Wheatstone Project

Permanent Onshore Facilities Waste Water Discharge Plan

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ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

aMDEA	Activated Methyldiethanolamine
ANSIA	Ashburton North Strategic Industrial Area
ANZECC	Australia and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BWRO	Brackish Water Reverse Osmosis
°C	Degrees Celsius
CAR	Compliance Assessment Report
CEO	Chief Executive Officer (of the Office of the Environmental Protection Authority)
Chevron Australia	Chevron Australia Pty Ltd
CIP	Clean In Place
CFU	Colony Forming Unit
Commissioning	Is taken to mean wet commissioning of all plant, facilities or associated infrastructure resulting in discharges via the permanent outfall outlined in this plan.
CORMIX	Software model used for modelling of near-field dilution
CV	Construction Village
CV WWTP	Construction Village Waste Water Treatment Plant
DO	Dissolved Oxygen
DOHWA	Department of Health, Western Australia
DOTEE	Department of the Environment and Energy (Commonwealth)
Domgas	Domestic gas
DWER	Department of Water and Environmental Regulation (WA)
EC_{50}	Concentration that produces 50% of the maximum possible effect, derived from regression analysis of toxicity data.
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
EDI	Electrodeionisation
EP	Equivalent Person
EP Act	*Environmental Protection Act 1986 (WA)*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC 2008/4469	The Commonwealth Primary Environmental Approval and conditional requirements for the Wheatstone Project. Commonwealth Government of Australia, Minister for Sustainability, Environment, Water, Populations and Communities, Hon. Tony Burke, 22 September 2011, with variations to EPBC 2008/4469 Conditions 44, 45, 55, 56 and 66 made pursuant to section 143 of the EPBC Act, as amended from time to time.
EQC	Environmental Quality Criteria
EQMF	Environmental Quality Management Framework

EQO	Environmental Quality Objectives
EQVR	Effluent Quality Validation Report
EQVRP	Effluent Quality Validation and Reporting Plan
EVs	Environmental Values
GTC	Gas Turbine Compressor
GTG	Gas Turbine Generators
IAH	Inlet Air Humidification
IC_{50}	50% Inhibitory concentration derived similarly to the EC_{50} values
kL	kilolitre
Km	kilometre(s)
LEP	Level of Ecological Protection
LNG	Liquefied Natural Gas
LNG PTF	LNG Plant Site Primary Treatment Facilities
LNG WWTP	LNG Plant Site Waste Water Treatment Plant
LOR	Limits of reporting. Minimum concentration of a residue used for reporting purposes
M	Metre(s)
mm	Millimetre(s)
m^3	Cubic Metre(s)
m^3/hr	Cubic Metre(s) Per Hour
MDMP	Marine Discharge Management Plan
MIKE3	Software model used for modelling of far-field dilution
MIKE21 NHD	Model system originally established for the EIS
MS 873	Ministerial Statement No. 873: The State (WA) Primary Environmental Approval, and conditional requirements for the Wheatstone Project. Government of Western Australia, Minister for the Environment; Water, Hon. Bill Marmion MLA, 30 August 2011 as amended by MS 903, MS 922, MS 931 and Attachments 1 to 4 and amended from time to time.
MSL	Mean Sea Level
MTPA	Million Tonnes Per Annum
NATA	National Association of Testing Authorities
Nearshore	Marine habitat from the 20 m contour to the shoreline
NOEC	No Observed Effect Concentration
Ntot	Total Nitrogen
NTU	Nephelometric Turbidity Unit
O&G TSE	Oil & Grease, Total Solvent Extractable
OEPA	Office of the Environmental Protection Authority
Offshore	Marine habitat beyond the 20 m contour to the shoreline
(The) Plan	Permanent Onshore Facilities Waste Water Discharge Plan

Project	The Wheatstone Project as assessed and approved under MS 873 and EPBC 2008/4469.
Practicable	Means reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge (*taken from the EP Act)*
Proponent	Chevron Australia Pty Ltd
Ptot	Total Phosphorous
RO	Reverse Osmosis
SWRO	Seawater Reverse Osmosis
TDS	Total Dissolved Solids
TEG	Triethylene Glycol
TRH	Total Recoverable Hydrocarbons
TTM	Total Toxicity of a Mixture
TIAH	Turbine Inlet Air Humidification
Typical conditions	Represents the seasonal facility operating scenarios when the various waste water treatment and discharge facilities (the seawater intake, WWTPs, seawater desalination system, primary treatment system, and waste water outfall) are jointly operating within their design limits as outlined in this Plan. Typical conditions do not include the commissioning period of any facility or the scenario(s) when one or more waste water treatment facilities are out of service or major disruptions such as cyclonic events or incidents (e.g. spills).
UF	Ultrafiltration
UMF	Upflow Media Filtration
µg/L	Microgram(s) Per Litre
WA	Western Australia
WET	Whole Effluent Toxicity
Wet Commissioning	Initial operation and testing that verifies the works and all relevant systems, plant, machinery and equipment have been installed and are capable of performing, to the maximum extent possible, in accordance with the design specification set out in the works approval application.
WWTP	Waste Water Treatment Plant

1.0 BACKGROUND

1.1 Project Overview

Chevron Australia Pty Ltd (Chevron Australia) will construct and operate a multi-train Liquefied Natural Gas (LNG) facility and domestic gas (Domgas) plant near Onslow on the Pilbara Coast, Western Australia. The Wheatstone Project (the Project) will process gas from various offshore fields in the West Carnarvon Basin. Ashburton North Strategic Industrial Area (ANSIA) is the approved site for the LNG and Domgas plants.

The Project requires installation of gas gathering, export and processing facilities in Commonwealth and State waters and on land. The initial Project will produce gas from Production Licences WA-46-L, WA-47-L and WA-48-L, 145 km offshore from the mainland, approximately 100 km north of Barrow Island and 225 km north of Onslow, and will also process gas from Production Licence WA-49-L operated by Woodside Petroleum Limited. Figure 1.1 shows the location of the Project.

The ANSIA site is located approximately 12 km south-west of Onslow along the Pilbara coast within the Shire of Ashburton. The initial Project will consist of two LNG processing trains, each with a capacity of approximately 4.45 million tonnes per annum (MTPA). Environmental approval was granted for a 25 MTPA plant to allow for the expected further expansions. The Domgas plant will be a separate but co-located facility and will form part of the Project. The Domgas plant will tie-in to the existing Dampier-to-Bunbury Natural Gas Pipeline infrastructure via third party DBP Development Group Pty Ltd Domgas pipeline.

1.2 Proponent

Chevron Australia is the proponent and the person taking action for the Project on behalf of its current joint venture participants Kuwait Foreign Petroleum Exploration Company, Woodside Petroleum Limited, and Kyushu Electric Power Company, together with PE Wheatstone Pty Ltd (part owned by JERA).

1.3 Environmental Approvals

The Project was assessed through an Environmental Impact Statement / Environmental Review and Management Program (EIS/ERMP) assessment process under the WA *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project was approved by the WA Minister for Environment on 30 August 2011 by way of Ministerial Statement No. 873 (MS 873) and as amended by Ministerial Statement No. 903, Ministerial Statement No. 922, Ministerial Statement No. 931 and Attachments 1 to 4. The Commonwealth Minister for Sustainability, Environment, Water, Population and Communities approved the Project on 22 September 2011 (EPBC 2008/4469) with variations to EPBC 2008/4469 Conditions 44, 45, 55, 56 66 and 71 made pursuant to section 143 of the EPBC Act. Other amendments may be made from time to time and if so will be reflected in the next revision of this Plan.

The requirements of the State and Commonwealth Ministerial Conditions, and reference to the relevant sections within this Plan are provided in Table 1.1 and Table 1.2 respectively. The implementation of matters required only to meet the requirements of MS 873 are not the subject of EPBC 2008/4469. Similarly, the implementation of matters required only to meet the requirements of EPBC 2008/4469 are not the subject of MS 873.

Table 1.1: Requirements of WA Ministerial Statement No. 873 Relevant to this Plan

No.	Condition	Section
13-11	Prior to submitting an application for a works approval to the Department of Water and Environmental Regulation (DWER) for any discharge from the onshore facilities, the Proponent shall submit a report to the DWER that:	This Plan
13-11 i.	spatially maps the areas where each Environmental Quality Objective (EQO) and Level of Ecological Protection (LEP) is to be achieved;	Figure 3.2
13-11 ii.	identifies the environmental quality criteria, for constituents of the discharge considered relevant by the DWER, that should be achieved to maintain the EQOs and LEPs established through Condition 13-1;	3.0
13-11 iii.	predicts the toxicity of the final discharge under typical conditions;	4.6
13-11 iv.	predicts the number of dilutions necessary to meet the required EQOs and LEPs. For example, a moderate LEP at the boundary of a Low and Moderate ecological protection area and a high LEP at the boundary of a Moderate and High ecological protection area, or to meet a high LEP at the boundary of a Low and High ecological protection area [predictions are based on achieving Environmental Quality Criteria (EQC) and effluent toxicity]; and	4.4
13-11 v.	presents contingency options for additional treatment or extending the diffuser to achieve greater dilutions if required.	5.2
13-12	Prior to submitting an application for a works approval to the DWER for any discharge from the onshore facilities, the Proponent shall develop an Effluent Quality Validation and Reporting Plan (EQVRP) in consultation with the DWER that addresses the following issues:	6.0
13-12 i.	Whole Effluent Toxicity (WET) Testing program for determining: a. the actual toxicity of any discharge post commissioning and post operation of the outfall and following any significant change in effluent composition; and b. the number of dilutions required to achieve each relevant level of ecological protection, testing is to be undertaken on a minimum of five locally relevant species from four different taxonomic groups using the recommended protocols from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000).	6.2.4 6.0
13-12 ii.	characterisation of any waste water discharge under typical operational conditions and after any significant changes in effluent composition;	6.0, 6.3
13-12 iii.	a revised set of EQC based on the contaminants of concern identified from Condition 13-12(ii);	6.2.5

No.	Condition	Section
13-12 vi.	given the results from Conditions 13-12(i) (ii) and (iii), the number of dilutions required to achieve the EQOs and LEPs identified in Condition 13-1 and described in Schedule 2; and	6.2.5
13-12 v.	reporting to the DWER within six months of commissioning of a discharge or within six months of any significant change in composition of a discharge, including any management actions necessary to ensure ongoing compliance with the EQOs and LEPs established through Condition 13-1 and described in Schedule 2.	7.1
13-15	In the event that the monitoring required by conditions 13-12 and 13-14 or through the discharge licences issued under Part V of the *Environmental Protection Act 1986* indicates that EQOs and LEPs established through conditions 13-1 and 13-9, and described in Schedule 2, are not being met, or are not likely to be met, the Proponent shall report the findings to the CEO and the DWER as soon as practicable, but within five working days, along with a description of the management actions to be taken to meet the required level of environmental quality.	7.1

Table 1.2: Requirements of Commonwealth Ministerial Conditions: EPBC 2008/4469 Relevant to this Plan

No.	Condition	Section
44.	The person taking the action must submit to the Minister the following reports and plans, as component parts of the Marine Discharge Management Program (MDMP) for discharges to marine and riverine habitats [(1)]: a. An Onshore facilities waste water discharge report and an Onshore Effluent Quality Validation and Reporting Plan (Onshore EQVRP). The Onshore EQVRP must include: (1) water quality targets based on the ANZECC Water Quality Guidelines (2000), (2) monitoring programs, (3) trigger levels, (4) management and corrective actions.	(1) 3.2 (2) 6.0 (3) 5.1 (4) 5.2
46.	The MDMP[(1)] may be developed in stages to address relevant construction, commissioning and operational activities. Each report and plan under the MDMP must be submitted to the Minister at least 2 months prior to the commencement of the relevant construction, commissioning and operational activities, unless otherwise approved in writing by the Minister. Construction, commissioning and operational activities for facilities which have a material marine discharge must not commence until the relevant report and/or plan required under the MDMP has been approved. The approved MDMP must be implemented.	This Plan 6.4

Note:

(1) The Plan is to be included into the collaborative of all discharge Environmental Management Plans prepared for the Wheatstone Project. Together, these Plans form the MDMP.

