Woodside

APPENDIX D NORTH WEST SHELF PROJECT EXTENSION

MARINE ENVIRONMENTAL QUALITY MANAGEMENT PLAN

REVISION 4

G2000RF1401194403

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1. Summary

Woodside Energy Ltd (Woodside), as Operator for and on behalf of the North West Shelf (NWS) Joint Venture (NWSJV), is the proponent for the North West Shelf Project Extension Proposal (the Proposal).

In summary, the Proposal is for the ongoing operation of the NWS Project to enable the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities until around 2070. The Proposal is described in its entirety in Section 2 of the NWS Project Extension Environmental Review Document (Woodside, 2019) and is duplicated into Section 2.1.1 of this Marine Environmental Quality Management Plan (MEQMP) for ease of reference.

This MEQMP was prepared in accordance with the 'Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans' published April 2018 by the Western Australian (WA) Environment Protection Authority (EPA) (EPA, 2018a).

This MEQMP details the measures that are required to manage the potential impacts to marine environmental quality from the Proposal. **Table 1-1** summarises the information contained in this MEQMP.

Table 1-1: MEQMP summary table

Title of Proposal	North West Shelf Project Extension
Proponent Name	Woodside Energy Ltd., as Operator for and on behalf of the NWSJV
Purpose of the EMP	This Marine Environmental Quality Management Plan: • identifies the environmental values (EVs) to be protected. • establishes the Environmental Quality Objectives (EQOs) to ensure the selected environmental values (marine environmental quality) are maintained. • establishes Environmental Quality Criteria (EQC) for indicators relevant to the discharges. • spatially defines areas of low, moderate, and high ecological protection around the wastewater discharge points (Jetty Outfall and Administration Drain) in alignment with the *Revised Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives* (DoE, 2006). • presents monitoring required to demonstrate that discharges meet the levels of ecological protection (LEPs) assigned to the discharge areas and EQC are achieved. • presents an adaptive management program based on the environmental quality management framework (EQMF as defined in EPA (2016a) designed to ensure the EQO continues to be achieved in the event of specified changes to the discharge or other factors.
Key Environmental Factor/s and Objective/s	**Key Environmental Factor:** Marine Environmental Quality **EPA Objective:** To maintain the quality of water, sediment, and biota so that environmental values are protected (EPA, 2018b) **Environmental Quality Management Framework Objective:** Maintain ecosystem integrity (DoE, 2006)
Key Provisions in the EMP	Management of discharges to the marine environment to maintain ecosystem integrity

2. Context, Scope, and Rationale

2.1 Introduction

The NWS Project is one of the world's largest liquefied natural gas (LNG) producers, supplying oil and gas to Australian and international markets from offshore gas, oil, and condensate fields in the Carnarvon Basin off the north-west coast of Australia. For more than 30 years, it has been WA's largest producer of domestic gas.

Woodside proposes to operate of the NWS Project to around 2070 as an LNG facility that is commercially capable of accepting gas for processing from other resource owners. Therefore, this Proposal will include processing third-party gas and fluids and any remaining or new NWSJV field resources.

The Proposal is described in its entirety in Section 2 of the NWS Project Extension Environmental Review Document (Woodside, 2019) and is duplicated into **Section 2.2** of this MEQMP for ease of reference.

This MEQMP will be implemented following receipt of approval under the *Environmental Protection Act 1986* (WA) (EP Act) and *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act). In the interim, the NWS Project will continue to operate under current license conditions and management practices.

2.1.1 Proposal

To enable the future operation of the NWS Project and the ongoing supply of gas and fluids to domestic and international markets, the Proposal seeks approval to transition the Existing NWS Project facilities to a new phase of the NWS Project; which is commercially capable of accepting gas for processing from other resource owners. The NWS Project Extension Proposal is seeking approval for the:

- long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities, including:
  - changes to feed gas composition including changed content of inerts, hydrocarbons and other components
  - changes to the composition of environmental discharges and emissions, although annual volumes of emissions and discharges are expected to be in line with current levels
  - modifications to the KGP onshore receiving facilities (that would not otherwise be undertaken if not for the Proposal) to accommodate third-party gas and fluids, as well as upgrades to metering to facilitate processing of third-party gas and fluids
  - potential construction of additional operational equipment to accommodate changes to feed gas composition or management of discharges and emissions
- ongoing operation of the NWS Project (from the date of the approval of this Proposal) to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070, including:
  - ongoing use of existing NWS Project facilities to process third-party gas and fluids and NWSJV field resources
  - inspection, maintenance, and repair (IMR) and improvement programs for trunklines (TL), 1TL and 2TL
  - Maintenance dredging associated with jetties and berthing pockets
  - Replacing equipment, plant, and machinery as required that would not otherwise be replaced if not for the Proposal.

- Ongoing, additional (and cumulative to existing approvals) emissions and discharges to the environment (Woodside, as operator for and on behalf of the NWS Project, will implement emission reduction opportunities that will result in a staged decrease in emissions over time)
- Monitoring and management of environmental impacts.

2.2 Scope of the MEQMP

Purpose of Management Plan

This MEQMP was written in accordance with the Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016a). This document sets out an Environmental Quality Management Framework (EQMF) to achieve the objective of maintaining ecosystem integrity within the WA marine environment. The approach to managing the Proposal in a way that achieves this objective is based on a combination of impact assessment, early response indicators, and past environmental performance of the NWS Project.

The impact pathways were assessed to determine if there is a risk of the Proposal activities impacting maintenance of ecosystem integrity. These criteria were applied:

- where mitigation for, and management of the activity is implemented under other regulatory instruments (e.g. Operational Licence approved under Part V of the EP Act or approved environment plan), the risk was determined to be sufficiently managed
- where the activity required management through design controls and those controls are already in place at the NWS Project, the risk was determined to be sufficiently managed.

The KGP Part V Operational Licence sets out monitoring requirements that apply to all planned marine discharges from the Proposal.

This MEQMP acknowledges that the nature of liquid discharges and the state of the receiving environment may change over the life of the Proposal. Therefore, this MEQMP includes an adaptive management program (**Section 8**) to confirm that the management measures proposed continue to be appropriate and ensure protection of the environment value.

Scope

This MEQMP specifically addresses the management of potential environmental impacts to the marine environment from planned discharges from the Proposal, via the KGP Jetty Outfall and Administration Drain, further described in **Section 6**.

These aspects and NWS Project components are outside the scope of this MEQMP:

- Trunklines 1TL and 2TL, which are managed under the North West Shelf Trunklines State Waters Operations Environment Plan (State Waters EP).
- Inspection, maintenance, monitoring, and repair activities, which are managed under the State Waters EP.
- Shipping, including ship loading. Woodside does not have direct control over these operations. Shipping is managed by vessel operators under the requirements of Marine Orders.
- Unplanned discharges from onshore or offshore accidents or emergencies, which are managed under the State Waters EP and Emergency Management Plan for the KGP.
- Presence and management of existing onshore contamination, which is managed in accordance with the *Contaminated Sites Act 2003* (WA).
- King Bay Supply Base (KBSB): Discharges from the KBSB are limited to treated sewage and site run-off from areas with a low likelihood of contamination by oils or other chemicals. These discharges are considered low risk in the context of the port environment and below thresholds for management under Part V of the EP Act.

Key Environmental Factors

This MEQMP addresses potential impacts from planned marine discharges on the key environmental factor, Marine Environmental Quality. Marine environmental quality is defined by the EPA (EPA, 2016b) as:

> *The term 'environmental quality' refers to the level of contaminants in water, sediments or biota or to changes in the physical or chemical properties of waters and sediments relative to a natural state. It does not include noise pollution, which is dealt with separately under the marine fauna factor.*

The EPA's objective for this environmental factor is:

> *To maintain the quality of water, sediment, and biota so that environmental values are protected* (EPA, 2018b).

A set of five environmental values (EVs) that require protection from the effects of pollution, waste discharges, and deposits in marine environments were agreed by all State, Territory and Commonwealth governments through the National Water Quality Management Strategy (NWQMS) (EPA, 2016b).

Justification for the selection of EVs and management approach is outlined below.

2.3 Rationale and Approach

The development of this MEQMP follows EPA 'Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans' (EPA, 2018a) and Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016a). EPA (2016a) describes an outline of an EQMF.

As required to enact the EQMF, this MEQMP includes these sections:

- identification of EVs relevant to the particular area (**Section 3.1**)
- establishment of spatially defined Environmental Quality Objectives (EQOs). Maintenance of the EQOs are designed to ensure that the associated EVs are protected (**Section 5**)
- The EQOs are represented spatially as part of the Environment Quality Plan (EQP)
- establishment of Environmental Quality Criteria (EQC). EQC represent scientifically based limits of acceptable change to a measurable environmental quality indicator that is important for the protection of the associated environmental value (**Section 5.2**).

The EQMF requires appropriate EQC to be established to ensure an appropriate framework is in place for measuring the extent to which the EQO is maintained and therefore demonstrating the EV is being protected.

Two types of EQC are defined under the EQMF:

- Environmental Quality Guidelines (EQGs). These are quantitative investigative triggers that, if achieved, indicate there is a low probability that the EQO is not being achieved
- Environmental Quality Standards (EQSs). These are management triggers based on multiple lines of evidence, which, if exceeded, signify that the EQO is not being met and that a management response is required.

The framework of this MEQMP is outlined in **Figure 2-1**.

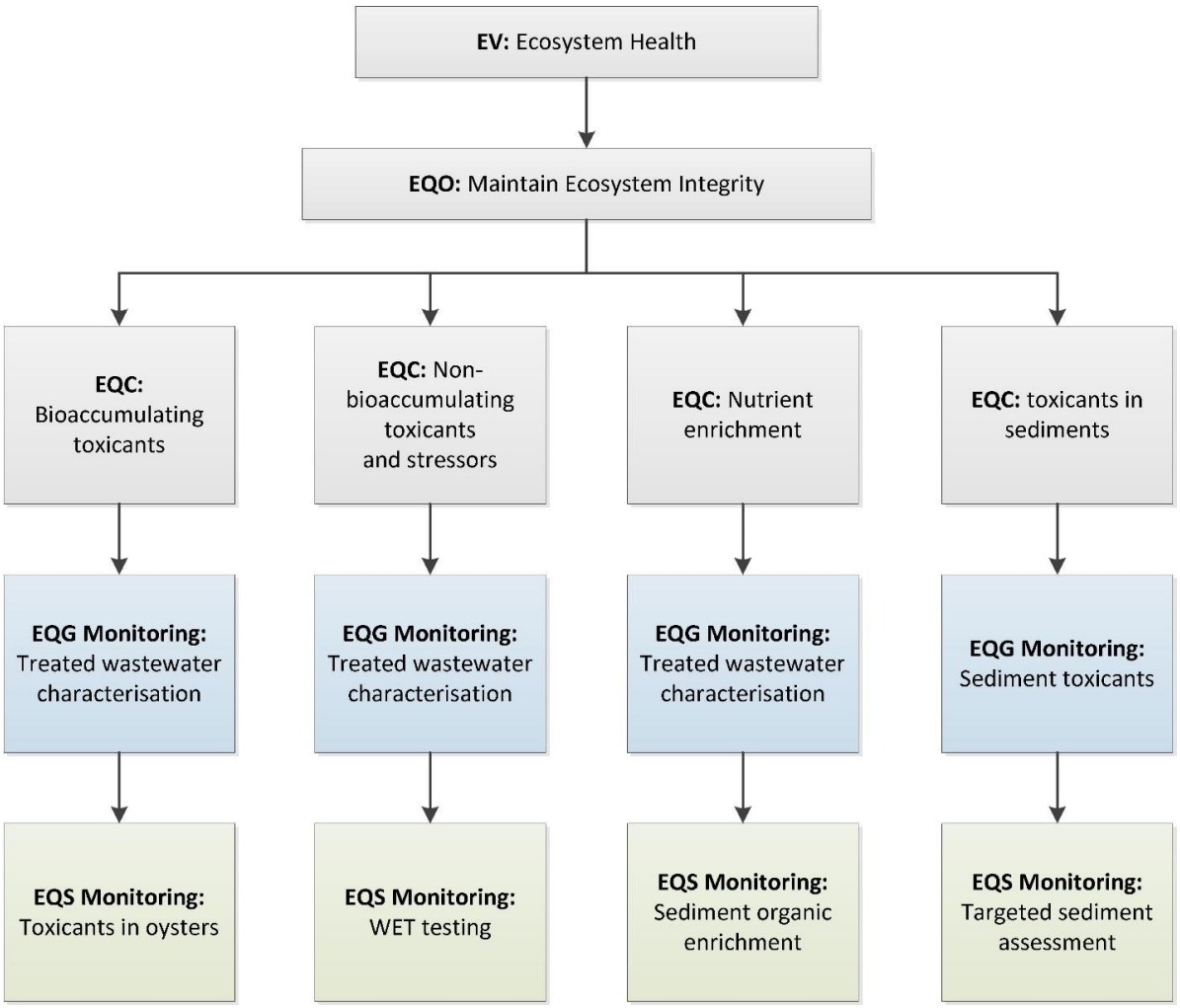

Figure 2-1 Environmental quality objectives, criteria, and monitoring programs for maintaining the environmental value Ecosystem Health

3. Existing Environment

The existing marine environment near the Proposal, while still largely a natural environment, is influenced by industrial activity, including shipping, and the presence of the existing NWS Project infrastructure and other industrial premises. Although Mermaid Sound and the wider marine environment have areas of high environmental quality that sustain significant marine ecosystems and important coastal processes, the existing marine disturbance footprint of the NWS Project is designated as a low or moderate environmental protection area because of the presence of trunklines and dredged areas on the seabed. The benthic environment was dredged to allow for liquefied natural gas (LNG), liquefied petroleum gas, and condensate vessels to transit to and from the NWS Project's product loading jetties at the KGP and is regularly traversed by large commercial vessels.

A large (minimum 800m) public safety exclusion zone surrounds the NWS Project infrastructure, including the product loading jetties. Fishing, aquaculture, or recreational activities are not permitted in this zone, which is under constant surveillance. No extraction of water for domestic or industrial purposes occurs near the Proposal development envelope.

Figure 3-1 has been developed to identify local sensitivities include the location the national park, Conzinc Bay Tourism Precinct and Edible Oyster Project.

A full description of the existing environment is contained in the NWS Project Extension Environmental Review Document (ERD) (Woodside, 2019).

