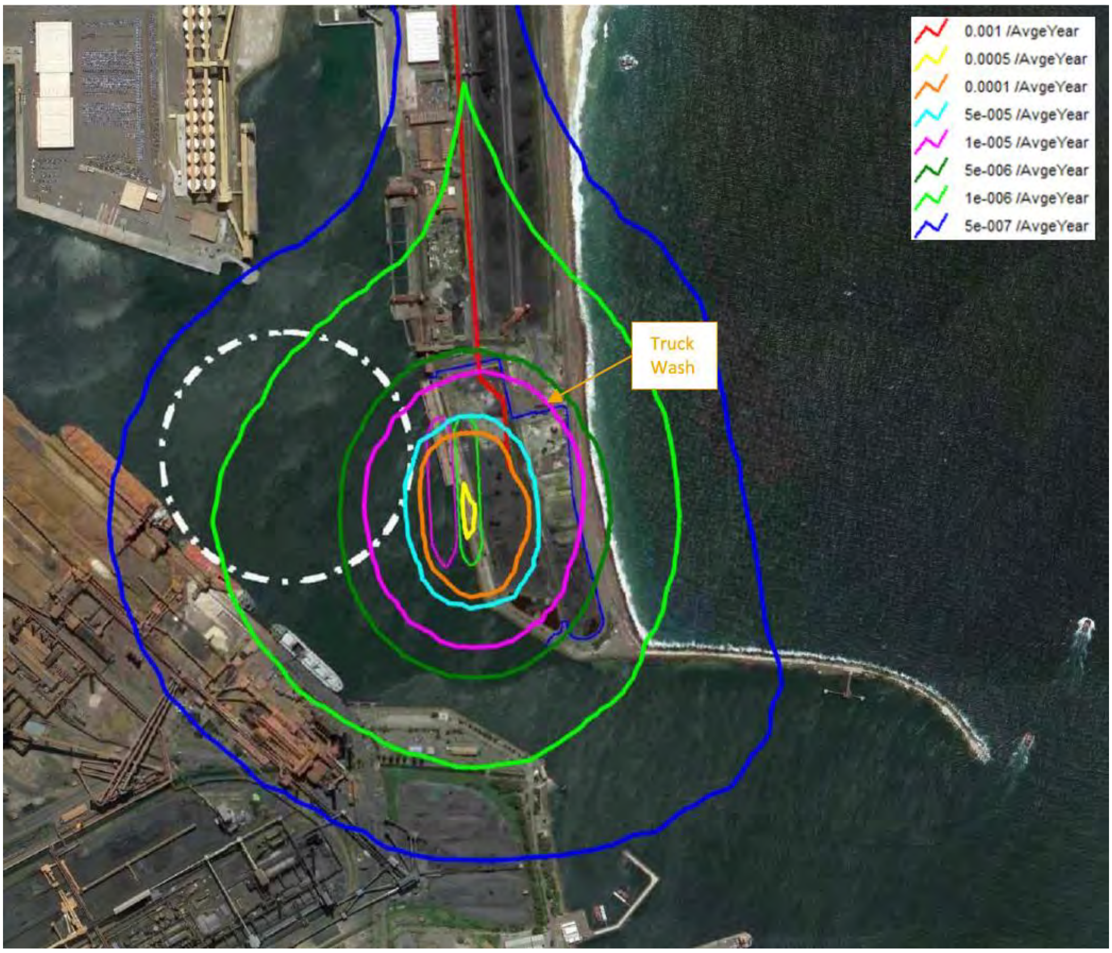

Figure 5-1 Low season scenario

High season

The indicative high season throughput of 500 TJ/day was assessed and the risk contours are shown below in Figure 5-2. The high demand case also incorporated a nominal increase in the frequency of LNG carriers to 52 per year, representing a potential worst case scenario.

The results indicate the contour for industrial areas (5-E05) extends beyond the site boundary and encroaches into an infrequently used area of the adjoining Port Kembla Coal Terminal currently used as an offsite truck washing area. While the exposure at the truck wash area is slightly greater than 5E-05, the risk to an individual is low as the truck wash area would not be permanently occupied and would be utilised by relatively small numbers of individuals for limited durations.

The results show the contour for open space (1E-05) also extends beyond the site boundary including across a section of Seawall Road. Seawall Road is a private road controlled by NSW

Ports and the Port Kembla Coal Terminal and is opened to the public during daylight hours only. Access restrictions can be implemented and enforced by NSW Ports if required. Exposure is likely to be for short durations and numbers are limited as indicated by NSW Ports:

> *"The road tends to be used by surfers, rock fishers and occasional on-lookers for unusual events, such as the arrival of a large cruise ship. However, numbers of users are in the dozens, not the [hundreds], with the largest crowds seen there for the arrival of the Port's first cruise ship. Subsequent cruise ship arrivals have seen the crowd numbers dwindle."*

It is noted that high season operation for the Port Kembla Gas Terminal will be restricted to the cooler winter months and the spring and autumn shoulder seasons. The high season rates are therefore not predicted to coincide with the more popular periods of use of Seawall Road for recreational activities which is typically over the summer months.

The nominal increase in the frequency of LNG carriers extends the sensitive areas contour (5E-07) and residential areas contour (1E-06) into the harbour including potential shipping routes for cruise ships. The overall risk to other port users is considered to remain negligible.

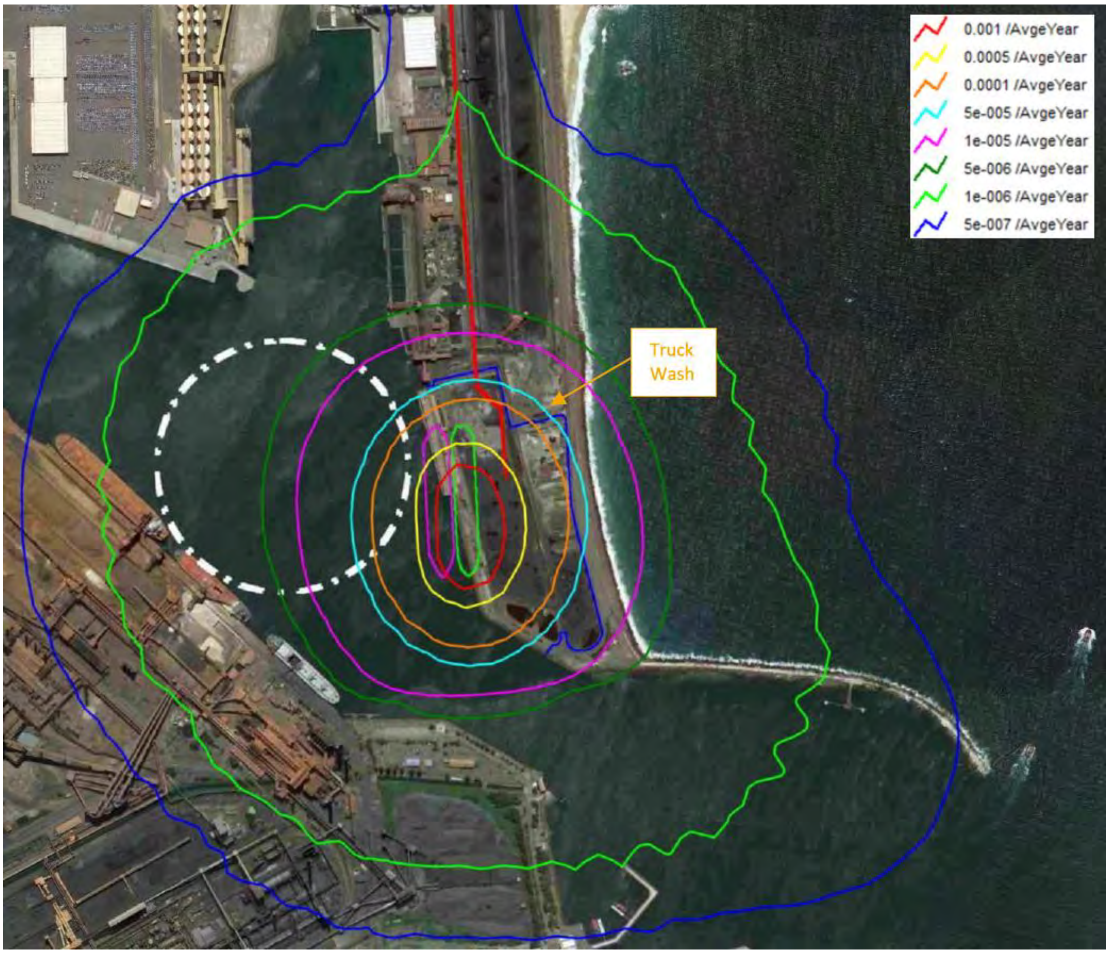

Figure 5-2 High season scenario

A sensitivity analysis of the high season scenario was also carried to include more realistic LNG leak rates and account for the mitigating effect of fire and gas detection, isolation and depressurising systems on the FSRU and LNG carriers, including:

- Estimating the largest isolatable volume of LNG
- Adopting mitigated leak rates and ignition probabilities
- Accounting for fire and gas detection while retaining a conservative probability of failure

The resulting risk contours for the sensitive analysis are shown below in Figure 5-2. The results indicate the contour for industrial areas (5-E05) contracts and would no longer encroach into the offsite truck washing area associated with the coal terminal adjacent to Berth 101. The results also show the contours for open space (5-E05), sensitive areas (5E-07) and residential areas (1E-06) also contract. Further reduction in the contours may be realised through calculation of individual isolatable section volumes and applying these to the risk model.

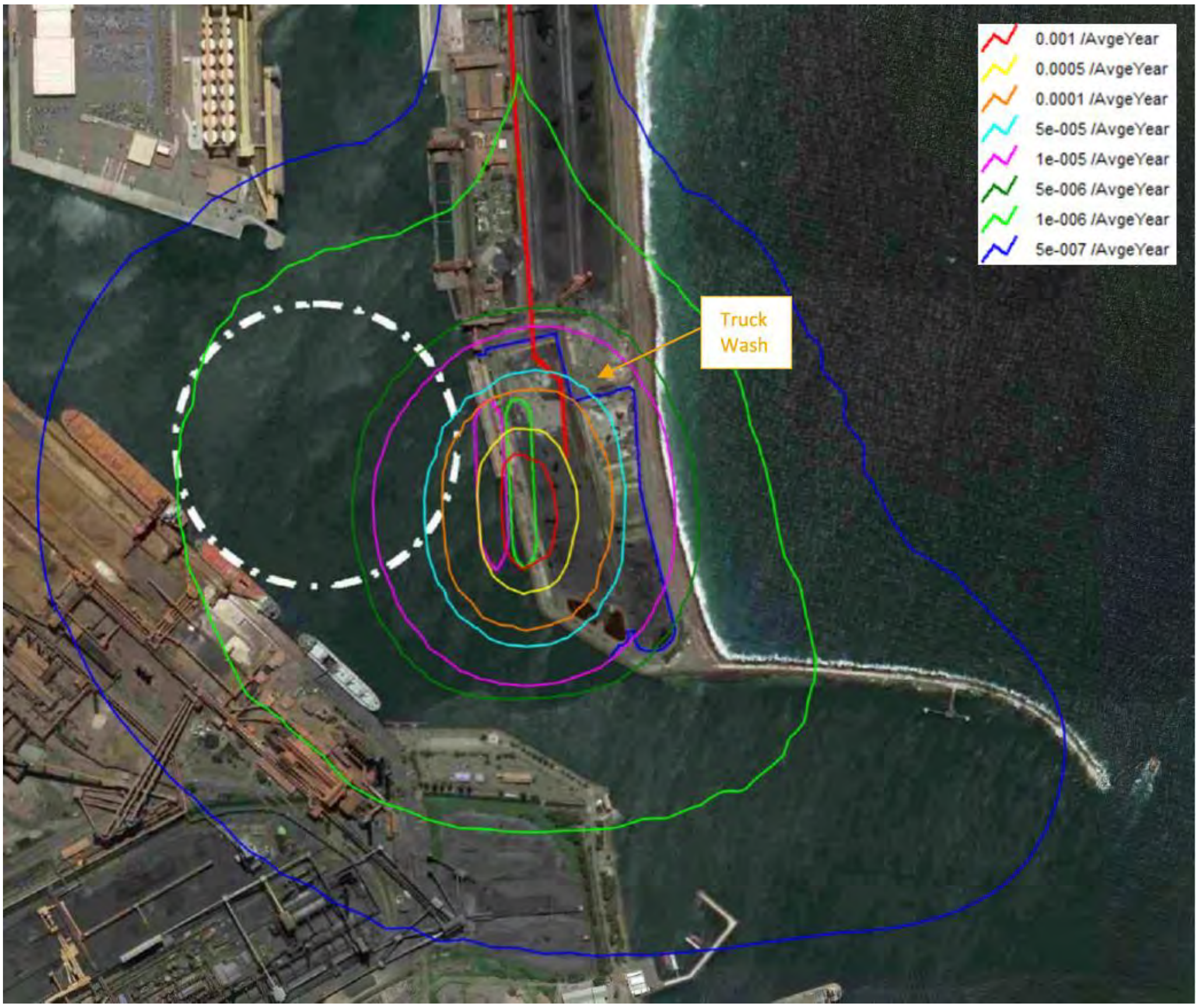

Figure 5-3 High season scenario (sensitivity analysis)

Assessments against the criteria for injury at sensitive and residential areas (5E-05) and propagation to industrial operations (5E-05) were also undertaken for the high season scenario. The results for heat flux and explosion overpressure are shown in Figure 5-4 and Figure 5-5.

The results indicated the potential for heat flux causing injury (4.7 kW/m^2) would extend marginally beyond the site boundary but would not affect any sensitive or residential areas. The potential for heat flux cause propagation to industrial operations (23 kW/m^2) was generally within the site boundary and would not extent to nearby onshore industrial operations. The results also indicated the potential for explosion overpressure causing injury (7kPa) or propagation to industrial operations (14 kPa) would similarly be contained to the site boundary and would not have the potential to affect sensitive or residential areas or industrial operations.

Figure 5-4 High season scenario (heat flux)

Figure 5-5 High season scenario (explosion overpressure)

5.2.4 Conclusion

Overall, the updated assessment of potential hazards and risks found the proposed modification would not introduce additional hazardous inventories or scenarios. Consistent with the findings of the EIS, the updated assessment has found the criteria for sensitive areas, residential areas and commercial development are met in all cases, as are the criteria for injury and propagation. Limited risks to open space and industrial areas have been identified which, consistent with the EIS, include a section of Seawall Road and the offsite truck washing area associated with the coal terminal adjacent to Berth 101. Given the consistency of the hazards and risks identified and assessed the EIS and in this updated assessed, it is not considered that additional measures are necessary to avoid, mitigate and manage the potential hazards and risks.

5.3 Water resources

5.3.1 Introduction

The potential impacts of the project on water quality, hydrodynamics and hydrology were originally assessed in the water resources chapter of the Port Kembla Gas Terminal EIS. The assessment described the existing conditions, including historical ambient water quality within the port and assessed the potential impacts of the proposed LNG import terminal during construction and operation.

During the operational phase of the project, the variation in gas demand between high season and low season is expected to result in greater intensity of operations and increased utilisation and release of seawater during the high season than those considered as part of the environmental assessment process. Likewise, the low season impacts are considerably lower than those described in the EIS.

Proposed modifications to seasonal seawater discharge rates are presented in Table 5-2.

Table 5-2 Proposed modification to seawater discharge rates

Parameter	EIS Base-Case	Low Season (approx. 6 months)	High Season (approx. 6 months)
Seawater discharge m^3/hr	10,500	3,250	13,000

The high demand scenario will operate for up to six months from April through to September and will continue to operate with two LNG trains in accordance with the EIS. Seawater discharges will have a maximum temperature differential of 7°C and residual sodium hypochlorite discharge concentration of 0.02 ppm or 20 ug/l consistent with the EIS and conditions included in the project approval.

5.3.2 Existing environment

The Port Kembla Gas Terminal EIS noted that water quality within the Inner Harbour and Outer Harbour of Port Kembla has been historically impacted by urban and industrial discharges as well as port activities. In particular, these past activities led to contamination of marine sediments, groundwater and harbour waters.

Previous water quality monitoring studies have been undertaken in order to define ambient water quality within the port and to monitor water quality parameters during previous dredging campaigns.

These studies identified a number of key issues relating to the following water quality parameters which are summarised in Table 5-3.

Table 5-3 Historical water quality

Parameter	Summary of historical results
Contaminants	Water samples collected under ambient conditions during the 2002-2005 monitoring program undertaken by the Port Kembla Environment Group identified concentrations of aluminium, cadmium, copper, lead, zinc, tin and arsenic in excess of the ANZECC (2018) 95% trigger values for protection of marine waters. Concentrations of all other analytes were below the adopted trigger values. Elevated levels of adverse water quality parameters were generally found in the vicinity of creeks and waterways that drain industrial and stockpile areas such as the entrance to Allans Creek (Site 1), Gurangaty Waterway (Site 5), near No. 1 Products Berth (Site 3), the Cut (Site 7) and Darcy Road Drain (Site 15).
Suspended Solids / Turbidity	TSS concentrations are known to be influenced by shipping movements and freshwater flood events. Long term data collected during the 2002-2005 monitoring program undertaken by the Port Kembla Environment Group measured average TSS concentrations of 5.9mg/L and 3.2mg/L within the Inner and Outer Harbours respectively. TSS concentrations within the Inner Harbour were shown to vary between 1.0mg/L and 17.9mg/L. TSS concentrations within the Outer Harbour were shown to vary between 0.5mg/L and 11.8mg/L. Previous dredging campaigns (Berth 103) established a relationship between Nephelometric Turbidity Units (NTU) and Total Suspended Solids (TSS) of 1 NTU = 2mg/L TSS. It is critical to note that the relationship between NTU and TSS is highly dependent on the material properties of the sediments in suspension.
pH	Previous monitoring campaigns have recorded pH levels within the Inner and Outer Harbour ranging between 7.6 and 8.1 and in some instances below the recommended ANZECC criteria for harbour waters (8.0-8.5). Previous investigations concluded that pH levels are lower in the Inner Harbour than the Outer Harbour, indicating pH levels within the Inner Harbour are likely influenced by freshwater discharges from existing waterways.
Temperature	Water temperatures within Port Kembla are generally higher than those measured offshore due to tidal flushing patterns and existing industrial discharges to the Inner Harbour. As a result, water temperatures within the Inner Harbour are generally one to two degrees warmer than sea temperatures beyond the entrance to the harbour. The Outer Harbour benefits from greater tidal flushing and is generally less than 0.25 degrees warmer than sea temperatures beyond the entrance to the harbour.
Salinity	Total Dissolved Solids (TDS) concentrations assessed during 2014 maintenance dredging campaign ranged from 31.15g/L to 35.38g/L. Concentrations have been shown to vary with depth indicating density stratification within the water column. Concentrations are also known to be influenced by freshwater flood events.

5.3.3 Adopted guidelines

ANZECC guidelines are typically considered to be the most relevant guidelines for assessing and managing ambient water quality in natural and semi-natural water resources within Australia. The ANZECC Guidelines present numerical guidelines which can be used as a basis to assess the impact of the development of the Port Kembla Gas Terminal against defined objectives or values for the receiving waters.

The core concept of the ANZECC Guidelines relates to managing water quality for environmental values. For each environmental value, the guidelines identify particular water quality characteristics or 'indicators' that are used to assess whether the condition of the water supports that value.

The environmental values expressed as water quality objectives provide goals to assist in the selection of the most appropriate management options for a waterway. The ANZECC Guidelines also advocate an ‘issues-based’ approach to assessing ambient water quality, rather than the application of rigid numerical criteria without an appreciation of the context. This means that the guidelines focus on:

- the environmental values we are seeking to achieve or maintain;
- the outcomes being sought; and
- the ecological and environmental processes that drive any water quality problem.

In the case of Port Kembla Harbour, the relevant values relate to Aquatic Ecosystems and Visual Amenity and it is recognised that community, government and industry have undertaken significant work since the 1970s to reduce the level of pollution and improve water quality within the harbour. Applicable trigger values for the project include:

- Construction — 90% of species protection criteria (95% for bioaccumulating substances)
- Operation — 95% of species protection criteria (99% for bioaccumulating substances)

It should also be noted that the environmental values and respective numerical indicator values apply to ambient background water quality and are not intended to be applied to mixing zones associated with a release from a point source discharge. Discharges from the FSRU therefore need to be considered in recognition of other land uses and existing water quality within the working harbour at Port Kembla.

It is noted that the revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) have been recently updated following scientific review of the ANZECC (2000) guidelines.

Chlorine

The EIS noted that the ANZECC guidelines provide a 95% species protection default guideline value (previously known as trigger value) for total residual chlorine within freshwater aquatic environments of 3 µg Cl/L. No equivalent values are provided for the marine environment however the guidelines note that the freshwater value “was adopted as a marine low reliability trigger value, to be used only as an indicative interim working level”.

Given the absence of an ANZECC default guideline value for total residual chlorine within marine environments, consideration was given to the IFC World Bank Group Environmental, Health, and Safety (EHS) *Guidelines for Liquefied Natural Gas (LNG) Facilities*. These guidelines have been developed to represent good international practice for environmental protection based upon the use of existing technologies available for a specific industry at reasonable cost. The guidelines stipulate the following in relation to residual sodium hypochlorite in seawater,

“Free chlorine (total residual oxidant in estuarine/marine water) concentration in cooling/cold water discharges (to be sampled at point of discharge) should be maintained below 0.2 parts per million (ppm) [200 µg\L].” (IFC, 2017).

It is recognised that the applicability of the IFC World Bank guidelines should be tailored to the risks and sensitivity of the local environment. As noted above, the ANZECC guidelines do not include a value for total residual chlorine within marine environments. The US EPA standards provide aquatic life ambient water quality criteria for significant risk to marine waters at 13µg/L (acute chlorine criteria) and 7.5 µg/L (chronic chlorine criteria).

Temperature

In relation to temperature decreases, the ANZECC guidelines state,

"for cold water discharges, the median temperature should not be permitted to fall below the 20th percentile temperature value obtained from the seasonal distribution of temperature data from the reference ecosystem." ANZECC (2000)

Accordingly, the revised modelling assessment has specifically taken into account 20th percentile temperature limits over four seasons, with and without existing warm water discharges to Port Kembla.

5.3.4 Impact assessment

As a result of the varied discharge rates presented in Table 5-2, potential water quality impacts associated with the following activities are expected to vary seasonally from those described in the original EIS:

- Cold water discharge plume associated with the regasification process (assessed below)
- Residual levels of sodium hypochlorite within the FSRU discharge to the harbour (assessed below)

Other operational phase impacts were originally assessed in the water resources chapter of the EIS, however these will not be impacted by the proposed modification and have not been considered as part of this report. These include:

- Hydrodynamic impacts associated with the expansion of the existing Berth 101 and changes to the previously approved Outer Harbour reclamation footprint
- Hydrological and flooding impacts associated with reductions in available flood flow areas due to the presence of pipelines and reclamation areas
- Use of chemicals such as antifouling paints applied to LNG tankers and the FSRU to minimise marine growth
- Stormwater and spill management

Similarly, the original assessment noted that potential construction phase impacts are primarily associated with water quality impacts generated during the removal, handling and placement of dredged sediments. Other proposed construction phase activities considered as part of the original water resources assessment include:

- Demolition of the existing Berth 101, including pile extraction, has the potential to disturb sediments leading to localised plumes in the immediate vicinity of the works.
- Movement and anchoring of construction vessels such as spudded dredging equipment, hopper barges, tugs, crew transfer vessels and survey vessels, which may lead to hydrocarbon spills, disturb bottom sediments and contribute to dispersal of suspended sediments.
- Onshore earthworks undertaken in the vicinity of the harbour foreshore, which have the potential to result in the release of hydrocarbons and turbid stormwater into the harbour.

As no additional construction is required for the proposed modification, no construction phase impacts to water quality, hydrodynamics and hydrology are expected to result. Consequently, no further consideration has been given to construction phase impacts to water resources in this report.

Assessment of cold water discharge

The nearfield and far field models described in the Port Kembla Gas Terminal EIS were used to assess the high season cold water discharge. Additional scenarios were modelled to characterise the configuration and boundaries of the near-field mixing zone and to define the resulting dilution factors and temperatures at the edge of the near-field mixing zone associated with high season discharge rates.

In accordance with the earlier modelling scenarios, consideration was given to changes in ambient water temperatures within the Inner Harbour over all four seasons to assess the resulting far field mixing behaviour with and without the existing warm water discharges associated with other nearby industrial discharges to the Inner Harbour.

The nearfield CORMIX model results have been reported in accordance with the EPA's definition of the nearfield as the initial mixing zone where the characteristics of momentum flux, buoyancy flux, and outfall geometry influence the plume trajectory and mixing. Results were also reported against 20th percentile temperature limits over four seasons as stipulated in the ANZECC guideline limits for cold water discharge.

The results of the additional modelling assessment are summarised below and described in full within Appendix C.

Table 5-4 summarises plume centreline temperature decrease, average temperature decrease, and temperature decrease at the edge of the nearfield mixing zone for the high season discharge rate of 13,000m^3/hr. The model results for the original EIS base case discharge rate of 10,500 m^3/hr are presented in Table 5-5 for comparison purposes.

Comparison of the high season discharge rates against those of the original EIS base case reveal that the increased velocity associated with the higher discharge rate results in improved mixing characteristics and smaller decreases in temperature at the edge of a similar radius nearfield mixing zone (42.5m for the EIS base case against 42.6m for the proposed high season discharge rate).

Table 5-4 Plume centreline temperatures (13,000 m^3/hr)

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Summer	LAT	0	34.5	4.7	3.8	38.3	1.3	0.8	0.5
Summer	LAT	0.05	34.4	4.8	3.5	37.9	1.5	0.9	0.5
Summer	LAT	0.1	32.7	5.1	3.7	36.4	1.3	0.8	0.5
Summer	MSL	0	36.6	4.9	3.5	40.2	1.5	0.9	0.5
Summer	MSL	0.05	35.7	5.0	3.6	39.3	1.4	0.8	0.5
Summer	MSL	0.1	33.8	5.3	3.8	37.6	1.2	0.7	0.4
Summer	MHWS	0	37.3	4.7	3.1	40.4	1.3	0.8	0.5
Summer	MHWS	0.05	36.5	5.1	3.7	40.2	1.4	0.8	0.5
Summer	MHWS	0.1	34.5	5.5	4.0	38.5	1.2	0.7	0.4
Winter	LAT	0	37.0	4.9	3.6	40.5	1.5	0.9	0.5
Winter	LAT	0.05	36.1	5.0	3.6	39.7	1.4	0.8	0.5
Winter	LAT	0.1	34.1	5.3	3.9	38.0	1.2	0.7	0.4
Winter	MSL	0	38.5	5.1	3.7	42.2	1.4	0.8	0.5
Winter	MSL	0.05	37.4	5.3	3.8	41.1	1.3	0.8	0.5
Winter	MSL	0.1	35.4	5.6	4.1	39.5	1.1	0.7	0.4
Winter	MHWS	0	39.4	3.8	3.3	42.6	1.4	0.8	0.5
Winter	MHWS	0.05	38.3	5.4	3.9	42.2	1.3	0.8	0.5
Winter	MHWS	0.1	36.1	5.8	4.2	40.2	1.1	0.6	0.4
Spring	LAT	0	38.2	4.6	3.1	41.3	1.4	0.8	0.5
Spring	LAT	0.05	35.6	5.0	3.6	39.2	1.4	0.8	0.5
Spring	LAT	0.1	33.8	5.3	3.8	37.6	1.2	0.7	0.5
Spring	MSL	0	37.9	3.7	1.8	39.8	1.4	0.8	0.5
Spring	MSL	0.05	37.1	5.2	3.8	40.8	1.4	0.8	0.5
Spring	MSL	0.1	35.0	5.5	4.0	39.0	1.2	0.7	0.4
Spring	MHWS	0	38.9	3.7	1.9	40.8	1.4	0.8	0.5
Spring	MHWS	0.05	37.9	5.0	3.3	41.3	1.3	0.8	0.5
Spring	MHWS	0.1	35.7	5.7	4.1	39.8	1.1	0.7	0.4
Autumn	LAT	0	35.4	3.4	1.7	37.2	1.5	0.9	0.6
Autumn	LAT	0.05	33.4	4.5	3.0	36.4	1.5	0.9	0.5
Autumn	LAT	0.1	32.8	5.1	3.7	36.5	1.3	0.7	0.5
Autumn	MSL	0	36.9	3.5	1.8	38.6	1.5	0.9	0.5
Autumn	MSL	0.05	35.9	5.0	3.6	39.6	1.4	0.8	0.5
Autumn	MSL	0.1	34.0	5.4	3.9	37.8	1.2	0.7	0.4
Autumn	MHWS	0	37.7	3.6	1.8	39.5	1.4	0.8	0.5
Autumn	MHWS	0.05	36.7	5.2	3.7	40.5	1.3	0.8	0.5
Autumn	MHWS	0.1	34.8	5.5	4.0	38.8	1.1	0.7	0.4

Table 5-5 Plume centreline temperatures (EIS base case - 10,500 m^3/hr)

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Summer	LAT	0	32.84	4.16	4.16	37.0	1.75	1.0	0.6
Summer	LAT	0.05	31.94	4.22	4.22	36.16	1.7	1.0	0.6
Summer	LAT	0.1	30.33	4.43	4.43	34.76	1.53	0.9	0.6
Summer	MSL	0	34.57	4.42	4.42	38.99	1.59	0.9	0.6
Summer	MSL	0.05	33.75	4.49	4.49	38.24	1.53	0.9	0.6
Summer	MSL	0.1	31.95	4.74	4.74	36.69	1.36	0.8	0.5
Summer	MHWS	0	35.85	4.58	4.58	40.43	1.48	0.9	0.5
Summer	MHWS	0.05	34.81	4.67	4.67	39.48	1.43	0.8	0.5
Summer	MHWS	0.1	32.98	4.95	4.95	37.93	1.26	0.7	0.5
Winter	LAT	0	31.23	3.98	3.98	35.21	1.78	1.1	0.7
Winter	LAT	0.05	30.38	4.03	4.03	34.41	1.73	1.0	0.6
Winter	LAT	0.1	29.09	4.21	4.21	33.3	1.57	0.9	0.6
Winter	MSL	0	33.01	4.22	4.22	37.23	1.6	0.9	0.6
Winter	MSL	0.05	32.05	4.29	4.29	36.34	1.55	0.9	0.6
Winter	MSL	0.1	30.62	4.5	4.5	35.12	1.4	0.8	0.5
Winter	MHWS	0	34.02	4.37	4.37	38.39	1.5	0.9	0.6
Winter	MHWS	0.05	33.13	4.45	4.45	37.58	1.45	0.9	0.5
Winter	MHWS	0.1	31.52	4.69	4.69	36.21	1.3	0.8	0.5
Spring	LAT	0	34.38	4.36	4.36	38.74	1.72	1.0	0.6
Spring	LAT	0.05	33.48	4.43	4.43	37.91	1.66	1.0	0.6
Spring	LAT	0.1	31.67	4.66	4.66	36.33	1.48	0.9	0.5
Spring	MSL	0	36.36	4.63	4.63	40.99	1.56	0.9	0.6
Spring	MSL	0.05	35.43	4.72	4.72	40.15	1.5	0.9	0.6
Spring	MSL	0.1	33.46	5	5	38.46	1.31	0.8	0.5
Spring	MHWS	0	37.7	4.8	4.8	42.5	1.46	0.9	0.5
Spring	MHWS	0.05	36.59	4.91	4.91	41.5	1.4	0.8	0.5
Spring	MHWS	0.1	34.73	5.2	5.2	39.93	1.22	0.7	0.5
Autumn	LAT	0	33.42	4.23	4.23	37.65	1.74	1.0	0.6
Autumn	LAT	0.05	32.51	4.3	4.3	36.81	1.68	1.0	0.6
Autumn	LAT	0.1	30.82	4.51	4.51	35.33	1.51	0.9	0.6
Autumn	MSL	0	35.3	4.49	4.49	39.79	1.57	0.9	0.6
Autumn	MSL	0.05	34.27	4.57	4.57	38.84	1.52	0.9	0.6
Autumn	MSL	0.1	32.55	4.83	4.83	37.38	1.34	0.8	0.5
Autumn	MHWS	0	36.51	4.66	4.66	41.17	1.48	0.9	0.5
Autumn	MHWS	0.05	35.46	4.76	4.76	40.22	1.42	0.8	0.5
Autumn	MHWS	0.1	33.6	5.05	5.05	38.65	1.24	0.7	0.5

Far field modelling results indicate that the median temperatures of the thermal plume are generally above the seasonal 20th percentile ambient temperatures and therefore generally comply with the ANZECC requirements. As summarised in Table 5-6 below, cases not complying with the ANZECC requirements are confined to median temperatures at the harbour floor which accounts for 2% of the modelled water column depth. An assessment of the second layer from the bottom (from 2% to 7% of the depth), indicates that the resulting water temperatures will comply with the ANZECC requirements under all of the simulated conditions beyond the nearfield mixing zone.

Table 5-6 Thermal plume compliance summary

Case	Season	Future Discharges	Ambient Discharges	Outcome
1	Summer	FSRU @ 13,000 m^3/hr and BlueScope	none	Bed Level: Approx 50m x 100m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
2	Summer	FSRU @ 13,000 m^3/hr and BlueScope	BlueScope	Bed Level: Approx 300m x 350m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
3	Summer	FSRU @ 13,000 m^3/hr	none	Bed Level: Approx 350m x 400m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
4	Autumn	FSRU @ 13,000 m^3/hr and BlueScope	none	Bed Level: Complies Mid depth: Complies Surface: Complies
5	Autumn	FSRU @ 13,000 m^3/hr and BlueScope	BlueScope	Bed Level: Approx 20m x 20m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
6	Autumn	FSRU @ 13,000 m^3/hr	none	Bed Level: Complies Mid depth: Complies Surface: Complies
7	Winter	FSRU @ 13,000 m^3/hr and BlueScope	none	Bed Level: Approx 50m x 50m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
8	Winter	FSRU @ 13,000 m^3/hr and BlueScope	BlueScope	Bed Level: Approx 300m x 400m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
9	Winter	FSRU @ 13,000 m^3/hr	none	Bed Level: Approx 300m x 400m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
10	Spring	FSRU @ 13,000 m^3/hr and BlueScope	none	Bed Level: Approx 30m x 30m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
11	Spring	FSRU @ 13,000 m^3/hr and BlueScope	BlueScope	Bed Level: Approx 300m x 500m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
12	Spring	FSRU @ 13,000 m^3/hr	none	Bed Level: Approx 250m x 500m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
13	Summer	FSRU @ 10,500 m^3/hr	none	Bed Level: Approx 50m x 100m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies
14	Summer	FSRU @ 10,500 m^3/hr and BlueScope	none	Bed Level: Complies Mid depth: Complies Surface: Complies
15	Summer	FSRU @ 10,500 m^3/hr and BlueScope	BlueScope	Bed Level: Complies Mid depth: Complies Surface: Complies
16	Autumn	FSRU @ 10,500 m^3/hr	none	Bed Level: Approx 50m x 100m area near the seabed exceeds ANZECC requirements for Temperature. Mid depth: Complies Surface: Complies

Case	Season	Future Discharges	Ambient Discharges	Outcome
17	Autumn	FSRU @ 10,500 m^3/hr and BlueScope	none	Bed Level: Complies Mid depth: Complies Surface: Complies
18	Autumn	FSRU @ 10,500 m^3/hr and BlueScope	BlueScope	Bed Level: Complies Mid depth: Complies Surface: Complies
19	Winter	FSRU @ 10,500 m^3/hr	none	Bed Level: Complies Mid depth: Complies Surface: Complies
20	Winter	FSRU @ 10,500 m^3/hr and BlueScope	none	Bed Level: Complies Mid depth: Complies Surface: Complies
21	Winter	FSRU @ 10,500 m^3/hr and BlueScope	BlueScope	Bed Level: Complies Mid depth: Complies Surface: Complies
22	Spring	FSRU @ 10,500 m^3/hr	none	Bed Level: Complies Mid depth: Complies Surface: Complies
23	Spring	FSRU @ 10,500 m^3/hr and BlueScope	none	Bed Level: Complies Mid depth: Complies Surface: Complies
24	Spring	FSRU @ 10,500 m^3/hr and BlueScope	BlueScope	Bed Level: Complies Mid depth: Complies Surface: Complies

The largest non-complying near bed footprint was associated with Scenario 11 which modelled the high season discharge rate (13,000 m^3/hr) along with BlueScope heated water discharge during Spring. Areas shown in blue in Figure 5-6 are colder than the 20th percentile ambient temperatures and are therefore colder than the guideline values outlined in ANZECC 2000. Under this scenario, the maximum extent of the non-compliant footprint is restricted to the lowest 2% of the water column over an area measuring approximately 300m x 500m within the Inner Harbour as shown in Figure 5-6. Within the non-compliant footprint, predicted median temperatures are approximately 0.5^{o}C colder than the 20th percentile ambient spring temperatures at the edge of the mixing zone and return to ambient temperatures over an approximately linear gradient to the edge of the impact zone.

Given that the high demand scenario will operate for up to six months from April through to September, the period of non-compliance during spring will actually be restricted to only one month of the three months of Spring. Similarly, the period of non compliance during Autumn will be restricted to April and May. During the remaining period from October through to March, rates of discharge will be reduced to 3,250 m^3/hr (significantly lower than the rate of 10,500 m^3/hr as assessed in the EIS) and will comply with the guideline values outlined in ANZECC 2000.

In the context of the overall development proposal, it should be noted that the predicted area of cold water impact during periods of non compliance will primarily be restricted to the bed of the proposed berth pocket. This area will be excavated and dredged during construction of the project which will result in removal of all existing biofouling and benthic communities from the site prior to the commencement of operations.

It should also be noted that the guideline values apply to ambient background water quality and are not intended to be applied to mixing zones associated with a release from a point source discharge. Discharges from the project therefore need to be considered in recognition of other land uses at Port Kembla and existing water quality within the working harbour including the existing warm water discharges from Allans Creek to the Inner Harbour.

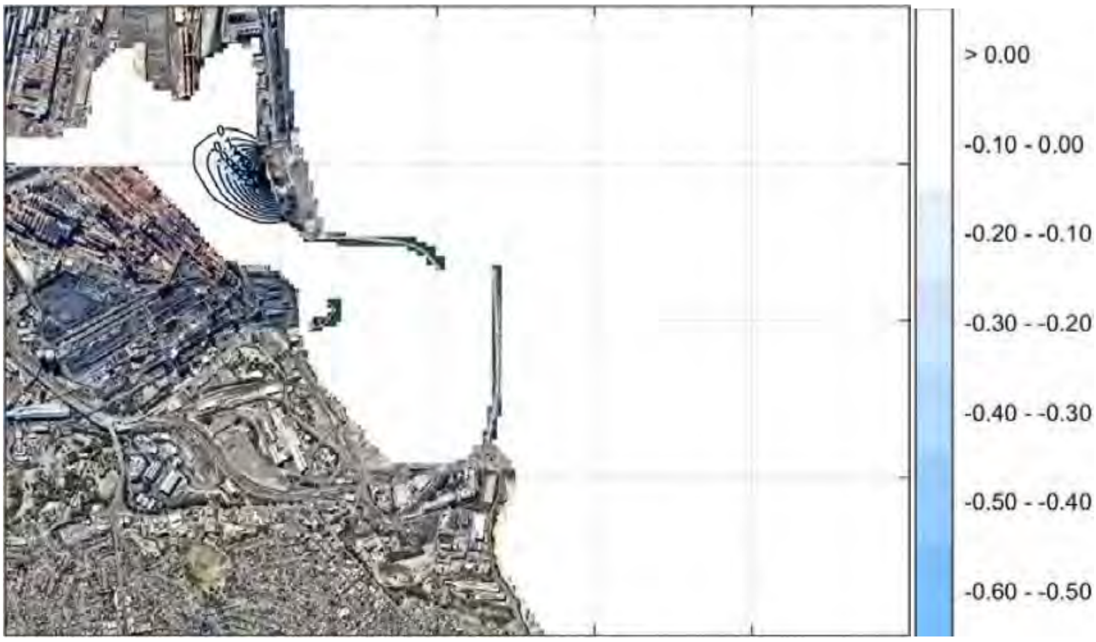

Figure 5-6 Maximum extent of near-bed temperature impacts – Spring [Deg. C]

Consideration has been given to the potential impacts of the increased discharge rates on the marine ecology of the Port of Kembla as described in Section 5.4 of this report.

