Perth Seawater Desalination Plant 2

Environmental Review Document

Fresh Water Thinking

Document Information

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Acronyms

Abbreviation	Definition
AMC	Australian Marine Complex
ASS	Acid sulfate soils
BCH	Benthic communities and habitats
BP	British Petroleum
BPP	Benthic primary producer
BTEX	Benze, tolulene, ethylene and xylene
CEMP	Construction Environmental Management Plan
CIP	Clean-in-place
CSMC	Cockburn Sound Management Council
DAF	Development area footprint
DBCA	Department of Biodiversity, Conservation and Attractions
DO	Dissolved oxygen
DOT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environment Regulation
EIA	Environmental impact assessment
EMP	Environmental Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EQC	Environmental quality criteria
EQG	Environmental quality guideline
EQO	Environmental quality objective
EQS	Environmental quality standard
ERD	Environmental Review Document
GIS	Gas insulated switchgear
GRP	Glass reinforced plastic
GWS	Groundwater Scheme
HEPA	High ecological protection area
IMS	Introduced marine species
ISQG	Interim sediment quality guideline
IWSS	Integrated Water Supply Scheme
KBT	Kwinana Bulk Jetty
KIA	Kwinana Industrial Area
LAC	Light attenuation coefficient
LAU	Local assessment unit

Abbreviation	Definition
LEPA	Low ecological protection area
MEPA	Moderate ecological protection area
MEMP	PSDP2 Marine Environmental Management Plan
NAGD	National Assessment Guidelines for Dredging
PAH	Polycyclic aromatic hydrocarbons
PFAS	Polyfluorinated alkyl substances
PRP	Peer Review Panel
PSDP	Perth Seawater Desalination Plant
PSDP2	Perth Seawater Desalination Plant 2
PSDP2A	Perth Seawater Desalination Plant 2 – Stage A (25 GL/a)
PSDP2B	Perth Seawater Desalination Plant – Stage B (25 GL/a)
RO	Reverse osmosis
SAP	Sampling and Analysis Plan
SBS	Safety Bay Sand
SEP	State Environmental Policy
SOP	Standard Operating Procedures
SSDP	Southern Seawater Desalination Plant
TDS	Total dissolved solids
TBT	Tributyltin
TSS	Total suspended solids
WA	Western Australia
WET	Whole of effluent toxicity
WWTP	Wastewater Treatment Plant
ZoHI	Zone of high impact
ZoI	Zone of influence
ZoMI	Zone of moderate impact

Units

Unit	Definition
°C	Degrees Celsius
GL	Gigalitres
GL/a	Gigalitres per annum
kV	Kilo volts
L/d	Litres per day
m	Metre
m^2	Square metre
m^3	Cubic metre
mg/L	Milligrams per litre

ML/day	Megalitres per day
ML/km^2	Megalitres per square kilometre
mm	Millimetre
m/s	Metres per second
m^3/s	Cubic metres per second
MVA	Mega volt amps
MW	Mega watts
pH	Potential of hydrogen (measure of acidity)
ppt	Parts per thousand
PSU	Practical Salinity Unit

Executive Summary

Introduction

Water Corporation is proposing a second desalination plant in Kwinana - Perth Seawater Desalination Plant 2 (PSDP2) - as an additional source of drinking water to supplement the existing metropolitan water supply.

The PSDP2 Proposal will be located within the Kwinana Industrial Area, ~38 km south of the Perth metropolitan area, Western Australia (Figure ES 1). The site identified by the Water Corporation as the location of the PSDP2 desalination facilities is Lot 1864, Riseley Road in Naval Base (Figure ES 2).

Background and context

Water source planning for Perth and the Integrated Water Supply Scheme (IWSS) have had to be adapted to a rapid drying of climate with an even greater reduction in streamflow to metropolitan dams and recharge to our aquifers. In response to this trend, Water Corporation has updated its long-term planning to reflect a future of reduced reliance on regular dam streamflow and is looking at a range of options for the next climate independent water source. Seawater desalination has proved to be an exceptionally reliable and essential source of water for Perth, providing almost half of the IWSS water supply, and are expected to become more important in the future.

The PSDP2 proposal is one of three new water source options considered viable by Water Corporation to supply the IWSS; the remaining two options include a seawater desalination plant at Alkimos and co-located groundwater treatment plant. The PSDP2 Proposal will be constructed on land adjacent to the existing Perth Seawater Desalination Plant (PSDP1) and utilise a reverse osmosis desalination process similar to that used at PSDP1, but that achieves higher recovery.

This Environmental Review Document (ERD) has been prepared in accordance with EPA's instructions on how to prepare an Environmental Review Document to support referral of the Proposal under the Environmental Protection Act 1986 (EP Act). In accordance with section 3.1.3 of the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016, this ERD has been prepared to provide sufficient information for the EPA to assess the Proposal.

Consultation with decision-making authorities (DMAs) has substantially commenced to support the Proposal.

Overview of proposal

PSDP2 will be developed in two 25 GL stages and will be operated independently of the existing PSDP1 (as per Table ES 1), but it is possible that the two stages may be merged to meet supply requirements. Environmental impacts considered in this ERD have been assessed based upon final Stage B potable water production rates (50 GL/a) for winter, spring and summer months, and Stage A rates (25 GL/a) for autumn months.

The concept design for the PSDP2 intake structure, outfall diffuser and pipeline is similar to PSDP1, although PSDP2 is to be developed to function as a standalone asset with limited integration to PSDP1 (Figure ES 2). Clearing, earthworks and the marine infrastructure for the ultimate development footprint will be completed as part of the construction of the first 25 GL stage. Stage B will involve mechanical (including installation of new pumps/replacement of existing pumps, above ground piping, processing equipment and filters), electrical and controls fit out using the civil infrastructure installed as part of Stage A; there will be no additional environmental disturbances associated with the construction of Stage B. The sequence of construction also minimises disruption to surrounding stakeholders as no further earthworks will to be undertaken for the 50 GL/a ultimate plant.

Table ES 1PSDP staged development

Stage	Capacity	Comment
A	25 GL/a SDP	PSDP2 will initially provide 25 GL/a* of potable water to the IWSS and the average seawater intake will be ~180–200 ML/d to produce ~75 ML/d of potable water
B	50 GL/a SDP	The second stage of the Proposal would provide a full production capacity of 50 GL/a* of potable water to the IWSS and the average seawater intake will be ~360–380 ML/d to produce ~150 ML/d of potable water

Notes:

1. The production capacity estimate is based on PSDP2 operations over 335 days per calendar year
2. Annual production may exceed this capacity in the event that fewer non-productive days are utilised during the operational period

The key proposal elements of PSDP2 are outlined in Table ES 2. Unless specified as Stage A or Stage B, maximum plant capacities associated with PSDP2 stage B have been provided.

Table ES 2PDSP2 key characteristics table

Proposal Title	Perth Seawater Desalination Plant 2
Proponent Name	Water Corporation
Short Description	The Water Corporation is proposing to construct and operate the second Perth Seawater Desalination Plant (PSDP2) to be located within the Kwinana Industrial Area. PSDP2 is proposed to be implemented in two 25 GL/a stages of development.
Element	**Description**
General	
Drinking Water Production[1]	Nominal 50GL per year (2 x 25GL Stages)
Power requirement[2] (For ultimate capacity)	174,000 MWh per annum
Clearing of native vegetation	Up to 8 ha
Intake	
Intake Volume[1]	400ML/day
Length[3] (indicative))	320m from intake pump station
Intake Structure Velocity	Maximum velocity 0.15m/sec
Outfall	
Discharge Volume[1]	230ML/day
Length[3] (indicative from outfall tank)	680m
Diffuser (in addition to outfall length)	250 m long linear diffuser containing 40 outlet ports.

Element	Description
Concentrated seawater discharge	
Salinity	Up to 65 000 mg/L

Notes:

1. PSDP2 drinking water production and the intake/outfall volume assumes 335 operational days per calendar year based on ~40% recovery and may vary by 20% depending on membrane performance and maintenance requirements. Annual production may exceed this capacity in the event that fewer non-productive days are utilised during the operational period.
2. The energy requirement assumes plant operation for 24 hours/day producing the maximum drinking water production of the SDP over 335 days per year. This may vary depending on maintenance requirements.
3. Length of intake may be altered during final design depending water quality monitoring and modelling.

This ERD provides supporting information to the EPA to enable it to undertake its assessment under Section 38 of the EP Act. The scope of this ERD provides environmental impact assessment of the following key environmental factors:

- marine environmental quality
- benthic communities and habitats
- marine fauna, and
- coastal processes.

Other environmental factors addressed in this report include:

- terrestrial flora and vegetation
- inland waters
- landforms
- air quality
- social surroundings.

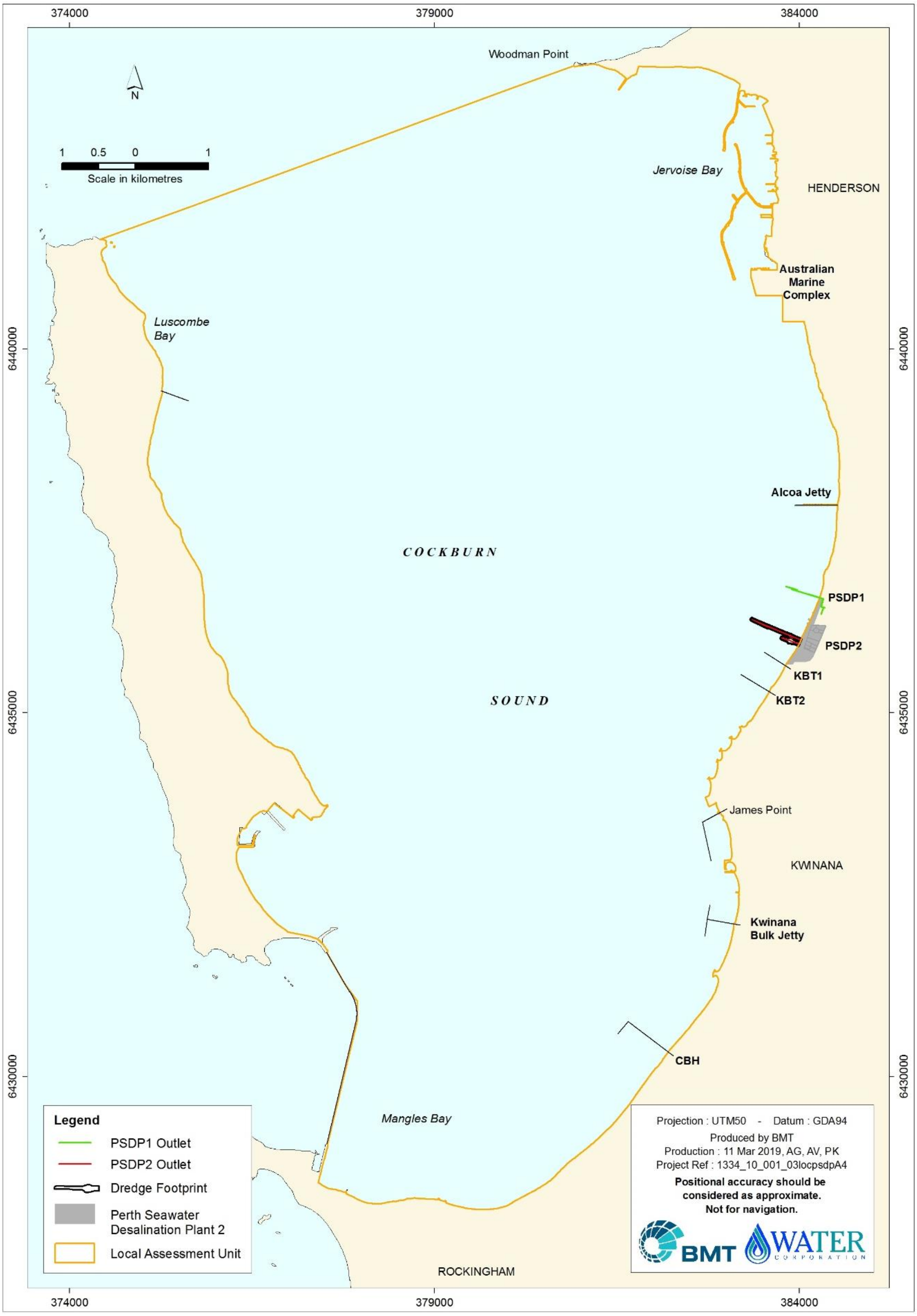


Figure ES 1 PSDP2 Site Location

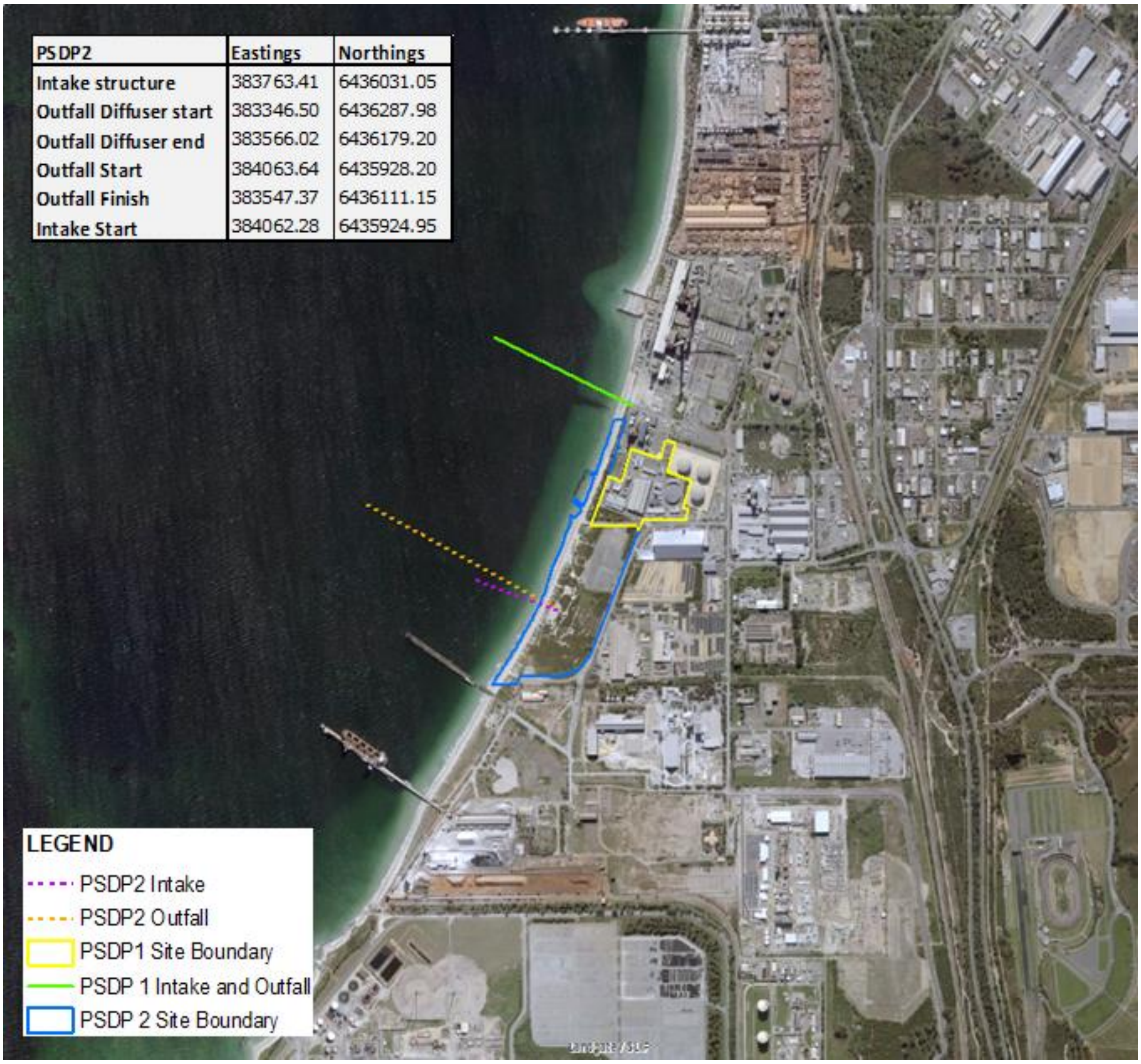


Figure ES 2 PSDP2 Marine Infrastructure

Figure ES 3 Proposed Trench design and layout

Summary of potential impacts, proposed mitigation and outcomes

This document provides information about the existing environment and potential impacts of implementation of the PSDP2 Proposal, in a local and regional context. This ERD explains Water Corporation's management approach to potential impacts for each of the EPA's preliminary key environmental factors identified for the Proposal. A summary of the environmental review is provided in Table ES 3.

Water Corporation has given due regard to the principles of ecological sustainable development of the EP Act and relevant EPA and other environmental guidelines in this assessment.

Water Corporation has used 3D hydrodynamic modelling that has undergone rigorous peer review to underpin impact predictions to the marine environment. Further, Water Corporation has extensive data sets from historic monitoring of the marine environment of Cockburn Sound, as well as proven management practices on which the EIAs were based for Western Australia's existing desalination plants (Southern Seawater Desalination Plant and PSDP1), resulting in a high level of confidence in impact predictions. Where inherent impacts have been assessed as significant, the application of the mitigation hierarchy has resulted in a reduction of potential impacts to a level Water Corporation considers reasonable.

The EIA undertaken by Water Corporation for this Proposal has concluded that for all factors outlined in the environmental scoping document, the EPA objectives can be met and the residual impacts to the environment resulting from the Proposal are not significant. Water Corporation considers that the information and assessment presented in this ERD adequately identifies and addresses environmental impacts relevant to the Proposal and is suitable to enable the EPA to undertake its EIA of the Proposal.

Table ES 3 Summary of Environmental Impact Assessment for Key Environmental Factors

Context	Potential impact(s)	Management and mitigation	Predicted outcomes
Marine quality	**EPA objective:** *to maintain the quality of water, sediment and biota so that environmental values are protected.*		
Cockburn Sound is a unique environment which undergoes natural changes in water quality associated with seasons, daily weather patterns, temporal currents, rainfall and biological events. Historically, nutrient discharges, contaminated land and groundwater inputs and coastal modifications have negatively influenced Cockburn Sound's marine environment leading to declines in marine quality. However, following concerted effort by government, industry and the community over the past two decades, marine water and sediment quality in Cockburn Sound is now considered acceptable when compared against relevant guidelines. The Cockburn Sound SEP establishes five environmental values for Cockburn Sound, all of which are relevant to the factor marine quality and this project: • ecosystem health • fishing and aquaculture • recreation and aesthetics • cultural and spiritual • industrial water supply.	*<u>During construction:</u>* • dredging of the seabed and laydown of rock armour • release of toxicants to the water column due to disturbance of sediments • short-term (3–4 months) flushing of the desalination outlets and intakes during commissioning to remove debris, including grouting materials. Some of the materials are potentially acidic resulting in a low pH discharge. *<u>During operation:</u>* • discharges of brine effluent can potentially enhance the strength of stratification and in turn, promote reduced DO • changes to marine salinity (osmotic stress) • elevated return water temperature (temperature stress) • release of toxicants in brine effluent used in the RO process.	Implementation of a CEMP during construction works Construction management to minimise turbidity and sedimentation will include: • use of a backhoe dredge, to reduce generation of TSS • containment of turbidity from the rest of construction use of silt curtain(s). Implementation of a Sediment Quality SAP in advance of dredging activities to update marine quality within the dredge footprint. Implementation of a MEMP to ensure compliance with EQC defined in EPA (2017) within HEPA and MEPA. Detailed management procedures for brine effluent discharges,	*<u>Outcome(s):</u>* During marine construction works, the Proposal is likely to result in temporary disturbances to water quality by elevating TSS, however, no long-term change is expected. There is not expected to be any impacts (contamination) to marine quality associated with disturbance of sediments through dredging, or during plant commissioning. During plant operations, the Proposal has the potential to slightly enhance the strength of natural patterns in stratification in northern areas of the deep basin, which in turn, may lead to slight reductions (2-3%) in DO relative to background concentrations, on occasions. Similar magnitude differences (relative to background concentrations) were predicted during low DO events, which are prompted by natural climatic events. Such events may lead to EQS being exceeded. An envelope drawn around each seasonal representation to compile a LEPA around both PSDP1 and PSDP2, consistent with the approach in EPA (2016d) has been proposed to manage the small area over which a moderate level of ecological protection cannot be maintained for salinity (within 100 m of each diffuser).

Context	Potential impact(s)	Management and mitigation	Predicted outcomes
			There are not predicted to be any impacts on marine water temperatures because of the Proposal. The comparatively low volumes of chemicals relative to the discharge will be efficiently diluted in the waste stream and further diluted after discharge. *Assessment against EPA objective:* After the application of mitigation measures, the EPA objective for marine quality is expected to be met.
Benthic communities and habitats	**EPA objective:** *to protect benthic communities and habitats so that biological diversity and ecological integrity are maintained.*		
Seagrasses are the dominant benthic primary producer of Cockburn Sound in terms of production and are mainly comprised of species from the genera *Posidonia* and *Amphibolis*. Historically (pre-1950s), Cockburn Sound supported large seagrass meadows that occupied ~4000 ha and covered most of the seabed to depths of 10 m. The extent of seagrass meadows in Cockburn Sound declined severely during the late 1960s and early 1970s due to poor water quality. However, since the 1980s, water quality conditions have improved considerably, and seagrass distribution has stabilised. The most recent estimate of seagrass extent in the assessment area is ~860 ha Benthic macrofauna are an important component of marine and coastal	*During construction:* • direct loss of benthic habitat in the diffuser pipeline corridor due to dredging and rock armour laydown • periods of elevated TSS and reduced light during dredging activities, which in turn may lead to loss of benthic primary producers • release of toxicants to the water column due to disturbance of sediments during dredging • release of toxicants to water column during PSDP2 plant commissioning. *During operation:* • discharges of brine effluent can potentially enhance the strength of stratification and in turn, promote reduced DO leading loss of fauna and fauna	Implementation of a CEMP, which include construction management to minimise turbidity and sedimentation (described above). Implementation of a MEMP which will include management to minimise impacts associated with stressor effects on benthic invertebrate communities.	*Outcome(s):* The construction of the Proposal is unlikely to result in the loss of any BCH. There is no known seagrass that occurs in the dredge footprint, and indirect effects of turbidity on seagrasses are not expected to result in either sublethal or lethal impacts. While it was determined that the operation of the Proposal may have a minor negative effect on DO concentrations and salinity at times, differences from background concentrations were predicted to be minor and within the known physiological tolerances of BCH in the project area. *Assessment against EPA objective:*

Context	Potential impact(s)	Management and mitigation	Predicted outcomes
ecosystems of Cockburn Sound. Studies have shown that over the last 40 years, there have been marked decadal changes in the benthic macrofauna communities between the 1970s and recent years. Differences between times include shifts in species abundances and distribution, as well as community indices such as species diversity. It is probable that modifications to the benthic marine environment, at least in part, explain these shifts	• changes to marine salinity can induce osmotic stress • elevated return water temperature can induce temperature stress • release of toxicants in brine effluent used in the RO process can contaminate marine organisms.		After the application of mitigation measures, the EPA objective for BCH is expected to be met.
Marine fauna	**EPA objective:** *to protect marine fauna so that biological diversity and ecological integrity are maintained.*		
Cockburn Sound supports a wide range of fauna and has significant ecological value because of its utilisation by dolphins, a large range of seabirds, protected migratory birds, and little penguins. The whole of Cockburn Sound is considered significant as a fish nursery/habitat. About 130 species of fish and 14 large crustacean and mollusc species are estimated to exist in Cockburn Sound. While there are 92 Marine Species, 49 Threatened and 58 Migratory species that are listed under the EPBC Act and which may occur near-by the proposed project area, most listed species are not permanent residents and only pass through/over/near the Project the area on occasions, for example during migration, as the area does typically not encompass waters or habitats that are critical to their survival (Bamford 2011 TSSC 2015, 2016, DoEE 2018 x,x).	*<u>During construction:</u>* • dredging of the seabed and rock armour laydown may lead to periods of increased turbidity, elevated TSS, and reduced light during dredging activities, which in turn may lead to: ○ impacts to benthic fisheries and aquaculture ○ loss of benthic communities and associated marine fauna habitat ○ reduction in water quality • presence of construction vessels and activities generating underwater noise which may lead to: ○ disruption to marine fauna migratory or foraging activities ○ changes in marine fauna behaviour • vessel strikes that may cause marine fauna injuries or displacement	Construction management to minimise turbidity and sedimentation will include: • the short duration and the design of the dredging will minimise impact on marine fauna communities • use of a backhoe dredge, to reduce generation of TSS during dredging and backfill activities • containment of turbidity from the rest of construction through use of silt curtain(s) • induction of all construction workers about correct waste management procedures	*<u>Outcome(s):</u>* During construction of the Proposal there will be some temporary elevated TSS and noise associated with dredging. Effects on marine fauna, including fish larvae, are expected to be minimal and will be managed under an appropriate CEMP that includes fauna observation protocols for whales, dolphins, little penguins, sea lions and turtles during dredging. While it was determined that the operation of the Proposal may have a minor negative effect on marine quality (DO concentrations and salinity) at times, differences from background concentrations were predicted to be minor and well within the known physiological tolerances of fish, in the project area. The proportion of pink snapper larvae entrainment was determined to be

Context	Potential impact(s)	Management and mitigation	Predicted outcomes
	• dredging plant and construction vessels impacting local biodiversity through introduction of non-indigenous marine species (introduced marine species; IMS) to the area. *During operation:* • intake of feed water for desalination, which may lead to: ○ entrainment of zooplankton/larvae ○ entrainment of resident fauna • release of brine into Cockburn Sound, which may lead to: ○ decreasing water quality through stratification, salinity, temperature or chemicals loss of benthic communities and associated marine fauna habitat.	• implementing strict environmental management standards for the Proposal during construction, including handling procedures for hazardous substances. Sheet piling used to temporarily maintain onshore trench integrity during construction will be installed using vibratory hammers, which minimise harmful underwater noise. The dredge contractor will ensure that: • any equipment or vessels are either new, or have been thoroughly cleaned, dried for >24 hours, and inspected prior to being deployed • report the presence of any suspected marine pests to FishWatch (1800 815 507).	negligible relative to the total number of eggs that are released each year, and no effects on snapper stocks are predicted. Snapper larvae can be used as a proxy for entrainment of larvae of other marine fauna; it therefore is assumed that the overall potential of adverse impacts due to entrainment of marine larvae, is negligible. *Assessment against EPA objective:* After the application of mitigation measures, the EPA objective for marine fauna is expected to be met.
Coastal processes	**EPA objective:** to maintain the geophysical processes that shape coastal morphology so that the environmental values of the coast are protected.		
The coastal zone in Cockburn Sound is highly valued for its aesthetic, cultural, social and recreational values; as well as being important for commercial infrastructure and facilities.	*During construction:* • dredging and shore-crossing activities may result in a disruption to local coastal processes, which may subsequently result in changes to erosion/accretion patterns, and/or an	Implementation of a Marine CEMP The use of buried infrastructure minimises any change in sediment transport and erosion/accretion zones.	*Outcome(s):* The Proposal is likely to result in temporary disturbances to local nearshore sediment transport, coverage of dune vegetation and public beach access;

Context	Potential impact(s)	Management and mitigation	Predicted outcomes
The beach is in the immediate area of the PSDP2 Proposal is classified as a low-energy, wave-dominated, reflective system. This beach receives slightly higher swell wave energy than James Point (i.e. the beach to the south), and typically maintains a narrow, attached bar. The beach is backed by a dune system of varied width. There is no foreshore reserve along Barter Road Beach, with the land to the low water mark owned by Water Corporation; this beach is within the Kwinana Strategic Industrial Area. This effectively makes the beach private property, however, there has been no formalisation of no-go zones by the Kwinana Town Council and this beach is informally used by public.	interruption to longshore sediment transport • construction of shore-crossing involves the removal of dune vegetation, which may result in enhanced erosion • restricting public use of the beach during construction works, which may result in a reduced public amenity of the area.	Design is based on only a temporary disturbance to the primary dune system. Primary dune will be back-filled and revegetated once construction works completed. The use of buried infrastructure through the coastal zone minimises the need for any long-term restriction to public access or change in beach usage	however, no long-term change to any of these elements is expected to occur. *Assessment against EPA objective:* After the application of mitigation, the EPA objective for coastal processes is expected to be met.

1. Introduction

1.1 Purpose and scope of the Environmental Review Document

The purpose of this Environmental Review Document (ERD) is to present an environmental review of a proposal to build and operate a second desalination plant in Cockburn Sound (the Proposal). The review includes a detailed description of the key components, potential environmental impacts and proposed environmental management measures.

This ERD describes the specific studies and investigations conducted by the Proponent in relation to the key environmental factors identified by the Proponent through consultation and screening processes. The objectives of the reviews and additional studies and investigations are to:

- ensure that the full environmental effects of the Proposal are properly understood
- inform mitigation and optimal management controls
- enable a reliable and knowledge-based environmental impact assessment (EIA) to be conducted.

1.2 Proponent

The Proponent for the Proposal is Water Corporation. Water Corporation is the principal supplier of water, wastewater and drainage services to over two million people throughout metropolitan Perth and Western Australia (WA).

The Proponent's details are:

Water Corporation

629 Newcastle St, Leederville WA 6000

ABN: 28 003 434 917

The key contact for this Proposal is:

Bree Atkinson

Water Corporation

629 Newcastle St, Leederville WA 6000

T: (08) 9420 2893

bree.atkinson@watercorporation.com.au

1.3 Environmental impact assessment process

The *Environmental Protection Act 1986* (EP Act) is the primary legislative instrument for environmental assessment in WA. It specifies procedures for assessment and appeal processes, including responsibilities and functions of the WA Minister for Environment and the Environmental Protection Authority (EPA). Under Part IV of the EP Act, the EPA is responsible for providing advice to the Minister for proposals assessed under part IV of the EP Act and considered by the EPA as likely to have a significant impact on the environment.

This ERD has been prepared in accordance with EPA's instructions on how to prepare an Environmental Review Document (EPA 2018a) to support referral of the Proposal under the EP Act. In accordance with section 3.1.3 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016*, this ERD has been prepared to provide sufficient information for the EPA to assess the Proposal.

Consultation with decision-making authorities (DMAs) has substantially commenced to support the Proposal.

1.4 Other approvals and regulation

1.4.1 Tenure

The Proposal occurs on land (Lot 1864, Riseley Road) owned by Water Corporation, and is within the Kwinana Strategic Industrial Area. This area is zoned as industrial under the City of Kwinana's Town Planning Scheme and the Department of Planning, Lands and Heritage's Metropolitan Region Scheme.

The land is owned freehold and is therefore not subject to Native Title.

1.4.2 Decision-making authorities

The authorities listed in Table 1.1 have been identified as the key decision-making authorities for environmental aspects of the Proposal. Other Decision-Making Authorities may be identified by the EPA through the referral and assessment process.

Table 1.1 Key decision-making authorities relevant to the Proposal

Decision-making authority	Relevant legislation
Western Australia	
Minister for Environment	*Environmental Protection Act 1986* (Part IV)
	Wildlife Conservation Act 1950
	Biodiversity Conservation Act 2016
Department of Water and Environmental Regulation	*Environmental Protection Act 1986* (Part V)
Department of Planning, Lands and Heritage	*Planning and Development Act 2005*
Department of Primary Industries and Regional Development (Fisheries)	*Fisheries Act 1905*
Chief Health Officer, Department of Health	*Health Act 1911*
Department of Transport	*Marine & Harbours Act 1981*
Commonwealth	
Department of the Environment and Energy (Commonwealth)	*Environment Protection and Biodiversity Conservation Act 1999*

1.4.3 Other approvals required

Following primary environmental approval of the Proposal under the EP Act (Part IV) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a number of other approvals will be required to construct and operate the Proposal of which the most complex are listed in Table 1.2. Other approvals may be identified through the referral and assessment process.

Table 1.2 Key Secondary approvals relevant to the Proposal

Proposal activity	Type of approval	Legislation regulating the activity
Environmental		
Construct a licenced premise	Works approval	*Environmental Protection Act 1986* (Part V)
Operate a licenced premise	Licence (part V)	
Vegetation clearing	Native vegetation clearing permit (if not assessed under part IV)	
Undertake banned works during total fire ban	Fire Ban Exemption	*Bush Fires Act 1954*
Storage of goods classified as dangerous goods during construction and operation	Licence	*Dangerous Goods Safety Act 2004*
Other		
Pre-requisites to Works		*Water Services Act 2012*
Construction of industrial structures	Building permit	*Building Act 2011*
Development within the City of Kwinana	Development application	*Planning and Development Act 2005*
Road closure	Section 58 approval	*Land Administration Act 1997*
Works affecting various utility provides (e.g. Western Power, Telstra, etc.)	Notifications	Various

2. Water Source Planning and Context

2.1 Water source planning

Water source planning for Perth and the Integrated Water Supply Scheme (IWSS) have had to be adapted to a drying climate over the past 40 years. Perth has seen a rapid drying of climate with an even greater reduction in streamflow to metropolitan dams and recharge to our aquifers. The 2017 and 2018 streamflows, combined with maximised source production, have resulted in contingency storage levels in dams expected to be sufficient for more than the next five years however, in a zero inflow scenario the next source will be required sooner. The next new source is currently expected to be required in 2028 to allow for increased demand as a result of the ongoing effects of climate change in south west Australia, increasing population with the metropolitan area and potential for a reduction in the Gnangara mound allocation.

From 2001, Water Corporation has invested over $2.2 billion in projects to build a more climate resilient water supply scheme for Perth.

Water Corporation developed a ten year water supply plan for Perth, *Water Forever – Whatever the Weather* (2011), which includes a number of climate independent initiatives. Water Corporation is over half-way through implementing the plan, but the climate has been drying faster than anticipated (although 2017 and 2018 were a welcome relief from the persistent decline in water resource availability) so these initiatives have been accelerated:

- transferring our groundwater abstraction to less sensitive locations, including the deeper aquifers, to protect groundwater dependent ecosystems
- replenishing deep aquifers with recycled water through a new groundwater replenishment scheme
- expanding seawater desalination capacity to offset impacts on the Gnangara groundwater system and the declining streamflow to our dams; and
- continuing to make gains in water use efficiency, while preserving our outdoor lifestyle and enabling continued growth of the city and state using wastewater recycling as a resource for industry, public open spaces and agriculture.

Increasing water use efficiency is an attractive option to keep demand low so that new water sources can be deferred. Consequently in 2018 Water Corporation committed to achieving a new water use target of 110 kL/p/yr in 2030, down from the current 125 kL/p/yr. Intensive study of water use behaviour commenced in 2018 via a study called H_2OME to identify where additional water use efficiencies could be made, noting that the easiest targets for significant reductions in per capita use have already been made.

With a trend towards a drying climate and very low streamflow reaching Perth's drinking water dams in recent years, the soil in the dams' catchments has dried out to such an extent that above average rainfall is needed, year on year, to make a major difference to the levels of our dams. For this reason, Water Corporation has updated its long-term planning to reflect a future of reduced reliance on regular dam streamflow, and is looking at a range of options for the next climate independent water source.

The main new sources under investigation for the IWSS are seawater desalination and groundwater replenishment. Water Corporation's first groundwater replenishment scheme is in the process of being expanded to deliver up to 28 GL per year, which is the current full capacity of the existing site (Beenyup). Water Corporation intends to obtain several years of experience with this first scheme before electing to expand groundwater replenishment to another wastewater treatment plant site. Investigation and design work required to implement further groundwater replenishment will also take several years to complete, so the best short-term option for a new major new drinking water source for Perth is seawater desalination.

Seawater desalination has proved to be an exceptionally reliable and essential source of water for Perth, providing almost half of the IWSS water supply. Desalination sources are expected to become more important in the future.

2.2 Timing for the next major water source

The 2017 and 2018 streamflows, combined with maximised source production, have resulted in contingency storage levels in dams sufficient for more than the next five years. The next new source is expected to be required in 2028 to allow for increased demand and a possible reduction in the Gnagara groundwater allocation.

The driver for the next source decision is based on dam storage (having sufficient contingency available) and on annual reliance on dam storage. If a groundwater allocation reduction does not eventuate or is relatively small and if the conservative streamflow forecast (75^{th} percentile streamflow that should be exceeded three out of four years) is consistently achieved over the next ten years, the next new source is expected to be required in 2028 to minimise reliance on dam storage. If larger streamflow volumes occur in the intervening period, it may be possible to defer the next new source.

2.3 Alternatives considered

2.3.1 Alternate water sources

In 2016, as part of the Corporation's Dry Season Response activities, a review of water source options for the IWSS was completed which covered a range of water source portfolios: upgrade of existing seawater desalination plants; new seawater desalination plants; new groundwater schemes; and groundwater replenishment (recycling).

A multi-criteria assessment (MCA) process was developed and applied across the water source options to evaluate options across the portfolios on a consistent basis and rank the water source options for priority within a source development program. To ensure a comprehensive and balanced approach to option assessment, the MCA comprised technical and design criteria, economic criteria, environmental criteria, social criteria and approvals and land matters criteria.

As a result of the source portfolio assessments, the water source options selected for initial priority and investigation within a source development program for the IWSS included:

- Alkimos SDP
- PSDP2
- Eglinton Groundwater Scheme (GWS)

While further groundwater replenishment at Woodman Point Wastewater Treatment Plant (WWTP) and Subiaco WWTP also scored favourably within the MCA, the timeline for investigation and delivery of these source options remains under review and presents significant risk in the event of requiring to fast-track source delivery. In addition, the first full scale GWS at Beenyup was not yet operational and it was desirable to see this scheme operating successfully before additional schemes were progressed. As a result, these options were ranked lower on the priority list of sources at the time of completing the options assessment in 2016. Water Corporation recognises that having a number of source options to consider provides greater flexibility for future source decisions and investigations into alternative source options remains ongoing at this time.

2.3.2 Desalination plant location options

Potential locations for new seawater desalination sources to the north and south of Perth have been part of the Corporation's long-term planning and were published in the Corporation's planning strategy document *Water Forever (2009)*.

Since 2008, twelve new potential desalination plant sites along the coast have been considered by the Water Corporation and its consultants over three separate studies. The sites extend from Lancelin to Binningup and were compared using multiple criteria, broadly categorised as:

- cost (capital and operating)
- environmental
- social
- technical feasibility
- water quality
- integration and demand
- deliverability
- land ownership and access
- local planning
- approvals
- water source security.

The latest of the planning studies evaluating siting options for the next seawater desalination plant was completed in 2015/16, with two preferred sites emerging – one in the north and one in the south of the Perth metropolitan area. These sites are Alkimos and Kwinana, and they provide the best overall options for the next seawater desalination site.

Detailed investigations into the Alkimos and Kwinana options are now complete. The investigation projects have refined numerous aspects of the project proposals, including scope, concept design and estimated cost, and brought clarity to key project delivery challenges including subsurface geology and ocean modelling, specific pipeline routes, flora and fauna considerations, and approval processes. Approvals will be sought for both projects in parallel to maintain flexibility in the selection of a preferred option for project delivery.

The Kwinana SDP option was selected as one of two preferred desalination plant options as it is well located to be easily integrated into the Water Corporations existing water supply system. The site for the Perth SDP is currently owned by Water Corporation.

2.4 Known developments in Cockburn Sound

The Corporation is aware of concept plans for further development projects in Cockburn Sound including a potential future port and associated shipping channels.

The Corporation has undertaken preliminary work to understand the potential implications of these developments on existing and future potential assets. When further detailed design information is released the Corporation is committed to working with the proponents to understand the potential cumulative impacts of future developments.

The following industrial discharges and developments as per the EPA's spatial dataset were incorporated into the modelling to ensure the consideration of cumulative impacts associated with the PSDP2 Proposal:

- PSDP1
- Kwinana Power Station
- Newgen Kwinana Gas Fired Power Station
- Cockburn Power Station
- British Petroleum (BP) refinery
- Tiwest.

To the best of the Water Corporations knowledge there are no other proposed developments that potentially effect this Proposal.

3. The Proposal

3.1 Proposal description

Water Corporation is proposing a second desalination plant in Kwinana, Perth Seawater Desalination Plant 2 (PSDP2) as an additional source of drinking water to supplement the existing metropolitan water supply. The PSDP2 Proposal will be located within the Kwinana Industrial Area (KIA), ~38 km south of the Perth metropolitan area (Figure 3.1).

PSDP2 will be constructed on land adjacent to the existing Perth Seawater Desalination Plant (PSDP1) and utilise a reverse osmosis desalination process similar to that used at PSDP1, but that achieves higher recovery. The site identified by the Water Corporation as the location of the PSDP2 desalination facilities is Lot 1864, Riseley Road in Naval Base (Figure 3.2).

PSDP2 will be developed in two 25 GL stages and will be operated independently of the existing PSDP1 (as per Figure 3.3), but it is possible that the two stages may be merged to meet supply requirements. Marine works will be completed as part of the construction of stage A to an ultimate capacity of 50 GL/a. Environmental impacts considered in this ERD have been assessed based upon final Stage B potable water production rates.

The layout of the Proposal is shown in Figure 3.4. Clearing, earthworks and the marine infrastructure for the ultimate development footprint will be completed as part of the construction of the first 25 GL stage. Stage B will involve mechanical (including installation of new pumps/replacement of existing pumps, above ground piping, processing equipment and filters), electrical and controls fit out using the civil infrastructure installed as part of Stage A; there will be no additional environmental disturbances associated with the construction of Stage B. The sequence of construction also minimises disruption to surrounding stakeholders as no further earthworks will to be undertaken for the 50 GL ultimate plant.

Table 3.1 PSDP staged development

Stage	Capacity	Comment
A	25 GL/a SDP	PSDP2 will initially provide 25 GL/yr* of potable water to the IWSS and the average seawater intake will be ~180–200 ML/d to produce ~75 ML/d of potable water
B	50 GL/a SDP	The second stage of the Proposal would provide a full production capacity of 50 GL/yr* of potable water to the IWSS and the average seawater intake will be ~360–380 ML/d to produce ~150 ML/d of potable water

Notes:

1. The production capacity estimate is based on PSDP2 operations over 335 days per calendar year
2. Annual production may exceed this capacity in the event that fewer non-productive days are utilised during the operational period

Minor upgrades to existing pipeline infrastructure are required to integrate a second desalination plant into the IWSS; as such, the Corporation will seek approvals separately for any minor integration asset requirements.