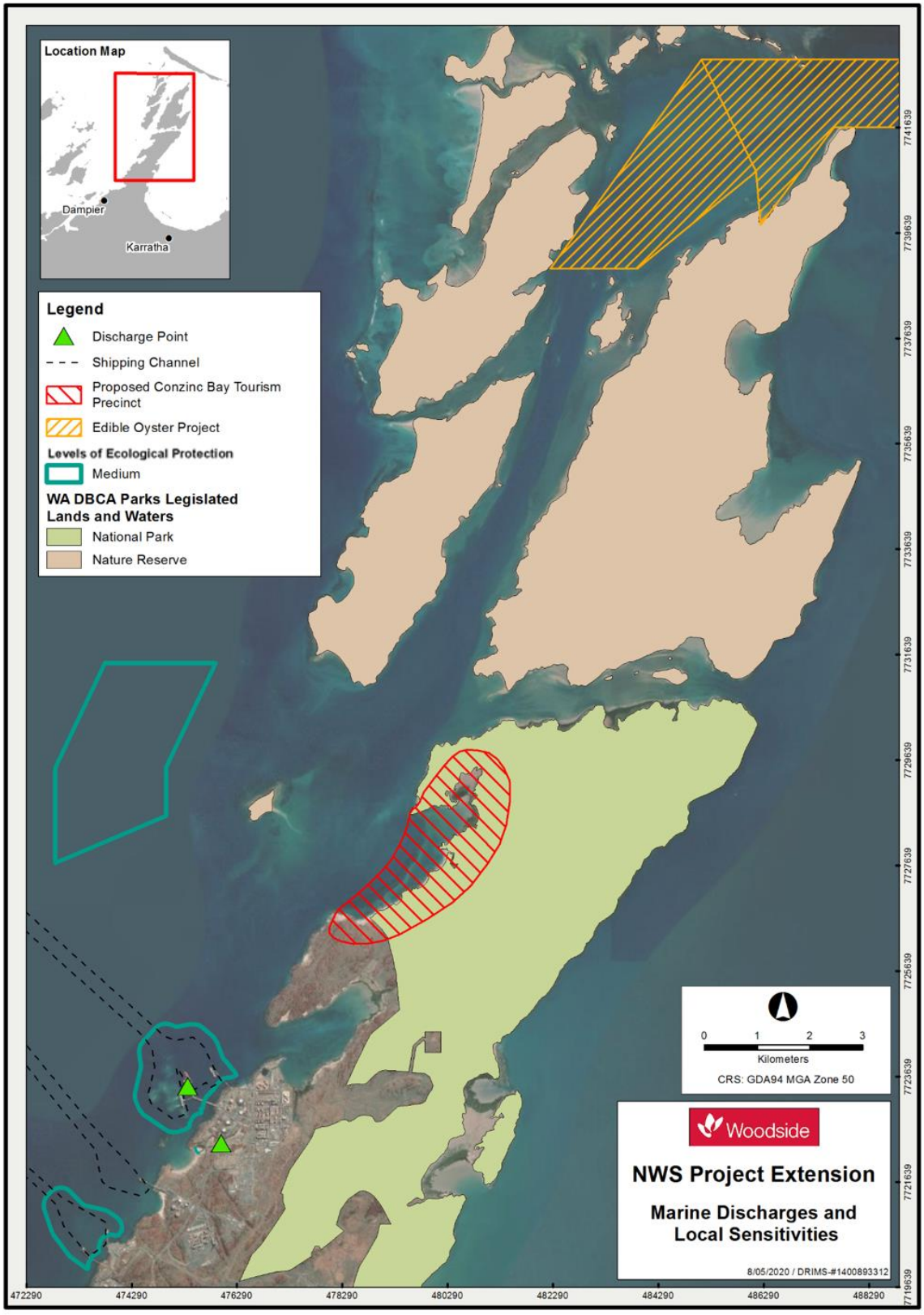

Figure 3-1 NWS Extension Marine Discharges and Local Sensitivities. All Ecological Protection Zones are noted on the Mermaid Sound Environment Qualiy Plan.

3.1 Assessment of Site-specific Environmental Values

The EPA has identified five EVs for marine environmental quality that should generally be protected through WA coastal waters:

- Ecosystem health;
- Fishing and aquaculture;
- Recreation and aesthetics;
- Industrial water supply; and
- Cultural and spiritual.

3.1.1 Ecosystem health

The risks and impacts to ecosystem health associated with discharges from the NWS are well understood and considered to be low. This assessment is support by extensive historic discharge composition monitoring and receiving environment health has been monitored extensively since the project commencement.

3.1.2 Fishing and aquaculture

EGC and EQS for the protection of societal values associated with fishing and aquaculture are included within this plan. These have been prepared consistent with EPA guidance (EPA 2017).

It should be noted that the risk from NWS Project discharges to fishing and aquaculture are intrinsically low, because;

- Shore based fishing/seafood collection is not permitted and controlled via restrictions to the site, that extend for multiple kilometres either side of the discharge locations, beyond which all contaminants of concern are diluted to below detectable concentrations.
- A boating exclusion zone excludes boats from at least 800m from the nearest discharge point.
- There are no currently exploited seafood populations near the point of discharge. The closest exploited seafood population is the Edible Oyster Project is located approximately 14kms away.
- Areas zoned for potential aquaculture are at least 10km from the nearest discharge locations.
- The objectives to protect ecosystem integrity (outlined in Table 6-1 of the MEQMP) also supports the protection of fishing and aquaculture.

3.1.3 Recreation and aesthetics

Primary contact recreation (i.e. swimming) from the coast is not permitted for more than 2km from each of the discharge points. This is due to the presence of Maritime Exclusion Zones around the NWS Project.

Secondary contact recreation (e.g. boating and fishing) is prohibited from occurring within a minimum of ~800m of discharge points and any boating activity that does occur at the edge of the maritime exclusion zone is typically associated with transiting to other locations.

To demonstrate the risks to secondary contact recreation are protected, relevant EQC regarding the demonstration of safe water quality are included in this plan. These have been prepared consistent with EPA guidance (EPA 2017).

The EGC established for the protection of secondary contact recreation pertain to the demonstration that pathogen levels in the discharged water are low. As such, this will also contribute to demonstrating the maintenance of seafood fit for human consumption.

3.1.4 Industrial water supply

No EQC and monitoring specific to the industrial water supply EV are specified in this Plan because the risk is already sufficiently managed and/or adequately protected by specified EQC for protecting ecosystem health. Specific details of the assessment are as follows:

- There are no nearby industrial water intakes.
- The nearest planned industrial discharge occurs approximately 6km away, from Multi User Brine Return Line (cumulative impacts have been assessed in Section 6.6.4.1 of the NWS Extension ERD).
- Discharges dissipate rapidly and do not impact potential industrial supply.

3.1.5 Cultural and spiritual

As per EPA guidance (EPA, 2016a), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, then this may go some way towards maintaining cultural values.

No Environmental Quality Guidelines (EQGs) were identified specifically for protecting cultural and spiritual values.

3.2 Existing Environment

The existing environment and habitats potentially influenced by the planned discharges are described in **Section 5.1**.

4. Impact Assessment

4.1 Activities Potentially Impacting Identified Environmental Values

Two existing discharges to the ocean from the KGP are licensed under Part V of the EP Act - the Jetty Outfall and the Administration Drain. As outlined in **Section 2.2**, this MEQMP only applies to discharges from these two licensed discharge points. Both discharge points have the potential to impact 'Ecosystem Health' and are subject to the management provisions described in this MEQMP. This section describes the waste streams, treatment technology, and discharge regimes for these two discharges. Other EVs have been assessed as sufficiently managed and/or adequately protected by specified EQC for protecting ecosystem health (see Sections 3.1.1 to 3.1.5).

4.2 Jetty Outfall

4.2.1 System Description

The KGP uses an oil-contaminated water (OCW) system to collect and treat, contaminated and potentially contaminated water generated on site for subsequent discharge. The OCW comprises two networks (LNG and domestic gas (Domgas)) for water collection, a series of holding basins for holding and treating collected water. Water from both systems is then combined in a common a buffer tank to balance inflows and a final holding basin is utilised for final treatment and to allow for the collection of a representative sample prior to discharge. Water in this final holding basin is sampled and tested against internal discharge limits before being discharged to a diffuser located on Berth 1 of the KGP LNG jetty, known as the Jetty Outfall (**Figure 4-1**). Sources of potential contaminated water inflows into the OCW are listed below. Equipment and collection zones are shown in **Figure 4-1**.

Sources of inflow to the LNG OCW system include:

- Process wastewater and bunded / collection areas within:
  - all LNG trains;
  - all fractionation units;
  - both trunkline onshore terminals;
  - utilities and power generation (excluding GT4009 and GT4010)
  - condensate pumping station; and
  - condensate tanks 3 and 4.
- Dewatering of condensate storage tanks.

Sources of inflow to the Domgas OCW system include:

- Process wastewater and bunded areas within:
  - domgas processing units;
  - stabilisation units;
  - flare units;
  - utilities, including diesel oil systems, HP fuel gas, GT4009-10, firewater, and fuel gas; and
  - condensate tanks 1 and 2.
- Domgas processing units (U1300 dehydration) and flare knockout drums.

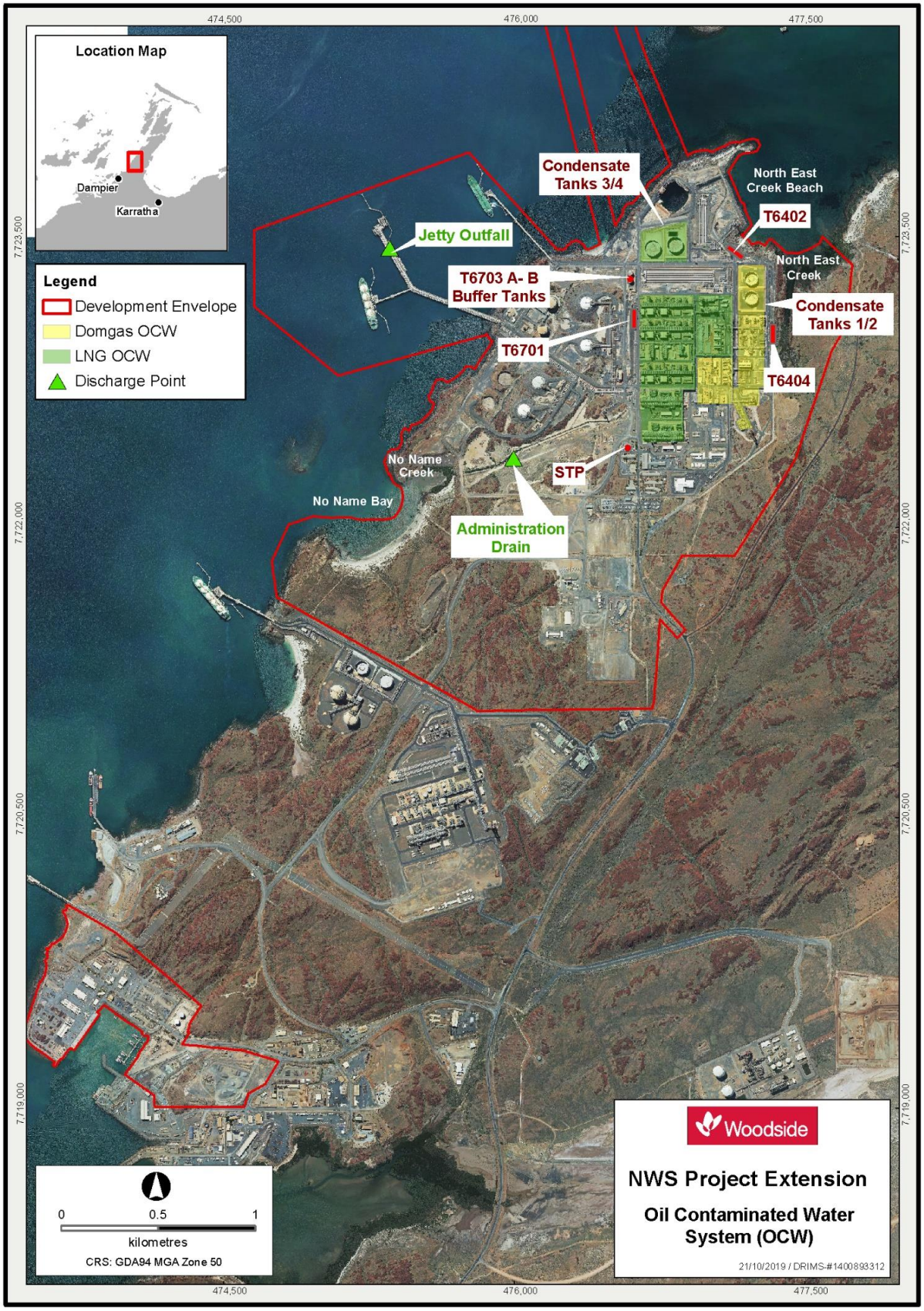

Figure 4-1 Layout of the KGP Oil Contaminated Water (OCW) System

4.2.2 OCW Treatment System

Once collected through the drainage networks, water is directed to the two intermediate holding/treatment basins (LNG –T6402 and Domgas – T6404) located on the northern and eastern sides of the KGP (**Figure 4-1**). Each system has a corrugated plate interceptor as the primary treatment to remove oil from the effluent streams, and a holding basin to allow settling, residence time, and aeration to remove organic and chemical contaminants. The recovered oil from each system is collected in a dedicated oil collection sump, from where it is sent to oil storage tanks and back into the main production process.

Once wastewater from each drainage network has passed through its dedicated holding/treatment basin, the treated water is pumped to a common buffer tank. The buffer tank provides capacity to manage water inflow to the final treatment system and provides additional storage capacity during high rainfall events.

A third common holding/treatment basin (T6701; the final holding basin) also has a corrugated plate interceptor for further oil/water separation. Samples of this water are collected and analysed by a National Association of Testing Authorities (NATA) accredited lab, to determine whether wastewater meets the discharge criteria (See **Section 4.4**).

If the discharge requirements are not met, the wastewater is retained in the final holding basin for further treatment until the discharge criteria are met. If discharge criteria cannot be achieved, alternative disposal options are evaluated and used as appropriate. Options include transferring to the on-site evaporation pond, using temporary treatment systems, or transferring to an appropriately licensed third-party disposal facility.

4.2.3 Jetty Outfall

Water is discharged in batches to the marine environment, via a subsurface diffuser located beneath Berth 1 on the LNG loading jetty. A discharge event will typically discharge up to 350 m^3 of water over two to three hours. Discharges typically occur between every three to seven days. Rainfall volumes are the primary determinant in the frequency of discharges and annual discharge volumes, as water volumes generated by onsite processes are relatively constant throughout the year. The buffer tank allows discharges to be sufficiently spaced to eliminate the risk of cumulative impacts from sequential discharges. Discharge events are targeted to occur at least three days apart, but may occur more frequently for certain reasons, such as if cyclonic rain is expected to occur or an aspect of the system requires maintenance.

4.2.4 Jetty Outfall - Contaminants of Concern

The Jetty Outfall receives wastewater from various facility process streams and bunded process areas as outlined in **Section 4.2.1**. Cause–effect pathways for potential impacts on marine environmental quality are associated with emissions from the production of gas and fluids by KGP processes.

Each batch discharge is analysed for the presence of 18 contaminants, in accordance with the KGP Part V Operational Licence, and the historic average concentrations of these is shown in **Table 4-1**. Internal approval to discharge is informed by a subset of the licence parameters identified as potentially driving acute toxicity, with the remaining reviewed on a regular basis. Every year, a representative sample of water discharged via the Jetty Outfall is analysed for an extended suite of potential chemical contaminants, informed by a list of contaminants that could be associated with oil and gas operations, to ensure the regularly monitored contaminants are aligned to the expected contaminants of concern present in the waste streams. Based on these results and the nature of the receiving environment, the following parameters are considered to be those which will govern the toxicity of the discharge:

- bioaccumulating toxicants:
  - cadmium
  - mercury

- non-bioaccumulating toxicants and stressors:
  - petroleum hydrocarbons (historically measured as total oil, in accordance with the KGP Part V Operational Licence)
  - ammonia-N
  - copper
  - lead
  - zinc
  - aMDEA
  - tri-ethylene glycol
  - sulphide
  - pH

Table 4-1 Average annual concentration of licensed discharge parameters in discharges to the Jetty Outfall

Parameters	Unit	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
a-MDEA	mg/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Anionic Surfactant	mg/L	2.6	6.8	18.1	15.8	11.6	6.1	9.1	1.2
COD	mg/L	205.5	411.7	154.9	84.9	75	76.9	605.9	85.8
Conductivity	µS/cm	3135.5	4058.9	3302.9	1157.6	2097.3	1269.2	1013.6	676.3
Mercury	µg/L	N/A[1]	N/A[1]	N/A[1]	0.3	0.1	0.4	1.8	0.1
pH	mg/L	8	8	8.3	7.8	8.1	6.9	6.6	8.1
Sulphate	mg/L	934	1114.6	947.6	143.9	380.5	86.2	28.5	18.8
Sulphide	mg/L	23	38.5	18.2	0.8	4.9	0.3	2.8	0.2
Cadmium	µg/L	0.1	N/A[1]	0.1	0.1	0.3	0.2	1.8	0.5
Copper	µg/L	2	0	1.9	4.7	14.6	28.2	18.4	6.1
Lead	µg/L	0.8	0	2.2	< LOR	9.9	1.2	9	2.9
Total Nitrogen	mg/L	3.2	3.6	4.5	2.9	4.4	3	4.3	1.9
Total Oil	mg/L	1.8	2.6	1.3	1.3	1	0.6	5	0.7
Total Phosphorous	mg/L	0.6	0.9	1.2	0.6	1.3	1	0.6	0.4
Total Suspended Solids	mg/L	19.5	25.7	14	16.4	14.7	22.5	27	21.2
Zinc	µg/L	45	100	43.8	44.2	31.5	39	194	90.9
Turbidity	NTU	81.5	84.5	50.4	18	18.7	12.3	43.6	18.3
Tri-ethylene glycol	mg/L	12.1	56.3	14	5.5	5.7	0	19.9	5.4
Volume (annual total)	m^3	19,869	26,506	12,430	11,907	6,819	10,352	16,065	21,061

Note 1 – Not measured in this period.