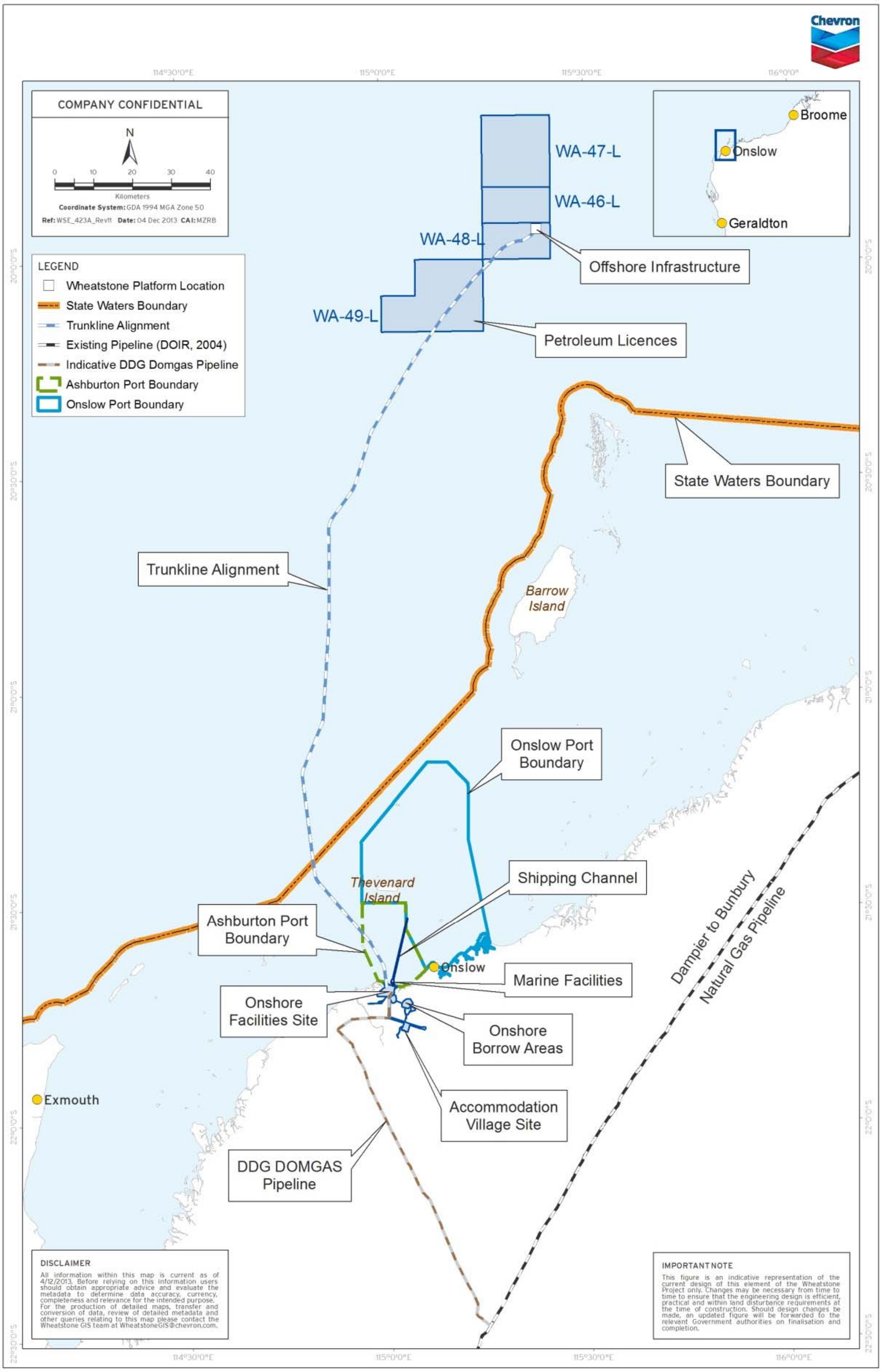


Figure 1.1: Location of the Project Infrastructure

1.4 Scope

The scope of the Plan is relevant to the commissioning and operation of the permanent onshore facilities waste water outfall of the Project. The facilities and treatment processes relevant to the expected discharges via this outfall are described in Sections 1.0 and 2.0 respectively. The location of the permanent onshore facilities waste water outfall (refer Figure 1.2) has been approved by the WA Minister for Environment under Conditions 13-2 through 13-4 of MS 873.

The potential impacts associated with the commissioning and operation of the construction onshore facilities waste water outfall are addressed in the Construction Onshore Facilities Waste Water Discharge Plan (Chevron Australia 2016) and are therefore outside the scope of this Plan.

The Plan presents the environmental monitoring and contingency management actions regarding permanent onshore facilities waste water discharges, as well as the proposed activities required to support the EQVRP required under Condition 13-12 (MS 873) and Condition 44a of EPBC 2008/4469. While the Plan includes contingency management in response to trigger level exceedances during all stages, the Environmental Quality Management Framework (EQMF) is focused on discharges from the various waste water treatment facilities under typical conditions.

> *Typical conditions are considered to represent the scenario when the various waste water treatment and discharge facilities (the seawater desalination system, primary treatment facilities, WWTPs and waste water outfall) are jointly operating within their design limits as outlined in this Plan. This includes the extraction of ambient seawater for the seawater desalination plant within the designed water quality parameters, the availability of reject brine for co-mingling of treated waste water streams, and the discharge characteristics of the treated effluent remaining within the rated design limits. Typical conditions do not include the commissioning period of any facility or the scenario(s) when one or more waste water treatment facilities are out of service or major disruptions such as cyclonic events or incidents (e.g. spills).*

If the composition of a discharge changes significantly during operations from that described in Section 4.0, validation monitoring will be reinstated and relevant monitoring will be conducted as necessary. An example may include a change in volume of effluent discharged (e.g. due to a significant increase in personnel) or addition of a new effluent stream. Day to day operation of the permanent onshore facilities waste water outfall under typical conditions will be via the Works Approval or Operating Licence.

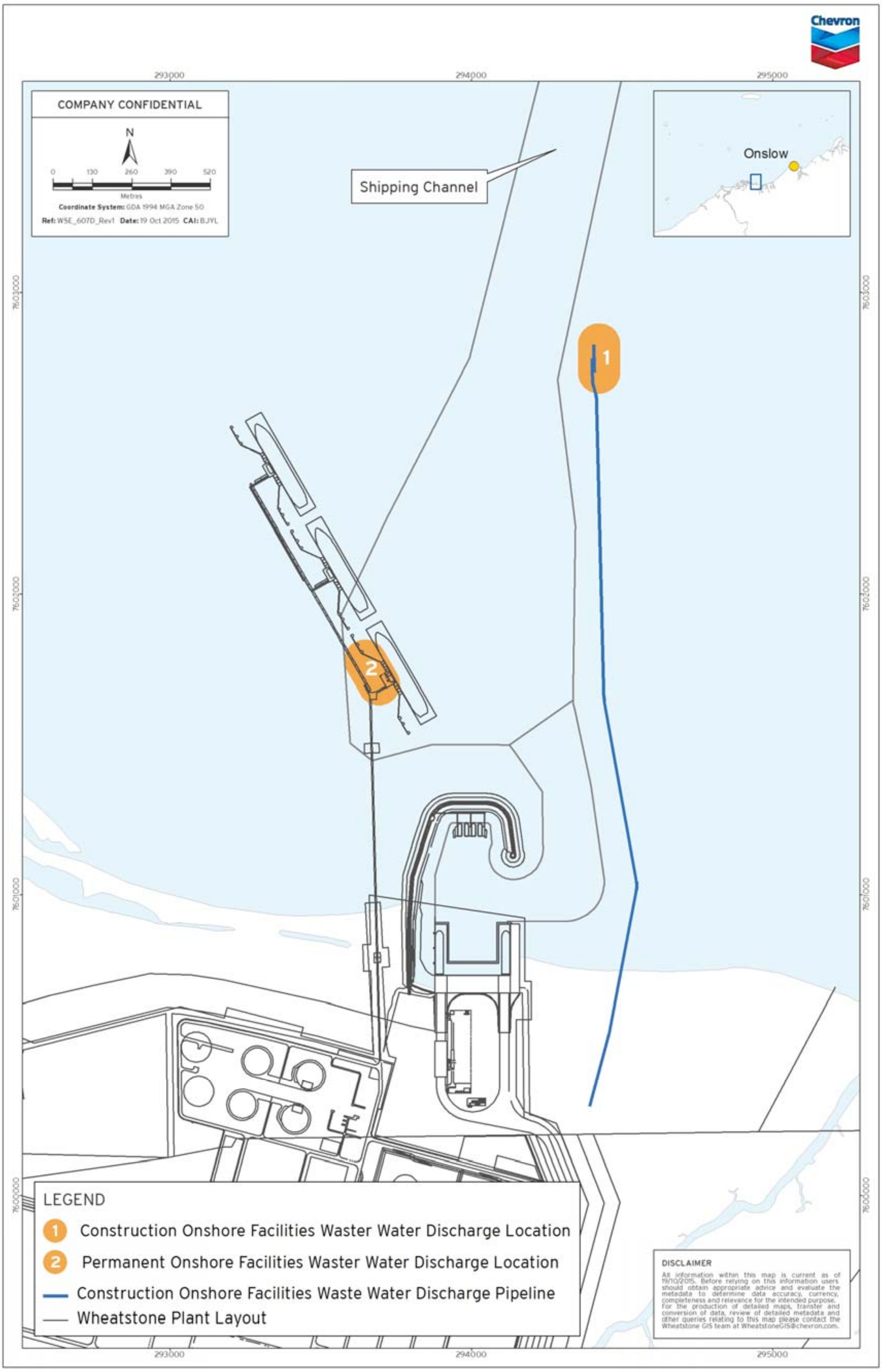


Figure 1.2: Location of the Construction and Permanent Onshore Facilities Waste Water Outfalls

1.5 Review, Approval and Revision

Chevron Australia is committed to conducting activities in an environmentally responsible manner and will review its environmental management measures as part of a programme of continuous improvement. This commitment to continuous improvement means that Chevron Australia will review and revise the Plan to address changes in environmental risks, environmental performance and changes in business conditions when required.

MS 873 condition 24-1 requires that Chevron Australia may only implement an amendment to this Plan from the date of the amendment. Significant amendments may only be implemented from the date of approval of the amendment by the CEO of DWER. Significant amendments are those amendments, which alter the obligations of the Proponent, that is, are not minor or administrative.

This Plan is submitted prior to application for any works approval from DWER and informs the construction and commissioning process. Ongoing management of discharges will be managed via the operating licence once issued. In the event of any difference or inconsistency between this Plan and works approval/licence documents, the works approval/licence documents will apply.

In accordance with Condition 5 of EPBC 2008/4469, if Chevron Australia wishes to undertake activities associated with the discharge of waste water from the permanent onshore facilities otherwise than in accordance with the provisions of this Plan (if approved), the revised activity shall not commence until the Commonwealth Minister has approved the varied plan in accordance with Condition 6 of EPBC 2008/4469.

1.6 Public Availability

The approved Plan will be made publicly available on Chevron Australia's website within one month of approval (EPBC 2008/4469 Condition 8) unless otherwise agreed to in writing by the Minister for the Department of the Environment and Energy (DOTEE).

2.0 PROJECT DESCRIPTION

The Project description which follows has been included for the purpose of contextualising the environmental monitoring and management measures required under this Plan, and are provided for information only as an approximate indication of how the processes may operate. Chevron Australia may change these processes as necessary to meet the relevant EQOs and LEPs. The Project description described below may be amended because of a change in planning, for example under section 45C of the EP Act. The Project description detailed in this Plan should therefore be read as subject to any Project amendments (refer to Figure 2.1).

2.1 Construction Village Waste Water Treatment Plants

A Construction Village (CV) has been constructed to accommodate the peak population of the Project. The Construction Village Waste Water Treatment Plant (CV WWTP) includes the following facilities:

- CV Trains 1-4 (capacity – 480 m^3/day per train)
- 2 x 600 equivalent person (EP) plants (capacity – 168 m^3/day each)
- Fly Camp WWTP (800 EP) (capacity – 205 m^3/day)

The CV WWTP facilities treat all water associated with the CV (sink/shower, sanitary, and other domestic waste water). Irrigation of treated effluent for construction and dust suppression may be utilised where approved under relevant licence.

CV Trains 1-4 are currently connected to the Project's construction onshore facilities waste water outfall (refer to the Wheatstone Project Construction Onshore Facilities Waste Water Discharge Plan WS0-0000-HES-PLN-CVX-000-00096-000). As the Project moves to a steady state operational workforce the CV WWTP configuration will be adjusted to optimise performance. Facilities will be decommissioned and the remaining facilities will be routed to the permanent outfall.