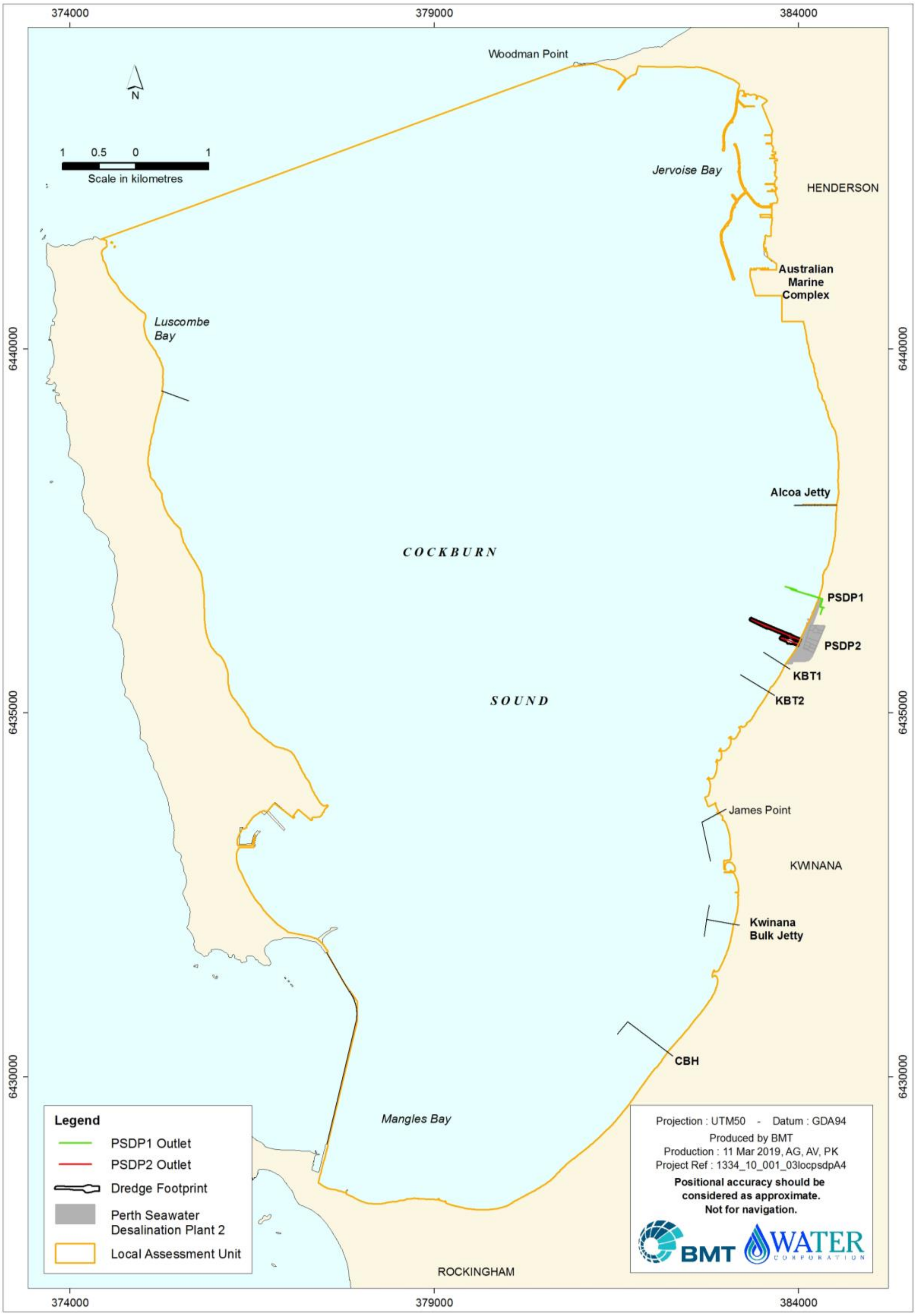


Figure 3.1 PSDP2 site location

Figure 3.2 Location of proposed PSDP2 site: Lot 1864, Riseley Street, Kwinana

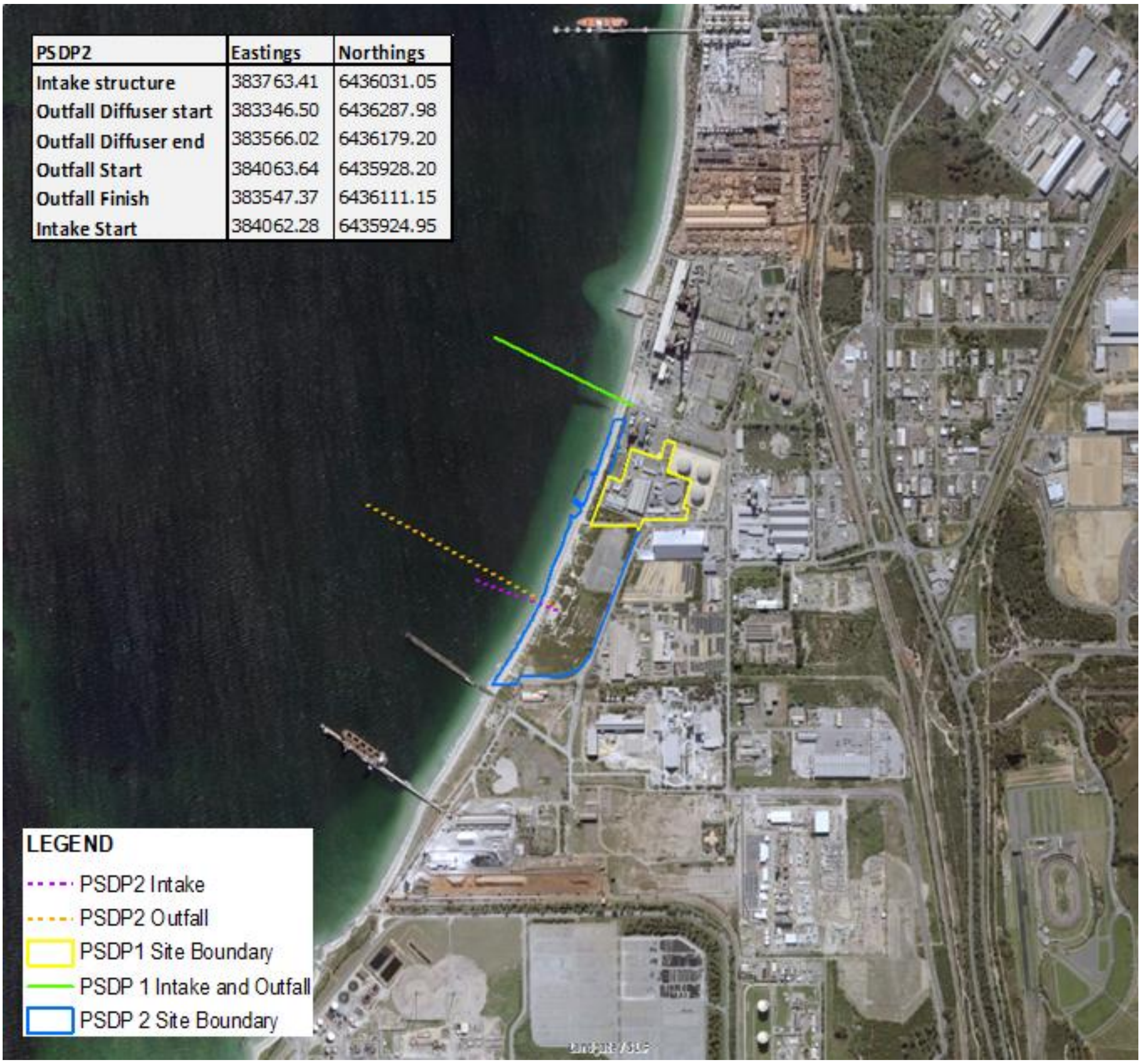


Figure 3.3 PSDP2 marine infrastructure

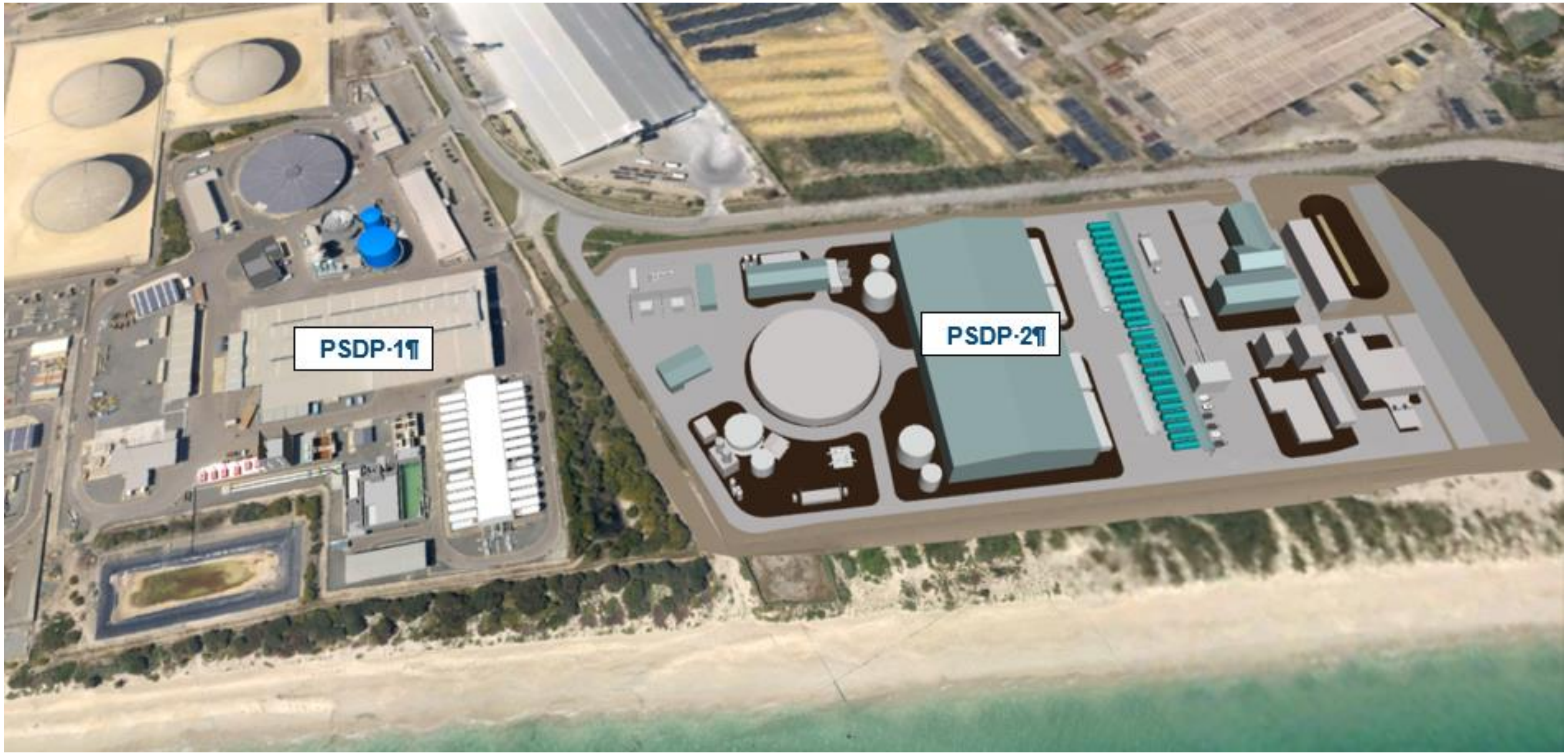


Figure 3.4 Conceptual site layout (subject to change)

3.1.1 Development area footprint

The Development Area Footprint (DAF) designates the area over which the EIA is based for the PSDP2 Proposal and comprises two elements:

- PSDP2 site – which covers an area of approximately 12.83 ha within the within KIA (Figure 3.2)
- Marine infrastructure – which requires dredging that covers an area of 6.29 ha (as shown in Figure 3.9 in Section 3.2.2).

3.2 Proposal elements

The development of PSDP2 will facilitate the increase in production capacity within the Water Corporation's IWSS. PSDP2 will require the construction and operation of new intake and outfall pipelines. The configuration of the additional marine pipelines is shown in Figure 3.3 (and described in detail in Section 3.2.2). The concept design for the PSDP2 intake structure, outfall diffuser and pipeline is similar to PSDP1, although PSDP2 is to be developed to function as a standalone asset with limited integration to PSDP1.

The key Proposal elements of PSDP2 are outlined in Table 3.2. Unless specified as Stage A or Stage B, maximum plant capacities associated with PSDP2 stage B have been provided and assumed for the EIA.

Table 3.2 PSDP2 key characteristics table

Proposal Title	Perth Seawater Desalination Plant 2
Proponent Name	Water Corporation
Short Description	The Water Corporation is proposing to construct and operate the second Perth Seawater Desalination Plant (PSDP2) to be located within the Kwinana Industrial Area. PSDP2 is proposed to be implemented in two 25 GL/a stages of development.

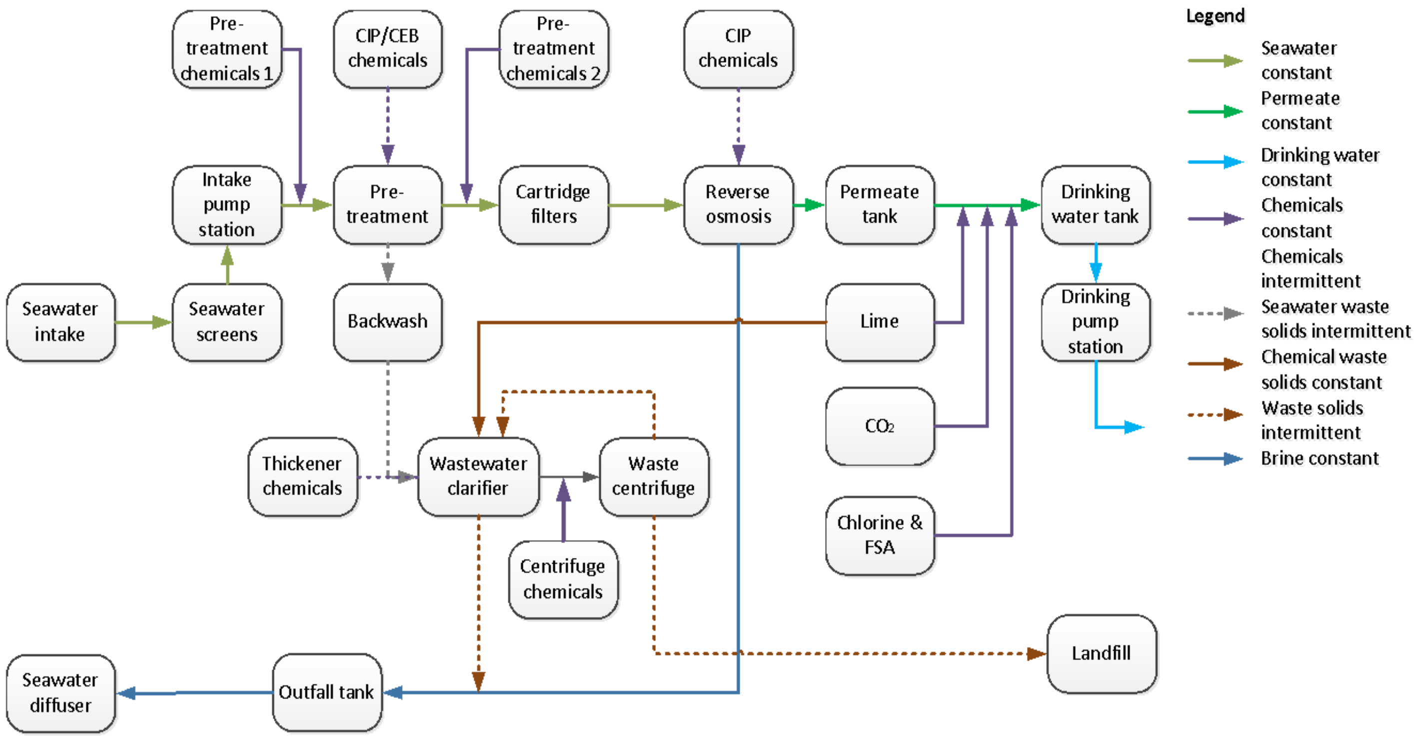
Element	Description
General	
Drinking Water Production	Ultimate 50GL per year1 (2 x 25GL Stages)
Power requirement (For ultimate capacity)	174,000 MWh per annum[2]
Clearing of native vegetation	Up to 8 ha
Intake	
Intake Volume	400ML/day
Length (indicative from intake pump station)	320m
Intake Structure Velocity	Maximum velocity 0.15m/s
Outfall	
Discharge Volume	230ML/day
Length (indicative from outfall tank)	680m
Diffuser (in addition to outfall length)	250m long linear diffuser containing 40 outlet ports.
Concentrated seawater discharge	
Salinity	Up to 65 000 mg/L

Note:

1. PSDP2 drinking water production and the intake/outfall volume assumes 335 operational days per calendar year based on ~40% recovery and may vary by 20% depending on membrane performance and maintenance requirements. Annual production may exceed this capacity in the event that fewer non-productive days are utilised during the operational period.
2. The energy requirement assumes plant operation for 24 hours/day producing the maximum drinking water production of the SDP over 335 days per year. This may vary depending on maintenance requirements.
3. Length of intake may be altered during final design depending water quality monitoring and modelling.

3.2.1 PSDP2 seawater desalination process overview

The desalination process for this project is similar to the reverse osmosis (RO) system used in PSDP1 with potential changes in pre-treatment and the RO system to optimise performance and system performance. The RO process involves the pre-treatment of seawater (removal of particulates using physical filtration and chemical treatment) and then pressurising it over an RO membrane so that freshwater is driven through and higher salinity seawater is left behind (Figure 3.5). The concentrated seawater stream is then discharged back to the sea, while the freshwater stream will undergo further treatment processing to ensure it is of a standard fit for drinking and meets drinking water quality specifications (Figure 3.5).



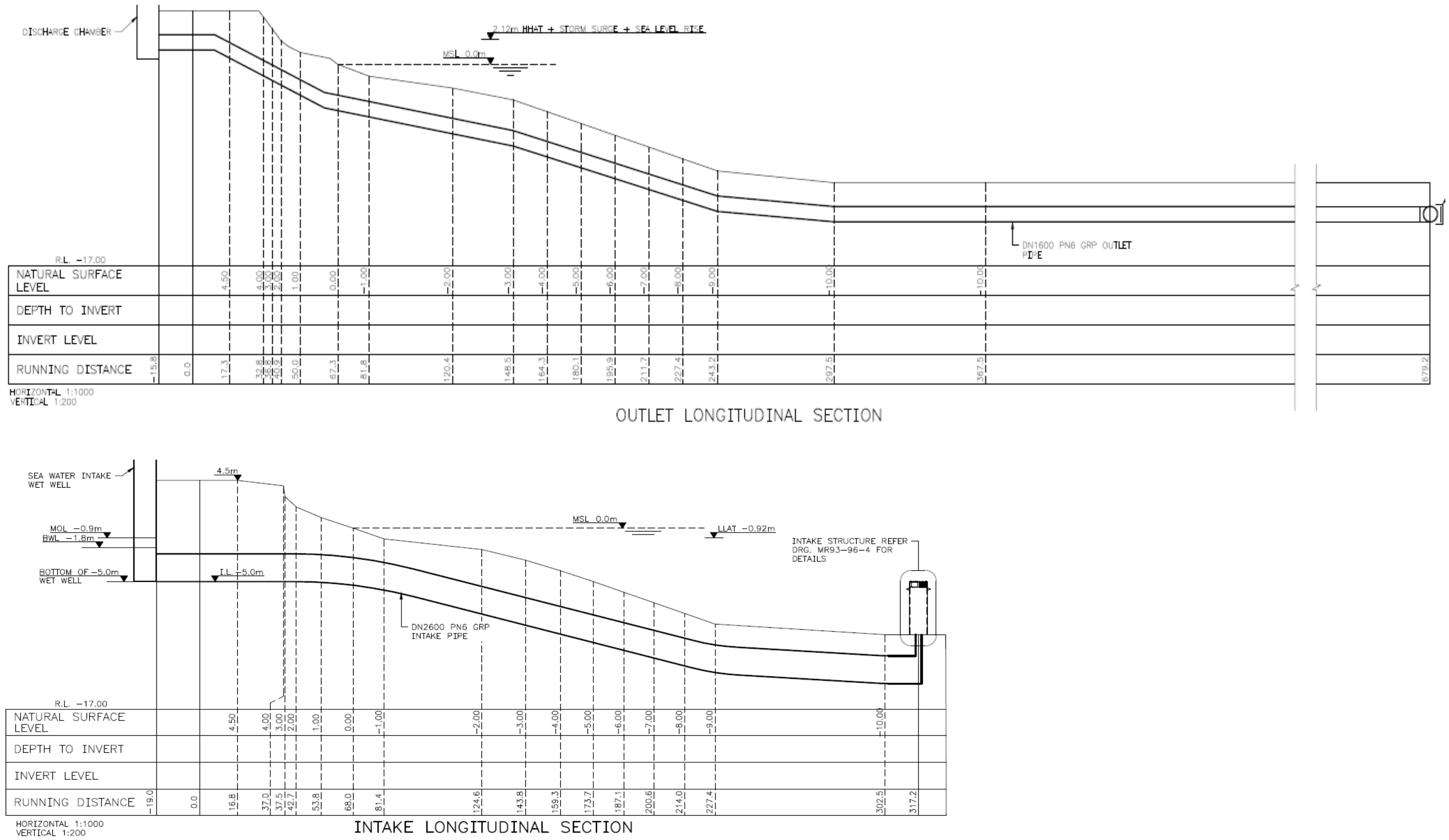
Note:
1. CEB = Chemical enhanced backwash, CIP = Clean-in-place, FSA = Fluorosilicic acid, CO_2 = Carbon dioxide

Figure 3.5 Seawater desalination process stream

3.2.2 Marine construction and arrangement

Offshore arrangement (general description)

The orientation of the intake pipeline will be slightly angled to the coastline to allow the outfall to be located in water at least 10 m deep. The intake and outfall pipeline will be installed using a cut and cover method and lie in separate trenches, as shown in Figure 3.6. The intake and outfall will be separated by a distance of ~246 m, with the outfall located further from shore.



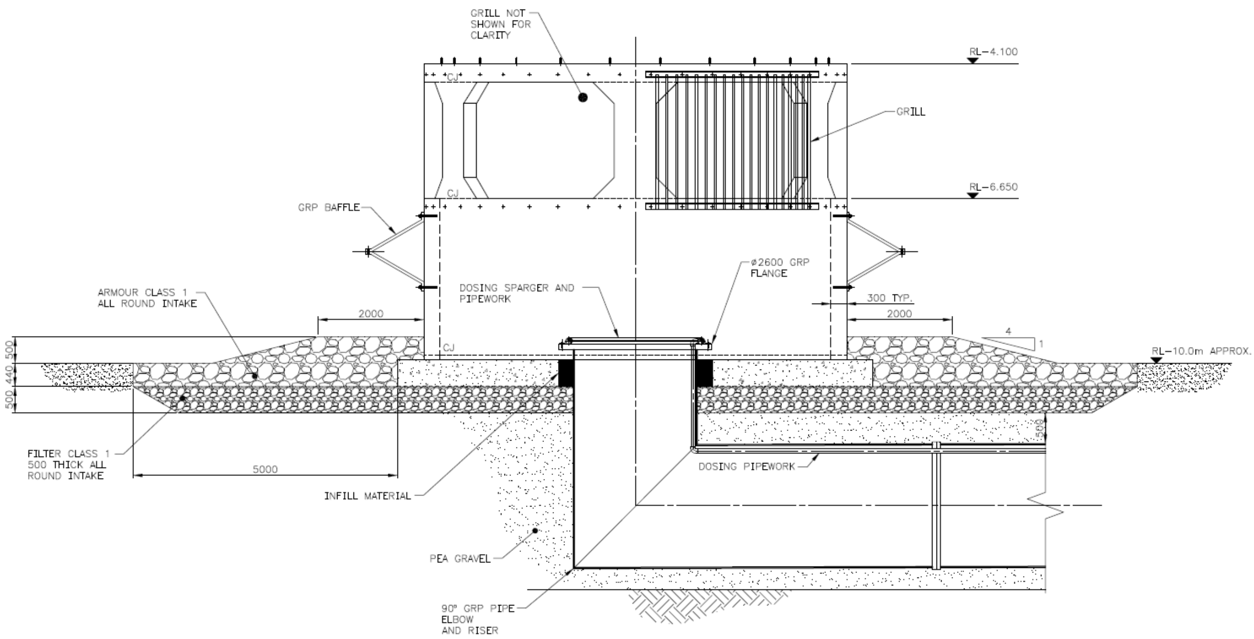
Note:

1. Pipeline and diffuser are subject to final design

Figure 3.6 Offshore intake (bottom) and discharge pipelines (top) – longitudinal sections

Seawater intake

The seawater intake will be located in water ~10 m deep and positioned ~250 m from shore. The intake will consist of a concrete structure (Figure 3.7) configured to place the intake grills at ~5 m depth to strike a balance between maintaining water quality but preventing a navigational hazard. A glass reinforced plastic (GRP) baffle will be installed to deflect stirred sediments away from the intake grill. The approach velocity of the intake grills is limited to 0.15 m/s (after marine fouling allowance) to avoid impingement of fish.



Note:
1. Intake is subject to final design

Figure 3.7 Proposed seawater intake structure

Pipeline

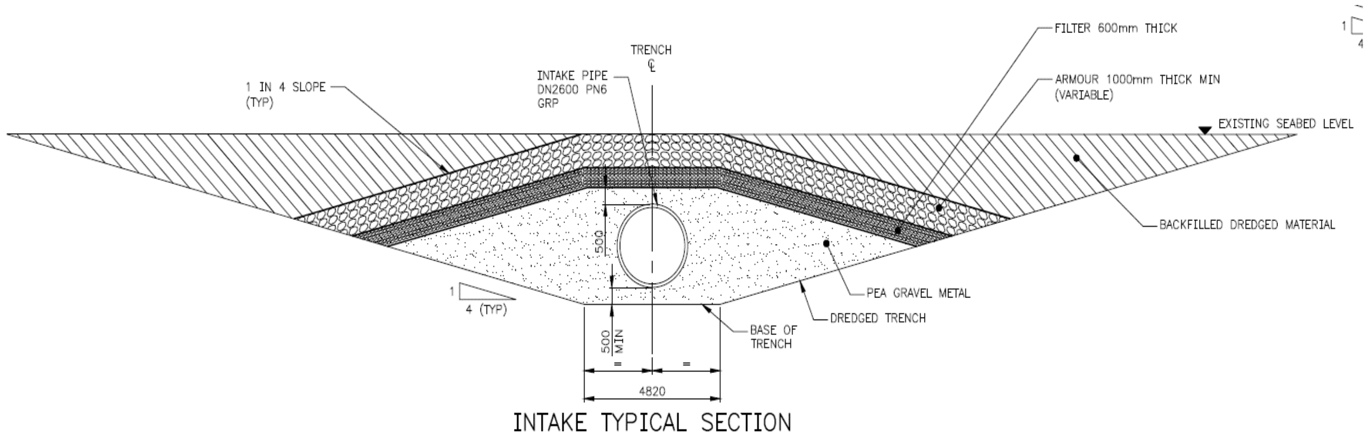
A commercially available GRP pipe is assumed for the purposes of concept design to provide a maximum of 0.15 m/s velocity with an allowance for a 33% occlusion of marine growth on the inside face of the pipeline. Experience with PSDP1 indicates that marine growth (primarily mussels) is naturally limited to approximately 250 mm in thickness and will fall off due to self-weight beyond this thickness. Therefore, 'oversizing' the pipe is preferred to super-chlorination of the intake pipeline as it avoids the need to collect and dispose of this biomass in large quantities.

Trench design and construction

To ensure the protection and structural integrity of the pipeline the intake and discharge pipelines will be buried below the seabed. Burying the pipeline additionally avoids impact on the shoreline erosion and coastal sediment transport and also provides structural integrity to the pipe structure. Rock protection will be required to avoid damage to the pipes due to dragging boat anchors. The top of the rock layer is set to be at the existing seabed level. Rock protection will consist of a primary layer, an under layer followed by some small pea gravel for general pipeline backfill purposes.

The construction sequence is likely to involve:

- dredging of the offshore pipeline trenches using a backhoe dredge and silt curtains to minimise dispersion of sediment
- excavation of the onshore pipeline trenches which may require temporary protection using bunds/sheet piles, etc
- fabrication of large sections of GRP pipe as subassemblies. Sections will then be towed out by two or three tugs offshore to the site. The GRP pipe is likely to be sealed for flotation and have buoyancy aids during the offshore transport
- positioning of the pipe over the trench and held using land winch and offshore tugs
- sinking of the pipe into the sea-bed trench by flooding and guidance by divers
- assembly of the pipeline sections by divers
- fabrication of the intake structure onshore and floating of the intake structure or barge transported to its intended location and positioned at its final location
- placing of the filter and rock armour to surround the pipe, using construction barges once the sinking operation is completed. A split barge will be used to place first an under layer. Armour is likely to be placed using GPS enabled cranes/grabs
- placement of onshore sections and connection to the offshore pipes
- installation of navigational aids and protection of the onshore elements
- removal of temporary works and testing of the pipes.



Notes:

1. Intake and outfall trench profile is subject to final design
2. Intake and outfall pipelines will be located in separate trenches, although trench profiles are the same

Figure 3.8 Intake and outfall trench profile

Table 3.3 Pipeline trench characteristics

Element	Nominal quantity
Length	~679 m
Depth	~4 m (below seabed surface)
Width: Surface Bottom	 ~20 m ~ 8 m
Volume excavated	~180,341 m^3
Duration: Dredging Backfill	 ~ 97–126 days ~93–121 days

Notes:

1. Pipeline trench characteristics are subject to final design and confirmation of construction methodology.
2. Duration assumptions are based on use of a backhoe dredge; ranges are based on high to low production rates, respectively (Appendix A)

Note:

1. Trench design and layout is subject to final design, but indicative of the marine-side development area footprint

Figure 3.9 Trench design and layout

Outfall diffuser and pipeline

The brine effluent will be discharged by pipeline to the sea through a specifically designed diffuser array. The pipeline would be buried with adequate protection against exposure and impact, and risers would terminate ~1 m above the seabed (Figure 3.10).

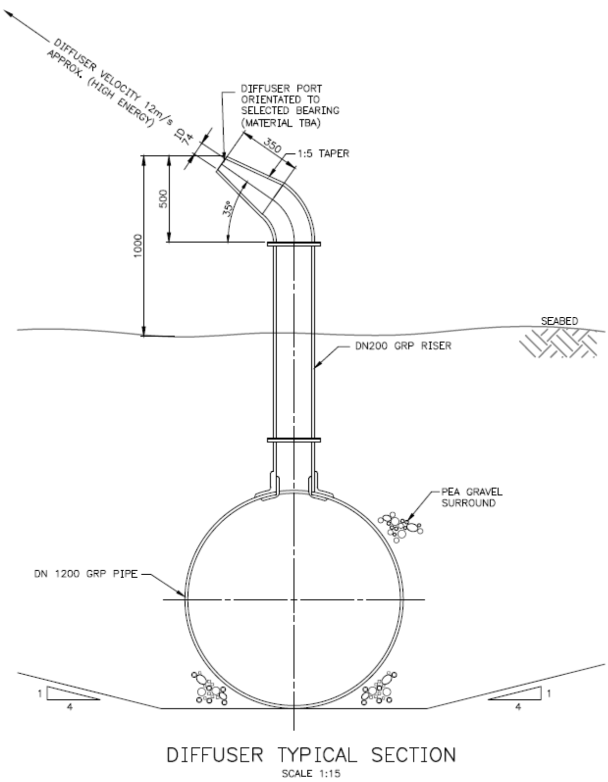
The diffuser design has yet to be finalised but is likely to be approximately 245 m in length with the order of 50 risers at approximately 5 m spacings (Table 3.4). The diffuser exit velocity will be ~4.13 m/s (Table 3.4). The diffuser has been designed to enhance the mixing capacity and approximately double the nearfield dilution achieved compared to similar installations.

Table 3.4 Diffuser concept design (subject to final design)

Element	Unit
Diffuser manifold length	245 m
Number of ports	50
Port elevation from seabed	1 m
Port spacing	5 m
Port diameter	12 cm
Port exit velocity	4.13 m/s

Note:

1. Diffuser design is subject to final design



Note:

1. Pipeline and diffuser are subject to final design

Figure 3.10 Outlet diffuser concept design

3.2.3 Plant construction and arrangement

General plant arrangement

The cadastral boundaries of the proposed lots extend to the low water mark on the western side and much of the western area of the site comprises primary and secondary sand dunes (Figure 3.11). The primary dunes are planned to be retained and the area available for development will align with the boundary of PSDP1 to the north. This provides an east-west site width of 185 m approximately with 15 m on the western side reserved for roads and access only (no buildings).

The closure of Barter Road is being discussed with key stakeholders including Water Corporation, Fremantle Ports & City of Kwinana. The closure remains subject to confirmation between these stakeholders. If Barter Road is to be closed it allows the PSDP1 drainage basin to be expanded into the old Barter Road reserve and shared with PSDP2 (Figure 3.11). The PSDP2 site layout has been prioritised from the north within the area shown and the remnant portion of the area has been left for future uses and facilities. This remnant Water Corporation owned area to the south of the site is shown in Figure 3.2 and is available for Stage B.

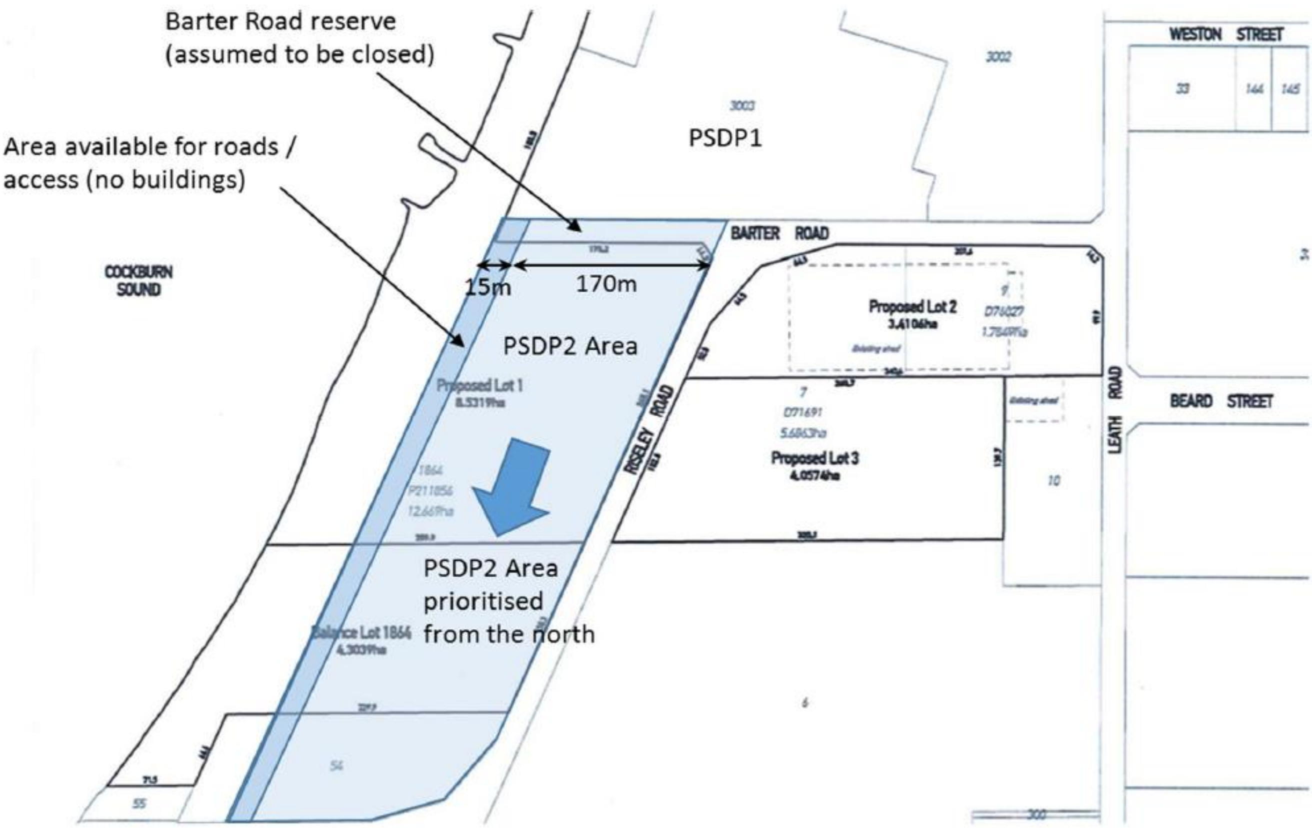
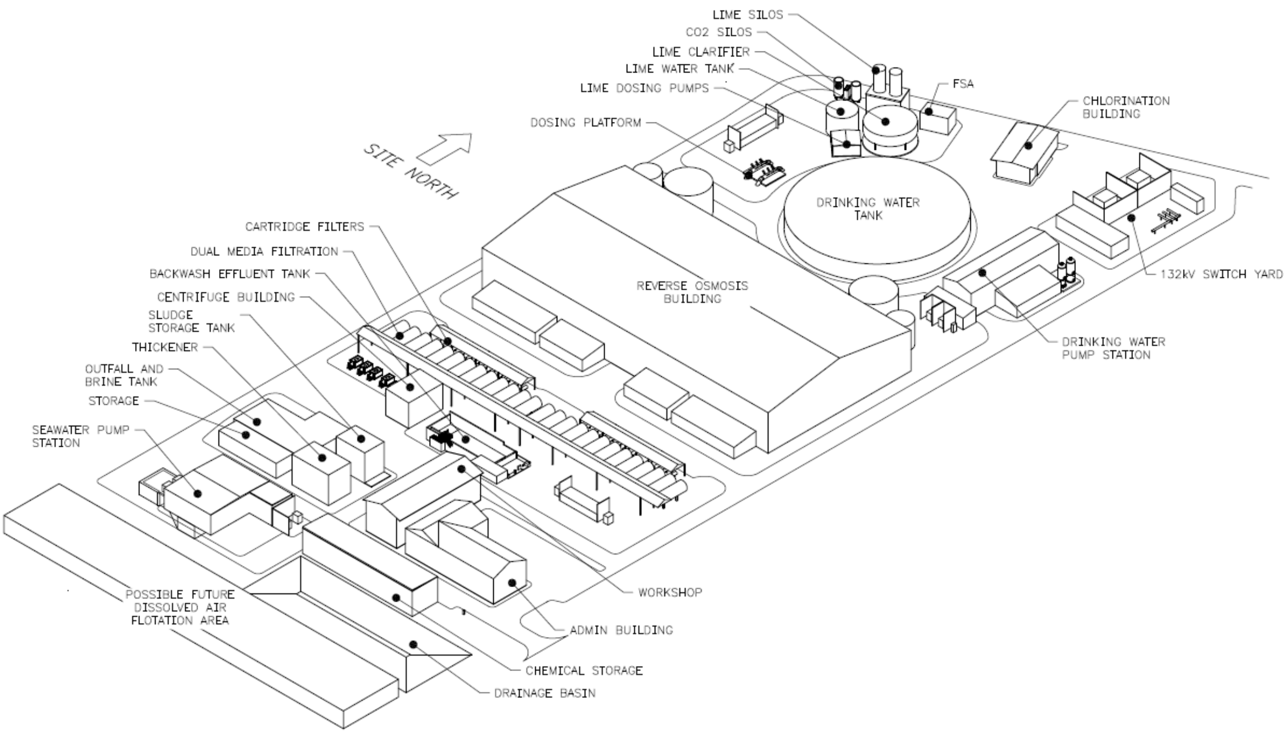


Figure 3.11 PSDP2 development area



Note:
1. Plant layout is subject to final design

Figure 3.12 PSDP2 indicative plant layout

Chlorination facility and dosing

Sodium hypochlorite dosing at the inlet will not be routinely undertaken during normal operation, though provision is made to facilitate dosing. A bunded area will be provided adjacent to the intake pump station for storage. It is anticipated that the sodium hypochlorite will be delivered ‘as required’ and not stored in this area for any significant duration.

It is anticipated that the dosing pump will be kept in store rather than permanently installed. When required, the dosing pump will be connected with ‘quick connect’ piping and plugged in to a weather proof electrical outlet, controlled by the PLC.

Other chemical storage

Chemicals used at PSDP2 shall be stored within a bunded chemical storage facility in compliance with relevant Australian Standards. Chemicals designated *Dangerous Goods* shall be diluted within the chemical storage facility prior to pumping to the dosing point.

Chemicals used at PSDP2 will be stored in two primary areas:

- bulk chemicals building, located close to the entry gate at the south end of the site
- post-treatment chemicals, located at the northern end of the site.

In addition, small quantities of chemicals, typically delivered in small packages (bags or drums) and used intermittently, will be located in the following areas:

- chemicals for clean-in-place (CIP) of the RO membranes and pre-treatment will be kept in proximity to the CIP system
- polymers for the residuals handling (thickener, centrifuge) will be kept and prepared in the centrifuge building
- sodium hypochlorite and metabisulphite solution for seawater intake dosing and de-chlorination will be delivered in 1000 L volumes when required.

Power

The incoming supply voltage to the site will be 132 kV. The main switchgear within the plant utilises an outdoor gas insulated switchgear (GIS) switchgear. Two feeders from the outdoor GIS switchgear will supply two 132 kV/11 kV transformers.

The maximum demand for the site is estimated to be to be 29 MVA. The desalination plant is designed to operate continuously over long periods and typically at full load; this is therefore the operating duty of the plant's electrical system.

Earthworks and stormwater drainage

The finished levels of the site have been designed to provide nominal drainage falls and flood routing to the north and south from a central high point at the RO building ridge line. The levels are designed to tie into existing levels at the road entry and exits and along the existing verge at Barter Road.