4.3 Administration Drain

4.3.1 System Overview

The Administration Drain is a concrete-lined open drain that discharges into No Name Creek, an unlined mangrove-fringed watercourse that terminates at a culvert at the site boundary, beyond which water continues to flow into the adjacent mangrove-fringed No Name Bay and Mermaid Sound. No Name Bay is within the general exclusion zone that applies to the KGP and no public access is permitted within 1.5 km of the discharge point.

The Administration Drain receives water from these KGP sources:

- treated sewage from the sewage treatment plant (STP);
- water discharged from the demineralisation water plant (DWP); and
- stormwater run-off.

4.3.2 Sewage Treatment Plant

The KGP STP is licensed to treat and discharge all sewage generated on site, with a maximum design capacity of 170 m^3/day of treated effluent. Peak volumes correspond to periods of elevated staffing, such as during major maintenance events. Average effluent discharge rates during steady state operations are approximately ~55 m^3/day.

The STP uses membrane bioreactor technology to treat sewage generated on site, and discharges tertiary-treated effluent to the Administration Drain. Discharges occur automatically approximately two to four times per day, once the buffer tanks reach a specified level. The current STP was commissioned in 2018 and is designed to treat effluent to a very high quality. The STP has discharge specifications to meet water quality parameters (**Table 4-2**) as outlined in the KGP Operational Licence issued in accordance with Part V of the EP Act (L5491/1984).

Table 4-2: Current sewage treatment plant discharge specifications

Parameter	Target
pH	6.5 to 8.5
Total Suspended Solids	<50 mg/L
Biological oxygen demand	<20 mg/L
Chemical oxygen demand (COD)	<125 mg/L
Total nitrogen	<10 mg/L
Total phosphorus	<2 mg/L
Total coliforms	<500 CFU/100 mL
Heavy metals	Below detection limit

Source: KGP Operational Licence L5491/1984. Version 18a at the time of MEQMP preparation.

4.3.3 Demineralisation Water Plant

The KGP DWP treats potable scheme water (using reverse osmosis membrane technology) with a maximum design capacity of 600 m^3/day of demineralised water produced for operational use. Depending on the incoming quality of the supplied scheme water, between 10% and 25% of it will be rejected as brine to the Administration Drain. Because the DWP's only input is potable water, the level for potential impact from discharges from this plant is very low. The brine released from the DWP is designed to achieve TDS levels of less than 4,000mg/l in the reject brine.

4.3.4 Stormwater Run-off

In addition to inflows from the STP and DWP, the Administration Drain also receives stormwater from various areas of KGP. This stormwater run-off has the potential to be contaminated with residual oils or chemicals, if it has come from areas where there may be residues of these contaminants.

To minimise the risk of accidental spills being discharged together with rainwater, most of the stormwater drainage network has a system have a series of weirs which aim to separate out any oil and allow cleaner stormwater to underflow. In advance of heavy rainfall (e.g. cyclonic rains), these drains are proactively sampled and emptied, as they may overflow during heavy rainfall events. Any overflow would then typically only contain clean run-off, with any residual contaminants being highly diluted with rainwater. Discharge targets applicable to stormwater are shown in **Table 4-3.**

In addition to the general site stormwater collection system, site run-off collected in the main site stormwater drain (referred to as the Road 14 drain) is isolated under normal flow conditions from the discharge point, which is the administration drain. Water held up in the Road 14 drain must meet the discharge criteria or undergo a risk assessment (per **Table 4-3**) before it can released to the admin drain.

Table 4-3: Current stormwater discharge targets

Parameter	Target
pH	6 to 9
aMDEA	15 mg/L
Total oil	10 mg/L

4.3.5 Administration Drain – Potential Contaminants

The Administration Drain receives wastewater from the STP, DWP, and site run-off. Cause–effect pathways for potential impacts on marine environmental quality are associated with emissions from nutrients/organic matter in discharge from the STP, and concentration of contaminants by the reverse osmosis process and potentially contaminated stormwater.

Samples (at least monthly) of discharges to the Administration Drain are analysed for the presence of 18 contaminants identified in the KGP Part V Operational Licence and the average results of this sampling are shown in **Table 4-4**. Based on these results and the nature of the receiving environment, the following parameters are considered to be those which will govern the toxicity of the discharge:

- bioaccumulating toxicants:
  - cadmium
  - mercury
- non-bioaccumulating toxicants and stressors:
  - ammonia-N
  - copper
  - lead
  - zinc
  - anionic surfactants
  - aMDEA
  - Total Petroleum Hydrocarbons
  - tri-ethylene glycol

- sulphide
- nutrients and organics:
- Total Nitrogen
- Total Phosphorus
- pH
- chemical oxygen demand

Table 4-4: Average concentration of licensed discharge parameters in the Administration Drain

Parameter	Units	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
COD	mg/L	17.9	50.5	24	17.2	18	16.8	11.9	18.1
Conductivity	µS/cm	1807.8	1849.6	2239	1639.3	2380.9	2010.6	1715.9	1485.2
Total Nitrogen	mg/L	11.3	11.4	7.3	5.2	19.2	29	20.4	5.1
Total Phosphorous	mg/L	0.5	0.8	1	1.4	1.4	1.4	0.4	0.6
pH	mg/L	8.6	8.8	8.8	9.1	8.4	8.5	8.7	8.9
Sulphate	mg/L	224.8	226.8	563.3	296.2	492.9	319.5	252.3	220.7
Sulphide	mg/L	0	0	0.2	0	0	0	0.5	0.1
Surfactants	mg/L	45.7	4	19	17.5	7.8	9.5	8.1	1.1
Total Suspended Solids	mg/L	16.7	11.8	33.4	13	12	39.2	18.2	250.3
Turbidity	NTU	3.9	4.7	8.5	4	5.8	7.5	4.7	68.9
aMDEA	mg/L	<LOR	<LOR	<LOR	30.2	7.5	0	<LOR	<LOR
Copper	µg/L	5	4	3	4.3	3.1	2.8	2	9.3
Zinc	µg/L	100	50	80	32.5	71.3	157.3	60.5	852.2
Cadmium	µg/L	0.1	nd	0.1	0.1	nd	nd	0.6	1
Lead	µg/L	9	nd	1	nd	3.8	0.9	2.8	6.3
Mercury	µg/L	nd	nd	nd	0.1	nd	nd	0.1	0.1
Total Oil	mg/L	1.2	8.4	1.3	0.9	0.5	0.5	0.9	0.3
Discharge Volume (annual total)	m^3	13,901	16,870	28,683	40,509	31,131	29,673	23,874	27,984

nd = no data,

4.4 Whole Effluent Toxicity Results

Toxicity of discharges from the KGP to the Jetty Outfall have been sampled on five previous occasions (once in 2006, 3 times in 2010 and once in 2018). Toxicity testing of discharges to the Administration Drain has not been conducted as, being primarily a sewage discharge, the nature of contaminants in this discharge are less complex and well understood.

The whole effluent toxicity (WET) testing, conducted on the Jetty Outfall sample from the KGP sampled on 26 June 2018, included eight toxicity tests incorporating a range of tropical and temperate Australian marine species, which were selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols, and known reproducibility and sensitivity as test species for assessing discharge effluent in marine environments.

The tests included:

- bacterial 5- and 15-minute luminescence using *Vibrio fischeri* (acute, temperate)
- microalgal 72-hour growth rate inhibition using *Nitzschia closterium* (chronic, tropical)
- copepod 7-day early life stage development test with *Gladioferens imparipes* (chronic, temperate)
- sea urchin 72-hour larval development with *Echinometra mathaei* (chronic, tropical/subtropical)
- sea urchin 1-hour fertilisation test with *Heliocidaris tuberculata* (chronic, temperate)
- oyster 48-hour larval development test with *Saccostrea echinata* (chronic, tropical)
- sea anemone 8-day pedal lacerate development with *Aiptasia pulchella* (chronic, tropical)
- fish 7-day larval development using *Seriola lalandi* (chronic, tropical/subtropical/temperate).

Overall, WET testing highlights the variability in the potential discharge toxicity. In 2018, the guideline values derived from the species sensitivity distribution were (PC95) = 1.7% wastewater and (PC99) = 0.36% wastewater] corresponding to safe dilution estimates of 1:59 and 1:280 respectively. In 2010, safe dilution estimates could not be calculated due to a general lack of toxicity in the 3 samples collected. In 2006, the 95% and 99% safe dilutions of KGP wastewater were 1:340 and 1:2,500.

4.5 Dilution Modelling

4.5.1 Jetty Outfall

Typically expected dilution values from discharges to the Jetty Outfall were modelled using a stochastic model (RPC, 2019). For the stochastical analysis, 150 scenarios were undertaken with wind, tide and phase-of-discharge relative to tide selected randomly for each simulation. Measured winds from a nearby meteorological station over a two-year period between 2016 and 2017 were applied.

The model was run for 24 hours and predicted concentrations stored every hour over the whole grid. Concentrations were converted to dilutions and the durations that they exceeded specified levels of dilution (50, 100, 200, 300, 400, 560) were calculated for each grid cell.

For the 150 scenarios, probability of dilutions exceeding the specified dilution levels for one hour or more were calculated. The 5% probability levels were plotted to provide the minimum dilutions achieved for 95% of modelled scenarios (i.e. 5% of worst-case scenarios were excluded from the plots). These are the minimum number of dilutions expected to be achieved under 95% of typical weather conditions. The results of the model are shown in **Figure 4-2**. While the model only shows the results for 95% of weather conditions, onsite management measures are in place to prohibit discharges from occurring during these worst conditions. However, it was not considered valid to remove these scenarios from the ambient conditions randomly selected for the modelling runs. The worst-case conditions occur on days with a high tidal range, but near still winds (less than 2 m/s). These conditions allow the discharge to be quickly carried out of the nearfield mixing zone and beyond the MEPA boundary before adequate dilution can occur.

The modelled dilution at the boundary of the Jetty Outfall low and moderate ecological protection areas was a minimum of 1:100. The modelled dilutions showed dilution sufficient to achieve the 99% species protection value (PC99 = 0.36% wastewater, equivalent to 280 dilutions – See **Section 4.3**) was always achieved within 400m of the discharge point, but generally occur within 300m (**Figure 4-2**). A theoretical circumstance in which toxicity of the discharge was double was also modelled. It showed only minor exceedance of the current MEPA boundary. Refer to Section 5 for a description of the ecological protection zone boundaries (i.e. the LEPA & MEPA).

Field validation of the dilution modelling was completed in November 2021 (**Section 4.5.3**). The validation found that modelling was conservative in estimating dilutions achived from the Jetty Outfall. Modelled dilution values have been been retained as the basis for establishing the EQG values presented in **Table 7-5**.

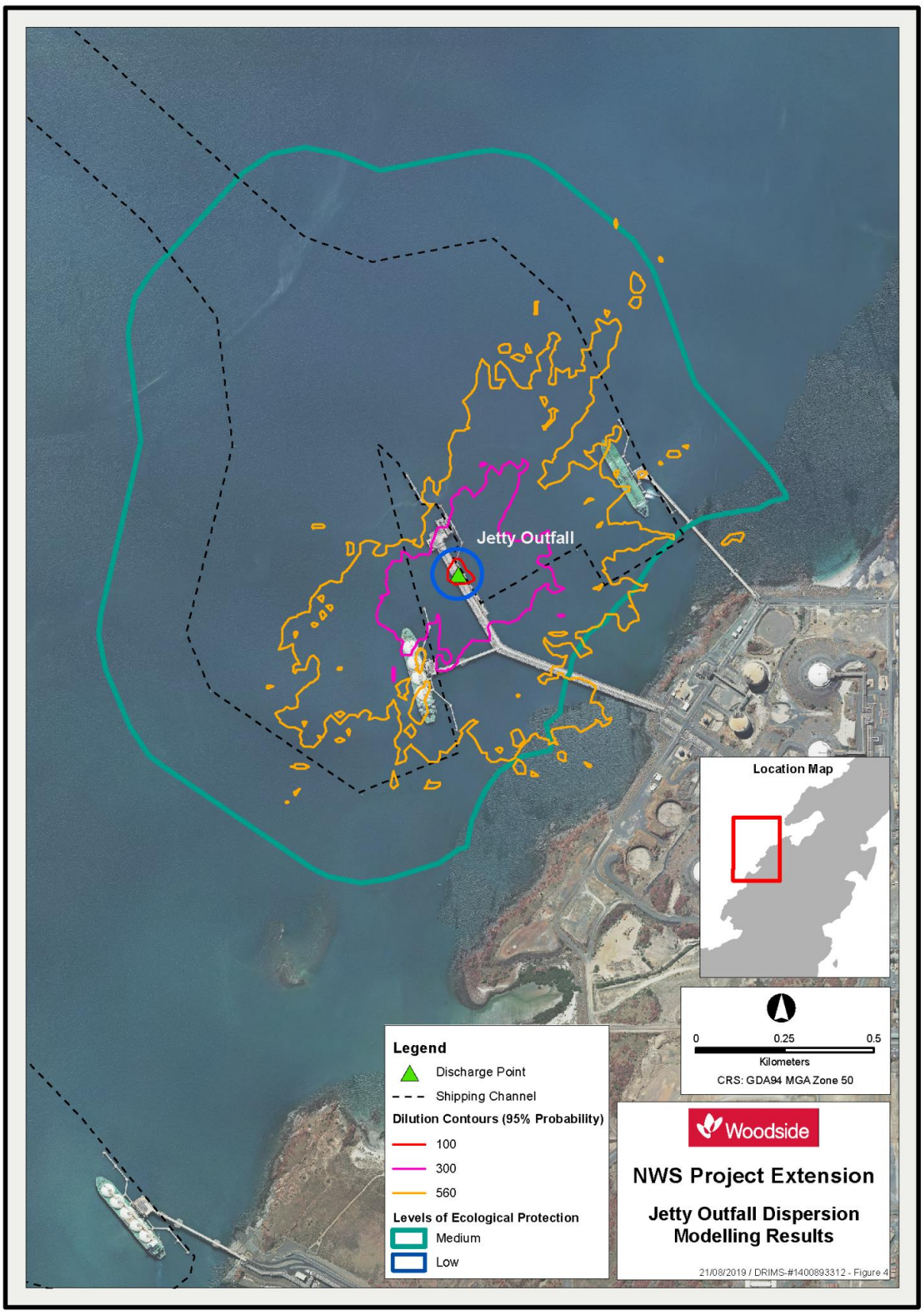

Figure 4-2 Dilution modelling results for the Jetty Outfall (RPC, 2019)

4.5.2 Administration Drain

The Administration Drain discharges into a 300m long unlined channel known as No Name Creek (NNC) which is tidally inundated with each high tide. Water in NNC can only flow into the receiving marine environment, No Name Bay (NNB), via a series 10" culverts that pass the boundary road at the western edge of the Karratha Gas Plant.