2.2 LNG Plant Site Waste Water Treatment Plant

The LNG plant Site Waste Water Treatment Plants (LNG WWTP) will consist of two treatment trains normally operating at 50% capacity. This configuration supports the overall system reliability as the treatment can be performed by in-service train if the other train is out of service. The LNG WWTP will treat waste water from site sinks/showers and sanitary facilities at the LNG plant site.

2.3 GTG & GTC Inlet Air Humidification System

The Turbine Inlet Air Humidification (TIAH) systems for the Gas Turbine Generators (GTGs) in the Power Generation Unit, and Gas Turbine Compressors (GTCs) in the LNG Trains each consist of inlet air humidifiers (evaporative coolers) for the gas turbine drivers and a common water supply system which supplies water to all the humidifiers in the system. As the turbine inlet air flows through the evaporative coolers, some of the TIAH system water evaporates, cooling the air before it enters the gas turbine and results in an increase in the available horsepower output of the gas turbine drivers.

The constant flow of water through the humidifier continuously cleans and flushes the cooler media surface, minimising or eliminating scale deposition. As water evaporates in the humidifier, insoluble inorganic constituents are left behind and continue to build-up in the circulation water. The increasing Total Dissolved Solids (TDS) concentration of the TIAH circulation water leads to scaling, fouling, and corrosion of the cooler, reducing its efficiency and operational life. Additionally, these solids can carry over with the inlet air to the turbines, resulting in corrosion and fouling of the gas turbine. A continuous amount of circulation water is removed from the system via blowdown to maintain the desired quality of the circulation water. The blowdown/purge water is sent to final waste water sump for discharge via the ocean outfall.

2.4 Seawater Desalination System

The seawater desalination system consists of two reverse osmosis (RO) treatment trains, although planned operation is for only one train to operate under normal conditions. This configuration supports the overall system reliability as the treatment can be performed by an in-service train if the other train is out of service, or both trains can operate in parallel simultaneously.

The function of the seawater desalination system is to remove impurities such as suspended solids, dissolved solids and biological constituents from raw seawater to produce utility water, potable water, and demineralised water that meets the plant quality requirements. The system consists of Upflow Media Filtration (UMF), Ultrafiltration (UF), Sea Water (first pass) Reverse Osmosis (SWRO), Brackish Water (second pass) Reverse Osmosis (BWRO), Electrodeionisation (EDI) and a Clean In Place (CIP) system.

The waste streams produced from the system will include brine, media filter backwash water and reject from the CIP and UF systems.

2.4.1 Upflow Media Filtration

Chlorinated seawater is pumped to up-flow coalescing seawater filters to remove suspended solids and biological constituents which would otherwise damage or foul the RO membranes. Each multi-media filter is comprised of three beds that consist of gravel/sand media decreasing in size. The filtered seawater is injected with sodium hypochlorite and then flows to the filtered seawater storage tank for flow into the UF system.

The seawater filtration system is designed to negate the requirement to remove the filter bed and dispose of filter waste. Chemical treatment with polymer and coagulant upstream of the filters is designed to improve filter efficiency. Regular backwash of this system ensures longevity and prevents the requirement to dispose to landfill.

2.4.2 Ultrafiltration

The UF system is provided to protect the downstream SWRO system by removing colloidal materials in the filtered seawater and reducing the turbidity of the SWRO feedwater. Filtered seawater is pumped through UF guard strainers, which remove particulates larger than 200 microns from the UF feed, and then dosed with a coagulant (e.g. ferric chloride) which improves the efficiency of the UF units and reduces the generation filter waste.

The UF system consists of individual UF hollow fibre membrane modules removing particles larger than 0.02 microns. The particles removed from the feed accumulate within the membrane pores and to prevent potential membrane damage, the UF system is routinely subject to an automatic backwash procedure at timed intervals. In addition to regular backwash, UF membranes are also periodically subjected to chemically enhanced backwash (approximately every 8 hrs) using chemicals such as sodium hypochlorite, sodium hydroxide and an acid (e.g. hydrochloric).

The backwash procedure enables the reuse/replenishment of filters and is a preferable waste minimisation strategy, reducing the amount of solid waste disposed to landfill and reducing energy and transport demands associated with the re-supply of new filters.

2.4.3 Seawater Reverse Osmosis System

UF product water is pumped through SWRO cartridge filters for the removal of remaining suspended solids potentially present in the feed to the SWRO units. The cartridge-filtered SWRO feed is treated with chemicals before entering the SWRO units to prevent potential fouling or damage to the RO membranes. Acid is injected for pH control (if required) and an antiscalant solution is added proportionately to the flow into the SWRO.

Bio-growth inhibitor on the membranes and a solution such as sodium bisulfite is added to remove chlorine in the SWRO feed. In the SWRO unit, dissolved salts and ions are separated and removed from the feedwater as concentrate or reject water. The desalted SWRO product water leaves as permeate. The SWRO reject is discharged to the final waste water sump for discharge via the marine outfall.

The RO membranes are flushed each time the SWRO system is shut down. Additionally, the SWRO units can be periodically cleaned via the common CIP system.

2.4.4 Brackish Water Reverse Osmosis System

The BWRO system is provided for further removal of dissolved ions from the SWRO permeate as the first step in producing demineralised water. SWRO permeate is pumped through dechlorination carbon filters to remove any residual chlorine. Periodic backwash of these filters is required to fluff the media and prevent clogging.

After dechlorination, the BWRO feed water flows to BWRO cartridge filters for removal of any suspended solids that may be introduced into the product water. It is also dosed with a caustic solution to improve rejection of dissolved carbon dioxide prior to being fed to the BWRO system. The BWRO product (permeate) is discharged to BWRO product water tank and the BWRO reject is discharged to the final waste water sump for discharge via the marine outfall.

2.4.5 Electrodeionisation Demineralisation System

Final demineralisation is accomplished by the EDI system which uses electricity and ion exchange to remove ionised species from water, exchanging them for H+ and OH- ions. BWRO product water passes through one or more chambers filled with ion exchange resins which are held between cation or anion selective membranes. Ions that bind to the ion exchange resins migrate to a separate chamber due to the electrostatic force of the externally applied electric field. This process also produces the H+ and OH- ions necessary to maintain the resins in their regenerated state.

2.4.6 Clean In Place System

A common CIP system is provided for periodic *in situ* cleaning of the UF, SWRO, BWRO and EDI systems. The system consists of a tank, heater, cartridge filter and manual circulation pumps to flush and clean the CIP system. It is anticipated that the SWRO unit would be cleaned annually and the UF, BWRO and EDI systems every three years. Chemicals such as citric acid and Tetrasodium diethylenetriaminetetraacetate (Na_4EDTA) are used in the CIP process for the SWRO, BWRO and EDI systems. Citric acid, sodium hypochlorite, sodium hydroxide, hydrochloric acid and sodium lauryl sulfate may be used in the CIP process for the UF system.

The CIP tank is filled with a chemical cleaning solution which is then pumped from the tank through the cartridge filter and then to the filtration modules to be cleaned (filter banks in the UF, SWRO, and BWRO units can be cleaned individually). An electric heater is used to heat the cleaning solution to 60°C to increase cleaning efficiency. The cleaning solution flows into filtration units and exits through the permeate and reject return lines back to the CIP tank.

The cleaning solution is recirculated through the system for a fixed period of time, and then disposed of to the final waste water sump once the cycle is complete.

2.4.7 Additional Water Treatment Systems

In addition to the above-mentioned systems, the seawater treatment plant will also include other necessary systems and associated equipment such as seawater intake system, sea water pumps, chemical dosing systems, hypochlorite generation system, potable and utility water remineralisation, UV disinfection and water storage and distribution.

2.5 LNG Plant Site Primary Treatment Facilities

The LNG plant site Primary Treatment Facilities (LNG PTF) will consist of two treatment trains normally operating at 50% capacity. The LNG PTF is designed to treat process waste water and potentially contaminated stormwater by removing free oil and suspended solids.

2.5.1 Process Waste Water Collection System

Waste waters from process equipment and/or areas that are contaminated or have the potential to be contaminated with free oil, hydrocarbons, Activated Methyldiethanolamine (aMDEA), Triethylene Glycol (TEG) and other contaminants are collected in various lift stations and area sumps located throughout the plant. Depending on the composition of the waste water, the waste water can be sent to the LNG PTF for processing or to the waste water tank (see Section 2.6 below) for storage and disposal off-site.

If the collected waste water only contains hydrocarbons, it is pumped from the sump/lift station, through a common collection header, to the LNG PTF. Suspended hydrocarbons and sludge are collected in the waste oil tank or sludge holding tank and ultimately disposed of off-site by a licenced operator. If detergent is used for turbine blade washing, the waste water is pumped to the waste water tank for off-site disposal (see Section 2.6 below).

2.5.2 Clean & Potentially Contaminated Storm Water Collection

Clean storm water is runoff from the non-process areas, unpaved areas, grassy areas, and other areas which is assumed to be suitable for discharge without treatment. Potentially contaminated stormwater includes the first flush (25 mm) of rain from hydrocarbon processing areas and stormwater collected in diked areas of LNG storage tanks.

The storm water is collected in various first flush sumps located throughout the plant. These sumps have an overflow/underflow baffle arrangement to separate any oil from the storm water and to prevent any oil from reaching the clean storm drain. Overflow around the diversion chamber is considered clean storm water and is routed to the clean storm water ditches and then to the storm water sedimentation ponds. From there, the overflow is sent to stormwater sedimentation ponds and then discharged to the environment.

After a storm event, the operator visually inspects and tests the storm water collected in first flush sumps located throughout the plant. Clean storm water is pumped to the clean water drainage system, whilst storm water contaminated with oil is sent to the LNG PTF for processing. First flush sumps are equipped with oil skimmer pump packages, which allow the operator to skim off and pump any floating oil in the sump to the LNG PTF. Storm water containing amine or surfactants, is pumped to the waste water tank for off-site disposal by a vacuum truck.

2.6 Waste Water Tank

Waste water, containing possible contaminants other than hydrocarbons (e.g. aMDEA, TEG, detergent from turbine blade washing etc), is sampled at certain process area lift stations, area sumps, first flush sumps, and flare KO drums where contamination is likely. If contaminants are detected, the waste water is pumped to the waste water tank for collection and off-site removal by a licenced operator. Overflow from the waste water tank is routed to waste water sump where the collected liquid can be removed via vacuum truck or pumped back to the waste water tank.

2.7 Permanent Waste Water Outfall

2.7.1 Sources of Waste Water

An overview of the permanent waste water treatment and discharge facilities described in this Plan is provided in Figure 2.1. Flow rates of each waste water stream and their expected constituents are summarised in Table 2.1. The treated waste water from all listed sources is routed to a final waste water sump that will source the outfall feeder pipe and diffuser.

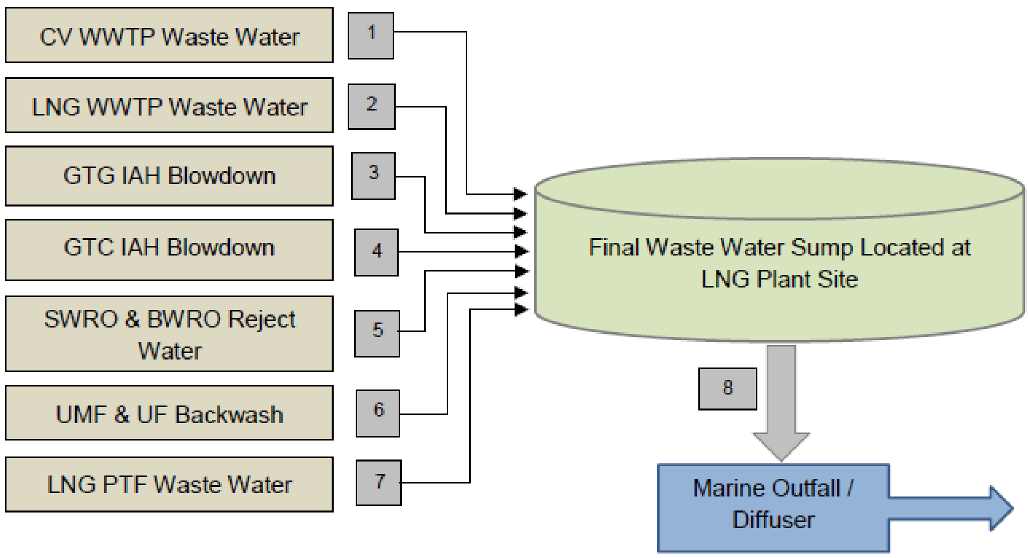


Figure 2.1: Flow Diagram of Permanent Waste Water Treatment Facilities

Table 2.1: Expected Flow Rates and Potential Constituents of the Various Waste Water Streams

Stream No.	Description	Flow rate m^3/hr	Constituents of the Discharge
1	Treated waste water from CV WWTP	8	Nutrients, dissolved solids, suspended solids
2	Treated waste water from LNG WWTP	2	Nutrients, dissolved solids, suspended solids
3	GTG IAH blowdown	8	Metals, dissolved solids, suspended solids
4	GTC IAH blowdown	24	Metals, dissolved solids, suspended solids
5	SWRO & BWRO reject	183	Metals, dissolved solids, nutrients
6	UMF & UF backwash	50	Metals, dissolved solids, suspended solids, nutrients
7	Treated waste water from LNG PTF	1	Hydrocarbons
8	Final waste water sump – to outfall	276[(1)]	All of the above

Notes:

1. *276 m^3/hr is the average equivalent incoming flow rate to the final waste water sump before discharge. 674 m^3/hr is the approximate discharge rate to the ocean outfall.*

2.7.2 Outfall Diffuser Configuration

The waste water streams listed in Section 2.7.1 will be comingled and discharged to the marine environment via a permanent outfall terminating in a diffuser, located adjacent to the Product Loading Facility (PLF), attached to a concrete block mattress (approximately 200 mm thick) that acts as scour protection (Figure 1.2).