A 12D earthworks model of the site was created and used to calculate earthworks volumes (GHD & Water Corporation 2018). These show that there is a requirement to import clean sand and/or limestone to a thickness of approximately 200 mm to achieve the required levels. This is deliberate and will help to create a clean, well compacted working surface during construction.

Road drainage along the eastern and western boundaries falls into perimeter open drains. Road drainage in more central areas is via conventional drainage pits and buried pipes in a similar manner to the existing PSDP1. It is expected that the pipes will be designed for ARI10[1] year flows and suitable flood routes provided for the ARI10 / ARI100[1] gap flow. The open drains and buried pipes deliver stormwater flows to the two drainage basins. Characteristics of the two basins have been calculated to serve the ARI100 year rainfall event.

3.2.4 Treatment process

The desalination process is based upon two equivalent parallel trains, each train of sufficient capacity to support production of a nominal capacity of 25 GL/a of drinking water. The two trains will be developed at separate times as Stage A and Stage B of PSDP2, with provision for crossover between the two trains at selected points within the process.

Pre-treatment

The pre-treatment system shall be adequate to treat unprocessed seawater to a quality suitable for supply to the RO plant. The proposed pre-treatment of the seawater is based upon the process currently used successfully at the adjacent PSDP1, comprising:

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[1] *ARI10 = the annual maximum **flow** with 10 years of average recurrence interval; ARO100 = the annual maximum **flow** with 100 years of average recurrence interval*

- intake coarse screening at the seawater intake structure to exclude large swimming marine organisms and detritus
- sodium hypochlorite dosing (only as required)
- primary screens on-shore of nominally 5 mm aperture
- coagulation and flocculation
- dual media filtration.

Primary screening will be effected by dual entry rotating band screens (or similar) installed in a flooded screen bay in the Screen Wet Well. Each screen consists of an endless band of mesh panels contained within a vertical self-supporting frame. The water being screened passes from the outside, through the mesh panels to the inside of the screen, and then out through an opening in the back concrete wall of the screen chamber.

As the band of mesh panels rotate, the debris collected on the outside of the mesh is lifted above deck level with a water spray washing the collected detritus off into a waste channel. Solid wastes washed from the screen will be transferred by channel and screw conveyor to an enclosed (for odour control) self-draining plastic bin. Collected solids will be periodically removed for transfer to an appropriate waste disposal facility.

Coagulation and flocculation is effected by in-line dosing of chemicals on exit from the Seawater Pump Station and prior to the media filters. The seawater pH is adjusted to nominally pH 7.0 and coagulant is added. A mixture of diluted coagulant and diluted sulphuric acid is dosed into the outlet of the seawater pumps and mixed using an in-line static mixer. The coagulant will be either ferric sulphate or ferric chloride solution. A coagulant aid, nominally polyDADMAC (diallyl-dimethyl-ammonium chloride), is dosed into the seawater just prior to the media filters, mixed by a second in-line static mixer, to enhance flocculation of particulate matter prior to removal on the media filters.

A single stage dual-media filtration system as installed at PSDP1 is proposed. Thirteen horizontal cylindrical filters will operate in parallel for Stage A, and a further thirteen vessels will be installed for Stage B, when constructed. As material is filtered from the seawater, the filter media will block, indicating by increasing differential pressure across the filters. Filter vessels will be ‘backwashed’ sequentially using RO brine effluent as backwash water. All other vessels remain on-line while one vessel is being backwashed.

Backwash effluent from the filters is collected in the backwash effluent tank then pumped to the thickener. The backwash effluent tank is agitated to maintain solids in suspension, using either air or water jets. The backwash pump station will pump the effluent at a relatively constant rate to the thickener. For the Stage A plant, only one filter will backwash at a time. After the Stage B filters are in operation, it is possible that a filter from each bank may backwash coincidentally. Therefore, the backwash effluent tank will be sufficient to hold the backwash volume from at least two filters. The quality of the product water from the pre-treatment system will be continuously monitored by on-line turbidity instruments (or equivalent).

The pre-treatment process described above is subject to change and will be confirmed during final design, however an alternate process will not result in any additional environmental impact to those assessed in this ERD.

RO process

The RO process will remove salt from the seawater influent. High-pressure pumps supply the pressure to enable the water to pass through membranes and have the salts rejected. The RO system for PSDP2 will comprise:

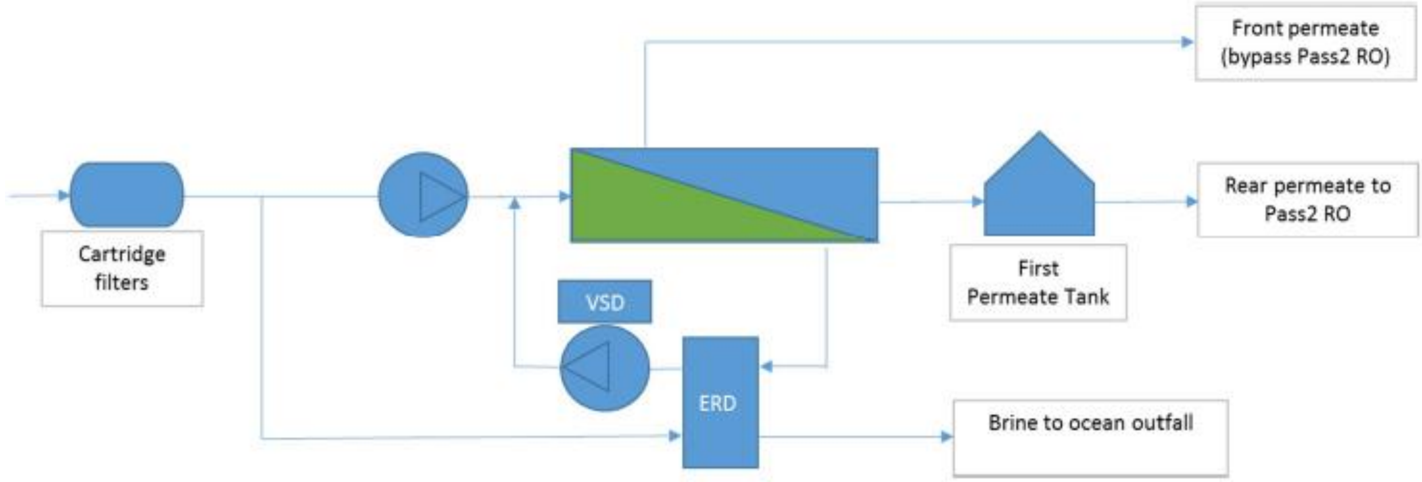
- cartridge (guard) filters
- two pass RO system including:
    - single stage first pass RO with energy recovery system
    - two stage second pass RO
- CIP system
- flushing system.

The two pass RO design is based upon the Southern Seawater Desalination Plant (SSDP) in, Binningup (WA), which is currently operating successfully.

CIP systems are provided for periodic off-line cleaning of the RO membranes. Spent CIP solution will discharged into a waste sump in the CIP area of the plant. The sump will be of sufficient capacity to contain at least the entire volume from one complete CIP (including rinse) of a RO train. While in the sump, the solution can be fully neutralised by addition of necessary chemicals (see Section 6.5.3). A pump set will be able to recirculate the waste CIP solution within the sump to facilitate mixing and, once neutralised, pump the spent CIP solution to the wastewater tank (see Figure 3.5).

On shut down of the first pass RO trains, the membranes will be flushed with at least one system volume of seawater followed by at least one system volume of RO permeate from the first permeate tank (rear permeate) to ensure that there is no backflow (permeate to feed side) through the membranes on standing. Seawater flushing is performed using the normal filtered seawater feed supplied by the seawater intake pumps. A flushing pump is installed on the first permeate tanks to flush the membranes in each first pass RO rack. In an emergency stop or power failure situation, flushing of the RO racks will not occur but the flushing pump will be operable from the emergency power supply, allowing the RO racks to be flushed with permeate under manual control.

First Pass RO Train



Second Pass RO Train

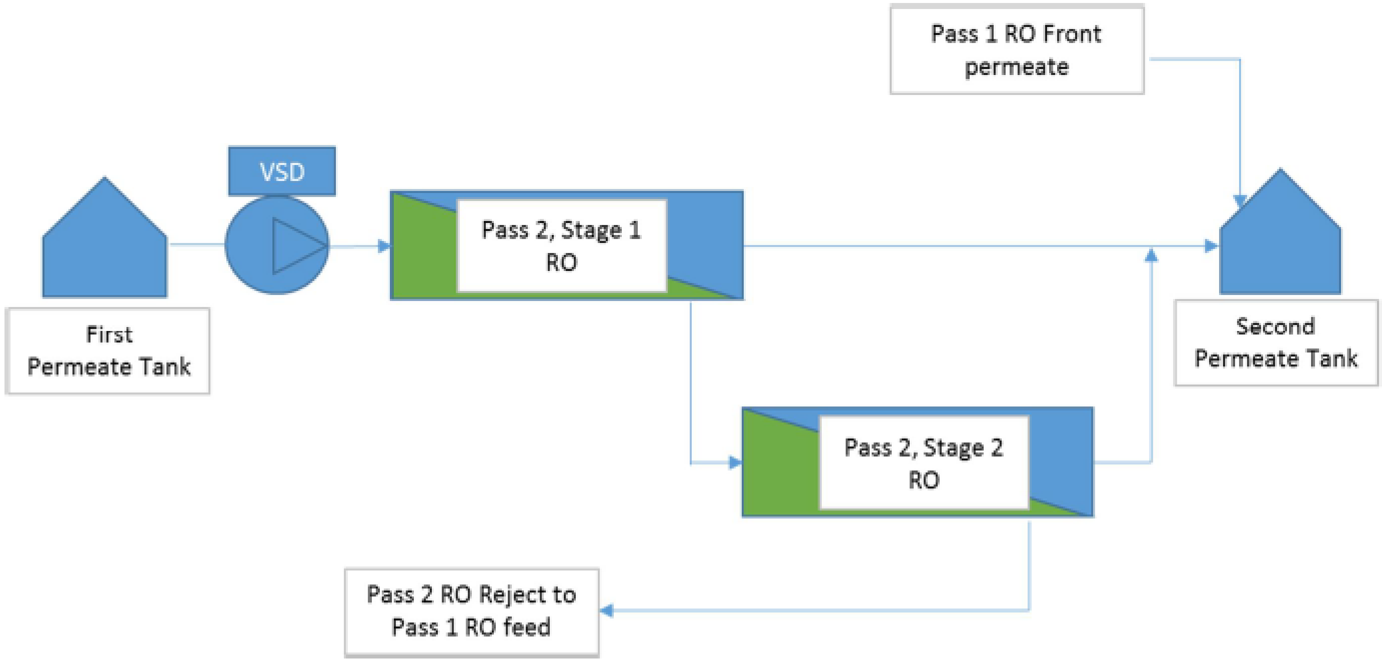


Figure 3.13 Schematic of first pass (top) and second pass (bottom) reverse osmosis (RO) trains

Post-treatment

The post-treatment system produces stabilised, chlorinated and fluoridated water suitable for drinking from the RO permeate. The design of the post-treatment system shall be as installed at PSDP1 and SSDP, using:

- hydrated lime (powder) and carbon dioxide gas for stabilisation
- chlorine gas for disinfection
- fluorosilicic acid solution for fluoridation.

The post-treatment process is largely based on plant and equipment to service up to 50 GL/a of drinking water. Where possible, equipment installation will be staged in alignment with the development of the plant. Post-treatment chemicals will be dosed into a dosing point between the second permeate tank and the drinking water tank as indicated in Figure 3.14.

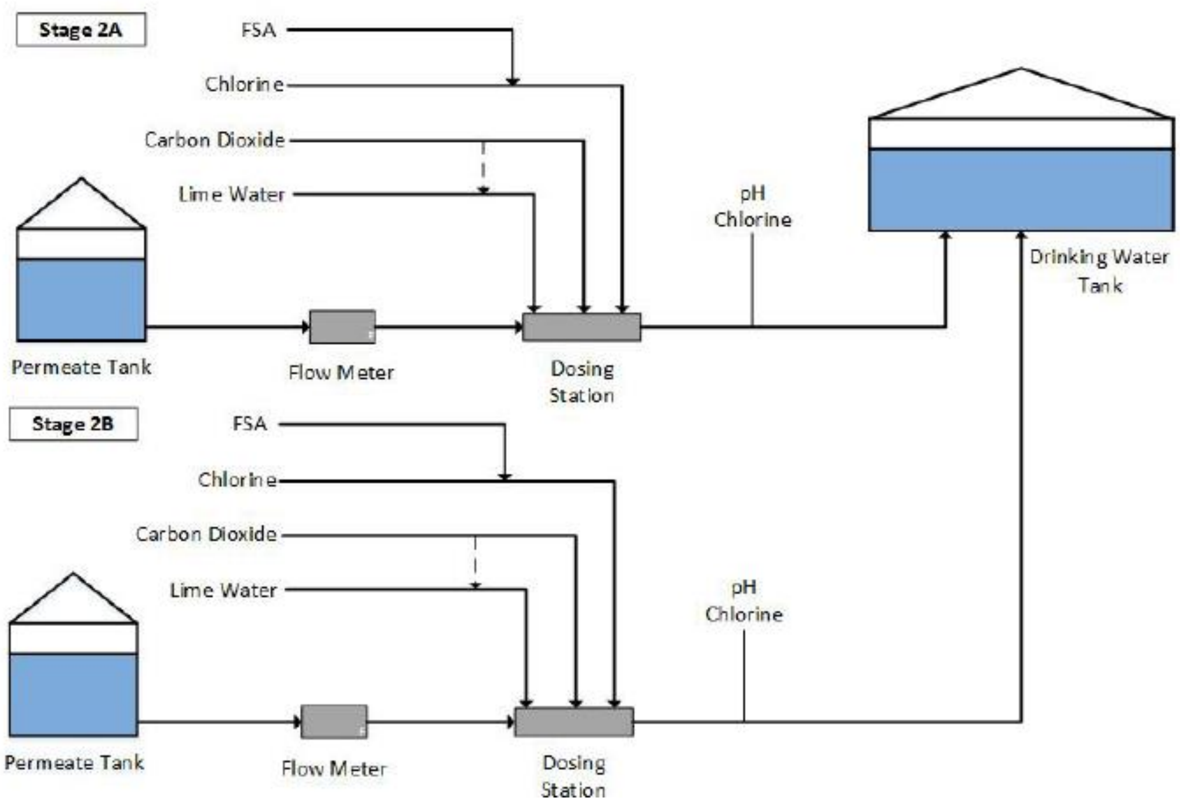


Figure 3.14 Schematic of post-treatment dosing

Residuals handling

All waste solids emanating from the process shall be collected, concentrated and dewatered for disposal to an appropriate off-site landfill facility, while any treated wastewater emanating from the waste handling process will be discharged to the ocean (Figure 3.15).

Seawater intake screen washings: solid wastes washed from the seawater intake screen will be transferred by channel and screw conveyor to an enclosed self-draining plastic bin. Collected solids will be periodically removed for transfer to an appropriate waste disposal facility.

Dissolved air flotation floated sludge: In the event that a dissolved air flotation plant (or other initial pre-treatment process plant) is installed prior to the media filters due to high contamination load in the influent seawater, the float (waste stream) is directed to the wastewater holding tank.

Media filtration plant backwash: solids collected by each media filter is periodically (typically daily) backwashed into the wastewater holding tank. Solids from the media filters will be a mixture of suspended solids from the influent seawater, solids precipitating from the seawater as a result of the pre-treatment and precipitated solids (iron salts) from the coagulant.

Lime clarifier sludge underflow: Sludge from the lime clarifier is composed of non-soluble matter fromcommercial lime and precipitated calcium salts. The sludge will be periodically drawn from the bottom of the clarifier and transferred to the wastewater holding tank.

Waste solids treatment system: Wastewater collected from the pre-treatment system and lime clarifier with high solids content is treated in a three step process through:

- a sludge thickener
- a sludge holding tank
- a centrifuge (decanter).

The wastewater collected in the wastewater holding tank is transferred by pump to the sludge thickener. The sludge thickener will increase the solids density of the wastewater to nominally 2% by weight solids. Supernatant from the thickener flows to the outfall tank for discharge to the ocean.

The thickener operates continuously, although flows in and out may not be continuous. Thickened sludge is transferred periodically to a stirred sludge holding tank. The thickened sludge is dewatered to a spadeable sludge using a centrifuge. Centrate from the centrifuge is returned back to the wastewater holding tank. Sludge from the thickener is transferred by screw conveyors to a waste skip for removal from site by truck.

The centrifuge will operate non-continuously, typically a few hours per day during daylight periods. A coagulant (same as the media filter coagulant) is dosed into the thickener. Two separate polymers will be dosed into the thickener and centrifuge, respectively.

The wastewater plant, including thickener, sludge tank, centrifuges and out-loading sludge screw conveyors, will be developed initially for the full plant capacity (50 GL/a) at the worst expected influent seawater quality.

Media filter rinse water: On completion of a filter backwash, each filter is rinsed for a period. The filter rinse water is directed to the outfall tank and discharged to the ocean.

RO brine effluent: discussed in Section 3.2.5.

RO flushing waste: On shutdown of a first Pass RO train, the membranes are flushed first with filtered seawater (i.e. normal RO feed water) and then with permeate water. The rinse water discharges through the RO brine effluent pipe to the brine effluent tank and ultimately to the ocean.

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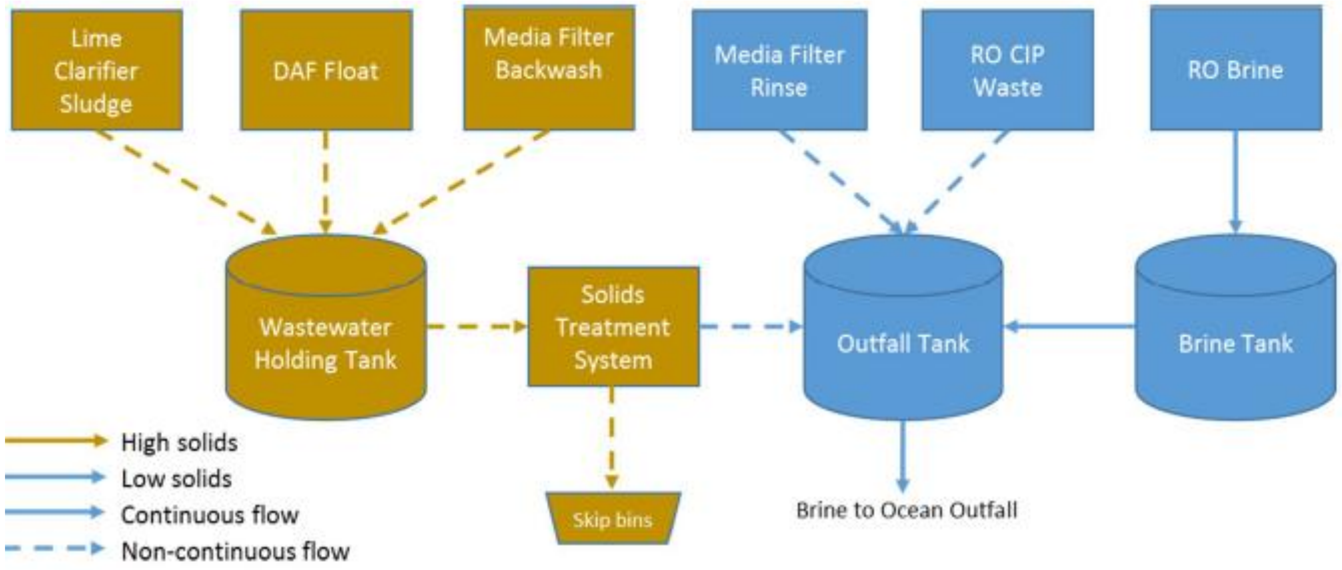


Figure 3.15 Schematic of residuals management system

3.2.5 Discharge characteristics

The discharge from the desalination plant will consist of brine effluent from the RO process and backwashes from the pre-treatment and cleaning processes (Table 3.5). Brine effluent from the first pass RO discharges into the brine effluent tank continuously while the plant is in operation. Any free chlorine will be neutralised with sodium metabisulphite prior to discharge. The expected salinity of the effluent stream just prior to discharge will be approximately 65,000 mg/L. The anticipated temperature discharge water will be ~2–4°C above that of ambient seawater, due to the transfer of heat via pipeline infrastructure and the heat produced by the pumps. Backwash water from pre-treatment will also be mixed into the return water before discharge. A very small volume of chemicals used for cleaning and biocide will also discharged in the brine effluent; these chemicals are described in detail in Section 6.5.3.

Table 3.5 Typical composition of brine effluent discharge

Parameter	Final discharge
Flow	202 ML/d
Temp (°C)	<2°C greater than ambient seawater
Dissolved oxygen	>100%
pH	7.5–8.0
Salinity	65,000 mg/L

Note:
1. chemicals used for cleaning and biocide will also discharged in the brine effluent; these chemicals are described in detail in Section 6.5.3 (see also Table 6.15 and Table 6.16)

3.2.6 Proposal timeframe

Both stages of PSDP2 will result in the production of drinking water. Water Corporation anticipates construction of PSDP2A in 2028 and PSDP2B in 2033. All major civil construction activities associated with the Proposal will be completed as part of PSDP2SA, whereas the major items of

PSDP2B will include upgrades of the delivery pipeline and additional mechanical equipment for the seawater pump station, pre-treatment, RO and drinking water pump station. All buried services and pipework outside of the PSDP2B project area will be installed as part of PSDP2A; there will be no additional terrestrial or marine impacts during PSDP2B upgrade activities.

It is anticipated that all major civil construction activities should take approximately two years to complete. The expected duration of major tasks are provided in Table 3.6.

Table 3.6 Proposal timing for major civil construction activities

Task[1]	Construction duration
Land clearing	~1 month
Installation of pipework/power	~6 months
Site grading/excavation	~3 months
Installation of drainage management system	~2 months
Installation of plant and plant equipment	~18 months
Coastal and dune cross-over	~18 months
Installation and connection of product water pipeline	~18–24 months
Marine dredging	~3 months
Installation of marine pipelines, intake and diffusers	~3 months
Backfill	~2 months

Note:
1. Listed tasks are not provided in sequential order and implementation of many tasks will occur in parallel.

3.3 Local and regional context

Cockburn Sound is a sheltered marine embayment and is one of the most intensively used marine areas in WA. It provides an important resource for a diverse mix of users and activities such as the Australian Navy, Kwinana commercial industries, commercial fishing and mussel farming, as well as recreational activities such as boating, fishing, dolphin watching, recreational diving and swimming. The Sound is also a significant breeding and nursery area for blue swimmer crabs and pink snapper, so is of importance to the fish stocks of the south-west coast including the Perth metropolitan region.

3.3.1 Physical and ecological characteristics of terrestrial environment

Cockburn Sound is influenced by the regional climatic pattern of hot, dry summers and cool, wet winters and the changing flow of the Leeuwin Current, which brings warm tropical waters down the WA coast from Indonesia. Classified as a temperate extra-tropical region, there is a prevailing influence from diffuse high pressure systems, an occasional influence from mid-latitude low pressure cells or fronts and the rare influence of tropical systems (Gentilli 1971). These synoptic conditions provide a distinct seasonal shift between a strong diurnal land-sea breeze cycle in summer (December–March) and more variable conditions in winter (July–September), but typically swinging from mild north-east winds to intense westerlies associated with storm events (Steedman & Craig 1979, Masselink & Pattiaratchi 2001). Storms can occur at any time of year but are most prevalent during winter. The average annual rainfall is 887 mm, of which the majority falls between May and October.

Geomorphology

PSDP2 is located on the Quindalup Dune System geomorphologic unit, which lies along the coastline of the Swan Coastal Plain in the southwest of WA. The Quindalup Dune System consists of unconsolidated Holocene sands west of the Spearwood Dunes. The major formations are low relief complex parabolic dunes fronted by foredunes with moderately inclined to steep slopes. The soils are well to rapidly drained, uniform pale calcareous sands. The Quindalup Dune System consists of wind-blown lime and quartz beach sand forming dunes or ridges that are orientated parallel to the present coast, but which may also occupy blowouts within the Spearwood Dune System relic foredune plain (DAL 2001).

Geology and soils

The surface geology of the area is Safety Bay Sand (SBS), which comprises calcareous medium-grained quartz sand with shell debris of shallow marine, coastal plain and aeolian origin. Tamala Limestone is the underlying formation of the present coastline. The coastal fringe of the SBS is also known as the Becher Sand due to its marine rather than aeolian origins (DMIRS 2018).

Heddle et al. (1980) have mapped the soils and landform of the area as follows:

- Quindalup soil: dunes and beach ridges composed of calcareous sand
- Cottesloe soil: low hilly landscape with shallow brown sands over limestone, much exposed limestone.

Most of the proposed DAF is within the Quindalup soil system, with a small section of the north-east portion mapped as the Cottesloe soil system.

Hydrology

Groundwater flow in the area is in a north-westerly direction, originating from the Jandakot Mound. Groundwater in the SBS aquifer flows eastward from the Jandakot Mound and discharges into the nearshore marine environment. Near the coast, fresh groundwater overlies saline marine water that has moved into the lower section of the aquifer due to its greater density (Smith et al. 2012).

No wetlands are located within the DAF. The closest Conservation Category Wetland is 'Long Swamp', located approximately 2.7 km north east of the DAF.

Flora and vegetation

Flora

Water Corporation commissioned GHD to survey the flora and vegetation in the PSDP2 area in spring 2016 (Appendix B). A total of 49 plant taxa (including subspecies and varieties) representing 26 families and 45 genera were recorded from the PSDP2 area during the field survey. Of these taxa, 34 were introduced species (GHD 2017).

One of the introduced species, *Tamarix aphylla*, is a declared pest under the *Biosecurity and Agriculture Management Act 2007.* Surveys have also identified the presence of the declared pest species bitou bush (*Chrysanthemoides monilifera subsp. Rotundata*) in the Kwinana Industrial Area, and the southern part of the site is known to contain bitou bush seeds (Batchelor et al 2017).

Conservation significant flora

A likelihood assessment of the occurrence of conservation significant flora within the DAF was conducted by GHD (2017). This assessment concluded that one flora species, *Austrostipa mundula* (Priority 3), was 'possibly' occurring. However, no conservation significant flora were recorded in the spring survey, or are expected to be present, due to the composition and condition of the vegetation within the proposed DAF (GHD 2017).

Broad vegetation mapping

The Proposal is in the Drummond Botanical Subdistrict of the Southwest Botanical Province (Beard 1990). Broad scale (1:250,000) pre-European vegetation mapping of PSDP2 was completed by Beard (1979) at an association level. One Vegetation Association is present within the DAF; Vegetation Association 3048: Shrublands; scrub-heath on the Swan Coastal Plain.

The pre-European mapping has been adapted and digitised by Shepherd et al. (2002). The extent of the vegetation associations has been determined by the state-wide vegetation remaining extent calculations maintained by the Department of Biodiversity, Conservation and Attractions (DBCA) (GoWA 2016). The current extent remaining of the vegetation association 3048 is less than 29% of its pre-European extent at all scales and therefore below the 30% threshold level. However, PSDP2 is proposed within a constrained area of the Swan Coastal Plain (within the Perth Metropolitan area) (DER 2014). In this case, vegetation association 3048 has more than 10% of its pre-European extent remaining at all scales and is therefore not considered to be a critical asset.

Vegetation mapping on the SCP has also been undertaken by Heddle et al. (1980). This mapping recorded two vegetation complexes within the Development Area:

- Cottesloe Complex – Central and South: Mosaic of woodland of *Eucalyptus gomphocephala* and open forest of *E. gomphocephala - E. marginata - E. calophylla;* closed heath on the limestone outcrops
- Quindalup Complex: Coastal dune complex consisting mainly of two alliances – the strand and fore dune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata - Callitris preissii* and the closed scrub of *Acacia rostellifera.*

The extent of vegetation complexes described and mapped by Heddle et al. (1980) for the SCP has been determined using the south-west vegetation remaining extent calculations maintained by DBCA (GoWA 2017). The Quindalup and Cottesloe Complexes have greater than 30% of their pre-European extents remaining on the SCP.

Vegetation types

Six Vegetation Types (Table 3.7) were recorded in the DAF (covering 8.69 ha), as well as highly disturbed areas (3.43 ha) and beach/ocean (2.98 ha). The dominant vegetation within the site was an *Acacia rostellifera* thicket (VT5), which occurs on flats behind the dunes. Other vegetation types are defined by the dune structure and age and potentially by levels of disturbance. The ground cover in all types primarily consists of introduced grasses and other herb species. The natural vegetation types are broadly consistent with vegetation association 3048 (Beard 1979) and the Quindalup Complex, which is mapped along much of the Perth metropolitan area coast (Heddle et al. 1980).

Table 3.7 Vegetation types mapped in the PSDP2 Development Area

Vegetation type	Vegetation description	Current extent (ha)	Landform
VT1 Foredunes with open / low shrubland / herbs	Open shrubland of *Acacia rostellifera* over low shrubland/grassland of **Tetragonia decumbens* and *Spinifex longifolia* with mixed introduced grasses and herbs including **Ammophila arenaria* (Marram grass) and **Lolium rigidum*.	1.06	Fore dunes
VT2 Dune shrubland of *Acacia rostellifera* with *Lepidosperma gladiatum*	Dense tall shrubland of *Acacia rostellifera* and **Rhamnus alaternus* over open shrubland of *Lepidosperma gladiatum* over dense grasses of **Avena barbata, *Bromus diandrus* with scattered *Acanthocarpus preissii*, and *Cassytha ?ramosa.*	2.68	Consolidated dune
VT3 Planted tall shrubland	Dense tall shrubland/low forest of *Melaleuca lanceolata, Eucalyptus ?platypus, E. gomphocephala* and *Agonis flexuosa* over open shrubland of *Acacia rostellifera, Calothamnus quadrifidus, Olearia axillaris* over herbfield of **Avena barbata.*	0.37	Deep sand on consolidated dunes
VT4 Open shrubland of *Acacia saligna* with *Alyxia buxifolia*	Open shrubland of *Acacia saligna* with *Alyxia buxifolia* and *Spyridium globulosum* over scattered *Acanthocarpus preissii* and *Spinifex longifolia with* dense grasses of **Avena barbata, *Cenchrus setaceus* and other introduced grasses and herbs.	0.78	White, calcareous sand on flat
VT5 Thicket of *Acacia rostellifera* over introduced grasses	Dense medium to tall shrubland of *Acacia rostellifera* over dense herbfield of **Avena barbata* and **Lagurus ovatus.*	3.16	White, calcareous sand on flat or very gentle slope
VT6 Herbfield of introduced grasses with isolated shrubs	Herbfield with a range of introduced grass and herbs. Previously cleared areas which have been stabilised with introduced species.	0.63	-
Completely Degraded / Highly Disturbed (VT7)	Vegetation has been cleared for previous use and tracks.	3.43	-

Source: GHD (2017)

<u>Vegetation condition</u>

The vegetation in the DAF ranged from Very Good to Completely Degraded. The area has been significantly disturbed and large areas of the understorey have been modified and are dominated by introduced species.

<u>Threatened and Priority ecological communities</u>

No Federally listed Threatened Ecological Communities (TECs) were identified as potentially occurring in the DAF. Similarly, no State listed TECs or Priority Ecological Communities (PECs) have been previously mapped within DAF. The nearest recorded TECs are approximately 4.2 km to the south and east of DAF and represent the sedgelands in Holocene dune swales of the southern Swan Coastal Plain, a dampland vegetation type (GHD 2017).

The flora and vegetation survey confirmed that none of the vegetation types within the DAF were representative of any TECs or PECs (GHD 2017).

Fauna

Fauna diversity

GHD (2017) carried out a fauna survey in spring 2016 and recorded nine species (Appendix B). The existing habitats in the DAF (beach, primary dunes and mixed shrublands) provide limited habitat for fauna species.

Conservation significant fauna

The threatened leatherback, loggerhead and green turtles have previously been recorded within 10 km of the DAF, but Cockburn Sound is south of the normal range of each species and the occasional presence of these species is likely due to straying. None of these species have been recorded as nesting south of the Shark Bay area and would not use the proposed DAF for breeding.

A likelihood of occurrence assessment conducted by GHD (2017) for all conservation significant fauna species identified that three species are likely to occur in the area based on habitat preferences and known records:

- quenda (*Isoodon obesulus* subsp. *fusciventer*) (Priority 5)
- Perth linked skink (*Lerista lineata*) (Priority 3)
- black-striped Snake (*Neelaps calonotos*) (Priority 3).

No conservation significant fauna species were recorded from the DAF during the fauna survey (GHD 2017).

Fauna habitat

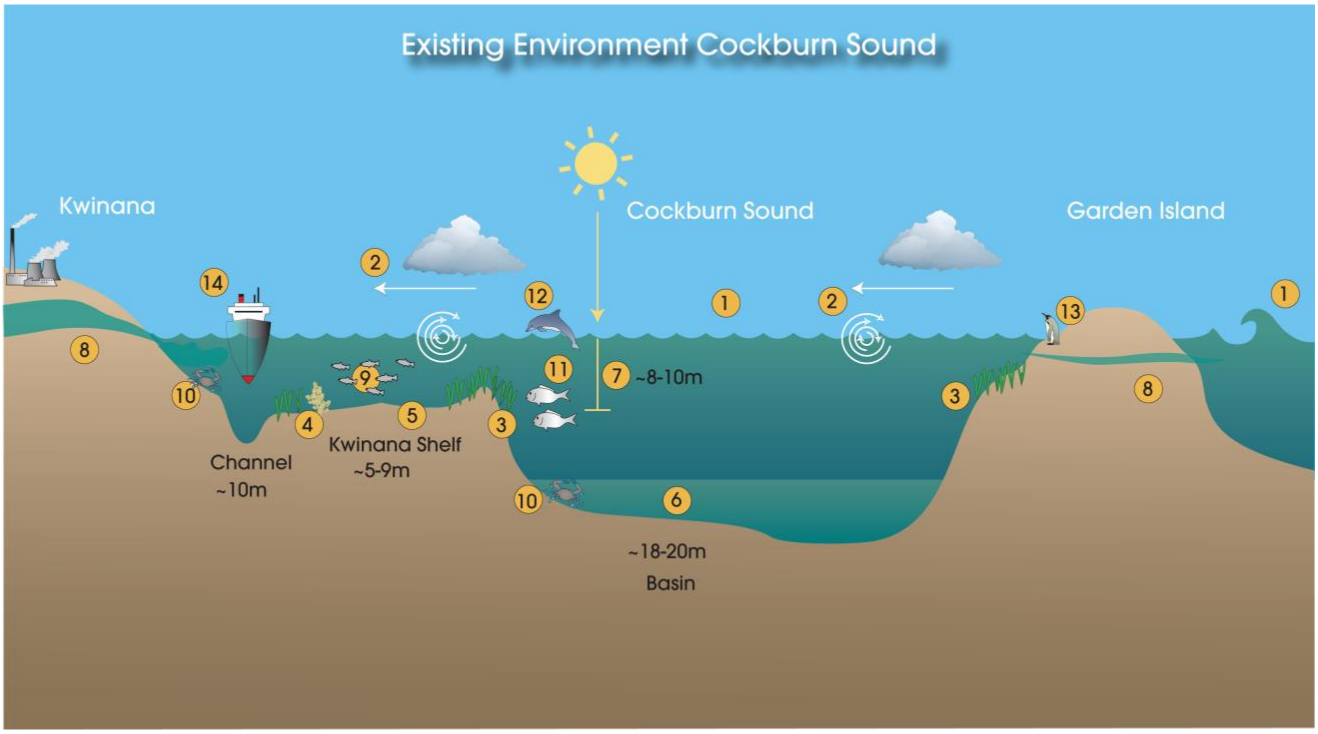
Three main fauna habitats as well as highly disturbed/cleared areas are present in the DAF, namely beach, primary dunes and mixed shrublands (GHD 2017). Much of the survey area has historically been modified, is relatively degraded and surrounded by the KIA. Connectivity with surrounding patches of habitat – the nearest found within the buffer zone of the KIA 2 km from the Proposal – is almost absent, except for small corridors of coastal vegetation and tree rows along property boundaries.

3.3.2 Physical and ecological characteristics of marine environment

General marine setting

Cockburn Sound's marine environment is naturally influenced by a complex interaction of physical and ecological processes. Physical features such as the Sound's protected embayment configuration, coastal sediment processes, marine water movements, groundwater and catchment runoff inputs are responsible for its regional ecological significance. Key ecological features include extensive areas of seagrass species that prefer sheltered conditions, and organic-rich silts on the seabed of the deep basin that support animals unique to the central west coast of WA.

Cockburn Sound is a shallow, elongated, partially-enclosed coastal basin located between two Pleistocene limestone dune ridges; the Garden Island Ridge to the west and the Spearwood Dunes to the east (Skene et al. 2005). The broad central basin has a general depth of 18–20 m, which rises steeply to sand banks to the north and south, the shoreline of Garden Island to the west and the Eastern Shelf to the east. The Eastern Shelf is a relatively flat shoal ~8 m deep that extends from James Point to Woodman Point and consists of a thin veneer of sediment underlain by limestone outcrops along the western margin as isolated reef.



Source: FP, DOP (2012)

Notes:

1. Garden Island, and the causeway between the island and the mainland, largely protects Cockburn Sound from oceanic waves and swells
2. Wind is the primary force responsible for mixing and moving the waters within Cockburn Sound
3. Approximately 80% of the original seagrass meadow area in Cockburn Sound has been lost due to the effect of past human activities, with remnant seagrass areas of varying health remaining
4. Historical dredge spoil disposal on the Kwinana Shelf created a 'Dredge spoil' reef habitat, which now supports a diverse habitat of mixed algae, seagrass and corals
5. Other areas of the Kwinana Shelf comprise shallow (generally less than 10 m water depth) sand and silt habitats, some of which once supported seagrass
6. The floor of the deeper basin (approximately 18–20 m water depth) never supported seagrass due to lack of light, but the sediments do support benthic fauna
7. Light is attenuated to about 90–95% of surface values within 8–10 m water depth, which is still enough light to allow seagrasses to grow at these depths
8. Groundwater flows into the intertidal zone along the coast and along Garden Island after winter. There may also be areas of submarine (offshore) groundwater discharge into the Sound. Contaminated groundwater flows are the main source of human-induced nutrient loads to the Sound
9. Cockburn Sound is an important fish nursery area
10. Crabs use the Kwinana Shelf and Cockburn Sound basin during various stages of their lifecycle
11. Cockburn Sound Basin and parts of the Kwinana Shelf are key spawning and nursery areas for pink snapper
12. Cockburn Sound is an important dolphin feeding ground and nursery
13. Little penguins roost on Garden Island and feed in Cockburn Sound
14. Dredged channels, with a depth of 10–12 m Chart Datum (CD), on the eastern side of the Kwinana Shelf provide shipping access to marine facilities at Jervoise Bay, Alcoa and the Kwinana Bulk Jetty.

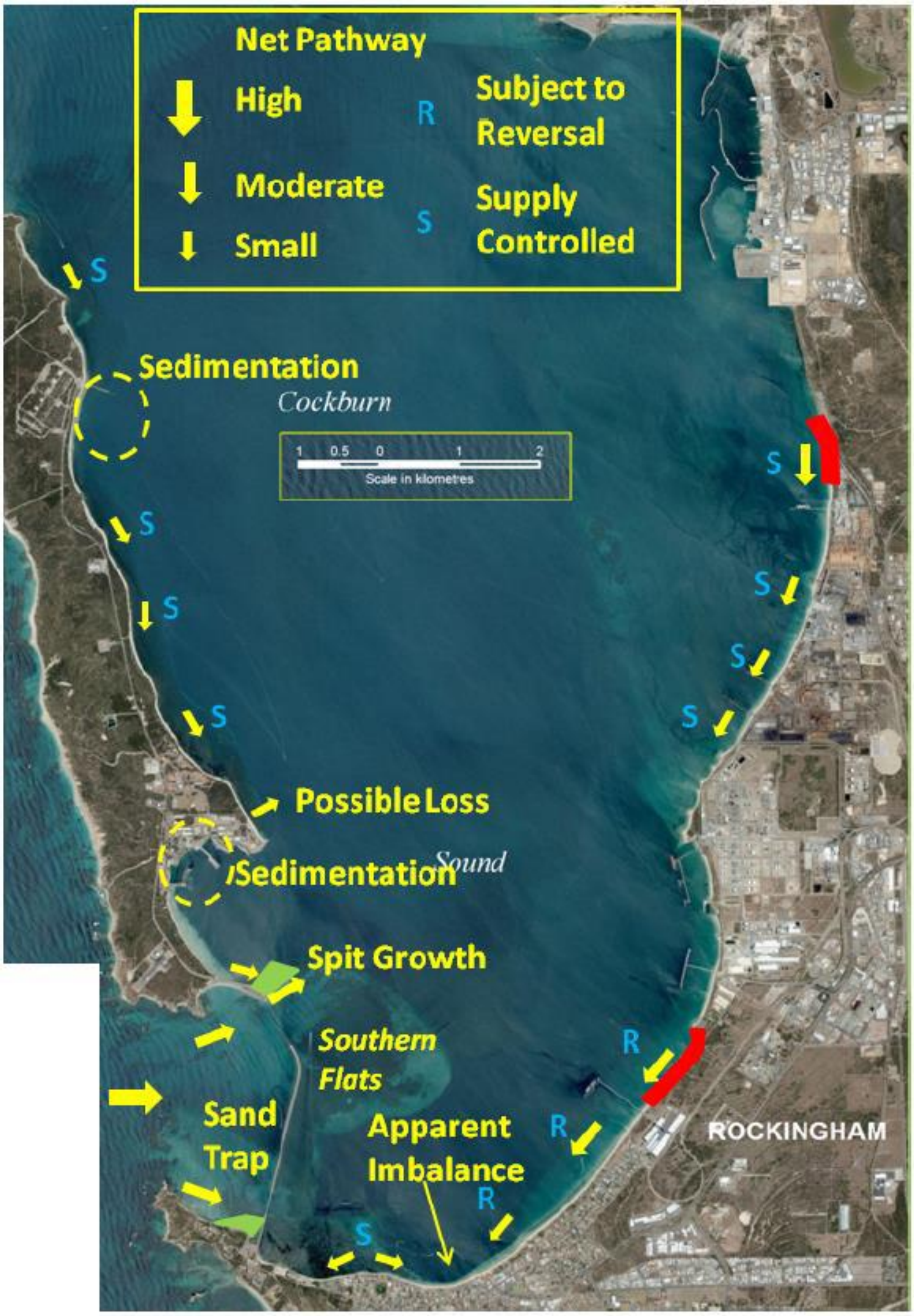
Figure 3.16 Key marine environmental features of Cockburn Sound

Coastal processes

The complex geology and geomorphology of Cockburn Sound plays an important role in controlling coastal processes and long-term sediment transport pathways (CZM et al. 2013). These broadscale controls have been highly modified at a local level through the placement of coastal structures and dredging/nourishment activities, which can cause significant local shoreline changes within the Sound. Due to the low-energy environment there can be a significant lag in the coastal response to these interventions (Stul et al. 2007, BMT Oceanica 2014).