When water is flowing into NNC (with the incoming tide) discharges from the Administration Drain are prevented by the inflowing tide from entering the marine environment. It is not until the tide begins to recede that the now diluted wastewater can flow into NNB. At low tide, the tidal flat extends at least 100m from the point where NNC outflows to NNB and approximately 500 m from where the Administration Drain discharges to the ocean (discharge point). The distance between the Administration Drain discharge point and NNB means that there is insufficient water volume to reach the marine environment unless carried with the outgoing tide. It must first mix with the incoming tide, within NNC, for this to occur.

NNC is densely inhabited by mangroves (where there is tidal influence) and a dense reed bed exists between the intertidal region and the concrete-lined Administration Drain. These mangroves and reeds have all naturally re-colonised NNC, which originally existed as an intertidal creek system which was altered as part of the original KGP development.

Refer to **Section 5.1** for a description of the ecological protection zone boundaries (i.e. the MEPA) applicable to the Admin Drain discharge.

Dilution Modelling & Validation

Dilution modelling precited discharges from the Administration Drain would receive approximately 150 to 830 dilutions (including the 12.5 dilutions received in the Inner Channel) when it first enters the Bay (depending on the tidal discharge rate). Thereafter, it is dispersed by tide and wind towards the west. At 70m from the discharge location concentrations range from 0% (dilution not applicable) when the flood tide is flowing into No Name Creek and around 0.08% (1:1,200 dilutions) on the ebb tide when water is leaving No Name Creek and flowing into the Ocean (RPC, 2019). Stochastic modelling was not undertaken for the Administration Drain discharge, as the nature of the receiving environment (into a shallow bay, close to the shoreline) means tidal forcing is the primary factor determining dilution rates. Tidal cycles are predictable and conservative tidal scenario was used to determine the minimum number of expected dilutions at the MEPA boundary. Modeling predicted that a minimum of 150 dilutions are expected to be achieved at the MEPA boundary in all tidal scenarios.

Field validation of the dilution modelling was completed in February 2021 (**Section 4.5.3**). The validation found that modelling over-estimated dilution from NNB when validated during worst case (neap) tides. This is largely due to the complexity of modelling a relatively small yet dynamic marine coastal environment. The dilution validation exercise found that during the most conservative conditions, an average of 14 dilutions (Jacobs 2021) would be achieved at the edge of the 70m LEPA boundary. This conservative dilution figure has been used as the basis for establishing the EQG values presented in **Table 7-5**.

4.5.3 Model Validation

Validation of the model used to determine dilutions of the Jetty Outfall and the Administration Drain was undertaken in 2021 (Jacobs 2021). The Model Validation Program was undertaken using a tracer of which a known quantity was discharged at the two discharge points (replicated twice for each discharge point), and then measured at specified locations the receiving environment to estimate dilutions. The measured dilutions were compared to modelled outputs for consistent ambient conditions. As a result of this validation exercise, it was found that modelled dilutions for the Jetty Outfall were conservative, with actual dilution rates up to four times higher than modelled predictions. For the Admin Drain, it was identified that the model did not accurately predict dilutions, largely due to the small but dynamic receiving environment that the model could not completely resolve. As a result, conservative measured dilutions have been used for the basis of establishing EQGs.

5. Management Framework

5.1 Environment Quality Plan

The EQO 'maintenance of ecosystem integrity' is to maintain a healthy and diverse ecosystem. For this EQO there are potentially four (low, moderate, high, or maximum) Levels of Ecological Protection (LEP) that may be applied, each corresponding to a different target environmental quality condition (**Table 5-1**). This method is seen as a practicable and auditable way of setting an objective for maintenance of ecosystem integrity while allowing for some discharge of waste to the marine environment in certain areas and under strictly controlled conditions.

Table 5-1: Definition of allowable changes to natural background under levels of ecological protection (EPA 2016a)

LEP	Definition
Low	Allows large changes in abundance and biomass of marine life, biodiversity, and rates of ecosystem processes, but only within a confined area.
Moderate	Applied to relatively small areas within inner ports and adjacent to heavy industrial premises where pollution from current and/or historical activities may have compromised a high LEP.
High	Allows for small measurable changes in the quality of water, sediment, and biota, but not to a level that changes ecosystem processes, biodiversity, or abundance and biomass of marine life beyond the limits of natural variation.
Maximum	Activities to be managed so that there were no changes beyond natural variation in ecosystem processes, biodiversity, abundance, and biomass of marine life or in the quality of water, sediment, and biota.

In 2006, the WA Department of Environment (DoE) published *Pilbara Coastal Water Quality Consultation Outcomes Environmental Values and Environmental Quality Objectives*, aimed at establishing an EQMF for the Pilbara region to help manage and protect the marine environment from the effects of waste inputs and pollution (DoE, 2006). Minor updates to this document were made in 2019, not affecting areas around the NWS Project Facilities. DoE (2006) identified EVs and EQOs relevant to Pilbara coastal waters and outlined the process for developing EQC.

The EPA (2016a) has published Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016a) that has established DoE (2006) as the approved 'Environmental Quality Plan' for spatially defining LEP for Pilbara coastal waters. The EQP includes a map showing notional LEPs around key infrastructure in Mermaid Sound, included below in **Figure 5-1**.

The EQP establishes required levels of protection for regions immediately surrounding both KGP Discharge points. This document establishes a Marine Environment Quality Management Plan to ensure requirements of the EQP are consistently and reliably achieved. There are no planned or identified likely deviations from the EQP that were identified as occurring with the implementation of this MEQMP.

The nearest point assigned a maximum LEP is approximately 8 km away from the Jetty Outfall, at the entrance to Flying Foam Passage.

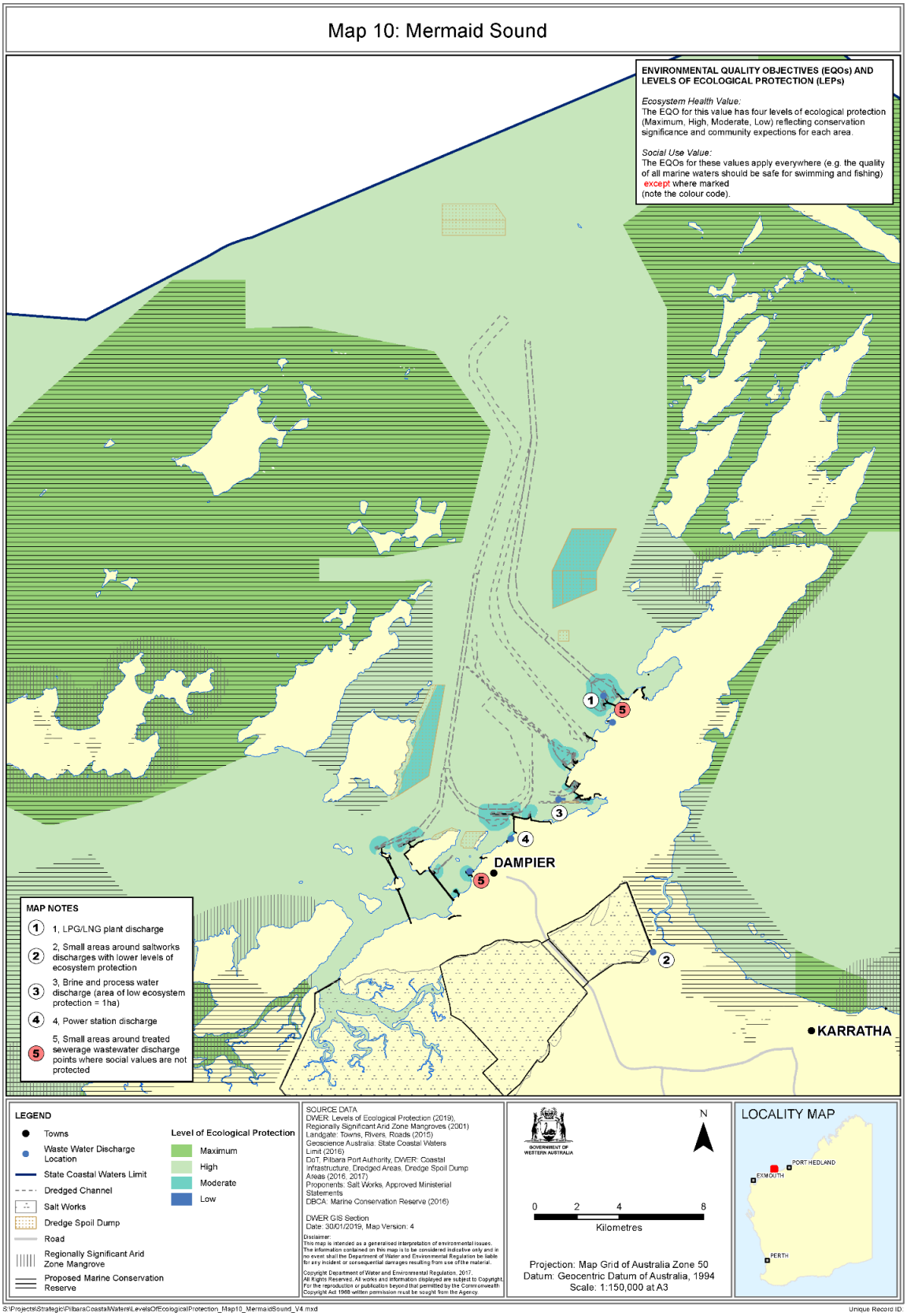

Figure 5-1: Environment Quality Plan for Mermaid Sound, showing infrastructure and established levels of ecological protection (DoE, 2006)

Ecological Protection Areas

Jetty Outfall

Under the existing EQP (**Figure 5-1**), there is a zone of Low Ecological Protection Area (LEPA) (i.e. area in which at least a 'low' level of ecological protection is maintained) extending 70m in all directions from the discharge point. Beyond this, the EQP requires a medium level of ecological protection to be maintained (i.e. a Medium Ecological Protection Area (MEPA)), which extends 250 m beyond the turning basins and berthing pockets surrounding the KGP LNG loading jetty, excluding areas where this is within 200 m of the shoreline. While not a uniform shape, the MEPA extends a minimum of 600m from the jetty outfall. The benthic habitats occurring within both the LEPA and MEPA are all classified as 'silt' (**Figure 5-2**). Despite the MEPA extending out to a minimum distance of 600m from the Jetty Outfall, WET testing results indicate that enough dilution to achieve the specified 99% species protection value (sufficient to achieve a high level of ecological protection) occurs within 400m of the discharge point, well within the MEPA.

Admin Drain

Within this MEQMP, a MEPA is established extending 70 m in all directions from the point where the artificial channel known as "No Name Creek" discharges into "No Name Bay" via a culvert under the site boundary road. This is shown in Figure 5-3 as the outfall to ocean.

Within this MEQMP, Environment Quality Criteria pertaining to discharges from the Admin Drain are set at a level consistent with achieving Moderate Ecological Protection Area (MEPA) for all water entering into No Name Bay. Beyond the 70m MEPA, a high level of ecological protection zone applies. All EQC are consistent with values to achieve a high level of ecological protection by this point. All EQC are measured at the existing 'admin drain' licenced discharge point.

As the Admin Drain discharges into a tidally influenced bay, there are no benthic primary producer habitats present (**Figure 5-3**). There are a strand of mangroves lining the Bay into which the discharge occurs as well as an artificially constructed rock embankment that has been colonised by intertidal organisms typical of the region.

The health of the mangroves is monitored as part of the NWS Project Chemical and Ecological Monitoring of Mermaid Sound (ChEMMS) program. Currently, mangrove health is monitored annually using the Normalised Difference Vegetative Index (NDVI) assessed using images captured from drone imagery. There have been no anthropogenically derived changes to mangrove health in NNB identified through these surveys.

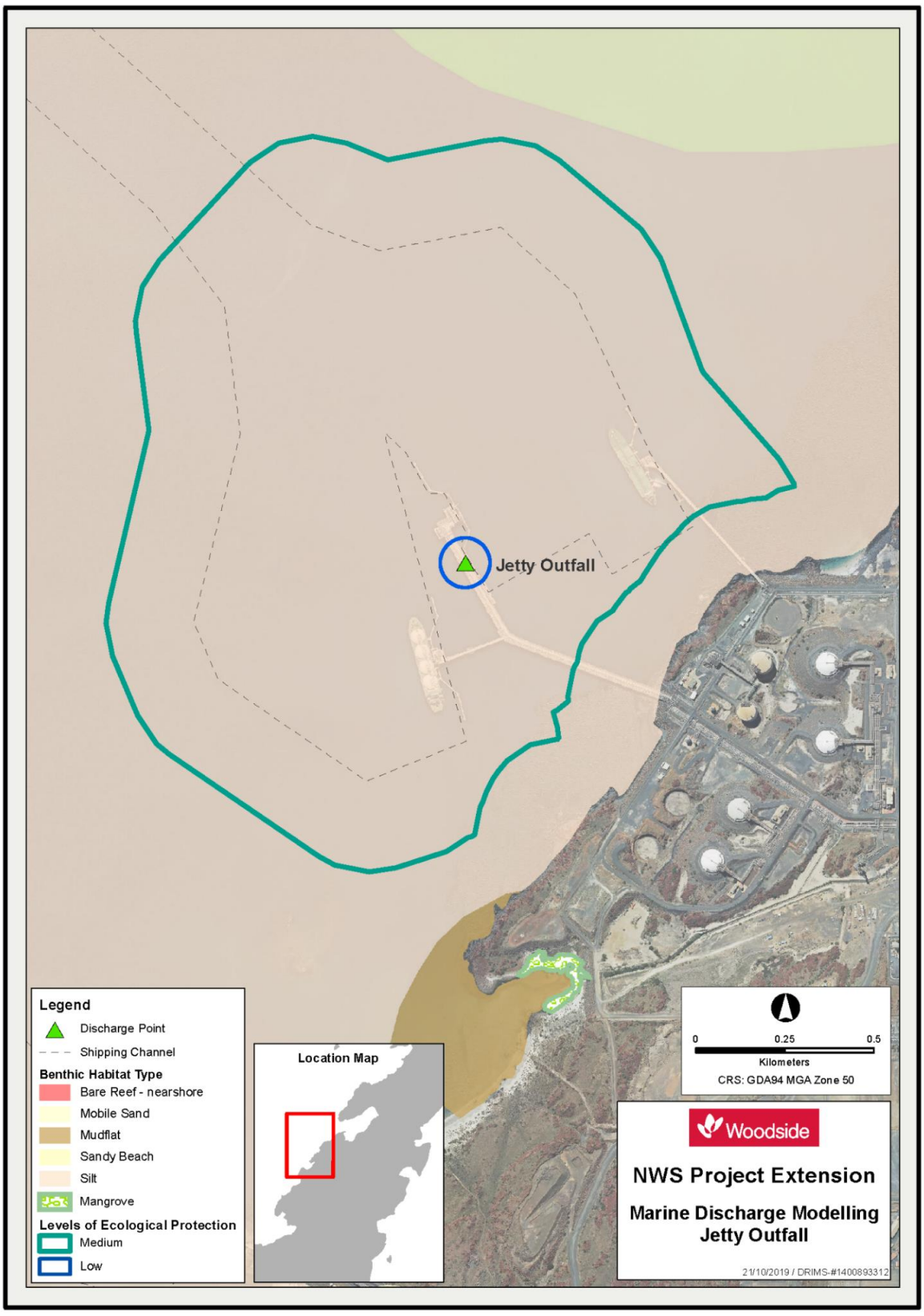

Figure 5-2 Habitat types and ecological protection areas surrounding the KGP Jetty Outfall. Immediately beyond the 'medium' LEPA, a high level of ecological protection applies (See Figure 5-1).