The unidirectional oblique diffuser design consists of 20 variable-area duckbill ports. Duckbill port design limits intrusion of ambient water and sediment into the diffuser, which can occur during low flows and during periods of poor flow distribution within the diffuser, in particular when combined with buoyant waste water discharges. The duckbill ports can also induce higher exit velocities for low discharges relative to a rigid round port, and vendors claim improvements to dilution as a result of the flattened discharge jet.

Owing to the presence of the desalination plant intake near the intersection of the access trestle and the basin cut, all diffuser ports are arranged on the offshore (north-east) side of the main diffuser pipe to direct waste water discharges away from the intake. The diffuser ports are also angled up in the water column to promote dilution, given the weighted average plume is negatively buoyant. Key details of the permanent outfall diffuser are summarised in Table 2.2.

Table 2.2: Indicative Design Parameters for Permanent Onshore Facilities Waste Water Outfall Diffuser

Attribute	Detail
Diffuser centrepoint	MGA-50: (293670, 7601738)
Water depth	-13.5 m lowest astronomical tide/ -14.8 m MSL
Discharge elevation	+2.5 m above sea bed/ -12.3 m MSL
Discharge rate	674 m^3/hr = 0.187 m^3/s
Outfall type	Unidirectional oblique diffuser
Length	89 m
No. of ports	20
Port spacing	4.5 to 5.0 m c/c
Port diameter (ID)	2” (50.8 mm)
Port exit velocity	4.6 m/s
Port angle in horizontal plane	60°N
Port angle in vertical plane	40°

3.0 ENVIRONMENTAL QUALITY MANAGEMENT FRAMEWORK

The aim of the EQMF is to establish an environmental quality framework for management and monitoring of project waste water discharges to coastal waters. The EQMF includes three objectives:

1. Describe the baseline water quality for the Project area
2. Establish the EQC that should be achieved to maintain the EQOs
3. Specify the zones of Low, Moderate and High LEP, prescribed EQC for each zone and map these areas.

3.1 Baseline Water Quality Conditions

The area around Onslow is characterised by relatively turbid inshore/nearshore waters that are subject to moderate tidal and residual flows (non-harmonic currents driven primarily by meteorological forcing, generally in the longshore direction over a period of days or weeks) and episodic highly turbid runoff from the Ashburton River. The mid and outer waters are generally clear (Chevron Australia 2010). The coastal waters generally have very low levels of anthropogenic contamination (Wenziker et al. 2006) and are oligotrophic with low availability of nitrogen limiting rates of primary production. However, on occasions blooms of nitrogen-fixing microbes such as *Trichodesmium* or mangrove tidal mud-flat cyanobacteria may contribute significant amounts of nutrients into the marine environment. High spatial and seasonal variability has previously been recorded in nutrient and chlorophyll-a concentrations within the Dampier Archipelago (Pearce et al. 2003; Buchan et al. 2003). Baseline nitrogen and phosphorus concentrations in the marine waters around Onslow occasionally exceeded the default trigger values of 100 µg/L total nitrogen (Ntot) and 15 µg/L total phosphorus (Ptot) specified by ANZECC & ARMCANZ (2000), with concentrations approaching 350 µg/L and 18 µg/L, respectively for Ntot and Ptot (Chevron Australia 2010).

Baseline water quality values were collected as part of the EIS/ERMP for the Project. Two separate monitoring programs provide relevant baseline values to characterise the existing environment:

1. A regional monitoring program of water quality in the area near the proposed turning basins along the proposed trunkline adjacent to Bessieres and Thevenard Island (MScience 2011), and
2. A localised monitoring program focussed on the water quality around the proposed nearshore outfall approximately 0.5-1.0 km from the shoreline (MScience 2013).

The second monitoring program was originally intended to provide information on the composition of intake water for use in the design and construction of the desalination plant. However, the four short vessel-borne synoptic sampling campaigns also provide baseline water quality values for the nearshore region for use in assessing impacts from the outfall. The baseline water quality conditions and results of these monitoring programs, in line with Schedule 2 (MS 873), are presented in terms of the concentrations of:

1. Toxicants
2. Other Physical and Chemical Parameters
3. Biological Parameters.

3.1.1 Toxicants

The results of the monitoring programs provide baseline concentrations and indicate the ANZECC & ARMCANZ (2000) guideline values for toxicants generally provide appropriate concentrations for protecting the environmental values of the nearshore waters around Onslow and managing the impacts of the onshore facilities waste water discharges. Baseline concentrations occasionally exceeded the lower reporting limit although these concentrations typically varied between surveys.

The baseline 95th percentile concentrations of cadmium, chromium, manganese, molybdenum, nickel, vanadium and mercury were always below the ANZECC & ARMCANZ (2000) guideline values for 99 or 90% species protection. The concentrations of arsenic, copper, lead, aluminium and selenium were always below the reporting limit and/or the ANZECC & ARMCANZ (2000) guideline values for 99 or 90% species protection. However, the Limit of Reporting (LOR) for these elements was, at times, above the guideline or low reliability guideline value. There are no published guideline values for iron. The 95th percentile concentration of zinc exceeded the guideline value for 99% species protection (High LEP) but not 90% species protection (Moderate LEP). A high reliability guideline concentration for aluminium is not available; the low reliability ANZECC & ARMCANZ (2000) guideline value is 0.5 µg/L and was exceeded. This published guideline for aluminium has been calculated from limited data and is provided as an indicative value only.

Oil and Grease, Total Solvent Extractable (O&G TSE) was rarely detectable and median concentration was usually below 5 mg/L. The test for chlorine was not sensitive enough to detect if chlorine concentrations approached the low reliability ANZECC & ARMCANZ (2000) guideline value. Under such circumstances a more sensitive method combined with comparison to reference sites will be used for monitoring purposes. Overall, the results indicate that the water quality guidelines for 99% and 90% species protection for all elements are suitable for application to the water around Onslow, notwithstanding the effects of potentially elevated background concentrations for constituents where guidelines values were below the LOR and periodic nitrogen and phosphorous excursions.

3.1.2 Other Physical and Chemical Parameters

The results of the monitoring programs indicate that the water quality guidelines recommended in ANZECC & ARMCANZ (2000) for other physical and chemical parameters are generally not suitable for protecting the environmental values of the nearshore waters around Onslow and managing the impacts of the onshore facilities waste water discharges. Schedule 2 of MS 873 (EPA 2011), requires triggers to be based on the 95th percentile of these natural background values for the Moderate LEP and the 80th percentiles of natural background values for the High LEP.

For nitrogen based water quality parameters (Ntot, nitrates + nitrites) baseline median concentrations in MScience (2013) were above the recommended guidelines specified in ANZECC & ARMCANZ (2000). The median concentrations for both Ptot and filterable reactive phosphorus in MScience (2013) were below the ANZECC & ARMCANZ (2000) default guideline values although Ptot did, at times, exceed the guideline value. Further from shore, Ntot exceeded guideline values, but nitrate + nitrite, ammonia, Ptot and filterable reactive phosphorus did not (MScience 2011). Monitoring undertaken in the specific area of interest therefore provides the most appropriate values for calculation of locally relevant triggers for nitrogen and phosphorus compounds as recommended by ANZECC & ARMCANZ (2000).

Most of the remaining other chemical and physical parameters, particularly turbidity, temperature and salinity (shown TDS), exhibit high natural variability. This has been well demonstrated in the regional monitoring of these parameters over a 2-year baseline period (SKM 2013). It is therefore recommended these triggers be based on a combination of long term statistics and near real-time comparative reference sites (Figure 6.1 for location of proposed reference sites). Only by using this combination will the program be able to address both the relationship between natural and discharge parameters together with an assessment of potential impact.

3.1.3 Biological Parameters

The ANZECC & ARMCANZ (2000) guideline values for biological parameters generally provide appropriate concentrations for protecting the environmental values of the nearshore waters around Onslow and managing the impacts of the onshore facilities waste water discharges. Total coliforms measured were well below guideline values for recreational water use.

3.2 Environmental Values, Quality Objectives and Criteria

The State Water Quality Management Strategy (Department of Environment 2004) provides for the establishment of Environmental Values (EVs) and EQOs in relation to the effects of waste inputs and pollution on marine water quality. Under this framework, EQOs are established in relation to prescribed EVs (Table 3.1). To determine achievement of each EQO, a set of EQC are required which measure chemical and physical water quality parameters relevant for baseline water quality conditions at the location of the discharge and for the constituents contained within the waste stream. The EQMF for the Wheatstone Project has been adopted from the *Environmental Quality Criteria Reference Document for Cockburn Sound (2017)* (EPA 2017) and is consistent with Schedule 2 of MS 873. The framework is provided in Figure 3.1.

Table 3.1: Environmental Values and Environmental Quality Objectives for Onshore Facilities Waste Water Discharges

#	Environmental Value	Environmental Quality Objectives	EQO
1.	Ecosystem Health	Maintenance of Ecosystem Integrity	EQO1
2.	Fishing	Maintenance of seafood for human consumption	EQO2
3.	Aquaculture	Maintenance of aquaculture	EQO3
4.	Industrial Water Supply(1)	Maintenance of industrial water supply	EQO4
5.	Recreation	Maintenance of primary contact recreation	EQO5
		Maintenance of secondary contact recreation	EQO6
6.	Aesthetic	Maintenance of aesthetic values	EQO7
7.	Cultural and spiritual values(1)	Maintenance of cultural and spiritual values.	EQO2, EQO5, EQO6, EQO7

Notes:

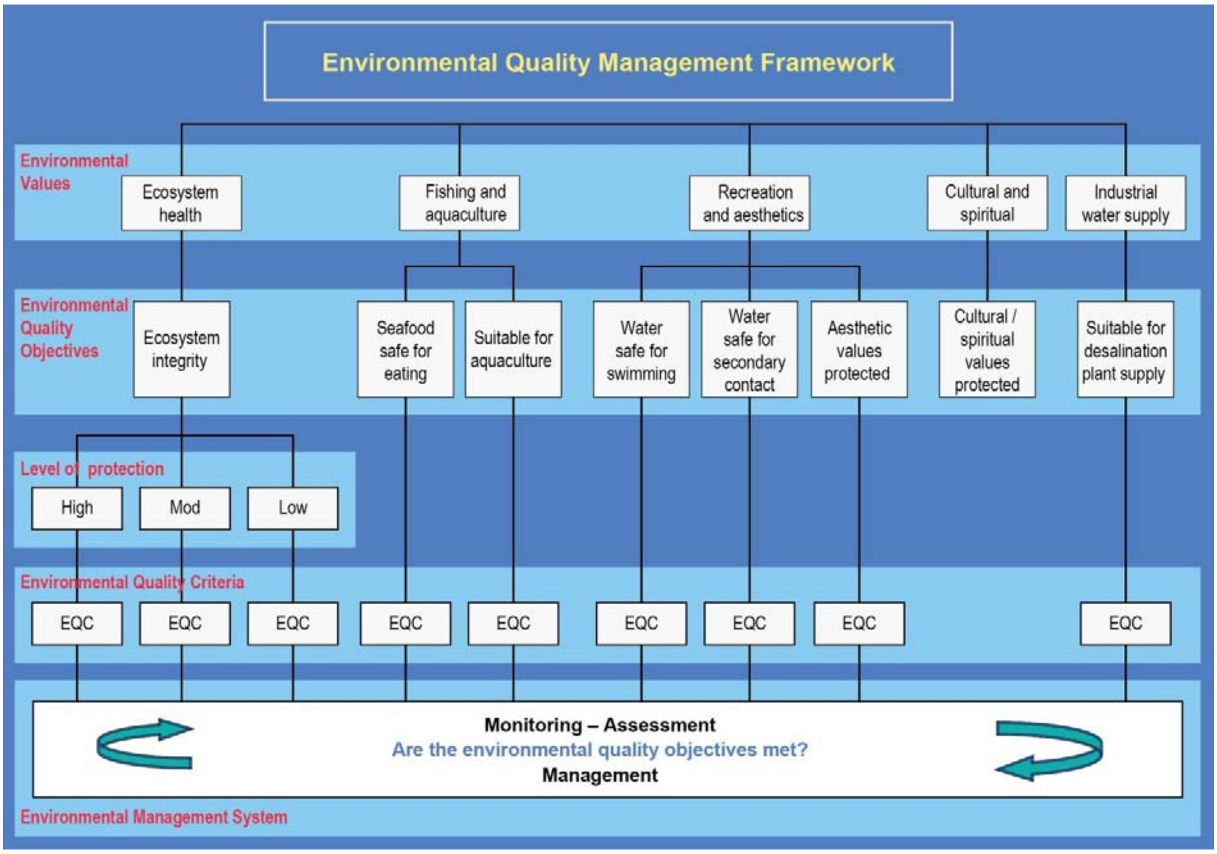
1. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) do not provide water quality guidelines for this environmental value.*