The interplay between the energy of the swell and wind waves determines the dominant sediment transport direction at the shoreline such that net sediment transport is typically southward in the north of the Sound and northward in the south, with a small net southerly trend resulting in accretion on the northern flank of James Point (Figure 3.17; DOT 2009). Along the east coast of Garden Island sediment net transport is generally southward driven by the penetration of swell wave energy.

An analysis of coastal hazards (CZM et al. 2013) identified three areas of existing acute erosion hazard in Cockburn Sound: Garden Island north of Colpoys Point, Palm Beach and the Kwinana Bulk Terminal. Two areas with anticipated severe long-term erosion were identified: Woodman Point and KIA. The historic shoreline erosion along the Kwinana Industrial strip and at Kwinana Beach has also been recognised by the Department of Transport (DOT) and these areas have been identified in a register of WA coastal erosion hotspots (Stead 2016).



Source: CZM et al. (2013)

Notes:

1. 'Subject to reversal' refers to direction of sediment movements. Sediment transport direction may reverse for seasonal changes in wind/wave/current regime, but the dominant or net direction is shown
2. 'Supply controlled' refers to sediment availability. This occurs where there is only a limited quantity of sediment available to be transported i.e. sediment transport is controlled by supply of sediment
3. Red blocks are sediment sources, with potential for erosion
4. Green blocks are locations of sediment accretion.

Figure 3.17 Cockburn Sound indicative sediment pathways

Wind and waves

The prevailing offshore waves are dominated by a south-westerly swell with a median significant wave height of 1–2 m during summer and 2–3 m during winter (Lemm et al. 1999). The swell wave energy decreases southward into the Sound with an associated change in the direction of wave approach at the shoreline from westerly to northerly. Wind waves within Cockburn Sound may be generated by storms (resulting in westerly and north-westerly waves), sea breezes (south to south-westerly waves) and land breezes (resulting in easterly waves). The energy of wind waves in the Sound is also a function of the fetch (amount of open water) the wind acts upon.

The Cockburn Sound coastline has a variable wave climate as a result of sheltering by Garden Island and the outer reefs. Variable wave fetches within Cockburn Sound provide local changes in prevailing and dominant wave conditions, resulting in local divergences in the mean direction of incoming waves (Travers 2007). Tidal influences in this region are weak due a microtidal regime with maximum diurnal tidal ranges of ~0.6 m (NTF 2000).

Circulation

Cockburn Sound circulation and exchange processes are driven at time-scales ranging from diurnal to annual by winds (including storm events), coastal currents, adjacent estuarine discharges, and differential heating and cooling. Natural hydrodynamics within the Sound have also been influenced by infrastructure development, in particular the presence of the Garden Island Causeway. Three distinct hydrodynamic regimes have previously been identified in Cockburn Sound based on the relative importance of wind and pressure gradients in determining circulation patterns and flushing (DEP 1996):

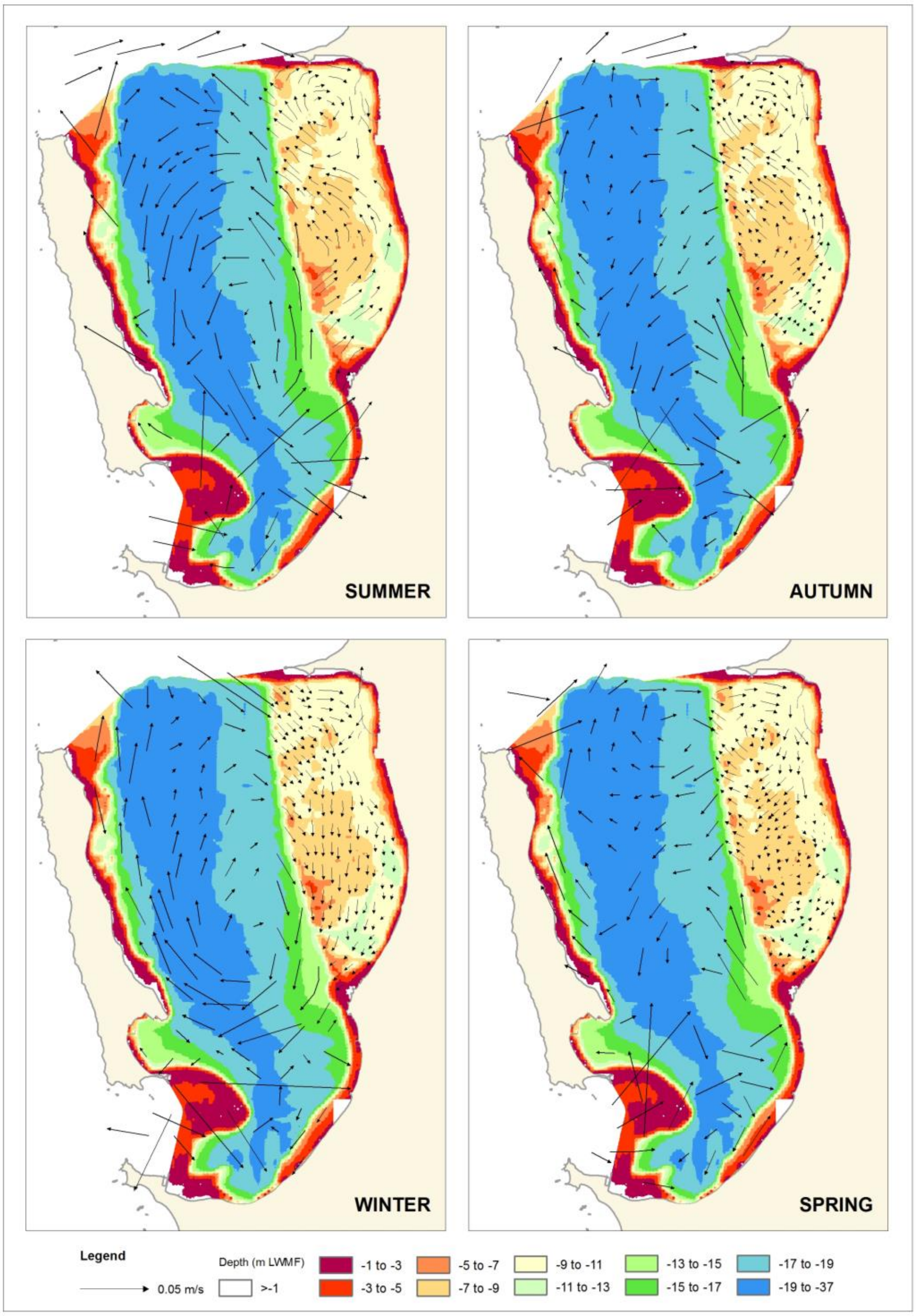
- 'summer'
- 'autumn'
- 'winter-spring' .

During summer, wind dominates the circulation within Cockburn Sound, and generates net northward flow in the upper ~10 m of the water column. Strong and persistent sea breezes ensure that waters are vertically mixed every ~1–2 days (DEP 1996). Wind-driven flows along the eastern margin of the Sound return southward along the east coast of Garden Island, creating an anticlockwise gyre in the northern portion of the Sound (Figure 3.17). Smaller clockwise gyres are also predicted in the southern end of the Sound and on the northern section of the eastern shelf (Harris & Antenucci 2009). During summer, much of the water exchange between Cockburn Sound and coastal waters to the north is driven by transient two-layer exchange flows forced primarily by local wind stresses (Ruiz-Montoya & Lowe 2014).

In autumn, depth-averaged currents are typically weaker and more variable than in summer (Figure 3.17), with less frequent vertical mixing due to the reduced wind energy. Basin waters have higher density due to higher salinities following summer evaporation, and lower water temperatures following differential cooling (DEP 1996). On the eastern shelf, flows are typically northwards, but with a clockwise gyre still persistent on the north of the shelf. Smaller-scale circulation cells may form during the autumn, including an anticlockwise gyre in the southern half of the Sound, driven by the residual currents through the Garden Island causeway (Harris & Antenucci 2009).

During the winter-spring period, the dynamics of the Sound are typically influenced by the passage of storm systems at 7–10 day intervals (with wind magnitudes sufficient to fully mix the water column) and an increase in the buoyant discharge from the Swan River. During winter, a reversal of circulation occurs due to northerly winds, setting up a clockwise-rotating gyre in the main basin of the Sound and a strong southward flow on the eastern shelf (Figure 3.17). In spring, the wind is less dominant and horizontal pressure gradients have a greater influence on circulation, resulting in reduced and more variable currents throughout the Sound (Harris & Antenucci 2009). Relatively low residual velocities and a complex flow pattern are observed on the eastern shelf, with a clockwise gyre in the northern region and a lower-velocity anti-clockwise gyre in the central region (Figure 2.1). Between storm events, Cockburn Sound's surface mixed layer is typically 5–10 m deep, with intermittent weak vertical stratification during periods of light winds (DEP 1996).

Flushing times for Cockburn Sound, as calculated using hydrodynamic modelling undertaken for Fremantle Ports and Water Corporation, are estimated at 24 days in summer, 31 days in autumn, 26 days in winter and 47 days in spring (Antenucci et al. 2009). The long flushing times in spring coincide with low residual velocities throughout the Sound during this season (Harris & Antenucci 2009). Regional-scale fluctuations of the alongshore pressure gradient, such as the propagation of coastally trapped waves down the WA coast, can also affect the local exchange and flushing of Cockburn Sound (Ruiz-Montoya & Rowe 2014).



Source: modified from Harris & Antenucci (2009)

Notes:

1. These residual currents represent the net movement of water over all depths of the water column for 90-day periods; they are an accurate representation of the overall average circulation of the Sound
2. A two-fold nested grid setup was used for the model – a 100 m x 100 m grid resolution within the within the main Cockburn Sound basin, and a 50 m x 50 m grid resolution on the eastern shelf

Figure 3.18 Modelled seasonal residual velocities within Cockburn Sound

Marine ecology

Cockburn Sound is within a region of marine 'biogeographical overlap' that extends from Cape Leeuwin to North West Cape. Perth's coastal waters essentially comprise a temperate environment for inhabitant marine flora and fauna but tropical species are also found due to the influence of the Leeuwin Current, which brings water from the north. Endemic species (i.e. species only found in Western Australia) typically make up 10–25% of the species in Perth's coastal waters, depending on the type of organism (e.g. crustaceans, shellfish, worms) (BMT 2018a). The diversity of seagrass species in Perth's coastal waters is high. There are less than 60 species of seagrass worldwide, 13 of which are found in the local region. The six main 'meadow-forming' seagrass species are *Amphibolis griffithii*, *A. antarctica*, *Posidonia australis*, *P. sinuosa*, *P. angustifolia* and *P. coriacea*. In Cockburn Sound, the densest stands of seagrass occur in shallow sheltered areas and consist of meadows of *P. sinuosa* or *P. australis*. Cockburn Sound had extensive areas of these species before massive seagrass loss occurred in the late 1960s / early 1970s (Cambridge & McComb 1984), although most species remain present in the remaining stands of seagrass.

3.3.3 Socio-economic environment

Planning and context

The Proposal is located within the City of Kwinana. The land-use zoning as identified by the Metropolitan Regional Scheme is 'industrial', resulting in a zoning category compatible with the intended land-use. Riseley Road and a pipe manufacturing plant bound the DAF to the east, Cockburn Sound is to the west, Barter Road and PSDP1 to the north, and the Kwinana Bulk Terminal to the south.

Population and land uses

Kwinana has been an industrial zone since the 1950s and 64% of those directly employed within the KIA live locally within Cockburn, Kwinana, and Rockingham. As such, there is a general understanding of the land use needs of industry and an acceptance of industrial facilities. Land uses within the KIA generally consist of heavy and light industry such as refineries, liquid gas storage, power generation, cement works, sand blasting/industrial painting, extractive industries, mineral processing and engineering. In addition, the Cockburn Sound also contains a defence base at Garden Island. In the larger Kwinana area surrounding the industrial estate are conservation estates including Woodman Point Regional Park and Beeliar Regional Park.

Aboriginal heritage

An interrogation of the Aboriginal Heritage Inquiry System identified that there are no Registered Sites or Other Heritage Sites within the DAF (DPLH n.d.). The search identified Registered Site 3710 (Thomas Oval) approximately 3.2 km to the south east. No other Registered Sites were identified within 5 km of the DAF. Other Heritage Place 3776 (Indian Ocean), a mythological site within the Cockburn Sound, was identified adjacent to the western boundary of the DAF.

Water Corporation facilitated an ethnographic and archaeological survey and assessment to understand recommendations in relation to the Proposal. As a result of consultations held with eight representatives of the Gnaala Karla Booja Native Title Claim group on 24 January 2018, no new ethnographic sites of significance, as defined by Section 5 of the *Aboriginal Heritage Act 1972*

AHA), were identified within the DAF. The Traditional Owners consulted were not aware of any ethnographic sites located within the area, and advised that the DAF would likely have been utilised by Nyungar people from inland areas for more customary cultural practices, such as camping and fishing, especially during the summer months.

No new archaeological sites, as defined by Section 5 of the AHA, were located within or near the DAF during the survey. No isolated artefacts were located and no previously recorded archaeological sites or heritage places were located within the survey area.

4. Stakeholder engagement

4.1 Key stakeholders

Key stakeholders have been identified in relation to the Proposal by Water Corporation including:

- Environmental Protection Authority
- Department of Water and Environmental Regulation
- Department of Environment and Energy
- Department of Health
- Department of Biodiversity, Conservation and Attractions
- Department of Primary Industries and Regional Development
- Department of Treasury Western Australia
- Department of the Premier and Cabinet (Ministers for Water and Environment)
- City of Kwinana (including Elected Members)
- Kwinana Industry Council
- Cockburn Sound Management Council
- Fremantle Ports
- City of Cockburn
- Main Roads Western Australia
- LandCorp
- WA Fishing Industry Council
- Recfishwest
- Conservation Council of Western Australia

Due to the concurrent engagement in regards to investigations completed for the Alkimos Seawater Desalination Plant, stakeholders were briefed on both Proposals where appropriate.

4.2 Stakeholder engagement process

Stakeholder engagement for the Proposal commenced in 2017 and has been conducted in several formats, including face to face meetings with state and local government agencies, corporations and public and industry interest groups; comprehensive marine modelling workshops and the establishment of an online community, which invited public feedback.

As a member of the Cockburn Sound Management Council, Kwinana Industry Council (Environment and Planning Committee) and Westport Taskforce, engagement for the Proposal has been subject to extensive discussion and consideration by these key stakeholder groups.

The Water Corporation has also operated the Perth Seawater Desalination Plant for more than 12 years and has established engagement processes for community and stakeholders in relation to the operating plant, with feedback from stakeholders during PSDP construction and operation reviewed as part of Proposal considerations.

Community engagement for the Proposal has included:

- 210 unique visits to the online community page, with five surveys completed

- More than 20 stakeholder briefings
- Eight marine modelling presentations, attended by more than 30 stakeholders
- Reference to the Proposal in local and State media articles

Stakeholder consultation processes remain ongoing, opportunities for engagement continue to be explored as further details of the Proposal and the potential impacts are understood.

Feedback from stakeholders and community has reflected three key areas:

1. Future planning for the Kwinana Industrial Area and how the Proposal may interact with future considerations
2. Marine impacts on Cockburn Sound
3. Public access to the beach during construction and operation

4.3 Stakeholder consultation

Table 4.1 below presents an overview of the stakeholder consultation to date. Further consultation is ongoing as the Proposal progresses through design and construction.

Table 4.1 Summary of stakeholder consultation

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
Department of Water And Environment Regulation and Environmental Protection Authority	17/11/2017	Meeting Tom Hatton, Anthony Sutton, Hans Jacob (DWER)	Discussion on the progress of the project and the proposed approach to delivery	Advice noted
Department of Water And Environment Regulation	20/12/2017	Meeting Hans Jacob, Kevin Mcalpine (DWER)	Marine Ecosystems and Impact Assessment	Advice noted
Department of Health	22/02/2018	Meeting Richard Theobald	Energy sources/carbon footprint Outer harbour: - Potential impact on infrastructure due to use of cape size vessels; mainly around damage and future depth of the Sound - Water quality impacts of possible Outer Harbour Consideration around the decision to focus on desal as the source and what other work was taking place in the recycling space	Advice noted
Department of Treasury	1/12/2017	Meeting Kaylene Gulich	General briefing on investigations	Advice noted

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
		Ross Murphy Jarrad Gardner Clint Brimson		
Minister for Water	5/12/2017	Meeting Hon Dave Kelly	General briefing on investigations	Advice noted. Regular briefing provided throughout investigations.
Department of Primary Industries and Regional Development	5/4/2018	Meeting	General briefing on investigations	Advice noted
City of Kwinana (Council)	5/02/2018	Council briefing Mayor Carol Adams Cllr Peter Feasey Cllr Wendy Cooper Cllr Merv Feasey Cllr Sandra Lee Cllr Sheila Mills Cllr Matthew Rowse Cllr Dennis Wood	• Outer Harbour and impact on current and future WC assets • Job opportunities as a result of construction and operations • Beach access (horse beach) • Supply to future industrial growth of Kwinana Industrial Area • Impact of salinity on Cockburn Sound • Renewable energy strategy for the expanded plant	Feedback considered during investigations. Corporation to re-engage Council prior to referral
City of Kwinana	5/02/2018	Meeting Maria Cooke – Director, City Regulation	• Impact of plant on possible Outer Harbour	Feedback considered during investigations. Corporation to re-engage City prior to referral

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
		• Sarah McCabe – Sustainability Officer • Jenny Hammington – Place Management Coordinator • Paul Nielson – Manager, Planning • Ash Harding – Manager, Environment • Warwick Carter – Economic Development Specialist	• Ensuring future growth of the Kwinana Industrial Area is considered in Corporation planning • Affect of rising sea levels and coastal erosion • Access to beach by public	
Kwinana Industry Council	21/2/2018	Meeting Director Chris Oughton Members of Environment and Planning Committee	• Water supply to industry (forecast and opportunities from possible future plant) • Outer Harbour and expected development resulting to Kwinana Industrial Area • Groundwater recharge vs. desalination (benefits/ cost) • Water quality and assessing impacts on the Cockburn Sound • Whether other sites had been considered	Responses provided and advice noted in investigations

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
			(for economic reasons (Outer Harbour))	
Cockburn Sound Management Council	2/3/2018	Meeting Council members	• Volume of water drawn from Sound to produce plant output • Impact/ research conducted on impact of intake on juvenile fish/ eggs • Power supply - likely source, renewables (solar?) • EPA assessment - what we expect to be assessed at. How will regulators assess cumulative impacts of multiple proposed projects in Sound • Encouraging water efficiency while bringing new major source online - Corp planning • Interest in marine modeling workshop	Advice noted and considered. Specific response to intake of intake on juvenile fish and eggs was provided via email: *The seawater intake servicing the proposed expansion of the Perth Seawater Desalination Plant will be the same design as the existing intake and both intakes will operate at low horizontal inflow velocities not exceeding 0.15 m/s in the screen slots and 0.1 m/s based on the gross screen area.* *This means that larger marine animals, such as fish and dolphins will not be drawn into the intake. There is a possibility that larvae within close proximity of the intake structure could be impacted due to entrainment, however the low velocities created by the intake structure ensure this is a very localised impact (specific to a small area surrounding the intake structure) and is unlikely to have an overall impact upon the fish populations*

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
				and other marine fauna in Cockburn Sound.
BP	19/2/2018	Meeting	Discussed possible pipeline route. Subject to further investigations	Route was not considered feasible
Fremantle Ports Authority	22/2/2018			
WA Fishing Industry Council (WAFIC)	11/04/2018	**Meeting** John Harrison	Proposal briefing. Discussion on Cockburn Sound marine impacts and associated fisheries and Alkimos offshore investigations.	General advice noted. Subsequent meeting with Executive Officer held.
Recfishwest	10/04/2018	**Email** Matthew Gillett	Advice regarding seismic and geotechnical work and likely concerns from recreational fishing community.	Information only.
WA Fishing Industry Council	20/06/2018	**Meeting** Mannie Shea (WAFIC) - Executive Officer	Briefing of Proposal and discussion on interest and engagement with commercial fishing sector	Advice noted and ongoing discussions maintained.
Westport Taskforce (Outer Harbour)	5/7/2018	Meeting Communications team - Elizabeth Jones and Alana Joske	Overview of community engagement, overview of Westport engagement, discussion on mutual stakeholders	Advice noted and ongoing discussions maintained.
Department of Biodiversity,	26/6/2018	Michael Roberts Jacqui Clinton	Proposal briefing	Information noted

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
Conservation and Attractions (DBCA)		Lyndon Mutter		
Cockburn Sound Management Council	30/8/2018	Prof Kateryna Longley (Chair) Council members	Technical presentation - marine model	
Aquaculture Council of WA				
Southern Seafood Producers (WA) Inc. Association		Don Nicholls Executive Officer		
DPIRD (Fisheries)	18/9/2018	Meeting Brett Molony Danielle Johnston David Fairclough Corey Wakefield"	Key fisheries impacts in Cockburn Sound General discussion on marine model	Information noted.
Department of Jobs, Tourism, Science and Innovation	9/10/2018	Meeting	Long term planning for Cockburn Sound	Information noted and engagement ongoing.
City of Kwinana	5/12/2018	Meeting CEO Joanne Abiss Maria Cooke – Director, City Regulation Ashley Harding - Manager, Environment Nino Scidone - Development Engineer	Summary briefing • Consideration of future planning (Outer Harbour)	

Stakeholder	Date	Form of engagement and attendees	Topic/issue raised	Proponent response/outcome
		Brenton Scambler - Coordinator, Statuatory Planning		
City of Kwinana Council	10/12/2018	Mayor Carol Adams Cllr Peter Feasey Cllr Wendy Cooper Cllr Merv Feasey Cllr Sandra Lee Cllr Sheila Mills Cllr Matthew Rowse Cllr Dennis Wood	Summary briefing • Consideration of future planning (Outer Harbour)	
Kwinana Industries Council	6/12/2018	Chris Oughton and Environment and Planning Committee	Summary briefing • Consideration of future planning (Outer Harbour)	
City of Cockburn	10/12/2018	Stephen Cain - CEO Daniel Arndt - Diretor Planning and Development Andrew Trosic - Manager Strategic Planning Nick Jones - Manager Environmental Health Chris Beaton - Environment Manager	Summary briefing • Consideration of future planning (Outer Harbour) • Energy source	

5. Environmental Factors and Principles

5.1 Identification of environmental factors and their significance

An assessment of potential key environmental factors against the EPA's *Statement of Environmental Principles, Factors and Objectives* (EPA 2018b) has identified key environmental factors that are to be considered within an environmental assessment as below (Table 5.1).

Table 5.1 Potential environmental factors (key factors bolded)

EPA Theme	EPA Factor	Significance	Relationship to Proposal
Sea	**Benthic Communities and Habitats**	Key environmental factor	• Temperate seagrass meadows constitute an important benthic habitat in Cockburn Sound. These seagrass meadows are foundation species in Cockburn Sound, providing critical ecosystem functions and services. Seagrasses respond rapidly to changes in environmental conditions such as light or nutrient availability, and therefore could potentially respond to changes in water quality associated with construction or operation of the PSD2 Project. • Assemblages of benthic macroinvertebrates occur in most parts of Cockburn Sound and provide a range of ecosystem services, including trophic links to higher order consumers. Macroinvertebrates can respond to changes in marine quality, habitat or food resources.
	Coastal Processes	Key environmental factor	• The beaches on the eastern shoreline of Cockburn Sound are narrow and there is historical evidence to suggest that significant erosion and accretion can occur. Construction works associated with nearshore trenching have the potential to temporarily alter the coastal profile, and in turn, cause erosion or accretion.
	Marine Environmental Quality	Key environmental factor	• Marine water and sediment quality in Cockburn Sound is presently considered acceptable when compared against relevant guidelines, which is imperative for maintaining ecosystem health values in the area. The Proposal has the potential to modify water and sediment quality during construction and operational phases of the Project through dredging activities associated with pipeline installation, and discharge of brine effluent.
	Marine Fauna	Key environmental factor	• A wide diversity of marine fauna occur in Cockburn Sound, including zooplankton, macroinvertebrates, fish, marine mammals and seabirds. Many of these taxa are present year-round, while others appear on a transitory basis. There is potential for the behaviour of some species, which are sensitive to underwater noise, to be modified during construction activities. There is also potential for small motile fauna, or fauna at early life stages (e.g. fish larvae) to become entrained in the seawater intake.

EPA Theme	EPA Factor	Significance	Relationship to Proposal
Land	Flora and vegetation	Environmental factor	• The vegetation in PSDP2 is considered to be of low diversity and does not contain any conservation significant flora or priority ecological communities. PSDP2 has been subject to high levels of disturbance and the condition of the vegetation has been significantly altered with much of the understorey dominated by introduced species. Clearing of vegetation for the construction of PSDP2 is not expected to impact regional flora or vegetation values.
	Landforms	Environmental factor	• Construction of the intake and outtake pipeline will result in a portion of the dune formation on the coastline adjacent to PSDP2 being removed. The dune formation provides coastal protection from erosion and storm surge events. There is potential for increased erosion to occur as a result of part of the dune formation being removed.
	Subterranean Fauna	Not relevant	• Geotechnical investigations conducted across the proposed PSDP2 site identified a predominant formation of siliceous carbonate sand and siliceous carbonate silty sand over Tamala Limestone. Typically, troglofauna require caves and voids as they are air breathing. The conditions of the subterranean environment identified in the geotechnical investigation did not identify any habitat suitable for troglofauna to be present. Stygofauna are aquatic organisms that require groundwater for survival although the presence of groundwater does not exclusively mean stygofauna are present. Geological features typically associated with stygofauna are calcretes; alluvial formations, fractures rock aquafers and karst limestone. Construction activities may impact stygofauna during dewatering activities and excavation for the wet well.
	Terrestrial Environmental Quality	Environmental factor	• During construction of PSDP2, activities have the potential to disturb potential acid sulfate soils that may be present across the Site; once constructed the ongoing operation of the PSDP2 may degrade soil quality as a result of chemical spills or inappropriate discharge of contaminated material. Prior to construction activities commencing an acid sulfate soils investigation will be commissioned to identify any potential acid sulfate soils that may be present within the PSDP2 site. A Construction Environmental Management Plan (CEMP) will be produced to manage and mitigate any potential impacts from acid sulfate soil disturbance; furthermore, an Environmental Management Plan (EMP) will be written prior to commissioning of the PSDP2 to guide operational activities to ensure chemical spills are appropriately managed and inappropriate discharges of contaminated material does not occur on the PSDP2 site. Consequently, terrestrial environmental quality is not considered a key environmental factor

EPA Theme	EPA Factor	Significance	Relationship to Proposal
	Terrestrial Fauna	Not relevant	• Fauna and flora surveys identified the vegetation within the PSDP2 Site is degraded due to historical activities. Due to the lack of connectivity with suitable habitat, the likelihood of conservation significant fauna listed in Section 3.3.1 relying on the site is very low; this is supported by the outcomes of the fauna survey, which did not identify any sign of these species occurring on the site. Therefore, this factor is not considered relevant to the Proposal.
Water	Inland Waters Environmental Quality	Environmental Factor	• No inland water ways occur within or near the PSDP2 site. • Groundwater abstraction during construction is likely to be required for the installation of infrastructure for PSDP2. Constructing the wet well for the capture of seawater gravity fed from the seawater intake pipe will require excavation to approximately 10 m below ground level. Excavation to that depth in that location will likely require dewatering during the construction and there is a small chance that the site may be susceptible to acid sulfate soils, which could contaminate the coastal environment.
Air	Air Quality	Environmental factor	• Air quality – Within the Kwinana industrial estate air quality criteria are set out in the Environmental Protection (Kwinana) (Atmospheric wastes) Policy 1999. The Proposal has the potential to contribute to cumulative impacts to air quality in the form of power generation. Emissions resulting from power consumption from the fully operational PSDP2 are anticipated to generate 76860 t/a CO_2-e, this constitutes 0.184% of Western Australia's' total CO_2 output for 2013/2014 (EPA 2016a); as such, air quality as a result of emissions is not considered a key environmental factor. • Dust – Generation of dust from construction activities has the potential to impact the local and surrounding areas and risk causing poor air quality associated with dust generation; however, dust suppression is a common construction activity and the management of dust generation is frequently a factor in construction projects. Consequently, dust mitigation practices are well understood, commonly applied and frequently performed in best practice construction activities and will form a part of the CEMP for the PSDP2. Dust generation is therefore not considered a key factor in this Proposal.

EPA Theme	EPA Factor	Significance	Relationship to Proposal
People	Social Surroundings	Environmental factor	• Aboriginal heritage – Impacts to Aboriginal heritage are unlikely to the absence of identified registered sites within 3 km of the Proposal. Construction activities will be managed with a CEMP to ensure that appropriate action is taken in the unlikely event that previously unidentified artefacts are suspected to be discovered during construction. • Visual amenity – Post construction of the intake and outtake pipeline, the primary dunes will be reinstated and rehabilitated where possible to pre-construction levels, to mitigate visual and amenity impacts to the shoreline from Cockburn Sound. The re-establishment of the primary dunes will also provide shoreline stability and assist with protection for the assets from storm surge events. Visual amenity is not considered a key environmental factor. • Fisheries – Impacts to commercial and recreational fisheries in Cockburn Sound may arise during dredging, or as a result of brine effluent discharges. Impacts are considered possible, but unlikely. Potential impacts to fisheries can be inferred from assessment of impacts to Marine Fauna.
	Human Heath	Environmental factor	• Noise – PSDP2 is proposed to be situated within the Kwinana industrial estate which already hosts several large noise polluting facilities. Noise generation machinery of the PSDP2 operation will be located within buildings which acts a as a noise shield for the immediate environment; therefore, the operational noise of PSDP2 is unlikely to significantly impacts upon the amenity of the Kwinana industrial estate. • Chemical storage – On site chemical storage for the treatment of intake and product water will be in accordance with all dangerous goods regulations; however, there is potential for the storage units to decay and corrode over time. All materials used to store dangerous chemicals will be coated with salt resistant material/paint to reduce the effects of salt on the housings. Furthermore, the location of all storage units will be in easily accessible positions to assist in identification of faults and ease of repairs. Chemical storage information will be accessible to personnel and all chemical storage units will be located on hardstands to significantly reduce discharge to the environment in the unlikely event of a rupture. Chemical storage is not considered a key environmental factor.

5.2 Consistency with environmental principles

The EP Act identifies a series of principles for environmental management. The environmental principles are the highest assessment level that a Proposal or scheme must meet in order to be found environmentally acceptable by the EPA. The Proponent has considered these principles in relation to the development and implementation of the Proposal. Table 5.2 outlines how the principles relate to the Proposal.

Table 5.2 EP Act principles

Principle	Consideration
The precautionary principle *Where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In the application of the precautionary principle, decisions should be guided by:* *a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* *b) an assessment of the risk-weighted consequences of various options.*	The Proponent has identified a number of environmental factors that are relevant to the Proposal. The Proposal has been designed to avoid, as far as practicable, any serious environmental harm. Specialist studies have been undertaken (e.g. hydrodynamic modelling, flora and fauna surveys) and used to supplement information from existing surveys/investigations, to inform the understanding of the existing environment and identify the potential impacts from the Proposal. Where there were areas of uncertainty regarding potential impacts, conservative assumptions were made. Management actions to address residual impacts and ensure impacts are as predicted are addressed within the construction and operations environmental management plans. The Proponent considers that the Proposal meets the application of the precautionary principle.
The principle of intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.*	The Proposal is part of a larger water resource development program by the Proponent that includes multiple options based around supply requirements and environmental sustainability. The Proposal is not predicted to have long-term adverse effects on the health, diversity or productivity of the environment. The Proponent considers that the Proposal meets the principle of intergenerational equity.
The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integration should be a fundamental consideration.*	The Proponent has identified four key environmental factors (marine environmental quality, benthic communities and habitats, marine fauna and coastal processes) relevant to the Proposal. Detailed investigations have been undertaken to identify potential impacts and mitigation options to minimise the impact of the Proposal and align with the EPA objective for each environmental factor. No long-term impacts on environmental values of Cockburn Sound are expected to occur. The Proponent considers that the Proposal meets the principle of conservation of biological diversity and ecological integrity.

Principle	Consideration
<u>Improved valuation, pricing and incentive mechanisms</u> *1) Environmental factors should be included in the valuation of assets and services.* *2) The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.* *3) The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which benefit and/or minimise costs to develop their own solutions and responses to environmental problems.*	The Proponent accepts that costs for environmental mitigation and management are part of the overall Proposal costs. This includes identified rehabilitation and/or residual impact management actions as addressed within the construction and operations environmental management plans. The Proponent considers that the Proposal meets the principle of improved valuation, pricing and incentive mechanisms.
<u>The principle of waste minimisation</u> *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	The Proposal's approach to waste is consistent with the waste management (avoid, recover, disposal) principles. The key ongoing waste item for the Proposal is the discharge of brine effluent to Cockburn Sound. The mitigation hierarchy has been applied to this waste stream to reduce the impact of this discharge. Waste management for the Proposal is addressed within the relevant construction and operations environmental management plans. This also includes consideration of reusing natural materials (e.g. excavated dune sediments) where practicable. The Proponent considers that the Proposal meets the principle of waste minimisation.

6. Marine Environmental Quality Impact Assessment

6.1 EPA objective

To maintain the quality of water, sediment and biota so that environmental values are protected.

6.2 Legislation, policy, guidance

The legislative instruments, policies and guidelines considered relevant to the environmental impact assessment of marine environmental quality are provided in Table 6.1.

Table 6.1 Legislative instruments, policies and guidelines relevant to marine environmental quality impact assessment

Legislative instrument
Environmental Protection Act 1986)
Contaminated Sites Act 2006
EPA policy or guidance
Statement of Environmental Principles, Factors and Objectives (EPA 2018b)
State Environmental (Cockburn Sound) Policy 2015 (EPA 2015)
Environmental Quality Criteria Reference Document for Cockburn Sound (EPA 2017)
Factor Guideline – Marine Environmental Quality (EPA 2016b)
Technical guidance – Environmental Impact Assessment (EIA) of Marine Dredging Proposals (EPA 2016c)
Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA 2016d)
Other policy or guidance
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
National Assessment Guidelines for Dredging (CA 2009)
Contaminated Sites Guidelines (DER 2014)
Acid Sulfate Soils Guidelines Series (DER 2015)

6.3 Receiving environment

6.3.1 Cockburn Sound environmental values

An important priority for the WA government is to ensure that Cockburn Sound continues to support the multiple values for which it is renowned. The *Cockburn Sound State Environmental Policy* (SEP) was first introduced by government in 2005 (updated in 2015) as a mechanism to ensure that the values and uses of Cockburn Sound are protected and fully considered in decision-making about ongoing and new uses of the Sound.

The overall objective of the SEP is to ensure that the water quality of the Sound is maintained and, where possible, improved so that there is no further net loss and preferably a net gain in seagrass areas, and that other environmental values and uses are maintained. The management framework established by the policy is based on that recommended by the *National Water Quality Management Strategy* (ANZG 2018), representing an agreed, Australia-wide approach to protecting water quality and associated environmental values.

The Cockburn Sound SEP establishes five environmental values for Cockburn Sound, all of which are relevant to the factor marine quality and this project:

- ecosystem health
- fishing and aquaculture
- recreation and aesthetics
- cultural and spiritual
- industrial water supply.

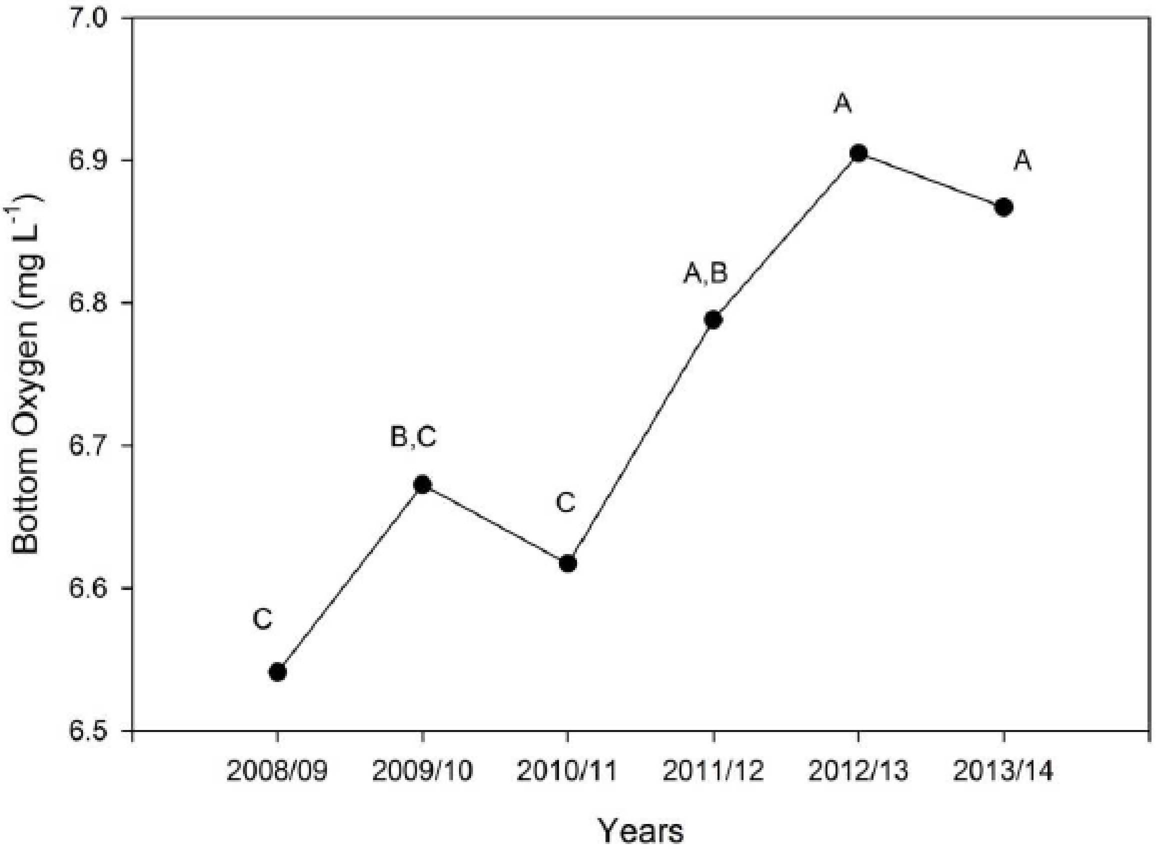
6.3.2 General description of marine environmental quality in Cockburn Sound

Cockburn Sound is a unique environment which undergoes natural changes in water quality associated with seasons, daily weather patterns, temporal currents, rainfall and biological events. Historically, nutrient discharges, contaminated land and groundwater inputs and coastal modifications have negatively influenced Cockburn Sound's marine environment leading to declines in marine environmental quality (BMT 2018a). However, following concerted effort by government, industry and the community over the past two decades, marine water and sediment quality in Cockburn Sound is now considered acceptable when compared against relevant guidelines (BMT 2018a).

Water quality

Natural salinity levels in Cockburn Sound show seasonal variation and usually range between 34.5–37 PSU annually (Water Corporation 2013). Seasonal patterns show salinity decreasing in winter months when rainfall and runoff dilute the water column, and an increase in salinity in the summer months due to evaporation (van Senden & Miller 2005). With respect to temperature, Keesing et al. (2016) found a strong seasonal signal in both surface and bottom water temperatures, with temperatures in January and February warmer than those in December and March. It was determined that a 2010/11 mean of 24°C was significantly warmer than other years and this is consistent with the well documented marine heat wave which occurred in early 2011 (e.g. Pearce et al. 2011; cited in Keesing et al. 2016). In the long-term, Keesing et al. (2016) determined that there has been an increase in both surface and bottom water temperatures in Cockburn Sound with increases in surface waters between 1985 and 2014 of 0.0325 ± 0.016 °C per year. These rates of change are very similar to those reported elsewhere off the WA coastline and are attributed to global climate change (Keesing et al. 2016).

There is a strong negative correlation between dissolved oxygen (DO) levels and sea water temperature at the sea bed, with the lowest levels of DO typically occurring in February (Keesing et al. 2016). Temporally, the recent years of 2012/13 and 2013/14 were found to have had the highest DO concentrations (6.9 mg/L; Figure 6.1), while spatially, areas near the causeway and Warnbro Sound had significantly higher levels of DO (7.3 mg/L) than any other site sampled during routine annual monitoring by the Cockburn Sound Management Council (Keesing et al. 2016).



Source: Keesing et al. (2016)

Note:

1. Letters indicate which means are significantly different from or equal to each other (i.e. A>B>C, $p<0.0001$ in all cases).

Figure 6.1 Mean bottom dissolved oxygen levels across Cockburn Sound from 2008/09 to 2013/14

While water quality has considerably improved in the past two decades (BMT 2018a), the waters of Cockburn Sound are known to stratify under certain conditions, whereby water of high density (e.g. higher salinity and/or lower temperature than ambient) will tend to gravitate towards the seabed and form a layer underneath the lighter, lower density waters above it. The intensity of stratification is proportional to the density difference between surface and bottom waters, the greater the difference the more intense the stratification. This is a natural process in Cockburn Sound and is not persistent throughout the year (Keesing et al. 2016).