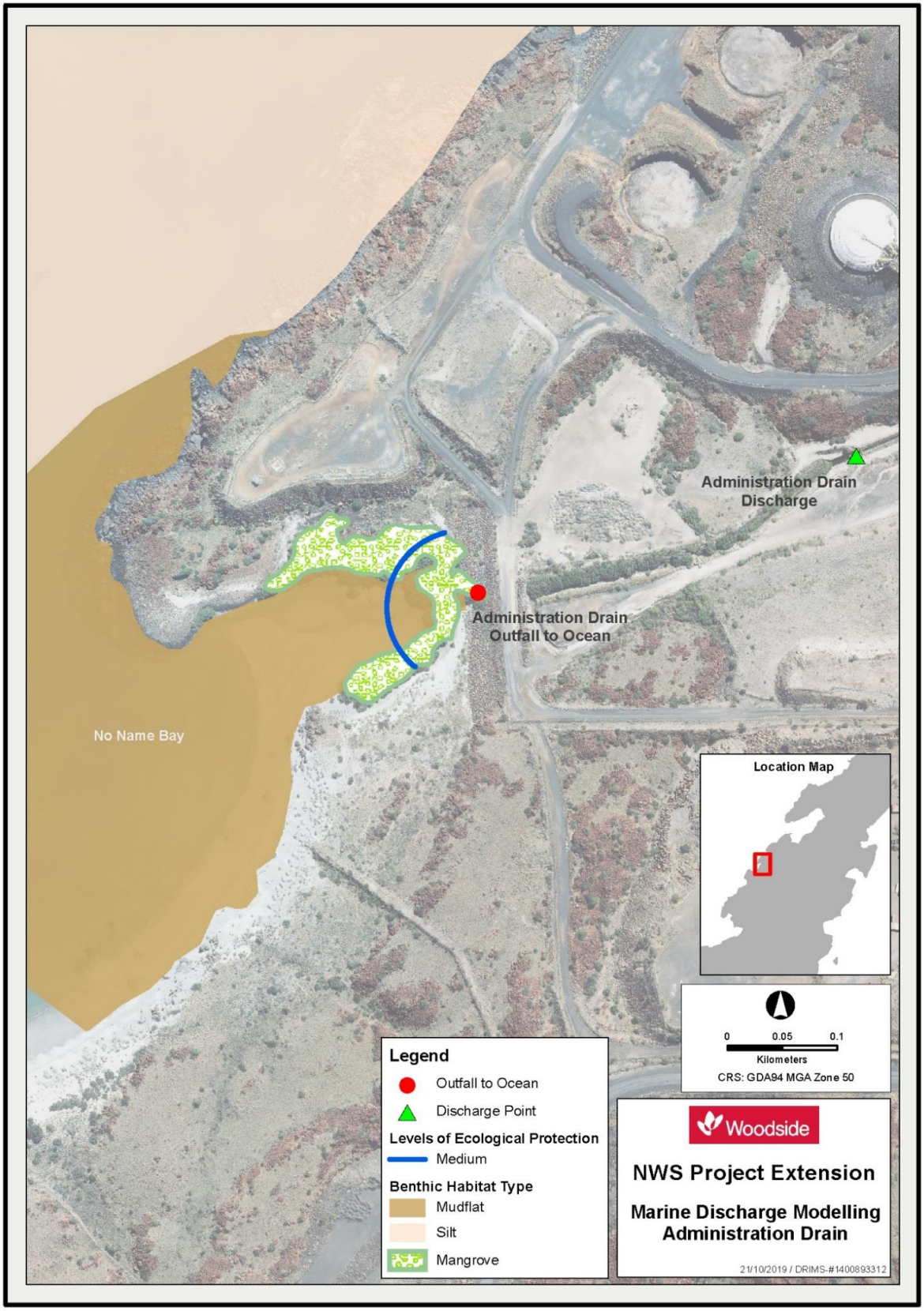

Figure 5-3 Habitat types and ecological protection area surrounding the KGP Administration Drain discharge point. Immediately beyond the 'medium' LEPA, a high level of ecological protection applies (See Figure 5-1).

5.2 Environmental Quality Criteria

Environmental quality criteria (EQC) represent scientifically based limits of acceptable change to a measurable environmental quality indicator that is important for the protection of the associated environmental value. The sources of potential impact to marine environmental quality are outlined in **Section 4.1**.

The EQC provide the benchmarks against which environmental quality is measured. Unlike the EVs and EQOs, which are largely qualitative and described narratively, the EQC are more quantitative and are described numerically. The EQC define the limits of acceptable change to the measured environmental quality indicators. They are not compliance limits. The key to successful marine environmental performance under the EQMF is to maintain environmental quality within the bounds of the EQC. If the EQC are met, then it is assumed that the EQOs are met and EVs are protected

There are two levels of EQC:

- EQGs - These are relatively simple and easy-to-measure triggers that, if met, indicate a high degree of certainty that the associated EQO was achieved. If the EQG is not met, there is uncertainty as to whether the associated EQO was achieved and a more detailed assessment against the EQS is required.
- EQSs - These are numerical values or narrative statements that, if not met, indicate a significant risk that the associated EQO has not been achieved and a management response is required. The management response focuses on identifying the cause (or source) of the exceedance and then reducing the loads of the contaminant of concern.

5.2.1 Environmental Quality Guidelines for discharges from the Jetty Outfall

The Jetty Outfall receives wastewater from the KGP process water and site run-off. Potential cause–effect pathways of impacts on marine environmental quality are associated with emissions from the production of gas and fluids by KGP processes. EQC are centred around identifying and managing contaminants (particularly hydrocarbons) in the wastewater (**Table 5-2**).

Table 5-2: Environment quality guidelines identified as relevant to the Jetty Outfall

Potential Impact	Source of Impact	Environmental Quality Guideline
Bioaccumulation of toxicants in biota	Discharge of bioaccumulating toxicants	95%ile of annual concentrations of bioaccumulating contaminants in the undiluted waste stream will not exceed the ANZG (2018) 80% species protection guideline
Toxic effect of toxicants/stressors on biota	Discharge of non-bioaccumulating toxicants and stressors	95%ile (median for pH) of annual concentrations of contaminants in the waste stream will not exceed specified values
Accumulation of toxicants in sediments	Discharge of toxicants	Sediment total contaminant concentration of specified toxicants immediately beyond the Moderate Ecological Protection Area boundary will not exceed the specified values.

5.2.2 Environmental Quality Guidelines for discharges to No Name Bay from the Administration Drain

The Administration Drain receives wastewater from the STP, DWP, and site run-off. Potential cause–effect pathways of impacts on marine environmental quality are associated with emissions from the production of gas and fluids by the KGP processes, nutrients/organic matter in discharge from the STP, and concentration of salts or solids by the reverse osmosis process. EQC are centred around identifying and managing contaminants (particularly hydrocarbons), nutrients, and organic matter in the wastewater (**Table 5-3**).

Table 5-3: Environment quality guidelines identified as relevant to the Administration Drain

Potential Impact	Source of Impact	Environmental Quality Guideline
Bioaccumulation of toxicants in biota	Discharge of bioaccumulating toxicants	95%ile of annual concentrations of bioaccumulating contaminants in the waste stream will not exceed the ANZG (2018) 80% species protection guideline.
Toxic effect of toxicants/stressors on biota	Discharge of non-bioaccumulating toxicants and stressors	95%ile (median for pH) annual concentrations of contaminants in the waste stream will not exceed specified values.
Accumulation of toxicants in sediments	Discharge of toxicants	Sediment total contaminant concentration immediately beyond the MEPA boundary will not exceed the specified values.
Nutrient enrichment and algal growth	Discharge of nutrients	Median annual nutrient concentrations in the discharge will not exceed the exceed the specified values.
Contamination of seafood	Discharge of bacteria	Thermotolerant coliform concentrations will not exceed the specified values
Risk to primary and secondary contact recreation	Discharge of bacteria	*Enterococci* spp. concentrations will not exceed the specified values

5.3 Rationale for Provisions

Formal management provisions (e.g. EQC) have yet to be established for the Pilbara region (DoE, 2006). In the absence of regionally specific EQC, those described here are based on those in the Environmental Quality Criteria Reference Document for Cockburn Sound (EPA, 2017). The framework adopted for applying EQC to Cockburn Sound is consistent with the approach applied to WA coastal waters generally (EPA, 2016b) and the National Water Quality Management Strategy (ANZG, 2018).

6. Management Provisions

For each environmental indicator monitored, the relevant EQC serve as a benchmark against which the monitoring data can be compared to determine whether the EQO has been achieved. If an EQG is exceeded, assessment against the EQS will commence. If an EQS is exceeded, a management response is required to ensure the EQO continues to be achieved. These responses are specific to maintaining the relevant EQO that is at risk of not being met. The response after triggering EQG/EQS typically requires reporting to the relevant agency (WA Department of Water and Environmental Regulation [DWER]). Responses include further investigations to determine the extent and source of the environmental impact and/or applying management options to reduce the impact.

Table 6-1: Outcomes-based provisions for planned discharges from the Jetty Outfall and Administration Drain to the marine environment

Environment Quality Objective	Monitoring Target	Monitoring	Environment Quality Guidelines	Management Response / Reporting	Environment Quality Standards	Management Response / Reporting
Maintenance of ecosystem integrity	Bioaccumulating toxicants	Monitoring discharges from the Jetty Outfall for dissolved cadmium and mercury	**EQG 1** Annual 95th percentile concentrations of contaminants in the waste stream will not exceed the ANZG (2018) 80% species protection guideline for bioaccumulating toxicants listed in Column 2 of **Table 7-2.**	Report the exceedance to DWER in the Annual Environment Report. Assessment against EQS 1 will then commence.	**EQS 1** Median concentrations of cadmium and mercury in oyster tissue from sites near the boundary of the Moderate Ecological Protection Area are ≤80th percentile of tissue concentrations from a suitable reference site.	Any exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER.
Maintenance of ecosystem integrity	Non-bioaccumulating toxicants and stressors	Monitoring discharges from the Jetty Outfall for toxicants and stressors of concern, as listed in Column 2 of Table 7-6	**EQG 2** Annual 95th percentile concentrations of contaminants in the waste stream will not exceed values listed in Column 2 of **Table 7-6.**	Report the exceedance to the DWER in the Annual Environment Report. Assessment against EQS 2 will then commence.	**EQS 2** The EQS will be exceeded where modelled dilution expected at either the LEPA and MEPA boundaries are lower than the number of dilutions required to achieve 90% and 99% species protection, respectively	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will

					determined through whole effluent toxicity testing.	be discussed with the DWER.
Maintenance of ecosystem integrity	Sediment contamination	Five-yearly monitoring of sediments	**EQG 3** A) Median sediment total contaminant concentration at the HEPA boundaries will not exceed the ANZG (2018) default guideline values (DGVs) as specified in **Section 7.3.2.1** B) Total contaminant concentration at individual sample sites will not exceed the ANZG (2018) high guideline value (GV-high).	Report the exceedance to DWER in the Annual Environment Report. An investigation against EQS 3 will then be conducted, in accordance with the framework developed in the Environmental Quality Criteria Reference Document for Cockburn Sound (EPA, 2017).	**EQS 3** A) The 80th percentile of bioavailable metal or metalloid concentrations in sediments from the defined sampling area will not exceed the ANZG (2018) default guideline values (DGVs) as specified in **Section 7.3.2.1.** B) The median bioavailable concentration for non-metallic contaminants from the defined sampling area will not exceed ANZG (2018) default guideline values (DGVs) as specified in **Section 7.3.2.1**. C) The median tissue concentration of chemicals that can adversely bioaccumulate or biomagnify will not exceed the 80th percentile of tissue concentrations from a suitable reference site	The management response based on an exceedance of the EQS is: Management measures to reduce the contaminant(s) of concern will be implemented, along with monitoring to confirm that the required results are being achieved. The monitoring could include wastewater characterisation, further WET tests, and in situ monitoring, subject to further consultation with the DWER.
Maintenance of ecosystem integrity	Bioaccumulating toxicants	Monitoring of Administration Drain discharges for dissolved cadmium and mercury	**EQG 4** Annual 95th percentile concentrations of contaminants in the waste stream will not exceed the ANZG (2018) 80% species protection guideline	Report the exceedance to the DWER in the Annual Environment Report. Assessment against EQS4 will then commence.	**EQS 4** Median concentrations of metals that may bioaccumulate (cadmium and mercury) in oyster tissue from sites near the boundary of the MEPA are lower than or equal to the 80th percentile of tissue	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any

			for bioaccumulating toxicants, as listed in Column 2 of **Table 7-2.**		concentrations from a suitable reference site.	required investigation/action will be discussed with the DWER.
Maintenance of ecosystem integrity	Non-bioaccumulating toxicants	Monitoring of Administration Drain discharges for toxicants listed in **Table 7-5** or pH	**EQG 5** Annual 95th percentile concentrations of contaminants in the waste stream will not exceed the site-specific triggers as listed in Column 3 of **Table 7-6**	Report the exceedance to the DWER in the Annual Environment Report. Assessment against EQS 5 will then commence.	**EQS 5** The EQS will be exceeded where modelled dilution expected at the LEPA/MEPA boundary are lower than the number of dilutions required to achieve 90% species protection and modelled dilution expected at the MEPA/HEPA boundary are lower than the number of dilutions required to achieve 99% species protection, determined through whole effluent toxicity testing.	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be discussed with the DWER.
Maintenance of ecosystem integrity	Nutrients as stressors	Monitoring of Administration Drain discharges for total nitrogen and phosphorus	**EQG 6** Annual median concentrations in the discharge will not exceed the values specified in **Table 7-11**.	Report the exceedance to the DWER in the Annual Environment Report Assessment against EQS 6 will then commence.	**EQS 6** No increases in sediment organic enrichment (total nitrogen & total phosphorus) that can be attributed to wastewater nutrients beyond the MEPA boundary.	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be discussed with the DWER.
Maintenance of seafood for human consumption	Thermotolerant Coliforms	Monitoring of Administration Drain discharges for	**EQG 7** Annual median thermo-tolerant coliform counts in the discharge will not	Report the exceedance to the DWER in the Annual Environment Report.	**EQS 7** Median thermo-tolerant coliform counts in oyster tissue from sites near the boundary of the MEPA will	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of

		thermotolerant coliforms	exceed the values specified in Table 7-13.	Assessment against EQS7 will then commence.	not exceed 2.3 MPN *E. coli*/g of flesh (wet wt.) in four out of five representative samples. The fifth sample should not exceed 7 MPN *E. coli*/g of flesh (wet wt.).	determining that this has occurred. The significance of the exceedance and any required investigation/action will be discussed with the DWER.
Maintenance of Secondary Contact Recreation	Faecal pathogens	Monitoring of Administration Drain discharges for *Enterococci* spp	**EQG 8** Annual 95th percentile *Enterococci* spp. counts in the discharge will not exceed the values specified in Table 7-15.	Report the exceedance to the DWER in the Annual Environment Report. Assessment against EQS 8 will then commence.	**EQS 8** Annual 95th percentile Enterococci spp. counts in the discharge will not exceed the values specified in Table 7-15.	Any instances of an exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be discussed with the DWER.