A comprehensive set of EQC have yet to be formally established by DWER for Pilbara coastal waters. There have been studies on background water and sediment quality in the region as summarised above (Wenziker et al. 2006) and these have been used together with the guidelines, approaches from ANZECC & ARMCANZ (2000) and consultation with the DWER, to develop EQC relevant for the expected constituents of the discharge from permanent onshore facilities waste water treatment processes. Toxicant EQC are provided in Table 3.2, other physical and chemical parameter EQC are shown in Table 3.3 and microbiological EQC are presented in Table 3.4. The microbiological EQC in Table 3.4 have been developed using the *Environmental Quality Criteria Reference Document for Cockburn Sound (2017)* (EPA 2017). Water quality EQC are intended to be used as a proxy in lieu of measuring sediment and biota directly.

EQC only need to be developed for those seasons where there is a risk of a significant impact on environmental quality (EPA 2016). The detailed modelling study undertaken by DHI in 2013 & 2015 included simulations for ambient and discharge conditions which were considered representative of both typical summer and winter environmental conditions, and of typical operating conditions at the Wheatstone facility. Two one-month periods, spanning Oct-Nov 2011 and Aug 2010, were identified which together characterised typical metocean forcing conditions during summer and winter respectively. The study concluded that the permanent onshore facilities waste water outfall would not have a significant impact on environmental quality. Therefore, Chevron Australia considered that the inclusion of seasonal EQC and ongoing monitoring of the marine environment to include seasonal variation was not required.

Based on Schedule 2 of Ministerial Statement 873 (EPA 2011), the EQC for physio-chemical stressors were calculated from 95th and 80th percentiles of baseline data (MScience 2013 – All dates i.e. sampling conducted Aug 2010, Nov 2010, Mar 2011, Jun 2011). In addition to a fixed EQC developed from the pre-impact baseline data (for most physiochemical stressors), a comparison of the impact median to near real-time and un-impacted local reference site data was included (refer to Table 3.3). Whilst seasonality is not a focus of the monitoring design, the inclusion of both near real-time reference sites and long-term percentiles will minimise the possibility of falsely attributing change to onshore discharge.

During construction, the area around the near-shore marine facilities has been designated as closed waters. This area is defined by a boundary a minimum 1.5 km from the near-shore marine facilities. A security regulated water-side exclusion zone has been prescribed for the port facilities (Port of Ashburton Port Handbook, 2016) shown in Figure 3.2. Access within this zone will be controlled and activities relating to social values (e.g. fishing and swimming) will not be permitted. Despite the security regulated water-side exclusion zone, the EVs of 'Fishing and Aquaculture' and 'Recreation and Aesthetics' have been considered to allow for a scenario where the exclusion zone is lifted in the future.



Reference: Environmental Quality Criteria Reference Document for Cockburn Sound (2017), EPA 2017.

Figure 3.1: The Environmental Quality Management Framework for the Wheatstone Project

Table 3.2: Characterisation and EQC for Toxicants in Permanent Onshore Facilities Waste Water Discharges

Environmental Quality Criteria		Baseline(1)	Combined Waste Water Concentration(2)		EQO1(3)			EQO2, EQO3(3)	EQO5, EQO6, EQO7(3)
Parameters	Units		Min	Max	Low LEP	Moderate LEP(7)	High LEP(8)		
Aluminium(4)	µg/L	< 10	4.23	13.88	N/A	Impact median < reference 95th percentile	0.5(5) & impact median < reference 80th percentile	10	200
Chlorine(4)	µg/L	< 100	6.82	28.97	N/A	4(6)	0.03(6)	3	N/A
Cadmium(4)	µg/L	< 0.6	0.25	0.83	36	14	0.7	5	5
Chromium (III)(4)(9)	µg/L	< 1	0.42	1.39	N/A	49	7.7	20	50
Chromium (VI)(4)(9)	µg/L	< 1	0.42	1.39	N/A	20	0.14	20	50
Copper(4)	µg/L	< 1	0.42	1.39	N/A	3	0.3	5	1000
Lead(4)	µg/L	< 10	4.23	13.88	N/A	6.6	2.2	7	50
Mercury	µg/L	0.04	0.02	0.07	1.4	0.7	0.1	1	1
Nickel(4)	µg/L	< 7	2.42	8.74	N/A	200	7	100	100
Silver(4)	µg/L	< 10	4.23	13.89	N/A	1.8	0.8	3	50
Vanadium	µg/L	1.1	0.30	2.37	N/A	160	50	100	N/A
Zinc	µg/L	3.9	1.23	12.22	N/A	23	7	5	5000
Total Recoverable Hydrocarbons (TRH)(4)	µg/L	0	110	1330	N/A	7(5) & impact median TRH < reference 95th percentile	7(5) & impact median TRH < reference 80th percentile	N/A	No visible surface slicks/ detectable odour
aMDEA	µg/L	ND	0	0	ID	ID	ID	ID	ID
Mixed toxicants(10)					TTM < 1				

Notes:

N/A = Not applicable
ND = Not determined
ID = Insufficient data (ANZECC & ARMCANZ, 2000)

(1) *Baseline data derived from "Wheatstone LNG Development: Outfall Baseline Report - Water Quality around the Proposed Nearshore Outfall", Report No. MSA188R1, 30 January 2013 (MScience 2013).*

(2) Table 3.2 represents the range of values across both winter and summer ambient and operating conditions. The character of the combined waste water discharge stream will vary depending upon intake seawater concentrations and the expected operation for the desalination system. Therefore, minimum and maximum concentrations to the final waste water sump is shown.

(3) EQC concentrations have been sourced from Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000). The EQC for TRH and aluminium is based on the Low Reliability Value (Chapter 8 of ANZECC & ARMCANZ, 2000) and comparison with Reference sites.

(4) Baseline toxicant concentration falls below the LOR.

(5) Low reliability guideline value. Presented here for comparison purposes, and will be further evaluated throughout the commissioning and validation period to ascertain applicability.

(6) Adopted from draft revised trigger values for chlorine in marine waters (on recommendation by DWER).

(7) Measured at the boundary of the Low and Moderate LEP zones.

(8) Measured at the boundary of the Moderate and High LEP zones.

(9) Chromium speciation data was not available, so data represents total dissolved chromium, conservatively applied for both oxidative states.

(10) TTM (total toxicity of the mixture) = Σ(Ci / where Ci is the concentration of the 'i'th component in the mixture and EQGi is the guideline for that component. If TTM exceeds 1, the mixture has exceeded the water quality guideline. ANZECC & ARMCANZ (2000) only recommends use of this formula on mixtures with up to 5 contaminants of concern.

Table 3.3: Characterisation and EQC for Chemical and Physical Parameters of Permanent Onshore Facilities Waste Water Discharges

Environmental Quality Criteria		Baseline(1)	Combined Waste Water Concentration(2)		EQO1				EQO2, EQO3	EQO5, EQO6, EQO7
Parameters	**Units**		**Min**	**Max**	**Moderate LEP(8)**		**High LEP(9)**			
TDS(3)	mg/L	37 700	27 303	57 436	39 500	and impact median < reference 95th percentile	39 400	and impact median < reference 80th percentile	33 000 - 37 000	N/A
Ntot(3)	µg/L	147	1490	5165	260		225		N/A	N/A
NOx (nitrate + nitrite)(3)	µg/L	9.3	1043	3616	16.6		12.0		< 100,000 + < 100	N/A
Ptot(3)	µg/L	5.0	146	582	17.5		7.5		N/A	N/A
Filterable reactive phosphorus(3)	µg/L	2.0	368	524	4.0		3.3		N/A	N/A
Chlorophyll-a	µg/L	0.6	N/A	N/A	1.4(7)		1.4(7)		N/A	N/A
Temperature	°C	21.1 - 28.2(3)	24.8	31.9	Impact median < reference 95th percentile		Impact median < reference 80th percentile		< 2^{0}C ΔT from reference median	15 - 35^{0}C
pH		8.1	6.0	9.0	Impact median between Reference 5th and 95th percentiles(4)		Impact median between Reference 20th and 80th percentiles(4)		6.0 - 9.0	5.0 - 9.0
Turbidity	NTU/SSC	5.5	9.16	49.53	Impact median < reference 95th percentile(4)		Impact median < reference 80th percentile(4)		< 10	Clarity should not reduce by > 20% Hue should not change by > 10 (Munsell Scale) Reflectance should not change by > 50% 200 mm diameter black disk should be visible > 1.6 m
Dissolved Oxygen (DO)(5)(6)	% Saturation	N/A	84	93	60% (spot sample ≤ 0.5 m from seafloor)		60% (spot sample ≤ 0.5 m from seafloor)		N/A	> 80%
					80% (6 week median at any site ≤ 0.5 m from seafloor)		90% (6 week median at any site ≤ 0.5 m from seafloor)		N/A	N/A

Notes:

N/A = Not applicable

(1) Baseline data derived from "Wheatstone LNG Development: Outfall Baseline Report - Water Quality around the Proposed Nearshore Outfall", Report No. MSA188R1, 30 January 2013 (MScience 2013).

(2) Table 3.3 represents the range of values across both winter and summer ambient and operating conditions. The character of the combined waste water discharge will vary depending upon intake seawater concentrations and the expected operation for the desalination system. Therefore, minimum and maximum concentrations to the final waste water sump is shown.

(3) Specified concentrations derived from the Project baseline studies (MScience 2013), percentile comparisons based on ANZECC & ARMCANZ (2000) guidelines.

(4) For the practical test, EQC will be based on reference comparison only due to high spatial and temporal variability in regional studies.

(5) Ministerial Statement 873 (EPA 2011).

(6) DO saturation percentages in raw seawater and waste water discharges is estimated. Percent saturation DO values for plant and village WWTP's are calculated based on process design requirement of 2 mg/L DO.

(7) 1.4 µg/L based on Table 3.3.4 from ANZECC & ARMCANZ (2000) for tropical Australia for slightly disturbed waters. Note for marine inshore areas a range between 0.7 - 1.4 µg/L is quoted, qualified with the statement that the upper limit is appropriate for application to the North-west Shelf of WA.

(8) Measured at the boundary of the Low and Moderate LEP zones.

(9) Measured at the boundary of the Moderate and High LEP zones.

Table 3.4: Characterisation and EQC for Biological Parameters in Permanent Onshore Facilities Waste Water Discharges

<table>
<tr><th>Environmental Quality Criteria(2)(3)</th><th>EQO2(4)</th><th>EQO5</th><th>EQO6</th><th>EQO7</th></tr>
<tr><th colspan="5">Environmental Quality Guideline</th></tr>
<tr><td>Faecal Pathogens</td><td>The median or geometric mean faecal coliform concentration in samples from a single site must not exceed 14 CFU/100 mL and the 90^{th} percentile must not exceed 21 CFU/100 mL(5)(6)</td><td>Impact 95^{th} percentile < 200 enterococci/100 mL(6)</td><td>Impact 95^{th} percentile < 2000 enterococci/100 mL(6)</td><td>N/A</td></tr>
<tr><td rowspan="11">Toxic Algae / Algal Biotoxins</td><td>Concentrations of toxic algae should not exceed the following environmental quality guideline values in any samples:</td><td rowspan="11">The phytoplankton cell count from a single site should not exceed 10,000 cells/mL or detect DOHWA watch list species or exceed their trigger levels.