Assessment of chlorine discharge

The nearfield and far field models described in the Port Kembla Gas Terminal EIS were used to assess the potential impacts associated with increased rates of sodium hypochlorite discharge during the proposed high season. Additional scenarios were modelled to characterise the configuration and boundaries of the near-field mixing zone and to define the resulting dilution factors and temperatures at the edge of the near-field mixing zone associated with high season discharge rates.

Low season discharge rates were not modelled given that the proposed rate of discharge of 3,250 m^3/hr is considerably lower than the high season rate (13,000 m^3/hr) and that modelled in the EIS (10,500 m^3/hr). Consequently, the zone of impact is predicted to be well within that associated with the high season scenarios.

The nearfield CORMIX model results have been reported in accordance with the EPA's definition of the nearfield as the initial mixing zone where the characteristics of momentum flux, buoyancy flux, and outfall geometry influence the plume trajectory and mixing.

These results are summarised below and described in full within Appendix B.

Table 5-7 summarises the plume centreline concentration, average plume concentration, and concentration at the edge of the nearfield mixing zone for the high season discharge rate of 13,000m^3/hr. The model results for the original EIS base case discharge rate of 10,500 m^3/hr are presented in Table 5-8 for comparison purposes.

The modelling predicts that the near field mixing zone is up to 42.6m (this is the sum of the straight line distance from the centre of the plume when it hits the bed and the plume ½ width as defined by CORMIX).

Comparison of the high season discharge rates against those of the original EIS base case reveal that the increased velocity associated with the higher discharge rate results in improved mixing characteristics and reduced discharge concentrations at the edge of a similar radius nearfield mixing zone (42.5m for the EIS base case against 42.6m for the proposed high season discharge rate).

Assuming a discharge concentration of 0.02ppm or 20 ug/l, the sodium hypochlorite concentration at the edge of the plume (at the end of the nearfield mixing zone) is predicted to be up to 1.6 ug/l (against a corresponding concentration of 1.9 ug/l as assessed in the EIS). The average concentration within the plume is predicted to be 2.6 ug/l, or less (against a corresponding concentration of 3.0 ug/l as assessed in the EIS).

Consideration has been given to the range of guideline values described in the EIS (IFC value of 200ug/l, US EPA value of 7.5-13 ug/l and ANZECC Freshwater value of 3ug/l). The nearfield modelling indicates that the sodium hypochlorite concentration at the edge of the near field zone does not exceed 1.6 ug/l, and therefore is predicted to comply with the most stringent of the available guidelines (ANZECC guidelines for fresh water, a value of 3ug/l).

Table 5-7 Chlorine discharge concentrations (13,000 m^3/hr)

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Summer	LAT	0	34.5	4.7	3.8	38.3	3.8	2.2	1.4
Summer	LAT	0.05	34.4	4.8	3.5	37.9	4.2	2.5	1.5
Summer	LAT	0.1	32.7	5.1	3.7	36.4	3.7	2.2	1.3
Summer	MSL	0	36.6	4.9	3.5	40.2	4.2	2.5	1.5
Summer	MSL	0.05	35.7	5.0	3.6	39.3	4.0	2.3	1.5
Summer	MSL	0.1	33.8	5.3	3.8	37.6	3.4	2.0	1.3
Summer	MHWS	0	37.3	4.7	3.1	40.4	3.8	2.3	1.4
Summer	MHWS	0.05	36.5	5.1	3.7	40.2	3.9	2.3	1.4
Summer	MHWS	0.1	34.5	5.5	4.0	38.5	3.3	1.9	1.2
Winter	LAT	0	37.0	4.9	3.6	40.5	4.3	2.5	1.6
Winter	LAT	0.05	36.1	5.0	3.6	39.7	4.1	2.4	1.5
Winter	LAT	0.1	34.1	5.3	3.9	38.0	3.4	2.0	1.3
Winter	MSL	0	38.5	5.1	3.7	42.2	4.0	2.4	1.5
Winter	MSL	0.05	37.4	5.3	3.8	41.1	3.8	2.3	1.4
Winter	MSL	0.1	35.4	5.6	4.1	39.5	3.2	1.9	1.2
Winter	MHWS	0	39.4	3.8	3.3	42.6	3.9	2.3	1.4
Winter	MHWS	0.05	38.3	5.4	3.9	42.2	3.7	2.2	1.4
Winter	MHWS	0.1	36.1	5.8	4.2	40.2	3.1	1.8	1.1
Spring	LAT	0	38.2	4.6	3.1	41.3	4.1	2.4	1.5
Spring	LAT	0.05	35.6	5.0	3.6	39.2	4.1	2.4	1.5
Spring	LAT	0.1	33.8	5.3	3.8	37.6	3.5	2.1	1.3
Spring	MSL	0	37.9	3.7	1.8	39.8	4.1	2.4	1.5
Spring	MSL	0.05	37.1	5.2	3.8	40.8	3.8	2.3	1.4
Spring	MSL	0.1	35.0	5.5	4.0	39.0	3.3	1.9	1.2
Spring	MHWS	0	38.9	3.7	1.9	40.8	3.9	2.3	1.4
Spring	MHWS	0.05	37.9	5.0	3.3	41.3	3.8	2.2	1.4
Spring	MHWS	0.1	35.7	5.7	4.1	39.8	3.3	2.0	1.2
Autumn	LAT	0	35.4	3.4	1.7	37.2	4.3	2.6	1.6
Autumn	LAT	0.05	33.4	4.5	3.0	36.4	4.3	2.5	1.6
Autumn	LAT	0.1	32.8	5.1	3.7	36.5	3.6	2.1	1.3
Autumn	MSL	0	36.9	3.5	1.8	38.6	4.2	2.5	1.5
Autumn	MSL	0.05	35.9	5.0	3.6	39.6	4.0	2.4	1.5
Autumn	MSL	0.1	34.0	5.4	3.9	37.8	3.4	2.0	1.2
Autumn	MHWS	0	37.7	3.6	1.8	39.5	4.0	2.4	1.5
Autumn	MHWS	0.05	36.7	5.2	3.7	40.5	3.8	2.3	1.4
Autumn	MHWS	0.1	34.8	5.5	4.0	38.8	3.3	1.9	1.2

Table 5-8 Chlorine discharge concentrations (EIS base case - 10,500 m^3/hr)

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Summer	LAT	0	32.84	4.16	4.16	37.0	5.0	2.9	1.8
Summer	LAT	0.05	31.94	4.22	4.22	36.16	4.9	2.9	1.8
Summer	LAT	0.1	30.33	4.43	4.43	34.76	4.3	2.6	1.6
Summer	MSL	0	34.57	4.42	4.42	38.99	4.5	2.7	1.7
Summer	MSL	0.05	33.75	4.49	4.49	38.24	4.3	2.6	1.6
Summer	MSL	0.1	31.95	4.74	4.74	36.69	3.9	2.3	1.4
Summer	MHWS	0	35.85	4.58	4.58	40.43	4.3	2.5	1.6
Summer	MHWS	0.05	34.81	4.67	4.67	39.48	4.1	2.4	1.5
Summer	MHWS	0.1	32.98	4.95	4.95	37.93	3.6	2.1	1.3
Winter	LAT	0	31.23	3.98	3.98	35.21	5.1	3.0	1.9
Winter	LAT	0.05	30.38	4.03	4.03	34.41	5.0	2.9	1.8
Winter	LAT	0.1	29.09	4.21	4.21	33.3	4.4	2.6	1.6
Winter	MSL	0	33.01	4.22	4.22	37.23	4.5	2.7	1.7
Winter	MSL	0.05	32.05	4.29	4.29	36.34	4.4	2.6	1.6
Winter	MSL	0.1	30.62	4.5	4.5	35.12	4.0	2.4	1.5
Winter	MHWS	0	34.02	4.37	4.37	38.39	4.3	2.5	1.6
Winter	MHWS	0.05	33.13	4.45	4.45	37.58	4.2	2.5	1.5
Winter	MHWS	0.1	31.52	4.69	4.69	36.21	3.7	2.2	1.4
Spring	LAT	0	34.38	4.36	4.36	38.74	4.9	2.9	1.8
Spring	LAT	0.05	33.48	4.43	4.43	37.91	4.8	2.8	1.8
Spring	LAT	0.1	31.67	4.66	4.66	36.33	4.3	2.5	1.6
Spring	MSL	0	36.36	4.63	4.63	40.99	4.4	2.6	1.6
Spring	MSL	0.05	35.43	4.72	4.72	40.15	4.3	2.5	1.6
Spring	MSL	0.1	33.46	5	5	38.46	3.8	2.2	1.4
Spring	MHWS	0	37.7	4.8	4.8	42.5	4.2	2.5	1.5
Spring	MHWS	0.05	36.59	4.91	4.91	41.5	4.0	2.4	1.5
Spring	MHWS	0.1	34.73	5.2	5.2	39.93	3.5	2.1	1.3
Autumn	LAT	0	33.42	4.23	4.23	37.65	4.9	2.9	1.8
Autumn	LAT	0.05	32.51	4.3	4.3	36.81	4.8	2.8	1.8
Autumn	LAT	0.1	30.82	4.51	4.51	35.33	4.3	2.6	1.6
Autumn	MSL	0	35.3	4.49	4.49	39.79	4.5	2.7	1.7
Autumn	MSL	0.05	34.27	4.57	4.57	38.84	4.3	2.6	1.6
Autumn	MSL	0.1	32.55	4.83	4.83	37.38	3.8	2.3	1.4
Autumn	MHWS	0	36.51	4.66	4.66	41.17	4.3	2.5	1.6
Autumn	MHWS	0.05	35.46	4.76	4.76	40.22	4.1	2.4	1.5
Autumn	MHWS	0.1	33.6	5.05	5.05	38.65	3.6	2.1	1.3

Far field modelling of sodium hypochlorite was undertaken in Deflt3D to assess the potential impacts associated with increased rates of sodium hypochlorite discharge during the high season. The far field modelling utilised the same model applied to the temperature dispersion modelling, however the model extended to include the advection/dispersion of a linearly decaying, neutrally buoyant tracer.

This approach acknowledges that sodium chlorite is very reactive in seawater, reacting with bromine and other elements to form a number of by-products including chloride ions and hypobromous acid (HOBr). The rate at which sodium hypochlorite forms bromine and chlorine residuals, as well as the resulting equilibrium between these different forms is governed by pH, temperature and ionic strength (ANZECC 2000).

Whilst the reactive nature of sodium hypochlorite in seawater leads to reduced concentrations, consideration must also be given to the potential impacts associated with its by-products.

It is for this reason that the ANZECC guidelines stipulate concentrations of total residual chlorine (TRC), which considers the effects of not only sodium hypochlorite but also its by-products in the form of free chlorine (Cl2, HOCl and hypochlorite ion OCl- in equilibrium) and combined chlorine (N-chlorinated compounds such as chloramines). The aquatic toxicology testing for marine waters where iodide and bromide are present, measured and assessed total residual oxidants as µg Cl per L.

Far field modelling predicts that the maximum concentration of sodium hypochlorite within the port would be less than 1 ug/l through the upper water column. The maximum concentration is predicted to be slightly larger near the seabed, where concentrations outside of the near field mixing zone are predicted to reach up to 1.5 ug/l. There is a small area, where the concentration at the seabed is predicted to exceed 3 ug/l, however this is at the point of discharge, and would be considered to be within the near field mixing zone.

5.3.5 Mitigation measures

During the development of the Port Kembla Gas Terminal EIS, consideration was given to a number of potential management measures to be implemented in the event that model results predicted a significant impact to marine ecology beyond the nearfield mixing zone. The potential options considered and adopted are described in Table 5-9.

Table 5-9 Cold water discharge - potential mitigation measures

Option	Description	Required
1	**Discharge to an alternative location** Following consideration of alternative discharge locations such as the stern of the vessel and ocean discharge via the coal loader seawall, it is apparent that the proposed discharge outlets at the bow of the FSRU (southern end of the berth) provide the greatest dilution capacity, minimise the likelihood of shoreline hugging plumes and confine potential impacts to the marine environment of the lowest value. In particular, the tidal velocities through the constriction between the Inner and Outer Harbour known as “the cut” are greater than those at the stern of the FSRU and those encountered at the relatively sheltered ocean shoreline immediately east of the site where the coal loader seawall meets the northern breakwater. Furthermore the marine environments beyond the Outer Harbour have been impacted to a lesser extent by historical activities and are considered of higher value. Consideration was also given to the beneficial reuse of cool water on or off-site. No potential uses for cool seawater were identified on the northern side of the Inner Harbour. Cool seawater was considered to be of value to the existing BlueScope operations on the southern shoreline however the engineering costs associated with transporting the relatively low volume of moderately cooler water through operational port areas rendered this option unfeasible.	No
2	**Pre-discharge dilution** The submissions note that the water quality criteria stipulated in the ANZECC guidelines should be achieved at the edge of the near-field mixing zone. In the case of cold water discharge, the median temperature should not be permitted to fall below the seasonal 20th percentile temperature value. Were temperatures to remain below the seasonal 20th percentile temperature values, additional seawater could be pumped into the system to raise the temperature of the stream at the point of discharge. Given the relatively small extent and seasonality of intermittent impacts, the operational costs and additional greenhouse gas emissions associated with pumping large volumes of seawater are not considered warranted.	No
3	**Use of diffusers** Consideration was given to the use of diffusers to improve plume mixing behaviour within the nearfield mixing zone. Given that the nearfield CORMIX model predicts a simple semicircular shape generally in accordance with the NSW EPA’s mixing zone principles, the use of diffusers would not significantly improve overall outcomes	No
4	**Visual inspection and relocation during construction** Management Measure ME1 as proposed in the EIS: Visual inspection and relocation of protected mobile fauna (e.g. Syngnathids).	Yes

Option	Description	Required
5	**Water temperature monitoring program** Management Measure ME3 as proposed in the EIS: Implementation of a water temperature monitoring program to document natural variations in water temperature and the extent of temperature differences and dispersion pathways of the cold water discharge plume.	Yes

Given the relatively small extent and seasonality of intermittent impacts, management measures 4 and 5 in Table 5-9 (ME1 and ME3 as proposed in the Port Kembla Gas Terminal EIS) are considered adequate in light of the additional modelling scenarios associated with the proposed modification.

In relation to sodium hypochlorite discharge, all reasonable and practicable actions have been taken to deliver an environmental outcome which is in line with ANZECC's objectives and environmental values for ambient water, as well as reflective of the other land uses, existing water quality and marine ecology of the working harbour. As such, no further mitigation measures are considered necessary.

5.4 Marine ecology

5.4.1 Introduction

A detailed analysis of marine ecological values within Port Kembla was undertaken as part of the Port Kembla Gas Terminal EIS. This section provides an overview of the marine ecological values and considers the potential impacts associated with the altered operational parameters in relation to the increase in seawater discharges during high season and increased frequency of LNG Carrier deliveries.

5.4.2 Existing Environment

Marine habitat within the port is restricted to the hard substrate habitat and the soft sediments. Hard substrate habitat consists of infrastructure such as piles, quay walls and breakwater around the perimeter of the port. Such hard substrate presents ideal habitat for biofouling communities within the sheltered environment. Assemblages around the Inner Harbour have been described as sparse with community structures reflective of the highly disturbed environment; species noted within these communities are polychaete worms, bryozoans, barnacles and ascidians (Worley Parsons, 2012).

Surveys undertaken for the EIS found communities generally consistent with those previously described, with the addition of the macroalgae *Dictyota dichotoma* on the shallow subtidal zone of the surveyed piles. The seabed within the Inner Harbour has previously been described as consisting of fine, unconsolidated silt expanses with large decapod burrows (Worley Parsons, 2012). Historically the seagrass species *Halophila ovalis* has been recorded within the Inner Harbour benthos (Pollard and Pethebridge, 2002; EcoLogical Australia, 2003), however seagrasses have not been detected on more recent surveys (2012, 2018).

Macroalgae has been known to occur in sparse distributions across soft sediments habitats within the port. More recent investigations (2018) did not identify any macroalgae within the proposed dredge footprint, other than those observed along the berth piles. The highly utilised and developed Inner Harbour is known to support species typical of inshore habitats being glass perchlet and Japanese striped goby (AWT, 1999; Pollard & Pethebridge, 2002; UNSW, 2009). Fish assemblages identified as part of these studies are common across the region and did not include any threatened species. The area also does not support any key fish habitat.

The following were identified as potentially occurring in the Port Kembla area and were thus reviewed under relevant assessment criteria:

- The Schedule 4, 4A and 5 FM Act assessment criteria: grey nurse shark (Carcharias taurus), Australian grayling (Prototrocetes marena), black rockcod (Epinephelus daemelii) and great white shark (Carcharodon carcharias)
- Schedule 1 of the BC Act criteria: southern right whale (Eubalaena australis), blue whale (Balaenoptera musculus), marine turtles (leatherback, loggerhead and green), long-nosed fur seal (Arctocephalus forsteri) and Australian fur seal(Arctocephalus pusillus)
- The EPBC Act Protected Matters Search Tool: southern right whale (Eubalaena australis), humpback whale (Megaptera novaeangliae), long-nosed fur seal (Arctocephalus forsteri), Australian fur seal (Arctocephalus pusillus), Indian ocean bottlenose dolphin (Tursiops aduncus), bottlenose dolphin (Tursiops truncates s. str.) and Syngnathids

Activities associated with the project were not predicted to significantly affect any critically endangered, endangered or threatened species likely occurring within the Port Kembla area.

5.4.3 Impact assessment

Modification of the LNG supply will increase the FSRU discharge from 10,500 m^3/s to 13,000m^3/s during the 6 months high season demand across April to September. Given no change anticipated to the construction footprint and methodology, key potential impacts from the modified case on marine ecology are concentrated on the operation of the project and associated increase in cold water and residual chlorine discharge. This section assesses the potential impacts from the increased operations on the existing marine ecology values particularly within the Inner Harbour.

Temperature

The Port Kembla Gas Terminal EIS determined that the marine communities in close proximity to the discharge point had potential be adversely affected by the maximum temperature differential of up to 7°C. Modelling of the higher discharge operations (13,000 m^3/s) determined that the increased velocity improved mixing characteristics resulting in smaller decreases in temperature at the edge of a similar radius nearfield mixing zone (42.5m for the EIS base case against 42.6m for the proposed high season discharge rate). Far field modelling suggests cold water discharges falling outside EPA Guideline limits will be limited to a discharge area of 300m by 500m confined to the bottom 2% of the water column depth during the spring season for scenarios incorporating Bluescope warm water discharges.

The existing environment within the predicted area of impact consist largely of unconsolidated silt expanses with burrows (Figure 5-7 left) and limited biofouling species smothered with sediment (Figure 5-7 right). These benthic and biofouling species will be disturbed during the construction period through the demolition of the wharf infrastructure and associated dredging works of the berth pocket within the Inner Harbour. Similarly, the predicted zone of impact lies within the proposed berthing area for visiting LNG tankers and the eastern portion of the existing vessel turning basin for the Inner Harbour. Given that this area will be exposed to high velocity currents generated by vessel movements and will be regularly dredged, the likelihood of recolonisation of the seabed by marine species different to the existing ones is considered extremely low.

Figure 5-7 Representative photos of predicted impacted area (left) benthic communities and (right) limited biofouling communities on bottom of piles

Within the predicted zone of impact, the median temperatures are estimated to be approximately half a degree colder than the 20th percentile ambient spring temperatures at the edge of the mixing zone; such temperature differentials are still within typical seasonal variations and levels of tolerance for the marine communities within the area of impact.

As such operational temperature differential impacts from the increased discharge will be limited to the otherwise disturbed environment and any remnant or recolonising benthic infaunal and biofouling communities inhabiting the seabed and area just above it. Likelihood of impacts to marine ecology within the impacted area is therefore considered low.

Management and mitigation measures relevant to water quality environmental hazards remain consistent with those proposed for the EIS which include implementation of an operational marine water quality monitoring program.

Chlorine

Similarly to temperature, the modelling of chlorine predicted that the near field mixing zone is up from 42.5 m to 42.6 m, a result of increased velocity/mixing associated with the higher discharge. Any toxicity risk from chlorine residues will be restricted to the predicted zone of impact which lies within the proposed footprint of wharf demolition and berth dredging works in the Inner Harbour. Assuming a discharge concentration of 0.02ppm or 20 ug/l, the sodium hypochlorite concentration at the edge of the plume is predicted to be less than the EIS scenario, 1.6 ug/l vs 1.9 ug/l. As such the concentration of residual chlorine is predicted to comply with the ANZECC guideline of 3 ug/l, at the point of discharge near the seabed. It is expected that the marine communities closest to the seabed (refer to Figure 5-7) at point of discharge will have been relocated or removed prior to commencement of operations and associated release of any sodium hypochlorite or associated by products.

Given that the area will be exposed to high velocity currents generated by vessel movements and will require regular maintenance dredging, the likelihood of recolonisation of the area by marine species different to the existing ones is considered extremely low. The likelihood of sodium hypochlorite related impacts to marine life is therefore considered low.

Management and mitigation measures relevant to water quality environmental hazards remain consistent with those proposed for the EIS which include implementation of an operational marine water quality monitoring program.

Interaction of marine megafauna with increased vessel traffic

The need for increased vessel traffic for the supply of the LNG during the 6 month peak system (April through to September) may increase the risk of marine fauna collision/interaction outside of the Port limits particularly during the migratory window of key protected whale species (humpback whale from April to November and southern right whale from May to November). The risk for potential strike however remains low given the number of LNG Carrier deliveries will be limited to around one per week. This risk accounts for the avoidance behaviour marine fauna species adopt to evade vessels until the vessel disruption has elapsed.

Management and mitigation measures for the project relevant to marine fauna collisions/interactions remain consistent with those proposed for the EIS. The interaction of all vessels with cetaceans and pinnipeds will be compliant with Part 8 of the Environment Protection and Biodiversity Conservation (EPBC) Regulations (2000) and the Australian Guidelines for Whale and Dolphin Watching (DoEE, 2017).

Noise and vibration

5.5.1 Introduction

An assessment of the potential noise and vibration impacts of the project was undertaken as part of the Port Kembla Gas Terminal EIS. The assessment describes the existing environment, identified compliance criteria for noise and vibration impacts, assessed potential impacts of the project against those criteria, and identified measures to avoid, mitigate and manage impacts. It concluded that construction would generate noise that would potentially exceed the compliance criteria in adjacent areas but that this would be temporary and typical of construction projects. It also found that operation would generate noise but this was found to comply with the criteria. A number of measures were proposed to avoid, mitigate and manage noise and vibration.

The assessment of potential noise and vibration impacts of the project has been updated to include the proposed modification. The updated assessment is provided in full as Appendix C while the findings of the updated assessment are summarised in the below sections.

5.5.2 Existing environment

There are a number of existing noise sources in Port Kembla. The port itself is a deep water harbour with a total of 18 berths providing services ranging from motor vehicle imports, grain and coal exports, general cargo facilities, and bulk materials import and storage facilities. The immediately surrounding land is primarily characterised by industrial or infrastructure use. The nearest residential properties to Berth 101 are two kilometres to the north, west and south.

Background noise monitoring at two residential locations in Port Kembla was undertaken in 2018 as part of the assessment of potential noise and vibration impacts in the EIS. Given that the background noise monitoring occurred recently it remains appropriate for the assessment of the proposed modification. The results of the monitoring are summarised in Table 5-10.

Table 5-10 Background noise levels

Location	Rating background level L_{A90}			Ambient level L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
Location 1	39	40	39	52	50	50
Location 2	43	42	45	51	49	50

Noise and vibration sensitive receivers are defined upon the type of occupancy and the activities performed within the land parcel. The receivers can be classified within the following categories:

- residential premises;
- educational institutes;
- hospitals and medical facilities;
- places of worship;
- passive and active recreation areas; and
- commercial or industrial premises.

Noise catchment areas (NCA) are used to represent areas with similar noise environments. Two NCAs have been identified for this assessment and are detailed in Table 5-11.

Table 5-11 Noise catchment areas

NCA	Distances to pipeline	Distances to operational areas	Description
NCA01	250 metres – 900 metres	2.5 kilometres – 3.5 kilometres	Mix of residential, commercial and industrial receivers located to the north of the project.
NCA02	100 metres – 900 metres	2.0 kilometres – 3.0 kilometres	Mix of residential, commercial and industrial receivers located to the south of the project.

The representative sensitive receivers used for noise modelling and assessment purposes are listed in Appendix C and shown in Figure 5-8. Representative sensitive receivers were modelled at the most affected point located within 30 metres of the building in accordance with the *Noise Policy for Industry* (EPA, 2017).

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Australian Industrial Energy
Port Kembla Gas Terminal

Representative sensitive receivers, noise monitoring locations and land use map

Project No. 21-27477
Revision No. A
Date 19 Nov 2019

Figure 5-8

5.5.3 Compliance criteria

Two noise catchment areas (NCA) were defined for the purposes of assessing the potential noise and vibration impacts of the project. These were NCA1 (to the north) and NCA2 (to the south). Compliance criteria were defined for these noise catchment areas and some further specific classes of sensitive receivers such as other commercial or industrial areas.

Compliance criteria have been developed based on background noise monitoring to assess the potential noise and vibration impacts of the project. The proposed modification would not have a material effect on the construction or the project and would not generate additional vibration. As such, only the compliance criteria for noise during operation are applicable and provided below.

Table 5-12 Operational compliance criteria

Receiver	Time period	Intrusiveness noise level $L_{Aeq(15\,min)}$	Project amenity noise level $L_{Aeq(15\,min)}$	Maximum noise level events	Project noise trigger level, dBA
Residential (NCA1)	Day	44	58	—	44 $L_{Aeq(15\,min)}$
	Evening	44	48	—	44 $L_{Aeq(15\,min)}$
	Night	44	43	54 L_{Amax}	43 $L_{Aeq(15\,min)}$ 54 L_{Amax}
Residential (NCA2)	Day	48	58	—	48 $L_{Aeq(15\,min)}$
	Evening	47	48	—	47 $L_{Aeq(15\,min)}$
	Night	47	43	—	43 $L_{Aeq(15\,min)}$
Place of worship	When in use	—	50[6]	—	53 $L_{Aeq(15\,min)}$
Active recreation	When in use	—	55	—	58 $L_{Aeq(15\,min)}$
Commercial	All	—	63	—	63 $L_{Aeq(15\,min)}$
Industrial	All	—	68	—	68 $L_{Aeq(15\,min)}$

5.5.4 Impact assessment

The proposed modification would not have a material effect on the construction of the project and would not generate additional vibration. As such, the updated assessment was concerned with the potential operational noise impacts of the project with the proposed modification.

The potential noise impacts were assessed for an indicative high season as outlined in section 4 and associated equipment including LNG trains, booster pumps and FSRU engines. The potential noise impacts were modelled for the following three operational scenarios (OS):

- OS1 — LNG carrier berthing
- OS2 — FSRU operation
- OS3 — LNG carrier berthing and FSRU operation

The key operational scenario for the proposed modification would be FSRU operation (OS2). While the LNG carrier berthing (OS1) would not be affected by the proposed modification, it was included for the purpose of a cumulative assessment along with FSRU operation (OS3). The predicted noise impacts for the three operational scenarios are summarised in Table 5-13.

Predicted noise levels for all operational scenarios were found to comply with the operational compliance criteria. The predicted noise levels were not expected to cause sleep disturbance impacts, and would not have impulsive, low frequency or tonal noise characteristics.

Table 5-13 Operational noise impacts

Receiver type	Noise criteria		Operational scenario		
			OS1	OS2	OS3
Residential (NCA1)	44 $L_{Aeq(15 min)}$ (Day/Evening) 43 $L_{Aeq(15 min)}$ (Night)	Highest noise level	16	32	32
		Worst affected receiver	R043	R042	R042
Residential (NCA2)	48 $L_{Aeq(15 min)}$ (Day) 47 $L_{Aeq(15 min)}$ (Evening) 43 $L_{Aeq(15 min)}$ (Night)	Highest noise level	26	34	34
		Worst affected receiver	R080	R076	R076
Commercial	63 $L_{Aeq(15 min)}$ (All time periods)	Highest noise level	24	29	29
		Worst affected receiver	R081	R041	R081
Industrial	68 $L_{Aeq(15 min)}$ (All time periods)	Highest noise level	29	34	34
		Worst affected receiver	R078	R078	R078
Place of worship	53 $L_{Aeq(15 min)}$ (When in use)	Highest noise level	16	30	30
		Worst affected receiver	R074	R074	R074
Active recreation	58 $L_{Aeq(15 min)}$ (When in use)	Highest noise level	12	26	26
		Worst affected receiver	R007	R007	R007

5.5.5 Conclusion

Overall, the findings of the updated noise and vibration assessment are consistent with the EIS. Consequently, additional measures to avoid, mitigate and manage impacts are not necessary.

5.6 Air quality

5.6.1 Introduction

An air quality assessment has been undertaken to assess and document the potential air quality impacts associated with the proposed modification to the project. The assessment is included as Appendix D and builds upon the previous air quality assessment undertaken as part of the Port Kembla Gas Terminal EIS to consider the refined operational scenarios required to support the seasonality of outputs for the project.

5.6.2 Existing Environment

Port Kembla is a deep water harbour located in the Illawarra region, approximately 3km south of the Wollongong Central Business District and 80km south of Sydney. Land use surrounding the terminal is predominantly heavy industrial or special uses associated with port operations. Wollongong Sewage Treatment Plant is located to the north of the coal export facility. The closest residential properties to Berth 101 are located approximately 2km to the north in Coniston, to the west in Cringila and to the south at Port Kembla and Warrawong.

The location of the nearest identified sensitive receptors to the site for the purpose of the air quality assessment are presented in Table 5-14 along with the address and receptor type. *The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (EPA, 2016) (the Approved Methods) defines sensitive receptors as locations where people are likely to work or reside and may include a dwelling, school, hospital, office or recreation area.

A figure showing the location of the site with representative receptors is supplied in Figure 5-9.

Paper Size ISO A4

0 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Australian Industrial Energy
Port Kembla Gas Terminal

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Site and sensitive receptor Location

Figure 5-9

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Print date: 27 Nov 2019 - 15:12 (SMA record: 2) (SMA record: 39)

Data source: ; (c) Department of Finance, Services and Innovation 2015; (c) Department of Finance, Services and Innovation 2012; (c) Forest Corporation of NSW 2017; (c) State of New South Wales and Office of Environment and Heritage; NSW Crown Copyright - Department of Planning and Environment; (c) Commonwealth of Australia (Department of the Environment) 2013; (c) Commonwealth of Australia (Department of the Environment) 2014. Created by: sross2

Table 5-14 Sensitive receptors locations

ID	X coordinate (m)	Y coordinate (m)	Address	Description
R01	306857	6187485	179 Corrimal St	Residential
R02	306232	6187186	398 Keira St	Baby Bounce (Commercial)
R03	306812	6186504	Port Kembla Rd	Industrial
R04	306396	6185950	Tom Thumb Rd	Incitec Pivot Fertilisers (industrial)
R05	305723	6184571	Port Kembla	Port Kemble steelworks (industrial)
R06	304834	6184104	41 Five Island Rd	GM fabrication (Commercial)
R07	305975	6183350	Port Kembla	Meatworks central (industrial)
R08	306606	6183717	16 Flinders St	Caltex (Commercial)
R09	306853	6184327	Christy Dr	Near Gabriella Memorial (Industrial)
R10	307390	6182968	Port Kembla	Port Kembla Station
R11	308190	6183101	Gloucester Blvd	Breakwater Battery Museum

Ambient air quality daily concentrations for the project area have been estimated using the NSW OEH ambient air quality monitoring stations. The nearest station to the site is Kembla Grange, however Wollongong has been included as it contains background data for sulfur dioxide (SO_2), $PM_{2.5}$ and carbon monoxide (CO). Daily pollutant average and maximum ambient concentrations for the modelled year (2014) are presented in 5-15.

Table 5-15 Ambient air quality daily concentrations (2014)

Pollutant		OEH monitoring site	
		Wollongong	Kembla grange
SO_2	Average (µg/m^3)	2.0	—
	Maximum (µg/m^3)	13.1	—
NO	Average (µg/m^3)	5.9	2.1
	Maximum (µg/m^3)	57.8	20.9
NO_2	Average (µg/m^3)	14.8	0.0
	Maximum (µg/m^3)	37.6	30.1
CO	Average (µg/m^3)	253.4	—
	Maximum (µg/m^3)	575.0	—
PM_{10}	Average (µg/m^3)	17.7	17.3
	Maximum (µg/m^3)	45.3	99.2
	70th percentile (µg/m^3)	20.2	20.3
$PM_{2.5}$	Average (µg/m^3)	7.0	—
	Maximum (µg/m^3)	17.3	—
	70th percentile (µg/m^3)	8.2	—

5.6.3 Compliance criteria

The Protection of the Environment Operations (POEO) Act 1997 provides the statutory framework for managing pollution in NSW, including the procedures for issuing licences for environmental protection on aspects such as waste, air, water and noise pollution control. Companies and property owners are legally bound to control emissions (including particulates and deposited dust) from construction sites under the POEO Act. Activities undertaken onsite must not contribute to environmental degradation, and pollution and air emissions must not exceed the standards. Where an environment protection licence applies, air quality requirements (including criteria) may be specified by the licence.

The Protection of the Environment Operations (Clean Air) Regulation 2010 provides regulatory measures to control emissions from motor vehicles, fuels, and industry.

The Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2016) (the Approved Methods) lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in NSW. It considers the above mentioned legislation and acts to construct pollutant assessment criteria. The Approved Methods assess the cumulative (background plus incremental site emissions) pollutant impact at the site boundary or the nearest existing or likely future off-site sensitive receptor depending on pollutant.

Assessment criteria has been taken from the Approved Methods to set the impact assessment criteria for the project. To ensure that environmental outcomes are achieved, the emissions impact from the project must be assessed against the assessment criteria shown in Table 5-16.

Note, the values of some of these pollutants have been converted from milligram (mg) to µg in order to be consistent. Impact assessment criteria included in the assessment are based on the pollutants listed in the supplied engine data from AIE.

Table 5-16 Impact assessment criteria

Pollutant	Averaging period	Percentile	Assessment criteria (µg/m^3)
TSP (total suspended particulates)	Annual	100th	90
PM_{10}	24 hour	100th	50
	Annual	100th	25
$PM_{2.5}$	24 hour	100th	25
	Annual	100th	8
CO	1 hour	100th	30000
	8 hour	100th	10000
NO_2	1 hour	100th	246
	Annual	100th	62
SO_2	1 hour	100th	570
	24 hour	100th	228
	Annual	100th	60
Benzene	1 hour	99.9th	29
Formaldehyde	1 hour	99.9th	20
Total PAHs (polycyclic aromatic hydrocarbons)	1 hour	99.9th	0.4

The Protection of the Environment Operations (Clean Air) Regulation 2010 provides exhaust air emission concentration limits for gas and liquid fuelled engines typically applicable in NSW are summarised Table 5-17.

Table 5-17 Exhaust air emission concentration limits

Pollutant	NSW emission limit (mg/m^3)	
	Gas fuelled engines	Liquid fuelled engines
PM_{10}	50	50
$PM_{2.5}$	50	50
NO_x	450	450
CO	125	5880
SO_2	1000	1000
Benzene	40[1]	1140[1]
Formaldehyde	40[1]	1140[1]
PAH	N/A	N/A

5.6.4 Impact Assessment

Emission Sources

The primary emission source associated with the operation of the project are the engines on board the FSRU and LNG carrier. These engines are used to power all other operational activities on board the FSRU and LNG carrier and are the primarily source of air quality emissions for each vessel.

It is understood that the FSRU and the LNG carrier can be operated using gas (LNG) or liquid fuel known as marine diesel oil (MDO). It is AIE's intention to primarily operate both the FSRU and LNG carrier using boil off gas (LNG) as an energy source. Liquid fuel would only be used in emergency situations for a short amount of time. Further details of the engine specifications and emission sources from the Wartsila engines used in the FSRU and LNG carriers is included in Appendix D.

It was identified during preparation of the Port Kembla Gas Terminal EIS that there was potential for exceedance of concentration limits under the Protection of the Environment Operations (Clean Air) Regulation 2010 when the engines were operating on MDO. Air emissions from discharge points on marine vessels (including the FSRU) are also regulated under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and the emission standards of the PoEO Regulation would not apply where there is inconsistency with Commonwealth legislation. The Infrastructure Approval includes a restriction to the use of MDO as a fuel to 72 hours cumulative over a calendar year. During these periods the FSRU would need to comply with Commonwealth legislative requirements.

Increasingly, international and national air emissions standards are reducing the levels of permissible NOx emissions from marine transportation vessels. AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations and reducing greenhouse emissions wherever possible. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on MDO mode to a level below the Protection of the Environment Operations (Clean Air) Regulation 2010 limit. The proposed modification therefore includes an adjustment to Condition 8 of SSI 9471 to allow the condition to be waived subject to data demonstrating compliance with the Protection of the Environment Operations (Clean Air) Regulation 2010.

[1] Shown limit is for VOCs as n propane

Modelling Scenarios

Atmospheric dispersion modelling was carried out using the CALPUFF version 6 dispersion model. CALPUFF is a non-steady-state dispersion model which incorporates local meteorological conditions to predict ground level concentrations of pollutants from the project.

An LNG carrier entering Port Kembla to offload its LNG cargo will be present in the local environment for a limited time. In most instances the carrier will enter and leave the port within 2 – 3 days as it takes between 24 – 36 hours to offload LNG from the Carrier to the FSRU.

To conservatively assess the cumulative impact from the project, the FSRU and LNG carrier have been modelled together to account for worst case emissions. During both the tethering and the unloading processes, only two engines on board the LNG carrier will be operational.

Seasonal demand scenarios have been developed to predicted variations in output throughout the year. The operational requirements of the predicted high and low seasonal variations are shown in .

Table 5-18 Proposed seasonal operational emissions sources

Operational emissions source	Low season (approx. 6 months)	High season (approx. 6 months)
FSRU emissions		
LNG Trains	1	2
LNG booster pumps	1	4
FSRU engines required	1	2
LNG carrier emissions		
LNG carrier	2	2

During the low season, one engine on board the FSRU would be required and during the high season, two engines would be required. The LNG carrier, while docked infrequently for short periods of time, would require two engines to be operational regardless of seasonal variation.

As more engines on board the FSRU are required to operate during the high season, emissions to air would be greater during the high season. Therefore, to account for worst case possible air borne emissions, operational scenarios during the high season have been conservatively modelled to occur over the entire year.

The FSRU and LNG carrier can be operated using gas (LNG) or liquid fuel (MDO). AIE has advised that the FSRU and LNG carrier will consume gas as their primary energy source. The following scenarios have been modelled (all scenarios assumed two engines are active on board the FSRU and two engines are active on board the LNG carrier):

Scenario 1 – gas fuelled FSRU and Liquid fuelled LNG carrier

Scenario 1 is composed of a gas fuelled FSRU (two engines are active) and a liquid fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 1 are presented in Table 5-19.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Scenario 2 - liquid fuelled FSRU and liquid fuelled LNG carrier

Scenario 2 is composed of a liquid fuelled FSRU (two engines are active) and a liquid fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 2 are presented in Table 5-20.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Scenario 3 – gas fuelled FSRU and gas fuelled LNG carrier

Scenario 3 is composed of a gas fuelled FSRU (two engines are active) and a gas fuelled LNG carrier (two engines are active). The predicted incremental and cumulative pollutant concentration for Scenario 3 are presented in Table 5-21.

No incremental or cumulative criteria exceedances are predicted at the sensitive receptor locations.

Benzene, formaldehyde and PAH concentrations are presented as 99.9th percentiles, which is consistent with their assessment criteria. All other pollutants are presented as the maximum 100th percentiles predicted concentrations.