7. Monitoring

7.1 Bioaccumulating Toxicants

7.1.1 Timing

Measurement of bioaccumulating toxicants in the Jetty Outfall discharge will be undertaken each time water is discharged to the marine environment (EQG 1).

Measurement of bioaccumulating toxicants in the Administration Drain discharge will be undertaken at least monthly (EQG 4).

7.1.2 Environmental Quality Criteria

EQGs and EQSs have been defined for bioaccumulating toxicants (**Table 7-1**). Only relevant contaminants of concern (as per **Section 4.2.4** and **Section 4.3.5**) are subject to the EQC.

Table 7-1: Environmental Quality Criteria for bioaccumulating toxicants

Environmental Quality Guideline	Environmental Quality Standard
EQG 1 and EQG 4 Annual 95th percentile concentrations of contaminants that may bioaccumulate (cadmium and mercury) in the waste stream will not exceed their ANZG (2018) 80% species protection guideline (Table 7-2).	**EQS 1 and EQS 4** Median concentrations of metals that may bioaccumulate (cadmium and mercury) in oyster tissue from sites near the boundary of the Jetty Outfall MEPA (EQS 1) / Admin Drain MEPA (EQS 4) are lower than or equal to the 80th percentile of tissue concentrations from a suitable reference site.

7.1.2.1 Environmental Quality Guideline

The wastewater characterisation sample used to compare water quality against the EQG will be a sample of wastewater collected prior to discharge (for EQG 1) or of a representative stream during continuous discharge (EQG 4).

Samples will be collected, stored and handled using appropriate techniques. All analyses will be undertaken by NATA-accredited laboratories. All analyses will be undertaken by NATA-accredited laboratories.

Compliance with the EQG will be assessed annually, based on the annual 95th percentile of concentrations compared with the relevant EQG values. However, trends from sampling results will be reviewed quarterly as an early warning indicator of potential exceedances. Any trigger values that are at risk of not being achieved will be identified through this quarterly discharge review process.

This EQG applies to the concentration in contaminants within the waste streams only when discharged to the environment but prior to dilution occurring (i.e. end of pipe concentrations).

Table 7-2: 80% species protection guideline for bioaccumulating toxicants of concern (ANZG 2018)

Parameter	EQG[1] (mg/L)
Cadmium	0.036
Mercury	0.0014

Note 1 – Value for protection of 80% of species started in ANZG 2018

7.1.2.2 Environmental Quality Standard

Oysters will be investigated for contamination if wastewater characterisation indicates that the concentrations of bioaccumulating contaminants exceed ANZG (2018) 80% species protection guidelines prior to dilution (i.e. EQG 1 and EQG 4). Oysters have routinely been collected in No Name Bay as part of Woodside's ChEMMS program and have been sufficiently abundant to serve as a reliable EQS. However, in the event that there are insufficient oysters an alternative filter feeder (for example barnacles) will be identified and sampled.

Naturally occurring shellfish will be collected in situ, from sites as close to the relevant management boundaries as practicable. The numbers of individuals collected at each site will depend on availability but will be enough to account for variability between individuals. A random selection of live adult shellfish of the relevant species will be collected from the nearest suitable surface (e.g. rock ledges, wharf pylons, channel markers) to each sampling site. The animals will be bagged and stored on ice/frozen before being transported to the laboratory. Appropriate handling practices will be used to minimise the risk of contamination.

Although the risk of fishing and aquaculture has been assessed as negligible, the risk of bioaccumulating toxicants to marine ecosystem health will be assessed by comparing the median tissue concentration of cadmium or mercury should not exceed the 80th percentile of tissue concentrations from a suitable reference site.

7.2 Non-bioaccumulating Toxicants

7.2.1 Timing

Measurement of non-bioaccumulating toxicants in the Jetty Outfall will be undertaken each time water is discharged to the marine environment (EQG 2).

Measurement of non-bioaccumulating toxicants in the Administration Drain will be undertaken at least monthly (EQG 5).

7.2.2 Environmental Quality Criteria

EQGs and EQSs have been defined for toxicants (**Table 7-3**).

Table 7-3: Environmental quality criteria for non-bioaccumulating toxicants

Environmental Quality Guidelines	Environmental Quality Standards
EQG 2 and EQG 5 Annual 95th percentile concentrations of bioavailable contaminants in the waste stream will not exceed the site-specific triggers listed in Table 7-6. These are derived from the ANZG (2018) 90/99% species protection guidelines or internally derived limits where guidelines are unavailable, corrected for dilution after discharge and accounting for background levels.	**EQS 2 and EQS 5** The EQS will be exceeded where modelled dilution expected at either the LEPA and/or MEPA boundary are lower than the number of dilutions required to achieve 90 and 99% species protection (as relevant), determined through whole effluent toxicity testing.

Annual median pH will fall within the range of the site-specific triggers listed in Table 7-6.	

7.2.2.1 Environmental Quality Guideline

Sampling protocol

The wastewater characterisation sample will be a representative sample of wastewater collected prior to discharge (for EQG 2) and of a representative stream during continuous discharge (EQG 5).

Samples will be collected, stored and handled using appropriate techniques. All analyses will be undertaken by NATA-accredited laboratories. Samples for bioavailable metals will be passed through a 0.45 µm filter before analysis.

Derivation of EQG values

Where possible the EQGs are based on the default ANZG (2018) marine guidelines for maintaining the associated level of ecological protection, scaled to account for dilutions achieved at the edge of the management zone boundary (the number of dilutions were determined by modelling), as per a modified formula in Zaker et al. (2001) (which also factors in background concentrations):

$$Trigger\ value = \left(Dilution\ x\ (guideline - background)\right) + background$$

where 'background' is the background concentration of the contaminant in seawater and 'dilution' is the modelled dilution at the relevant ecological protection boundary. **Section 4.5** of this MEQMP describes the dilution modelling that was conducted for wastewater discharges.

EQG for maintaining both a high and moderate level of ecological protection (99 and 90% species protection levels, respectively) were calculated for the Jetty Outfall (**Table 7-4**) and high level of ecological protection for the Administration Drain (**Table 7-5**). The most conservative (i.e. lowest) was selected as the site-specific trigger value, with a listed of compiled triggers for each discharge point shown in **Table 7-6**.

For contaminants where no ANZG (2018) trigger is available, long-term internal criteria were adopted. For all internally derived triggers, EQG values ensure that, after dilution, values at the edge of the MEPA are at or near laboratory limits of detection. These internal working targets have been in place for a considerable time, with no evidence observed of associated adverse environmental effects.

The area immediately (i.e. within 70 m) around the Jetty Outfall has been afforded a low level of ecological protection (DoE, 2006). The Jetty Outfall low ecological protection area is contained within a broader moderate ecological protection area surrounding the shipping infrastructure. The Administration Drain moderate ecological protection area is within a surrounding high level of ecological protection area.

Table 7-4: Published environmental guideline values and derived EQG values for non-bioaccumulating toxicants relevant to Jetty Outfall discharges

Parameter	Guideline Value (µg/L)[1]	Background (µg/L)	Derived EQG (µg/L)	Derived EQG (mg/L)
Moderate Protection (ANZG 90% species protection value)				
Ammonia-N	1,200	9.8[1]	119,030	119
Copper	3	0.165[2]	284	0.28
Lead	6.6	0.01[2]	659	0.66
Zinc	23	0.14[2]	2,286	2.3
High Protection (ANZG 99% species protection value)				
Ammonia-N	500	9.8[1]	137,266	137
Copper	0.3	0.165[2]	38	0.38
Lead	2.2	0.01[2]	613	0.61
Zinc	7	0.14[2]	1,921	1.9

Note 1: Sourced from Pearce et al (2003)

Note 2: Sourced from Table 15 of Wenziker et al (2006)

Table 7-5: Published environmental guideline values and derived EQG values for non-bioaccumulating toxicants relevant to Admin Drain discharges

Parameter	Guideline Value (µg/L)[1]	Background (µg/L)	Derived EQG (µg/L)	Derived EQG (mg/L)
Moderate Protection (ANZG 90% species protection value)				
Ammonia-N	1,200	9.82[1]	14,292	14
Copper	3	0.165[2]	34	0.03
Lead	6.6	0.013[2]	79	0.08
Zinc	23	0.14[2]	274	0.3
High Protection (ANZG 99% species protection value)				
Ammonia-N	500	9.8[1]	7,000	7
Copper	0.3	0.165[2]	2.05	0.002
Lead	2.2	0.01[2]	30.7	0.03
Zinc	7	0.14[2]	95.0	0.1

Note 1: Sourced from Pearce et al (2003)

Note 2: Sourced from Table 15 of Wenziker et al (2006)

Table 7-6: Site specific (compiled) triggers for toxicants in Jetty Outfall and Admin Drain discharge

Parameter	Jetty Outfall EQG triggers (mg/L)	Admin Drain EQG triggers (mg/L)
Non-bioaccumulating toxicants with trigger values derived from ANZG (2018)[1]		
Ammonia-N	119	7
Copper	0.28	0.002
Lead	0.61	0.03
Zinc	1.9	0.1
Non-bioaccumulating toxicants with internally determined trigger values[2]		
Anionic surfactants	150	150
aMDEA	15	15
Total petroleum hydrocarbons	10	10
Tri-ethylene glycol	100	100
Sulphide	1	1
Stressors		
pH	6 to 9	6 to 9
COD	600	350

Note 1: Derived using methodology described in **Section 7.2.2.1**

Note 2: See below section on *Internally derived trigger values* and Appendix A for an explanation as to the suitability of these limits.

Compliance against the EQG will be assessed annually. However, sampling results are reviewed quarterly and trends compared to guideline values as an early warning indicator of potential exceedances. Any trigger values that are exceeded can be identified through this quarterly discharge review process.

Internally derived trigger values

Where approved guideline values were not available in published literature, the trigger values currently in place at KGP within internal procedures were utilised (see Appendix A for justification of limits for key contaminants). The requirement to derived appropriate discharge limits is required by internal procedures and has been utilised to manage discharges from these two licenced discharge points for many years. In the case of the Jetty Outfall discharges, internally derived trigger values are complimented by the completion of three yearly whole effluent toxicity testing to determine a 99% species protection value that considers the acute and chronic toxicity of the waste stream. The results of this WET testing are reviewed against modelled dilution values to confirm that the relevant MEPA/HEPA boundaries continue to be achieved (see section 4.4). These results are supported by the results of the ChEMMS program which continue to demonstrate impacts from these discharges are aligned to the relevant ecological protection target levels. The ChEMMS program includes monitoring of contaminant concentrations (e.g. metals, hydrocarbons) in sediments, oysters and mud whelks on an annual basis. In 2017 and 2018 there were no exceedances of any sediment toxicant criteria (ANZECC/ARMCANZ 2000; CofA 2009) or FANZ (2009) criteria in oyster/mud whelks at any sites associated with the jetty outfall or administration drain discharges (Advisian 2018; 2019).

In relation to the Admin Drain, these parameters are not expected to be present in the discharge but EQG values have been set consistent with the Jetty Outfall.

7.2.2.2 Environmental Quality Standard

WET testing is a direct indicator of toxicity and involves exposing organisms to dilutions of wastewater and determining its impact on their health, growth or reproduction over a selected period. The full suite of WET testing measures the responses of several biota (from a number of trophic levels) to a range of salt-adjusted wastewater solutions. The number and type of tests will be determined at the time and will include at least five species from at least four taxonomic groups. Previous WET testing results and associated methods are described in Jacobs 2018. Data generated are used to calculate the toxicity of wastewater required to protect 90 - 99% of species and this will be done using the BurrliOZ 2.0 software or equivalent relevant statistical package.

The sample used to conduct WET testing will be a grab sample of wastewater collected prior to discharge.

Dilutions required to be protective of the environment are expected to be lower than modelled dilutions at the relevant management zone boundary - these are 1:100 at the boundary of the Jetty Outfall LEPA/MEPA and a minimum of 1:500 at the MEPA/HEPA boundary, however detailed modelling results should be consulted when interpreting compliance with the Jetty Outfall EQC. A minimum dilution of 1:14 is achieved at the boundary of the Administration Drain MEPA/HEPA. Dilutions achieved within the No Name Creek channel are approximately 12.5, between the licenced discharge point and entry into the No Name Bay MEPA.

7.3 Sediments

7.3.1 Timing

Sediments at the boundary of the Jetty Outfall MEPA and Administration Drain MEPA will be sampled every five years. Sediment sampling will also be conducted in the year following an exceedance of EQG 1 or EQG 4.

7.3.2 Environmental Quality Criteria

An EQG and EQS have been defined for toxicants in sediment (**Table 7-7**).

Table 7-7: Environmental Quality Criteria for sediments

Environmental Quality Guidelines	Environmental Quality Standards
EQG 3 A) Median sediment total contaminant concentration at the HEPA boundaries will not exceed the ANZG (2018) DGVs as specified in **Section 7.3.2.1** B) Total contaminant concentration at individual sample sites will not exceed the ANZG (2018) GV-high. If so, repeat sampling will be conducted to define the extent of the contamination, which will be assessed as in point A.	**EQS 3** Depending on the contaminant exceeding the EQG, either of the following EQS may apply; A) The 80th percentile of bioavailable metal or metalloid concentrations from the defined sampling area should not exceed the EQG. B) The median bioavailable concentration for non-metallic contaminants from the defined sampling area should not exceed the EQG. C) The median tissue concentration of chemicals that can adversely bioaccumulate or biomagnify will not exceed the 80th percentile of tissue concentrations from a suitable reference site.

7.3.2.1 Environmental Quality Guideline

Sediment contaminant concentrations in areas beyond the Jetty Outfall MEPA or Administration Drain MEPA will be compared directly to the DGVs listed in ANZG (2018). The use of these values as EQGs is consistent with the DEC (2006) recommendations. The concentrations of total petroleum hydrocarbons (TPH) will be normalised to 1% total organic carbon (TOC) before comparison with the

guidelines. For TOC contents of <0.2% or >10%, multiplication factors of 5 and 0.1 will be used for normalisation, respectively.

If an individual site exceeds the GV-high trigger for contaminants in sediments, additional sampling will be conducted to define the spatial extent of the contamination; this sampling will be assessed against the DGV. Where applicable, only bioavailable concentrations of contaminants will be compared to guideline values.

Table 7-8: Environmental Quality Guideline values for sediments (ANZG, 2018)

Potential Contaminant	DGV (mg/kg dry weight)	GV-high (mg/kg dry weight)
Cadmium	1.5	10.0
Chromium	80	370
Copper	65	270
Lead	50	220
Zinc	200	410
Mercury	0.15	1.0
Zinc	200	410
TPH	280	550
PAH	4000	4500

There are currently no formally recognised screening levels for PFOA, PFOS or PFAS in any media for use in Australia. As an interim measure, DER have recommended screening values in the Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) (DWER, 2017). These are shown in the table below and will be used to assess impacts from fire fighting foam in sediments. These substances are not routinely used on site and would only be discharged in emergency circumstances

Table 7-9: Interim screening values to be utilised for sediment EQG relating to PFOS/PFOA (DWER 2017)

Potential Contaminant	Guideline Value[1]
PFOA	40 mg/kg
PFOS / PFHxS	100 mg/kg

Note 1: Values for soil have been assumed relevant, in the absence of authorised sediment guideline values.