No reports of skin, eye or respiratory irritation or potential algal poisoning of recreational users considered by a medical practitioner as potentially resulting from toxic algae when less than 10,000 cells/mL is present in the water column.</td><td rowspan="11">The median phytoplankton cell count for a defined sampling area should not exceed 25,000 cells/mL

No reports of skin, eye or respiratory irritation or potential algal poisoning of recreational users considered by a medical practitioner as potentially resulting from toxic algae when 25 000 cells/mL is present in the water.</td><td rowspan="11">N/A</td></tr>
<tr><td>Alexandrium = 100 cells/L
(A. acatenella, A. catenella, A. cohorticula, A. fundyense, A. lusitanucum, A. minitum, A. ostenfeldii, A. tamiyavanachi, A. tamarense)</td></tr>
<tr><td>Dinophysis = 500 cells/L
(D. acuta, D. fortii, D. norvegica)</td></tr>
<tr><td>Dinophysis = 3000 cells/L
(Dinophysis acuminata)</td></tr>
<tr><td>Prorocentrum = 500 cells/L
(P. lima)</td></tr>
<tr><td>Gymnodinium = 1000 cells/L
(Gymnodinium catenatum)</td></tr>
<tr><td>Karenia = 1000 cells/L
(K. brevis, K. brevis-like, K. mikimotoi)</td></tr>
<tr><td>Pseudonitzchia = 250,000 cells/L
(P. australis, P. pungens, P. turgidula, P. fraudulenta, P. delicatissima, P. pseudodelicatissima)</td></tr>
<tr><td>Pseudonitzchia = 100 cells/L
(Gonyaulax cf. Spinifera)</td></tr>
<tr><td>Pseudonitzchia = 500 cells/L
Protoceratium reticulatum (Gonyaulax grindley)</td></tr>
</table>

Environmental Quality Criteria[(2)(3)]	EQO2[(4)]	EQO5	EQO6	EQO7
Nuisance organisms	N/A	N/A	N/A	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus not present in excessive amounts.
Environmental Quality Standard				
Faecal Pathogens	The median or geometric mean faecal coliform concentration in samples from a single site must not exceed 70 CFU/100 ml and the 90th percentile must not exceed 85 CFU/100 mL[(5)(6)]	Impact 95th percentile < 500 enterococci/100 mL[(6)]	Impact 95th percentile < 5000 enterococci/100 mL[(6)]	N/A
Toxic Algae / Algal Biotoxins	N/A[(7)]	The phytoplankton cell count from a single site should not exceed 50,000 cells/mL or detect DOHWA watch list species or exceed their trigger levels. No visual presence of algal scums or relatively widespread visible presence of *Lyngbya majuscula* filaments (NHMRC 2008). No confirmed incidences by report from a medical practitioner, of skin, eye or respiratory irritation caused by toxic algae or of algal poisoning of recreational users.	No confirmed incidences, by report from a medical practitioner, of skin, eye or respiratory irritation or poisoning in secondary contact recreational users caused by toxic algae or chemical contaminants.	N/A
Nuisance Organisms	N/A			

Notes:

N/A = Not applicable

(1) *All EQC in Table 3.4 have been derived from EPA 2017, Environmental Quality Criteria Reference Document for Cockburn Sound (2017).*

(2) *Baseline data [derived from "Wheatstone LNG Development: Outfall Baseline Report - Water Quality around the Proposed Nearshore Outfall", Report No. MSA188R1, 30 January 2013 (MScience 2013)] was derived for total coliforms only (2.25, 5.0 and 7.25 for the median, 80th percentile and 95th percentile respectively).*

(3) The predicted combined waste water discharge concentration was derived for faecal coliforms across both winter and summer ambient and operating conditions, given that the character of the discharge will vary depending upon intake seawater concentrations and the operation of the desalination system. The minimum and maximum concentrations are 5 and 15 CFU/100 mL respectively.

(4) There are no EQC outlined in ANZECC & ARMCANZ (2000) to meet EQO3 and EQO4. Criteria for achievement of EQO2 will be sufficient for achievement of both EQO3 & EQO4.

(5) As per EPA 2017, Environmental Quality Criteria Reference Document for Cockburn Sound (2017), measured using the membrane filtration method AS 4276.7) for the Guideline and Standard, respectively.

(6) Percentile statistics for bacteriological water quality assessments to be calculated using the Hazen method.

(7) Toxin concentration in seafood is not proposed to be tested during the monitoring program and therefore the EQS relevant to this parameter is not applicable. Where the environmental quality guideline has been exceeded, the monitoring results will be referred to the Department of Health for advice prior to consideration of further assessment against the relevant environmental quality standard stated in the Environmental Quality Criteria Reference Document for Cockburn Sound (2017).

3.3 Levels of Ecological Protection for the Maintenance of Ecosystem Integrity

The LEP for the maintenance of ecosystem integrity for onshore facilities waste water discharges are prescribed under Schedule 2 (MS 873) and are set out in Table 3.5. The LEPs have been used to derive a set of appropriate trigger values for each identified EQC in accordance with the recommended approaches in ANZECC & ARMCANZ (2000). The Low LEP zone allows for large changes in the quality of water, sediment and biota and occurs within a maximum radius of 70 m around the diffuser or discharge. The Moderate LEP zone allows moderate changes in the quality of water, sediment and biota within 250 m from the ship turning basin and nearshore marine facilities. The High LEP zone allows small changes in the quality of water, sediment and biota in marine waters beyond the Low and Moderate LEP zones.

A map of the Low, Moderate and High LEP zones where the EQOs will be achieved is presented with the outfall diffuser and nearshore infrastructure in Figure 3.2. Monitoring undertaken during commissioning and through operations will be used to confirm achievement of the validated EQC which will be determined through the monitoring described in Section 6.0.

Table 3.5: Levels of Ecological Protection for the Maintenance of Ecosystem Integrity

Level of Ecological Protection	Extent	Intent	Environmental Quality Criteria		
			Toxicants(1)	Physical	Dissolved Oxygen
LOW	within a maximum radius of 70 m around the diffuser or discharge	allow for large changes in the quality of water, sediment and biota	80% species protection guideline trigger values(2)	N/A	N/A
MODERATE	within 250 m from the ship turning basin	allow moderate changes in the quality of water, sediment and biota	90% species protection guideline trigger values(2)	95th percentile of natural background measurements	median DO concentration(3) > 80% saturation at any site, but never below 60% saturation.
HIGH	marine waters beyond the Low and Moderate LEPs	to allow small changes in the quality of water, sediment and biota	99% species protection guideline trigger values(2) (except cobalt: 95% species protection guideline)	80th percentile of natural background measurements	median DO concentration(3) > 90% saturation at any site, but never below 60% saturation.

Notes:

N/A = Not applicable

(1) Applies for potentially bio-accumulating toxicants in water: For discharges that contain a mixture of toxicants, the sum of the concentrations of the primary toxicants (up to five toxicants) should not exceed the sum of the relevant trigger values (ANZECC & ARMCANZ, 2000).

(2) Water quality EQC are intended to be used as a proxy in lieu of measuring sediment and biota directly.

(3) For waters monitored within 0.5 m of the seafloor, over a period of up to six weeks.

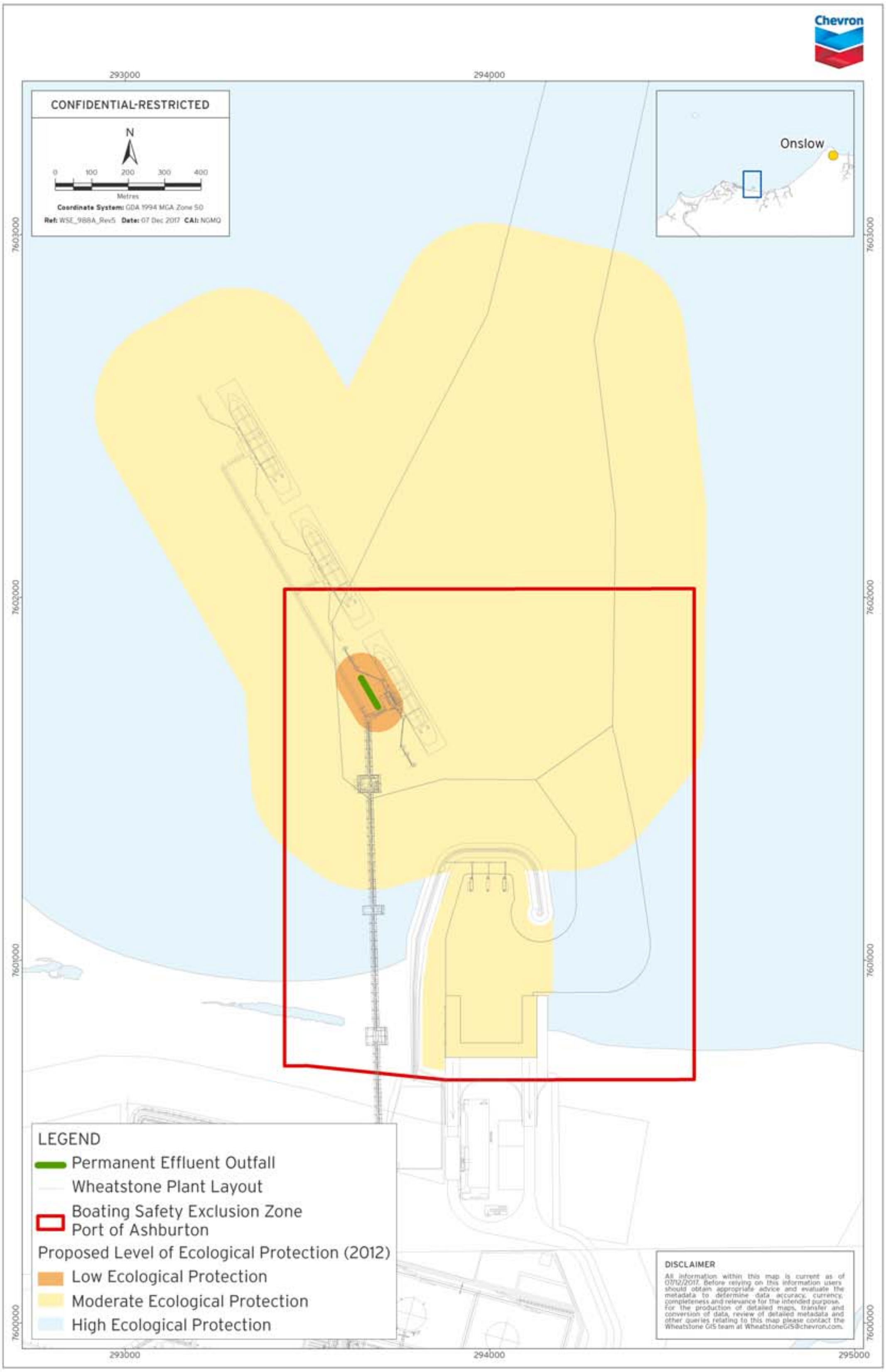


Figure 3.2: The Low, Moderate and High LEP Zones and the indicative Exclusion Zone where the EQOs will be achieved in relation to the outfall diffuser and nearshore infrastructure

4.0 NUMERICAL MODELLING OF COMBINED WASTE WATER TOXICITY, DILUTION RATES AND RECIRCULATION

The objectives of the numerical modelling study (DHI 2013, DHI 2015) were to:

- Characterise the water quality conditions at the location of the discharge outfall and the constituents contained within the combined waste water discharge stream
- Evaluate the potential toxicity of the permanent onshore facilities waste water discharge under typical conditions
- Predict the number of dilutions necessary to achieve the EQC at the boundaries of the Moderate (boundary of the Low and Moderate) and High (boundary of the Moderate and High) LEP zones
- Predict the magnitude of recirculation between the outfall and the seawater intake.

Water quality at the location of the discharge outfall and character of the waste stream are dependent on the background water quality (raw intake seawater described in Section 3.1) and the effectiveness of the permanent onshore treatment facilities and process (as described in Section 2.0). The prediction of the toxicity and dilution rates of the combined waste water discharge into the environment is based on concentrations of constituents at the boundaries of the Moderate and High LEP zones as outlined in the applicable conditions of MS 873, so they can be compared against the Moderate and High EQC. Recirculation at the seawater intake is assessed relative to the desalination plant design range specification for each constituent.