Table 5-19 Scenario 1 — Predicted incremental and cumulative pollutant concentrations

Receptor	Predicted incremental pollutant concentrations (µg/m³)										Predicted cumulative pollutant concentrations (µg/m³)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	CH2O	PAH	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	CH2O	PAH
	24 hr	Annual	24 hr	Annual	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	24 hr	Annual	24 hr	Annual	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
Criterion	50	25	25	8	246	30000	570	29	20	0.4	50	25	25	8	246	30000	570	29	20	0.4
R01	1.3	0.08	0.60	0.04	81	123	36	0.3	3	0.00002	43.6	16.9	17.3	6.5	85	1848	86	0.3	3.00	0.00002
R02	1.7	0.09	0.83	0.04	102	226	59	0.4	4	0.00004	43.6	16.9	17.3	6.5	105	1951	109	0.4	4.00	0.00004
R03	1.1	0.10	0.50	0.05	97	98	29	0.3	3	0.00002	43.6	16.9	17.4	6.5	101	1823	79	0.3	3.00	0.00002
R04	2.1	0.14	0.98	0.07	125	192	50	0.3	4	0.00004	43.6	16.9	17.5	6.5	129	1917	100	0.3	4.00	0.00004
R05	1.3	0.10	0.62	0.05	98	216	57	0.3	3	0.00004	43.6	16.9	17.3	6.5	102	1941	107	0.3	3.000	0.00004
R06	1.0	0.06	0.50	0.03	77	167	44	0.2	3	0.00002	43.6	16.8	17.4	6.5	82	1892	94	0.2	3.00	0.00002
R07	0.9	0.17	0.43	0.08	71	80	23	0.2	3	0.00002	43.8	17.0	17.4	6.5	86	1805	73	0.2	3.00	0.00002
R08	1.0	0.17	0.50	0.08	82	141	44	0.2	3	0.00003	43.9	16.9	17.6	6.5	105	1866	94	0.2	3.00	0.00003
R09	0.9	0.07	0.46	0.03	134	176	57	0.3	4	0.00004	43.7	16.9	17.8	6.5	153	1901	107	0.3	4.00	0.00004
R10	1.4	0.15	0.65	0.07	84	139	40	0.3	4	0.00003	44.2	16.9	17.6	6.5	102	1864	90	0.3	4.00	0.00003
R11	1.5	0.12	0.72	0.06	98	195	58	0.4	4	0.00004	43.7	16.9	17.3	6.5	103	1920	108	0.4	4.00	0.00004

Table 5-20 Scenario 2 — Predicted incremental and cumulative pollutant concentrations

Receptor	Predicted incremental pollutant concentrations (µg/m³)										Predicted cumulative pollutant concentrations (µg/m³)									
	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	CH2O	PAH	PM_{10}		$PM_{2.5}$		NO_2	CO	SO_2	Benzene	CH2O	PAH
	24 hr	Annual	24 hr	Annual	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	24 hr	Annual	24 hr	Annual	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
Criterion	50	25	25	8	246	30000	570	29	20	0.4	50	25	25	8	246	30000	570	29	20	0.4
R01	2.0	0.1	1.2	0.07	89	192	66	0.5	0.05	0.00001	43.6	16.9	17.4	6.5	91	1917	116	0.5	0.05	0.00001
R02	3.0	0.2	1.5	0.08	123	400	125	0.7	0.07	0.00001	43.6	16.9	17.3	6.5	127	2125	175	0.7	0.07	0.00001
R03	2.0	0.2	1.0	0.09	113	172	59	0.5	0.05	0.00001	43.6	16.9	17.4	6.5	117	1897	109	0.5	0.05	0.00001
R04	4.0	0.2	2.0	0.13	136	296	88	0.5	0.05	0.00001	43.6	17.0	18.1	6.6	140	2021	138	0.5	0.05	0.00001
R05	2.0	0.2	1.1	0.09	105	341	107	0.6	0.06	0.00001	43.6	16.9	17.3	6.5	109	2066	157	0.6	0.06	0.00001
R06	1.0	0.1	0.7	0.06	89	197	59	0.4	0.04	0.00001	43.6	16.9	17.4	6.5	103	1922	109	0.4	0.04	0.00001
R07	2.0	0.3	0.9	0.16	90	135	46	0.4	0.04	0.00001	43.9	17.1	17.4	6.6	103	1860	96	0.4	0.04	0.00001
R08	2.0	0.3	1.0	0.16	125	218	75	0.4	0.04	0.00001	44.1	17.1	18.0	6.6	154	1943	125	0.4	0.04	0.00001
R09	2.0	0.1	1.0	0.07	142	346	119	0.5	0.05	0.00001	43.7	16.9	17.9	6.5	161	2071	169	0.5	0.05	0.00001
R10	2.0	0.3	1.3	0.14	99	236	82	0.6	0.06	0.00001	44.7	17.0	18.0	6.6	116	1961	132	0.6	0.06	0.00001
R11	3.0	0.2	1.4	0.11	109	341	117	0.7	0.07	0.00001	43.7	17.0	17.4	6.6	112	2066	167	0.7	0.07	0.00001

Table 5-21 Scenario 3 — Predicted incremental and cumulative pollutant concentrations

Receptor	Predicted incremental pollutant concentrations (µg/m3)								Predicted cumulative pollutant concentrations (µg/m3)							
	PM_{10}		NO2	CO	SO2	Benzene	Formaldehyde	PAH	PM_{10}		NO2	CO	SO2	Benzene	Formaldehyde	PAH
	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	1 hour	24 hour	Annual	1 hour	1 hour	1 hour	1 hour	1 hour	24 hour
Criterion	50	25	246	30000	570	29	20	0.4	50	25	246	30000	570	29	20	0.4
R01	0.4	0.02	45	38	0.04	0.05	6	0.00002	43.6	16.8	58	1763	50	0.1	6.00	0.00002
R02	0.4	0.02	57	74	0.08	0.06	8	0.00002	43.6	16.8	59	1799	50	0.1	8.00	0.00002
R03	0.3	0.03	40	39	0.04	0.05	5	0.00002	43.6	16.8	58	1764	50	0.1	5.00	0.00002
R04	0.7	0.04	70	65	0.07	0.06	7	0.00002	43.6	16.8	70	1790	50	0.1	7.00	0.00002
R05	0.3	0.03	48	65	0.07	0.05	7	0.00002	43.6	16.8	58	1790	50	0.1	7.00	0.00002
R06	0.2	0.02	31	42	0.04	0.04	5	0.00002	43.6	16.8	58	1767	50	0.0	5.00	0.00002
R07	0.3	0.05	30	28	0.03	0.04	5	0.00001	43.6	16.8	63	1753	50	0.0	5.00	0.00001
R08	0.3	0.05	52	56	0.07	0.04	5	0.00002	43.7	16.8	63	1781	50	0.0	5.00	0.00002
R09	0.4	0.02	61	98	0.12	0.05	6	0.00002	43.6	16.8	80	1823	50	0.1	6.00	0.00002
R10	0.4	0.04	46	47	0.05	0.06	7	0.00002	43.8	16.8	58	1772	50	0.1	7.00	0.00002
R11	0.5	0.03	37	88	0.10	0.07	8	0.00003	43.6	16.8	58	1813	50	0.1	8.00	0.00003

5.6.5 Mitigation Measures

Operational air quality impacts are not anticipated and no specific mitigation is provided. It is recommended that the project remains compliant with IMO legislation and domestic air quality guidelines to ensure future operations comply with air quality standards.

AIE and FSRU provider Hoegh LNG are committed to achieving sustainable operations. Given the pace of technological change, it is possible that technology may become available which could reduce NOx emissions when the FSRU is running on MDO mode to a level below the Protection of the Environment Operations (Clean Air) Regulation 2010 limit.

This would significantly reduce NOx emission from the FSRU below POEO limits.

AIE will continue to monitor the potential to reduce NOx emissions when operating in MDO mode and if economically feasible and effective technology becomes available, AIE would seek to remove the 72 hour per annum operating restriction from the Infrastructure approval.

5.7 Port navigation

5.7.1 Introduction

An assessment of potential impacts of the project upon navigation within Port Kembla was undertaken as part of the Port Kembla Gas Terminal EIS. The assessment included a review of applicable navigational guidelines and port protocols at Port Kembla and completion of navigation simulation study to demonstrate safe passage of LNG carriers was possible. This section outlines the key findings of the port navigation assessment and potential for impacts associated with the increased ship movements proposed as part of the modification.

5.7.2 Navigation within the port

Overview

The Port Authority of NSW is responsible for the management of shipping operations in Port Kembla, including the provision of Harbour Master functions, pilotage, navigation services and ship scheduling.

The port has a deep-water shipping channel that can accommodate vessels with ship length (LOA) of up to 311 metres and has capacity for Capesize vessels (at nominated berths) (Port Authority of NSW, 2015). Pilotage is compulsory for vessels over 30 metres in length.

Passage from Port Kembla's Outer Harbour to the Inner Harbour requires navigating through a relatively narrow channel known as The Cut and in close proximity to other berthed vessels.

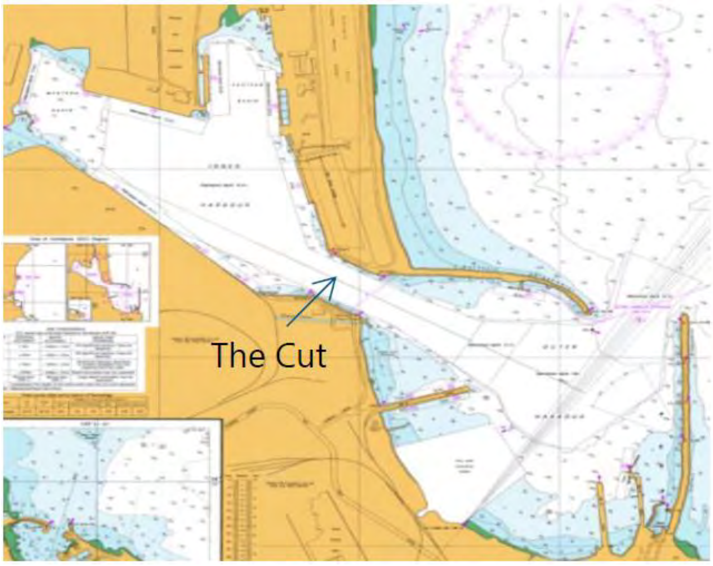

Figure 5-10 **Port Kembla's navigational area**

As shown in Figure 5-10 the entrance to Port Kembla's Outer Harbour is open to the north-east, which exposes the Outer Harbour to swell and wind. After arriving through the entrance, a 90 degrees turn is required to pass through The Cut into the Inner Harbour. A vessel speed of at least 2.5 knots through The Cut is required to maintain vessel steerage. Ship-to-ship interactions can occur between transiting and berthed vessels depending on vessel speed and proximity.

The channel is well marked with navigational buoys, sector lights and leading marks.

Challenges to navigating the channel include unpredictable currents at the port entrance, as well as strong winds and currents in and around The Cut resulting from waves and vessel or tide induced currents. There is also a localised water level change in the Inner Harbour as vessels enter and exit through The Cut (Advisian, 2018), especially fully laden Panamax and Capesize vessels.

Navigational guidelines

Guidelines set by SIGTTO (SIGTTO, 2000) and PIANC (PIANC, 2014) state that the diameter of the turning basin should be twice the LOA of the maximum vessel length (600 metres). This guideline recognises that the diameter can be rationalised subject to further investigation and study. The diameter of the existing turning basin in the Inner Harbour is 500 metres (Advisian, 2018).

With respect to the channel width, SIGTTO (2000) states that the channel width required is five times the vessel beam (B), which is 250 metres for the 50 metres design beam. PIANC (2014) states the channel width to be at least 3.5 x B, which is 175 metres (Advisian, 2018). Both these required widths are greater than the 160 metres width of The Cut. This guideline recognises that the channel width can be rationalised subject to further investigation and study.

Port protocols

Within Port Kembla, the Harbour Master and the Port Authority of NSW are accountable for the safe navigation of all vessels, including LNG carriers. Emergency response and navigational safety within the port is managed by the Port Authority of NSW and the Harbour Master establishes port operational procedures (port instructions) relating to vessel navigation protocols, ship scheduling, berthing and under keel depth requirements, as well as performance standards to achieve safe, effective, reliable and cost efficient shipping (Port Authority of NSW, 2015).

Detailed Port Kembla protocols are provided in the Port of Kembla - Port Instructions document (Port Authority of NSW, 2015). This document outlines instructions for vessels accessing the port along with general port information. Instructions and protocols relevant to port navigation include those around vessel manoeuvring, anchorage, vessels at anchor, vessel sizes, traffic management, draught requirements, underkeel clearance depths, and mooring arrangements.

Key navigational safety guidelines (Port Authority of NSW, 2015) include:

- Port Parameters (Annex H of *Port of Kembla - Port Instructions*) detail port capacity and maximum vessel size, including maximum LOA, maximum displacement and limiting environmental conditions for the port.
- To allow for safe passage in the port, the underkeel clearance for ships undertaking pilotage in Port Kembla is required to be not less than 1.25 metres, or as required through the use of dynamic underkeel clearance.
- Static underkeel clearance is calculated by the following formula: Depth of channel + height of tide, divided by 1.08 metres (Annex D of *Port of Kembla - Port Instructions*).
- Alongside berth underkeel clearance requirements, vessels are required to have a minimum underkeel clearance of 0.6 metres in the Outer Harbour and 0.3 metres in the Inner Harbour at all times (Annex D of *Port of Kembla - Port Instructions*).

5.7.3 Potential impacts

The EIS assessed potential impacts on vessel navigation within Port Kembla harbour during operations to include:

- Collision of LNG carriers into structures or other vessels entering and exiting the channel and their berths, therefore impacting other vessels port navigation and safety, as well as safety of personnel on or around vessels, impacts to infrastructure and economic impacts to other businesses.
- Grounding of LNG carriers transferring LNG from the new berth through the navigational channel, therefore impacting other vessels port navigation and safety, and potentially resulting in partial or full port closures.
- Interaction of LNG carriers with other vessels transiting past Berth 101 as they enter or exit the port, impacting their speed and ability navigate the port.
- Reduced visibility from other vessels navigating the port due to the stationed FSRU and LNG carriers side by side at the new berth, therefore impacting other vessels port navigation and safety.

The assessment concluded that LNG carriers would be able to safely navigate to and from the Port Kembla Gas Terminal.

Port Kembla handles loaded Capesize and Panamax vessels which would host a total carrying capacity in tonnes of up to 205,000 deadweight tonnage (DWT), including vessels departing Berth 102 where coal loading operations would be taking place. Impacts associated with the LNG carrier's interaction with these passing vessels includes the need for reduced speed of vessels passing Berth 101 and passing vessels may require the use of existing Port Kembla tugs for shiphandling, especially when wind speed is over 10 knots.

Results from the navigation simulation study (Advisian, 2018) included as Appendix C in Volume 2 of the Port Kembla Gas Terminal EIS, indicated that there will need to be some minor modifications to the operating practices when turning other vessels in the Inner Harbour to maintain safe clearances from the proposed berth arrangements. This was successfully tested in the simulators and will require ongoing consultation with the Harbour Master to update operational protocols. It was also determined that the aid to navigation (the navigational lead light) located at the north-western side of The Cut will be impacted by the facility and require relocation and/or raised to a new height to increase the visibility and avoid collision (Advisian, 2018). The new navigation light tower will be piled into the water area and the final position to be confirmed with further consultation with the Port Authority of NSW.

Overall, results of the navigational simulation study showed that safe navigation through the channel and in the Inner Harbour is possible for all vessels when combined with the proposed berth layout.

There are no changes proposed to the spatial layout of the berth or the maximum size of LNG Carriers proposed to be utilised by the gas terminal as part of the proposed modification. The modification may result in smaller LNG carriers delivering to the terminal based upon markets and availability of supply. Incoming vessels may vary in size from 140,000 cubic metres to 180,000 cubic metres but will not exceed the maximum vessel dimensions considered as part of the navigation simulation assessment. The findings of the original navigation assessment will therefore continue to apply to the project and the FSRU and LNG carrier at berth will not limit other vessels visibility or therefore their ability to safely navigate the port

The proposed modification would introduce variability in the schedule and options for deliveries by LNG carriers. The proposed modification has potential to increase LNG shipments to an approximate weekly basis during high season. LNG carrier movements will remain low in proportion to the vessels movements anticipated from other operational arrangements at the port (1,680 to 2,380 vessel movements per year). All vessel movements are required to adhere to the navigation guidelines and port protocols administered by the Port Authority of NSW including port capacity, maximum vessel size and clearance. Additional LNG carrier movements are not expected to significantly increase traffic in the port and will be subject to the management protocols proposed as part of the Port Kembla Gas Terminal EIS.

It is also noted that NSW Ports has separately proposed the removal of shipment limits on port tenants, enabling NSW Ports to manage the overall capacity of the port for all port users.

AIE will continue to consult with NSW Ports and the Port Authority of NSW regarding the project and deliveries by LNG carriers throughout operation to ensure the project integrates safely and efficiently with port operations.

5.8 Greenhouse gas

The potential greenhouse gas emissions of the project were originally assessed in the greenhouse gas technical report and associated chapter of the EIS. The assessment considered the Scope 1 emissions, from direct energy use, and Scope 2 emissions, from indirect energy use such as electricity from the grid. The annual greenhouse gas emissions inventory was calculated to be 8,314 t CO_2-e during construction and 44,146 t CO_2-e during operation. The primary source of greenhouse gas emissions is electricity generation from LNG on board the FSRU, which contributed 85% of greenhouse gas emissions during operation. This greenhouse gas emissions inventory was found to be above the 25,000 t CO_2-e threshold under the National Greenhouse and Energy Reporting Scheme and would consequently trigger annual reporting requirements under that scheme. Overall, the greenhouse gas emissions inventory was found to comprise about 0.01 % of Australia’s national greenhouse gas emissions. The assessment recommended a range of measures to minimise greenhouse gas emissions, which would be implemented in the design, procurement, construction and operation of the project.

The annual greenhouse gas emissions inventory has been updated to incorporate the proposed modification. Specifically, the greenhouse gas emission inventory has been updated to reflect:

- Increased LNG consumption for electricity generation proportionate to the nominal increase in indicative LNG throughput under the modification scenario
- Increased LNG combustion during transfers from LNG carriers to the FSRU proportionate to the nominal increase in the number of LNG carriers under the modification scenario
- Increased fugitives from LNG processing proportionate to the nominal increase in indicative LNG throughput under the modification scenario

The annual greenhouse gas emissions inventory for construction is not affected by the proposed modification and therefore remains at 8,314 t CO_2-e. The updated annual greenhouse gas emissions inventory for operation has increased to 53,919 t CO_2-e as shown in Table 5-22. This represents a 19 % increase in the annual greenhouse gas emissions inventory compared to the EIS. As such, the inventory remains above the threshold under the National Greenhouse and Energy Reporting Scheme and trigger annual reporting requirements. The greenhouse gas emissions inventory continues to comprise about 0.01 % of Australia's national greenhouse gas emissions. Given the proposed modification does not introduce any new sources of greenhouse gas emissions and results in a relatively modest increase in the inventory it is considered that the measures to minimise greenhouse gas emissions in the EIS continue to be appropriate.

Table 5-22 Greenhouse gas inventory (operation)

Activity	Emissions (t CO_2-e)	Percentage
Diesel — community	0.3	<0.1 %
Diesel — emergency generator	113	0.2 %
MDO — electricity generation	588	1.1 %
LNG/NG — electricity generation	43,172	80.1 %
LNG/NG — LNG transfer	7,070	13.1 %
LNG/NG — auxiliary boiler	336	0.6 %
LNG/NG — fugitives	2,574	4.8 %
Natural gas transmission — operations	66	0.1 %
Total	53,919	100 %

5.9 Social and economic

The potential social and economic impacts of the project were originally assessed in the social and economic chapter in the EIS. The assessment described the existing social and economic conditions relevant to the project, identified the social and economic impacts (including benefits) of the project, and recommended measures to mitigate those impacts or enhance their benefits.

The social and economic assessment identified the following potential impacts during operation:

- Investment and employment
- Population and demography
- Amenity and character
- Access and connectivity.

With regard to investment and employment, the project was expected to generate economic benefits through direct job creation as well as supporting of gas-reliant industrial users and jobs estimated to be in the order of 15,000 jobs in the region and 300,000 jobs across NSW.

As discussed in section 3, the project with the proposed modification would not only provide long-term contracts to industry users but would also provide long-term contracts to retailers and in turn a supply of gas to over 1.5 million mass market residential and commercial customers. It would also potentially increase the total gas throughput of the project to the market and users.

As such, in addition to the potential industrial investment and employment benefits identified in the EIS, the proposed modification would potentially enhance those benefits while diversifying the recipients of potential benefits to include residential and smaller scale commercial customers.

As the proposed modification would not require a larger operational workforce or additional infrastructure, potential impacts to population and demography, amenity and character or access and connectivity would not be expected to differ from those assessed in the EIS.

5.10 Other matters

Other matters that were considered, but were not considered likely to be materially affected by the proposed modification, included soils and contamination, terrestrial biodiversity, heritage, traffic and access, waste management, climate change risk and cumulative impacts.

Soils and contamination, terrestrial biodiversity and heritage would not be affected by the proposed modification as it would not involve any changes to project construction, berthing arrangements, pipeline connection or other activities with potential to affect these matters.

With regard to traffic and access, the proposed modification would not be expected to result in a material increase in the workforce or road traffic and accordingly impacts are not predicted. The potential impacts of the project with regard to port navigation are discussed in section 5.7.

With regard to waste management, the proposed modification would not be expected to result in a material increase in waste generated on board the FSRU such as grey water, sewage, bilge water, rubbish or food waste. As stated in the EIS, similar wastes may be generated on board LNG carriers but were not included in the monthly inventory as where and how the waste from LNG carriers is managed would depend on the operator of the particular LNG carrier.

Lastly, the proposed modification would not be expected to have any effect with regard to the climate change risks or cumulative impacts identified and assessed in the EIS. Potential cumulative impacts with regard to hazard and risk are assessed separately in section 5.2.

6. Consistency assessment

A consistency assessment of the proposed modification and the existing conditions that attach to the development approval for Port Kembla Gas Terminal is contained in Table 6-1.

It is noted that only approval conditions potentially requiring amendments have been included and the proposed modification is considered consistent with remaining conditions.

Table 6-1 Consistency assessment

Condition	Consistency
TERMS OF APPROVAL 2. The Proponent must carry out the development: (a) generally in accordance with the EIS; and (b) in accordance with the conditions of this approval	Requires update to incorporate proposed modification.
LIMITS ON OPERATIONS 6. The Proponent must not import more than 26 shipments of liquified natural gas from LNG carriers in any calendar year.	Requires an update to either remove Condition 6 or to modify it to permit operational flexibility in view of seasonality of demand. Removal of Condition — It is understood that NSW Ports has requested that port tenants not receive limits on the number of vessel movements associated with their developments. NSW Ports prefers total port capacity to be managed by NSW Ports. Modification of Condition — The forecast LNG carrier movements with the proposed modification discussed in section 4.2 are indicative only and subject to significantly more variability than proposed in the original EIS, which assumed a steady-state of demand. Seasonality in demand introduces a greater number of variables on the supply side, which need to be managed through greater flexibility in shipment numbers and sizes.
8. Unless otherwise authorised by Commonwealth law, the Proponent must not operate the FSRU using marine diesel oil for more than 72 hours in any calendar year while berthed at the site, and must maintain records of the hours that marine diesel oil is used to power the FSRU to track compliance against this condition.	As discussed in 4.2.2, given the pace of technological and regulatory change in the marine transportation sector, it is likely cost-effective technologies may become available in a reasonable period of time which could reduce NOx emissions, when in MDO mode, to below Clean Air limits. In order to be able to benefit from the new technologies as quickly as possible and provide operational flexibility, Hoegh LNG has requested a possible change to the Condition, which removes the 72 hour limit, subject to compliance with the Protection of the Environment Operations (Clean Air) Regulation 2010 being demonstrated.

7. Conclusion

AIE is seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the *Environmental Planning and Assessment Act 1979*. The modification is to accommodate potential more variability in customer demand profiles and associated flexibility in operational parameters including the delivery schedule and options of LNG cargoes.

An environmental assessment has been prepared to consider the potential environmental impacts arising from the proposed modification under Section 5.25 of the EP&A Act. The proposed modification will not significantly alter the construction footprint or methodology which have been previously assessed as part of the Port Kembla Gas Terminal EIS. The assessment has therefore focussed upon potential environmental impacts during operation.

The key issues that were found to be potentially affected by the proposed modification include hazard and risk, water resources, marine ecology, noise and vibration, air quality, port navigation, greenhouse gas, and social and economic matters. In general the proposed modification was not found to significantly affect or introduce additional environmental impacts.

Overall, the Port Kembla Gas Terminal will remain substantially the same development as approved under the original Infrastructure approval (SSI 9471). The proposed modification does not seek to significantly alter the nature or scale of the proposed development.

8. References

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Appendices

Appendix A
Hazard and risk assessment

AUSTRALIAN INDUSTRIAL ENERGY

Port Kembla Gas Project

Preliminary Hazard Analysis Addendum - Seasonal Variations

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PROJECT 401010-01496-SR-TEN-0003 – Port Kembla Gas Project

Rev	Description	Original	Review	WorleyParsons Approval	Date	Customer Approval	Date
A	Issued for Information	A Stembridge	A Fergusson	PP F Losty	25-Nov-19		

Contents

1. INTRODUCTION

1.1 Project Overview

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a Liquefied Natural Gas (LNG) import terminal at Port Kembla, south of Wollongong in New South Wales (NSW). The project will be the first of its kind in NSW and provides a simple, flexible solution to the state's gas supply challenges.

NSW currently imports more than 95% of the natural gas it uses, with the majority of supplies coming from Victoria and South Australia. In recent years, gas supplies to the Australia east coast market have tightened, resulting in increased prices for both industrial and domestic users.

Port Kembla Gas Terminal consists of four key components:

- LNG Carrier (LNGC) vessels — there are hundreds of these in operation worldwide, transporting LNG from production facilities all around the world to demand centres;
- Floating Storage and Regasification Unit (FSRU) — a cape-class ocean-going vessel, which would be moored at Berth 101 in Port Kembla;
- Berth and wharf facilities — including landside offloading facilities to transfer natural gas from the FSRU into an underground natural gas pipeline located on shore; and
- Gas pipeline — a Class 900 carbon steel high-pressure pipeline connection from the berth to the existing gas transmission network.

LNG will be sourced from worldwide suppliers and transported by LNG carriers to the Port Kembla Gas Terminal. The LNG will then be regasified for input into the NSW gas transmission network. The project will be the first of its kind in NSW and provide a simple, flexible solution to the state's gas supply challenges.

1.2 Proposed Modification

The Project was declared Critical State Significant Infrastructure (CSSI) in accordance with section 5.13 of the Environmental Planning and Assessment Act 1979 (EP&A Act) and received Infrastructure Approval from the Minister for Planning and Public Spaces on the 24th of April 2019.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

The EIS stated the project would have the capacity to deliver in excess of 100 petajoules (PJ) per annum and also indicated that the capacity of the project could be increased further to 140–150 PJ per annum in the future. The EIS assumed a relatively flat demand profile throughout the year based upon the predicted demands from a predominantly industrial customer base. The assessment presented in the EIS for operation of the gas terminal was therefore based upon a flat rate of production with two LNG trains operating within the FSRU.

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. The rate of production will need to respond to this demand and will also be influenced by operational parameters such as the calorific content of LNG delivered to the project. Accordingly, the supply will likely vary from the assumed flat rate of around 300 Terajoules (TJ) per day for any given season or shipment of LNG.

AIE is therefore seeking a modification of the Minister's approval for the Port Kembla Gas Terminal under section 5.25 of the Environmental Planning and Assessment Act 1979. The modification will seek authorisation to increase capacity of the project and allow for seasonality.

The modification will also require an increase to the overall number of LNG carrier deliveries per year to accommodate both the seasonality and the increase in capacity. The EIS anticipated the arrival of 24 consistently sized (170,000 cubic metre) vessels. However, with seasonality, incoming vessels may vary considerably in size from approximately 140,000 cubic metres to 180,000 cubic metres.

1.3 Objectives

The objective of this addendum to the Preliminary Hazard Analysis (PHA) [3] is to assess the proposed operational changes at the planned Port Kembla Gas Terminal against the Hazard and Risk requirements of the Secretary's Environmental Assessment Requirements (SEARs) issued 10 August 2018 specifically the requirements of Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 Risk Criteria for Land Use Planning [2].

1.4 Acronyms

The abbreviations utilised in this project are listed below.

Abbreviation	Definition
AIE	Australian Industrial Energy
CSSI	Critical State Significant Infrastructure
EIS	Environmental Impact Statement
F & G	Fire and Gas
FSRU	Floating Storage and Regasification Unit
HIPAP	Hazardous Industry Planning Advisory Paper
LNG	Liquefied Natural Gas
LNGC	Liquefied Natural Gas Carrier

Abbreviation	Definition
NSW	New South Wales
PHA	Preliminary Hazard Analysis
PJ	Petajoules
PKCT	Port Kembla Coal Terminal
RTS	Response to Submissions
SIL	Safety Integrity Level
SSI	State Significant Infrastructure

2. PROPOSED MODIFICATION DETAILS

The intent of the proposed modification is to account for potential additional delivery of natural gas, driven in part by higher retail customer demand, and associated changes to project operating parameters such as deliveries by LNG carriers.

The PHA [3] presented in the EIS was based on the assumed flat demand profile of 309 TJ per day for any given season. For the modification of the Minister's approval, the seasonal demands are modelled separately. The PHA has been updated based on the operating conditions summarised in Table 2-1.

Table 2-1: Proposed Modification [1]

Parameter	Base Case	Proposed Modification	
		Low Season	High Season
LNG Trains	2	1	2
LNG Trains Operating Pressure barg	120	120	100
Seawater discharge m^3/hr	10,500	3,250	13,000
LNGC Deliveries per year	26	26	52
Approximate TJ/day	309	120	500

Figure 2-1 shows the expected demand profile.

Figure 2-1:Seasonal Demand Profile [1]

3. HAZARD AND RISK ASSESSMENT

The Port Kembla Gas Terminal will remain substantially the same development as originally approved under SSI 9471. The proposed modification does not seek to significantly alter the nature or scale of the proposed development. Therefore, the proposed operational changes are not expected to significantly alter safeguarding systems proposed under the original development.

The proposed operational changes do not introduce additional hazardous inventories or scenarios. The hazards, hazardous scenarios and potential consequences identified within the PHA [3] remain unchanged.

The increase in the frequency of LNGC movements and LNG unloading increases the potential for loss of containment of LNG during transfer or ship collision during vessel movements. The risk assessment has therefore conservatively assumed 52 LNGC movements and unloading activities per year for the base case, low and high demand cases.

Production flowrate influences the consequences of low frequency, large loss of containment events such as full bore ruptures where the loss of pressure is rapid, and the release rate drops to the production rate before further reducing after detection, isolation and blowdown / depressuring if provided. The increase in production rate drives up the release rate and ignition probability which is proportional to the release rate, increasing risk.

The risk contours presented in the existing PHA [3] conservatively take no credit for detection and isolation. This approach has been maintained for the initial analysis presented in this addendum. In addition, a sensitivity analysis has been completed to include detection and isolation. The results of the initial modelling and sensitivity case are presented in the following sections.

3.1 Risk Criteria

The impact of modifications will be assessed by comparing the updated risk contours to the Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 Risk Criteria for Land Use Planning [2]. These criteria are presented in Table 3-1.

Table 3-1: Fatality Risk Criteria

Risk (pa)	Land Use
5E-07	Sensitive land use; e.g. hospitals, schools, child-care facilities, old age housing
1E-06	Residential area; including hotels, motels, tourist resorts
5E-06	Commercial development; including retails centres, offices and entertainment centres
1E-05	Active open space; including sporting complexes
5E-05	Industrial

3.1.1 Propagation Risk

Heat radiation levels of 23 kW/m^2 and explosion overpressure levels of 14 kPa are considered sufficient to cause damage at neighbouring industrial operations to the extent where further hazardous incidents can potentially occur [2].

In order to ensure the risk of property damage at neighbouring installations the frequency of these impact levels occurring should not exceed a risk of 50 in a million per year (5E-05 pa).

3.1.2 Injury Risk

Heat radiation levels of 4.7 kW/m^2 and explosion over pressure levels of 7 kPa [2] are considered sufficient to cause injury to the public. As such the frequency of these impact levels should not exceed 50 in a million per year (5E-05 pa) at residential and sensitive areas.

3.2 Risk Assessment

3.2.1 Base Case

The base case assumes an averaged flat demand profile of 309 TJ/day throughout the year based on the seasonal demands presented in Figure 2-1. The PHA risk model [3] inputs were maintained as outlined in the PHA with the exception of the LNGC deliveries. To accommodate the increased production from April to September it is conservatively assumed 52 LNGC deliveries are required per year.

Figure 3-1 and Figure 3-2 show the fatality risk contours generated with the LNGC deliveries increased to 52 per year.

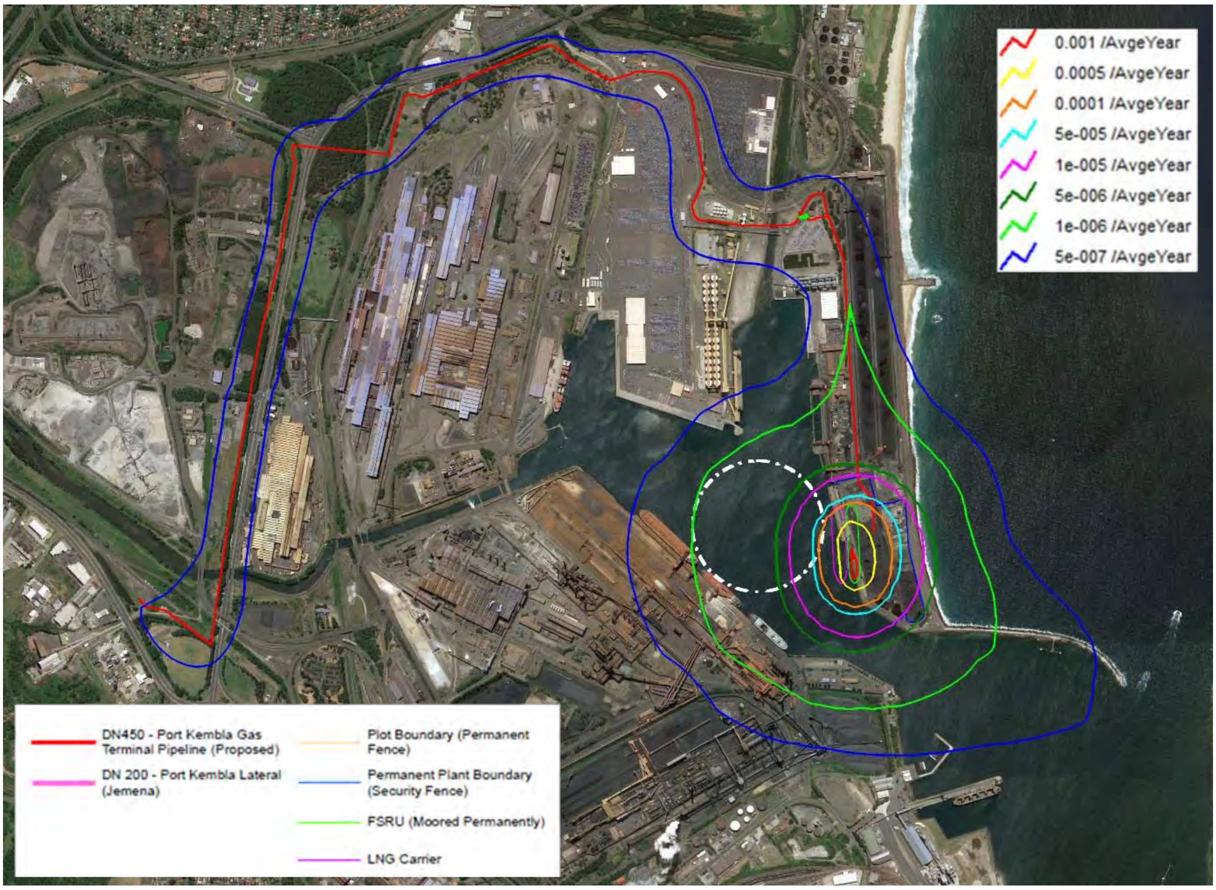

Figure 3-1: Fatality Risk Contours – Base Case

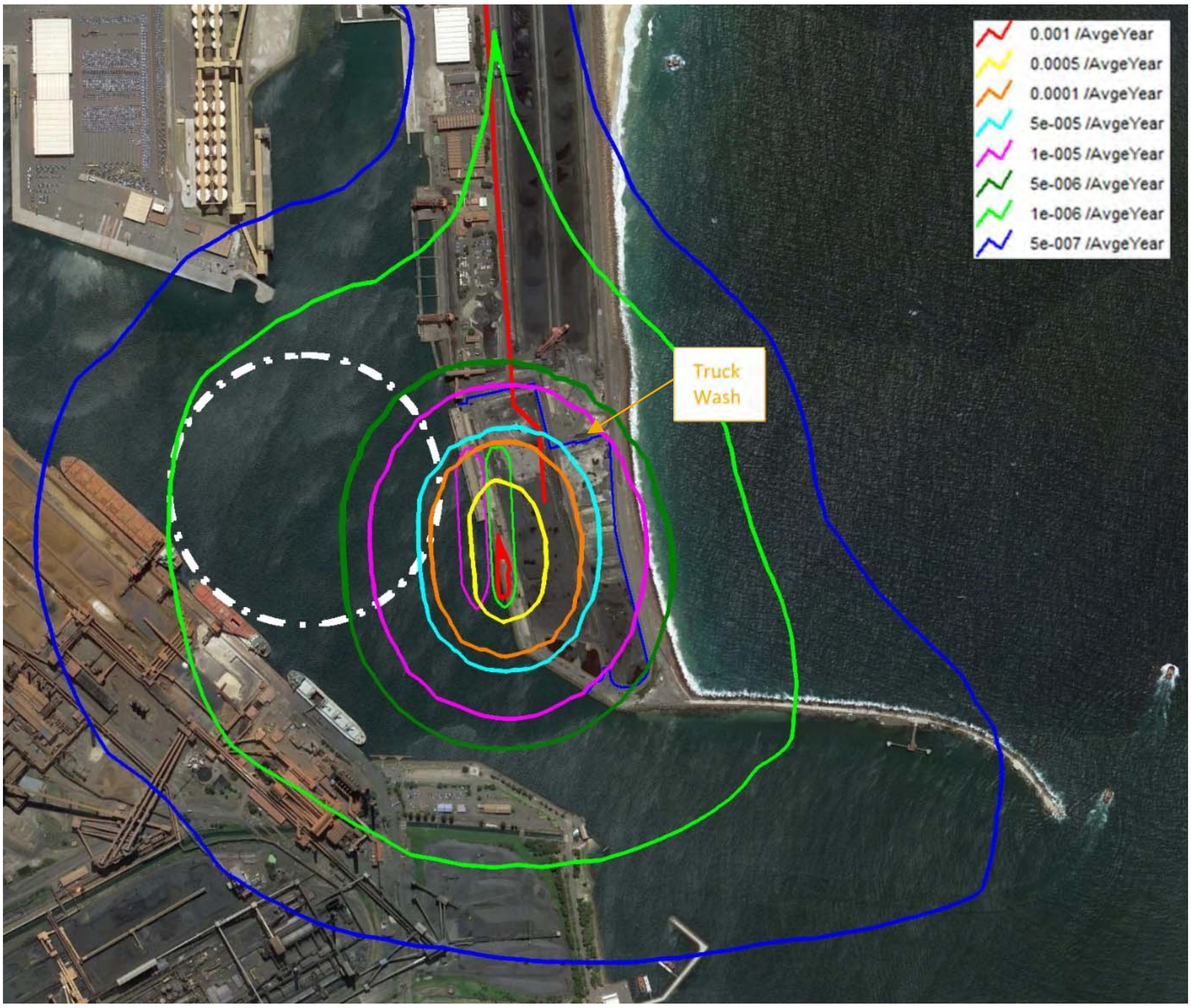

Figure 3-2: Berth Fatality Risk Contours – Base Case

The HIPAP4 Land Use Planning criteria states that the 5E-05 pa risk contour, as a target, should be contained within the boundaries of the industrial site where applicable. This risk contour is largely within the site boundary. However, it slightly extends beyond the wharf fence line at the north-east. It does not impact the truck wash located in this area.

The 1E-05 pa risk contour for active open spaces also extends beyond the wharf fence line, across Seawall Road and extends into the harbour. Seawall Road is a private road located on industrial land, controlled by NSW Ports and the Port Kembla Coal Terminal. It is opened to the public during daylight hours only and regularly closed for poor weather and/or other operational needs, including bulk haulage, construction/maintenance, etc. The road can be closed and secured at these times via security fencing and lockable gates. Access restrictions can be implemented and enforced by NSW Ports as required. Exposure for public users of Seawall Road is likely to be for short durations and numbers are limited as indicated by NSW Ports:

"The road tends to be used by surfers, rock fishers and occasional on-lookers for unusual events, such as the arrival of a large cruise ship. However, numbers of users are in the dozens, not the 100's, with the largest crowds seen there for the arrival of the Port's first cruise ship. Subsequent cruise ship arrivals have seen the crowd numbers dwindle."