Stratification events are a concern as they can reduce normal dissolved oxygen (DO) levels from natural levels typically greater than 90% saturation throughout the water column to 60% saturation or lower in the bottom of the water column. In turn, low DO can induce direct adverse effects on the benthic biota. DO concentrations are typically high in Cockburn Sound waters, but there is a seasonal reduction as seawater temperature increases (Keesing et al. 2016) and low DO events do occasionally occur. A recent example followed elevated water temperatures associated with an abnormal heat wave for >8 weeks in the summer of 2011 (February to mid-March), which reduced DO concentrations across the Sound to as low as 3.12 mg/L in the deep southern basin (Rose et al. 2012). No instances of dead fish or other biota were reported during this event but the low

DO event did highlight the susceptibility of benthic primary producers and faunal communities to enhanced patterns of stratification (BMT 2018a).

Concentrations of potential toxicants in Cockburn Sound were last comprehensively assessed in 2008 (PB 2009). Concentrations of potential contaminants were below their environmental quality criteria (EQC) values (where available) for both moderate and high ecological protection areas. A further 70 potential toxicants without guidelines were mostly below their respective detection limits or limits of reporting, or present at low concentrations. Contaminants with concentrations above the limit of reporting (but with no EQC) were all within accepted international standards where such standards are available (PB 2009).

Sediment quality

Sediment exposure to contamination in Cockburn Sound has largely been a consequence of industrial development, shipping and other boating activity, similar to those pressures affecting marine water quality (BMT 2018a). Due to the proximity of existing wharves to the proposed project area, shipping and port activities are key potential sources of sediment contaminants including the antifoulant tributyltin (TBT), various petroleum hydrocarbons and some metals.

6.3.3 Study effort

Water Corporation has used the outcomes from the surveys outlined in Table 6.2 to support the assessment of potential impacts of the Proposal on marine environmental quality. Relevant reports are presented as appendices.

Table 6.2 Marine environmental quality studies used to inform the Proposal

Title	Description
Perth Desalination Plant Discharge Modelling: Model Validation (BMT 2018b; Appendix C)	To better understand the risk of the PSDP2 Proposal to marine quality in the Sound, Water Corporation has developed a hydrodynamic and water quality numerical model of Cockburn Sound and its surrounds, to provide a platform by which the assessment of the fate and transport of return waters from the existing and proposed PSDP2 plant can be undertaken (key elements of the model set-up and calibration process are described below).
Perth Desalination Plant Discharge Modelling: Model Scenarios (BMT 2019a; Appendix E)	This report describes results from numerical model simulations designed to assist in understanding the likely behaviour of brine effluent discharged from the PSDP2 Proposal. Simulations made use of an existing peer reviewed three-dimensional hydrodynamic, transport and DO model of Cockburn Sound and its surrounds (referred to above).
Perth Seawater Desalination Plant 2 Construction Impact Assessment (BMT 2019b; Appendix A)	As part of the impact assessment, an existing numerical model of Cockburn Sound (referred to above) was used to simulate the advection and dispersion of sediment plumes generated by the proposed construction works.
Perth Desalination Plant Discharge Modelling: Effects of Desalination Discharges on Dissolved Oxygen (BMT 2019c; Appendix F)	This report describes the hydrographic mechanisms that impact patterns in DO concentration in the deep basin of Cockburn Sound, including: • natural patterns in stratification and DO • mechanisms driving those patterns • the relative influence of desalination discharges associated with PSDP2 on those patterns

Title	Description
	• potential ecological risks to marine biota as a consequence of the Proposal.
Perth Seawater Desalination Plant 2 Dredging Engineering Advice (BMT 2018d; Appendix G)	This technical advice provides an assessment of dredge engineering options and production rates to enable sediment plume dispersion modelling for proposed PSDP2 marine construction activities.
Other relevant studies	
Perth Seawater Desalination Plant Marine Monitoring and Management Plan: Final Report (Water Corporation 2013)	In line with Ministerial Statement 832 (Condition 8) for the PSDP1, Water Corporation implemented a Marine Monitoring and Management Plan to track declines in DO in the bottom waters of Cockburn Sound for a continuous period extending over at least two autumn periods (June 2011 to June 2013). This report describes monitoring results and outcomes.
Fremantle Ports Kwinana Quay Project Sediment Sampling and Analysis Implementation Report (Oceanica 2009a)	In 2008, Fremantle Ports proposed to develop a major outer harbour port facility (Kwinana Quay) within Cockburn Sound to accommodate long-term container trade growth (this proposal has since been closed). As part of the environmental impact assessment program, Fremantle Ports implemented a broad scale marine sediment quality monitoring program to test for suitability of dredge material for offshore disposal. A subset of results from this program (collected in 2008) was used to inform the PSDP2 Proposal.
Fremantle Ports Marine Quality Monitoring Program Annual Reports (BMT Oceanica 2014a, 2015, 2016, 2017, BMT 2018c)	As part of their Marine Quality Monitoring Program (MQMP), Fremantle Ports undertakes annual marine quality monitoring in Cockburn Sound, alongside the Kwinana Bulk Terminal, to meet licence conditions L4476/1984/12. A subset of sediment quality results from this program (for the years 2014–2018) was used to inform the PSDP2 Proposal.

Hydrodynamic modelling

Water Corporation engaged BMT to develop a three-dimensional hydrodynamic and water quality numerical model of Cockburn Sound and its surrounds. The intent of developing the model was to inform the design and EIA of the Proposal. The scope of the modelling program and investigation included:

- configuration of a farfield model previously validated for a range of ambient conditions and simulation periods
- development of PSDP2 diffuser designs and configuration to ensure a suitable nearfield dilution (see Section 6.5)
- determining the likely level of dilution attained with the operation of both PSDP1 and PSDP2 discharges (see Section 6.5)
- determining the likely effects of the PSDP1 and PSDP2 discharges on salinity, temperature and DO concentrations on the marine environment of Cockburn Sound (see Section 6.5)
- deployment of a hydrodynamic model particle transport module to simulate the fate of total suspended solids (TSS) during dredging activities and quantification of TSS dispersion and sediment deposition rates (see Sections 6.5, 7.5 and 8.5)
- deployment of a hydrodynamic model particle transport module to simulate the fate of pink snapper (*Pagrus auratus*) larvae following spawning events and quantification of larvae

dispersion, mortality and their potential entrainment into PSDP1 and PSDP2 intakes (see Section 8.5).

Selection of modeller and peer review process

As the modelling is such a key tool to the assessment, a procurement and review process was established prior to commencement to ensure that the work would be of suitable quality to inform this assessment:

- An expression of interest process was used to identify four quality commercial modelling teams with previous experience in modelling both desalination discharges and Cockburn Sound.
- The four teams were then invited to submit technical fee proposals to Water Corporation for assessment by an independent expert and internal Water Corporation staff with relevant experience.
- Following award, an independent Peer Review Panel (PRP) was then established comprising: Prof. Chari Pattiaratchi (University of Western Australia), Dr Nick D'Adamo (Bureau of Meteorology), Dr Jason Antenucci (Expert modeller, DHI), and Dr Desmond Lord (Chair)
- The PRP:
  - reviewed the initial stages of model set-up (grid, domain, approach, etc.)
  - received briefings on the draft model calibration and validation process
  - provided advice on data requirements and the scope required for successful calibration and validation
  - provided independent advice to Water Corporation
  - received briefings on the final model validation and calibration and reviewed the draft calibration and validation report
  - signed off on the final model validation and calibration report
  - reviewed and provided advice on the final preferred scenario report
  - signed off on the final scenario report.

The PRP's final report on the validation and calibration of the model is included as Appendix G.

Model set-up

The hydrodynamic model construction, calibration and assumptions are described in full by BMT (2018b; Appendix D). In summary, the modelling package includes:

- OpenFOAM (Open Field Operation and Manipulation) which was developed for detailed representation of the nearfield dilutions, and
- TUFLOW FV and Aquatic Ecosystem Model v.2 (AED2) were used for three-dimensional simulation of temperature, salinity and DO.

OpenFOAM was adopted as the computational fluid dynamics modelling tool for the diffuser assessment performance, while AED2 was coupled to TUFLOW FV to simulate DO in Cockburn Sound (Hipsey et al. 2013).

In AED2, DO dynamics account for atmospheric exchange, sediment oxygen demand, microbial consumption during organic matter mineralisation and nitrification, photosynthetic oxygen production and respiratory oxygen consumption, and respiration by other optional biotic components (Hipsey et al. 2013). TUFLOW FV was used to calculate water levels and both advection and diffusion of scalars (temperature, salinity and DO) and AED2 was applied to calculate source and sink terms specific to the DO dynamics.

The hydrodynamic modelling component of these assessments used the TUFLOW FV software. TUFLOW FV is a numerical hydrodynamic model for the two-dimensional (2D) and three-dimensional (3D) non-linear shallow water equations. The model is suitable for simulating a wide range of hydrodynamic systems ranging in scale from open channels and floodplains, through estuaries to coasts and oceans. The three-dimensional model was deployed in this study.

Marine quality scenarios

Model scenarios were required to sufficiently define the characteristics and fate of the PSDP1 and PSDP2 discharges under various seasonal and climatic conditions to help inform the potential environmental risks of the Proposal, and included:

- **Scenario 1A NoDESAL** – this is a baseline scenario that assumes there are no desalination plant intakes or discharges in Cockburn Sound. This scenario was required to support the method of presentation of model results.
- **Scenario 1A** – this is a scenario of existing conditions, which assumes only the PSDP1 intake and discharge operate in Cockburn Sound at a production rate of 45 GL/year, and that discharges occur via the existing diffuser arrangement.
- **Scenario 2A –** This is a scenario based on proposed conditions, which assumes both PSDP1 and PSDP2 intakes and discharges operate in Cockburn Sound. For this scenario, PSDP2 operating at a 50GL/year production rate was included in the simulation, in addition to the 45 GL/year PSDP1 production rate. The PSDP1 and PSDP2 discharges were delivered through separate diffusers.
- **Scenario 2C –** This is a scenario based on proposed conditions at a reduced production rate during Autumn months from PSDP2 in Scenario 2a.

Table 6.3 PSDP2 modelling scenarios

<table>
<tr><th rowspan="2">Modelling scenario</th><th rowspan="2">Timing</th><th colspan="2">Discharge (ML/d)</th><th colspan="2">Diffuser design</th><th rowspan="2">Modelling outcome</th></tr>
<tr><th>PSDP1</th><th>PSDP2</th><th>PSDP1</th><th>PSDP2</th></tr>
<tr><td>1A. Existing PSDP1 baseline</td><td>All year</td><td>195</td><td>0</td><td rowspan="3">Length: 163 m
No. of ports: 40
Port diameter: 13 cm
Port spacing: 4 m
Port orientation: north</td><td rowspan="3">Length: 245 m
No. of ports: 50
Port diameter: 12 cm
Port spacing: 5 m
Port orientation: alternating (north, south)</td><td>• Define extent of existing brine effluent plume under worst-case mixing conditions
• Examine risk of recirculation (brine effluent entering intake)</td></tr>
<tr><td>2A. PSDP2 baseline 50 GL with existing PSDP1</td><td>Applied for summer, winter and spring</td><td>195</td><td>202</td><td>• Define extents of both brine effluent plumes under worst-case mixing conditions
• Confirm estimated impact of construction on suspended sediment and light
• Assess scale of entrainment risk to snapper eggs/larvae
• Assess interaction between PSDP1 and PSDP2 brine effluent plumes</td></tr>
<tr><td>2C. PSDP2 baseline 25 GL with existing PSDP1</td><td>Applied for autumn period only</td><td>195</td><td>101</td><td>• Define extents of both brine effluent plumes under worst-case mixing conditions
• Assess interaction between PSDP1 and PSDP2 brine effluent plumes</td></tr>
</table>

Incorporation of other industrial intakes and discharges

Intakes and outfalls related to other industries operating in Cockburn Sound were incorporated into the model, and boundary conditions were set according to relevant periods of operation (BMT 2018b; Appendix D). Industries included in the model were:

- Kwinana Power Station (stages A and C)
- Newgen Power Station
- Kwinana Power Station Gas Fired
- Cockburn Power Station
- PSDP1
- BP Refinery
- Tiwest.

The following steps were used to incorporate industrial discharges during model simulations:

1. initially, a simulation set without any industrial discharges is run
2. boundary conditions associated with the industrial discharges are then created
3. simulations were performed without PSDP1 discharges, but with all other industrial discharges
4. boundary conditions associated with the PSDP1 discharge are then created
5. a simulation set is run with PSDP1 and with the other industrial discharges, but without the PSDP2 discharge
6. boundary conditions associated with the PSDP2 discharge are created
7. the final simulation set with PSDP1 and PSDP2, and with all other the industrial discharges, is run.

Model simulations

Following finalisation of elected scenarios (Table 6.3), modelling was used to simulate the extent, duration and intensity of impacts under ‘normal’ and most likely ‘worst-case’ climatic conditions, and in combination with any other changes in marine environmental quality caused by adjacent activities.

To generate ‘normal’ climatic conditions, a full year run based on climatic conditions experienced from 01 March 2008 to 01 March 2009 was modelled. Post processing of model outputs was undertaken to further examine seasonal variations:

- autumn: 1 March 2008 to 1 June 2008
- winter: 1 June 2008 to 1 September 2008
- spring: 1 September 2008 to 1 December 2008
- summer: 1 December 2008 to 1 March 2009.

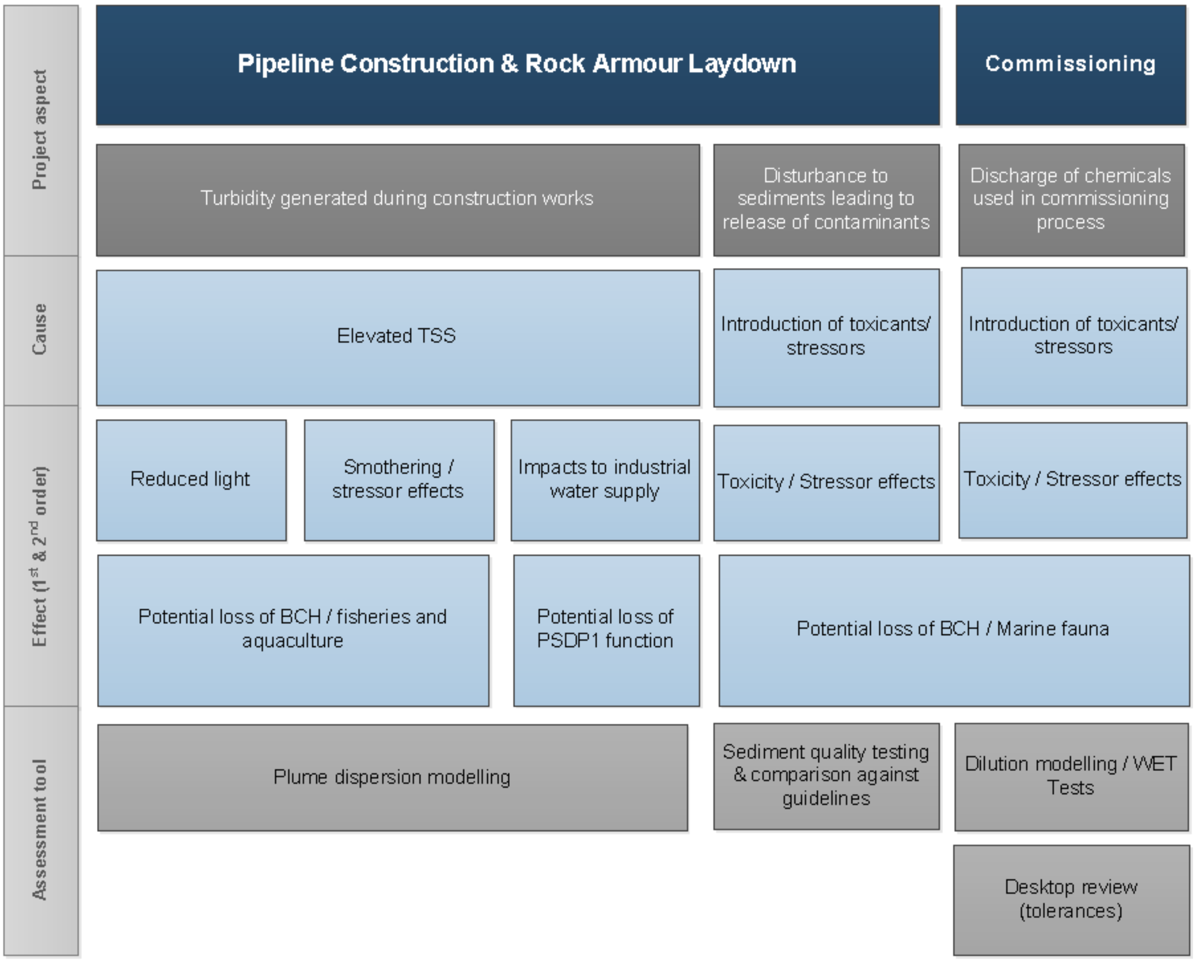
To simulate worst-case conditions, modelling was undertaken based on climatic conditions experienced in autumn 2013, when a low DO event occurred (BMT 2018b,c). This simulation period covered 5 April to 1 May 2013.

6.4 Potential impacts

6.4.1 Potential construction impacts to marine environmental quality

Potential cause-effect pathways of impacts of construction activities on marine environmental quality associated with the Proposal are shown in Figure 6.2. Impacts may arise as a result of:

- dredging of the seabed and back-filling over the pipelines, which can lead to periods of elevated enhanced TSS and reduced light during construction, which in turn may lead to:
  - loss of benthic communities and habitat
  - disruption to fisheries and aquaculture activities
  - disruption to quality of industrial intake water
- release of toxicants to the water column due to disturbance of sediments
- short-term (3–4 months) flushing of the desalination outlets and intakes during commissioning to remove debris, including grouting materials.



Note:

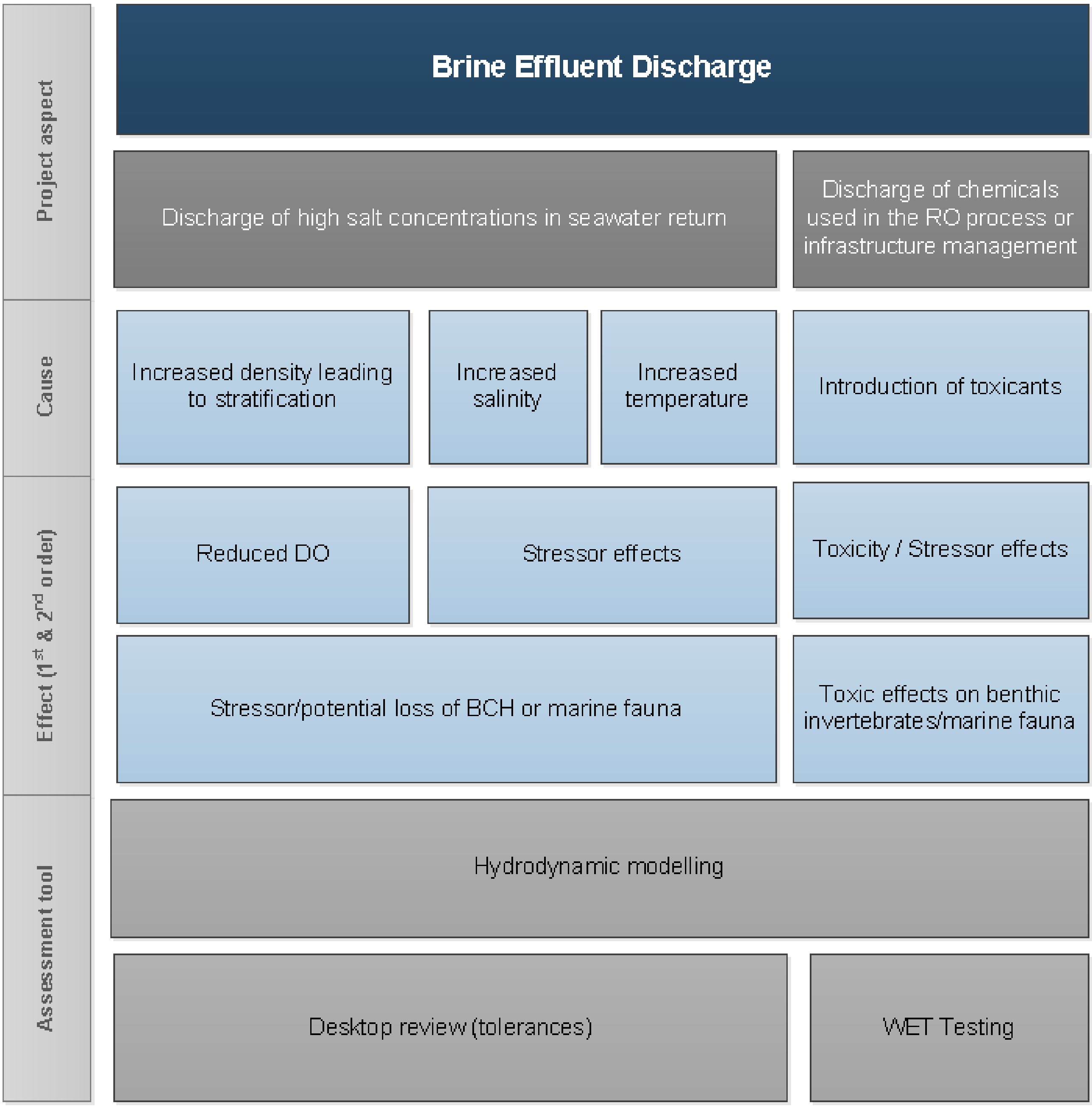
1. BCH = benthic communities and habitats; PSDP1 = Perth Seawater Desalination Plant 1; TSS = total suspended solids; WET = whole of effluent toxicity

Figure 6.2 Potential impacts to marine environmental quality, and flow-on effects, associated with PSDP2 marine construction activities

6.4.2 Potential operational impacts to marine environmental quality

Desalination plants produce brine effluent that may also contain constituents that can alter marine environmental quality, including high salt concentrations, chemicals used for defouling of the plant equipment (biocides), and metals (in-particular iron, used for flocculation and removal of particulates prior to RO treatment). Potential operation impacts considered relevant to the Proposal are shown in Figure 6.3. Such impacts may arise as a result of:

- discharges of brine effluent can potentially enhance the strength of stratification and in turn, promote reduced DO
- changes to marine salinity (osmotic stress)
- elevated return water temperature (temperature stress)
- release of toxicants in brine effluent used in the RO process
- recirculation leading to slight increases in salinity of diluted effluent.



Note::

1. DO = dissolved oxygen; RO = reverse osmosis; WET = whole of effluent toxicity

Figure 6.3 Potential impacts to marine environmental quality, and flow-on effects, associated with PSDP2 marine operations

6.5 Assessment of impacts

6.5.1 Assessment framework

Assessment of construction impacts

To assess potential impacts on marine quality of toxicant release during dredging, the environmental quality guidelines (EQG) for moderate ecological protection were applied in accordance with the recommendations of ANZG (2018) as follows:

- application of the default 90% species protection guideline trigger levels for toxicants in water
- the *National Assessment Guidelines for Dredging* (CA 2009) ISQG-low guideline trigger levels for toxicants in sediments (CA 2009).

While it is recognised that the *National Assessment Guidelines for Dredging* (NAGD) framework is not strictly applicable to the Proposal (as the disposal of sediments are set for terrestrial landfill and backfill to the dredge location), it does provide a suitable framework to use for understanding the risk of dredge related impacts and potential toxicant release.

To assess impacts of dredging on water quality for desalination plant intake water, the EQG for total suspended solids was applied (EPA 2017):

- *The rolling median concentration of total suspended solids adjacent to the Perth Seawater Desalination Plant intake, calculated over a period not exceeding four weeks, should not exceed 4.5 mg/L and no individual total suspended solids value should exceed 9 mg/L at any time.*

Potential changes to marine environmental quality associated with turbidity and sedimentation as a result of dredging are described here, while indirect impacts on benthic communities and habitats are assessed in Section 7.4.1 in-line with the EPA's (2016c) *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals*.

Assessment of operational impacts

In accordance with *Environmental Factor Guideline – Marine Environmental Quality* (EPA 2016b), a review of Cockburn Sound's five environmental values (ecosystem health, fishing and aquaculture, recreation and aesthetics, cultural and spiritual, and industrial water supply) was undertaken to identify those environmental quality objectives (EQOs) that may be affected by the Proposal and may therefore require the setting of specific EQC to ensure their protection (further discussed in Section 6.5.1).

The review identified that three environmental values and four corresponding EQOs require the setting of specific EQCs (Table 6.4). The remaining environmental values and EQOs are still relevant to the Proposal, but are expected to be protected by default through the protection of other environmental values or objectives (Table 6.4).

Table 6.4 Summary of environmental values and environmental quality objectives

Environmental value	Environmental quality objectives	Relevant for the development of specific EQG
Ecosystem health	*Maintenance of ecosystem integrity*	Yes
Fishing and aquaculture	*Maintenance of seafood safe for human consumption*	Protection of ecosystem health will protect this value
	Maintenance of aquaculture	Protection of ecosystem health will protect this value
Recreation and aesthetics	*Maintenance of primary contact recreation values*	*Yes*
	Maintenance of secondary contact recreation values	Protection of primary contact recreation values will protect this value
	Maintenance of aesthetic values	*Yes*
Cultural and spiritual	*Cultural and spiritual values of the marine environment are protected*	Protection of ecosystem health will protect this value
Industrial water supply	*Maintenance of water quality for industrial use*	Protection of ecosystem health will protect this value

EQC have been derived from EPA's *Environmental Quality Criteria Reference Document for Cockburn Sound* (EPA 2017; Table 6.5). The EQC encompass EQG and environmental quality standards (EQS):

- EQGs: are threshold numerical values or narrative statements which, if met, indicate there is a high degree of certainty that the associated EQO has been achieved. If the guideline is not met then there is uncertainty as to whether the associated EQO has been achieved and a more detailed assessment against an EQS is triggered. This assessment is risk-based and investigative in nature
- EQSs: are threshold numerical values or narrative statements that indicate a level which if not met indicates there is a significant risk that the associated EQO has not been achieved and a management response is triggered. The response would normally focus on identifying the cause (or source) of the exceedance and then reducing loads of the contaminant of concern (i.e. source control) and may also require in situ remedial work to be undertaken.

The conceptual framework for applying the EQC to operational impacts associated with the PSDP2 Proposal is illustrated in Figure 6.4.

Table 6.5 Relevant environmental indicators and environmental quality guidelines for assessment of potential impacts to marine environmental quality during plant operations

Environmental quality objectives	Environmental indicator(s)	Environmental quality guidelines	
		High protection	Moderate protection
Maintenance of ecosystem integrity	DO	The median DO concentration in bottom waters at the site (measured in daylight hours and defined to be within 50 cm of the sediment surface), calculated over a period of no more than one week, is greater than 90% saturation	The median DO concentration in bottom waters at the site (measured in daylight hours and defined to be within 50 cm of the sediment surface), calculated over a period of no more than one week, is greater than 80% saturation
	Salinity	Median salinity at an individual site over any period, measured according to standard operating procedures (SOP), not to deviate beyond the 20^{th} and 80^{th} percentiles of the natural salinity range measured at a suitable reference site for the same period	Median salinity at an individual site over any period, measured according to SOP, not to deviate beyond the 5^{th} and 95^{th} percentiles of the natural salinity range measured at a suitable reference site for the same period
	Temperature	Median temperature at an individual site over any season, measured according to SOP, not to exceed the 80^{th} percentile of the natural temperature range measured at a suitable reference site for the same season	Median temperature at an individual site over any season, measured according to SOP, not to exceed the 95^{th} percentile of the natural temperature range measured at a suitable reference site for the same season
	Toxicants (water quality)	The 95^{th} percentile of the sample concentrations from a single site or a defined area should not exceed the ANZG (2018) 99% species protection trigger values	The 95^{th} percentile of the sample concentrations from a single site or a defined area should not exceed the ANZG (2018) 90% species protection trigger values
Maintenance of primary contact recreation values	Water clarity - TSS	To protect the visual clarity of waters used for swimming, the horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m	
	Toxicants chemicals	The 95^{th} percentile of the sample concentrations from the area of concern (either from one sampling run or from a single site over an agreed period of time) should not exceed the environmental quality guideline values provided below	
Maintenance of aesthetic values	Visual aspects - TSS	The natural visual clarity of the water should not be reduced by more than 20%. Seagrass should generally be visible in up to 10 m of water under calm conditions in summer	

Environmental quality objectives	Environmental indicator(s)	Environmental quality guidelines	
		High protection	Moderate protection
Maintenance of water quality for industrial use	Temperature	The 90^{th} percentile of temperature measurements adjacent to the Perth Seawater Desalination Plant intake over a period not exceeding one month should not exceed 28°C	
	TDS	The median concentration of total dissolved solids adjacent to the Perth Seawater Desalination Plant intake over a period not exceeding one month should not exceed 40,000 mg/L	
	TSS	The rolling median concentration of total suspended solids (TSS) adjacent to the Perth Seawater Desalination Plant intake, calculated over a period not exceeding four weeks, should not exceed 4.5 mg/L and no individual total suspended solids value should exceed 9 mg/L at any time	
	DO	The median DO concentration 5 m above the sea floor adjacent to the Perth Seawater Desalination Plant intake, calculated over a period not exceeding one month, should be ≥2 mg/L	
	pH	The median pH adjacent to the Perth Seawater Desalination Plant intake over a period not exceeding one month should not exceed 8.5	
	Boron	The 90^{th} percentile boron concentration adjacent to the Perth Seawater Desalination Plant intake over a period not exceeding one month should not exceed 5.2 mg/L	

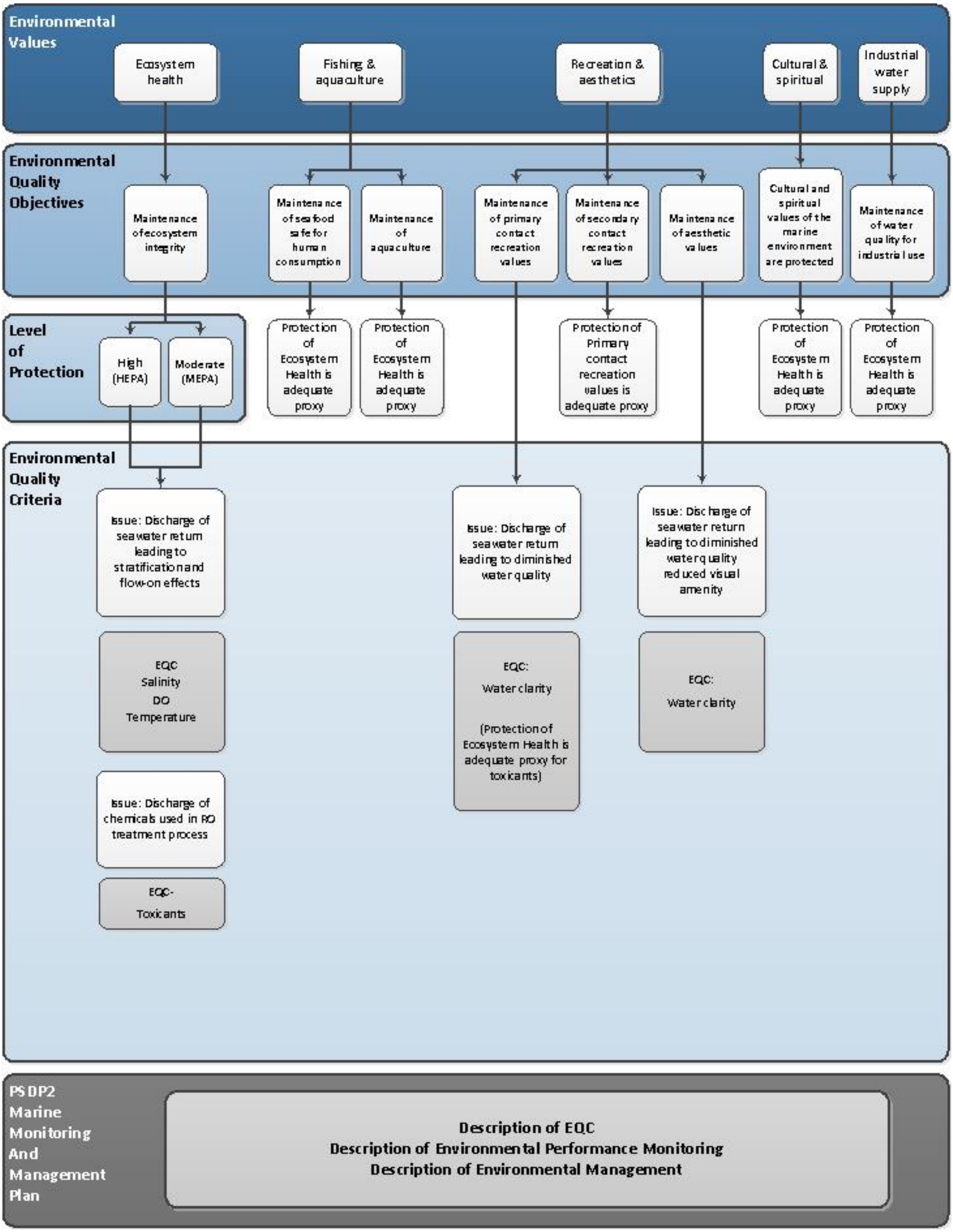


Figure 6.4 PSDP2 marine environmental quality management framework

Environmental Quality Plan

The Environmental Quality Plan for Cockburn Sound is gazetted in EPA (2015). To ensure the protection of the environmental value of 'Ecosystem health', EPA designate separate levels of ecological protection to be maintained. The ecological protection areas are set at one of the three levels:

i. high level of ecological protection area (HEPA)
ii. moderate level of ecological protection area (MEPA)
iii. low level of ecological protection area (LEPA).

These areas have been spatially defined in the Cockburn Sound SEP (EPA 2015) and are shown in Figure 6.5. The proposed PSDP2 intake and outlet would be located on the Eastern Shelf of Cockburn Sound within an area designated by EPA as MEPA (Figure 6.5). The PSDP2 will be managed to ensure that:

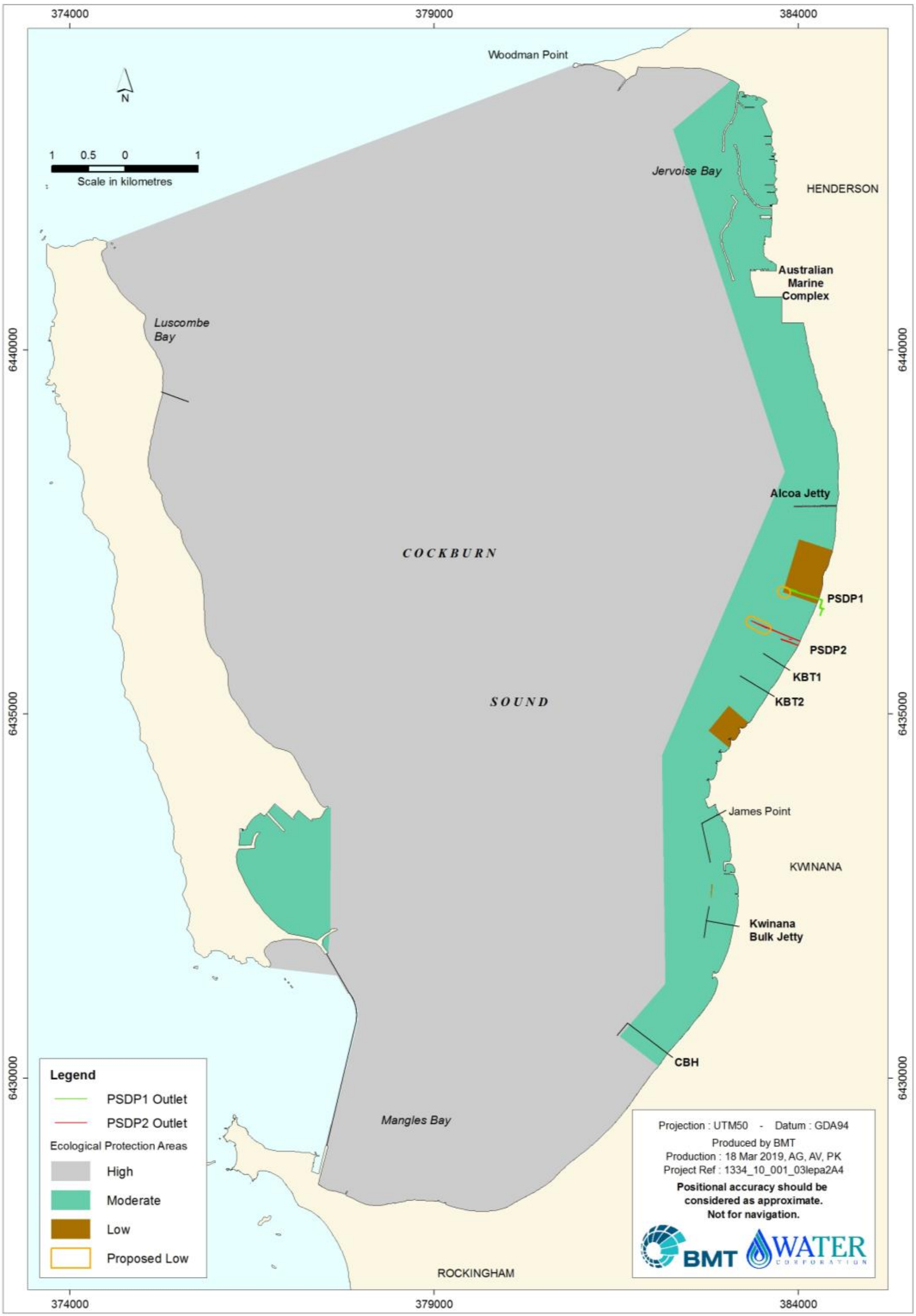
- HEPA: any aspect of the Proposal that affects areas designated as HEPA in Cockburn Sound will correspond with 99% ANZG (2018) species protection levels, and
- MEPA: any aspect of the Proposal that affects areas designated as MEPA correspond with a 90% ANZG (2018) species protection levels.

As RO desalination discharge will require a short period of mixing before the return water is able to dilute to required protection levels within the MEPA, Water Corporation is seeking to modify the Environmental Quality Plan (EPA 2015) and level of protection of waters immediately around the proposed PSDP2 discharge outlet to LEPA (Figure 6.5). Water Corporation is also seeking to designate a MEPA / LEPA boundary around the PSDP1 discharge outlet once PSDP2 becomes operational.

Hydrodynamic modelling, as required by EPA (2016d), has been used to spatially define the size of each proposed LEPA based on the distance from the diffusers where the EQG for salinity would not be met (results of salinity modelling are provided in Appendix E, and described in Section 6.5.3). An iterative approach was undertaken to determine LEPA boundaries; initially modelling incorporated the PSDP2 plant operating at full capacity (50 GL/a) year-round. However, it was resolved that in autumn, the size of the salinity footprint (~44 ha), and in turn LEPA, generated at this operating capacity would far exceed EPA's 5% cumulative water surface area designated for LEPAs within the MEPA on the eastern side of Cockburn Sound (EPA 2017); 4.39% of the area has already been designated as LEPA, therefore only 0.61%, or 7.25 ha, is the maximum remaining area which is permitted to be designated as LEPA.

In response, Water Corporation modified the Proposal to operate the plant at 25 GL/a in autumn, and 50 GL/a for the remainder of the year (autumn being the time of year when mixing potential is lowest). Under this revised scenario, modelling determined that the salinity footprint would be significantly reduced in autumn (<4 ha) and far smaller again in all other seasons (see also Section 6.5.3). In-line with EPA (2016a), the area bounded by the revised salinity footprint, plus an allowance for symmetry, was then used to spatially define the LEPA around PSDP2. It is noted that the resulting LEPA boundary (5.11 ha) has irregularity in distances north and south of the diffuser array (the diffuser is separated from the LEPA boundary by a distance of ~61 m to the north and ~89 m to the south) due to a depression in the seafloor that lies immediately south-east of the PDP2 diffusers.

Through modelling, it was also determined that the cumulative effect of operating both PSDP1 and PSDP2 plants simultaneously would result in a small area (<1.8 ha) around the PSDP1 diffuser where the EQG for salinity would be unlikely to be met in autumn (see Section 6.5.3); this impact does not occur when PSDP1 operates in isolation and is due to the desalination plumes merging (BMT 2019a). To manage this cumulative effect, Water Corporation is proposing to designate the area around the PSDP1 (2.08 ha) as LEPA when PSDP2 comes into operation. The total area of both LEPA's combined equates to 7.19 ha and therefore meets EPA's 5% cumulative water surface area designated for LEPAs within the MEPA on the eastern side of Cockburn Sound (EPA 2017).



Source: amended from EPA (2015)

Notes:

1. PSDP = Perth Seawater Desalination Plant, KBT = Kwinana Bulk Terminal, CBH = Cooperative Bulk Handling
2. Area within proposed PSDP2 LEPA boundaries = 44.73 ha
3. PSDP2 and PSDP1 LEPA boundary coordinates are provided in Appendix I

Figure 6.5 Environmental Management Plan for PSDP2: high, moderate and low ecological protection areas in Cockburn Sound

6.5.2 Construction impacts

Turbidity generated during dredging activities

Turbidity generated by dredging and disposal of material can lead to a range of impacts, including loss of benthic flora and fauna due to reduced light available for photosynthesis and enhanced rates of sediment deposition. While dredging can significantly increase turbidity, specific patterns in sediment loads and their distribution in the water column can be highly stochastic. Communities of colonising, ephemeral seagrasses like *Halodule* spp. and *Halophila* spp. can often recover from a period of stress or disturbance (due to fast reiteration of ramets and a viable seed bank) whereas perennial species such as *Posidonia* spp. can be left permanently impacted, depending on the duration and intensity of light reduction effects (Collier et al. 2009, Lavery et al. 2009).