4.1 Model Approach and Inputs

4.1.1 Discharge Sequencing and Properties

The Wheatstone LNG plant has been designed such that liquid wastes are accumulated into a final waste water sump which is periodically emptied by a single-speed pump into the feeder pipe to the outfall diffuser. The discharge rate is constant based on the designed flow rate of 674 m^3/hr, however the discharge frequency and duration of discharge events will vary, as will the content of the combined waste water. Given the sizing of the final waste water sump and associated pump, discharges are typically released into the marine environment in short bursts of 11 to 16 minute duration, interspersed by somewhat longer periods of no discharge (27 to 101 minutes) as the system refills.

Operational waste discharges were simulated over a range of representative conditions, and modelling outputs evaluated for key waste water constituents (TDS, Ntot, Ptot and O&G TSE). Temporal and spatial variability in constituent concentrations within the discharge plume were evaluated to derive reasonable estimates for dilution at the boundaries of the Moderate and High LEP zones; a key parameter to be validated through the commissioning and validation stages in order to set EQC to protect the environmental values.

Individual discharge characteristics vary over the year, due to both the differing character of the intake seawater, as well as the differing requirements and operations of the facility by season. Further, the character of the combined waste water will vary depending upon whether the desalination system is online, offline, or transitioning between those two states. Finally, the “receiving water” ambient environmental conditions vary throughout the year. Representative ‘summer’ and ‘winter’ simulations of combined waste water (and desalination intake) character and cycling were performed for typical environmental conditions and at a time when the LNG berth is unoccupied. Two one-month periods, spanning Oct–Nov 2011 and Aug 2010, were considered to represent typical metocean forcing conditions during summer and winter, respectively.

4.1.2 TDS, Salinity and Excess Density of Permanent Onshore Facilities Waste Water Discharges

Temperature, TDS, salinity and excess density for ambient and combined waste water discharges relevant to typical summer and winter discharge simulations are summarised in Table 4.1 and Table 4.2 below. The time weighted average of TDS values for all discharge cases in Table 4.1 and Table 4.2, excluding periods of no discharge, was calculated to be 45,300 mg/L indicating an overall dense waste water discharge. For the typical summer simulation, dense waste water was discharged 38% of the time, buoyant waste water 1% of the time, and periods of no discharge occurred 61% of the time. For the typical winter simulation, dense waste water was discharged 11% of the time, buoyant waste water 6% of the time, and periods of no discharge 83% of the time.

Table 4.1: Temperature, TDS, Salinity and Excess Density for Ambient and Waste Water Discharges relevant to a Summer Simulation

Discharge Case	Temp. (°C)	TDS (mg/L)	Salinity (ppt)	Excess Density (kg/m^3)	% Occurrence in Simulation	% Occurrence (Excluding no Discharge)
Summer ambient	29.9	34 900	34.18	N/A	N/A	N/A
Desalination system on	31.9	45 809	44.55	7.1	38.0%	97.44%
Desalination system transitioning from on to off	31.9	27 303	26.90	-6.1	0.4%	1.03%
Desalination system transitioning from off to on	31.9	32 540	31.94	-2.4	0.6%	1.54%
No discharge	N/A	N/A	N/A	N/A	61.0%	N/A

Notes:

N/A = Not applicable

(1) *Positive excess density values denote waste water which is heavier than ambient receiving waters and will tend to sink, with negative excess densities denoting buoyant waste water.*

Table 4.2: Temperature, TDS, Salinity and Excess Density for Ambient and Waste Water Discharges relevant to a Winter Simulation

Discharge Case	Temp. (°C)	TDS (mg/L)	Salinity (ppt)	Excess Density (kg/m^3)	% Occurrence in Simulation	% Occurrence (Excluding no Discharge)
Winter Ambient	22.8	39 500	38.48	N/A	N/A	N/A
Desalination plant on	24.8	57 436	55.29	12.1	5.8%	33.92%
Desalination plant transitioning from on to off	24.8	49 967	48.35	6.8	2.1%	12.28%
Desalination plant off	24.8	31 772	31.13	-6.2	6.3%	36.84%
Desalination plant transitioning from off to on	24.8	46 305	44.92	4.2	2.9%	16.96%
No discharge	N/A	N/A	N/A	N/A	82.8%	N/A

Notes:

N/A = Not applicable

(1) *Positive excess density values denote waste water which is heavier than ambient receiving waters and will tend to sink, with negative excess densities denoting buoyant waste water.*

4.2 Model Methodology

The behaviour of the plume and subsequent modelled concentrations of constituents at the boundaries of the Moderate and High LEP zones are based on representative seasonal environmental conditions (e.g. meteorological and oceanographic) established from historic and baseline records for the Project area. A summary of the source of these historic and baseline records are provided in Table 4.3.

Table 4.3: Summary of the Source of Historic and Baseline Meteorological and Oceanographic Conditions for the Model

Condition	Description
Current	An AWAC (acoustic Doppler current profiler) deployed intermittently over the last several years at the site.
Bathymetry	Bathymetry was compiled from a combination of different data sets including local surveys, digital nautical charts accessed via DHI's software MIKE C-MAP and satellite images. In addition, bathymetry was later updated with LADS (LIDAR) data. The different input data sets were analysed and combined by referencing all to mean sea level (MSL) based on several tidal stations in the area.
Wind	Wind data is available both as time- and space-varying modelled wind fields from the Australian Bureau of Meteorology's numerical weather prediction system MesoLAPS (Mesoscale Limited Area Prediction System) and as time-varying measured winds at Onslow Met Station1 installed at the Onslow Salt Jetty.
Tide	Water depth determined from the pressure sensors on bottom mounted AWAC current meters deployed at the Jetty location. The depth was related to tidal heights in Australian Height Datum (AHD).
Salinity and Temperature	Ambient salinity and temperature are based on the recorded values from baseline water quality surveys between 2009 and 2010 and temperature was also measured by the AWAC on site.

The essential approach of the study was to numerically model the dilution of the outfall discharge as a function of time and space, and determine the concentrations of constituents at the boundaries of the Moderate and High LEP zones and at the intake location.

A 3D transient (time variable) model was applied to simulate the dynamic tidal nature of the ambient environmental conditions in the area, and ensure discharge plume buoyancy effects and vertical mixing were accommodated as the behaviour of the discharge plume cannot be treated using a steady state model. For example, under some conditions the discharge plume may "pool" near the outfall around slack tide, creating a slug of concentrated waste water; these "pools" are then advected away as the current increases. Alternatively, the plume may return to the outfall location as the tide reverses, producing elevated concentrations due to re-entrainment and recirculation. Given the discharge buoyancy can be either positively or negatively buoyant, and the degree of vertical mixing is important to the dilution, three-dimensional modelling was performed.

Close to the outfall the behaviour is determined by the properties of the waste water and the outfall design, termed the near-field region. As distance from the diffuser increases, the initial properties of the discharge (such as velocity of the discharge, buoyancy, instantaneous current speed and direction relative to the diffuser) become relatively less significant compared to the influence of the ambient conditions (such as winds, currents, transient shifts in current direction, barometric effects and bathymetry) in determining the plume behaviour, termed the far-field region. As the boundaries of the Moderate and High LEP zones are located relatively close to the outfall, both hydrodynamic regions must be considered in a single integrated approach. In the present study, a state-of-the-art coupled approach was used where the near-field model (CORMIX) has been dynamically linked to a far-field model (MIKE3) to capture the important unsteady behaviour of the plume.

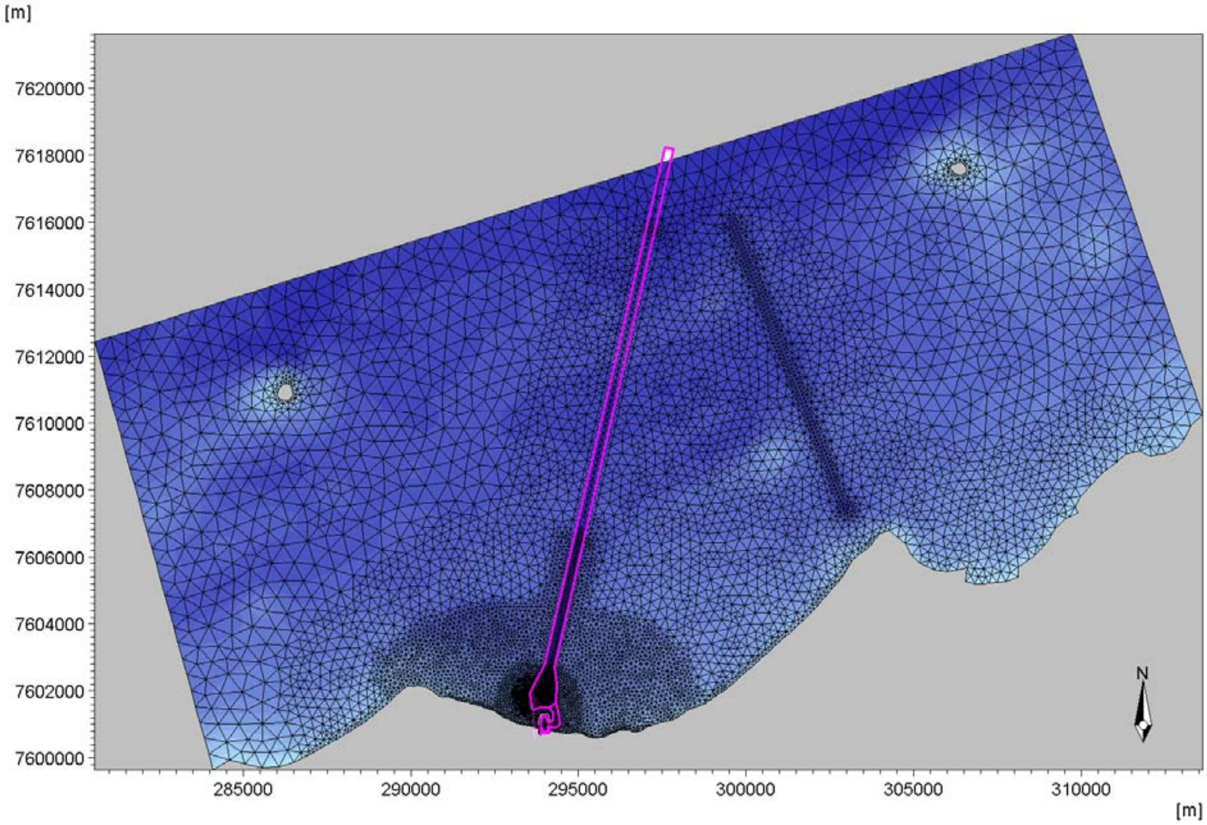
The CORMIX model was run for a three-dimensional matrix of parameters that envelop the conditions at the site of the diffuser and the waste water stream. These parameters included the ambient current speed, the ambient current direction and the density of the waste water. The ambient current and ambient direction portions of the three-dimensional parameter space have been determined based upon a year-long time series of current velocities predicted at the permanent outfall diffuser location by the well-calibrated regional MIKE21 NHD model established in DHI (2010). Based upon initial prospective testing, near-field plume characterization in CORMIX was performed for a total of 34 combinations of current speeds and directions, as well as for the seven waste water densities, yielding a total of 238 combinations (7 x 34 = 238).