Vessel entry into the Port Kembla Inner Harbour is controlled by the Port Authority and unauthorised entry is prohibited and enforced. Exposure of the public in this area is therefore expected to be low.

Propagation and injury risks have been calculated for the high demand case only as this higher rate will drive the consequences and hence the risk see Section 3.2.4.

3.2.2 Low Demand Case (120 TJ/day)

The low demand case will operate for up to six months from October through to March and will only operate with a single LNG train and LNG Booster pump required for the lower gas output. All other model inputs were maintained as outlined in the PHA.

Figure 3-3 and Figure 3-4 show the risk contours generated for the Low Demand 120 TJ/day case.

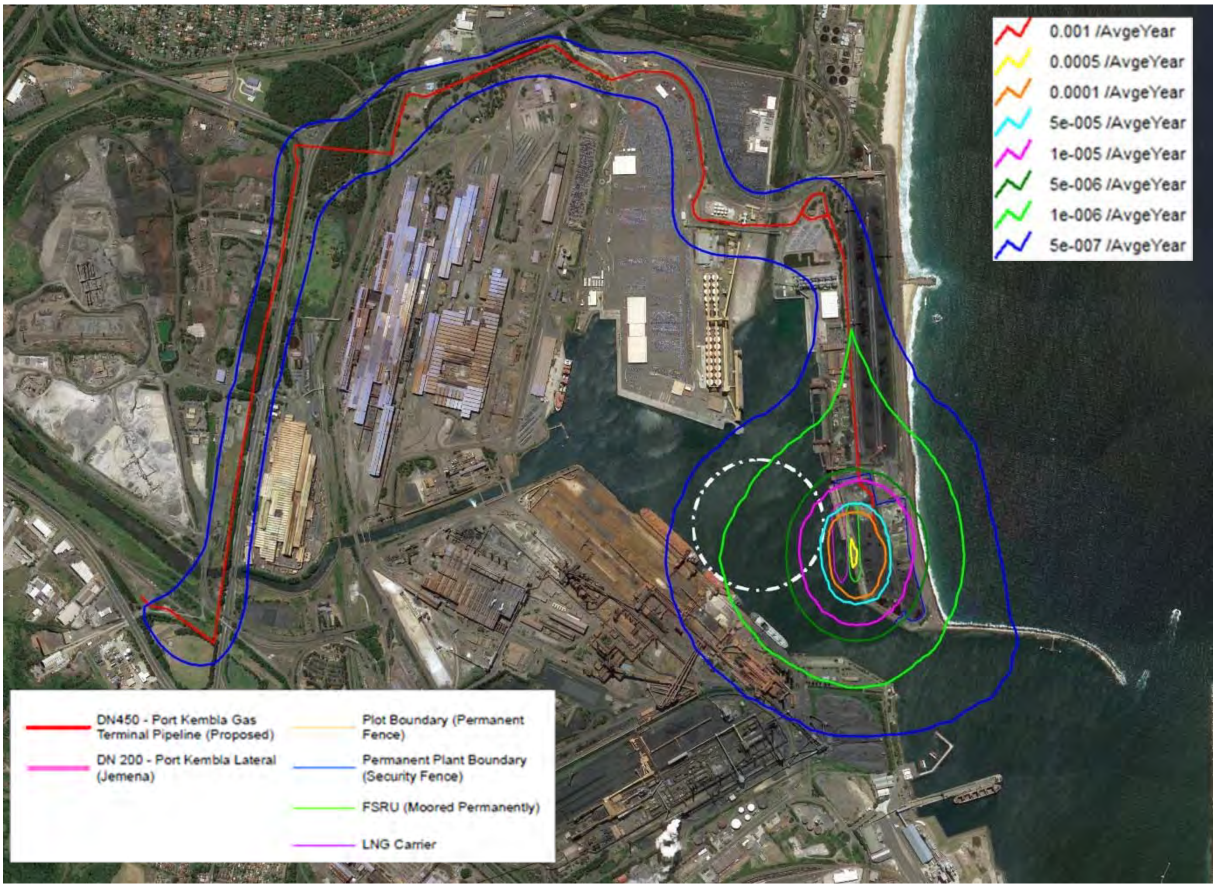

Figure 3-3: Overall Risk Contours – Low Demand Case

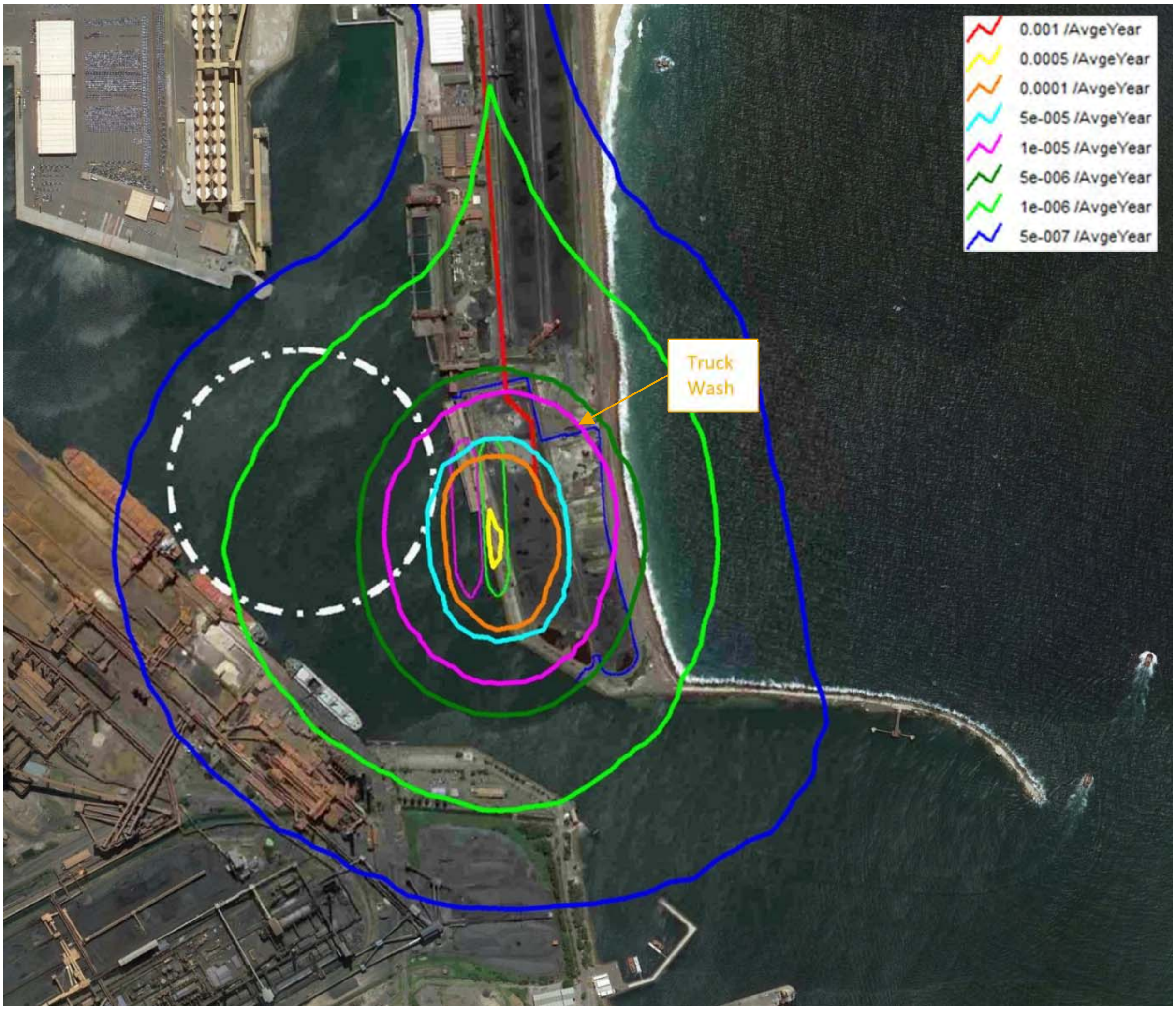

Figure 3-4: Berth Risk Contours – Low Demand Case

The 5E-05 pa risk contour for industrial areas is within the site boundary and does not impact the truck wash located near the north-east boundary fence line.

The 1E-05 pa risk contour for active open spaces extends beyond the wharf fence line and across a small portion of Seawall Road, where public exposure to risk is slightly greater than 1E-05 pa. The discussion in Section 3.2 relating to Seawall Road equally applies to the Low Demand Case.

3.2.3 High Demand Case (500 TJ/day)

The high demand case may operate for up to six months from April through to September and will continue to operate with two LNG trains in accordance with the EIS. However, the high demand case will operate with one additional LNG booster pump to achieve higher gas output. To accommodate the increased production, it is conservatively assumed 52 LNGC deliveries are required per year.

Figure 3-5 and Figure 3-6 show the risk contours generated for the High Demand Case.

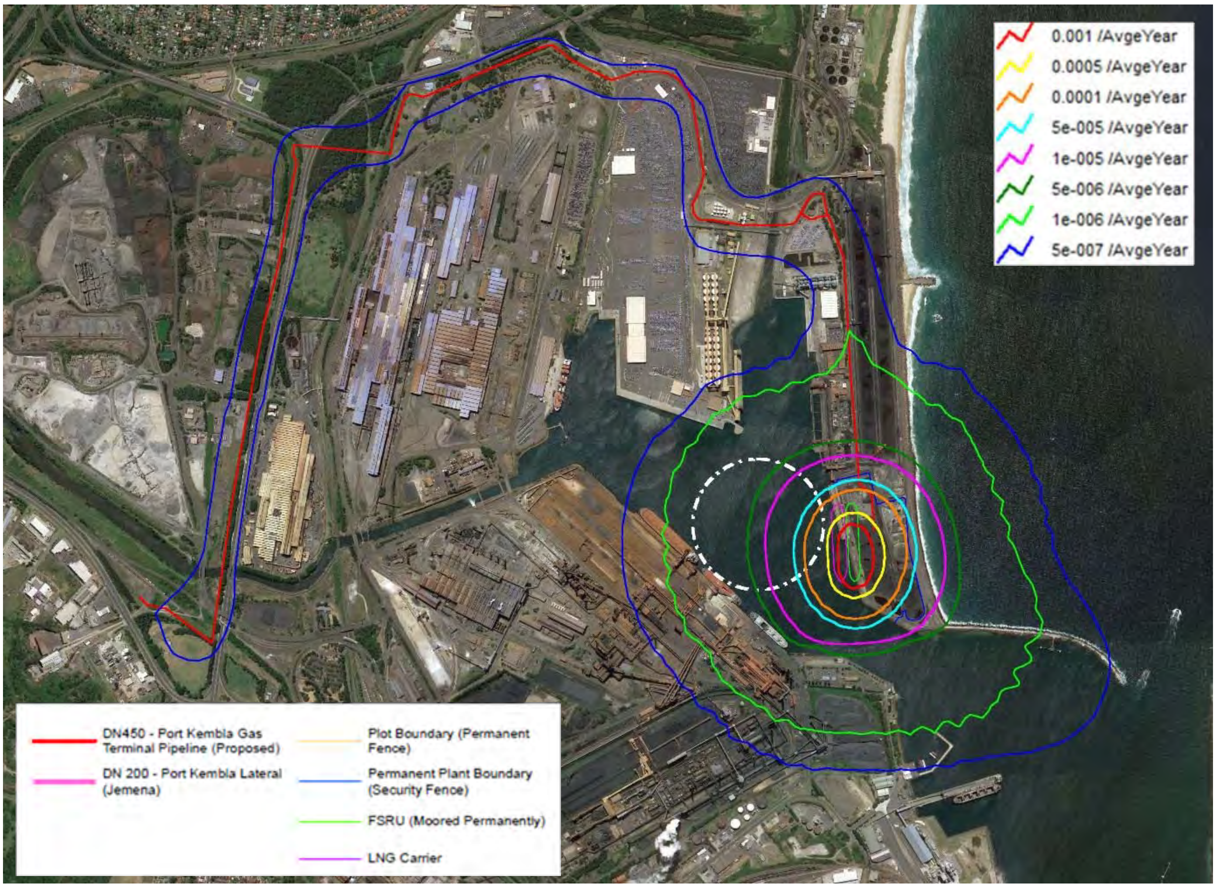

Figure 3-5: Fatality Risk Contours – High Demand Case

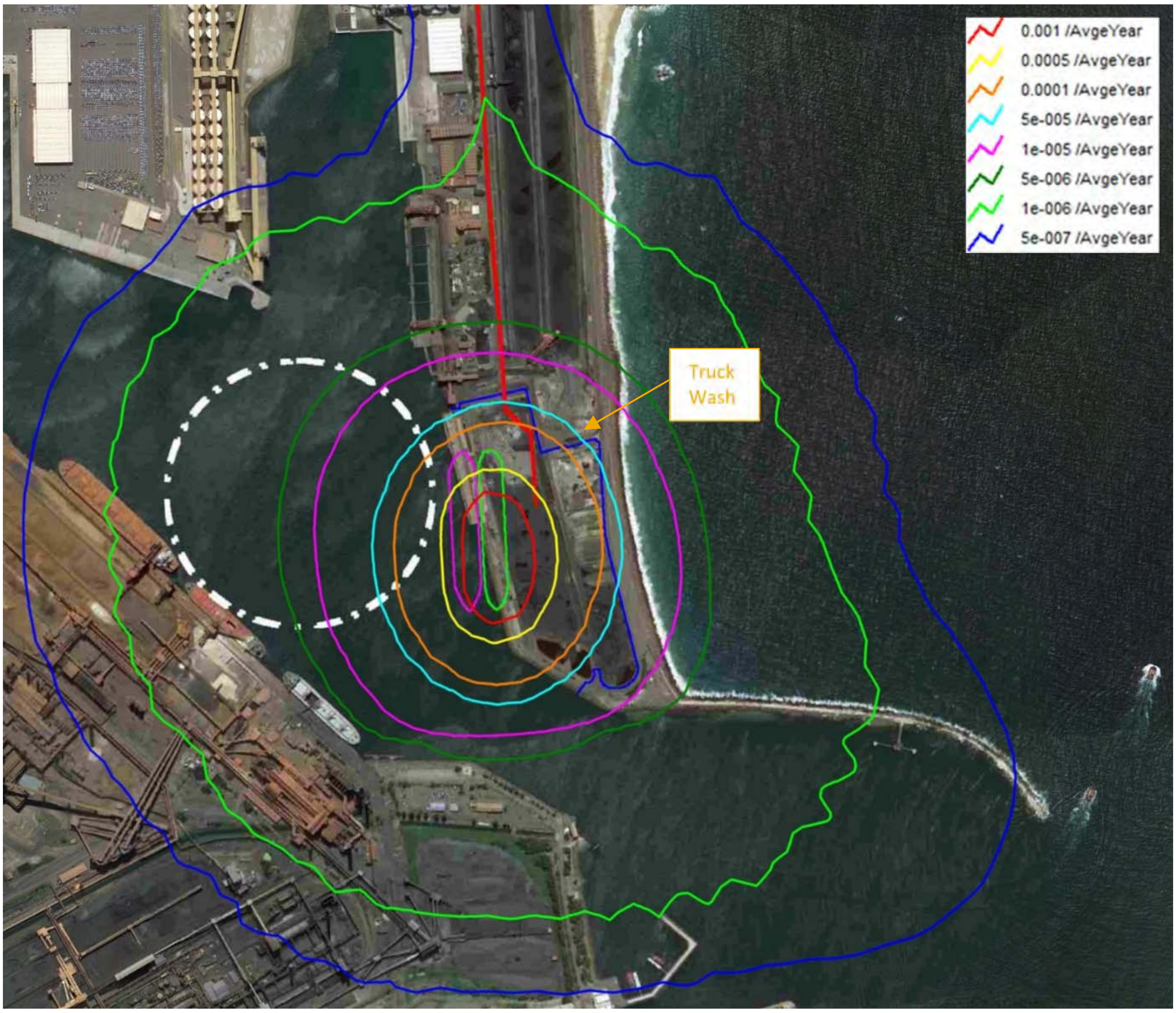

Figure 3-6: Berth Fatality Risk Contours – High Demand Case

The 5E-05 pa risk contour for industrial areas extends beyond the wharf fence line on the east boundary and extends beyond the truck wash located in this area. While the exposure at the truck wash area is slightly greater than 5E-05 pa risk, the risk to an individual is low due to limited exposure durations (i.e. low truck wash usage with limited duration).

The 1E-05 pa risk contour for active open spaces also extends beyond the wharf fence line, across Seawall Road and extends into the harbour. The discussion in Section 3.2 relating to Seawall Road equally applies to the High Demand Case noting that the high demand case is expected to occur during winters months when public access to Seawall Road for recreation is likely to be lower than during summer months.

The increased LNGC deliveries has extended the 1E-06 and 5E-07 pa risk contours along the ship route through the harbour. However, this has negligible risk impact to the other port users (including cruise ship terminal at berth 106) in the harbour.

The methodology used in the Quantitative Risk Assessment (QRA) to generate the risk contours presented is based on a number of conservative assumptions. Two of the more prominent conservative assumptions are:

- Fire and Gas (F&G) detection and isolation depressuring systems available on the FSRU and LNGC are not taken into account; and
- All leak scenarios are modelled with an infinite volume, taking no account of detection and isolation or finite volumes.

Detection, isolation and depressuring reduces the release rate and the ignition probability and therefore reduces risk significantly.

A sensitivity analysis has been conducted for the 500 TJ/day high demand case to account for detection and isolation. The steps taken are as follows:

1. Existing QRA parts count data and FSRU plot plans is used to estimate the largest isolatable volume for topside equipment (i.e. header between LNG storage and regasification unit including regasification suction drum).
2. Mitigated (averaged) depressuring leak rates for 5.5 barg and 100 barg liquid handling equipment are determined using the largest isolatable volume from step 1 (accounting for 30 seconds for F&G detection and isolation).
3. Using the mitigated (averaged) leak rates from step 2 the mitigated Ignition Probability (IP) is determined using the United Kingdom Offshore Operators Association (UKOOA) IP model.
4. Using the equation presented below and an assumed SIL 1 F&G detection and isolation system (with Probability of Failure on Demand (PFD) of 0.1), the reduced IP is calculated. Note: The F&G detection and isolation system is expected to be as a minimum SIL 2 capable with a minimum PDF of 0.01. However, a SIL 1 PFD is assumed to account for the probability the leak is detected.

Event	Detection & Isolation Initiated?	Risk
Leak	No - 0.1	Leak Freq (L_f) x Unmitigated IP (use peak discharge rate) (IP_U)
	Yes - 0.9	Leak Freq (L_f) x Mtigated IP (use averaged discharge rate) (IP_M)
Fire Frequency = L_f x IP_U x 0.1 + L_f x IP_M x 0.9 = L_f x (0.1 x IP_U + 0.9 x IP_M)		

5. Apply the reduced IP percentage, [0.1 x IP_U + 0.9 IP_M]/ IP_U, determined for the 5.5 barg liquid handling equipment leak scenario to all leak scenarios with pressure ≤ 5.5 barg.
6. Apply the reduced IP percentage determined for the 100 barg liquid handling equipment leak scenario to all leak scenarios with pressure > 5.5 barg.
7. Apply the largest isolatable volume for topside equipment on the FSRU taken from step 1 to all leak scenarios.

Note that the IPs and inventory volumes of the LNGC and FSRU cargo storage tanks and export pipeline leak scenarios were not unchanged.

By applying the above steps to reduce the ignition probability and isolatable volumes, accounting for SIL 1 F&G detection and isolation system, the resulting risk contours generated from the proposed 500 TJ/day high demand production and increased weekly LNGC deliveries were modelled and are presented in Figure 3-7 and Figure 3-8.

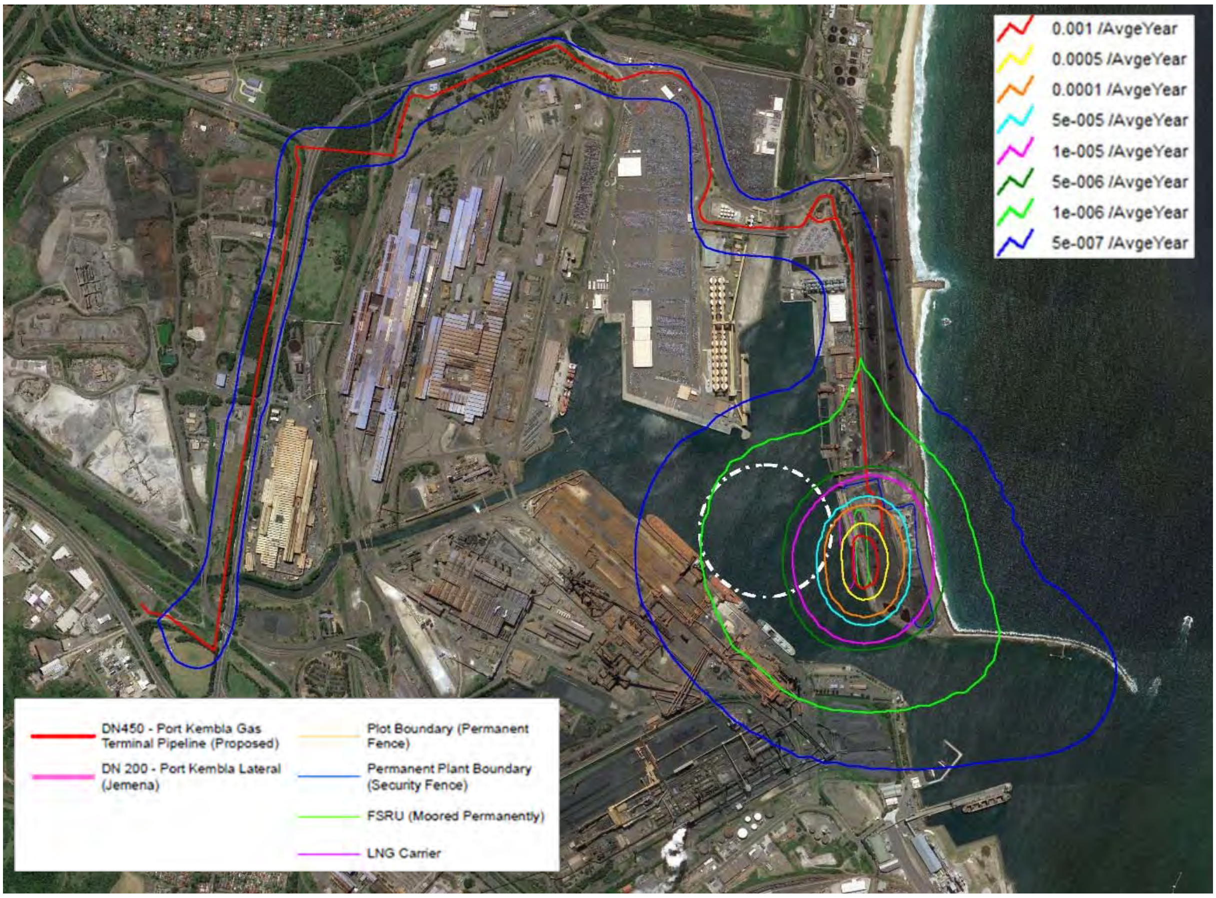

Figure 3-7: Fatality Risk Contours – High Demand Sensitivity F&G Detection & Isolation

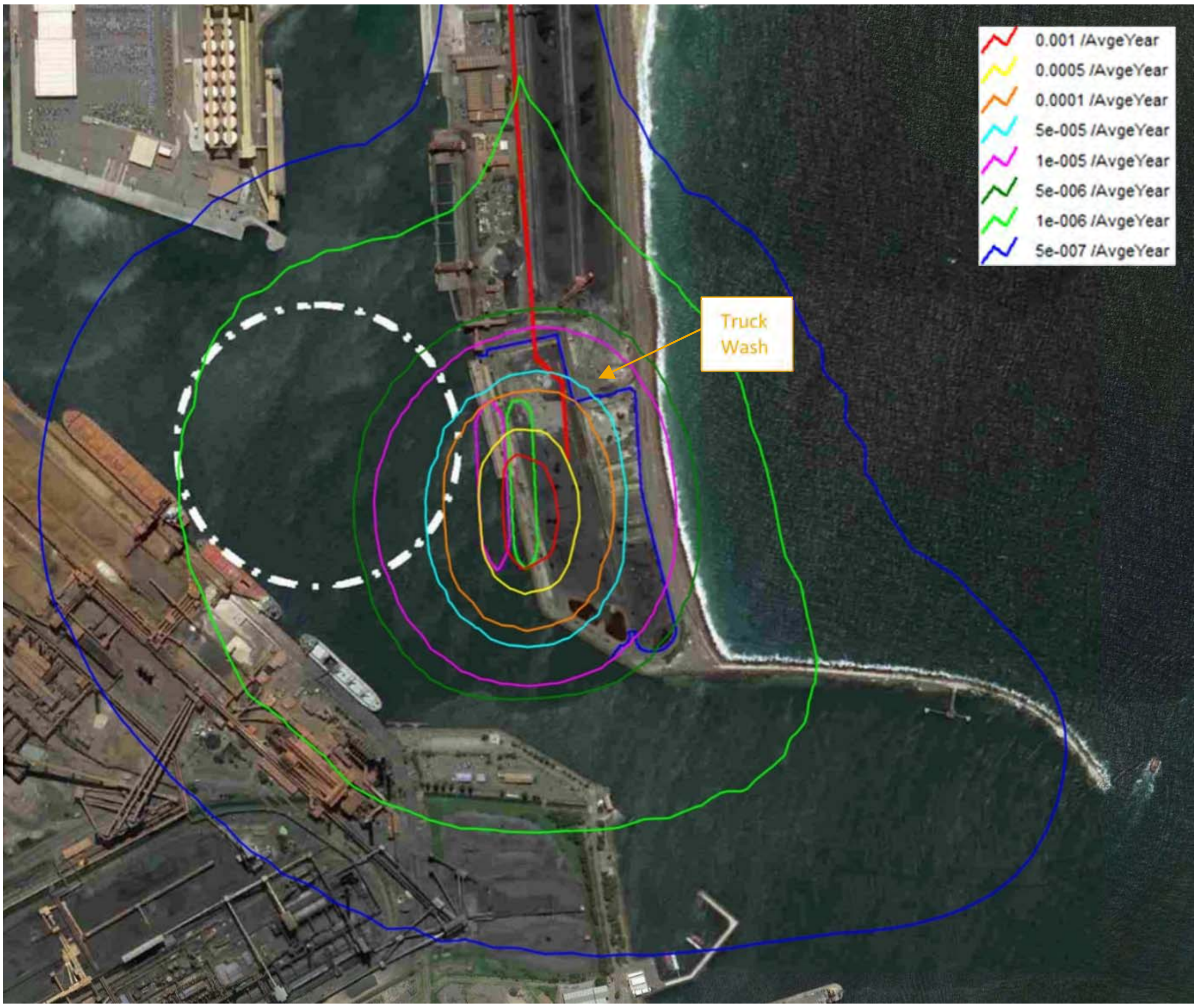

Figure 3-8: Berth Fatality Risk Contours – High Demand Sensitivity F&G Detection & Isolation

Comparing the sensitivity case in Figure 3-7 and Figure 3-8 to the High Demand Case in Figure 3-5 and Figure 3-6 the 5E-05 and 1E-05 risk contours have contracted. The 5E-05 pa risk contour for industrial areas extends slightly beyond the wharf fence line on the north-east boundary and does not impact the truck wash located in this area. Note further reduction in the contours may be realised through calculation of individual isolatable section volumes and applying these to the risk model.

The 1E-05 pa risk contour for active open spaces extends beyond the wharf eastern fence line and across Seawall Road to the shoreline. The 1E-06 and 5E-07 pa risk contours have contracted.

3.2.4 Propagation and Injury Risks

Damage and propagation risk due to heat radiation levels in excess of 23 kW/m^2 and explosion overpressure levels greater than 14 kPa were assessed for the Port Kembla Gas Terminal site operating at the High Demand rate to determine whether there was a potential for the site to present a risk of escalation at neighbouring facilities. Additionally, injury risk due to heat radiation levels in excess of 4.7 kW/m^2 and explosion overpressure levels greater than 7 kPa were assessed. This assessment considered the entire project scope including the LNGC, FSRU, wharf facility and pipeline.

Figure 3-9 shows the 5E-05 pa frequency of heat radiation levels of 4.7 kW/m^2 which have the potential to cause injury extends marginally outside of the fence line. However, there are no sensitive or residential areas are within this area.

The 5E-05 pa frequency of heat radiation levels of 23 kW/m^2 which have the potential to cause damage and escalation at neighbouring facilities is generally within the fence line. The 23 kW/m^2 at 5E-05 pa frequency contour does not impact the nearby onshore industrial facilities including the coal terminal truck wash.

Figure 3-9: High Demand Case 23 kW/m^2 Heat Flux Risk Contours

Figure 3-10 shows the 5E-05 pa frequency of explosion overpressure levels of 7 kPa which has the potential to cause injury remains on the FSRU, in the vicinity of the regasification module. It does not impact any sensitive or residential areas.

The 5E-05 pa frequency contour for explosion overpressure levels of 14 kPa which have the potential to cause damage and escalation at neighbouring facilities, in the vicinity of the regasification module. There is no risk of damage or propagation at the surrounding industrial facilities due to explosion at the berth.

Figure 3-10: High Demand Case 14 kPa Explosion Overpressure Risk Contours

Propagation and injury risks determined for 500 TJ/day high demand case (see Section 3.2.4), which comply with HIPAP 4, are more onerous compared to the Base Case and the 120 TJ/day low demand case and hence the assessment was not repeated at the lower rates.

4. FINDINGS

The hazards and risks associated with the proposed operational changes at the planned Port Kembla Gas Terminal were assessed.

The assessment found that the proposed operational changes do not introduce additional hazardous inventories or scenarios. The hazards, hazardous scenarios and potential consequences identified within the PHA remain unchanged.

The PHA risk model was updated to consider the seasonal demands presented in the Port Kembla Gas Terminal Modification Scoping Report [1] and the updated risk contours compared to the HIPAP 4 Risk Criteria for Land Use Planning [2]. The results are presented in Table 4-1 and Table 4-2 below.

Table 4-1: Fatality Risk Results Summary

HIPAP 4 Criteria (pa)	Land Use	Criteria Met
5E-07	Sensitive land use; e.g. hospitals, schools, child-care facilities, old age housing	Yes – All Cases
1E-06	Residential area; including hotels, motels, tourist resorts	Yes – All Cases. Cruise ships will berth outside the 1E-06 contour and will only be exposed to higher than 1E-06 risk whilst entering / leaving the Inner Harbour, i.e. exposure is low.
5E-06	Commercial development; including retails centres, offices and entertainment centres	Yes – All Cases
1E-05	Active open space; including sporting complexes	No – Limited risk exposure to people accessing Seawall Road. The area is on industrialised land and is a private road. It is only open during daylight hours and may be closed during daylight hours for a variety of other port operational requirements. As a result, large numbers of people do not use this road regularly or gather in this area.
5E-05	Industrial	Yes - Low Demand Case No – Base Case and High Demand Case. The risk contour is largely within the proposed facility boundary. The contour is beyond the facility boundary in the north eastern corner in the vicinity of the PKCT truck wash.

The 309 TJ/day Base Case with increased LNGC deliveries is generally identical to the original risk contours presented in the PHA [3] and there are no significant changes in the impact to neighbouring land users.

The 120 TJ/day low demand case, contours shows neighbouring industrial land users are not exposed to risk greater than 5E-05 pa and the majority of Seawall Road is not exposed to risk greater than 1E-05 with the exception of a small portion to the east of the PKGT facility.

The increased production rate considered in the 500 TJ/day high demand case pushes the 1E-05 and 5E-05 contours further from the FSRU than those for the Base Case shown in Figure 4-1. Applying credit for gas detection, isolation and accounting for limited inventories within the FSRU topsides to the high demand case reduces the contours and they are largely similar to the base case. Refer to Figure 4-2.

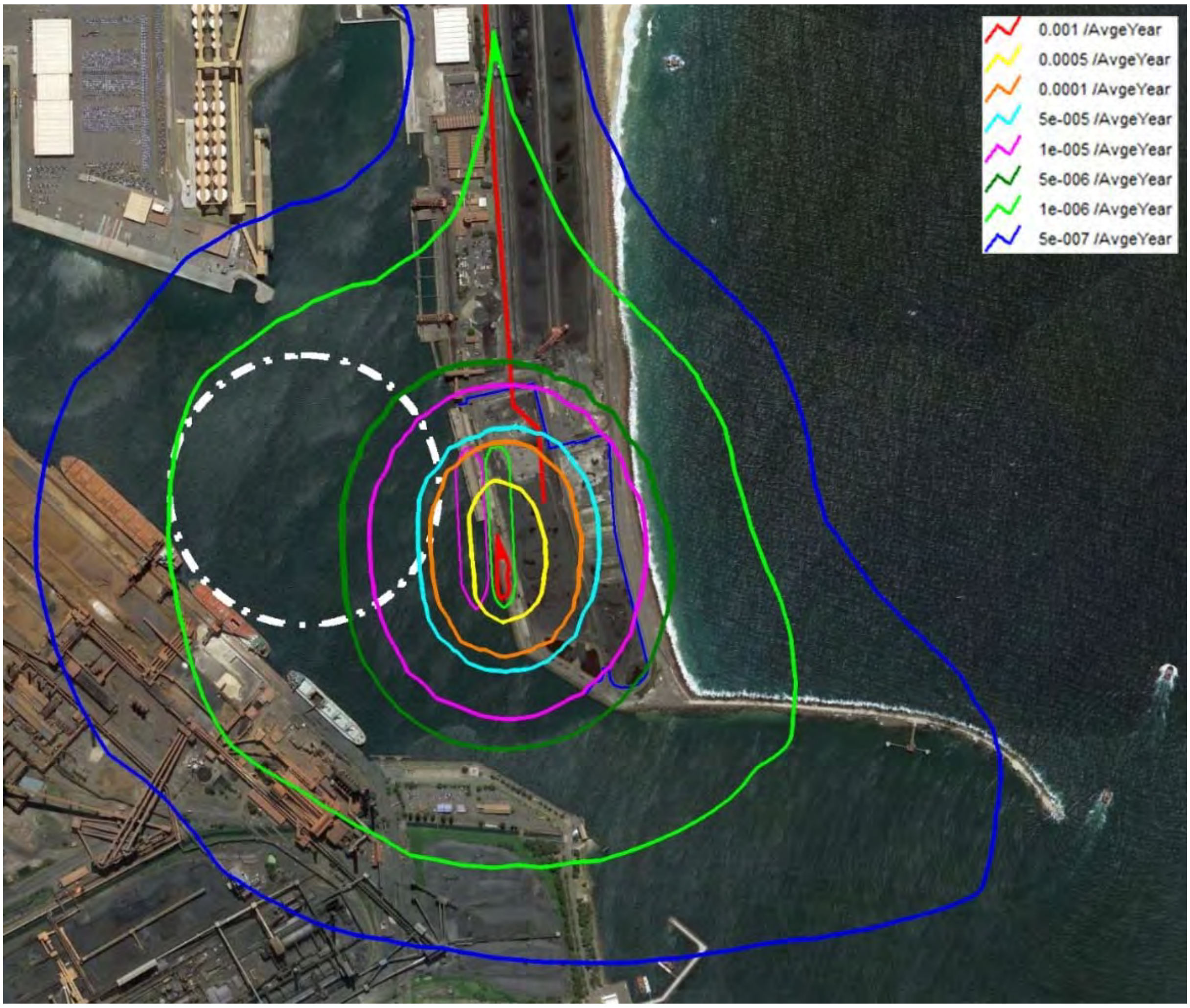

Figure 4-1: Berth Fatality Risk Contours – Base Case Scenario

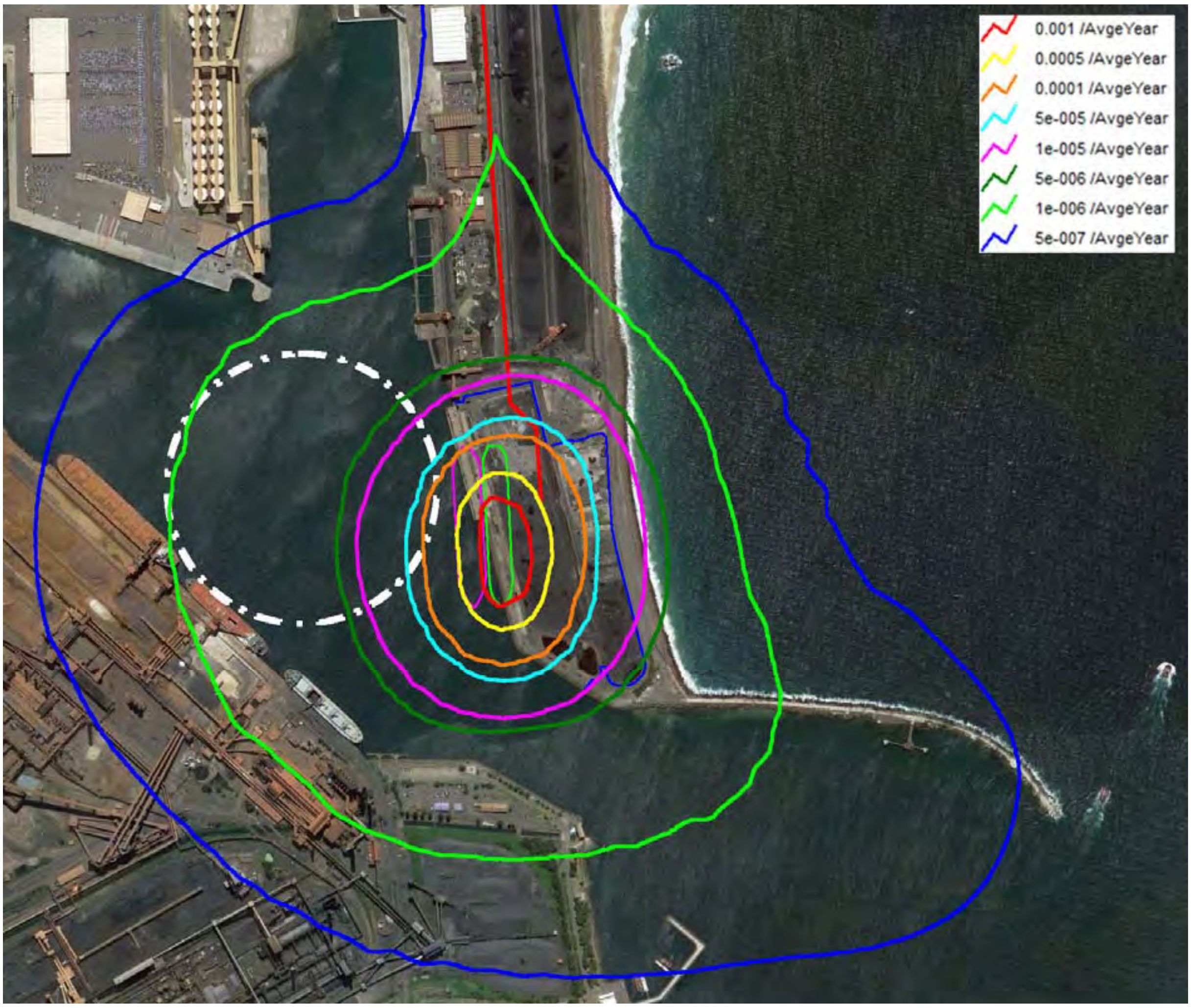

Figure 4-2: Berth Fatality Risk Contours – High Demand Sensitivity F&G Detection & Isolation Scenario

The 5E-05 pa risk contour for industrial areas extends beyond the wharf fence line on the east boundary and extends beyond the truck wash located in this area. While the exposure at the truck wash area is slightly greater than 5E-05 pa risk, the risk to an individual is low due to limited exposure durations (i.e. low truck wash usage with limited duration).

The 1E-05 pa risk contour for active open spaces also extends beyond the wharf fence line, across Seawall Road and extends into the harbour.

Seawall road is a private road located on industrial land, controlled by NSW Ports and the Port Kembla Coal Terminal. It is opened to the public during daylight hours only and regularly closed for poor weather and/or other operational needs, including bulk haulage, construction/maintenance, etc. The road can be closed and secured at these times via a security fencing and lockable gates. Access restrictions can be implemented and enforced by NSW Ports has required. Exposure for public users of Seawall Road is likely to be for short durations and numbers are limited as indicated by NSW Ports:

"The road tends to be used by surfers, rock fishers and occasional on-lookers for unusual events, such as the arrival of a large cruise ship. However, numbers of users are in the dozens, not the 100's, with the largest crowds seen there for the arrival of the Port's first cruise ship. Subsequent cruise ship arrivals have seen the crowd numbers dwindle."