To characterise the advection and dispersion of sediment plumes generated by the proposed dredging and backfill activities, the current assessment utilised the existing TUFLOW FV Cockburn Sounds hydrodynamic model that was constructed and validated as per BMT (2018b). Summer wind conditions across individual years from 2002 to 2018 were analysed to select three summer periods representative of the design conditions, forming the simulation ensemble for assessing potential construction impacts. The respective ensemble periods simulated were:

- typical seasonal wind conditions, February/March 2007 – normal conditions
- easterly dominated wind conditions, February/March 2011 – to assess worst-case scenario for seagrass meadows
- southerly dominated wind conditions, February/March 2004 – to assess potential worst-case scenario for PSDP1 intake.

Plume dispersion

The dredge plume modelling results from the ensemble simulations were processed as spatial plots to illustrate dispersion of the plume, and timeseries plots for assessing impact in terms of TSS concentration above threshold values at key sensitive receptor sites. It is important to highlight that elevated TSS itself does not harm seagrasses, rather it is the continuous light reduction (measured as light attenuation coefficient (LAC)) associated with the sediments held in suspension that can result in seagrass loss. As such, to determine light equivalent tolerance thresholds, TSS concentrations from sediments collected at the site were initially converted to LAC using the equation[2] $LAC_{norm} = 0.0079 \times TSS + 0.0197$. Predicted dredge-generated elevations (above background) in TSS were then examined using nominal values[3] of 2, 5, 10 and 20 mg/L, where:

- 2 mg/L (or LAC_{norm} = ~0.0355) which approximates a potentially visible plume
- 5 mg/L (or LAC_{norm} = ~0.0592) which approximates a value that may pose a low risk to seagrasses
- 10 mg/L (or LAC_{norm} = ~0.0987) which approximates a value that may pose a moderate risk to seagrasses

[2] *This relationship was determined following laboratory testing of samples collected to inform the Kwinana Quay Outer Harbour environmental impact assessment and is specific to the sediment characteristics (particle size classes and distribution) at the location.*

[3] *Nominal values were derived from Strategen (2012) and were applied in a similar manner during the benthic primary producer habitat impact assessment of the Mangles Bay Tourist Precinct Proposal.*

- 20 mg/L (or LAC_{norm} = ~0.178) which approximates a value that poses a high risk of impacts to seagrass health.

Acute exceedance level 95th and 99th percentile TSS plots are shown for average conditions (average of ensemble periods) and worst case (peak of ensemble periods) in Figure 6.6 and Figure 6.7, respectively. The 99th percentile TSS contours highlight the potential for the sediment plume to advect north-west along the coastline. This behaviour is likely due to elevated wave-induced bed shear stress in the shallow areas along the coastline preventing fine sediment from settling, which in combination with the stronger afternoon southerly winds encountered in the summer, provide adverse conditions for water quality at the PSDP1 intake during dredging. However, these water movements also mean the plume largely bypasses the nearest seagrass receptor sites to the west of the PSDP2 diffuser. Worst-case 99th percentile TSS contours indicate TSS values will occasionally exceed 10 mg/L at the PSDP1 intake, and 2 mg/L across the majority of the seagrass area on the Kwinana Shelf, except for a narrow band of seagrass/reef area immediately west of the Australian Marine Complex (AMC) and a small patch further offshore (Figure 6.7).

Figure 6.8 shows the TSS time series at the PSDP1 seawater intake for the dredging periods during typical wind conditions (results for southerly and easterly wind patterns are provided in Appendix A). In all scenarios, both the rolling median threshold value of 4.5 mg/L and the instantaneous threshold value of 9 mg/L are exceeded during the dredging campaign (Figure 6.8). The results indicate that the most severe impacts to PSDP1 intake water quality occur under typical wind conditions (2007 ensemble period), where maximum TSS values of ~15 mg/L can be expected, with frequent exceedance of the instantaneous TSS threshold and a sustained exceedance of the rolling median threshold (Figure 6.8, Appendix A). Typical wind conditions appear to produce the most severe impacts at PSDP1 due to the southerly winds advecting the dredge plume to the PSDP1 intake without excessive dispersion of the plume, resulting in elevated concentrations relative to a more diffusive environment caused by stronger southerly winds (2004 ensemble period; Appendix A). Modelling also shows that TSS will decrease with increasing distance from the dredge location, and maximum instantaneous TSS projections for Kwinana Gas Fired power station sweater intake (~940 m from the dredge area) and the Kwinana Power station seawater intake (~1.2 km from the dredge area) are likely to reach a maximum of ~12 mg/L and ~5 mg/L, respectively (Figure 6.10 and Figure 6.11)

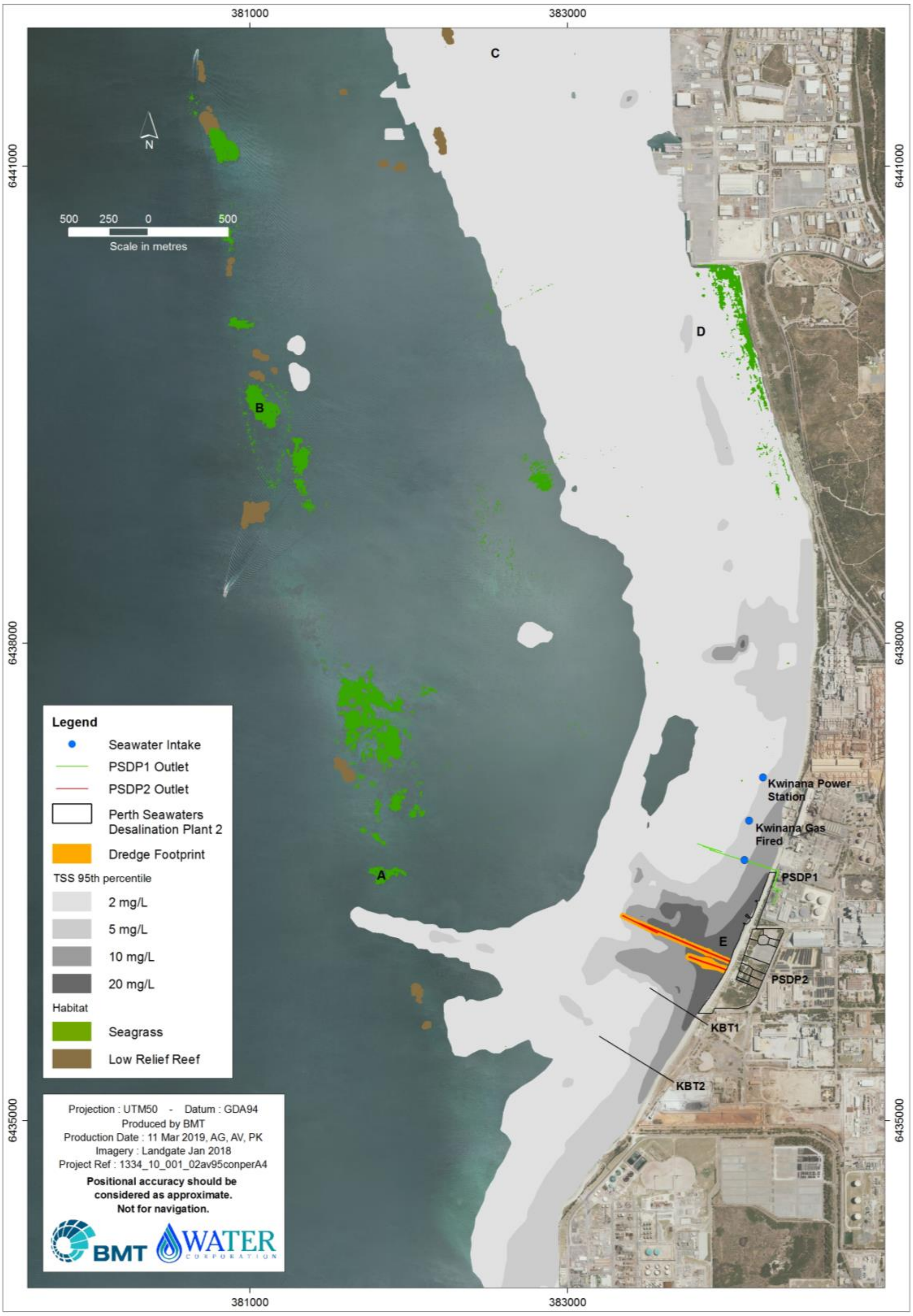
At the nearest seagrass sensitive receptor site to the dredge area (location ‘A’, Figure 6.6), the time series plots in Figure 6.12 demonstrate the instantaneous TSS is effectively <2 mg/L and the median TSS is <0.25 mg/L across the entire dredge campaign, indicating potential for a visible plume at this location without any adverse impacts. It was estimated that that TSS concentrations at this location would likely only exceed 2 mg/L for 0.1 days in total during the dredge and backfill campaign and would be extremely unlikely to exceed 5 mg/L (Table 6.6). Down current of the ‘plume’, TSS concentrations in waters immediately south of the AMC were predicted to be slightly higher than offshore seagrass meadows (location ‘D’, Table 6.6). However, even under worst-case scenarios, the 99th percentile for this location was still predicted to between 5–10 mg/L for a maximum duration of 0.9 days (Table 6.6).

Table 6.6 Approximate number of days that nominal thresholds are predicted to exceed 99th percentile total suspended solid (TSS) concentrations

	Total number of days nominal TSS values are predicted to be exceeded during dredging and backfill activities			
Location	2 mg/L	5 mg/L	10 mg/L	≥20 mg/L
Nearest seagrass meadow (A)	<0.1	0	0	0
Offshore seagrass receptor (B)	0.42	< 0.1	0	0
Woodman Point (C)	0.8	< 0.1	0	0
Seagrass abutting AMC (D)	18	0.9	0	0
Dredge footprint (E)	56	34	21	17

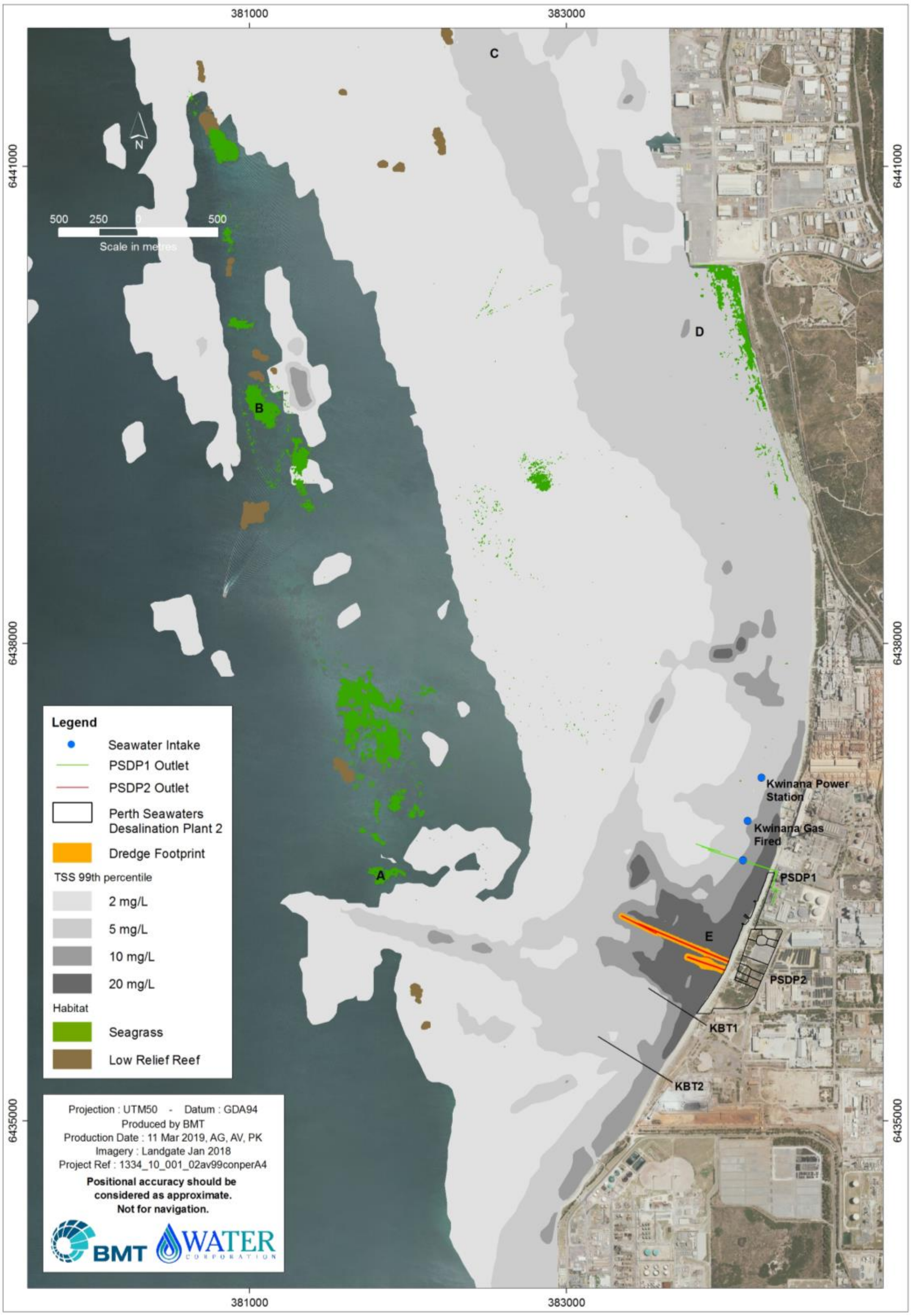
Notes:

1. Letters in brackets (A–E) correspond with Figure 6.7
2. Number of days was calculated based on the average (mean) number of days exceeding threshold values for each of the three respective ensemble periods
3. AMC = Australian Marine Complex



Note:
1. 95th percentile means the values shown are maxima expected to occur 5% of time or less

Figure 6.6 95th percentile contours of total suspended solids (mg/L) during dredging



Note:
1. 99th percentile means that the values shown are extreme maxima and expected to occur 1% of the time or less

Figure 6.7 99th percentile contours of total suspended solids (mg/L) during dredging

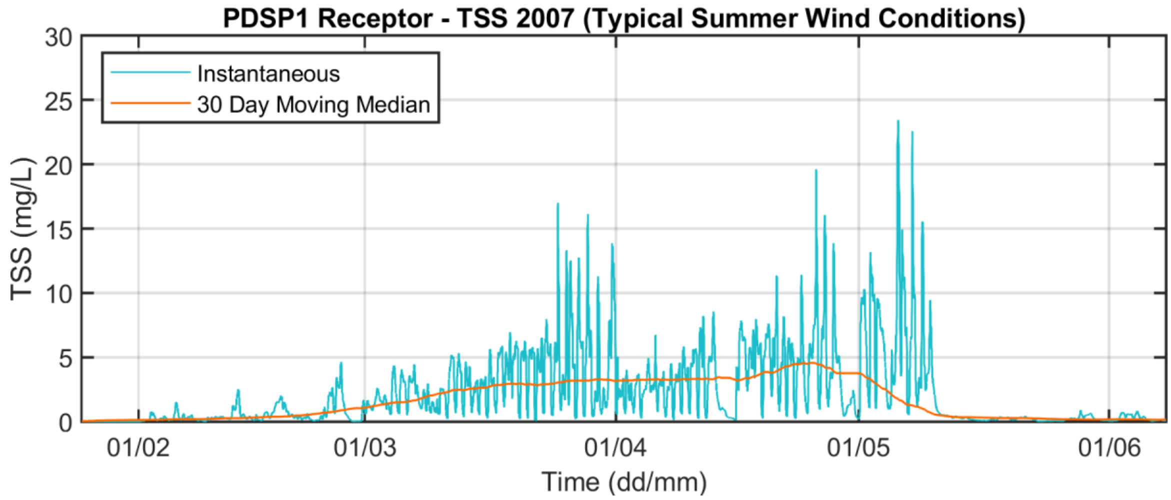


Figure 6.8 Predicted instantaneous and median total suspended solids (mg/L) at PSDP1 seawater intake – typical wind conditions

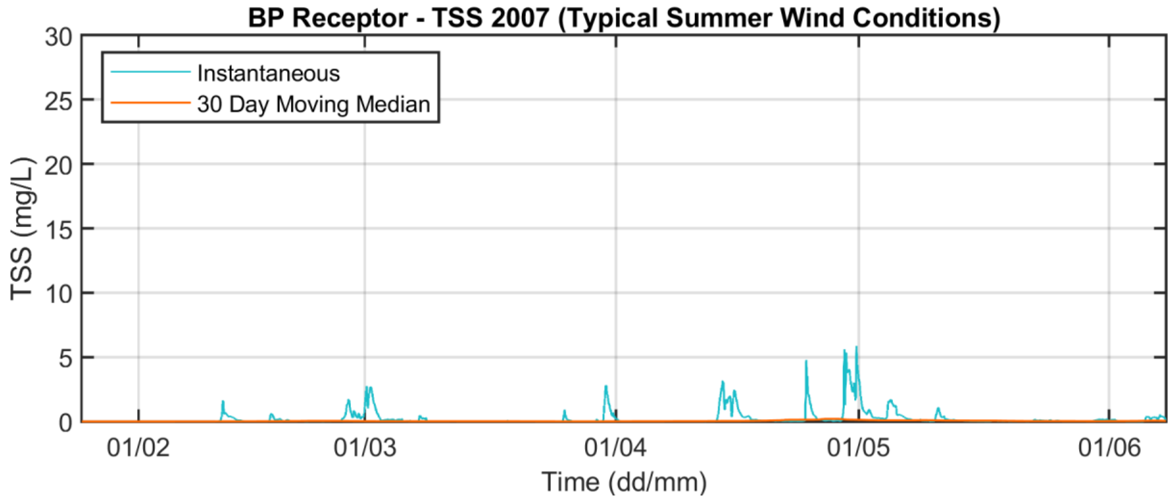


Figure 6.9 Predicted instantaneous and median total suspended solids (mg/L) at BP seawater intake – typical wind conditions

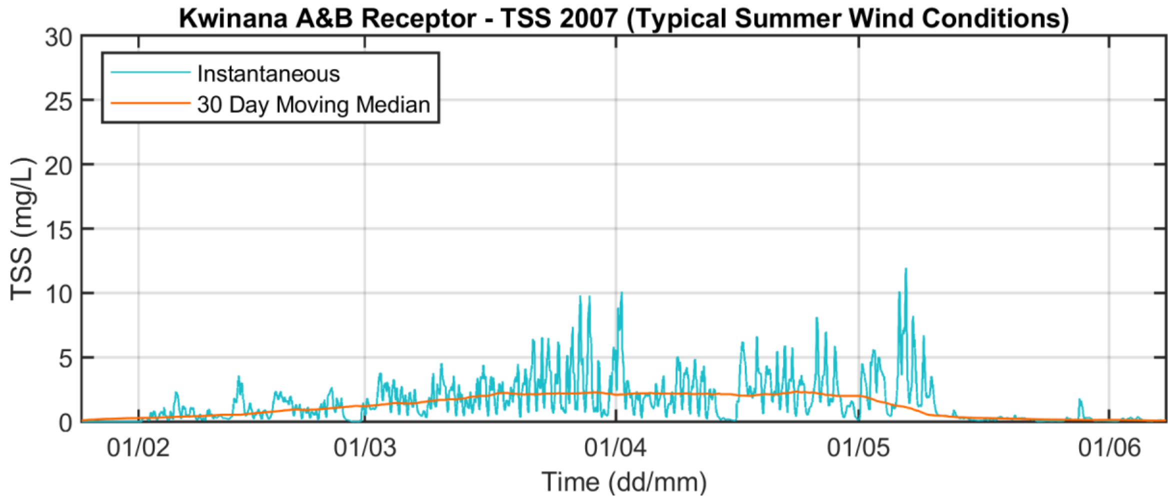


Figure 6.10 Predicted instantaneous and median total suspended solids (mg/L) at Kwinana A and B seawater intake – typical wind conditions

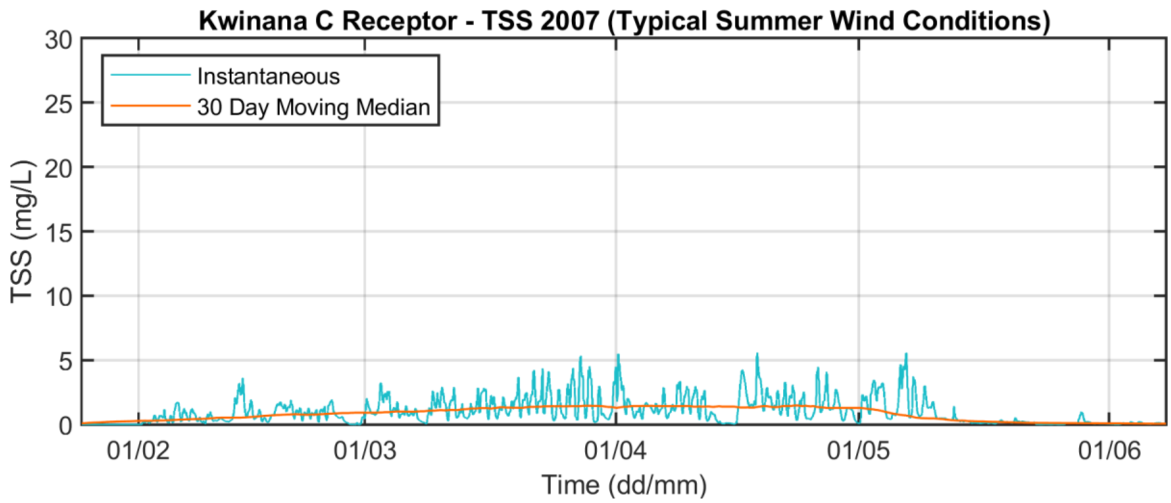


Figure 6.11 Predicted instantaneous and median total suspended solids (mg/L) at Kwinana C sweater intake – typical wind conditions

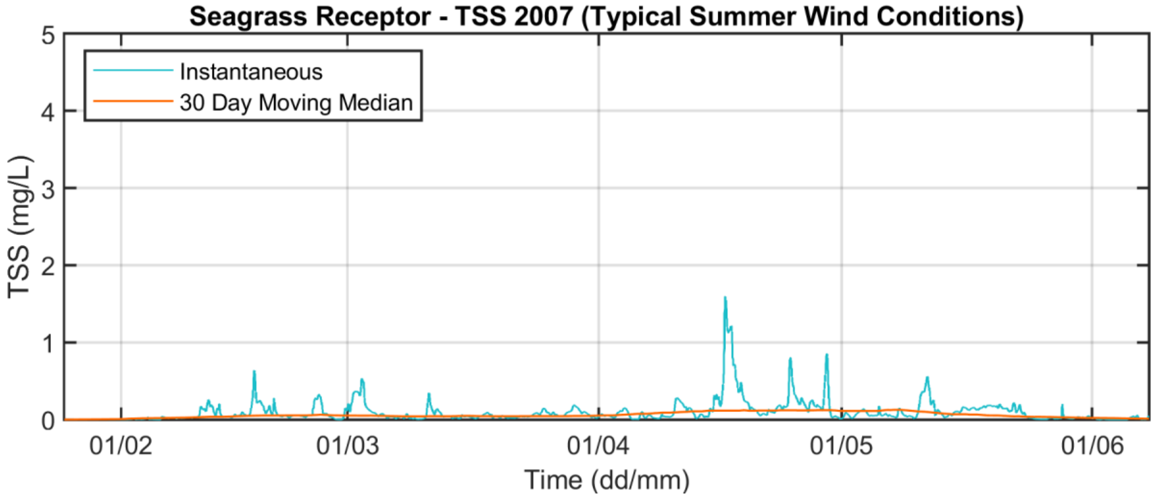
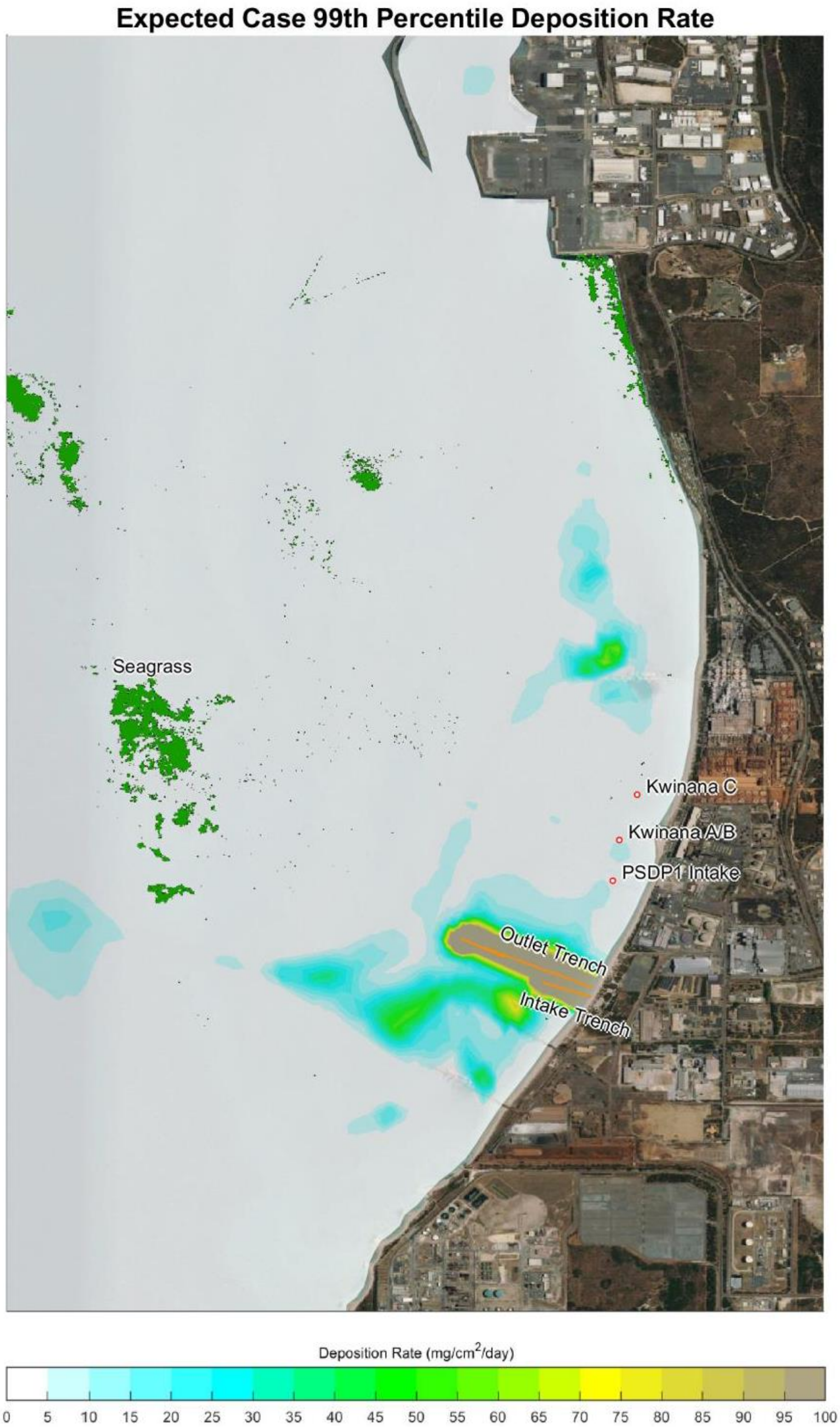


Figure 6.12 Predicted instantaneous and median total suspended solids (mg/L) at nearest seagrass receptor site during easterly dominated wind patterns

Sediment deposition

Plots showing the 99th percentile of expected sediment deposition rate and final expected distribution of net sedimentation across the simulation period for the average conditions are shown in Figure 6.13. These results indicate that acute levels of deposition will only occur in the immediate vicinity of, and to the south-west of, the dredge area, and there will be no deposition over nearby seagrass meadows (Figure 6.13). Net deposition across the entire program was forecast not to exceed 100 mg/cm (Figure 6.14), which is the equivalent of a veneer of ~1 cm/m^2 in the area of maximum deposition around the pipe trench.



Note:

1. 99th percentile means that the values shown are extreme maxima and expected to occur 1% of the time or less

Figure 6.13 99th percentile deposition rate (mg/cm^2/day) contours for the dredge and backfill program

Figure 6.14 Net deposition (mg/cm^2) contours for the dredge and backfill program

Outcome

From results presented above, and those in Appendix A, it was determined that the dredging campaign will likely result in a temporary increase in turbidity at the proposed dredging areas. Elevated turbidity in the water column may result in reduced light penetration, causing a reduction in marine flora and fauna productivity if turbidity is sufficiently persistent in time and space. Consistent with EPA (2016c), potential impacts to benthic communities and habitats due to dredging activities are assessed in Section 7.5.2.

Contamination from release of toxicants from sediments during dredging

Physical disturbance of the seabed during dredging can potentially lead to the release of toxicants bound in sediments, to the water column. This section describes the quality of sediment to be dredged and reclaimed within the general vicinity of the project area, based on the results of sediment sampling by Fremantle Ports in 2009 (Oceanica 2009a) and 2014–2018 (BMT Oceanica 2014a, 2015, 2016, 2017 and BMT 2018c).

A subset of data collected by Oceanica (2009a) is provided in Appendix G, while a summary of Fremantle Ports' data is presented below. It is noted that while some samples were collected more than five years ago (Oceanica 2009a), the results remain suitable for this ERD as the location has been undisturbed since 2009 so it is considered unlikely that sediment composition and characteristics would have changed since sampling was last undertaken. Recently collected sediment quality data (from the years 2014–2018) from the nearby Kwinana Bulk Terminal (KBT) are also provided as further evidence of sediment quality in the general dredge area. Prior to dredging, Water Corporation will implement a sediment quality sampling and analysis plan (SAP) to verify that sediment quality within the dredge footprint meets required environmental quality thresholds (CA 2009, DER 2014, DER 2015).

Samples from the Kwinana Quay program were collected by SCUBA divers using mechanical coring techniques; the 'Diver' locations were sampled for contaminants in the surface 1 m, while the 'Environmental & Geotech' locations were sampled at regular intervals deeper than 1 m through to greater than 5 m. Samples from KBT were collected according to EPA (2005) from the top 2 cm of sediments, also by SCUBA divers. The identified contaminants of concern included in the testing are presented in Table 6.7.

A summary of the results of sediment testing for contaminants of concern from the relevant Kwinana Quay program sites is presented below (see Appendix G for full report):

- petroleum hydrocarbons: The screening of unconsolidated material showed that PAH, TPH and BTEX concentrations in all sampled locations were below recommended guideline levels. The sediments in these areas were considered to be uncontaminated by hydrocarbons
- metals: The vast majority of both unconsolidated and consolidated material, at all sampled depths in proximity of PSDP2, had metal concentrations below recommended guideline levels and were considered to be uncontaminated by metals. TBT concentrations in all sampled locations – in the unconsolidated surface material less than 1 m in depth – were below guideline levels
- acid sulfate soils: Analyses of an initial 20% of all samples indicated that all samples were potential acid sulfate soils but all exhibited sufficient neutralising capacity to result in no net acidity formation. No development of acid sulfate soil is therefore deemed likely as a result of disturbance during dredging.

Table 6.7 Potential sediment contaminants in the PSDP2 project area

Sediment material	Contaminant of concern	Parameters
Unconsolidated	Petroleum hydrocarbons	Polycyclic aromatic hydrocarbons (PAH)
		Total petroleum hydrocarbons
		Benzene, toluene, ethylene and xylene (BTEX) in the surface 1 m only
	Metals	Various including tributyltin (TBT) in the surface 1 m only, antimony, arsenic, chromium, copper, lead, mercury, nickel and others
	Acid sulfate soils	Chromium, reducible sulfur
	Polyfluorinated alkyl substances (PFAS)	Including PFOS, PFOA and PFHxS
Consolidated	Metals	Various including antimony, arsenic, chromium, copper, lead, mercury, nickel and others

Notes:

1. Two distinct geological layers are found in the project footprint, namely unconsolidated sand on the seabed surface, and a layer of consolidated coastal limestone and calcarenite gravel underneath (Tamala Limestone). The thickness of the layer of undisturbed unconsolidated sand varies mainly depending on the extent of previous dredging
2. PFAS = Polyfluorinated alkyl substances, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFHxS = perfluorohexane sulfonate

More recent results from Fremantle Ports' annual Marine Quality Monitoring Program surveys (BMT Oceanica 2014a, 2015, 2016, 2017 and BMT 2018c), summarised over a five-year period from 2014 to 2018, are provided in Table 6.8. Like the Kwinana Quay sampling program (Oceanica 2009a), KBT samples also demonstrate that the risk of contamination from toxicants in sediments in the area is very low (Table 6.8). For comparative purposes, results are compared against NAGD values (CA 2009) and demonstrate that over the five-year period, there were only three instances when single samples marginally exceeded the NAGD screening levels (chromium and copper at KBT1 in 2016 and zinc at KBT3, also in 2016), but the long-term median for each is well below guideline levels (Table 6.8). It is also noted that while at present there are no guidelines for assessing acceptable concentrations of PFAS species in marine sediments, the results of sampling in 2018 demonstrated the risk of contamination from this source is negligible (Table 6.8).

From the results presented above, it can be concluded that sediment quality in the vicinity of the dredge area is high (largely void of toxicants) and therefore the risk of contamination of marine waters during PSDP2 dredging activities is extremely low.

Table 6.8 Metal and tributyltin (TBT) concentrations from sediment samples collected at KBT between 2014 – 2018

		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Zinc	TBT	PFAS (PFOS)	PFAS (PFOA)	PFAS (PFHxS)
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg Sn/kg	mg/kg	mg/kg	mg/kg
	ISQG Low	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**-**	**200**	**9**	**-**	**-**	**-**
	ISQG High	**70**	**10**	**370**	**270**	**220**	**1**	**-**	**410**	**70**	**-**	**-**	**-**
	LOR	**2**	**0.4**	**5**	**5**	**5**	**0.1**	**2**	**5**	**0.5**	**0.0002**	**0.0002**	**0.0002**
2014	**KBT1**	4.9	<0.4	17	16	6.9	0.1	<0.5	33	2.12	-	-	-
	KBT2	4.2	<0.4	14	30	4.9	<0.1	<0.5	21	1.21	-	-	-
	KBT3	5.1	<0.4	12	14	3.9	<0.1	<0.5	36	3.40	-	-	-
2015	**KBT1**	6.4	<0.4	24	24	9.8	0.1	<0.5	54	1.53	-	-	-
	KBT2	6.4	<0.4	19	37	7.4	<0.1	<0.5	34	2.27	-	-	-
	KBT3	9	<0.4	18	12	6.3	<0.1	<0.5	45	8.8	-	-	-
2016	**KBT1**	**<2**	0.8	**85**	**71**	31	<0.1	<0.5	160	0.62	-	-	-
	KBT2	**<2**	0.4	55	59	19	<0.1	<0.5	79	2.38	-	-	-
	KBT3	**<2**	1.4	46	54	20	<0.1	<0.5	**220**	4.25	-	-	-
2017	**KBT1**	2.5	<0.4	29	19	15	<0.1	<0.6	79	0.70	-	-	-
	KBT2	2	<0.4	25	20	10	<0.1	<0.7	28	1.21	-	-	-
	KBT3	4	<0.4	8.4	**5**	**5**	<0.1	<0.8	**5**	0.91	-	-	-
2018	**KBT1**	5.6	0.13	33	17	12	0.16	0.37	61	0.70	<0.0002	<0.0002	<0.0002
	KBT2	4.8	0.1	30	18	10	0.12	0.35	23	1.67	<0.0002	<0.0002	<0.0002
	KBT3	3.7	0.09	9.5	5.2	2.9	0.01	0.11	9.9	3.71	<0.0002	<0.0002	<0.0002
	Median	**4.8**	**0.4**	**21.5**	**18.5**	**8.6**	**0.1**	**0.36**	**35**	**1.6**	**<0.0002**	**<0.0002**	**<0.0002**
	Mean	**4.7**	**0.5**	**26.9**	**25.4**	**10.6**	**0.1**	**0.7**	**55.8**	**2.2**	**<0.0002**	**<0.0002**	**<0.0002**

Notes:

1. data supplied by Fremantle Ports (BMT Oceanica 2014a, 2015, 2016, 2017 and BMT 2018c)
2. KBT = Kwinana Bulk Terminal; sites are located ~300–500 m south the planned dredging location
3. ISQG low and ISQG high values are in line with the NAGD (CA 2009)
4. BOLD red indicates an exceedance of ISQG low value; exceedance of individual ISQG low value
5. PFAS = polyfluorinated alkyl substances, PFOS = perfluorooctane sulfonate, PFOA = perfluorooctanoic acid, PFHxS = perfluorohexane sulfonate

In light of the above assessment, it was determined that the potential for release of toxicants during construction is considered low. Section 6.4.1 summarised the results of sediment quality investigations (Appendix G). All sediment samples collected from sites sampled nearby to the proposed dredge location were below the NAGD screening levels for metal concentrations and organotins (CA 2009). These results and those of the geotechnical testing indicate that the sediment is expected to be clean with a low risk of contamination release during dredging.

Prior to the commencement of dredging, Water Corporation will undertake further assessment of sediment quality to verify risk, as described in Section 6.6.

Contamination from release of toxicants during plant commissioning

Commissioning requires disinfection (flushing) and pressure testing of the pipelines and RO plant. Commissioning is expected to take around 30 weeks and will begin with the initial flooding and flushing of the intake and outfall pipelines with seawater, followed by flushing of the membrane filtration system and reverse osmosis piping with potable water from the drinking water mains. Risks to marine environmental quality are considered negligible given the benign nature of the flushing agents (discussed in greater detail below). In-line with EPA expectations (EPA 2008) Water Corporation plan to undertake a similar process that was used to manage environmental risks during plant commissioning of the SSDP (SSWA 2015), in the commissioning of PSDP2.

Risk to the receiving environment

The risks of discharging the various chemical additives and their degradation products formed during the pressure testing and pipeline disinfection process have been examined so that appropriate management measures can be implemented during the disposal of the pressure test and disinfection water.

Sodium Hypochlorite

Sodium hypochlorite is expected to be dosed between 5 mg/L to 20 mg/L (reported as residual chlorine) within the pressure test and disinfection waters. Sodium hypochlorite dissociates to hypochlorous acid in potable water which is then subject to an equilibrium distribution with the hypochlorite ion. The relative proportion of each total residual oxidant (TRO) compound (sodium hypochlorite, hypochlorous acid, hypochlorite ion and other chemical oxidants present) is predominately determined by the pH.

The water used in the pressure test process will be neutralised with an excess of sodium bisulphite. Following treatment of pressure test and disinfection water with sodium bisulphite, the concentration of residual chlorine (residual oxidants) in the effluent will be zero. To ensure this, chlorine levels in the pressure test and disinfection water will be monitored prior to discharge.

Sodium Bisulphite

Sodium bisulphite is used to chemically reduce chlorine. It is proposed that the dose rate will be 120% of the stoichiometric demand to ensure that no chlorine remains. The excess sodium bisulphite will consume approximately 0.9 mg/L of DO from its fresh water body before it is discharged into the environment. The maximum concentration of all derivatives from sodium bisulphite and its reaction with sodium hypochlorite is approximately 57 mg/L.

Sodium bisulphite reduces the residual chlorine to produce chloride, sodium and sulphate ions. These ions are present in the background potable water used for pressure testing and are also relatively abundant in seawater. The concentration of these ions in the neutralised (de-chlorinated) disinfection/pressure test water will be significantly lower than the natural concentration in the receiving seawater. All end products resulting from the addition of sodium bisulphite are unlikely to present an adverse environmental impact on the marine environment.

Calcium Carbonate

Leaching of calcium carbonate may occur during pressure testing, which may in turn increase the pH and alkalinity of the pressure test water. The dissolved calcium carbonate will be present in the water as calcium and bicarbonate ions, both of which are relatively abundant in seawater. The pH of the pressure test water will be adjusted, where required, by the addition of sulphuric acid.

Calcium carbonate is ubiquitous in the marine environment and is the major constituent of marine shell and coral reefs. Acute toxicity (48-hour LC50) from exposure to calcium carbonate was reported in the mosquitofish, *Gambusia affinis*, at 56,000 mg/L (Fisher Scientific 2008), which is considerably higher than the residual concentrations expected to be discharged. Calcium carbonate present in the pressure test water is unlikely to impact the marine or freshwater environments given that it has limited potential to affect aquatic organisms.

Outcome

Unlike the brine for which the brine discharge pipeline was designed, the essentially freshwater effluent from the pressure test and disinfection waters will be buoyant in seawater and will form a plume that will naturally rise to the water surface. Water Corporation has committed to no residual chlorine or TRO in the pressure test and disinfection waters discharged to the marine environment through the diffuser outlet following treatment.

The impacts of pH will be controlled by neutralisation with sulphuric acid (H_2SO_4) if the pH of the discharge does not meet the criteria stated in the ANZEG (2018) guidelines. This requires the Water Corporation to ensure the discharge is not outside the 8.0–8.4 pH range required to be in compliance with discharge to south west inshore marine areas.

To ensure compliance, the pH of the pressure test water and disinfection water will be field tested using a water quality meter at the discharge point prior to discharge. Testing will take place to ensure that there is no residual chlorine in the wastewater discharged into the marine environment.

Considering the potential risks from the chemical additives and the respective management measures to be implemented, no significant adverse environmental impacts are expected to result from the discharge of the treated disinfection and pressure test waters beyond the boundary of the LEPA (Figure 6.5). Water Corporation is of the view that all relevant known impacts from flushing and pressure testing have been sufficiently incorporated into the impact assessment and that there is no requirement for further assessment on marine environmental quality within Cockburn Sound because of this Proposal.

6.5.3 Operational impacts

Stratification and effects on dissolved oxygen

The discharge of brine effluent can create a body of high salinity water along the seafloor, causing episodes of stratification in deeper waters when mixing and exchange processes are not sufficient to mix the full depth of the water column. Although stratification is a regular, naturally occurring event in water bodies such as Cockburn Sound, an increase in the duration or strength of stratification can potentially lead to further depletion of oxygen in the bottom waters, which in turn may impact benthic communities and sediment metabolism, and also potentially, altered osmotic gradients (addressed in Section 7.4).