7.3.2.2 Environmental Quality Standard

An investigation against the EQSs will be conducted in accordance with the framework developed in the Environmental Quality Criteria Reference Document for Cockburn Sound (EPA, 2017). These EQSs are adapted from the risk-based approach recommended in ANZG (2000), which is:

- if the contaminant of concern is a metal or metalloid, adopt EQS 3A.
- if the contaminant of concern is an organometallic or organic contaminant, adopt EQS 3B.
- if the contaminant of concern has the potential to bioaccumulate, adopt EQS 3C.

7.4 Nutrients

7.4.1 Timing

Wastewater characterisation for nutrients in discharges from the Administration Drain will be undertaken at least monthly.

7.4.1.1 Environmental Quality Criteria

An EQG and EQS have been defined for nutrients (**Table 7-10**). These EQC only apply to discharge from the Administration Drain.

Table 7-10: Environmental Quality Criteria for nutrients in discharges from the Admin Drain

Environmental Quality Guidelines	Environmental Quality Standards
EQG 6 Annual median concentrations in the discharge will not exceed the values specified in Table 7-11.	**EQS 6** No increases in sediment organic enrichment (total nitrogen & total phosphorus) that can be attributed to wastewater nutrients beyond the MEPA boundary.

7.4.1.2 Environmental Quality Guideline

The wastewater characterisation sample will be a grab sample of water collected from the Administration Drain discharge stream during continuous discharge using appropriate collection techniques. All analyses will be undertaken by NATA-accredited laboratories. The EQGs for nutrients are summarised in **Table 7-11**. Annual median percentile nutrient concentrations will be compared to these values.

Table 7-11: Wastewater discharge guideline values for nutrients in discharges from the Admin Drain

Parameter	EQG trigger values (mg/L)
Total phosphorus	5
Total nitrogen	30

7.4.1.3 Environmental Quality Standard

The EQS is based on an assessment of sediment chlorophyll a concentrations to identify potential enrichment. Median concentrations of sediment chlorophyll a at sites immediately beyond the MEPA will be compared to 80th percentile values in unimpacted reference areas. This is consistent with the methodology applied in EPA (2017), as relevant to high ecological protection areas which is the classification of region immediately beyond the Admin Drain MEPA.

7.5 Seafood Safe for Human Consumption (Fishing and Aquaculture)

7.5.1 Timing

Measurement of thermotolerant coliforms in the Sewage Treatment Plant discharge will be undertaken monthly (EQG7).

7.5.2 Environmental Quality Criteria

EQGs and EQSs have been defined for thermotolerant coliforms (Table 7-12).

Table 7-12: Environmental quality criteria for thermotolerant coliforms

Environmental Quality Guidelines	Environmental Quality Standards
EQG 7 Annual median thermo-tolerant coliform counts in the discharge will not exceed the values specified in Table 7-13. These are derived from the EPA (2018) corrected for dilution after discharge.	**EQS 7** The EQS will be exceeded where annual median thermo-tolerant coliform counts in the discharge exceed the values specified in Table 7-13.

7.5.2.1 Environmental Quality Guideline

Sampling protocol

The wastewater characterisation sample will be a of a representative stream collected from the sewage treatment plant, final discharge sampling point (EQG 7).

Samples will be collected, stored and handled using appropriate techniques. All analyses will be undertaken by NATA-accredited laboratories.

Derivation of EQG values

The EQG and EQS is based on the EPA (2017) guidelines for maintaining seafood for human consumption, scaled to account for dilutions achieved at the edge of the MEPA (the number of dilutions were determined by modelling), as per a modified formula in Zaker et al. (2001) (which also factors in background concentrations):

$$Trigger\ value = \left(Dilution\ x\ (guideline - background)\right) + background$$

where 'background' is the background concentration of the contaminant in seawater and 'dilution' is the modelled dilution at the relevant ecological protection boundary.

Section 4.5 describes the dilution modelling that was conducted for wastewater discharges. The modelled dilution at the edge of the Administration Drain low ecological protection area were modelled to be a minimum of 1:150.

Table 7-13: EQG and EQS values for Thermotolerant Coliforms in the Administrative Drain discharge

Parameter	Guideline Value (MPN/100 mL)	Background (MPN/100 mL)	Derived EQG/EQS (MPN/100 mL)
EQG			
Thermotolerant coliforms	14	0	2,100
EQS			
Thermotolerant coliforms	70	0	10,500

7.5.2.2 Environmental Quality Standard

Median thermotolerant coliform concentrations will be compared to the EQS trigger in Table 7-13.

Oysters will be investigated for contamination if wastewater characterisation indicates that the concentrations of thermotolerant coliforms exceed the EQG in Table 7-13.

Naturally occurring shellfish will be collected in situ, from sites as close to the relevant management boundaries as practicable. The numbers of individuals collected at each site will depend on availability but will be enough to account for variability between individuals. A random selection of live adult

shellfish of the relevant species will be collected from the nearest suitable surface (e.g. rocks) to each sampling site. The animals will be bagged and stored on ice/frozen before being transported to the laboratory. Appropriate handling practices will be used to minimise the risk of contamination.

Although seafood is not permitted to be collected and consumed by the public from within the MEPA, as it is within the KGP maritime exclusion zone, the risk to seafood for human consumption will be assessed by via the EQS (median thermo-tolerant coliform counts in oyster tissue from sites near the boundary of the MEPA not to exceed 2.3 MPN *E. coli*/g of flesh (wet wt.) in four out of five representative samples, and the fifth sample should not exceed 7 MPN *E. coli*/g of flesh (wet wt.), with a maximum total plate count of 250,000 organisms/g.

7.6 Secondary Contact Recreation

7.6.1 Timing

Measurement of *Enterococci* spp. in water discharged from the sewage treatment plan to the administration drain (as measured in the final holding tank) will be undertaken at least monthly (EQG 8).

7.6.2 Environmental Quality Criteria

EQGs and EQSs have been defined for *Enterococci* spp. (Table 7-14).

Table 7-14: Environmental quality criteria for *Enterococci* spp.

Environmental Quality Guidelines	Environmental Quality Standards
EQG 8 Annual 95th percentile *Enterococci* spp. in the discharge will not exceed the values specified in Table 7-15. These are derived from the EPA (2018) corrected for dilution after discharge.	**EQS 8** No increases in *enterococci* spp counts beyond the EQS values in Table 7-15, that can be attributed to wastewater discharges, beyond the MEPA boundary.

7.6.2.1 Environmental Quality Guideline

Sampling protocol

The wastewater characterisation sample will be a of a representative stream during continuous discharge (EQG 7).

Samples will be collected, stored and handled using appropriate techniques. All analyses will be undertaken by NATA-accredited laboratories.

Derivation of EQG values

The EQG and EQS is based on the EPA (2017) guidelines for maintaining primary and secondary contact recreation, scaled to account for dilutions achieved at the edge of the MEPA (the number of dilutions were determined by modelling), as per a modified formula in Zaker et al. (2001) (which also factors in background concentrations):

$$Trigger\ value = \left(Dilution\ x\ (guideline - background)\right) + background$$

where 'background' is the background concentration of the contaminant in seawater and 'dilution' is the modelled dilution at the relevant ecological protection boundary.

Section 4.5 describes the dilution modelling that was conducted for wastewater discharges. The modelled dilution at the edge of the Administration Drain low ecological protection area were modelled to be a minimum of 1:150.

Table 7-15: EQG and EQS values for *Enterococci* spp in the Administrative Drain discharge

Parameter	Guideline Value (CFU/100 mL)	Background (CFU/100 mL)	Derived EQG/EQS (CFU/100 mL)
EQG			
Enterococci spp (secondary contact recreation)	2,000	0	300,000
EQS			
Enterococci spp (secondary contact recreation)	5,000	0	750,000

7.6.2.2 Environmental Quality Standard

The 95th percentile *Enterococci* spp. concentrations will be compared to the EQS triggers in Table 7-15.

8. Adaptive Management and Review of the EMP

8.1 Adaptive Management

Recognising that the nature of the discharge, the environment, and the science underpinning environmental impact assessment is not static, adaptive management also allows monitoring programs to feed back into the management processes so that environmental management continues to be fit-for-purpose. The EQMF that underpins this MEQMP is inherently an adaptive management framework.

In line with the concept of adaptive management, the management actions presented in this MEQMP shall be monitored, reviewed, evaluated and updated, as required, considering:

- Persistent exceedances, systematic changes to the discharge/environmental conditions, and/or changes to the science underpinning the monitoring and management of marine discharges
- There are material updates to the scientific literature supporting the guideline values or management framework underpinning this MEQMP
- A comparison of monitoring data that shows unexpected results, which vary significantly from previous and baseline results or predictions
- The results of annual chemical characterisation or trienniel WET testing (See Section 8.2.2) that indicate changes that warrant remodelling of the mixing zone, which could result in a change to the existing LEP established in the marine environment adjacent to the KGP
- The results of annual chemical characterisation testing detect contaminants in the waste stream at levels where guideline values may be exceeded if discharged, specifically reviewing the concentrations of BTEX and PAH in the waste stream.

With relevant updates included in a revised MEQMP. In addition, this MEQMP may be reviewed:

- Changes in State or Commonwealth legislation or policy.
- Based on EPA and decision-making authorities (DMAs) comments during the Environmental Review Document (ERD) approval process
- After any new or revised operating licence is issued under Part V of the Environmental Protection Act 1986 (WA)
- If the model validation program determines dilutions achieved from discharges are less than predicted
- If a significant environmental incident occurs related to the protection of ambient air quality and human health
- If a new process or activity is proposed to be introduced that has the potential to alter the emissions from the Proposal (and that is not in accordance with this MEQMP)

Technical review and evaluation of the management actions outlined in this MEQMP will be conducted every five years[1] (if not initiated prior to that time) to ensure the management actions are adequately addressing the key risks and meeting EPA objectives. If, as a result of any review, any significant changes are required to be made to this MEQMP, a revised MEQMP will be provided to the EPA for approval.

When the five-yearly review cycle is triggered, or if a significant change to either the facility, activity, or risk is identified, a revised MEQMP will be submitted to the EPA. When approved, the revised plan will be made publicly available.

[1] Frequency no more than annually.

A key significant change will be a significant modification of feed gas source. Should a new feed gas source be processed by plant, the adaptive management testing program (Section 8.2) will be utilised to confirm compliance with the EQP and that management measures in the MEQMP remain suitable for maintenance of specific environment quality objectives.

8.2 Adaptive Management Testing Program

To complement and inform the adaptive management measures, and to ensure the environment management framework remains robust, a periodic testing regime will be implemented to conduct a detailed review of discharge wastewater quality, composition and toxicity.

8.2.1 Annual Wastewater Characterisation

To ensure that there are no new or unexpected contaminants of concern within marine discharges, Woodside will undertake full suite chemical characterisation on the KGP Jetty Outfall discharge stream annually. This is an extensive assessment of the levels of all possible or probably contaminants within a discharge stream. The full suite chemical characterisation will be performed in line with the requirements of Table 8-1.

If changes to discharge characteristics, such as new contaminants, or elevated contaminant levels are identified, the MEQMP may be reviewed to include this contaminant in the routine discharge monitoring program. This may be supported by additional investigative testing before MEQMP updates are made, to confirm results were not anomalies.

Table 8-1: Chemical Characterisation Analytes for Jetty Outfall Discharge Stream

Analyte	Method	Limit of detection (or limit of reporting)
Ammonia (total)	NW_D8	0.005 mg/L
	Merck Test Kit with modifications by CSIRO	0.03 mg N/L
Enterococci	AS 4276.9 (PM 4.4)	1CFU/100ml
Sulphide	NW_D16	0.05mg/L
Metals[2] (total and dissolved)	C-209 (ICP-MS)	0.01-1 µg/L
Metals[2] (total and dissolved)	C-229 (ICP-AES)	200 µg/L for Ca and Mg
Mercury (Total)	C-220 (AFS)	0.0003 µg/L
Organic carbon (total and dissolved)	NW_S15	0.5 mg/L
Biological oxygen demand (BOD)	NW_S2	4 mg/L
Total dissolved solids (TDS)	NW_B10A	1 mg/L
Total suspended solids (TSS)	NW-S13 2 mg/L	2 mg/L
BTEX	NGCMS_1121	1-2 µg/L
TPH	NGCMS_1121 and _1122	0.05-0.1 mg/L
TRHS (NEPM)	NGCMS_1121 and _1122	0.05-0.1 mg/L
PAHs	NGCMS_1111	0.5 – 10 µg/L
Phenols	NGCMS_1111	0.01-0.01 m/L
Organic acids (volatile fatty acids)	NGCMS_1131	5 mg/L

Microtox	N/A	N/A

8.2.2 Tri-ennual WET Testing

To support assessments of safe dilution levels for individual contaminants, this plan requires the determination of WET of discharges from the jetty outfall. This is due to potential for complex, cumulative effects from multiple contaminants requiring minimum safe dilution levels beyond that of any individual contaminant.

A requirement of this plan is that WET testing will be completed on a sample of treated wastewater from the jetty outfall at least every 3 years, or within 12 months of receiving a new source of third-party gas that comprises a change equivalent to at least 20% of overall production throughput.

However, a full suite of WET testing on the admin drain discharge is considered unnecessary on a periodic basis or in response to feed gas changes for the following reasons:

- Comprised of discharges of treated sewage, brine reject or stormwater runoff, which are less complex and well understood;
- the composition and toxicity of this wastewater is not affected by changes to the composition of feed gas.

Upon completion of WET testing, the results of these tests are combined into 'safe' dilution estimates for the protection of each of the levels of ecosystem protection specified in the EQP, using the methods for deriving water quality guideline values based on species sensitivity distributions (SSDs) (Warne et al. 2018). The specific whole of effluent (WET) tests undertaken will be dictated by the species available at the time and should be selected based on the advice of the laboratory and/or suitable subject matter expert. The minimum data requirements for using a SSD is at least five species that belong to at least four taxonomic groups. However, using toxicity data from at least eight species will be done where possible. Tests should incorporate a range of tropical and temperate Australian marine species, selected based on their ecological relevance (known sensitivity to contaminants, availability of robust test protocols, known reproducibility and sensitivity as test species). Warne et al. (2018) provides classification of toxicity tests as acute or chronic toxicity. Chronic toxicity tests are preferred. Tests that rely on a biochemical endpoints (i.e. bacterial bioluminescence) can be employed as indicator species but should not be included in the toxicity assessment unless their ecological relevance has been demonstrated. To maximise the likelihood that a suitable dilution series will be employed, it should be selected in collaboration with the laboratory and/or suitable subject matter expert, informed by the previous studies on this and/or similar waste streams.

9. Stakeholder Consultation

Comprehensive public consultation was undertaken by the DoE to develop EVs, EQOs, and LEPs for the greater Pilbara coast, including the waters of Mermaid Sound (DoE, 2006). This process resulted in a robust and publicly approved basis for establishing an interim Environmental Quality Plan (EVs, EQOs, and LEPs) for the waters of Mermaid Sound surrounding the NWS infrastructure. The EQP remains a key guideline for managing potential impacts to the marine environment in Northern WA and has been identified as the EPA as being the formal EQP for management of the marine environment in this region.

This MEQMP is included as an Appendix to the NWS Extension ERD (Woodside, 2019) and therefore is reviewed by the EPA, key decision-making authorities (DMAs), and the general public as part of the assessment process for the ERD. Relevant comments received from the EPA and DMAs during the initial review are incorporated into this MEQMP before publication of the ERD (and associated management plans) for public review and comment. All comments received during the public review period that relate to this MEQMP are considered, and changes made to this MEQMP where required.