The high demand case is expected to occur during winters months when public access to Seawall Road for recreation is likely to be lower than during summer months.

Vessel entry into the Port Kembla Inner Harbour is controlled by the Port Authority and unauthorised entry is prohibited and enforced. Exposure of the public in this area is therefore expected to be low.

Propagation and injury risks were assessed against the HIPAP4 Risk Criteria for Land Use Planning [2] for the 500 TJ/day high demand case to present a risk of injury to personnel and escalation at neighbouring facilities. The assessment considered the entire project scope including the LNGC, FSRU, wharf facility and pipeline and showed the propagation and injury risk both comply with the 5E-05 pa criteria. Refer to Table 4-2 below.

Table 4-2: Propagation and Injury Risk Results Summary

Frequency (pa)	HIPAP 4 Criteria	Criteria Met
5E-05	Damage and propagation – 23kW/m^2	Yes
5E-05	Damage and propagation – 14kPa	Yes
5E-05	Injury – 4.7kW/m^2	Yes
5E-05	Injury – 7kPa	Yes

Propagation and injury risks determined for 500 TJ/day high demand case (see Section 3.2.4), which comply with HIPAP 4, are more onerous compared to the Base Case and the 120 TJ/day low demand case and hence the assessment was not repeated at the lower rates.

5. REFERENCES

1. Port Kembla Gas Terminal – Modification Scoping Report, GHD, October 2019
2. Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning, January 2011
3. Port Kembla Gas Project Preliminary Hazard Analysis, 401010-01496-SR-REP-0002 Rev 00

Appendix B
Hydrodynamic plume modelling

Port Kembla Re-Gasification Project

Updated Hydrodynamic Plume Modelling

59919002

Prepared for

AIE

19 November 2019

Cardno

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Job title

Date Approved 19/11/2019

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A	30-Oct-2019	Issued for Review	Chris Scraggs	Doug Treloar
B	15-Nov-2019	GHD Comments incorporated	Chris Scraggs	Doug Treloar
C	19-Nov-2019	GHD Comments incorporated	Chris Scraggs	Doug Treloar

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1 Introduction

AIE are proposing to install a floating storage and regasification unit (FSRU), which is to be moored permanently within the Port Kembla Inner Harbour (IH) at Berth 101 and would receive liquid gas periodically from a visiting LNG carrier.

As part of the process, the facility would draw-in seawater from within the inner harbour and then discharge colder water back into the harbour as part of the liquid gas warming process

AIE have engaged Cardno to provide numerical modelling and coastal processes investigations in support of their design process. Cardno's tasks for this project involve, in total, two studies:

1. Thermal modelling to predict the near field dispersion and far field transport of the cold water discharged by the FSRU under all four seasons; and
2. Tracer modelling to estimate the mixing and dilution of sodium hypochlorite discharged as part of the outfall stream,

Cardno has undertaken previous cooling water and sodium hypochlorite dispersion modelling for the project, which assumed a constant discharge of 10,500 m^3/hr. This report presents the results of the additional near and far field simulations for a discharge of 13,000 m^3/hr during peak demand periods.

1.1 Project Description

The proposed FSRU will be will be constructed at Berth 101 in the Port Kembla Inner Harbour. The proposed layout of the new berth is presented in **Figure 1.1**.

2 Data

2.1 General

A range of data items were required to set up and operate the numerical models applied to this study, and then to assess the impacts. Some of these inputs were prepared and adopted for the previous ICP modelling studies undertaken by Lawson and Treloar. The following section describes the inputs used in the modelling process and the sensitivity of the model to each of these inputs.

These inputs are described in Table 2.1, below.

Figure 2-1 Data requirements for the various modelling studies

Input	Required for	Source
Bathymetry	Hydrodynamic modelling	Surveys and nautical charts, described below
Tidal Forcing	Hydrodynamic Modelling	Global tide models
Measured ADCP data	Long wave analysis	Port Authority of NSW
Heat Loads	Thermal Plume Modelling	Cardno's previous studies, WorleyParsons for FSRU data
Meteorological forcing	Thermal Plume Modelling	Cardno's previous studies, BoM
Seawater Temperature	Thermal Plume Modelling	Cardno's previous studies at Port Kembla
Salinity	Thermal Plume Modelling	Cardno's previous studies at Port Kembla

This data has been collated and is described in the relevant sections of the report.

3 Hydrodynamic Model

3.1 General

The scope of work to be undertaken by Cardno included modelling the cooling water outflows associated with the FSRU during operations, as well as predicting the extent and magnitude of sodium hypochlorite which is generated in the heating water process.

In order to undertake these studies, a 3-Dimensional hydrodynamic model is required. For this study, Cardno's existing, calibrated 3D model of Port Kembla has been extended and applied.

3.2 DELFT 3D

Whilst the hydrodynamics required for this application could be modelled successfully by many models, it is our experienced opinion that no other package offers the same extensive cooling water modelling capabilities and backup experience as the Deltares modelling system Delft3D.

The Delft3D modelling system includes wind, pressure, tide and wave forcing, three dimensional current, stratification, sediment transport, cooling water and water quality descriptions and is capable of using rectilinear or curvilinear coordinates.

Delft3D has been used recently by Cardno Lawson Treloar for cooling water re-circulation studies in Lake Macquarie, in Lake Illawarra for power station investigations and in the Hunter River to assess the impact of a heated nitric acid spill near Kooragang Island. During these projects, the model produced either good agreement between modelled output and observed temperature data or was readily accepted by regulators.

Delft3D is comprised of several modules that provide the facility to undertake a range of studies. All studies generally begin with the Delft3D-FLOW module. From Delft3D-FLOW, details such as velocities, water levels, density, salinity, vertical eddy viscosity and vertical eddy diffusivity can be provided as inputs to the other modules. The wave and sediment transport modules work interactively with the FLOW module through a common communications file.

3.2.1 Hydrodynamic Numerical Scheme

The Delft3D FLOW module is based on the robust numerical finite-difference scheme developed by G. S. Stellling (1984) of the Delft Technical University in The Netherlands. Since its inception, the Stelling Scheme has had considerable development and review by Stelling and others.

The Delft3D Stelling Scheme arranges modelled variables on a staggered Arakawa C-grid. The water level points (pressure points) are designated in the centre of a continuity cell and the velocity components are perpendicular to the grid cell faces. Finite difference staggered grids have several advantages including:

- Boundary conditions can be implemented in the scheme in a rather simple way;
- It is possible to use a smaller number of discrete state variables in comparison with discretisations on non-staggered grids to obtain the same accuracy; and
- Staggered grids minimise spatial oscillations in the water levels.

Delft3D can be operated in 2D (vertically averaged) or 3D mode. In 3D mode, the model uses the σ-coordinate system first introduced by N Phillips in 1957 for atmospheric models. The σ-coordinate system is a variable layer-thickness modelling system, meaning that over the entire computational area, irrespective of the local water depth, the number of layers is constant. As a result a smooth representation of the bathymetry is obtained. Also, as opposed to fixed vertical grid size 3D models, the full definition of the 3D layering system is maintained into the shallow waters and until the computational point is dried.

From a user point of view, the construction of a 3D model from a 2D model using the σ-coordinate system in Delft3D is effected by entering how many layers are required and the percentage of the depth for each layer. It is most common to define more resolution at the surface and at the bed where the largest vertical gradients occur. Boundary conditions can also be adjusted from depth averaged to specific discharges and concentrations per layer also.

Horizontal solution is undertaken using the Alternating Direction Implicit (ADI) method of Leendertse for shallow water equations. In the vertical direction (in 3D mode) a fully implicit time integration method is also applied.

Vertical turbulence closure in Delft3D is based on the eddy viscosity concept.

3.2.2 Wetting and Drying of Intertidal Flats

Many estuaries and embayments contain shallow intertidal areas; consequently Delft3D incorporates a robust and efficient wetting and drying algorithm for handling this sort of phenomenon.

Careful refinement in the intertidal areas and appropriate setting of drying depths to minimise discontinuous movement of the boundaries ensures oscillations in water levels and velocities are minimised and the characteristics of the intertidal effects are modelled accurately.

3.2.3 Conservation of Mass

Problems with conservation of mass, such as a ‘leaking mesh’, do not occur within the Delft3D system.

However, whilst the Delft3D scheme is unconditionally stable, inexperienced use of Delft3D, as with most modelling packages, can result in potential mass imbalances.

Potential causes of mass imbalance and other inaccuracies include: -

- Inappropriately large setting of the wet/dry algorithm and unrefined inter-tidal grid definition;
- Inappropriate bathymetric and boundary definition causing steep gradients; and
- Inappropriate timestep selection (i.e. lack of observation of the scheme’s allowable Courant Number condition) for simulation

3.2.4 Other Issues

Note that there were a number of processes not included in the modelling, such as currents caused by shipping and freshwater floods. Shipping would cause greater mixing and flooding would transport surface plumes further downstream. Both processes would be intermittent and transitory.

3.3 Model Setup

3.3.1 Grid Resolution and Extent

Figure 3.1 presents the model grid applied to this study. A rectilinear grid of 30m resolution was applied, with 251 by 253 grid cells in the north-south and east-west directions, respectively.

The model has been run with 10 vertical sigma layers, of varying thickness as described in **Table 3-1** below. The model includes higher vertical resolution at the surface and near the seabed.

Table 3-1 Vertical Grid Resolution

Sigma Layer	Thickness (% of water depth)
1 (surface layer)	2
2	5
3	9
4	14
5 (mid-depth)	20
6	20
7	14
8	9
9	5
10 (bottom layer)	2

3.3.2 Bathymetry

Bathymetric data is required to describe the seabed of the harbour basins, Allans Creek and the shoreline perimeter of the waterways of Port Kembla. This detailed information was available from a range of sources including

1. Recent bathymetric survey data provided by WorleyParsons inside the Inner and Outer Harbours
2. Nautical charts offshore of Port Kembla (AUS Chart 195)
3. Survey data in Cardno's internal database from previous projects in Port Kembla.

The model bathymetry is depicted in **Figure 3.1**. The model bathymetry has been defined based upon the datasets depicted in **Section 2.2** of this report. Before interpolating the bathymetric data onto the model grid, each dataset was transformed to common horizontal and vertical datums (MGA zone 56 and AHD). The data interpolation process was also prioritised such that where overlapping survey data is available, the more recent surveyed data is used.

3.3.3 Boundary Conditions

Offshore tidal boundary conditions were extracted from a combination of the DTU10 (Technical University of Denmark Tidal Model), which is based on a finite element solution of the global tides with data assimilated from seventeen years of satellite altimeter readings. The methodology of the global tide models is described in Cheng and Anderson (2010). DTU10 provides up to twelve tidal constants on a 1/8 degree resolution full global grid. The tides are provided as complex amplitudes of earth-relative sea-surface elevation for ten primary (M_2, S_2, N_2, K_2, K_1, O_1, P_1, Q_1, S_1 and M_4) harmonic constituents. Four additional constituents (M_f, M_m, MS_4 and MN_4) were sourced from the TPx07.2 tide model, which uses along track averaged altimeter data from the TOPEX/Poseidon and Jason (on TOPEX/Poseidon tracks since 2002) satellites.

3.3.4 Time-Step

A time-step of 6 seconds was adopted to fulfil accuracy requirements based on the Courant Number.

4 Thermal Plume Modelling

4.1 Introduction

During the operational phase of the project, the FSRU will use seawater for its internal processes. The seawater would be drawn into the FSRU through the hull of the floating unit and used for heating. The seawater is then discharged back into the port through an outlet in the hull. During this process the seawater is cooled by a maximum of 7 degrees compared to the water drawn in through the intake.

There are also a number of cooling water intakes and outfalls currently in operation within Port Kembla, operated by BlueScope Steel. The discharge and heat load for these existing intakes/outfalls have been taken from Cardno's previous cooling water investigations in Port Kembla (Cardno Lawson Treloar, 2007).

The discharge data applied in the model are presented below in **Tables 4.1** to **4.4**. Note that the warming water modelling has been undertaken for ambient conditions (i.e. without the existing cooling water discharges) and typical existing summer, winter, spring and autumn conditions. In these simulations the average flows from the existing intakes and outfalls have been applied to the model, as described in the following tables..

Table 4-1 Cooling water flows – summer conditions

Modelled Drain Flows - Summer Conditions					
Model Source No	Drain	Ambient Condition		Existing Condition	
		Flow (m^3/s)	ΔT(°C)	Flow (m^3/s)	ΔT(°C)
1	Main Drain	-	-	1.174	7.1
2	No.2 Blower Station	-	-	7.953	6.44
3	Iron Making East	-	-	0.208	4.05
4	3500mm Plate Mill Drain	-	-	0.395	2.84
5	Slab Mill Drain	0.013	31.41*	0.013	31.41*
6	No. 1 Flat Products East Drain	-	-	0.112	4.64
7	Allans Creek Flow	0.17	22.5*	0.17	22.5*
8	North Gate Drain	0.077	28.06*	0.077	28.06*

* presented as absolute temperature rather than excess

Table 4-2 Cooling water flows – winter conditions

Modelled Drain Flows - Winter Conditions					
Model Source No	Drain	Ambient Condition		Existing Condition	
		Flow (m^3/s)	ΔT(°C)	Flow (m^3/s)	ΔT(°C)
1	Main Drain	-	-	1.517	6.28
2	No.2 Blower Station	-	-	8.211	7.11
3	Iron Making East	-	-	0.100	3.06
4	3500mm Plate Mill Drain	-	-	0.408	2.41
5	Slab Mill Drain	0.016	21.37*	0.016	21.37*
6	No. 1 Flat Products East Drain	-	-	0.196	4.35
7	Allans Creek Flow	0.170	16.80*	0.170	16.80*
8	North Gate Drain	0.102	17.98*	0.102	17.98*

* presented as absolute temperature rather than excess

Table 4-3 Cooling water flows – Autumn conditions

Modelled Drain Flows - Autumn Conditions					
Model Source No	Drain	Ambient Condition		Existing Condition	
		Flow (m^3/s)	ΔT(°C)	Flow (m^3/s)	ΔT(°C)
1	Main Drain	-	-	1.174	7.1
2	No.2 Blower Station	-	-	7.953	6.44
3	Iron Making East	-	-	0.208	4.05
4	3500mm Plate Mill Drain	-	-	0.395	2.84
5	Slab Mill Drain	0.013	27*	0.013	27*
6	No. 1 Flat Products East Drain	-	-	0.112	4.64
7	Allans Creek Flow	0.17	20.6*	0.17	20.6*
8	North Gate Drain	0.077	25*	0.077	25.0*

* presented as absolute temperature rather than excess

Table 4-4 Cooling water flows – Spring conditions

Modelled Drain Flows - Spring Conditions					
Model Source No	Drain	Ambient Condition		Existing Condition	
		Flow (m^3/s)	ΔT(°C)	Flow (m^3/s)	ΔT(°C)
1	Main Drain	-	-	1.517	6.28
2	No.2 Blower Station	-	-	8.211	7.11
3	Iron Making East	-	-	0.100	3.06
4	3500mm Plate Mill Drain	-	-	0.408	2.41
5	Slab Mill Drain	0.016	23.0*	0.016	23.0*
6	No. 1 Flat Products East Drain	-	-	0.196	4.35
7	Allans Creek Flow	0.170	16.8*	0.170	16.8*
8	North Gate Drain	0.102	19.0*	0.102	19.0*

* presented as absolute temperature rather than excess

4.2 FSRU Outflows

In Cardno's previous investigation, a constant flow rate of 10,500 m^3/hour was simulated. The purpose of this study is to estimate the dispersion of higher heating water flows during peak demand periods. The flow rates that were simulated were:

FRSU, Q = 3.611 m^3/s (13,000 m^3/hour);

The ΔT of the FSRU that has been applied to the model is -7ºC (i.e., cools the seawater passing through the plant by seven degrees). Heating water is drawn-in through the hull of vessel, and discharged horizontally out of the side of the vessel.

4.3 Nearfield Modelling

In order to properly model and understand the plume behaviour, both near and far field modelling has been undertaken. The main purpose of the near field assessment was to estimate the plume width, height and dilution at the end of the near field region. This data is then fed into the Delft3D modelling system to simulate the far field dispersion.

4.3.1 CORMIX

CORMIX is a nearfield analytical model developed by Mixzon Inc. and is used by the U.S. E.P.A. for regulatory investigations. It describes the development of a positively or negatively buoyant jet(s) as it discharges into the receiving water environment. It includes single port, multi-port and surface channel discharges. The model is useful in describing the interaction in mixing zones – where a discharge is introduced to a receiving water. The model includes the effects of density difference, receiving water velocity, depth of the jet(s) below the surface, merging of jets, wind mixing, discharge port configuration and discharge rate.

Cardno has used this system for a number of outfall diffuser systems with success. CORMIX has been shown to suitably predict mixing effects. As part of investigations undertaken for Hunter Water for augmentation of the Belmont ocean outfall, Cardno Lawson Treloar undertook a field verification of the CORMIX model. That work entailed the measurement of salinity in the water column near the existing outfall in known discharge and receiving water conditions. Analyses of the results showed that CORMIX provided realistic results though it slightly under-estimated dilution. The ‘map’ of dilution above a discharge point is spatially and temporally very variable and this characteristic needs to be considered in analyses of this type by recognising this variability in any sampling that may be undertaken

For this assessment, CORMIX was selected from a suite of available near-field models and was used to assess the mixing zone effects. The results of the CORMIX modelling are provided below.

4.3.2 CORMIX Results

For this assessment the CORMIX modelling has been undertaken using the CORMIX 1 model, which is for submerged single port discharges.

Note that CORMIX does not natively support a cool water discharge. To overcome this, the model has been setup based on the ambient and discharged density based on a seven degree temperature difference, and a tracer with an initial (unitless) concentration of seven was applied to the effluent.

Given the modelling is predicting only very small current speeds in the area (typically of the order of 2cm/s), the near field modelling has been undertaken under calm conditions and under low cross currents (0, 0.05 and 0.1 m/s).

As the ship moves up and down with the tide, near field mixing has been assessed under three tidal conditions, these being LAT, MSL and MHWS. At LAT the vessel is closest to the seabed, and as such this is expected to be the scenarios with the least near field mixing.

A total of 36 near field simulations were undertaken for each discharge rate to estimate the plume characteristics at the end of the near field mixing zone. These characteristics are presented below in **Table 4-5.** For comparison, the plume characteristics determined during the previous study for a discharge of 10,500m^3/hr are presented in **Table 4-6**.

Table 4-5 Simulated Plume Dilution at the End of the Near Field for a discharge of 13,000 m^3/hour

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	centreline dilution	average dilution	Dilution at plume edge
Summer	LAT	0	34.5	4.7	3.8	38.3	5.3	9.0	14.4
Summer	LAT	0.05	34.4	4.8	3.5	37.9	4.8	8.1	12.9
Summer	LAT	0.1	32.7	5.1	3.7	36.4	5.5	9.3	14.9
Summer	MSL	0	36.6	4.9	3.5	40.2	4.8	8.2	13.0
Summer	MSL	0.05	35.7	5.0	3.6	39.3	5.0	8.6	13.7
Summer	MSL	0.1	33.8	5.3	3.8	37.6	5.8	9.9	15.9
Summer	MHWS	0	37.3	4.7	3.1	40.4	5.2	8.9	14.2
Summer	MHWS	0.05	36.5	5.1	3.7	40.2	5.2	8.8	14.1
Summer	MHWS	0.1	34.5	5.5	4.0	38.5	6.1	10.3	16.5
Winter	LAT	0	37.0	4.9	3.6	40.5	4.7	8.0	12.8
Winter	LAT	0.05	36.1	5.0	3.6	39.7	4.9	8.3	13.3
Winter	LAT	0.1	34.1	5.3	3.9	38.0	5.8	9.9	15.8
Winter	MSL	0	38.5	5.1	3.7	42.2	5.0	8.5	13.6
Winter	MSL	0.05	37.4	5.3	3.8	41.1	5.2	8.8	14.1
Winter	MSL	0.1	35.4	5.6	4.1	39.5	6.2	10.5	16.9
Winter	MHWS	0	39.4	3.8	3.3	42.6	5.1	8.7	13.9
Winter	MHWS	0.05	38.3	5.4	3.9	42.2	5.4	9.2	14.7
Winter	MHWS	0.1	36.1	5.8	4.2	40.2	6.5	11.1	17.7
Spring	LAT	0	38.2	4.6	3.1	41.3	4.9	8.3	13.3
Spring	LAT	0.05	35.6	5.0	3.6	39.2	4.9	8.3	13.3
Spring	LAT	0.1	33.8	5.3	3.8	37.6	5.7	9.7	15.5
Spring	MSL	0	37.9	3.7	1.8	39.8	4.9	8.3	13.3
Spring	MSL	0.05	37.1	5.2	3.8	40.8	5.2	8.8	14.1
Spring	MSL	0.1	35.0	5.5	4.0	39.0	6.1	10.4	16.6
Spring	MHWS	0	38.9	3.7	1.9	40.8	5.1	8.7	13.9
Spring	MHWS	0.05	37.9	5.0	3.3	41.3	5.3	9.0	14.4
Spring	MHWS	0.1	35.7	5.7	4.1	39.8	6.0	10.2	16.3
Autumn	LAT	0	35.4	3.4	1.7	37.2	4.6	7.8	12.5
Autumn	LAT	0.05	33.4	4.5	3.0	36.4	4.7	8.0	12.8
Autumn	LAT	0.1	32.8	5.1	3.7	36.5	5.5	9.4	15.0
Autumn	MSL	0	36.9	3.5	1.8	38.6	4.8	8.2	13.0
Autumn	MSL	0.05	35.9	5.0	3.6	39.6	5.0	8.5	13.6

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	centreline dilution	average dilution	Dilution at plume edge
Autumn	MSL	0.1	34.0	5.4	3.9	37.8	5.9	10.0	16.0
Autumn	MHWS	0	37.7	3.6	1.8	39.5	5.0	8.5	13.6
Autumn	MHWS	0.05	36.7	5.2	3.7	40.5	5.2	8.8	14.1
Autumn	MHWS	0.1	34.8	5.5	4.0	38.8	6.1	10.4	16.6

Table 4-6 Simulated Plume Dilution at the End of the Near Field for a discharge of 10,500 m^3/hour

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	centreline dilution	average dilution	Dilution at plume edge
Summer	LAT	0	32.84	4.16	4.16	37.0	4	6.8	10.9
Summer	LAT	0.05	31.94	4.22	4.22	36.16	4.1	7.0	11.1
Summer	LAT	0.1	30.33	4.43	4.43	34.76	4.6	7.8	12.5
Summer	MSL	0	34.57	4.42	4.42	38.99	4.4	7.5	12.0
Summer	MSL	0.05	33.75	4.49	4.49	38.24	4.6	7.8	12.5
Summer	MSL	0.1	31.95	4.74	4.74	36.69	5.1	8.7	13.9
Summer	MHWS	0	35.85	4.58	4.58	40.43	4.7	8.0	12.8
Summer	MHWS	0.05	34.81	4.67	4.67	39.48	4.9	8.3	13.3
Summer	MHWS	0.1	32.98	4.95	4.95	37.93	5.6	9.5	15.2
Winter	LAT	0	31.23	3.98	3.98	35.21	3.9	6.6	10.6
Winter	LAT	0.05	30.38	4.03	4.03	34.41	4	6.8	10.9
Winter	LAT	0.1	29.09	4.21	4.21	33.3	4.5	7.7	12.2
Winter	MSL	0	33.01	4.22	4.22	37.23	4.4	7.5	12.0
Winter	MSL	0.05	32.05	4.29	4.29	36.34	4.5	7.7	12.2
Winter	MSL	0.1	30.62	4.5	4.5	35.12	5	8.5	13.6
Winter	MHWS	0	34.02	4.37	4.37	38.39	4.7	8.0	12.8
Winter	MHWS	0.05	33.13	4.45	4.45	37.58	4.8	8.2	13.0
Winter	MHWS	0.1	31.52	4.69	4.69	36.21	5.4	9.2	14.7
Spring	LAT	0	34.38	4.36	4.36	38.74	4.1	7.0	11.1
Spring	LAT	0.05	33.48	4.43	4.43	37.91	4.2	7.1	11.4
Spring	LAT	0.1	31.67	4.66	4.66	36.33	4.7	8.0	12.8
Spring	MSL	0	36.36	4.63	4.63	40.99	4.5	7.7	12.2
Spring	MSL	0.05	35.43	4.72	4.72	40.15	4.7	8.0	12.8
Spring	MSL	0.1	33.46	5	5	38.46	5.3	9.0	14.4
Spring	MHWS	0	37.7	4.8	4.8	42.5	4.8	8.2	13.0
Spring	MHWS	0.05	36.59	4.91	4.91	41.5	5	8.5	13.6
Spring	MHWS	0.1	34.73	5.2	5.2	39.93	5.7	0.0	0.0
Autumn	LAT	0	33.42	4.23	4.23	37.65	4.1	7.0	11.1
Autumn	LAT	0.05	32.51	4.3	4.3	36.81	4.2	7.1	11.4
Autumn	LAT	0.1	30.82	4.51	4.51	35.33	4.6	7.8	12.5
Autumn	MSL	0	35.3	4.49	4.49	39.79	4.4	7.5	12.0
Autumn	MSL	0.05	34.27	4.57	4.57	38.84	4.6	7.8	12.5

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	centreline dilution	average dilution	Dilution at plume edge
Autumn	MSL	0.1	32.55	4.83	4.83	37.38	5.2	8.8	14.1
Autumn	MHWS	0	36.51	4.66	4.66	41.17	4.7	8.0	12.8
Autumn	MHWS	0.05	35.46	4.76	4.76	40.22	4.9	8.3	13.3
Autumn	MHWS	0.1	33.6	5.05	5.05	38.65	5.6	9.5	15.2

4.4 Discussion

The EPA guidelines for cold water discharges are that the future median seawater temperature at the edge of the near field mixing zone should be greater than the ambient 20th percentile temperature. Based on long term seawater temperature measurements outside of the port, the ambient 20th percentile, 50th percentile (median) and 80th percentile seawater temperatures are provided in **Table 4-7**.

Table 4-7 Ambient seawater temperature offshore of Port Kembla

Season	Seawater Temperature (ºC)		
	20th Percentile	Median	80th Percentile
Summer	20.0	21.2	22.4
Autumn	19.2	20.5	21.8
Winter	15.6	16.6	17.4
Spring	16.4	17.5	18.7

The above table indicates that to comply with the EPA requirements, the seawater temperature decrease at the edge of the nearfield mixing zone should be less than 1ºC to 1.3ºC, depending on the season.

Applying a temperature decrease of 7ºC at the point of discharge to the dilution values predicted by CORMIX, the centreline, average and plume edge temperatures at the edge of the nearfield mixing zone are presented overleaf in **Table 4-8** for a 13,000m^3/hr discharge and **Table 4-9** for the 10,500 m^3/hr discharge.

These tables indicate that the temperature at the edge of the plume, at the end of the nearfield region is predicted to be up to 0.6 degrees lower than the ambient conditions for a flow rate of 13,000 m^3/hour and up to 0.7 degrees lower than ambient conditions for a flow rate of 10,500 m^3/hour. It is noted that the largest decrease in temperature predicted at the edge of the near field meets the EPA requirements. For all simulated conditions, the average temperature decrease in the plume at the end of the near field is also predicted to be lower than 1.1 degrees.

The CORMIX modelling indicates that the nearfield mixing zone is semi-circular in shape with a maximum radius of 42.6m extending horizontally from the point of discharge for a discharge rate of 13,000 m^3/hour, and 42.5m for a flow rate of 10,500 m^3/hr.

Table 4-8 Simulated temperature decrease at the end of the near field for a discharge of 13,000 m^3/hour

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Summer	LAT	0	34.5	4.7	3.8	38.3	1.3	0.8	0.5
Summer	LAT	0.05	34.4	4.8	3.5	37.9	1.5	0.9	0.5
Summer	LAT	0.1	32.7	5.1	3.7	36.4	1.3	0.8	0.5
Summer	MSL	0	36.6	4.9	3.5	40.2	1.5	0.9	0.5
Summer	MSL	0.05	35.7	5.0	3.6	39.3	1.4	0.8	0.5
Summer	MSL	0.1	33.8	5.3	3.8	37.6	1.2	0.7	0.4
Summer	MHWS	0	37.3	4.7	3.1	40.4	1.3	0.8	0.5
Summer	MHWS	0.05	36.5	5.1	3.7	40.2	1.4	0.8	0.5
Summer	MHWS	0.1	34.5	5.5	4.0	38.5	1.2	0.7	0.4
Winter	LAT	0	37.0	4.9	3.6	40.5	1.5	0.9	0.5
Winter	LAT	0.05	36.1	5.0	3.6	39.7	1.4	0.8	0.5
Winter	LAT	0.1	34.1	5.3	3.9	38.0	1.2	0.7	0.4
Winter	MSL	0	38.5	5.1	3.7	42.2	1.4	0.8	0.5
Winter	MSL	0.05	37.4	5.3	3.8	41.1	1.3	0.8	0.5
Winter	MSL	0.1	35.4	5.6	4.1	39.5	1.1	0.7	0.4
Winter	MHWS	0	39.4	3.8	3.3	42.6	1.4	0.8	0.5
Winter	MHWS	0.05	38.3	5.4	3.9	42.2	1.3	0.8	0.5
Winter	MHWS	0.1	36.1	5.8	4.2	40.2	1.1	0.6	0.4
Spring	LAT	0	38.2	4.6	3.1	41.3	1.4	0.8	0.5
Spring	LAT	0.05	35.6	5.0	3.6	39.2	1.4	0.8	0.5
Spring	LAT	0.1	33.8	5.3	3.8	37.6	1.2	0.7	0.5
Spring	MSL	0	37.9	3.7	1.8	39.8	1.4	0.8	0.5
Spring	MSL	0.05	37.1	5.2	3.8	40.8	1.4	0.8	0.5
Spring	MSL	0.1	35.0	5.5	4.0	39.0	1.2	0.7	0.4
Spring	MHWS	0	38.9	3.7	1.9	40.8	1.4	0.8	0.5
Spring	MHWS	0.05	37.9	5.0	3.3	41.3	1.3	0.8	0.5
Spring	MHWS	0.1	35.7	5.7	4.1	39.8	1.1	0.7	0.4
Autumn	LAT	0	35.4	3.4	1.7	37.2	1.5	0.9	0.6
Autumn	LAT	0.05	33.4	4.5	3.0	36.4	1.5	0.9	0.5

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Autumn	LAT	0.1	32.8	5.1	3.7	36.5	1.3	0.7	0.5
Autumn	MSL	0	36.9	3.5	1.8	38.6	1.5	0.9	0.5
Autumn	MSL	0.05	35.9	5.0	3.6	39.6	1.4	0.8	0.5
Autumn	MSL	0.1	34.0	5.4	3.9	37.8	1.2	0.7	0.4
Autumn	MHWS	0	37.7	3.6	1.8	39.5	1.4	0.8	0.5
Autumn	MHWS	0.05	36.7	5.2	3.7	40.5	1.3	0.8	0.5
Autumn	MHWS	0.1	34.8	5.5	4.0	38.8	1.1	0.7	0.4

Table 4-9 Simulated temperature decrease at the end of the near field for a discharge of 10,500 m^3/hour

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Summer	LAT	0	32.84	4.16	4.16	37.0	1.75	1.0	0.6
Summer	LAT	0.05	31.94	4.22	4.22	36.16	1.7	1.0	0.6
Summer	LAT	0.1	30.33	4.43	4.43	34.76	1.53	0.9	0.6
Summer	MSL	0	34.57	4.42	4.42	38.99	1.59	0.9	0.6
Summer	MSL	0.05	33.75	4.49	4.49	38.24	1.53	0.9	0.6
Summer	MSL	0.1	31.95	4.74	4.74	36.69	1.36	0.8	0.5
Summer	MHWS	0	35.85	4.58	4.58	40.43	1.48	0.9	0.5
Summer	MHWS	0.05	34.81	4.67	4.67	39.48	1.43	0.8	0.5
Summer	MHWS	0.1	32.98	4.95	4.95	37.93	1.26	0.7	0.5
Winter	LAT	0	31.23	3.98	3.98	35.21	1.78	1.1	0.7
Winter	LAT	0.05	30.38	4.03	4.03	34.41	1.73	1.0	0.6
Winter	LAT	0.1	29.09	4.21	4.21	33.3	1.57	0.9	0.6
Winter	MSL	0	33.01	4.22	4.22	37.23	1.6	0.9	0.6
Winter	MSL	0.05	32.05	4.29	4.29	36.34	1.55	0.9	0.6
Winter	MSL	0.1	30.62	4.5	4.5	35.12	1.4	0.8	0.5
Winter	MHWS	0	34.02	4.37	4.37	38.39	1.5	0.9	0.6
Winter	MHWS	0.05	33.13	4.45	4.45	37.58	1.45	0.9	0.5
Winter	MHWS	0.1	31.52	4.69	4.69	36.21	1.3	0.8	0.5
Spring	LAT	0	34.38	4.36	4.36	38.74	1.72	1.0	0.6
Spring	LAT	0.05	33.48	4.43	4.43	37.91	1.66	1.0	0.6
Spring	LAT	0.1	31.67	4.66	4.66	36.33	1.48	0.9	0.5
Spring	MSL	0	36.36	4.63	4.63	40.99	1.56	0.9	0.6
Spring	MSL	0.05	35.43	4.72	4.72	40.15	1.5	0.9	0.6
Spring	MSL	0.1	33.46	5	5	38.46	1.31	0.8	0.5
Spring	MHWS	0	37.7	4.8	4.8	42.5	1.46	0.9	0.5
Spring	MHWS	0.05	36.59	4.91	4.91	41.5	1.4	0.8	0.5
Spring	MHWS	0.1	34.73	5.2	5.2	39.93	1.22	0.7	0.5
Autumn	LAT	0	33.42	4.23	4.23	37.65	1.74	1.0	0.6
Autumn	LAT	0.05	32.51	4.3	4.3	36.81	1.68	1.0	0.6

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centreline temp Decrease [deg C]	Average Temp Decrease [deg C]	Temp decrease at edge of nearfield mixing zone [deg C]
Autumn	LAT	0.1	30.82	4.51	4.51	35.33	1.51	0.9	0.6
Autumn	MSL	0	35.3	4.49	4.49	39.79	1.57	0.9	0.6
Autumn	MSL	0.05	34.27	4.57	4.57	38.84	1.52	0.9	0.6
Autumn	MSL	0.1	32.55	4.83	4.83	37.38	1.34	0.8	0.5
Autumn	MHWS	0	36.51	4.66	4.66	41.17	1.48	0.9	0.5
Autumn	MHWS	0.05	35.46	4.76	4.76	40.22	1.42	0.8	0.5
Autumn	MHWS	0.1	33.6	5.05	5.05	38.65	1.24	0.7	0.5

5 Far Field Modelling of Temperature

The near field modelling presented in the previous section describes the plume behaviour in the near field zone. As near field models are steady state they do not include affects such as accumulation of pollutants or recirculation between the intake and the outfall. To assess the potential for these effects, far field modelling using a 3-dimensional hydrodynamic model has been applied.

5.1 Scenarios

Far field modelling was undertaken in Deflt3D for sixteen additional scenarios. For each discharge simulation, typical conditions have been simulated under summer, autumn, winter and spring. These simulations are outlined in Table 5-1 below. Note that simulations 1 to 16 have been reported previously but are reported in this report for ease of reference. The simulations undertaken for this study are simulations 17 to 24.

Table 5-1 Far field dispersion simulations

Simulation	Season	Bluescope Cooling Water Discharges	FSRU Warming Water Discharges	Description
1	Summer	-	-	Ambient in summer
2	Summer	Yes	-	Existing Conditions in Summer
3	Summer	Yes	Yes 10,500 m^3/hr	Future bluescope and FSRU in summer
4	Summer	-	Yes 10,500 m^3/hr	Future FSRU only in summer
5	Autumn	-	-	Ambient in summer
6	Autumn	Yes	-	Existing Conditions in Autumn
7	Autumn	Yes	Yes 10,500 m^3/hr	Future bluescope and FSRU in Autumn
8	Autumn	-	Yes 10,500 m^3/hr	Future FSRU only in Autumn
9	Winter	-	-	Ambient in Winter
10	Winter	Yes	-	Existing Conditions in Winter
11	Winter	Yes	Yes 10,500 m3/hr	Future bluescope and FSRU in Winter
12	Winter	-	Yes 10,500 m^3/hr	Future FSRU only in Winter
13	Spring	-	-	Ambient in Spring
14	Spring	Yes	-	Existing Conditions in Spring
15	Spring	Yes	Yes 10,500 m^3/hr	Future bluescope and FSRU in Spring
16	Spring	-	Yes 10,500 m^3/hr	Future FSRU only in Spring

17	Summer	Yes	Yes 13,000 m^3/hr	Future bluescope and FSRU in summer
18	Summer	-	Yes 13,000 m^3/hr	Future FSRU only in summer
19	Autumn	Yes	Yes 13,000 m^3/hr	Future bluescope and FSRU in autumn
20	Autumn	-	Yes 13,000 m^3/hr	Future FSRU only in autumn
21	Winter	Yes	Yes 13,000 m^3/hr	Future bluescope and FSRU in winter
22	Winter	-	Yes 13,000 m^3/hr	Future FSRU only in winter
23	Spring	Yes	Yes 13,000 m^3/hr	Future bluescope and FSRU in spring
24	Spring	-	Yes 13,000 m^3/hr	Future FSRU only in spring

For the FSRU simulations, the Delft3D model was coupled with CORMIX in the sense that the outlet flow was distributed over the horizontal and vertical grid cells covered by the plume at the end of the near field zone.

Ambient seawater temperature was assumed to be 22ºC in summer, 20.6 ºC in Autumn, 16.8ºC in winter and 17.6 ºC in Spring. An ambient salinity of 33.5 PSU was applied in all of the simulations. These are consistent with the previous cooling water simulations undertaken by Cardno at Port Kembla.

Each simulation was undertaken over a period of 45 days, with the first 5 days being discarded – to allow for development of dynamic heat content equilibrium. Simulations included solar heating and cooling.

5.1.2 Results

Comparison plots assessing the results against the EPA requirements (i.e. the future median temperature minus the ambient 20th percentile temperature) are presented in **Figures 5.1** to **5.24.** In these plots, the areas in blue exceed the EPA requirements for cold water discharge, and the white colours comply.

The modelling results are summarised in Table 5-2. The modelling undertaken for the project predicts that the FSRU will not comply with the EPA requirements under most of the simulated conditions for a discharge of 13,000m^3/hr. However, when considered in combination with the BlueScope discharges the exceedance areas are of a similar size to the near field mixing zones predicted by CORMIX (see figures 5.1, 5.4, 5.7 and 5.10).

The model also indicates that the discharge will comply with the EPA guideline values considering the case where the BlueScope cooling water system is not operating during autumn. Note that the model does predict that the temperature decrease will exceed the EPA guideline values in an area covering approximately 400m x 400m considering the larger discharge rate.

The model also indicates that the impacts are confined to the bottom 2% of the water column. An assessment of the 2nd layer from the bottom (from 2% to 7% of the depth), indicates that outside of the nearfield mixing zone the water temperatures will comply with the EPA guidelines under all of the simulated conditions.

The model is also predicting that there will be no impacts to water temperature outside of the port breakwaters for any of the simulated conditions.