The oxygenation of marine waters mainly depends upon diffusion of oxygen from the atmosphere through the sea-air interface and mixing processes (e.g. wind, waves, currents, heating and cooling) which can distribute the oxygenated surface waters through the water column (D'Adamo 2002, Okely et al. 2007a). Oxygen is also produced as a by-product of photosynthesis by algae, phytoplankton (dominated by benthic species in Cockburn Sound) and seagrasses, while oxygen is consumed during respiration by marine plants, animals and bacteria in the sediment and the water column. Because photosynthesis only occurs during daylight hours, there is a diurnal cycle due to these to natural sources and sinks of DO, with the peak production typically during middle of the day and the minima in the early hours of the morning. If the rate of respiration exceeds the rate of oxygen replenishment, then the DO concentrations will typically decline.

The waters of Cockburn Sound are typically well oxygenated (Keesing et al. 2016) but oxygen transfer via surface re-aeration can be reduced as the wind intensity diminishes (D'Adamo 2002, Okely et al. 2007). At the same time, the density differences between the Sound and adjacent waters under the action of coastal shelf waves combine to strengthen vertical stratification of the water column (BMT 2018b), which in turn limits vertical mixing and transfer of DO to lower portions of the water column. As wind transfer is reduced and vertical stratification sets in, DO demand, particularly in the sediment, cannot be met by oxygen transfer at the surface, so DO concentrations become progressively lower until a meteorological and/or other event is sufficiently energetic to promote water column mixing and, by extension, reaeration (D'Adamo 2002, Okely et al. 2007a). When natural stratification events occur they can reduce normal DO levels from greater than 90% saturation throughout the water column to 60% saturation or lower in the bottom of the water column (Water Corporation 2013).

Discharge of desalination return water has the potential to enhance natural patterns in stratification, which in turn, can promote conditions which can lead to reductions in DO. Water Corporation has operated PSDP1 in Cockburn Sound since 2006 and through numerous, peer reviewed investigations has determined that the return water discharge from PSDP1 has had negligible influence on DO concentrations in the Sound (Okely et al. 2007a,b,c, Water Corporation 2013). Despite this, due to the natural occurrence of stratification, the DO balance in Cockburn Sound remains sensitive to any mechanisms which potentially increase stratification (D'Adamo 2002).

Due to risks associated with the Proposal, hydrodynamic modelling has been used to predict patterns in stratification and DO across Cockburn Sound under 'normal' (2008) and 'worst case' (April 2013) conditions (BMT 2018b, BMT 2019a,c; see also Appendix F). Modelling was used to predict changes in DO in surface and bottom waters (0.5 m from the water surface and the seafloor, respectively) at various spatial scales, including whole of Cockburn Sound and at specific locations (Perth Buoy North, Perth Buoy Central, Perth Buoy South and S2) to enable comparison with historic in-situ monitoring data (Figure 6.15), and over temporal scales relevant to comparison with with EQC defined by EPA (2017).

Through this modelling, it was determined that the PSDP2 Proposal under 'normal' conditions does not increase stratification in the deep waters of the Sound for most of the year (summer, winter and spring) and following dispersion of the plume into the deep basin, fluctuations in density typically dissipate within hours (Appendix F). However, during autumn, which is generally considered the period most conducive to stratification and low DO events, the saline effluent discharge can marginally increase background stratification in the north of the deep basin by ~0.1–0.2 kg/m^3 (Figure 6.16). Modelling outputs from this period also show a clear north–south transition in the strength of stratification - north being stronger than south (Figure 6.16). The data suggest that stratification in the south is predominantly temperature driven while salinity differences drive stratification in the north and a combination of salinity and temperature drive stratification in the central part of the Sound (Figure 6.16). The addition of the desalination discharges does not affect these stratification patterns (Figure 6.16).

DO (% saturation) was plotted on density graphs (Figure 6.16) to assess the relationship to density when brine effluent is discharged. From these results, it is clear that while DO depletion in the deep basin is related to overall stratification strength (Figure 6.16), the effect of the addition of desalination discharges on DO concentrations is only very subtle and appears to account for less than 2–3% (or 0.21 mg/L at a water temperature of 23°C) of the decline in %saturation (and often much less). This difference is only a fraction of the change in DO driven by natural density changes, which can induce declines by up to 35%, or by 3 mg/L (BMT 2019a,c; also demonstrated in Figure 6.16). The addition of the brine effluent, however, does appear to increase the period that DO concentrations are held low, mostly by hours, but up to days (Figure 6.16).

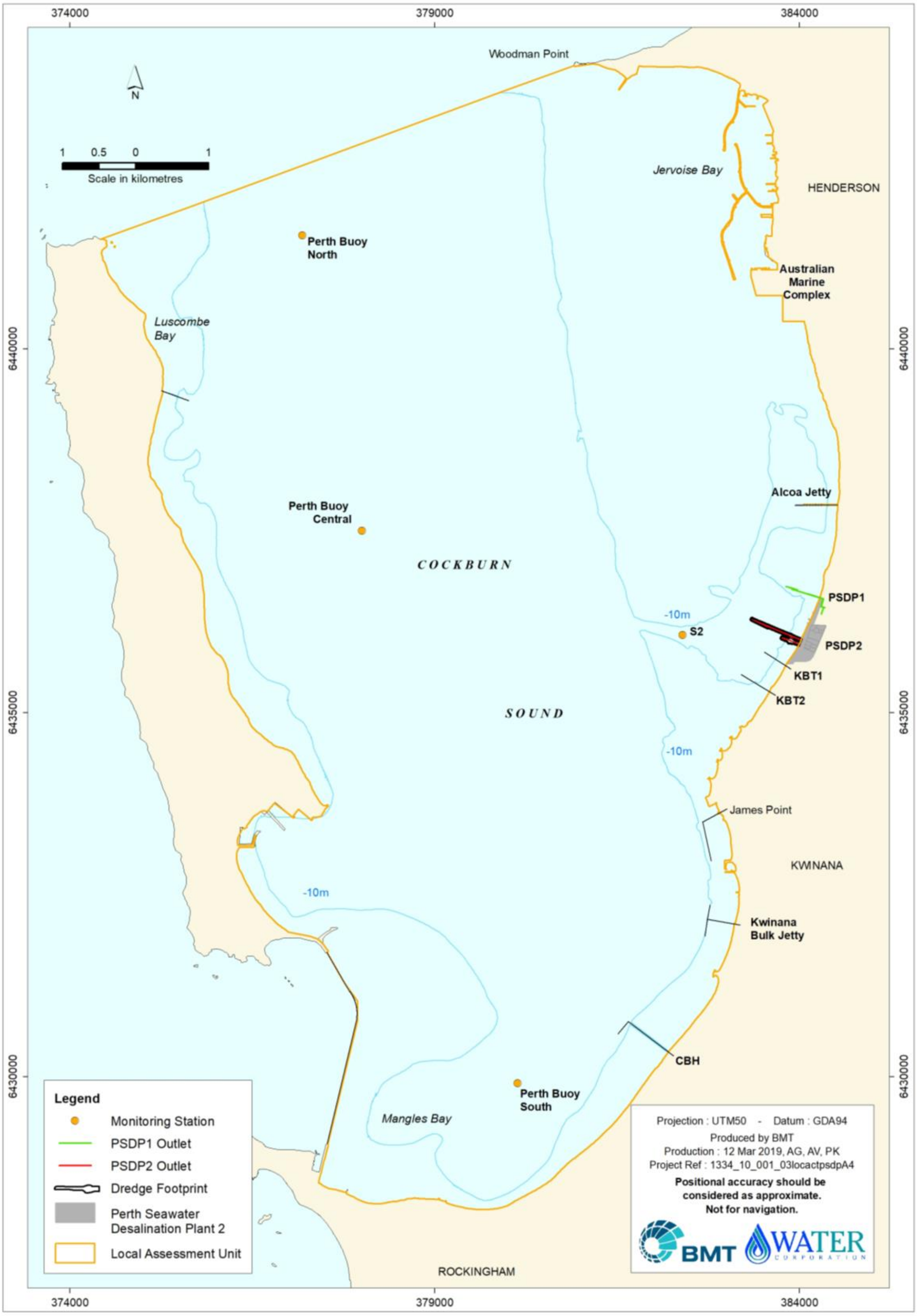
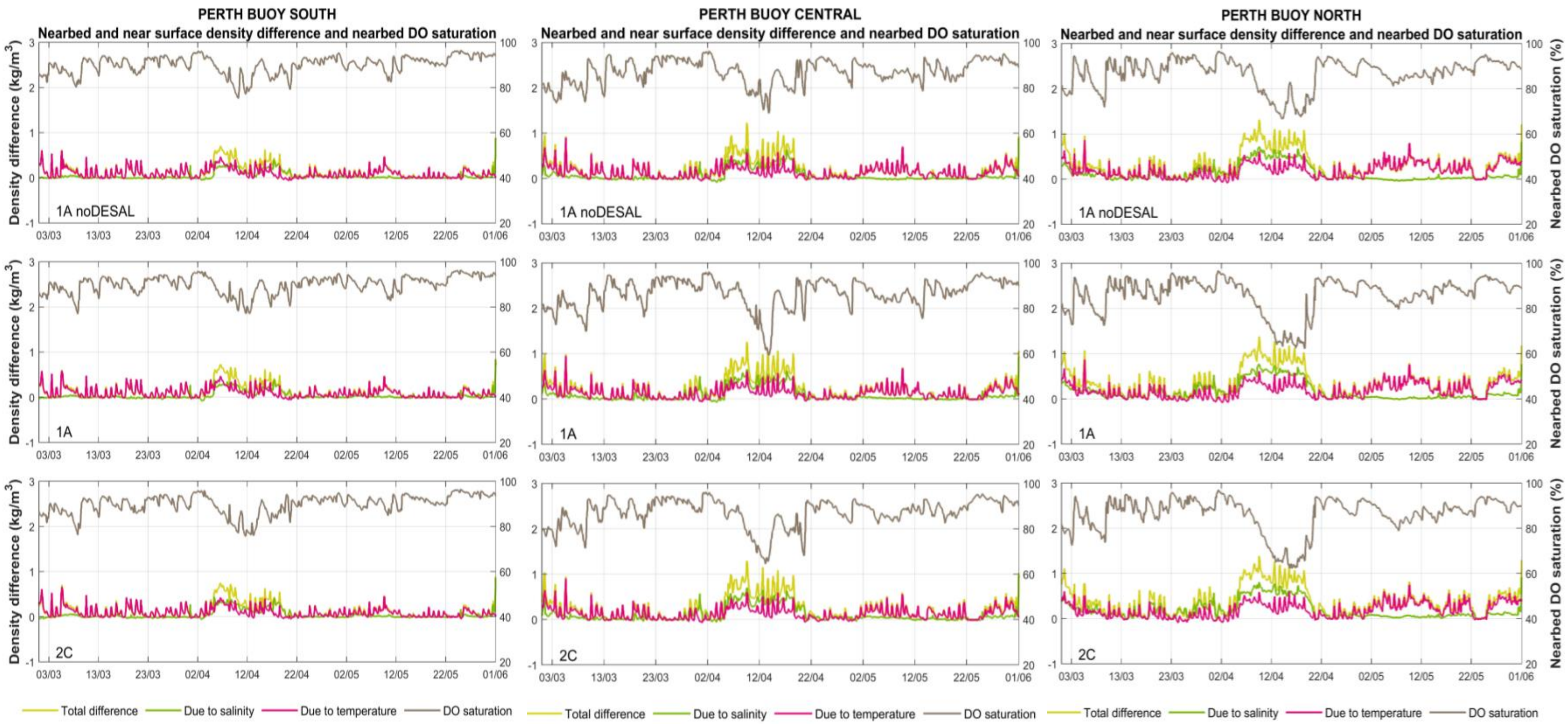


Figure 6.15 Location of marine quality sampling stations referenced in the impact assessment



Notes:

1. Density differences are shown as bottom minus top
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2C = PSDP1 and PSDP2 desalination discharges

Figure 6.16 Time series of simulated top-to-bottom density difference at Perth Buoy South (left) and Perth Buoy North (right) based on climatic conditions experienced in autumn 2008

Timeseries data verified that lowest DO concentrations in the bottom of the water column were likely to occur during autumn periods in Cockburn Sound (Figure 6.17). DO saturation in the north of the deep basin was predicted to decline to ~71% (~6.09 mg/L) under a 'no desalination' scenario, and to ~67% (~5.75 mg/L) under both desalination scenarios (Figure 6.17), thus exceeding the EQG in all cases (Figure 6.17). In the south of the deep basin, DO was predicted to remain above 80% during autumn, and differences between 'with' and 'without' desalination discharge were typically very small (mostly <2–3%; Figure 6.17). Low DO conditions in the north of the deep basin were likely driven by the reduced wind stress exacerbating density stratification and curbing DO re-aeration below the pycnoclines (BMT 2019a,c; Appendix E).

During the 'worst case' scenario, patterns in DO in bottom waters appear similar between locations (south, central and north of the deep basin), there are slight but significant differences (Figure 6.18). In the south of Cockburn Sound, modelling predicted that DO concentrations would be lower for 2C than 1A and '1A noDesal' by ~2% (Figure 6.18), but in all scenarios, the rolling 7-day median remained above 60% saturation. Results are similar in the north of the deep basin for 2C, but 1A is slightly lower than 2C by ~1% (Figure 6.18). In contrast, in the centre of the deep basin, the rolling 7-day median for DO for both scenarios 1A and 2C was predicted to drop to 59% (or ~5.06 mg/L based water temperature of 23°C) for ~ 2 days (Figure 5.7), while 1A noDesal, was predicted to drop to ~61% (or 5.23 mg/L at the same temperature) for the same duration of time (Figure 6.18).

The results described above are in agreement with the findings of field surveys (Water Corporation 2013) and the considerable monitoring of PSDP1 discharges that found that after the plume moves both north and south along the shipping channels and then exits the eastern bank, it rapidly becomes more dilute as it moves into the deeper waters of the Sound (discussed further in Appendix F). Due the rapid dilution, its effect on stratification is diminished, in particular in the south of the deep basin where natural fluctuations in density gradients far exceed the influence of the desalination plume (Water Corporation 2013). However, in the north of the deep basin, the discharge appears to have a very subtle enhancing effect on stratification in autumn, which in turn, appears enough to reduce DO levels by a small degree; typically <2–3%, but by up to as much as 4–5%.

In accordance with EPA (2017), the approach for identifying the potential for a significant and unacceptable change in DO in Cockburn Sound is to compare the median DO concentration in bottom waters at a site, calculated over a period of no more than one week, to ensure that is does not decline below the values for respective levels of protection described in areas (Table 6.9).

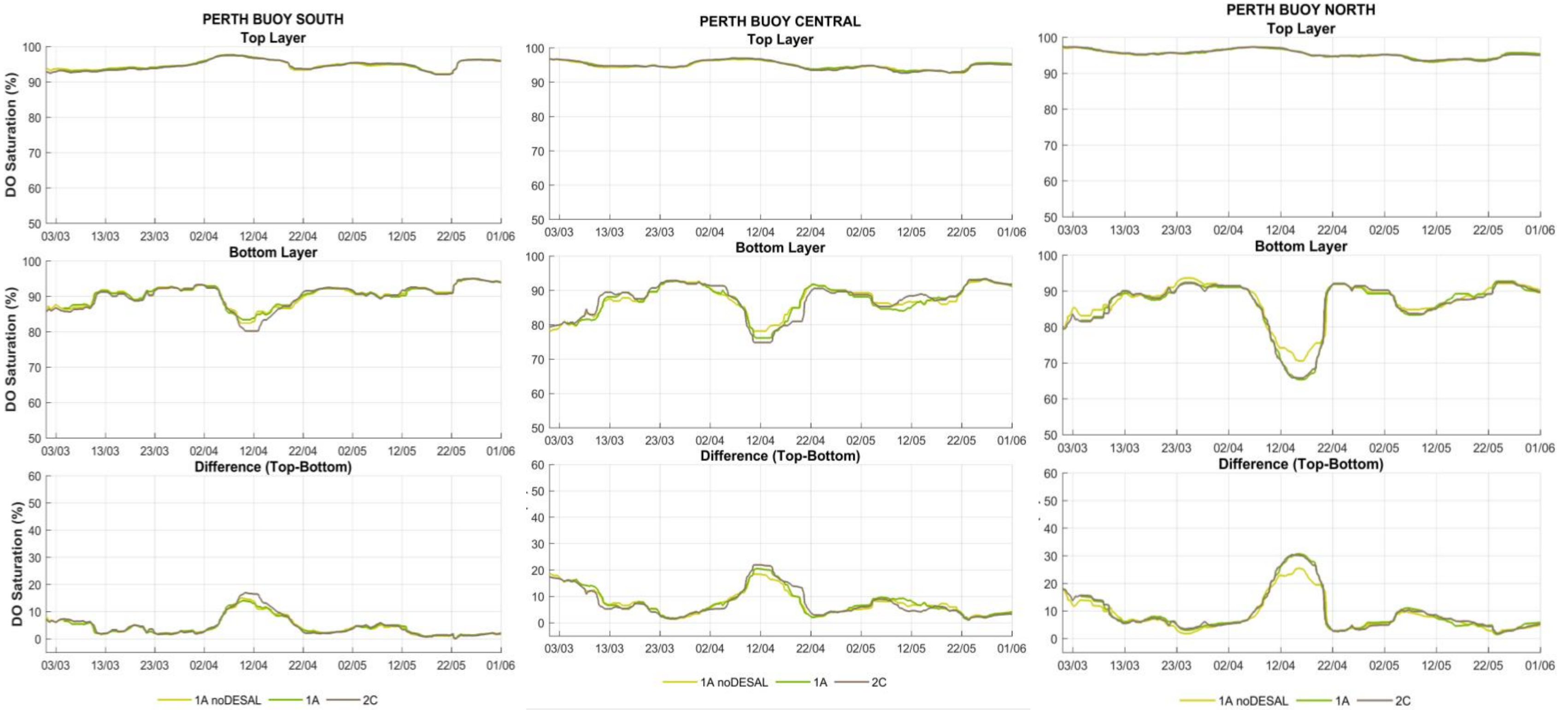
Table 6.9 Default dissolved oxygen trigger values developed for Cockburn Sound

	EQG		EQS	
	High protection	Moderate protection	High protection	Moderate protection
DO (% saturation)	90%	80%	60%	60%

Source: EPA (2017)

However, predicting the impact of desalination discharges on exceedance of EPA (2017) trigger values for DO concentrations in the bottom waters of Cockburn Sound is problematic – as shown by modelling and verified by sampling (Water Corporation 2013) – because the trigger values are frequently exceeded across the whole of Cockburn Sound due to natural mechanisms, especially in autumn (Figure 6.19). This can be seen in Figure 6.19, which shows the proportion of time that Cockburn Sound is likely to be exceeding EQG (Figure 6.19). Common to all maps is the similarity between scenario 1A noDesal (baseline conditions), and the discharge scenarios (1A = PSDP1 only; 2A and 2C = PSDP1 + PSDP2 discharges), particularly throughout the deep basin (Figure 6.19). However, the discharge of brine effluent did appear to impede oxygen replenishment for periods of hours to days (as can be seen in Figure 6.16), and in worst case conditions, would have led to an exceedance of EPAs (2017) EQS trigger value in central Cockburn Sound (noting that natural background DO concentrations without desalination discharge were also within 2% of exceeding the EQS trigger at the same location).

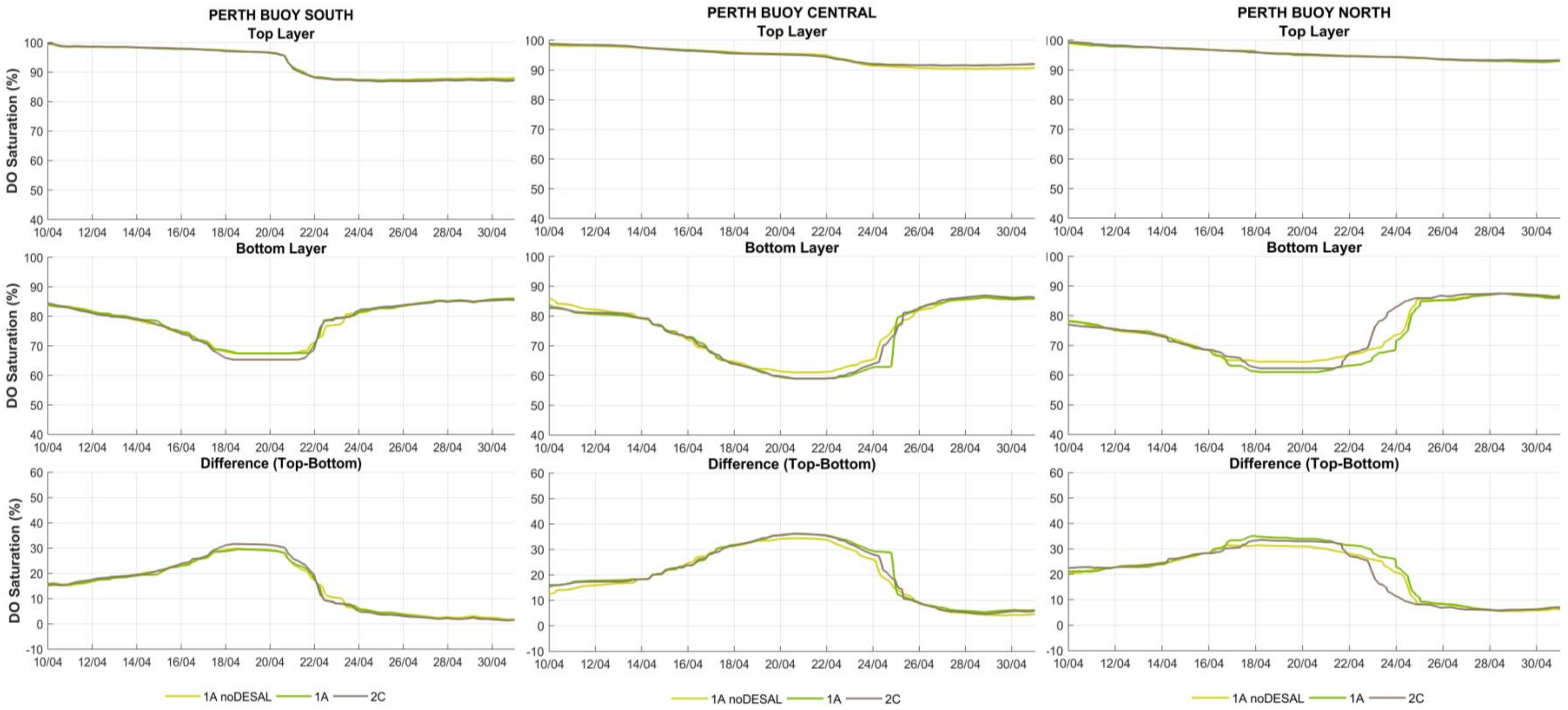
From results described above, is it apparent that brine effluent discharges can have a temporary and subtle effect on DO concentrations, however, given the ambiguity in applying EPA (2017) trigger values, Water Corporation commissioned an assessment of the ecological risk of the PSDP2 Proposal on DO in Cockburn Sound, which is provided in Appendix F. The outcomes of this ecological risk assessment, and implications for benthic invertebrate communities and other marine are further described in Sections 7.5.3 and 8.5.3.



Notes:

1. DO differences are shown as top minus bottom
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2C = PSDP1 and PSDP2 desalination discharges

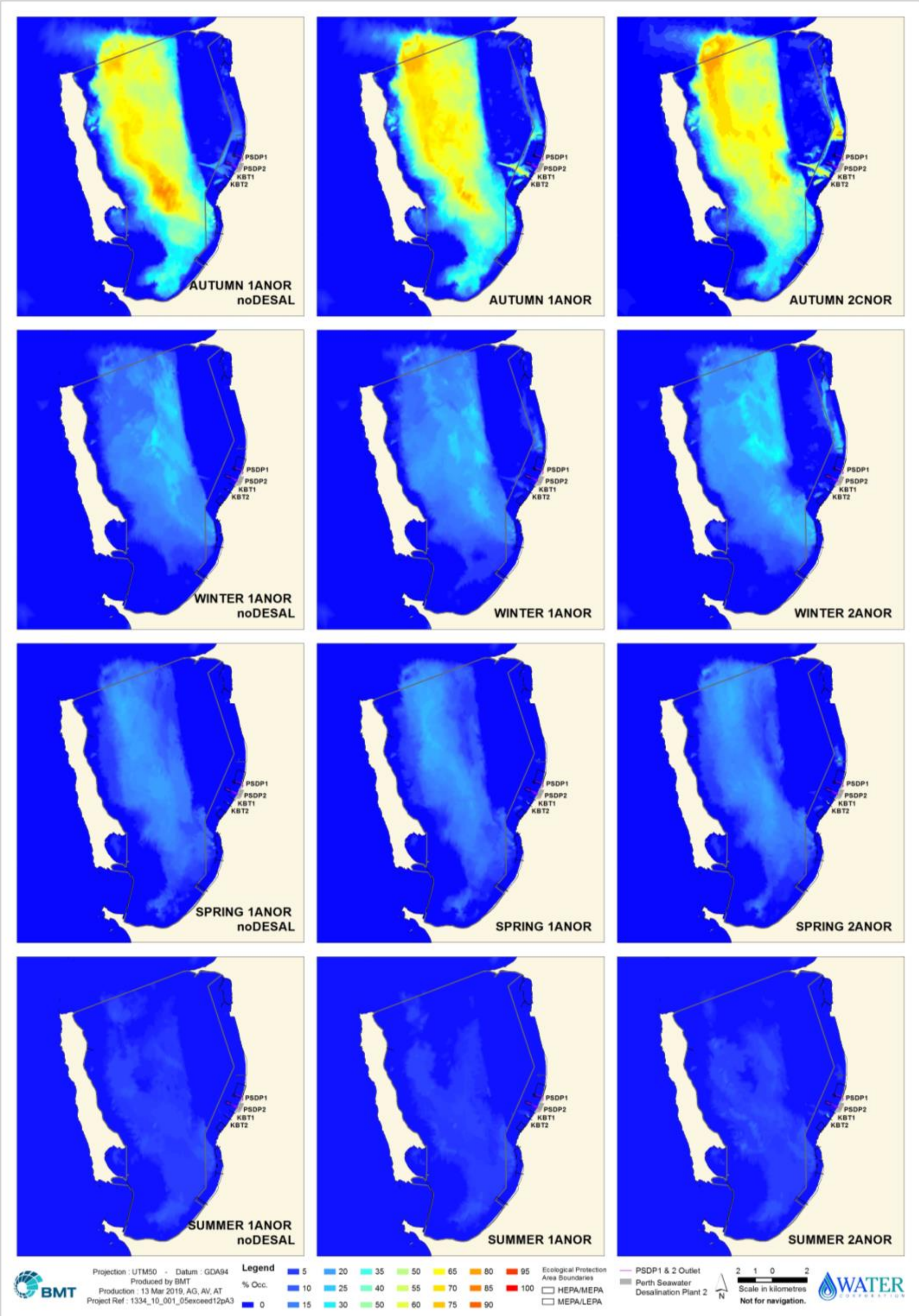
Figure 6.17 Dissolved oxygen (% saturation, rolling median) at Perth Buoy South (left), Perth Buoy Central (middle) and Perth Buoy North (right) in autumn 2008



Notes:

1. DO differences are shown as top minus bottom
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2C = PSDP1 and PSDP2 desalination discharges

Figure 6.18 Simulated dissolved oxygen (% saturation, rolling median) time series at Perth Buoy South (left), Perth Buoy Central (middle) and Perth Buoy North (right) based on 'worst case' climatic conditions experienced in April 2013



Note:

1. 1A noDESAL = no desalination discharge, 1ANOR = PSDP1 desalination discharge only, 2A/2C NOR = PSDP1 and PSDP2 desalination discharges

Figure 6.19 Proportion (% occurrence) of time based on 2008 climatic conditions that bottom waters in the deep basin fall below 90% saturation

Changes to marine salinity (osmotic stress)

The RO process produces a liquid brine concentrate by-product that is roughly twice the salinity of seawater; assuming an ambient salinity of 36.5 PSU, the discharge salinity is expected to be approximately 62-64 PSU, prior to dilution. High salinity results in osmotic stress for many flora and fauna (impacts to marine biota associated with osmotic stress are addressed in Sections 7 and 8). Accordingly, it is important that diffusers are engineered to achieve a very high rate of initial dilution, to mitigate potential osmotic/physiological effects.

The initial dilution phase is the dilution which occurs due to the physical mixing achieved through the jettisoning of the brine through the diffuser ports, and then its rise and fall due to gravity (see Figure 6.20). After the initial dilution phase (which is the most efficient stage of mixing), the brine sinks to the seafloor, before slowly dispersing and diluting along shallow to deep water gradients.

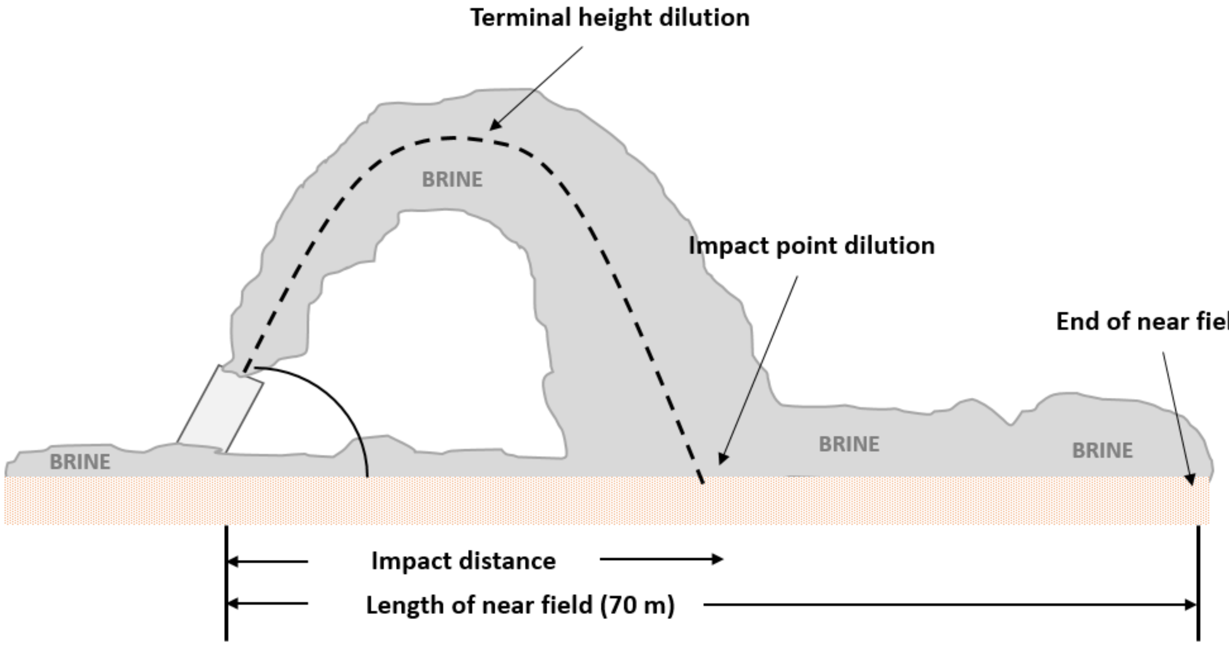
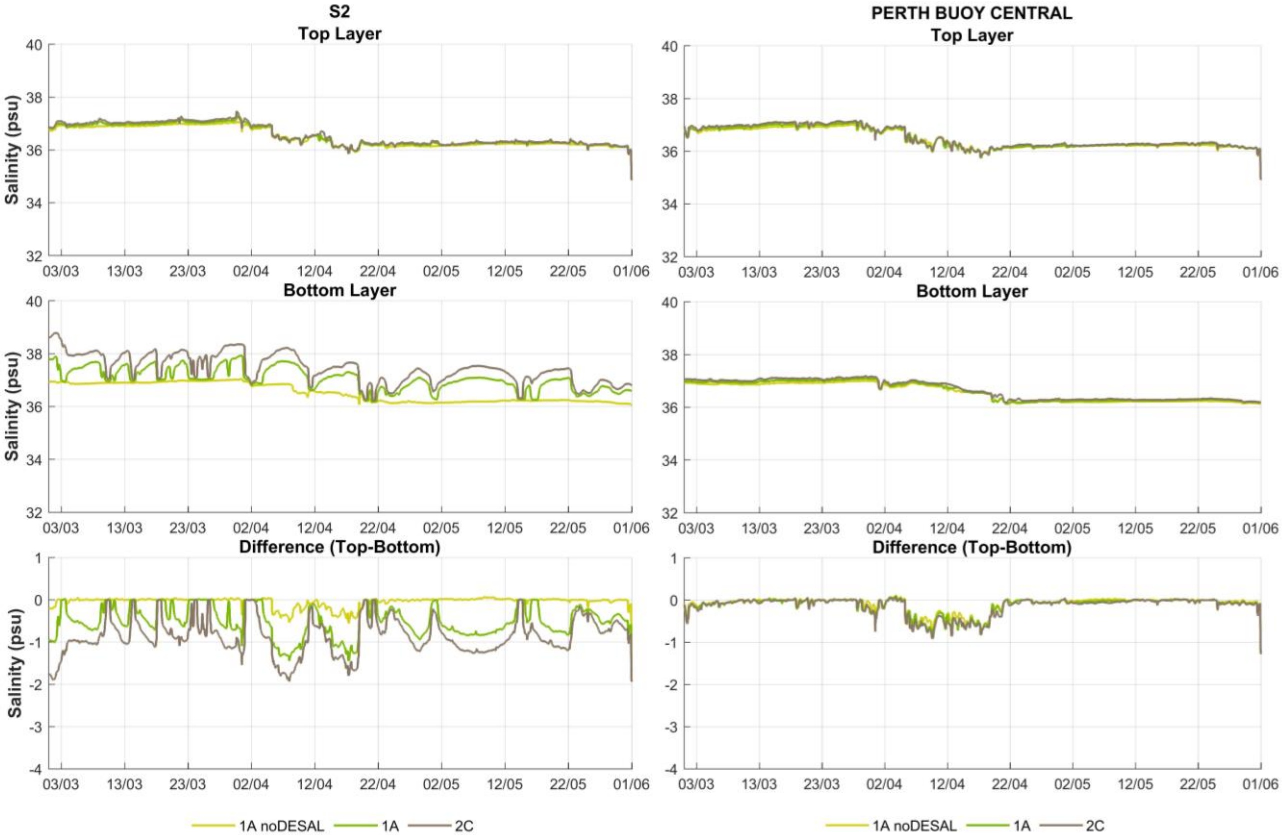


Figure 6.20 Conceptual diagram showing the dilution of the brine waste stream in the near field environment

Outcomes from modelling (BMT 2019a) show how mixing processes rapidly dilute desalination brine with distance from the outlet. Key results from hydrodynamic modelling are presented here to illustrate behaviour of the plume following discharge and subsequent mixing as the plume enters the Stirling Channel and then into the deep basin of Cockburn Sound (see Appendix E for full set of results).

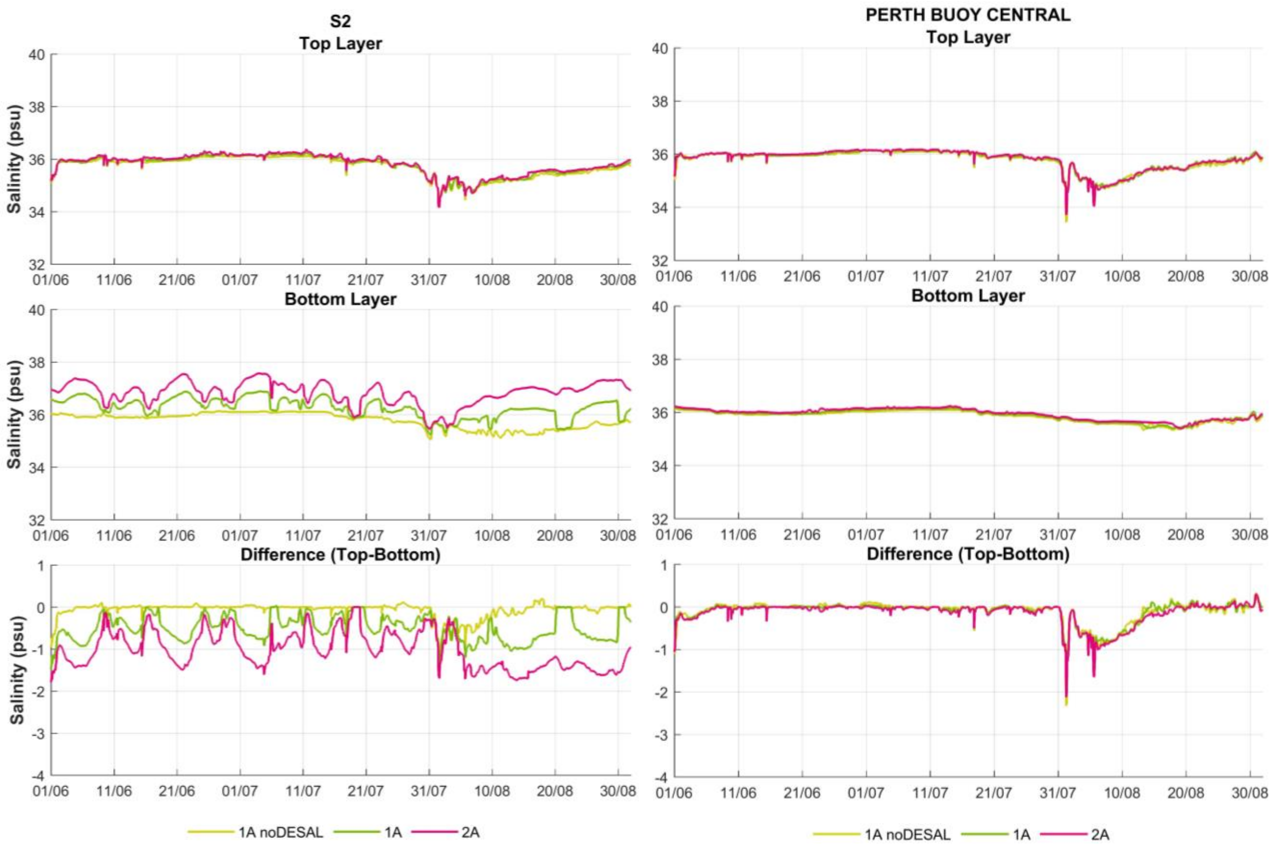
In the absence of any desalination plant operations, bottom water salinity prior to entering the Stirling Channel (at Site S2; see Figure 6.15) would match that at the surface (Figure 6.21), while the PSDP1 discharge increases bottom water salinity at the S2 site above the baseline condition in the low mixing autumn period by ~0.8 PSU for intervals from a few days up to around two weeks (Figure 6.21). Because the water column is regularly mixed during this period, salinity is expected to briefly reduce back to baseline conditions (Figure 6.21). The addition of PSDP2 brine effluent was predicted to increase the bottom water salinity at the S2 site above the baseline condition by a maximum of ~1.8 PSU for periods of up to a week, before the same mixing processes reduce salinity back to baseline conditions (Figure 6.21). Despite the periodic mixing, operation of PSDP1 and PSDP2 is not projected to impact on surface water salinity at the S2 site (Figure 6.21).



Notes:
1. Salinity differences are shown as top minus bottom
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2C = PSDP1 and PSDP2 desalination discharges

Figure 6.21 Simulated top-to-bottom salinity difference at S2 Monitoring Station (left) and Perth Buoy Central (right) with PSDP2 discharge during autumn 2008

The impact of the desalination discharges on bottom waters is predicted to be spatially restricted, with the bottom water salinity at locations within the deep basin (e.g. Perth Buoy Central, see Figure 6.15) matching that at the surface and the PSDP1 and PSDP2 timeseries matching the timeseries with no desalination discharge (Figure 6.21). In typical years, the same elevations in bottom water salinity in autumn are also evident at site S2 in higher energy seasons (i.e. winter) (Figure 6.22).



Notes:

1. Salinity differences are shown as top minus bottom
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2A = PSDP1 and PSDP2 desalination discharges

Figure 6.22 Simulated top-to-bottom temperature difference at S2 Monitoring Station (left) and Perth Buoy Central (right) with PSDP2 discharge during winter 2008

The approach for identifying the potential for a significant and unacceptable change in salinity is to compare model projections with the 20th and/or 80th percentile (for high ecological protection) or 5th and/or 95th percentile (for moderate ecological protection) of salinity at an equivalent unimpacted reference site (EPA 2017). Locally relevant ΔS guidelines (Table 6.10) based on local reference site data in Cockburn Sound have been developed by the EPA based on the percentile approach recommended in ANZG (2018).

Modelling outputs are presented for scenario 1A (PSDP1 brine discharges; Figure 6.23) alongside scenario 2A / 2C (PSDP2 +PSDP1 brine discharges; Figure 6.24) as they demonstrate cumulative effects of brine discharge from both plants, and provide rational for establishing LEPA boundaries around each of the respective diffusers (see Section 6.5.1). The remainder of this section discusses scenario 2A / 2C.