Woodside has undertaken a number of engagement activities with Traditional Owner groups on the NWS Extension ERD including presentations to the Ngarluma Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong-Goo-Tt-Oo representatives, the Ngarluma Yindjibarndi Foundation Ltd and the Murujuga Aboriginal Corporation. These presentations have provided an overview of the project as a whole, outlined major themes of the ERD (including Greenhouse Gas, marine discharges, restrictions to heritage areas, emissions impacts on rock art, emissions impacts on human health, hydrocarbon spills), and invited questions to address any community concerns. Woodside is continuing to consult with Traditional Owners on potential impacts of cultural and spiritual significance to local Indigenous peoples.

The proposal anticipates indirect impacts to marine flora and fauna may result from planned discharges, maintenance dredging and shipping, unplanned discharges from offshore or onshore accidents or emergencies, and the presence and potential migration of onshore contamination.

- Impacts from these activities are summarised in Section 6.6.4.1 of the ERD as follows;
- No impacts to Benthic Primary Producer Habitats (e.g. corals and seagrass) are predicted as a result of ongoing planned discharges into Mermaid Sound from the Proposal
- Annual monitoring programs have shown historical and ongoing discharges from the Administration Drain have not been linked to any impact on Mangrove habitats
- Any potential for toxicity to marine organisms would be expected to be limited to surface waters within the described zones of impact (LEPA/MEPA) assigned to each discharge, and therefore these concentrations will only potentially affect a limited number of marine fauna species and individuals (e.g. cetaceans, turtles and pelagic fish) which are transient through the region, including those with heritage value
- If marine fauna are transient within the receiving environment adjacent to the discharge location, they are unlikely to be exposed to sufficient concentrations or for a sufficient duration to elicit a toxic response. Behavioural responses, such as avoidance, may be exhibited by mobile organisms.
- Cetaceans are highly unlikely to be present in the vicinity of discharge locations and therefore unlikely to be impacted

Woodside has identified the cultural and spiritual environmental value to is protected through the MEQMP. As per EPA guidance (EPA, 2016a), in the absence of any specific environmental quality requirements for protection of ‘Cultural and Spiritual’ values, it is assumed that if water quality is managed to protect ecosystem integrity, then this may go some way towards maintaining cultural values. Therefore, no Environmental Quality Guidelines (EQGs) were identified specifically for protecting cultural and spiritual values.

10. References

Advisian 2018. Chemical and Ecological Monitoring of Mermaid Sound - 2017 Compliance Report. Report prepared for Woodside Energy Limited by Advisian Pty Ltd. Report 401012-02487-REP001, January 2018

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11. Terms

Terms	Definitions
~	Approximately
<	Less/fewer than
>	Greater/more than
≤	Less than or equal to
µg	Microgram
µm	Micrometre
µS	micro Siemens
1TL, 2TL	Subsea trunklines
aMDEA	Activated methyl diethanolamine
ANZECC	Agriculture and Resource Management Council of Australia and New Zealand
ARMCANZ	Australian and New Zealand Environment and Conservation Council
CFU	Colony-forming unit; used to estimate the number of viable bacteria or fungal cells in a sample
cm	Centimetre
COD	Chemical oxygen demand
DGV	Default Guideline Value
DMA	Decision-making Authority
DoE	Former Western Australian Department of Environment
Domgas	Domestic Gas
DWER	Western Australian Department of Water and Environmental Regulation
DWP	Demineralisation Water Plant
EC_{10}	A concentration or dose that yields biological effects in 10% of test animals/species
EC_{50}	A concentration or dose that yields biological effects in 50% of test animals/species
EMP	Environmental Management Plan
EP	Environmental Plan
EP Act	Western Australia *Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guidelines
EQS	Environmental Quality Standard
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
ERD	Environmental Review Document
EV	Environmental Value
GV-high	Guideline Value (high)

HEPA	High Ecological Protection Area
KBSB	King Bay Supply Base
kg	Kilogram
KGP	Karratha Gas Plant
L	Litre
LEP	Level of Ecological Protection
LEPA	Low Ecological Protection Area
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
m	Metre
m3	Cubic metres
MEPA	Moderate Ecological Protection Area
MEQMP	Marine Environmental Quality Management Plan
mg	Milligram
mL	Millilitre
NATA	National Association of Testing Authorities
NTU	Nephelometric Turbidity Unit
NWS	North West Shelf
NWS Project	The North West Shelf (NWS) Project is one of the world's largest liquefied natural gas producers, supplying oil and gas to Australian and international markets from offshore gas, oil, and condensate fields in the Carnarvon Basin off the north-west coast of Australia. The NWS Project is owned by the NWSJV participants and since the 1980s, it has been Western Australia's largest producer of domestic gas. The NWS Project currently processes resources owned by the NWSJV and CNOOC NWS Private Limited and is proposed to also process third-party gas and fluids as part of the NWS Project Extension Proposal.
NWSJV	North West Shelf Joint Venture. A joint venture comprising six companies; Woodside Energy Ltd. (Operator), BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, and Shell Australia Pty Ltd. The North West Shelf Joint Venture owns the infrastructure used as part of the North West Shelf Project and, together with CNOOC NWS Private Limited, the North West Shelf Joint Venture owns the resources processed as part of the NWS Project.
OC	Organic Content
OCW	Oil-contaminated Water
PC	Protection Concentration; e.g. PC99 is 99% protection concentration, PC95 is 95% protection concentration etc.
pH	Measure of acidity or basicity in a solution
Proposal	NWS Project Extension Proposal. The Proposal as described in the NWS Project Extension Section 38 Referral Supporting Information (Woodside, 2018) to continue to use the Existing NWS Project facilities for the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities; and ongoing operation of the NWS Project to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070.
State Waters EP	North West Shelf Trunklines State Waters Operations Environment Plan

STP	Sewage Treatment Plant
TL	Trunkline
TOC	Total Organic Carbon
TWW	Treated waste water
WA	Western Australia
WET	Whole Effluent Testing
Woodside	Woodside Energy Ltd

APPENDIX A – Suitability of internally derived limits

For contaminants where no ANZG (2018) trigger is available, long-term internal criteria were adopted as the basis for determining EQG listed in Table 7-6. Internally derived triggers have been in place for managing marine discharges from the Karratha Gas Plant for many years, with no evidence of determinantal environmental effects. Further justification as to the suitability of internally derived limits for key contaminants is included below.

For all remaining internally derived triggers, EQG values ensure that, after dilution, values at the edge of the MEPA are at predicted to be at or near laboratory limits of detection or approaching background levels.

Chemical oxygen demand (COD)

There is no ANZG (2018) or EPA (2017) guideline for chemical oxygen demand (COD) but there is a guideline related to oxygen consumption (≥90% saturation). The Streeter-Phelps oxygen sag equations can be used to model the oxygen depletion generated by wastewater with distance away from the outlet. The model is based on biological oxygen demand (BOD). The ratio between COD and BOD is variable (depending on the extent of treatment) and there is no standard conversion. However, BOD is lower than COD because more organic compounds are chemically oxidised than biologically oxidised. As such, considering COD as equivalent to DOD represents and extremely conservative approach.

A revised trigger of 350 mg/L continues to maintain DO well above 90% saturation for the Administration Drain discharge (Figure A-1) and a revised trigger of 600 mg/L continues to maintain DO well above 90% saturation for the Administration Drain discharge (Figure A-2).

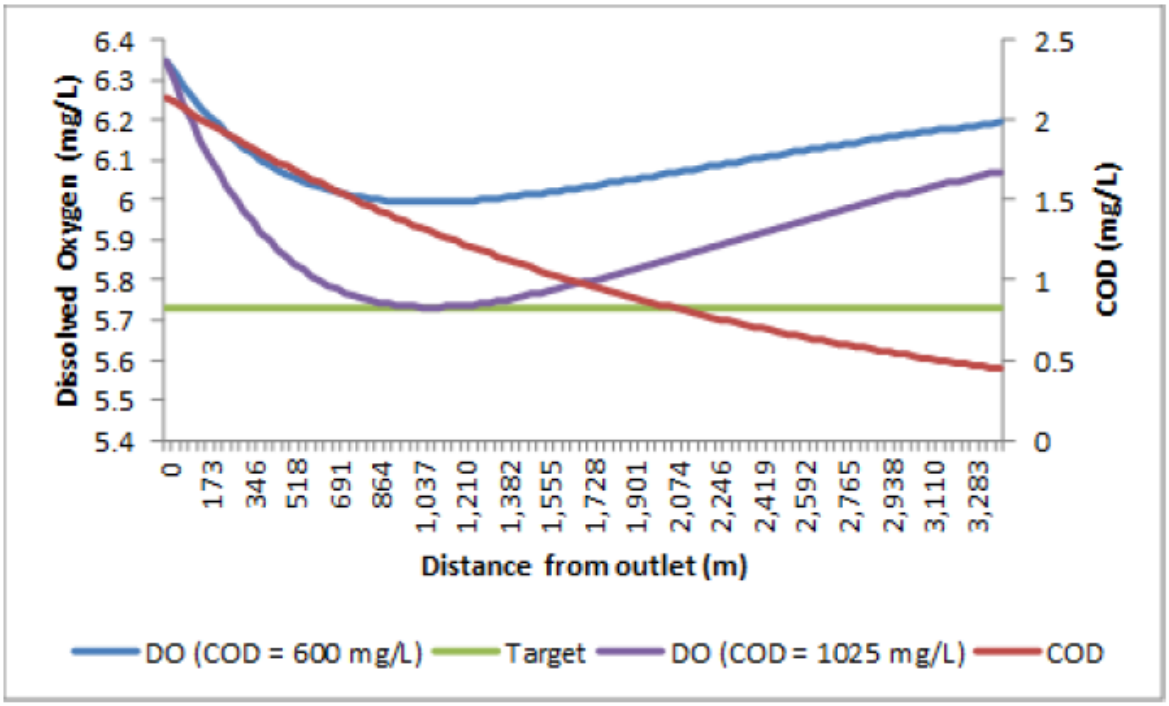

Figure A-1 Streeter-Phelps equations for the Jetty Outfall

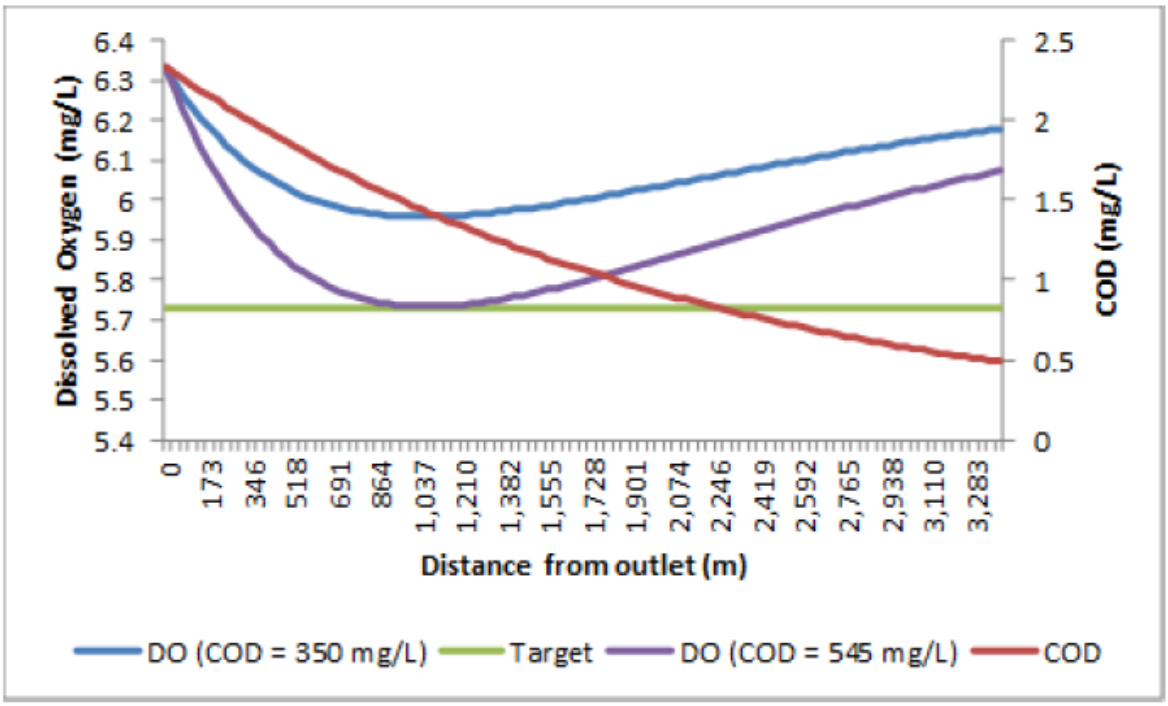

Figure A-2 Streeter-Phelps equations for the Administration drain

pH

The proposed acceptable pH range of 6 to 9 is based on longstanding internal targets and details below further justify this range as acceptable and conservative in relation to achieving the specified environment quality outcomes specified in the EQP.

Background wastewater seawater inorganic carbon concentrations were calculated assuming a pH of 8.2 and alkalinity 2.33 meq/L (estimates typical of seawater) using the CO2SYS model (Lewis & Wallace 1998). Wastewater seawater inorganic carbon concentrations were calculated for the maximum and minimum pH triggers assuming an alkalinity of 1.00 meq/L. The pH after mixing was determined using the CO2SYS model (Lewis & Wallace 1998). The pH after a 1:150-fold dilution with background seawater was 8.19 for treated wastewater discharged at the lower pH limit and 8.20 for wastewater discharged at the upper pH limit (Table A-1). This modelling suggests that pH after mixing equivalent to that occurring at the jetty outfall LEPA boundary is likely indistinguishable from baseline (i.e. ≤0.01 pH unit) (Table A-1).

Table A-1 Final pH after dilution

Guideline (µg/L)	Treated wastewater	Background		Dilution	After Dilution		
	Alkalinity (meq/L)	Alkalinity (meq/L)	pH		Alkalinity (meq/L)	Inorganic carbon (mmol/kg)	pH
6	1.0	2.33	8.2	1:150	2.27	1.82	8.19
9	1.0	2.33	8.2	1:150	2.27	1.81	8.2

Nutrients

Average discharge to the admin drain is approximately 55 m^3/day. At this rate, the total nitrogen and phosphorus triggers would represent a maximum daily total nitrogen load to the marine environment of just 1.65 kg/day and a total phosphorus load of 0.28 kg/day (Table A-2). It is likely that the

assimilative capacity (i.e. sustainable levels of uptake by biota combined with dilution) of the receiving environment is entirely adequate to cope with discharge at these low TN loads without any measurable change in local marine ecosystem health measures. Point source discharges to the marine environment from WWTPs rely on this assimilative capacity to sustainably discharge TWW. Elsewhere in Western Australia, WWTPs are typically licensed to discharge TN loads on the scale of tonnes per day (t day-1) (Table A-3) and subsequent monitoring suggests that these much higher nitrogen loads do not overwhelm the assimilative capacity of the surrounding environment (PLOOM 1996–2019; BMT 2019abc and references therein).

Table A-2 Potential nutrient loads

Parameter	Guideline (mg/L)	Discharge volume (L/day)	Load (mg/day)	Load (kg/day)
Total P	5	55000	275000	0.28
Total N	30	55000	1650000	1.65

Table A-3 Licensed TN loadings at WWTP outlets in WA

Source	Licence number	Licensed TN load
Beenyup WWTP	L7882/1991/13	3.6 t day^{-1}
Subiaco WWTP	L4726/1991/13	1.2 t day^{-1}
SDOOL	L4201/1991/10 and MS665	4.9 t day^{-1}
Alkimos WWTP	L8434/2010/1	2.4 t day^{-1}