Table 5-2 Summary of Far Field Modelling Results

Comparison Figure	Season	Future Discharges	Ambient Discharges	Outcome
5.1	Summer	13,000 m^3/hr FSRU and BlueScope	none	Approximately 50m by 100m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.2	Summer	13,000 m^3/hr FSRU and BlueScope	BlueScope	Approximately 300m by 350m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.3	Summer	13,000 m^3/hr FSRU	none	Approximately 350m by 400m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.4	Autumn	13,000 m^3/hr FSRU and BlueScope	none	Complies
5.5	Autumn	13,000 m^3/hr FSRU and BlueScope	BlueScope	Approximately 20m by 20m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.6	Autumn	13,000 m^3/hr FSRU	none	Complies
5.7	Winter	13,000 m^3/hr FSRU and BlueScope	none	Approximately 50m by 50m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.8	Winter	13,000 m^3/hr FSRU and BlueScope	BlueScope	Approximately 300m by 400m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.9	Winter	13,000 m^3/hr FSRU	none	Approximately 300m by 400m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.10	Spring	13,000 m^3/hr FSRU and BlueScope	none	Approximately 30m by 30m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.11	Spring	13,000 m^3/hr FSRU and BlueScope	BlueScope	Approximately 300m by 500m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply

Comparison Figure	Season	Future Discharges	Ambient Discharges	Outcome
5.12	Spring	13,000 m^3/hr FSRU	none	Approximately 250m by 300m area near the seabed that exceeds EPA requirements for Temperature. Mid depth and surface comply
5.13	Summer	10,500 m^3/hr FSRU	none	Approx 50m x 100m area near the seabed exceeds EPA requirements for Temperature. Mid depth and surface comply
5.14	Summer	10,500 m^3/hr FSRU and BlueScope	none	Complies
5.15	Summer	10,500 m^3/hr FSRU and BlueScope	BlueScope	Complies
5.16	Autumn	10,500 m^3/hr FSRU	none	Approx 50m x 100m area exceeds EPA requirements for Temperature Mid depth and surface comply
5.17	Autumn	10,500 m^3/hr FSRU and BlueScope	none	Complies
5.18	Autumn	10,500 m^3/hr FSRU and BlueScope	BlueScope	Complies
5.19	Winter	10,500 m^3/hr FSRU	none	Complies
5.20	Winter	10,500 m^3/hr FSRU and BlueScope	none	Complies
5.21	Winter	10,500 m^3/hr FSRU and BlueScope	BlueScope	Complies
5.22	Spring	10,500 m^3/hr FSRU	none	Complies
5.23	Spring	10,500 m^3/hr FSRU and BlueScope	none	Complies
5.24	Spring	10,500 m^3/hr FSRU and BlueScope	BlueScope	Complies

6 Sodium Hypochlorite Modelling

6.1 General

It is understood that sodium hypochlorite will be present in the warming water discharge. Concentrations at the point of discharge are predicted to be up to 20 ug/l.

The near field mixing and dispersion of the sodium hypochlorite has been undertaken to assess the potential concentrations in the near field mixing zone, as well as in the far field model.

6.2 Near Field Mixing

Applying a discharge concentration of 20 ug/l at the point of discharge to the dilution values predicted by CORMIX, the centreline, average and plume edge concentrations at the end of the nearfield mixing zone are presented overleaf in Table 6-1 for the 13,000 m^3/hr simulations and Table 6-2 for the 10,500 m^3/hr simulations.

This table indicates that the sodium hypochlorite concentration at the edge of the plume, at the end of the nearfield region is predicted to be up to 1.8 ug/l for both discharge cases. The average concentration within the plume is predicted to be 3.0 ug/l, or less.

Considering the ANZECC guidelines for fresh water, a guideline value of 3ug/l is recommended. The near field modelling indicates that the sodium hypochlorite concentration at the edge of the near field zone is less than 2 ug/l, and therefore is predicted to comply with this value.

Note that for the near field modelling, the modelling considered a conservative tracer. In reality, there is likely to be an initial rapid decay of the chlorine concentration, and therefore, the concentrations predicted at the end of the near field are likely to be conservative.

Table 6-1 Simulated temperature decrease at the end of the near field for a 13,000 m^3/hr discharge

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Summer	LAT	0	34.5	4.7	3.8	38.3	3.8	2.2	1.4
Summer	LAT	0.05	34.4	4.8	3.5	37.9	4.2	2.5	1.5
Summer	LAT	0.1	32.7	5.1	3.7	36.4	3.7	2.2	1.3
Summer	MSL	0	36.6	4.9	3.5	40.2	4.2	2.5	1.5
Summer	MSL	0.05	35.7	5.0	3.6	39.3	4.0	2.3	1.5
Summer	MSL	0.1	33.8	5.3	3.8	37.6	3.4	2.0	1.3
Summer	MHWS	0	37.3	4.7	3.1	40.4	3.8	2.3	1.4
Summer	MHWS	0.05	36.5	5.1	3.7	40.2	3.9	2.3	1.4
Summer	MHWS	0.1	34.5	5.5	4.0	38.5	3.3	1.9	1.2
Winter	LAT	0	37.0	4.9	3.6	40.5	4.3	2.5	1.6
Winter	LAT	0.05	36.1	5.0	3.6	39.7	4.1	2.4	1.5
Winter	LAT	0.1	34.1	5.3	3.9	38.0	3.4	2.0	1.3
Winter	MSL	0	38.5	5.1	3.7	42.2	4.0	2.4	1.5
Winter	MSL	0.05	37.4	5.3	3.8	41.1	3.8	2.3	1.4
Winter	MSL	0.1	35.4	5.6	4.1	39.5	3.2	1.9	1.2
Winter	MHWS	0	39.4	3.8	3.3	42.6	3.9	2.3	1.4
Winter	MHWS	0.05	38.3	5.4	3.9	42.2	3.7	2.2	1.4
Winter	MHWS	0.1	36.1	5.8	4.2	40.2	3.1	1.8	1.1
Spring	LAT	0	38.2	4.6	3.1	41.3	4.1	2.4	1.5
Spring	LAT	0.05	35.6	5.0	3.6	39.2	4.1	2.4	1.5
Spring	LAT	0.1	33.8	5.3	3.8	37.6	3.5	2.1	1.3
Spring	MSL	0	37.9	3.7	1.8	39.8	4.1	2.4	1.5
Spring	MSL	0.05	37.1	5.2	3.8	40.8	3.8	2.3	1.4
Spring	MSL	0.1	35.0	5.5	4.0	39.0	3.3	1.9	1.2
Spring	MHWS	0	38.9	3.7	1.9	40.8	3.9	2.3	1.4
Spring	MHWS	0.05	37.9	5.0	3.3	41.3	3.8	2.2	1.4
Spring	MHWS	0.1	35.7	5.7	4.1	39.8	3.3	2.0	1.2
Autumn	LAT	0	35.4	3.4	1.7	37.2	4.3	2.6	1.6
Autumn	LAT	0.05	33.4	4.5	3.0	36.4	4.3	2.5	1.6

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Autumn	LAT	0.1	32.8	5.1	3.7	36.5	3.6	2.1	1.3
Autumn	MSL	0	36.9	3.5	1.8	38.6	4.2	2.5	1.5
Autumn	MSL	0.05	35.9	5.0	3.6	39.6	4.0	2.4	1.5
Autumn	MSL	0.1	34.0	5.4	3.9	37.8	3.4	2.0	1.2
Autumn	MHWS	0	37.7	3.6	1.8	39.5	4.0	2.4	1.5
Autumn	MHWS	0.05	36.7	5.2	3.7	40.5	3.8	2.3	1.4
Autumn	MHWS	0.1	34.8	5.5	4.0	38.8	3.3	1.9	1.2

Table 6-2 Simulated temperature decrease at the end of the near field for a 10,500 m^3/hr discharge

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Summer	LAT	0	32.84	4.16	4.16	37.0	5.0	2.9	1.8
Summer	LAT	0.05	31.94	4.22	4.22	36.16	4.9	2.9	1.8
Summer	LAT	0.1	30.33	4.43	4.43	34.76	4.3	2.6	1.6
Summer	MSL	0	34.57	4.42	4.42	38.99	4.5	2.7	1.7
Summer	MSL	0.05	33.75	4.49	4.49	38.24	4.3	2.6	1.6
Summer	MSL	0.1	31.95	4.74	4.74	36.69	3.9	2.3	1.4
Summer	MHWS	0	35.85	4.58	4.58	40.43	4.3	2.5	1.6
Summer	MHWS	0.05	34.81	4.67	4.67	39.48	4.1	2.4	1.5
Summer	MHWS	0.1	32.98	4.95	4.95	37.93	3.6	2.1	1.3
Winter	LAT	0	31.23	3.98	3.98	35.21	5.1	3.0	1.9
Winter	LAT	0.05	30.38	4.03	4.03	34.41	5.0	2.9	1.8
Winter	LAT	0.1	29.09	4.21	4.21	33.3	4.4	2.6	1.6
Winter	MSL	0	33.01	4.22	4.22	37.23	4.5	2.7	1.7
Winter	MSL	0.05	32.05	4.29	4.29	36.34	4.4	2.6	1.6
Winter	MSL	0.1	30.62	4.5	4.5	35.12	4.0	2.4	1.5
Winter	MHWS	0	34.02	4.37	4.37	38.39	4.3	2.5	1.6
Winter	MHWS	0.05	33.13	4.45	4.45	37.58	4.2	2.5	1.5
Winter	MHWS	0.1	31.52	4.69	4.69	36.21	3.7	2.2	1.4
Spring	LAT	0	34.38	4.36	4.36	38.74	4.9	2.9	1.8
Spring	LAT	0.05	33.48	4.43	4.43	37.91	4.8	2.8	1.8
Spring	LAT	0.1	31.67	4.66	4.66	36.33	4.3	2.5	1.6
Spring	MSL	0	36.36	4.63	4.63	40.99	4.4	2.6	1.6
Spring	MSL	0.05	35.43	4.72	4.72	40.15	4.3	2.5	1.6
Spring	MSL	0.1	33.46	5	5	38.46	3.8	2.2	1.4
Spring	MHWS	0	37.7	4.8	4.8	42.5	4.2	2.5	1.5
Spring	MHWS	0.05	36.59	4.91	4.91	41.5	4.0	2.4	1.5
Spring	MHWS	0.1	34.73	5.2	5.2	39.93	3.5	2.1	1.3
Autumn	LAT	0	33.42	4.23	4.23	37.65	4.9	2.9	1.8
Autumn	LAT	0.05	32.51	4.3	4.3	36.81	4.8	2.8	1.8
Autumn	LAT	0.1	30.82	4.51	4.51	35.33	4.3	2.6	1.6

Season	Water Level	Current Speed (m/s)	Centreline Distance to end of nearfield (m)	Plume 1/e vertical thickness (m)	Plume horizontal half width (m)	Mixing Zone Radius (m)	Centre Chlorine Conc [ug/l]	Average Chlorine Conc [ug/l]	Chlorine conc at edge of nearfield mixing zone [ug/l]
Autumn	MSL	0	35.3	4.49	4.49	39.79	4.5	2.7	1.7
Autumn	MSL	0.05	34.27	4.57	4.57	38.84	4.3	2.6	1.6
Autumn	MSL	0.1	32.55	4.83	4.83	37.38	3.8	2.3	1.4
Autumn	MHWS	0	36.51	4.66	4.66	41.17	4.3	2.5	1.6
Autumn	MHWS	0.05	35.46	4.76	4.76	40.22	4.1	2.4	1.5
Autumn	MHWS	0.1	33.6	5.05	5.05	38.65	3.6	2.1	1.3

6.3 Far Field Modelling

As noted in the previous sections, near field modelling describes the plume behaviour in the near field zone of the discharge. These models are steady state they do not include affects such as accumulation of pollutants or recirculation between the intake and the outfall. To assess the potential for these effects, far field modelling using a 3-dimensional hydrodynamic model has been applied.

Far field modelling of sodium hypochlorite was undertaken in Deflt3D, using the same model applied to the temperature dispersion modelling, however extended to include the advection/dispersion of a linearly decaying, neutrally buoyant tracer.

As per the warming water simulations, the sodium hypochlorite simulation was undertaken over a period of 45 days, with the first 5 days being discarded – to allow for development of dynamic equilibrium. The simulations also included the heating and cooling water discharges, as well as solar heating and cooling.

The maximum concentration of sodium hypochlorite simulated by the model is presented in **Figure 6.1** This figure shows that the sodium hypochlorite concentration within the port is predicted to be less than 1 ug/l through the upper water column. The maximum concentration is predicted to be slightly larger near the seabed, where concentrations outside of the near field mixing zone are predicted to reach up to 1.5 ug/l. There is a small area, less than 50m in radius, where the concentration is predicted to exceed 3 ug/l, however this at the point of discharge, and would be considered the near field mixing zone.

7 Discussion

This report presents the outcomes of the updated dispersion modelling studies undertaken for the proposed FSRU berth in Port Kembla. The main outcomes from the modelling are:

1. The near field mixing zone is predicted to be semi-circular in shape, with a 42.6m radius for a discharge of 13,000m^3/hr and 42.5m for a discharge of 10,500m^3/hr. These mixing zone dimensions originate from the point of discharge;
2. Near field modelling indicates that the relevant water quality objectives for temperature and chlorine will be met in the near field zone for both discharge rates;
3. Thermal plume modelling has been undertaken for the operational phase of the project, under all four seasons. The modelling predicts that the combination of the FSRU and BlueScope will generally comply with the EPA requirements during winter and Autumn. The impacts are larger during Spring and Summer, however all impacts are confined to within the port area;
4. Far field simulations of sodium hypochlorite were undertaken to estimate the peak concentration in the far field. This modelling indicates that the peak concentration will be less than 3 ug/l outside of the initial mixing zone.

8 References

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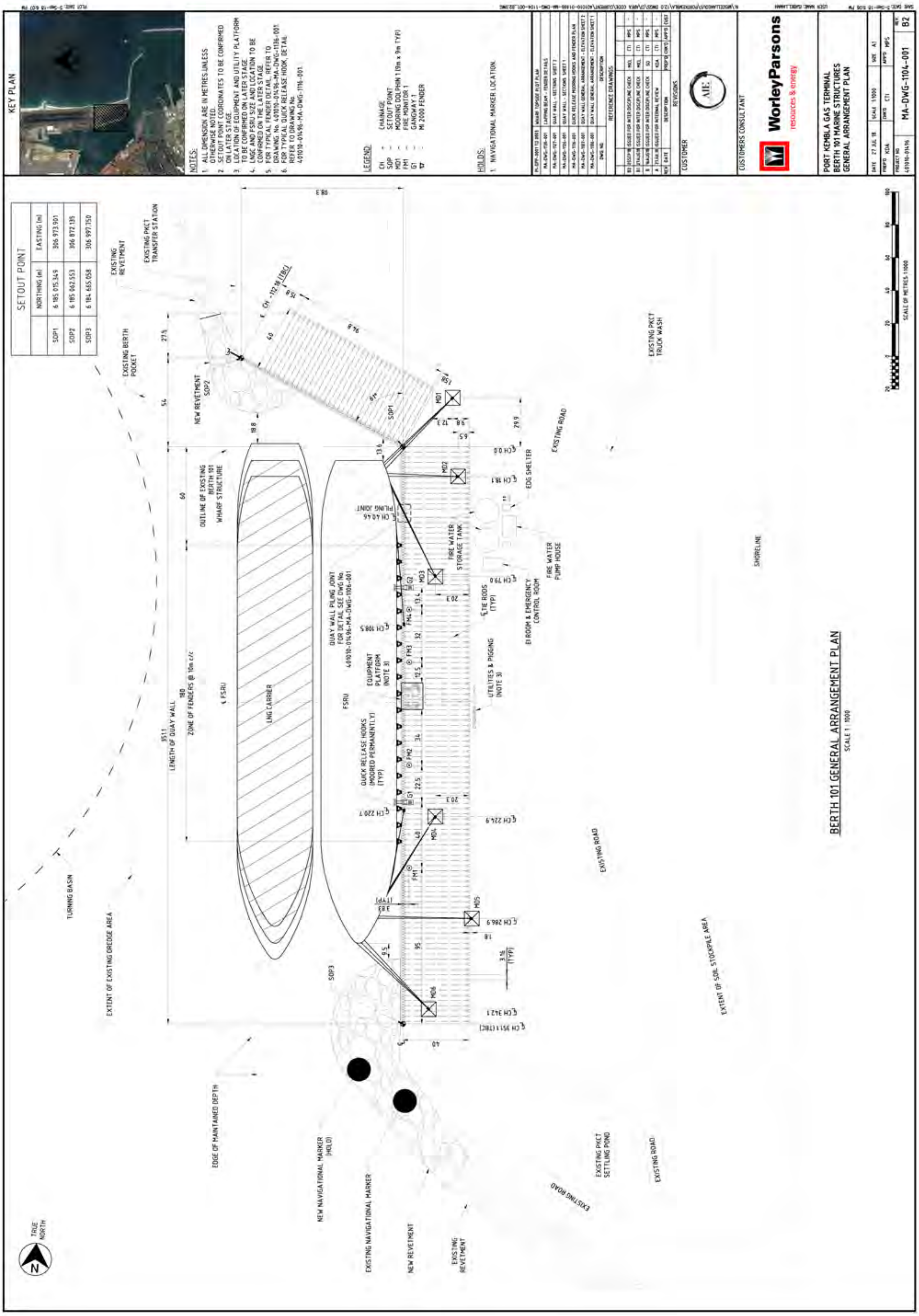
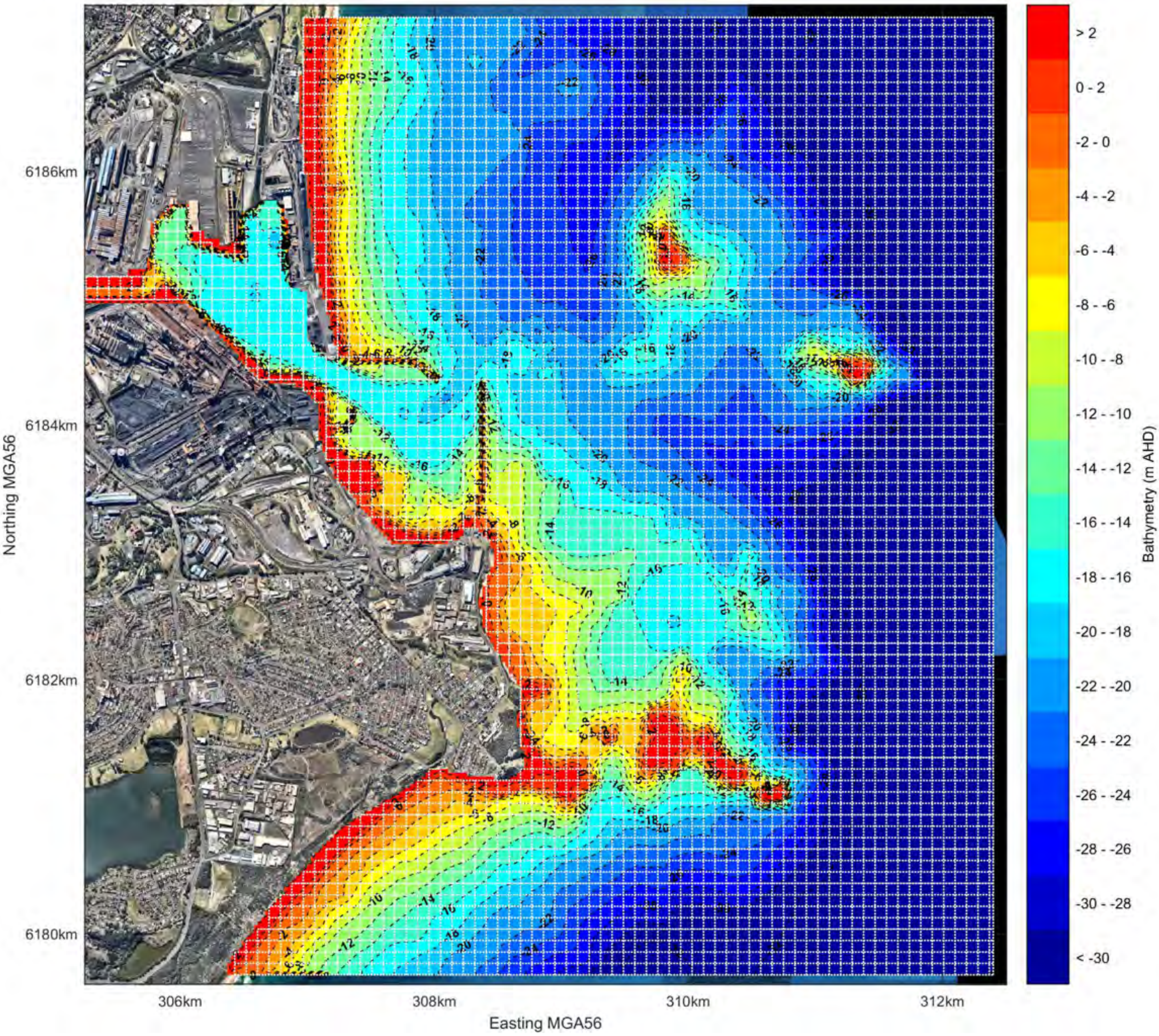
FIGURES



Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

General arrangement of the proposed FSRU berth

Figure 1.1



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Delft3D Model Extent and Bathymetry
Every 3rd Grid Line Shown

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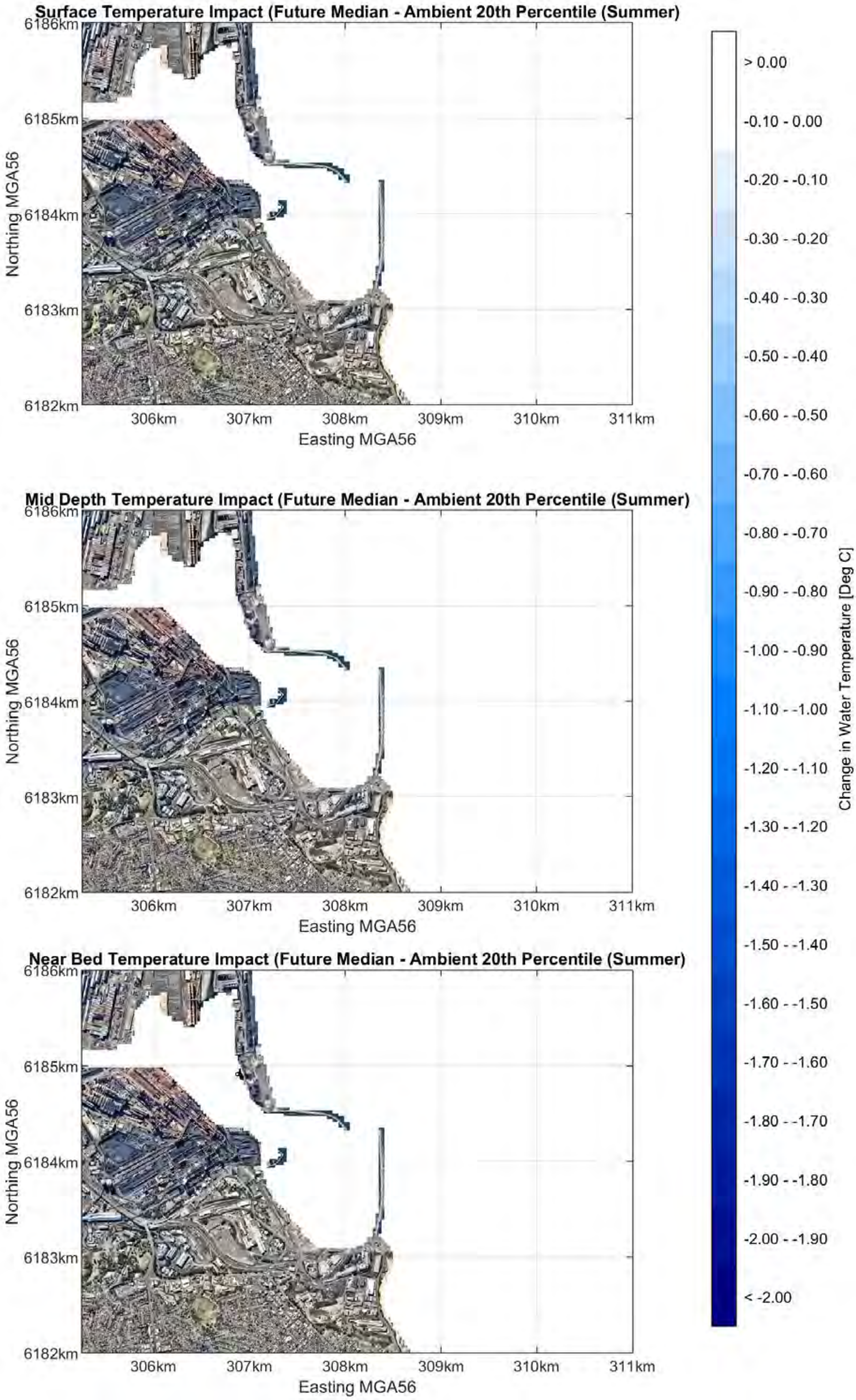
Figure 3.1



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 13000m^3/hr FSRU+BS compared to ambient

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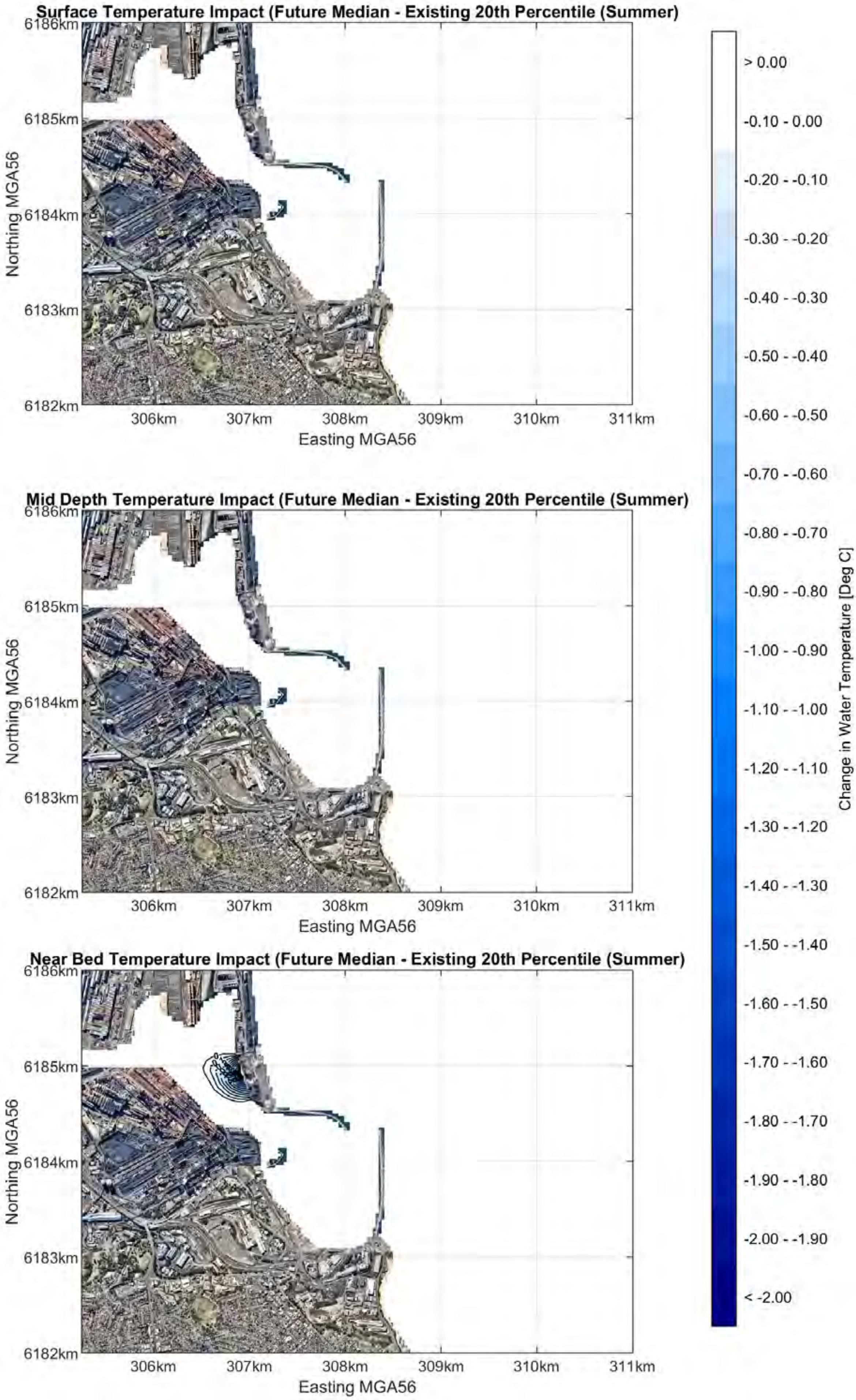
Figure 5.1



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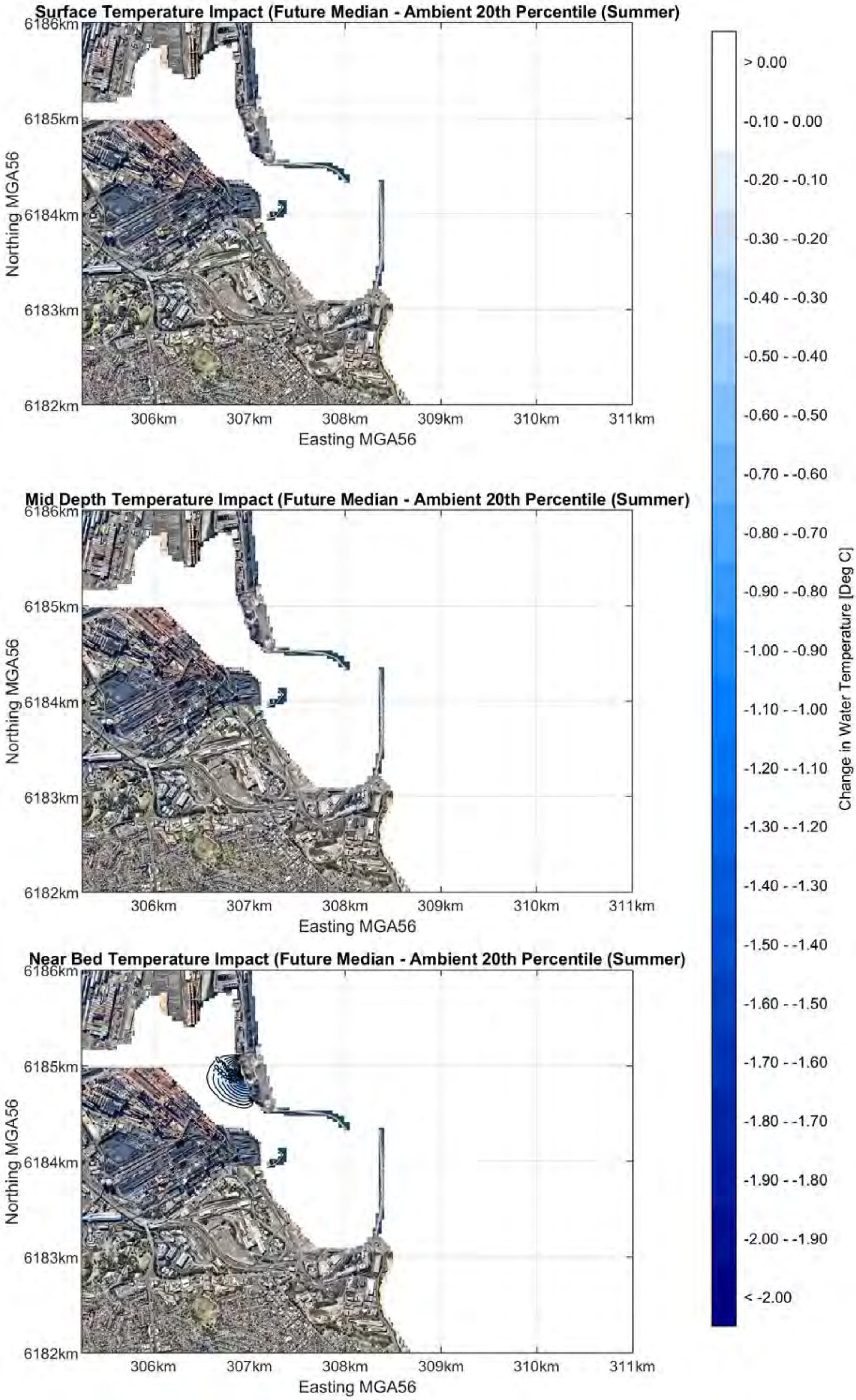
Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 13000m^3/hr FSRU+BS compared to existing

Figure 5.2



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 13000m^3/hr FSRU compared to ambient

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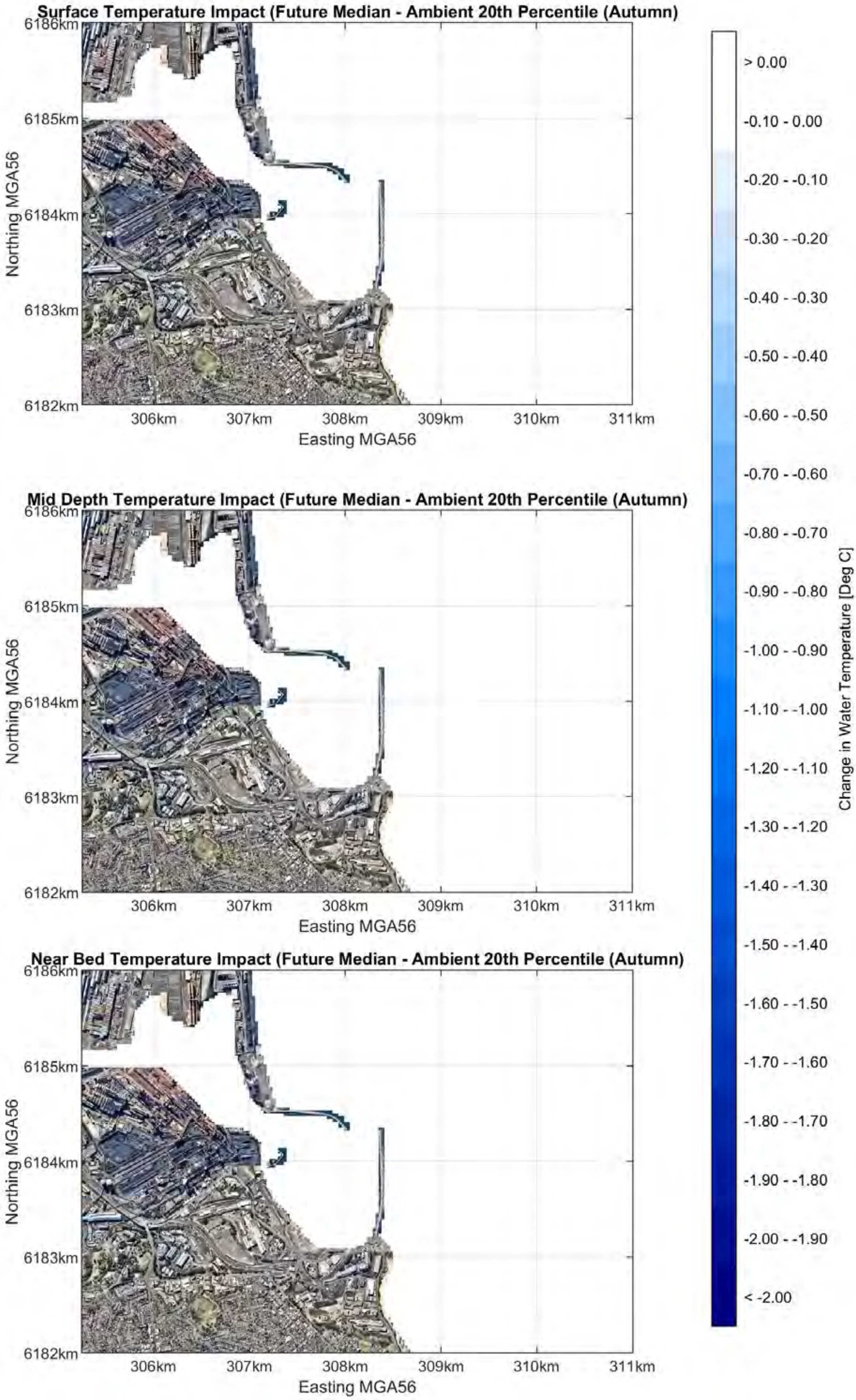
Figure 5.3



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 13000m^3/hr FSRU+BS compared to ambient

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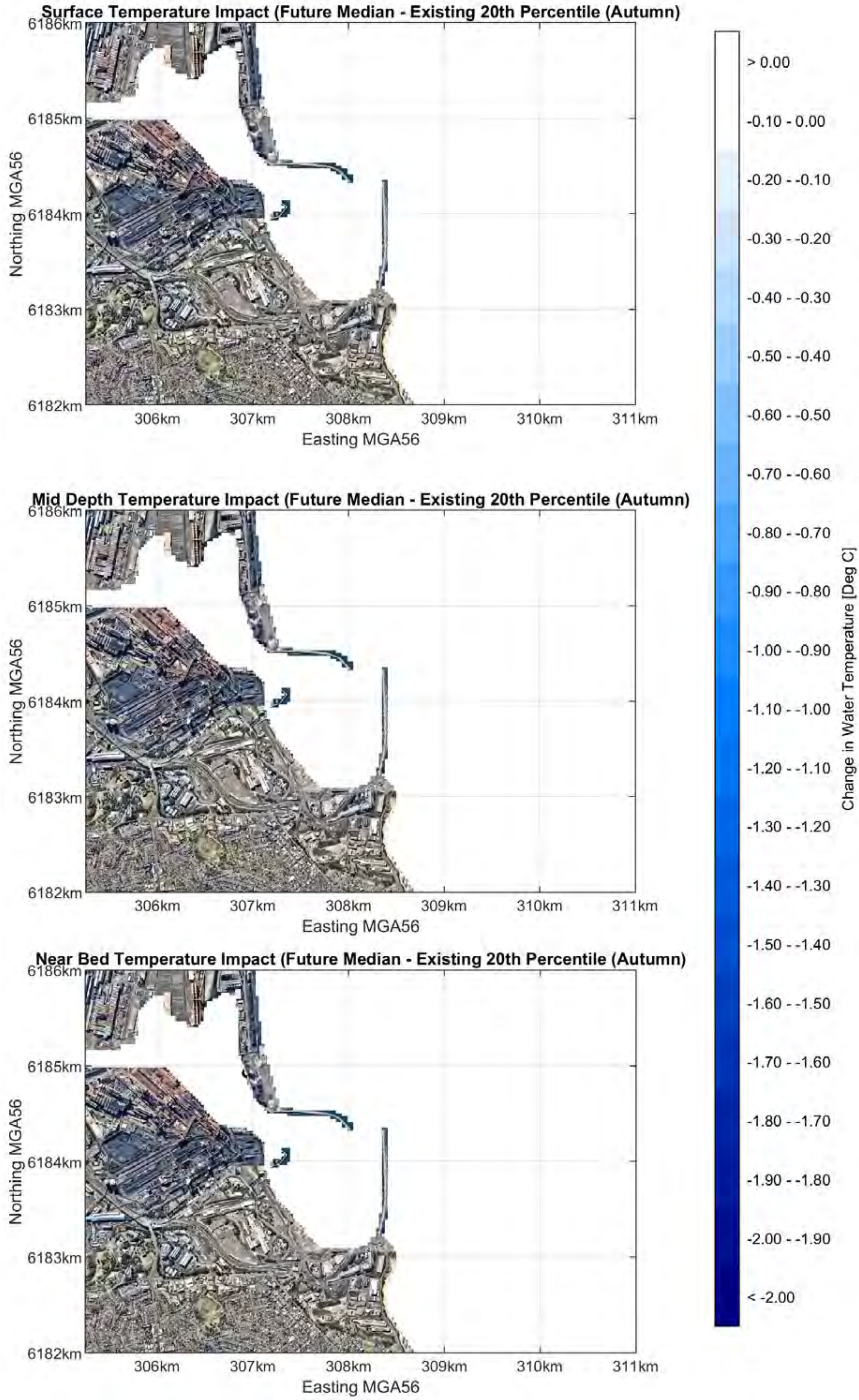
Figure 5.4