Table 6.10 Default salinity trigger values developed for Cockburn Sound

	High protection	Moderate protection
Salinity (ΔS)	± 1.3	± 1.4

Source: EPA (2017)

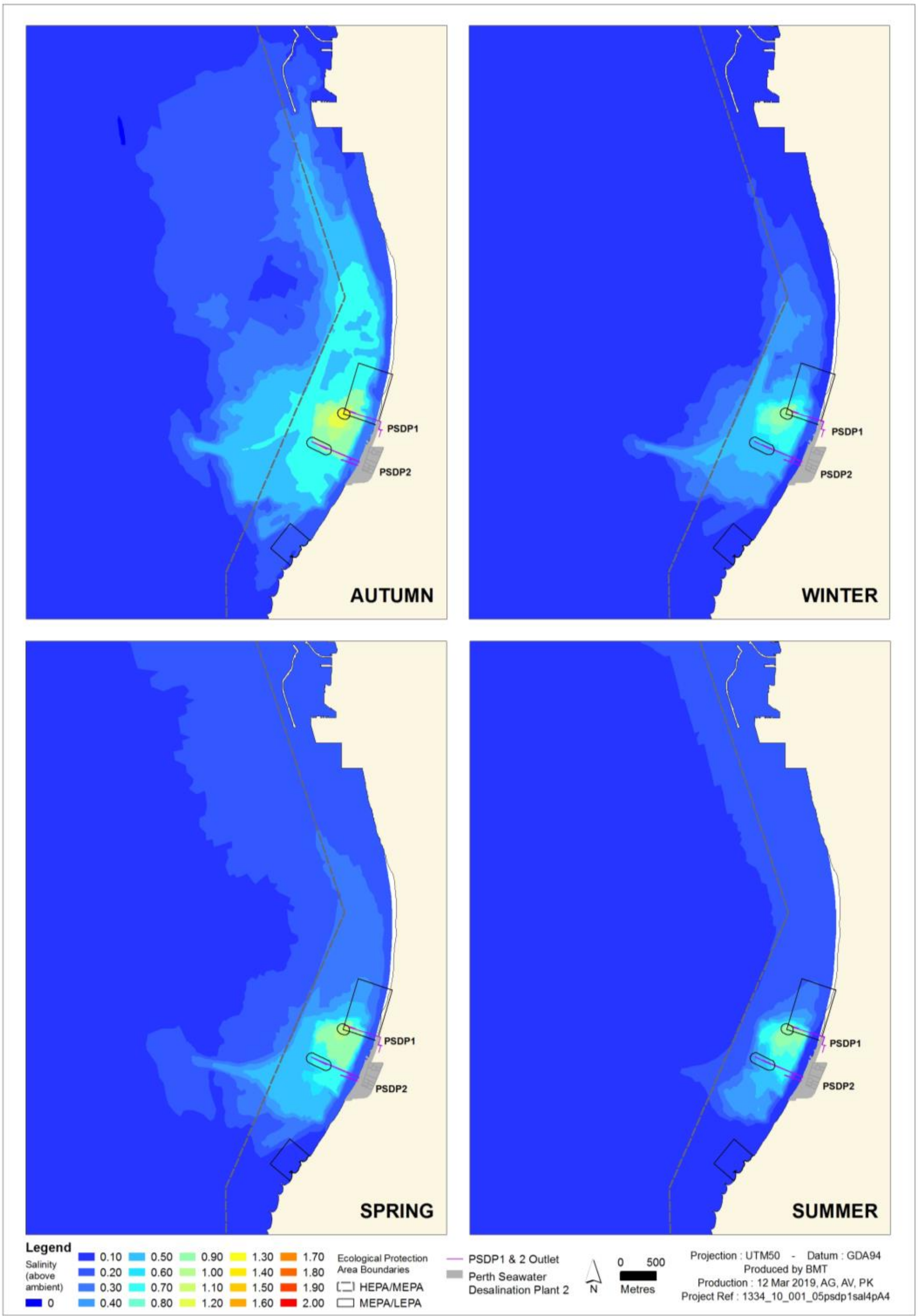
During winter, salinity was predicted not to increase above the +1.4 ΔS moderate ecological protection salinity trigger at any location throughout the model domain and the +1.3 ΔS high ecological protection salinity trigger was only exceeded very near to the existing diffusers (Figure 6.24). During spring the +1.4 ΔS moderate ecological protection salinity trigger and the +1.3 ΔS high ecological protection salinity trigger were each met within ~90 m of the existing/proposed diffusers (Figure 6.24). In summer, salinity was predicted not to increase above either the +1.4 ΔS moderate ecological protection salinity trigger or the +1.3 ΔS high ecological protection salinity trigger, at any location throughout the model domain (Figure 6.24). While autumn was the period where mixing was lowest and the area over which the +1.4 ΔS moderate ecological protection salinity trigger and the +1.3 ΔS high ecological protection salinity trigger were greatest (Figure 6.24), both footprints are still small and do not extend more than 90 m from the diffusers in any direction (Figure 6.24).

In light of the above results, it is clear that under normal conditions:

- for scenario 1A (PSDP1 only) that EPA (2017) salinity triggers would be met in all seasons in all areas of Cockburn Sound (Figure 6.23)
- for scenario 2C / 2A (PSDP1 + PSDP2) it is expected that a moderate level of ecological protection will be maintained within designated MEPA boundaries, except for the area in the immediate vicinity of the PSDP1 and PSDP2 diffusers where a low level of ecological protection will be achieved (Figure 6.24)
- for both scenarios, it is expected that a high level of ecological protect will be met within designated HEPA boundaries, at all times (Figure 6.24).

As such, in accordance with EPA (2016d), an envelope based on the distance from the diffusers where the EQG for moderate ecological protection (+1.4 ΔS) would not be met is proposed to designate LEPA boundaries for scenario 2A / 2C (see also Section 6.5.1). LEPA boundaries would be set once PSDP2 becomes operational.

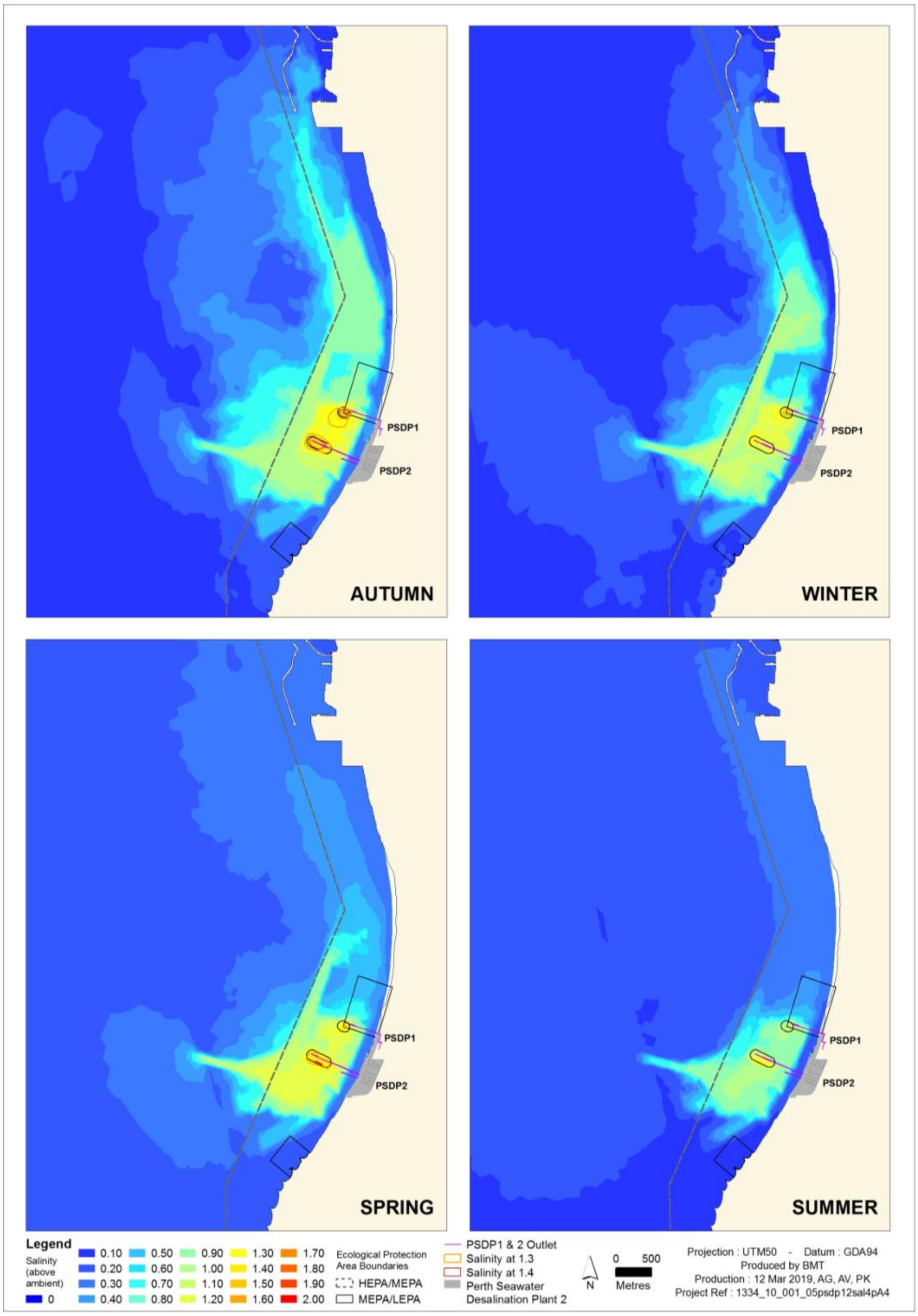
During 'worst case' climatic events that result in unusually low water column mixing (e.g. April 2013), it is predicted that the area over which the moderate and high ecological protection salinity triggers will exceed, will increase (Figure 6.25). However, the extent of exceedances is predicted to remain within shipping channels, only marginally exceed triggers (by 0.1–0.2 PSU) and only last for a period of weeks. Such isolated occurrences are not expected to pose a high ecological risk (addressed in Sections 7.5.3 and 8.5.3).



Notes:

1. Salinity are shown as predicted elevation above ambient salinity (PSU)
2. Data are based on depth-average of salinity from 0 to 0.5 m above the seabed

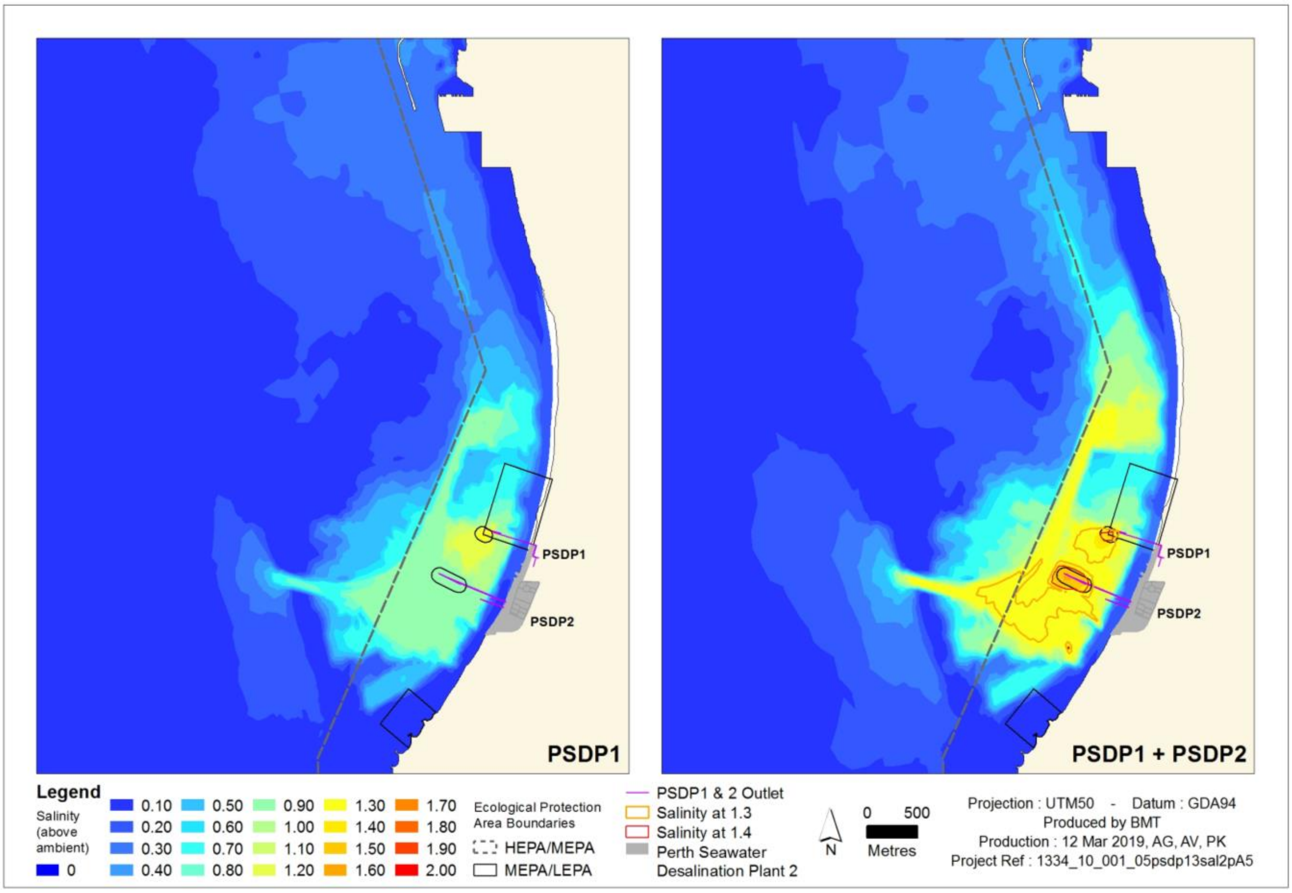
Figure 6.23 Median elevations in salinity above baseline relative to moderate (orange) and high (red) ecological protection criteria for scenario 1A (PSDP1 brine effluent discharges)



Notes:

1. Salinity are shown as predicted elevation above ambient salinity (PSU)
2. Data are based on depth-average of salinity from 0 to 0.5 m above the seabed
3. 2C (autumn) = 25 GL/a operating capacity, 2A (winter, spring, summer) = 50 GL/a operating capacity

Figure 6.24 Median elevations in salinity above baseline relative to moderate (orange) and high (red) ecological protection criteria for scenario 2A and 2C (PSDP1 + PSDP2 brine effluent discharges)



Notes:

1. Salinity are shown as predicted elevation above ambient salinity (PSU)
2. Data are based on depth-average of salinity from 0 to 0.5 m above the seabed
3. 1A = PSDP1 brine effluent discharges; 2C = PSDP1 + PSDP2 brine effluent discharges

Figure 6.25 Median elevations in salinity above baseline relative to moderate (orange) and high (red) ecological protection criteria in April 2013 for scenario 1A (left) and scenario 2C (right)

Elevated return water temperature

The temperature of the brine effluent upon discharge to the marine environment is anticipated to be in the range of 22–26°C prior to dilution (Section 3.2.5), while the mean temperature for bottom waters in Cockburn Sound is typically ~23–24°C (Keesing et al. 2016). Through the discharge of brine effluent, benthic habitats and their associated communities may be exposed to water temperatures elevated above background but still within the range of temperatures found naturally. Potential changes to ambient water temperature associated with the PSDP2 Proposal were investigated using hydrodynamic modelling to inform the risk of increases causing impacts to marine biota (addressed in Sections 7.5.3 and 8.5.3).

The modelling predicted that the PSDP2 discharge would only have a minor effect on ambient temperature throughout the year, and that those effects would be localised to the seabed near the diffuser (BMT 2019c); simulated data provided below are for spring where temperature differences (relative to background) were predicted be greatest in a normal climatic year. As shown in Figure 6.26, elevated temperature in bottom waters – typically <0.2°C but up to ~1.7°C – is expected with the PSDP2 discharge nearby the outlet (monitoring station S2). However, as the plume is carried into the deep basin and transport and mixing processes take over, the ambient conditions dominate, and differences are not expected to be measurable (see Perth Buoy Central, Figure 6.26).

Similarly, Figure 6.27 shows the simulated effect of PSDP1 (left) and PSDP2 (right) discharges on ambient temperature in bottom waters and that the increases in temperature (ΔT) around the diffuser are likely to be in the order of 0.3–0.4°C for PSDP1 and 0.4–0.5°C for PSDP2, which is lower than the 80th and 95th percentiles of the natural temperature range from Cockburn Sound (+2.7°C and +3. 7°C, respectively; EPA 2017). These data also highlight that the PSDP2 Proposal does not increase effects on temperature relative to the existing PSDP1 plant, and it is predicted that operation of both PSDP1 and PSDP2 would not lead to a cumulative impact on temperature outside of natural variability.

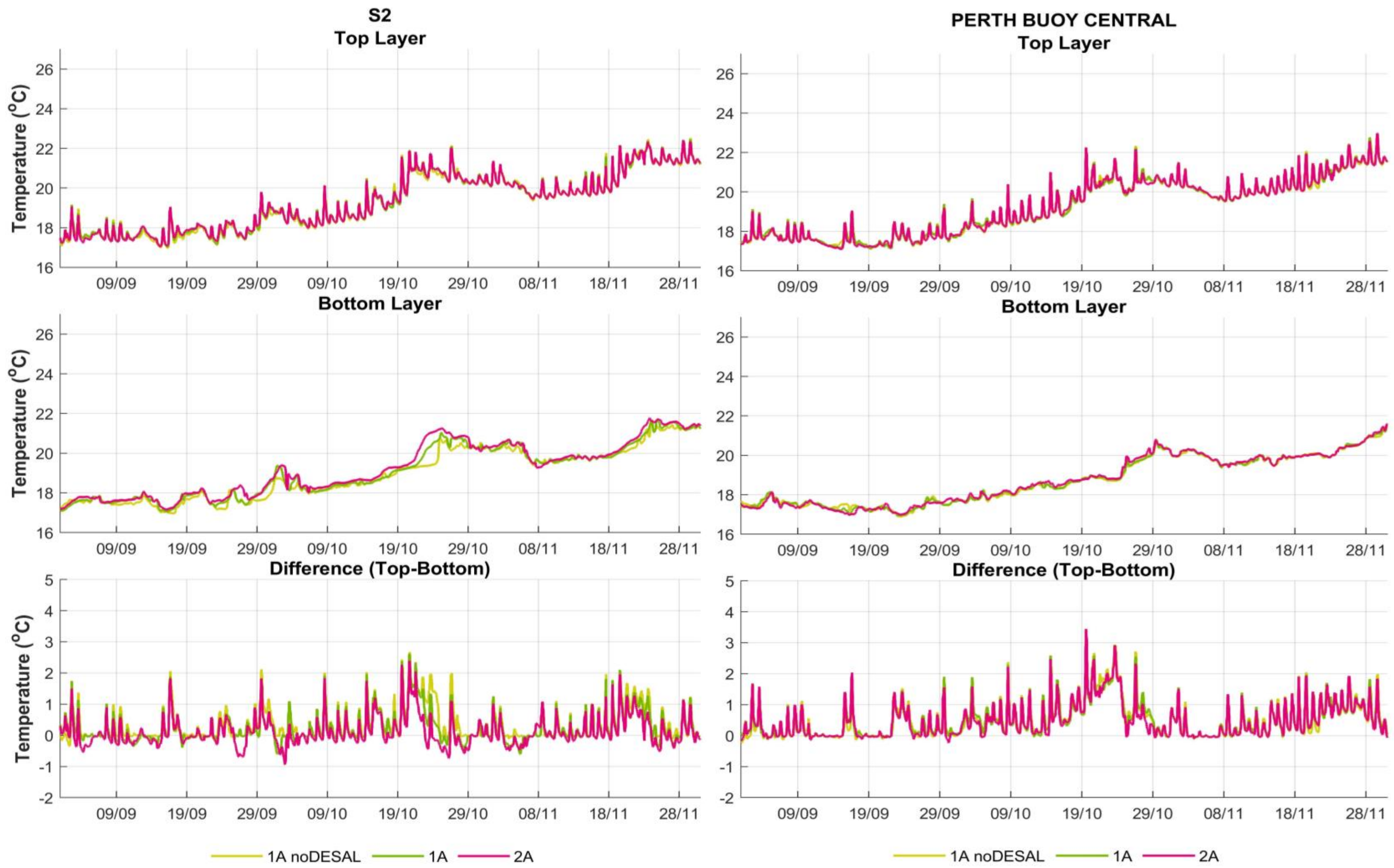
The approach for identifying the potential for a significant and unacceptable change in temperature is to compare model projections with the 20th and/or 80th percentile (for high ecological protection) or 5th and/or 95th percentile (for moderate ecological protection) of temperature at an equivalent unimpacted reference site (EPA 2017). Locally relevant ΔT guidelines (Table 6.11) based on local reference site data in Cockburn Sound have been developed by the EPA based on the percentile approach recommended in ANZG (2018).

The discharge of brine effluent is not expected to increase the temperature above the relevant ΔT criteria in any location across the model domain in any season (Figure 6.27).

Table 6.11 Default temperature trigger values developed for Cockburn Sound

	High protection ΔT (°C)	Moderate protection ΔT (°C)
Summer	+1.5	+1.9
Autumn	+2.6	+4.0
Winter	+1.6	+3.6
Spring	+2.7	+3.7

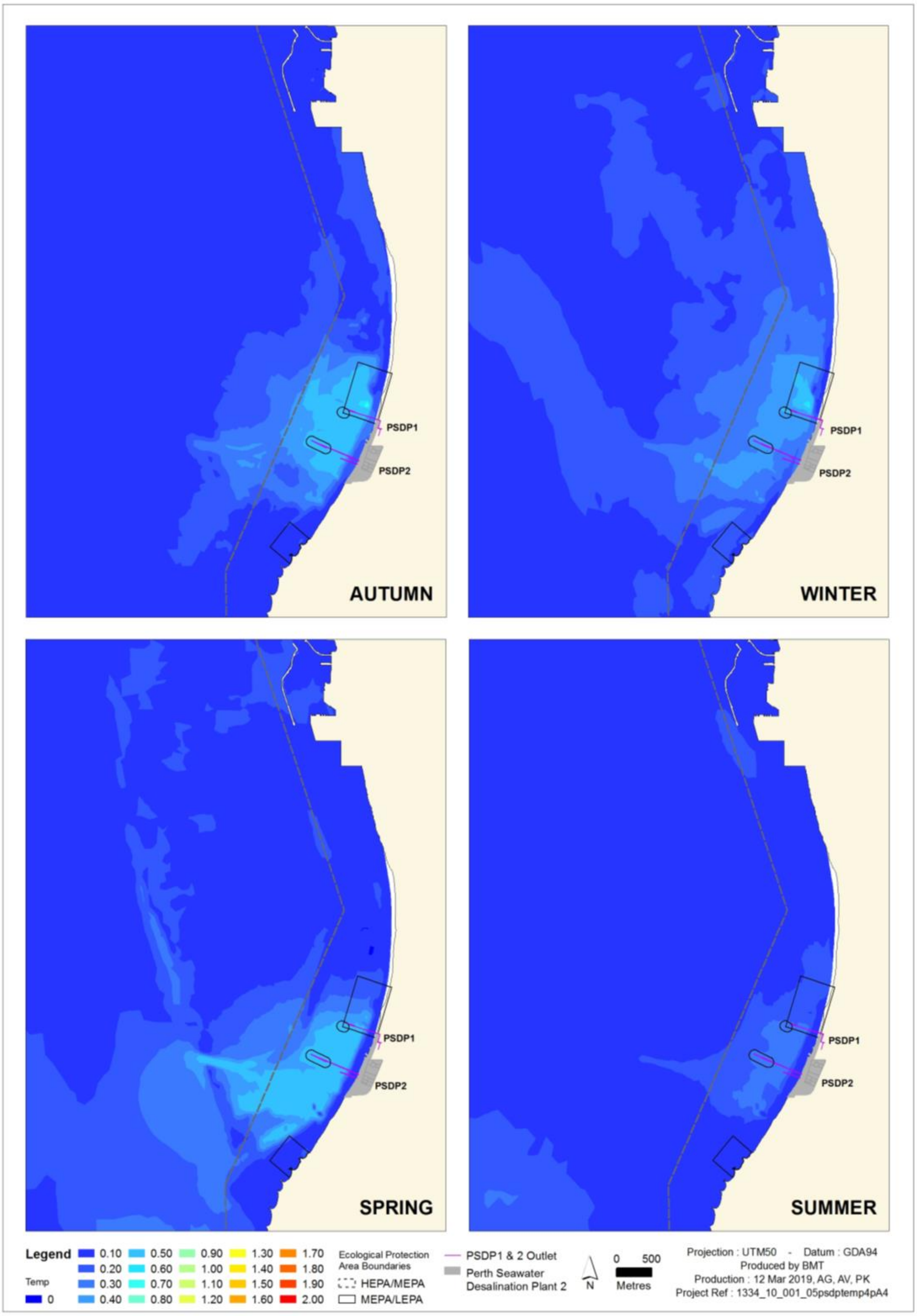
Source: EPA (2017)



Notes:

1. Temperature differences are shown as top minus bottom
2. Top layer is 0.5 m below surface, bottom layer is 0.5 m above seabed
3. 1A noDESAL = no desalination discharge, 1A = PSDP1 desalination discharge only, 2A = PSDP1 and PSDP2 desalination discharges

Figure 6.26 Simulated top-to-bottom temperature difference at S2 Monitoring Station (left) and Perth Buoy Central (right) with PSDP2 discharge during spring 2008



Notes:

1. Temperature are shown as predicted elevation above ambient temperature (°C)
2. Data are based on depth-average of salinity from 0 to 0.5 m above the seabed
3. 2C (autumn) = 25 GL/a operating capacity, 2A (winter, spring, summer) = 50 GL/a operating capacity

Figure 6.27 Median elevations in temperature above baseline for scenario 2A (winter, spring, summer) and 2C (autumn)

Contamination from release of reverse osmosis return water

Ambient concentrations of potential toxicants in Cockburn Sound waters are low (PB 2009). The desalination process will increase these ambient concentrations by a factor of approximately two but it is still expected that the ANZG (2018; Table 6.12) guidelines will be easily met prior to discharge. The risk of toxicity from the concentrating effect of desalination is low.

Table 6.12 Environmental quality triggers for toxicants in marine waters

Contaminant	High protection trigger (µg/L)[1]	Worst case HEPA concentration (µg/L)[2]	Moderate protection trigger (µg/L)[1]	Worst case MEPA concentration (µg/L)[2]
Napthalene	50	<0.01	90	<0.01
TBT	0.006	<2	0.02	<2
endrin	0.004	<0.01	0.01	<0.01
Endosulfan Sulfate	0.005	<0.001	0.02	<0.001
Phenol	400	<1	520	<1
Pentacholrophenol	11	<2	33	<2
Benzene	500	<1	900	<1
Cholopyrifos	0.009	<0.01	0.04	<0.01
Cadmium	0.7	<0.7	14	<0.7
copper	1.3	<1	3	<1
Chromium III	27.4	<2	49	<2
Chromium VI	4.4	<0.05	20	<0.05
lead	4.4	<2	6.6	<2
Mercury	0.1	<0.05	0.7	<0.05
Nickle	7	<2	200	<2
Silver	1.4	<1	1.8	<1
Zinc	15	<2	23	3.1

Notes:
1. High and moderate protection triggers for inshore marine waters derived from ANZEG (2018)
2. Data sourced from PB (2009)

Whole of effluent toxicity (WET) testing involves exposing organisms to various dilutions of an effluent, and then measuring effects on growth or reproductive characteristics after a selected period of exposure (ANZG 2018). A statistical fit is applied to the ecotoxicity data to model the minimum amount of dilution required to be protective of a theoretical percentage of species (99% for a high level of ecological protection and 90% for a moderate level of ecological protection). While brine from the PSDP2 process is not yet available, estimates can be made from a sample collected at the SSDP.

In a brine only solution, the toxic effect is predominantly due to the osmotic imbalance caused by the elevated salinity. For brine only, the number of dilutions required to achieve a high level of ecological protection was 1:22 (Table 6.13). A 1:22 dilution of brine discharge with background seawater is equivalent to a salinity increase of around 1.25–1.28 PSU (Table 6.14) above the existing baseline. This elevation is slightly lower than the +1.4 PSU trigger derived from the distribution of baseline salinity and therefore within the range of natural variability in Cockburn Sound. The fact that the high ecological protection trigger derived from WET testing is within the range of natural variability is indicative of the analytical uncertainty and conservative nature of the test, as well as the uncertainty in the statistical fit. Salinity is already assessed as a 'stressor' using the high ecological protection threshold of +1.4 PSU above background. Negligible toxicity impacts due to elevated salinity are predicted if median salinity elevations are within +1.4 PSU of background.

Table 6.13 Dilutions required to achieve high or moderate ecological protection derived from whole of effluent toxicity testing

Level of Ecological Protection	Dilutions required to achieve level of protection	
	Brine only	**Brine + CIP chemicals**
High	21.7	29.4
Moderate	9.1	9.1

Table 6.14 Salinity change associated with target dilutions derived from whole of effluent toxicity testing

Date	Effluent salinity (PSU)	Background salinity	Dilution	Salinity after dilution (PSU)	Salinity elevation (PSU)
Feb 2008-Mar 2008	64.75	37.00	1:21.7	38.28	1.28
Mar 2008 – Feb 2009	63.56	36.32	1:21.7	37.57	1.25
Summer 2007-2008	65.03	37.16	1:21.7	38.44	1.28
2013	63.74	36.42	1:21.7	37.68	1.26

The filters (ultrafiltration and RO membranes) are regularly cleaned using commercial 'clean-in-place' (CIP) compounds (e.g. ferric sulphate as a coagulant, hypochlorite, small volumes of sulphuric acid and sodium metabisulphite) (Table 6.15). The CIP chemicals in the backwash do not contain material quantities of the contaminants listed in the ANZG (2018) guidelines but may include potential biocides (e.g. chlorine and DBNPA) and chemicals with the capacity to alter the characteristics (particularly the pH) of receiving waters (e.g. acids).

Table 6.15 Potential chemicals required for the treatment process

Stage	Potential Chemical Used	Purpose	Frequency of use
Pre-treatment – feed water	Sodium metabisulphite	Neutralisation of shock chlorination	Rarely
	Coagulant (e.g. ferric sulphate)	Coagulation of feed for solids removal	Continuous
	Sulphuric acid	Adjusted feed pH to aid coagulation	Continuous
	Cationic polymer	Aid coagulation of feed for solids removal	Continuous
Pre-treatment – CIP[2]	Sulphuric acid or hydrochloric acid	CIP Neutralisation of sump	Occasionally
	Citric acid	RO CIP	Occasionally
	Sodium metabisulphite	Neutralisation of chlorine residual in sump	Occasionally
	Sodium hydroxide	RO CIP Neutralisation of sump	Rarely
	Chlorine / hypochlorite	CIP	Continuous
	Anti-scalant (likely phosphonate based)	CIP	Continuous
Reverse osmosis	Citric acid	CIP	Occasionally
Reverse osmosis – CIP	Sodium hydroxide	CIP	Occasionally
	DBNPA	Biocide	Rarely
	Sodium metabisulphite	Membrane preservation	Rarely
	Sulphuric acid or hydrochloric acid	Neutralisation of sump	Occasionally
Post-treatment	Chlorine Lime Fluorosilicic acid Carbon dioxide Chlorine	Drinking water quality compliance	Continuous

Notes:
1. CIP = Clean-in-place, DBNPA = 2,2-Dibromo-3-Nitrilopropionamide
2. Pre-treatment CIP: only implemented if a membrane based pre-treatment process is applied

WET testing completed on the SSDP reject stream complete with CIP chemicals suggested that the dilutions required to maintain a high level of ecological protection are only marginally increased above dilution required for the brine only solution (1:22 to 1:29). The small increase in toxicity between the osmotic effect and osmotic effect plus CIP samples suggests that the CIP chemicals make, at most, a small contribution to the toxicity results. CIP chemicals will be used infrequently (~15% of the time) and chemicals in the backwash will be diluted by mixing after discharge. The additional toxicity (i.e. beyond the effect of salinity) posed by the discharge of RO maintenance chemicals is therefore considered negligible.

The biocides (e.g. chlorine and DBNPA) and chemicals with the capacity to alter the characteristics (particularly the pH) of receiving waters (e.g. acids) will be fully neutralised by addition of necessary chemicals to correct pH prior to discharge. The comparatively low volumes of other chemicals relative to the discharge (Table 6.16) will be efficiently diluted in the waste stream and further diluted after discharge. Because of the low volumes and high levels of dilution, the risk posed by the maintenance wash chemicals is negligible.

Table 6.16 Chemical use relative to discharge volumes

Chemical	Daily demand (at 50 GL/a)	% of daily discharge
Antiscalant	0.48 m^3/d	0.00032
Coagulant aid (polyDADMAC)	0.32 m^3/d	0.00021
Coagulant – ferric sulphate	6.7 m^3/d	0.0044
Coagulant – ferric chloride	5.7 m^3/d	0.0038
Sulphuric acid	3.6 m^3/d	0.0024

Toxicant concentrations in the Cockburn Sound source water are low and the concentrating effect of the desalination process is not of sufficient magnitude to increase background toxicant concentrations to the extent that they risk exceeding the ANZG (2018) triggers. The toxic effect of the brine is predominantly due to the osmotic imbalance caused by salinity which will be managed by applying the locally relevant ΔS guidelines derived from reference site data in Cockburn Sound (EPA 2017). There may be a small contribution to toxicity from CIP chemicals and additives. The CIP chemicals will be used intermittently and in low volumes relative to the overall volume of the discharge. The risk posed by the discharge of RO maintenance chemicals is therefore considered negligible.

6.5.4 Cumulative impacts

Cumulative impacts are considered by EPA (2016b) to include the total impact of this Proposal and other proposals, in this instance, on marine environmental quality. No cumulative impacts were identified relating to construction activities on marine environmental quality during the environmental impact scoping process.

However, the additive effect of desalination discharges from PSDP2 to PSDP1 resulting in plumes merging, and to other industrial discharges to Cockburn Sound[4], was identified as a potential cumulative impact from operational activities. This impact has was addressed during model construction (see in *Hydrodynamic modelling* description Section 6.3.3 and Appendix C); intakes and outfalls related to all other industries operating in Cockburn Sound were incorporated into the model, and boundary conditions were set according to relevant periods of operation (BMT 2018b). Accordingly, all results presented in Section 6.5.3 have inherently incorporated the additive effects on marine environmental quality due to multiple marine discharges to Cockburn Sound.

Water Corporation is of the view that all relevant known cumulative impacts have been sufficiently incorporated into the impact assessment and that there is no requirement for further assessment of

[4] *Other industries intakes and diffusers in Cockburn Sound relevant to the impact assessment: Kwinana Power Station (stages A and C), Newgen Power Station, Kwinana Power Station Gas Fired, Cockburn Power Station, BP Refinery and Tiwest.*

cumulative impacts on marine environmental quality within Cockburn Sound because of this Proposal.

6.6 Mitigation

Water Corporation has applied the mitigation hierarchy to the Proposal to ensure the quality of marine water, sediment and biota is maintained so that environmental values are protected in Cockburn Sound. Mitigation measures are summarised in Table 6.17.

Table 6.17 Summary of mitigation measures to ensure maintenance of marine quality

Impact	Avoid	Minimise	Management and monitoring
Turbidity generated during construction works	The marine construction footprint is sufficiently separated in distance from significant benthic primary producer habitats (seagrasses) to avoid indirect effects of turbidity generated during dredging. Planned onshore disposal of surplus dredge sediment material will avoid potential for direct and/or indirect impacts on marine quality associated with disposal of dredge spoil at sea.	Water Corporation has developed a hydrodynamic model to predict sediment plume dispersion to quantity changes in marine quality (turbidity and light) due to dredging activities. Pre-selection of dredging equipment/approach (informed by modelling outcomes) to minimise turbidity generation.	Implementation of a Construction Environmental Management Plan (CEMP).
Disturbance to sediments leading to release of contaminants	N/A	N/A	Implementation of a CEMP. Implementation of a Sediment Quality Sampling and Analysis Plan (SAP) in advance of dredging activities to update marine quality within the dredge footprint.
Discharge of brine effluent	The planned location of the desalination discharge outlet is sufficiently separated from benthic macroinvertebrate communities so that mixing occurs prior to interaction with the desalination plume.	Water Corporation has developed a hydrodynamic model to predict changes in marine quality (stratification) associated with discharge of RO return water during operations. An iterative approach was used to assess impacts and minimise the desalination plume footprint in high risk periods (autumn).	Implementation of a PSDP2 Marine Environmental Management Plan (MEMP). Defining of LEPA boundaries to ensure marine quality around the PSDP1 and PSDP2 desalination diffusers are managed to the requirements of the EPA.

Impact	Avoid	Minimise	Management and monitoring
		Seawater outlet diffusers will be oriented to optimise mixing and therefore prevent stratification	
Discharge of chemicals used in the Seawater Desalination process	N/A	Water Corporation has developed a hydrodynamic model to predict changes in marine quality (toxicants) associated with discharge of RO return water during operations. CIP dosing will be accompanied by sodium metabisulfite dosing to neutralise free chlorine prior to discharge to marine environment.	Implementation of MEMP.

6.6.1 Construction

A preliminary register of measurable and/or auditable environmental commitments to manage the environmental impacts associated with construction activities (Section 6.5.2) are provided in a CEMP to be finalised prior to commencement of dredging. The CEMP will include:

- detailed monitoring and management requirements (in-line with)
- timing/frequency of monitoring and management commitments
- responsibilities for monitoring and management commitments
- contingency planning/measures in the event of an environmental or safety issue
- stakeholder consultation
- reporting requirements to government and environmental regulators.

Table 6.18 Construction: relevant environmental objectives, performance indicators and proposed measurement criteria

Environmental objective	Performance criteria[1]	Standards[2]	Performance indicators[3]
To maintain the quality of water, sediment and biota so that environmental values are protected	No persistent impacts to marine environmental quality as a result of construction activities	Detailed procedures for: • Implementation of a sediment quality SAP, prior to dredging, to verify sediment quality within the dredge footprint meets required environmental quality thresholds (CA 2009, DER 2014, DER 2015) • Implementation of management controls (including silt curtains) to help contain TSS plume • Implementation of in-water turbidity monitoring, visual plume observations as per the CEMP • Waste management and disposal in-line with existing regulatory requirements • Hydrocarbon spill management • Remain compliant with the International Maritime Organisation International Convention for the Prevention of Pollution from Ships as a contractual requirement	• System in place to ensure waste management and spill prevention procedures • Inspect plant daily • Adherence to refuelling procedures. • Audit spill response and clean-up procedures • Third-party audit of CEMP outcomes

Notes:

1. Performance criteria = the performance criteria are the proposal-specific desired state for an environmental factor/s that an organisation sets out to achieve from the implementation of outcome-based provisions
2. Standards = can include company standards, regulatory requirements, and recognised Australian and International Standards
3. Performance indicators = measurable/auditable outcomes that ensure the company's environmental performance

6.6.2 Operations

A preliminary register of measurable and/or auditable environmental commitments to manage the marine environmental impacts associated with PSDP2 plant operations (Section 6.5.3) will be detailed in a PSDP2 Marine Environmental Management Plan (MEMP), which will be finalised prior to commencement of plant operations.

A MEMP will include:

- detailed monitoring and management requirements (as per
- timing/frequency of monitoring and management commitments
- responsibilities for monitoring and management commitments
- contingency planning/measures in the event of an environmental or safety issue
- stakeholder consultation
- reporting requirements to government and environmental regulators.

Table 6.19 Operations: relevant environmental objectives, performance indicators and proposed measurement criteria

Environmental objective	Performance criteria[1]	Standards[2]	Performance indicators[3]
To maintain the quality of water, sediment and biota so that environmental values are protected	No persistent impacts to marine environmental quality as result of brine effluent discharges	Detailed procedures for: • Implementation of a MEMP to ensure compliance with EQC defined in EPA (2017) within HEPA and MEPA • Detailed management procedures for brine effluent discharges, including: o on-going real-time salinity monitoring within Cockburn Sound o control of brine effluent discharges at PSDP2 plant	• Operate and maintain plant to specification • Third-party audit of MEMP outcomes

Notes:
1. Performance criteria = the performance criteria are the proposal-specific desired state for an environmental factor/s that an organisation sets out to achieve from the implementation of outcome-based provisions
2. Standards = can include company standards, regulatory requirements, and recognised Australian and International Standards
3. Performance indicators = measurable/auditable outcomes that ensure the company's environmental performance

6.7 Predicted outcome

During marine construction works, the Proposal is likely to result in temporary disturbances to water quality by elevating TSS, but no long-term change is expected. The implications of elevated TSS on benthic communities and habitats is assessed in Section 7.5.2, and for fish in Section 8.5.2. There are not considered to be any significant or long-term impacts (contamination) to marine environmental quality associated with disturbance of sediments through dredging or during plant commissioning. Further, standard management controls, including use of silt curtains, will be employed to limit sediment plume dispersion.

During plant operations, the Proposal has the potential to increase the strength of natural patterns in stratification in northern areas of the deep basin, which in turn, may lead to slight reductions in DO relative to background concentrations. This effect was predicted to only occur at certain times and to be temporary and rapidly eroded by wind. The model also predicted that the differences in DO saturation 'with' desalination discharges versus 'without' desalination discharges were minor, while differences between PSDP1 and PSDP2 scenarios were considered negligible. DO was not predicted to drop below required EQSs at any point during a year experiencing normal climatic conditions. Only very small differences (relative to background concentrations) were predicted in DO during low DO events, which are prompted by natural climatic events; the potential ecological consequence of these changes in DO on benthic communities and habitats is assessed in Section 7.5.3, and on fish in Section 8.5.3.

For salinity, a high level of ecological protection is expected to be maintained in waters zoned as HEPA, except for small areas within the shipping channel where the modelling suggests the salinity guideline criteria may be exceeded during worst case conditions. A moderate level of ecological protection is expected to be maintained within the MEPA, except for the area in the immediate vicinity of the PSDP 1 and PSDP2 diffusers where a low level of ecological protection will be maintained. For most of the year, the size of the area where a moderate level of ecological protection cannot be maintained is small (within 80 m of each diffuser). An envelope drawn around each seasonal representation to compile a LEPA consistent with the approach in EPA (2016d), would be equivalent to this autumn footprint as the area derived for each of the other seasons fall within its boundary. The area is considered unlikely to support significant marine flora or fauna. The potential ecological consequences of temporary elevations in salinity outside of proposed LEPAs and MEPAs on benthic communities and habitats is assessed in Section 7.5.3, and on fish in Section 8.5.3.

There are not predicted to be any adverse impacts due to changes in water temperatures because of the Proposal.

The comparatively low volumes of chemicals relative to the discharge will be efficiently diluted in the waste stream and further diluted after discharge. Because of the low volumes and high levels of dilution, the contamination risk posed by the maintenance wash chemicals to marine environmental quality is considered negligible.

After the application of mitigation measures as described in Section 6.6, the EPA objective for marine environmental quality (i.e. to maintain the quality of water, sediment and biota so that environmental values are protected) is expected to be met.

There is no significant residual impact to marine quality predicted to occur from the construction and operation of the Proposal, so consideration of offsets for this environmental factor is not required.