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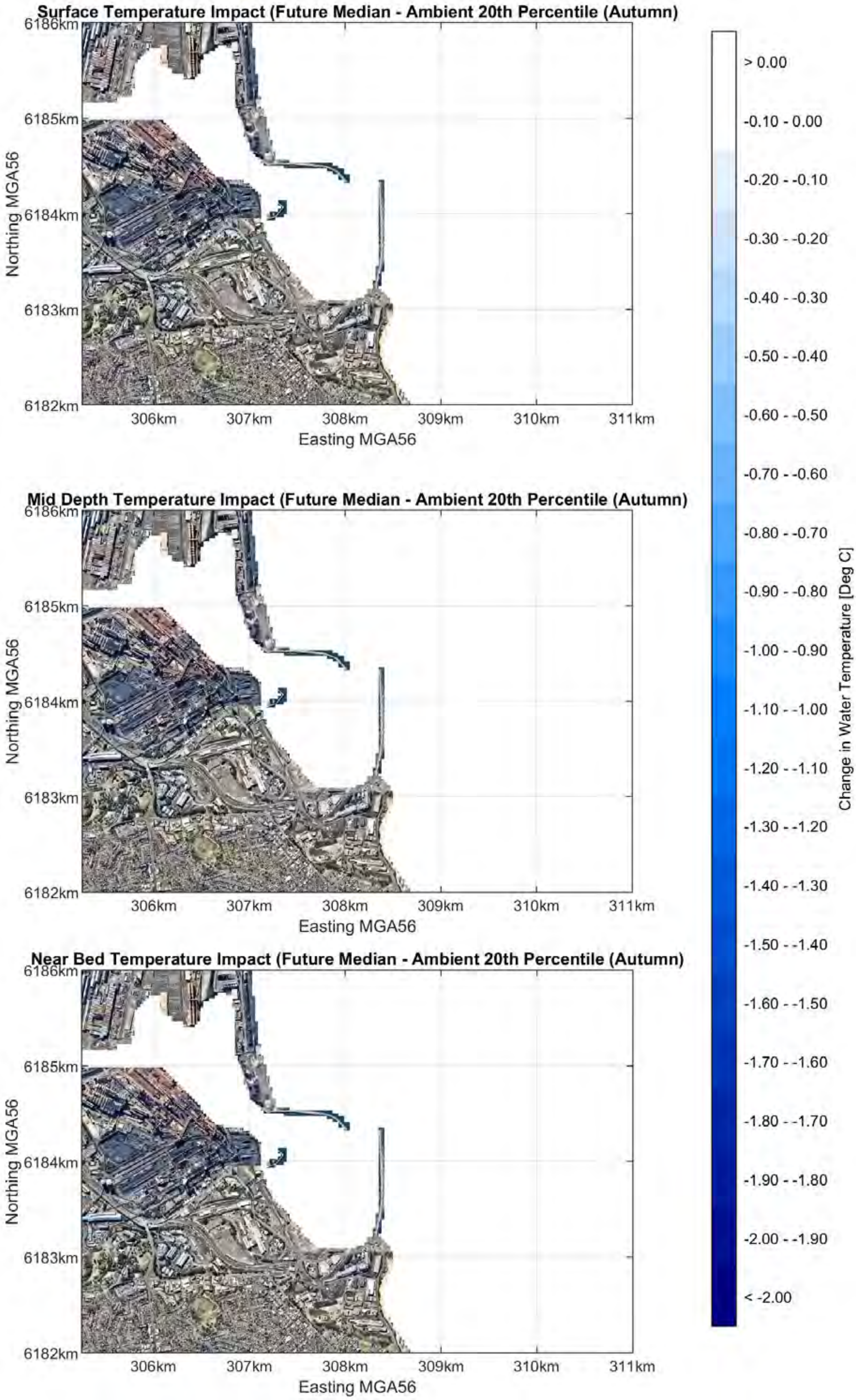
Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 13000m^3/hr FSRU+BS compared to existing

Figure 5.5



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 13000m^3/hr FSRU compared to ambient

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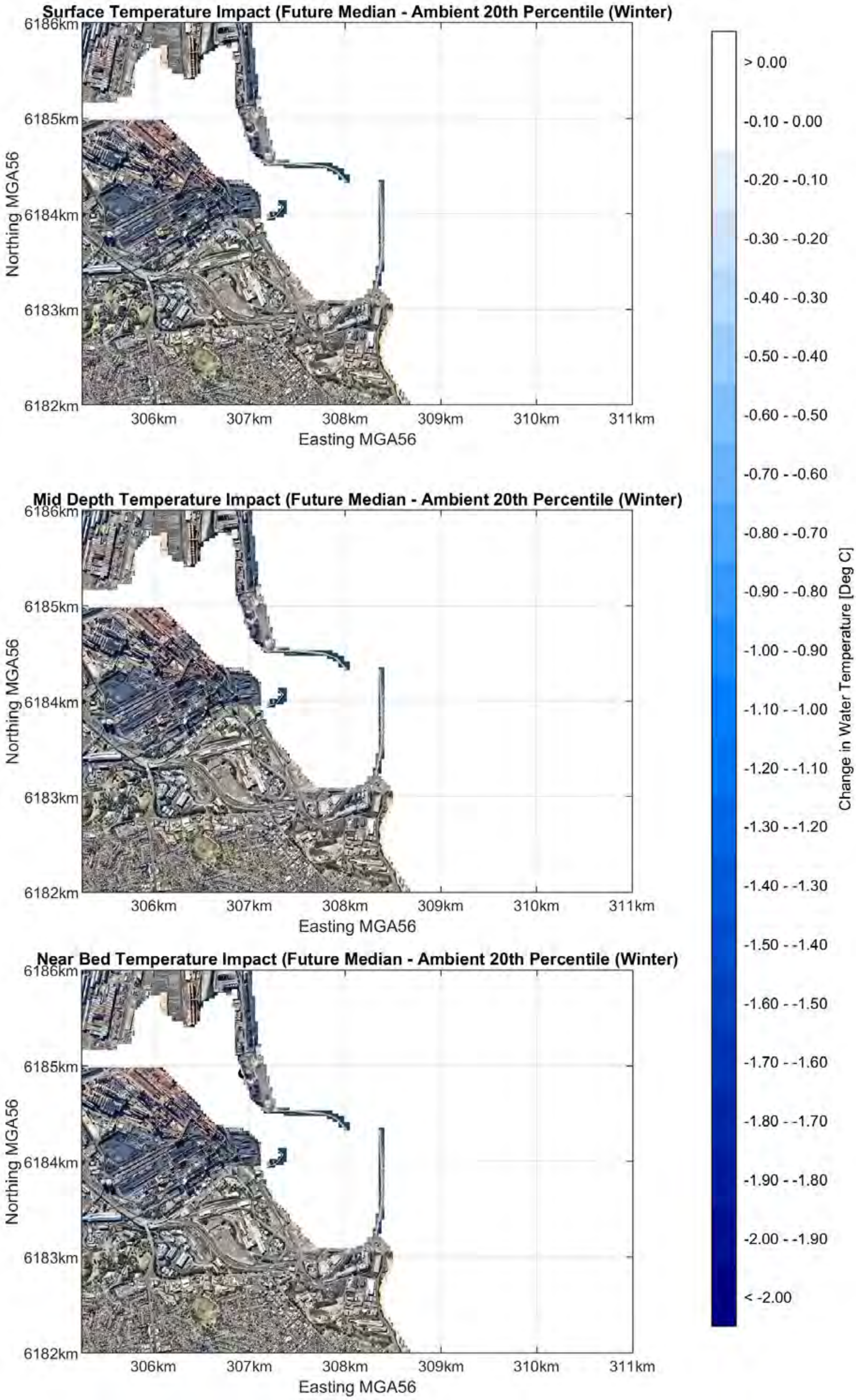
Figure 5.6



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 13000m^3/hr FSRU+BS compared to ambient

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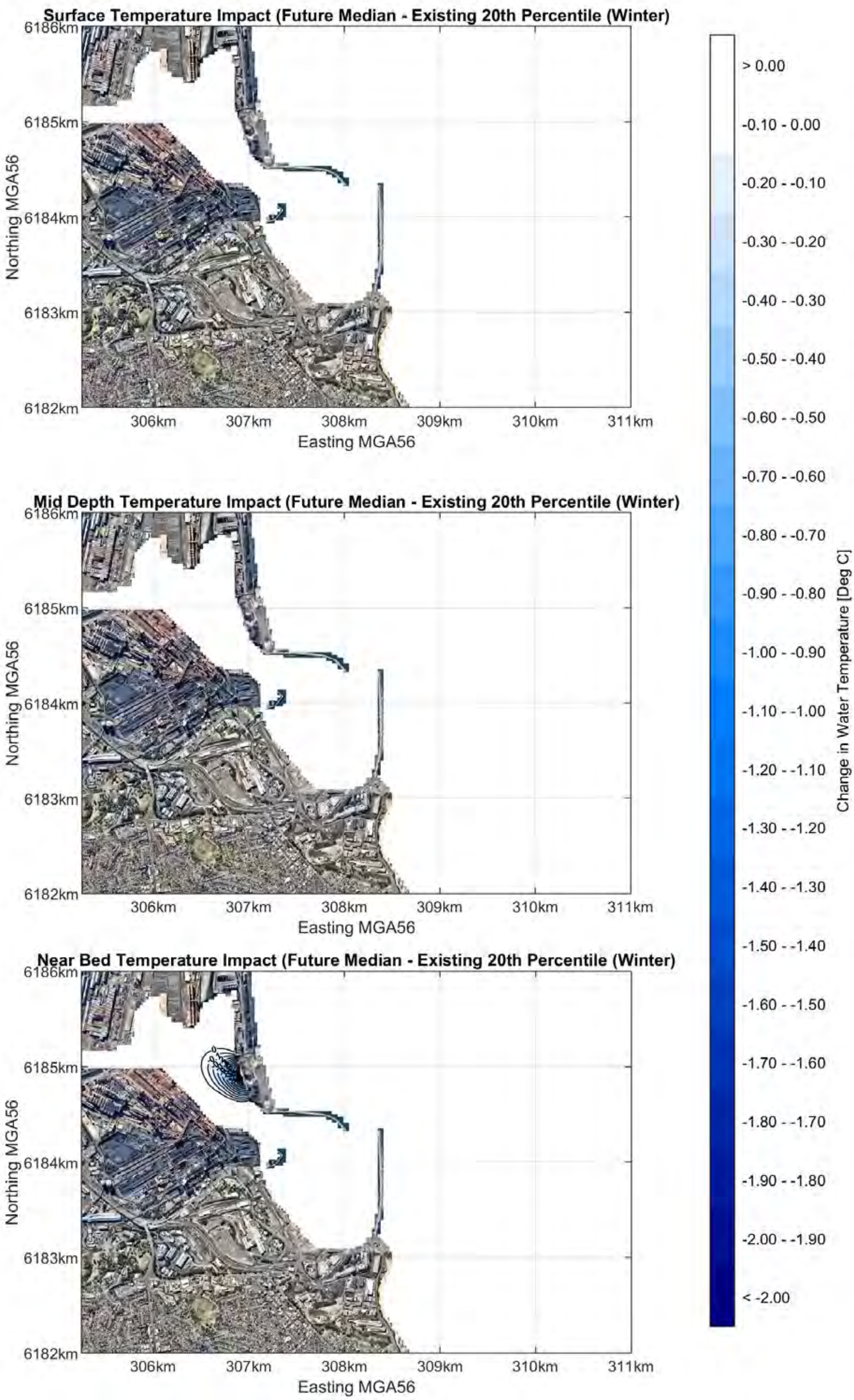
Figure 5.7



Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 13000m^3/hr FSRU+BS compared to existing

Figure 5.8

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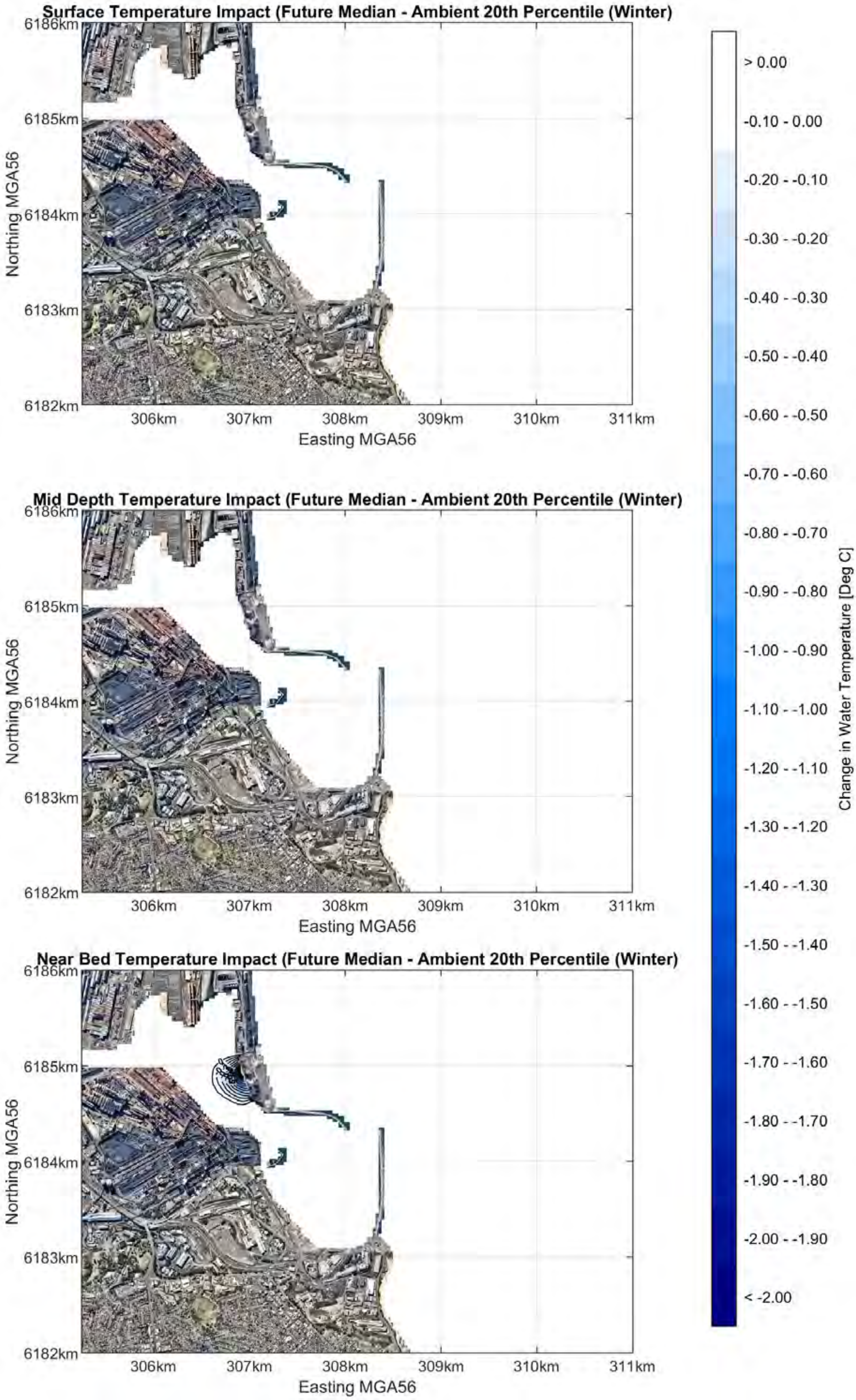

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 13000m^3/hr FSRU compared to ambient

Figure 5.9

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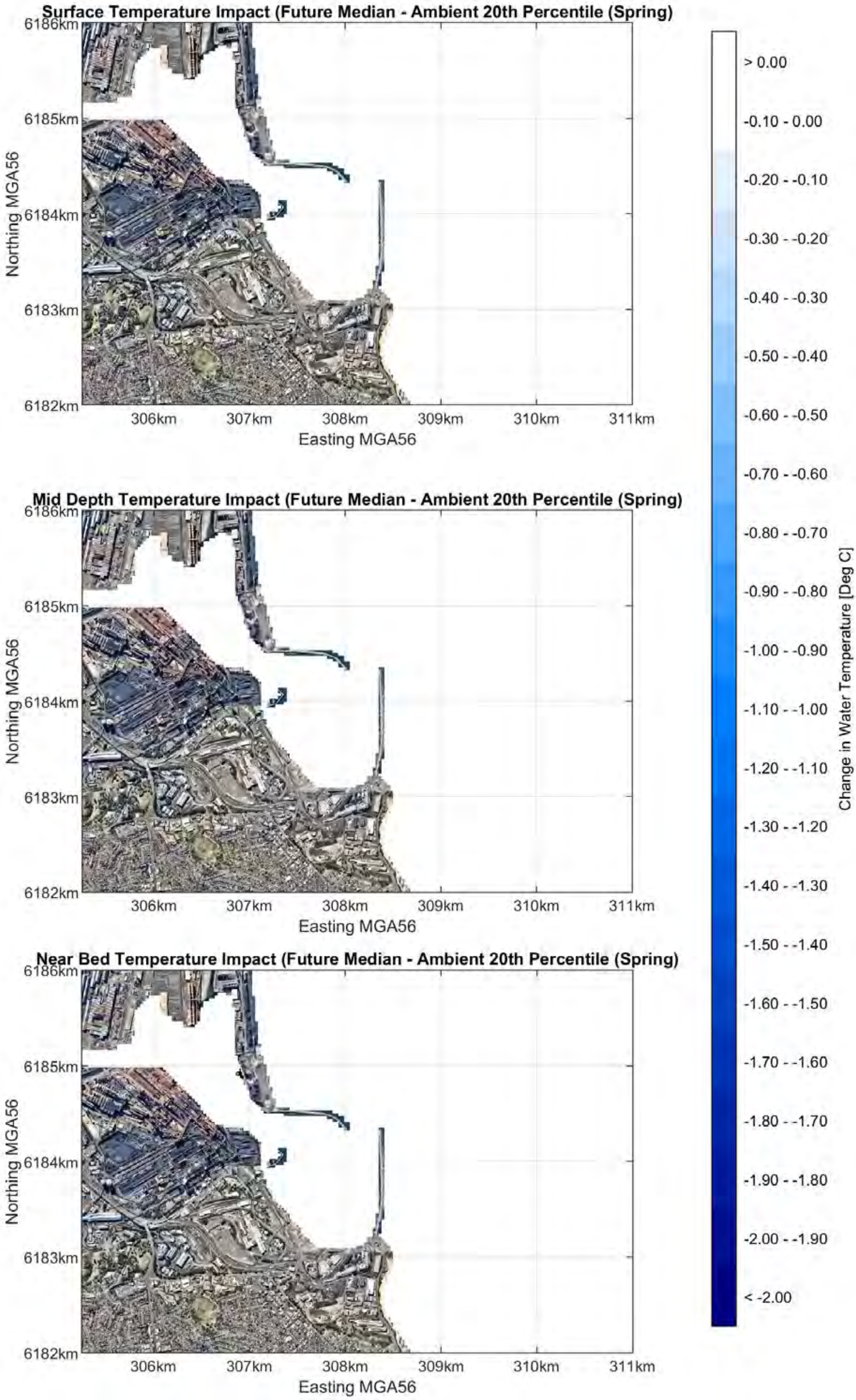
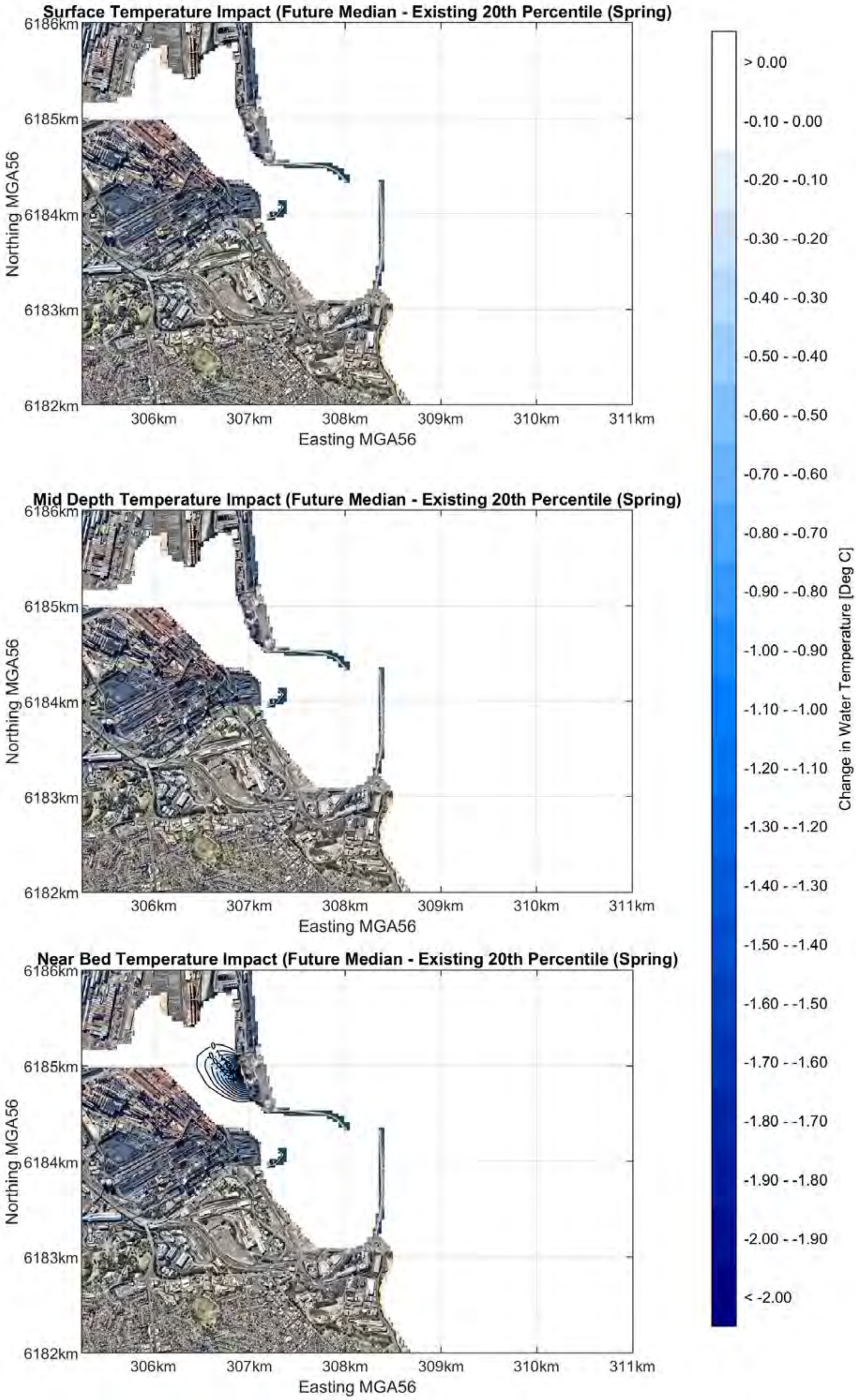


Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 13000m^3/hr FSRU+BS compared to ambient

Figure 5.10



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 13000m^3/hr FSRU+BS compared to existing

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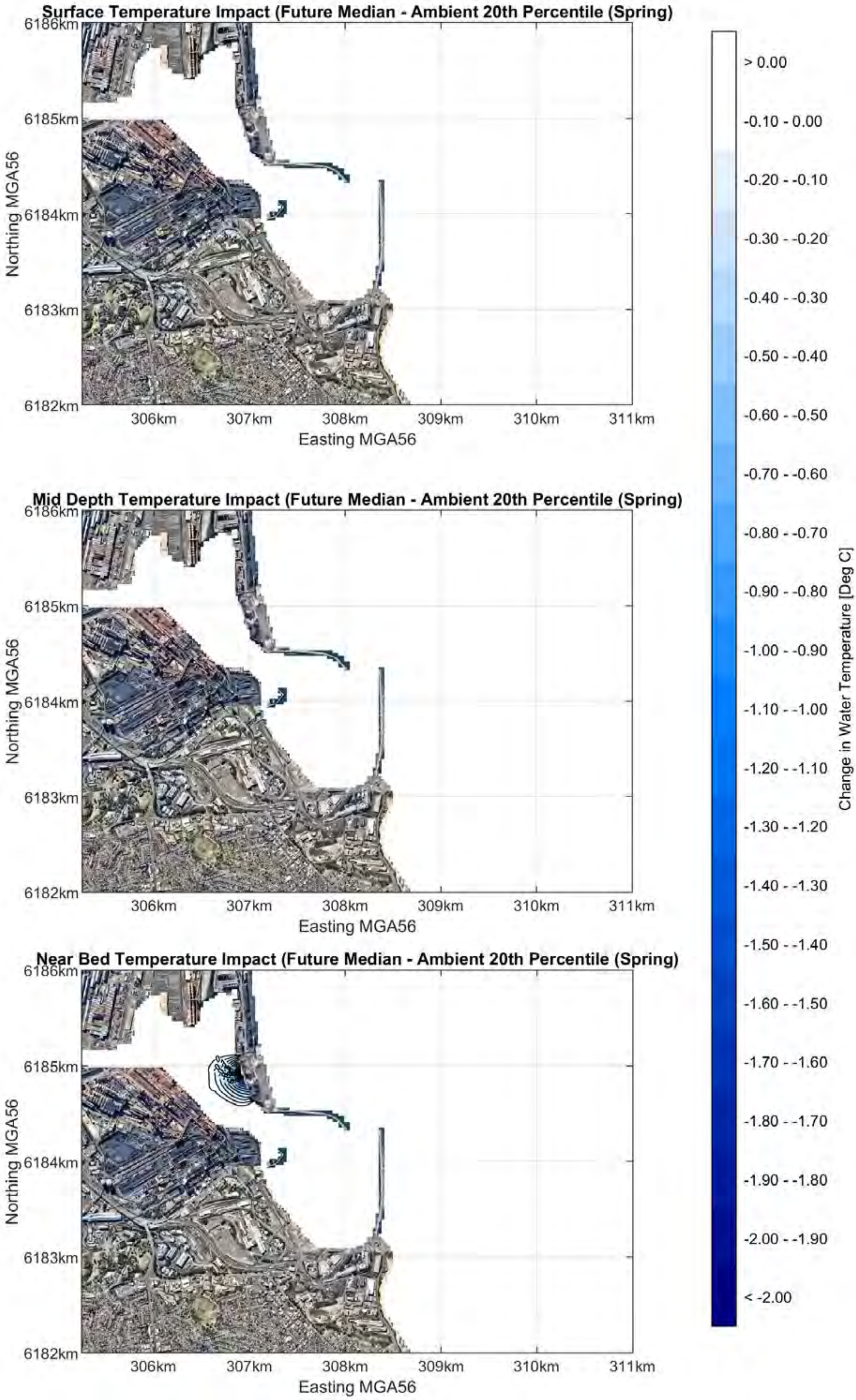
Figure 5.11



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 13000m^3/hr FSRU compared to ambient

Figure 5.12

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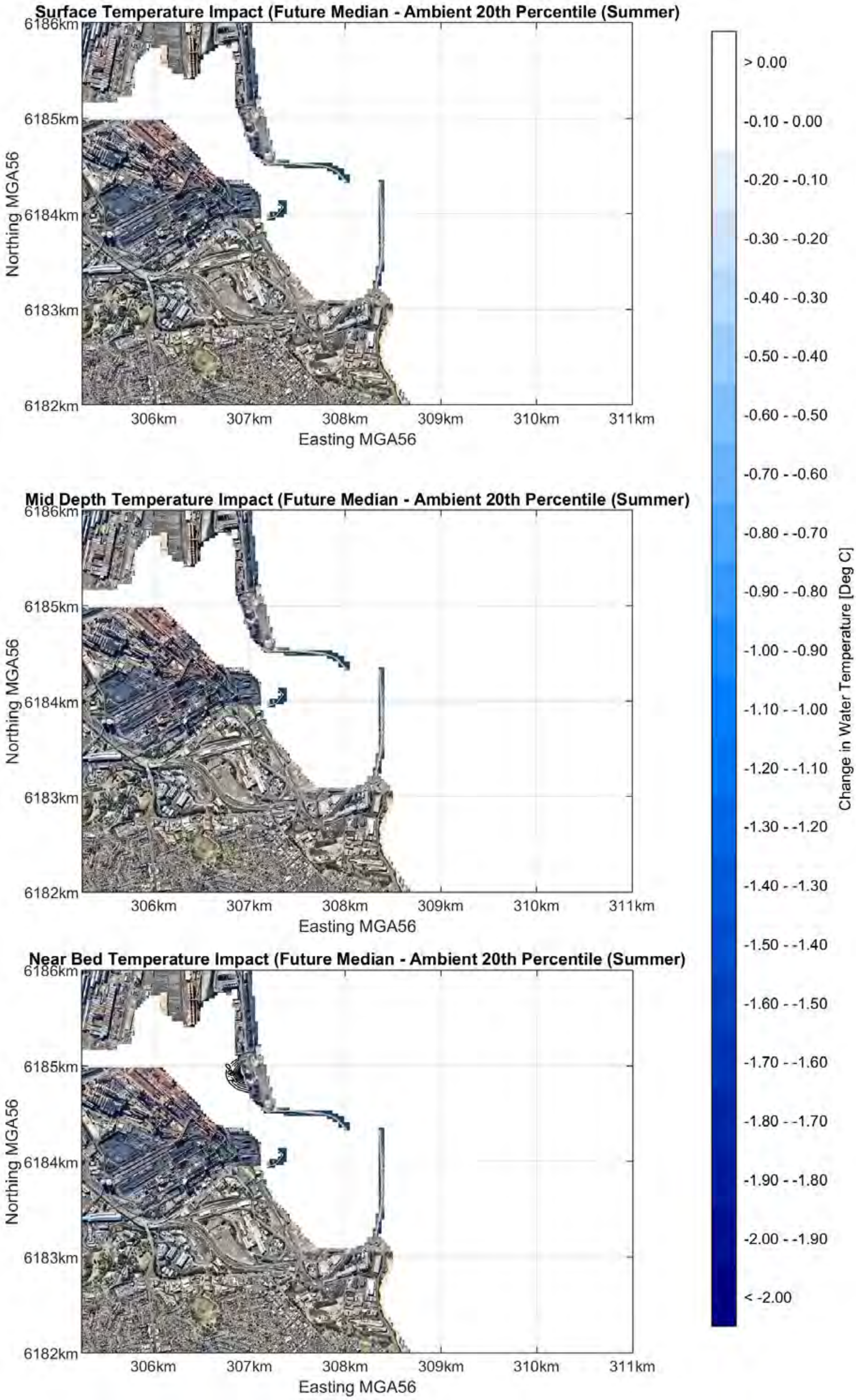

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 10,500m^3/hr FSRU+BS compared to ambient

Figure 5.13

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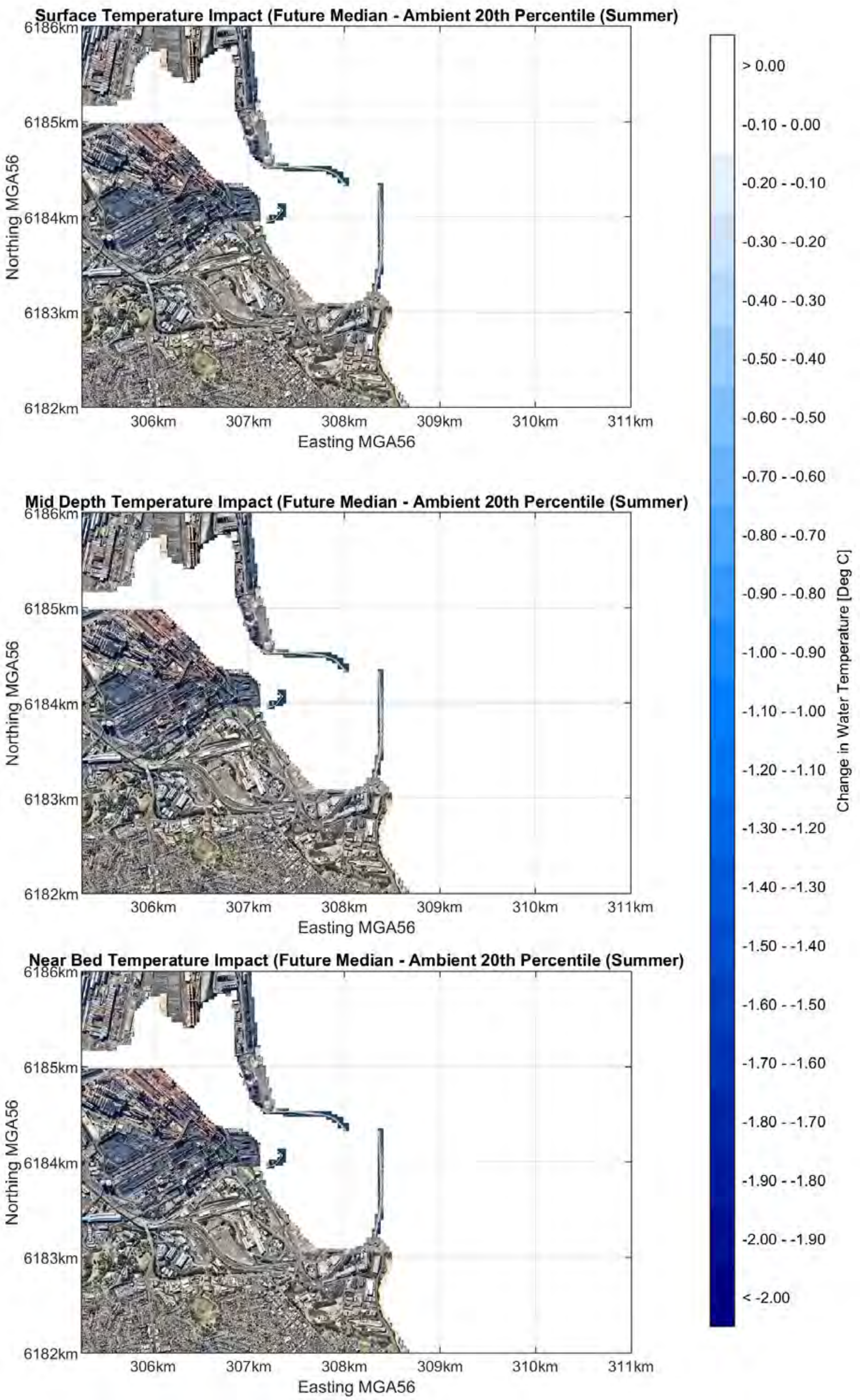

Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 10,500m^3/hr FSRU+BS compared to existing

Figure 5.14

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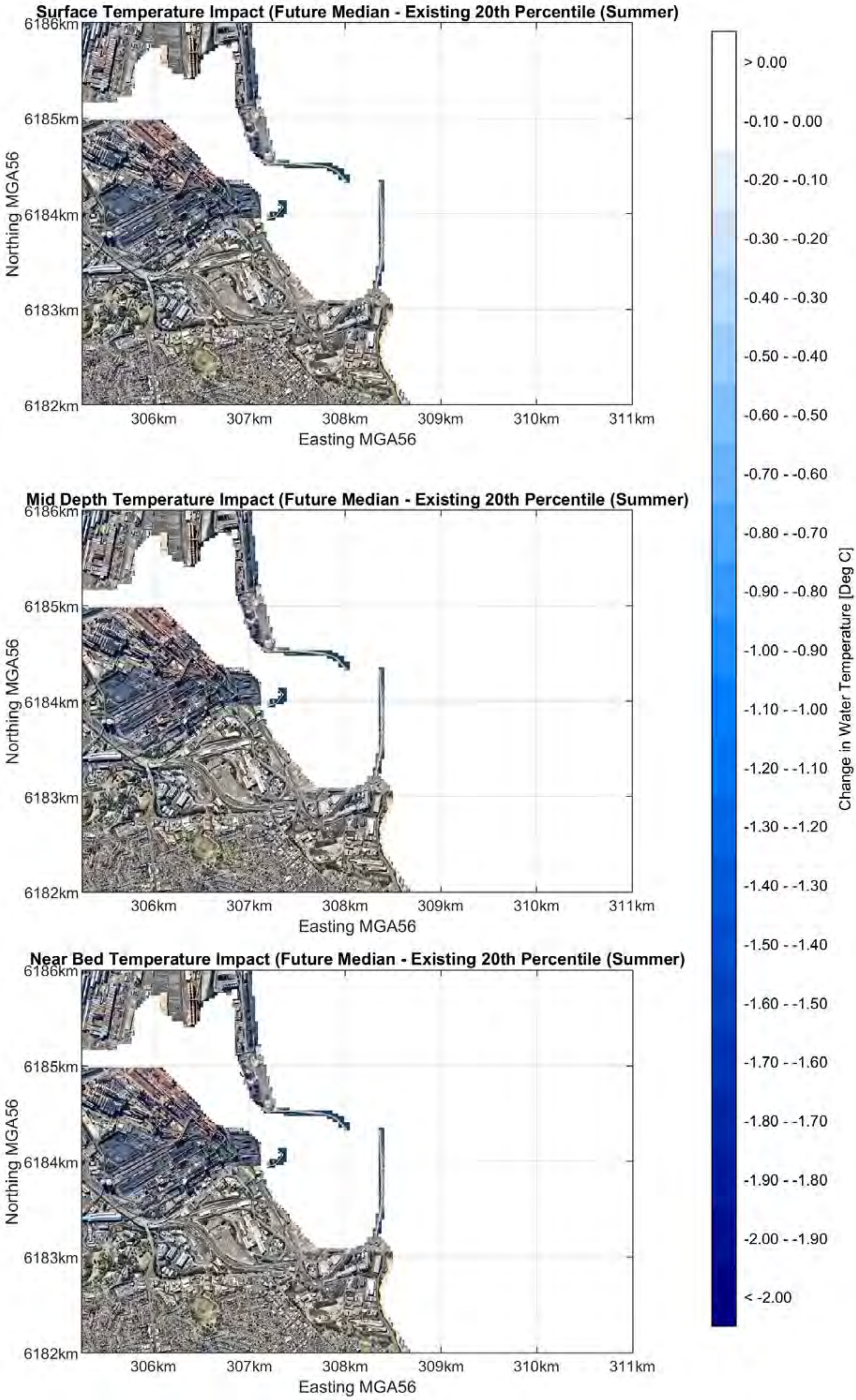

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Summer)
Future 10,500m^3/hr FSRU compared to ambient

Figure 5.15

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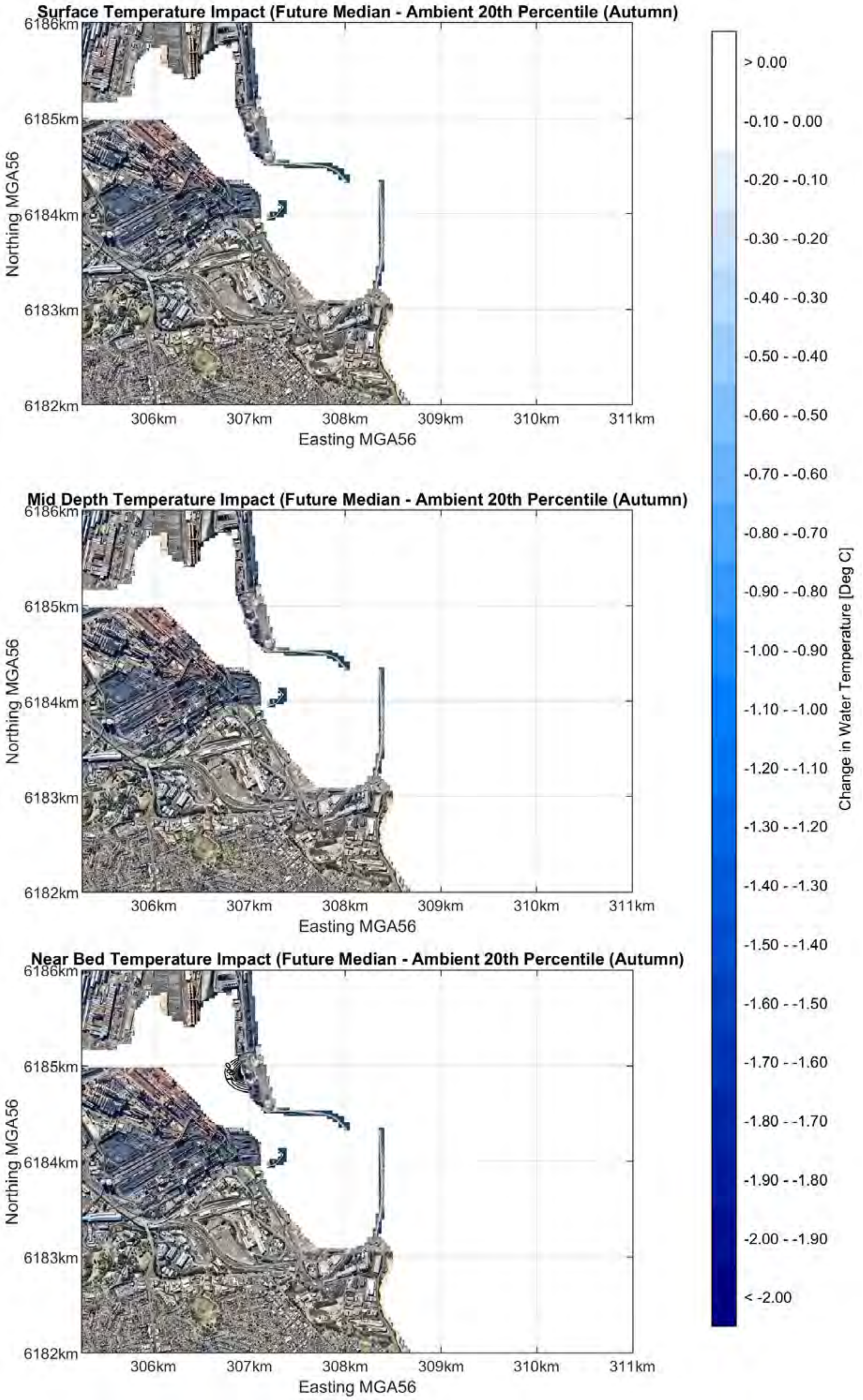

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 10,500m^3/hr FSRU+BS compared to ambient

Figure 5.16

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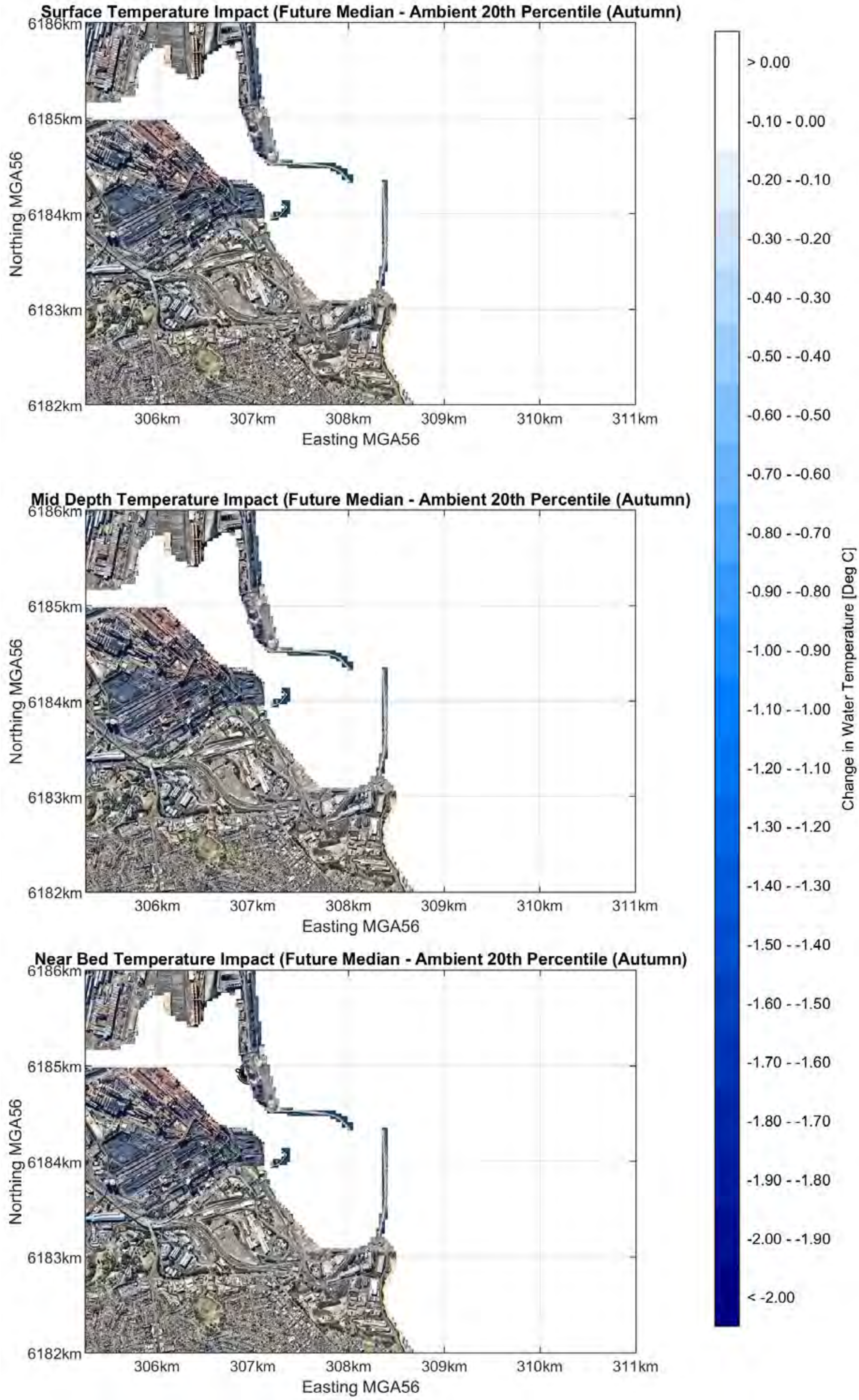

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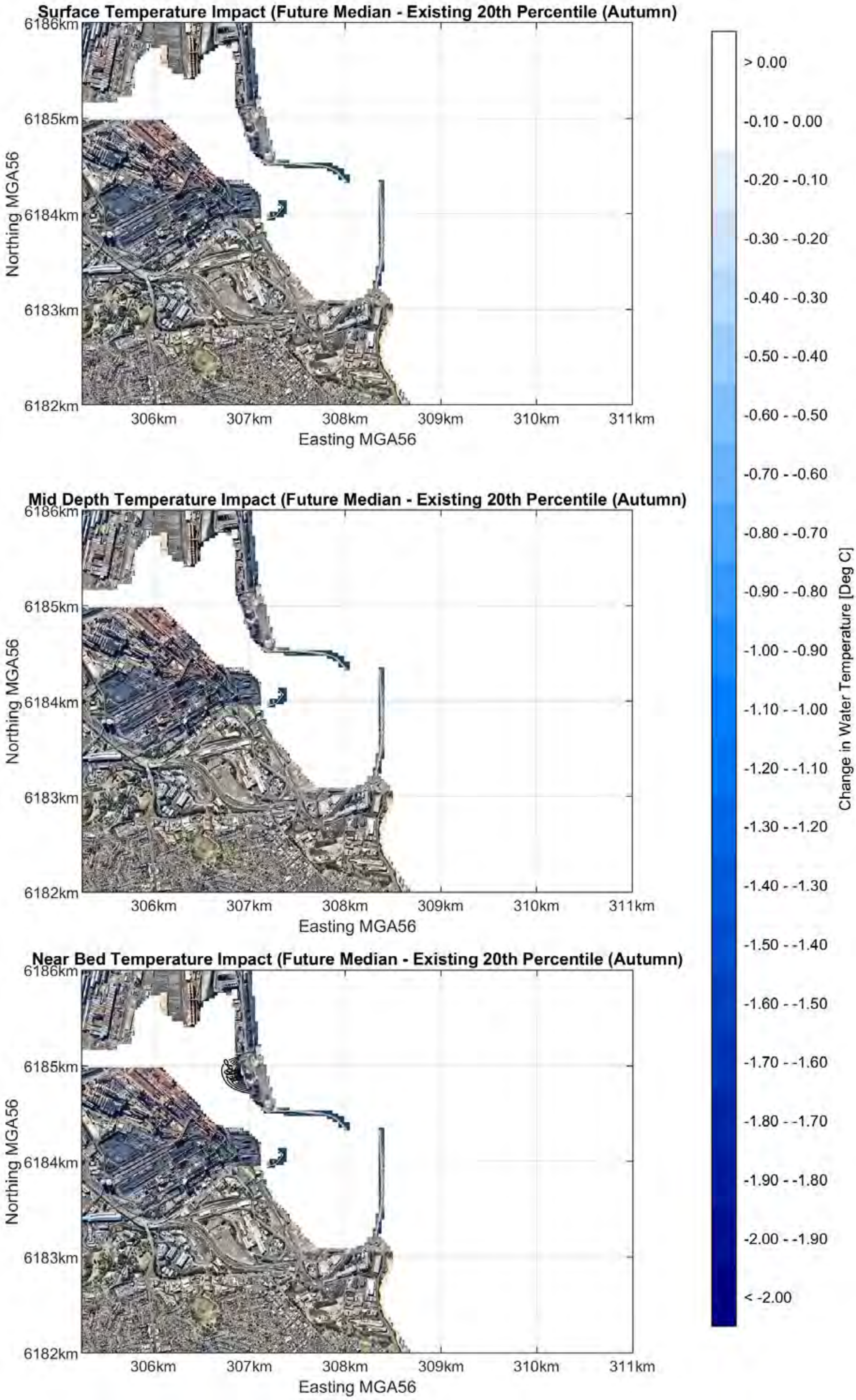
Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 10,500m^3/hr FSRU+BS compared to existing

Figure 5.17



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Autumn)
Future 10,500m^3/hr FSRU compared to ambient

Figure 5.18

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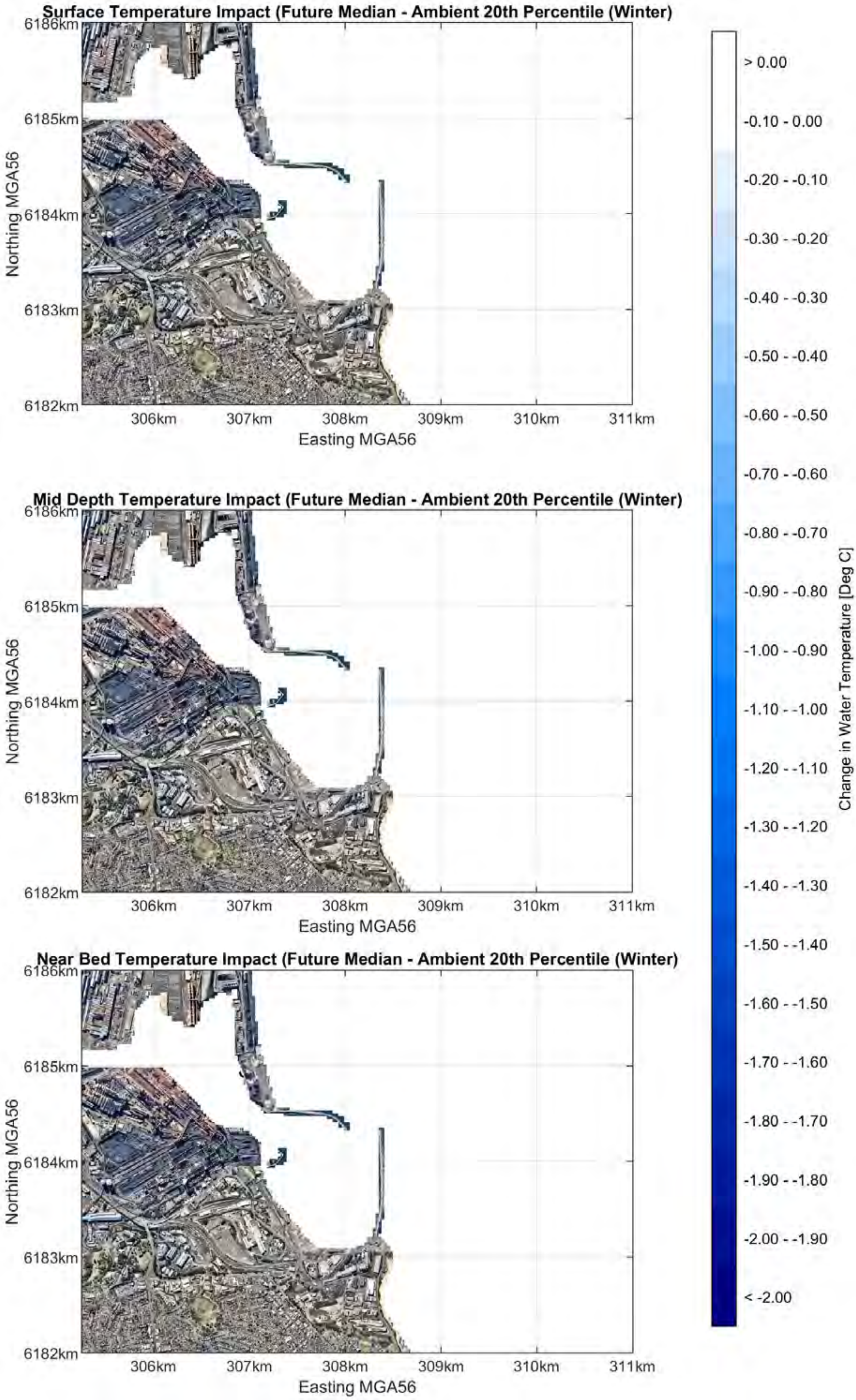

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 10,500m^3/hr FSRU+BS compared to ambient

Figure 5.19

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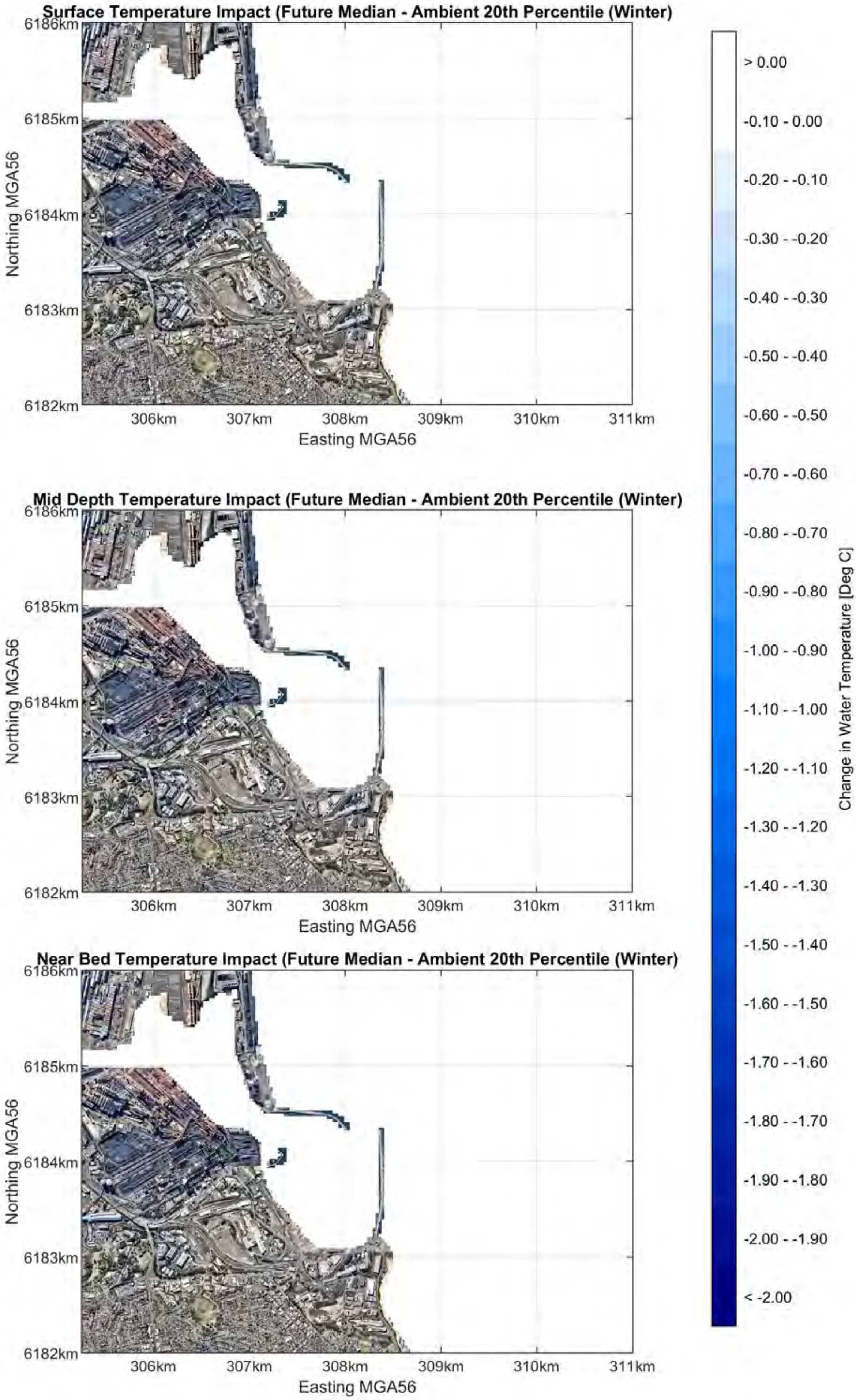

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 10,500m^3/hr FSRU+BS compared to existing

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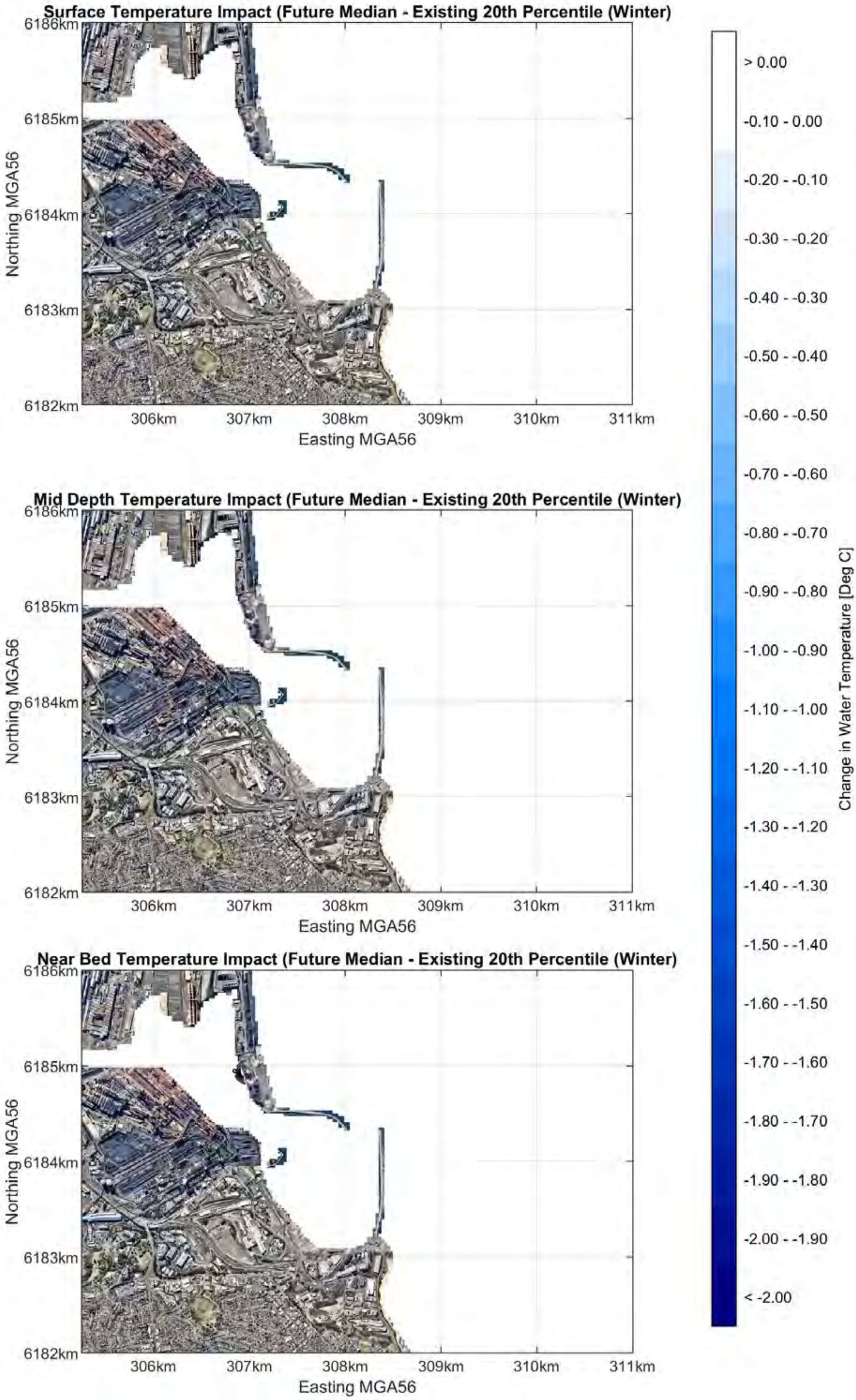
Figure 5.20



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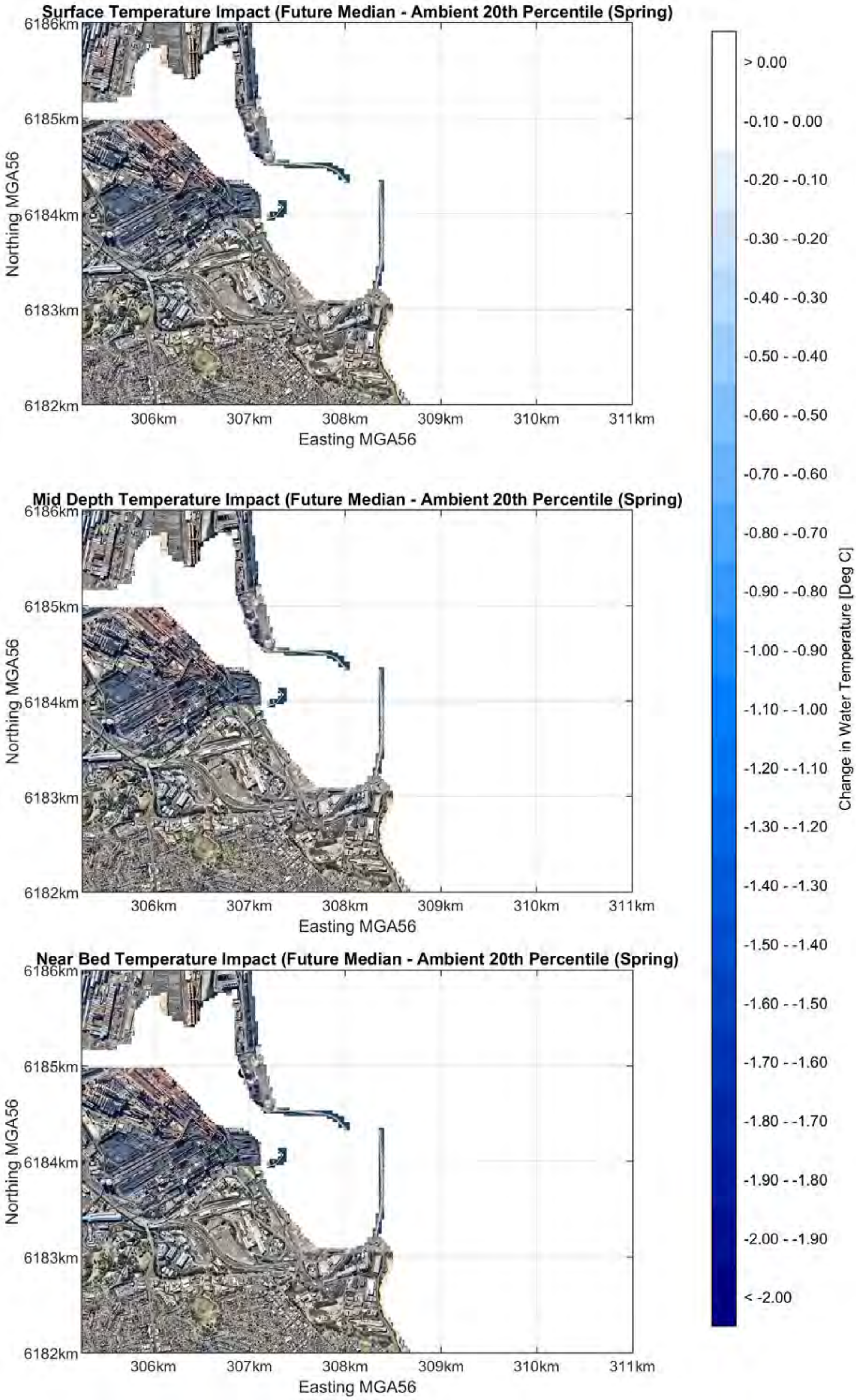
Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Winter)
Future 10,500m^3/hr FSRU compared to ambient

Figure 5.21



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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 10,500m^3/hr FSRU+BS compared to ambient

Figure 5.22

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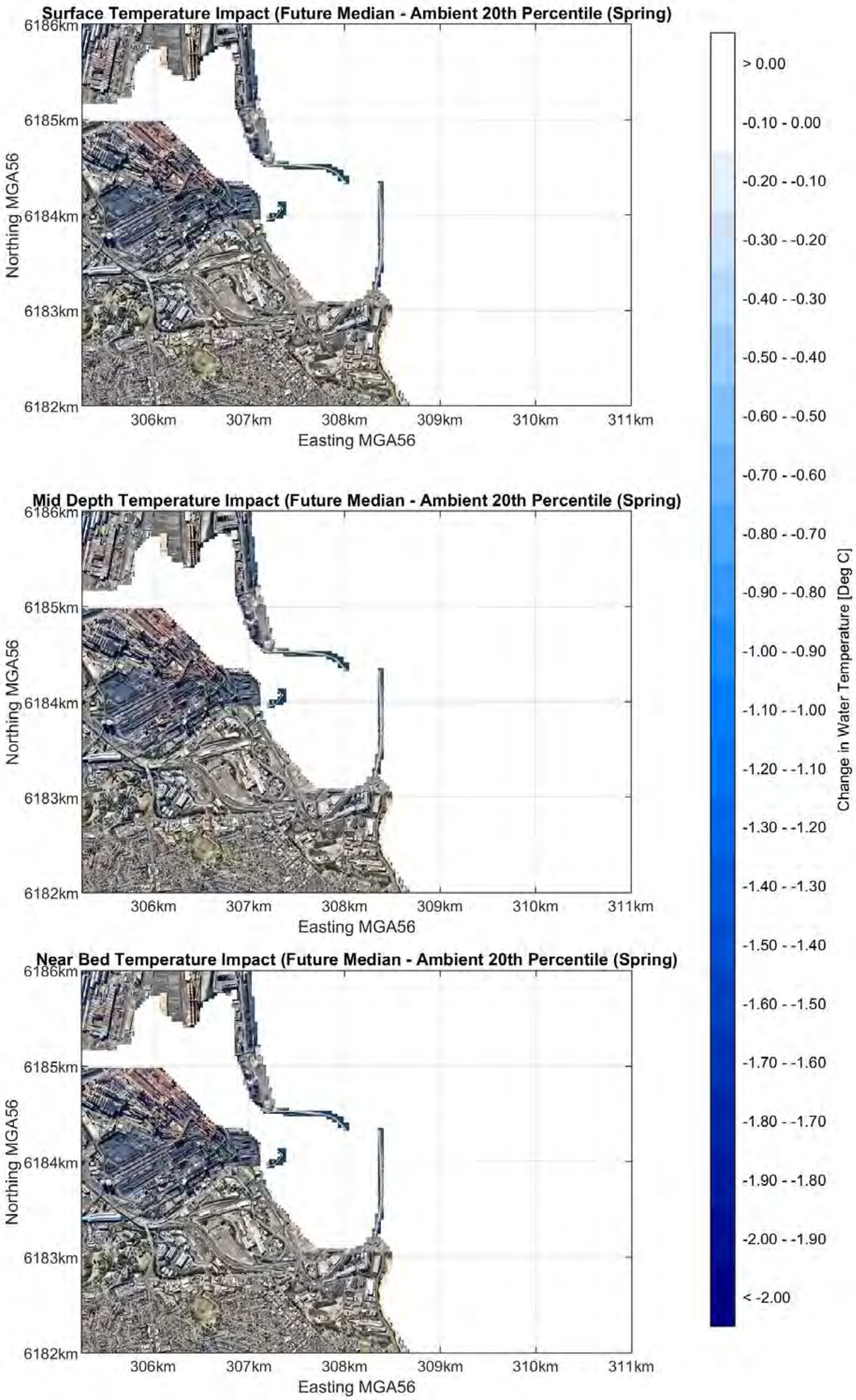

Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 10,500m^3/hr FSRU+BS compared to existing

Figure 5.23

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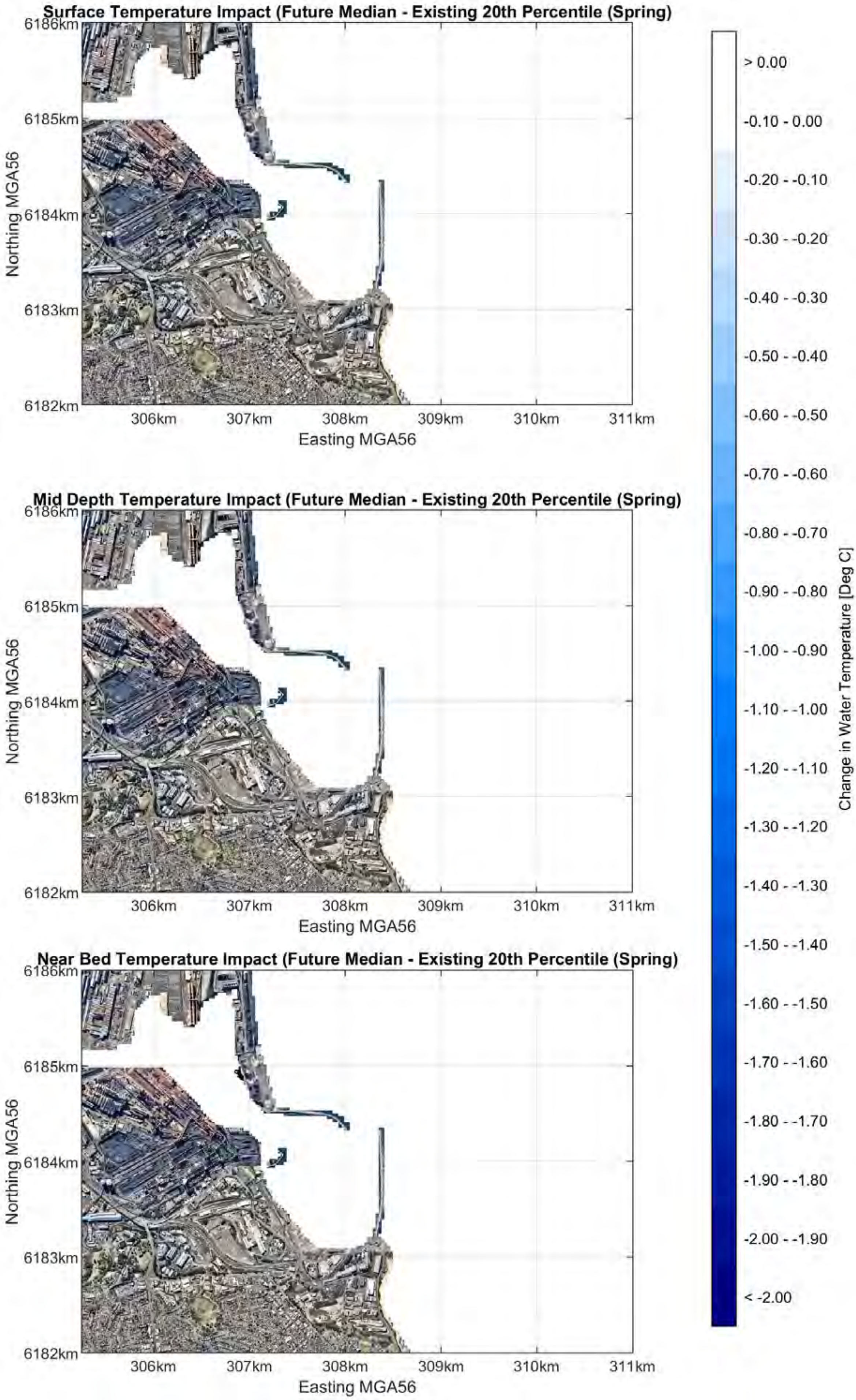

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Comparison to EPA guidelines (Spring)
Future 10,500m^3/hr FSRU compared to ambient

Figure 5.24

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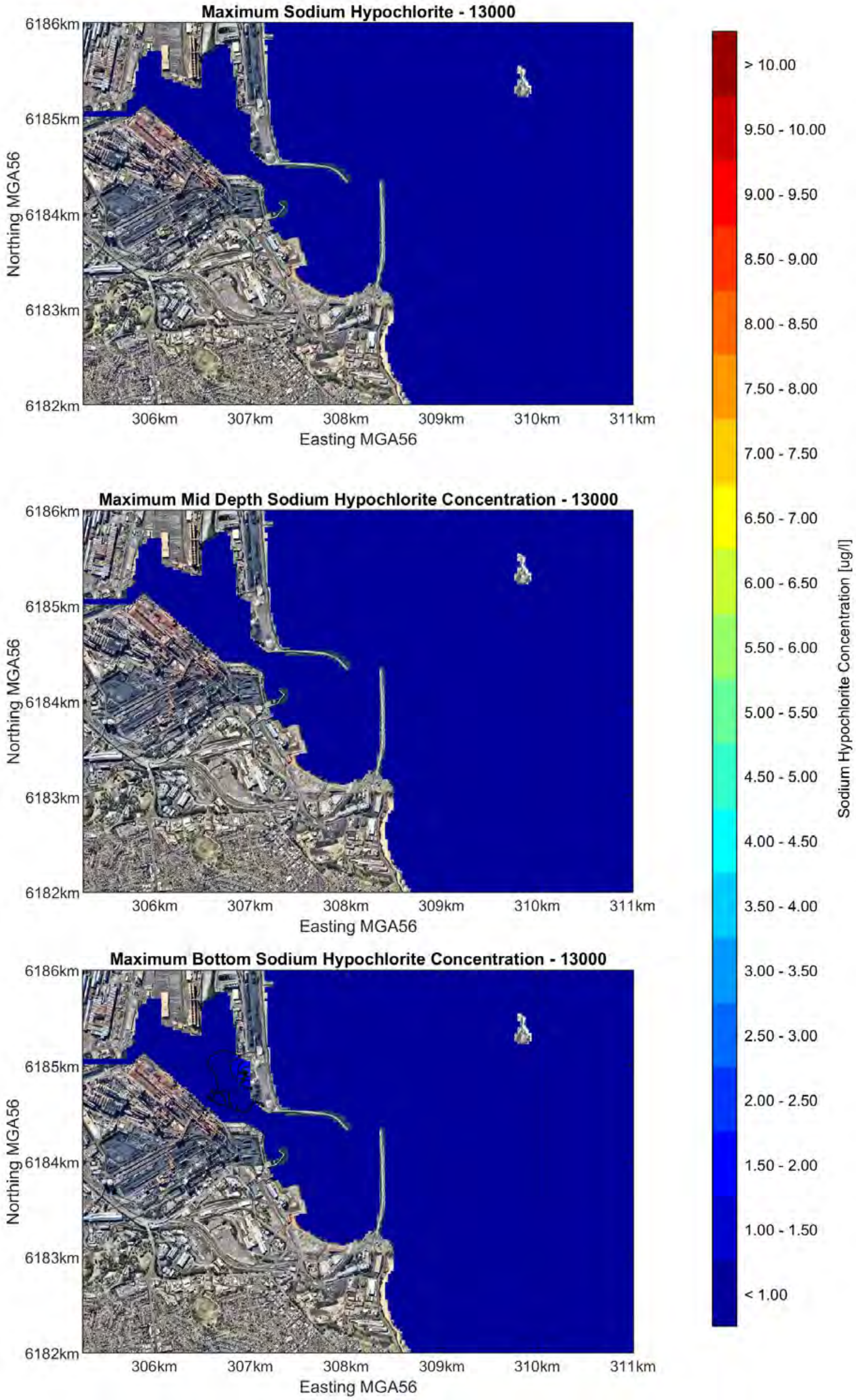

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Port Kembla Regasification Project − Updated Hydrodynamic Plume Modelling

Maximum sodium hyperchloride concentration
13000m^3/hr simulation

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Figure 6.1

About Cardno

Cardno is a professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company listed on the Australian Securities Exchange [ASX:CDD].

Contact

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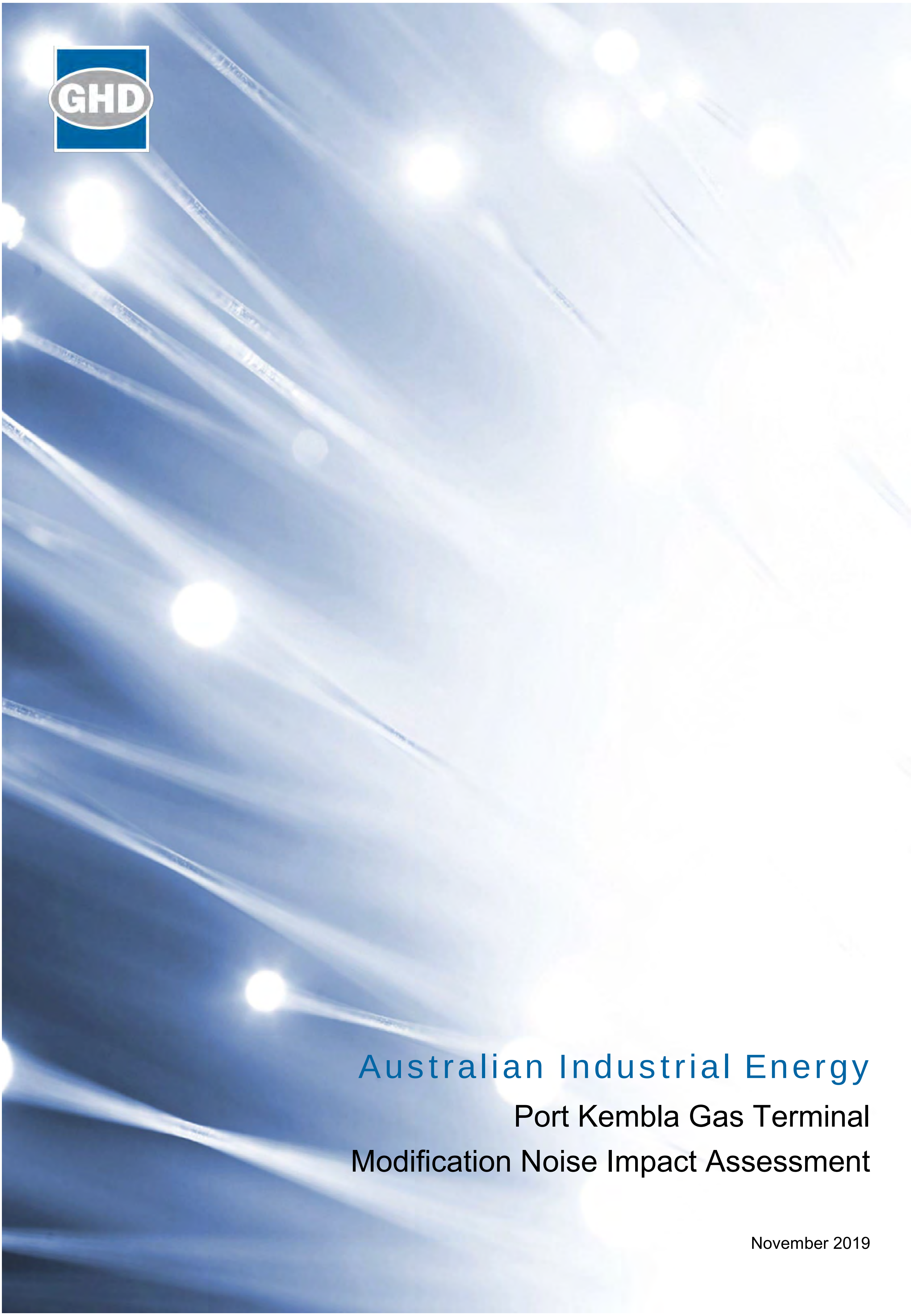
Web Address
www.cardno.com

Appendix C

Noise and vibration assessment



Australian Industrial Energy

Port Kembla Gas Terminal
Modification Noise Impact Assessment

November 2019

Executive summary

Australian Industrial Energy (AIE) proposes to develop the Port Kembla Gas Terminal (the project). The project involves the development of a liquefied natural gas (LNG) import terminal at Port Kembla, south of Wollongong in NSW.

Approval of the project was based upon the development described in the Port Kembla Gas Terminal Environmental Impact Statement (EIS) (GHD 2018) as amended in the Response to Submissions (RTS) (GHD 2019).

Further analysis of market has identified that demand for gas would be seasonally dependant, with higher demand, particularly from retail customers in winter months. This seasonal variation was not considered in the EIS

This noise impact assessment has been prepared to assess the potential operational noise impacts due to the proposed modification to the Port Kembla Gas Terminal to provide for seasonal variations.

Construction noise and vibration and operational traffic noise are expected to remain unchanged from the original approval under SSI 9471 and no changes to the impacts are anticipated and have not been re-assessed in this modification.

An updated operational noise scenario based on worst-case emissions due to seasonal variations in demand was used to assess potential operational noise impacts. Operational noise levels are not predicted to exceed the project noise trigger levels. No modifying factor corrections to the noise are required as the predicted noise levels do not contain tonal or low-frequency noise characteristics.

Operational noise mitigation measures have been recommended and shall be implemented prior to operation of the project.