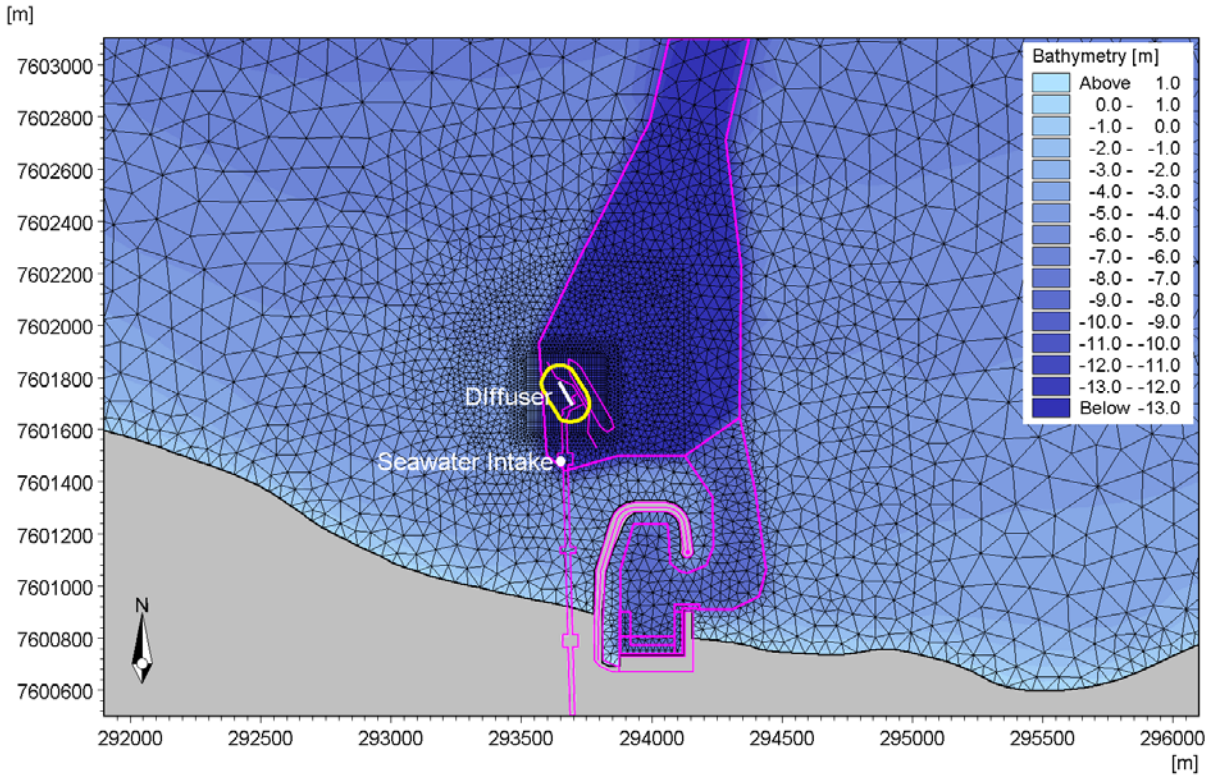
After near-field plume characterization in CORMIX, the high-resolution three-dimensional far-field model was implemented in the numerical modelling software MIKE3 FM. The model domain extends roughly 10 km west, 35 km east and about 15 km offshore of the discharge point. The horizontal resolution varies from 10 m at the diffuser location to nominally 500 m near the outer boundaries. The computational model mesh showing the resolution used in the area surrounding the planned infrastructure and the diffuser site is presented in Figure 4.1. Note that quadratic (square) mesh elements have been used around the diffuser site to ensure that all elements containing near-/far-field coupling points have the same volume to aide in coupling the models.

The vertical resolution of the model was defined by ten discrete layers of equal thickness covering the entire water column, and the thickness of the layers adjusted according to the local total water depth. At the diffuser location, this yielded a vertical resolution varying between approximately 1.40 m at low spring tide and 1.57 m at high spring tide. The layers were numbered from one to ten, from bottom to surface.

The model (MIKE3) was forced by local wind observations and output from an existing validated two-dimensional model which was used extensively for dredge spoil modelling. The MIKE3 model was compared to *in situ* measurements and shown to agree to a level acceptable per standard international guidelines (DHI, 2013).

To account for the dynamics close to the outfall, an advanced one-way coupling was implemented, where the near-field model (CORMIX) was used to simulate the characteristics of the outfall plume in the near-field region for a large range of ambient conditions. These results were then input as the time-varying sources in the MIKE3 model. The resulting model system included both baroclinic effects due to the density of the outfall discharge, the effect of the proposed diffuser in the near-field, the timing of the discharge releases via the outfall and the complex dynamics of tidal reversals, pooling and re-entrainment.





Note: Coordinates are the MGA-50 projection using the GDA94 datum.

Figure 4.1: Full Horizontal Model Mesh (top) and Detail of the Area Surrounding the Planned Infrastructure and the Diffuser Site (bottom)

The location of the permanent onshore facilities waste water outfall and the boundaries of the Moderate and High LEP zones are shown in Figure 3.2. The Moderate LEP EQC are imposed on the boundary of the Low and Moderate LEP zones while the High LEP EQC are imposed on the boundary of the Moderate and High LEP zones. Time series concentration data near the outfall, and LEP boundaries were post-processed as follows:

- For each physical constituent (TDS, Ntot, and Ptot) the temporal median was calculated for the respective time series, producing a median value for each constituent at each extraction point on the boundary of the Moderate and High LEP zones. The same procedure was repeated for O&G TSE using the 95th percentile.
- For all constituents, the spatial maximum (in the horizontal and the vertical) of the percentile values along the boundaries of the Moderate and High LEP zones were calculated, yielding one value for each constituent: the spatial maximum of the temporal percentile.

In summary, modelling was used to predict concentrations of key constituents at the boundaries of the of the Moderate and High LEP zones. Conservative values were adopted for the number of dilutions that the discharged water will undergo by the time it reaches each boundary based on the results of modelling. The predicted dilution value (and more broadly the model's ability to reliably simulate conditions) will be validated and the results documented in the Effluent Quality Validation Report (EQVR) (refer to section 7.1).

4.3 Waste Water Characterisation of Modelled Constituents

As discussed in Section 2.7.1, the combined waste water flow rate is comprised of treated waste water from sanitary treatment plants, treated stormwater runoff, reject from a desalination plant and IAH blowdowns from GTGs and GTCs. Table 4.4 shows the waste water discharge concentrations of modelled constituents along with predicted concentrations for simulations representing typical summer and winter ambient and operating conditions.

Ambient raw seawater intake values for modelling are based on concentrations recorded during October-November and August for summer and winter, respectively. These values do not directly represent baseline concentrations discussed in Section 3.1 derived from complete summer and winter datasets. Variations in raw seawater intake values to be applied to the model will be incorporated during validation monitoring. Detailed results of the modelling study along with the required number of dilutions to meet the EQO are provided in Appendix B.

For each of the modelled waste water constituents, the corresponding EQC at the boundaries of the Moderate and High LEP zones are provided in Table 4.4. Additionally, the table provides the predicted concentrations at the boundaries of the Moderate and High LEP zones. The results provided in Table 4.4 and Appendix B indicate that all modelled constituents meet their respective EQC at the LEP boundaries, with the exception of situations where the ambient concentration is already at or above stipulated target concentration.

Table 4.4: Waste Water Characterisation for Modelled Permanent Onshore Facilities Waste Water Discharges

<table>
<tr><th colspan="2" rowspan="2">Stream Description</th><th colspan="2" rowspan="2">Raw Seawater Intake</th><th colspan="2" rowspan="2">Combined Waste Water Concentration(1)</th><th colspan="6">EQC and Predicted Concentrations</th></tr>
<tr><th colspan="3">Moderate LEP</th><th colspan="3">High LEP</th></tr>
<tr><th>Parameters</th><th>Units</th><th>Summer</th><th>Winter</th><th>Min</th><th>Max</th><th colspan="2">EQC(5)</th><th>Max Conc.(2)</th><th colspan="2">EQC(6)</th><th>Max Conc.(2)</th></tr>
<tr><td>TDS</td><td>mg/L</td><td>34 900</td><td>39 500</td><td>27 303</td><td>57 436</td><td>39 500</td><td rowspan="4">& impact median < reference 95th percentile</td><td>39 500</td><td>39 400</td><td rowspan="4">& impact median < reference 80th percentile</td><td>39 500</td></tr>
<tr><td>Ntot</td><td>µg/L</td><td>237.7</td><td>158.0</td><td>1490</td><td>5165</td><td>260</td><td>240</td><td>225</td><td>240(7)</td></tr>
<tr><td>Ptot</td><td>µg/L</td><td>7.5</td><td>5.0</td><td>146</td><td>582</td><td>17.5</td><td>7.6</td><td>7.5</td><td>7.5</td></tr>
<tr><td>O&G TSE(4)</td><td>µg/L</td><td>0</td><td>0</td><td>110</td><td>1330</td><td>7(3)</td><td>6</td><td>7(3)</td><td>1</td></tr>
</table>

Notes:

(1) *Table 4.4 represents the range of values across both winter and summer ambient and operating conditions. The character of the waste water will vary depending upon intake seawater concentrations and the expected operation for the desalination system. Therefore, minimum and maximum waste water discharge concentrations to the collecting sump are shown.*

(2) *The highest temporal median concentration of the modeled constituent is shown, except for O&G TSE where the spatial maximum of 95th percentile concentration of the modeled constituent is shown. Please see Appendix B for detail modeling results.*

(3) *ANZECC & ARMCANZ (2000) do not have a TRH guideline so the EQC is based on the Low Reliability Value (Chapter 8 of ANZECC & ARMCANZ, 2000) and comparison with reference sites.*

(4) *TRH will be used as the constituent to determine the EQC based on a direct assumed relationship with O&G TSE.*

(5) *Measured at the boundary of the Low and Moderate LEP zones.*

(6) *Measured at the boundary of the Moderate and High LEP zones.*

(7) *The constituent meets the target concentration in both the Moderate LEP and High LEP zones, except for situations where the background concentration is already at or above the target concentration.*

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4.4 Predicted Dilution Rates

The required dilutions necessary to meet the EQOs at the boundaries of the Moderate and High LEP zones are presented in Table 4.5.

For TDS, Ntot, Ptot, the spatial maximum of the temporal median outputs resulted in dilution values of 3895, 6244 and 6480 respectively at the Moderate LEP boundary (taking most conservative / lowest dilution of the summer and winter simulations), and >10,000 (all parameters) at the High LEP boundary. For O&G, the spatial maximum of the temporal 95% outputs resulted in a dilution of 289 at the Moderate LEP boundary, and 1458 at the High LEP boundary.

The O&G derived dilution estimates will initially be applied at each LEP boundary – refer comparison in Table 4.5 against the 'required' dilutions for each constituent. Noting that required dilutions have been calculated in consideration of the following formula modified from Zaker et al. (2001):

- [((End of Pipe Measured – Baseline) / Dilution) + Baseline] ≤ EQC,
- 'Required' Dilution = (End of Pipe Measured – Baseline) / (EQC – Baseline)

This approach is considered conservative given the assumptions and methodology taken in generating and processing modelled data. This approach provides a single dilution value for each boundary which will be validated as monitoring data is generated. The constituent's pH, temperature, turbidity and DO were excluded from Table 4.5 as the EQC will be compared against reference sites and hence dilution estimates have not been derived for these parameters. Other constituents not expected in the discharge were excluded from Table 4.5.

In comparing required versus modelled dilutions, a slight NOx EQC exceedance was predicted by the model at the Moderate LEP boundary, within close proximity to the outfall. Further from the outfall (within the MEP area), NOx was predicted to meet the EQC. As indicated by the baseline programme, background NOx has been measured to exceed guidelines in the near shore region which is likely to be attributable to loading from the Ashburton, and high variability is anticipated. MScience (2009) indicated that although baseline concentrations were elevated, in some sampled locations being more than an order of magnitude higher than EQC presented herein, ecological changes have not been reported for this area (e.g. eutrophication).

All other constituents are expected to meet the EQC at the Moderate and High LEP boundaries, with the exception of some dissolved metals where the EQC value is less than 50% of the reporting limit that was used as the raw seawater intake concentration (Chlorine, Aluminium, Chromium, Copper, Lead, and Silver). A value of 50% of the reporting limit was used to calculate statistics where all measured values during baseline were less than the reporting limit. For these constituents, ecological risk will be evaluated by comparison with the 80^{th} or 95^{th} percentile of reference sites. For the remaining constituents, required dilutions are well within model predicted dilutions. Modelling outputs for the constituents modelled are presented in Appendix B.

4.5 Recirculation

To evaluate the degree of recirculation to the seawater intake, the temporal mean, maximum and minimum predicted concentrations at the location and depth of the seawater intake were calculated for each constituent, and compared to the desalination plant design concentrations. In addition, the percentage time that intake values were likely to be above design concentrations was calculated. No significant recirculation of the outfall plume into the seawater intake was observed in model simulations. Predicted concentrations at the intake show that both the mean and temporal maxima values are within the acceptable range at the intake, with the exception of Ntot for which the predicted summer ambient concentration is above design limits. In other cases, the temporal mean concentrations are close to ambient levels while temporal maxima are modestly elevated but well below the maximum of the design range. On this basis, the assessment concluded that constituents released from the outfall will not exceed the EQC as a result of seawater intake recirculation.

Table 4.5: Calculation of the Predicted Dilutions of the Discharge Required to Meet EQC at the Moderate and High LEP Boundaries

Waste Water Constituents	Units	Raw Seawater Intake[(2)]	Final Waste Water Sump Outlet: Maximum Predicted Concentration	Moderate LEP Boundary		High LEP Boundary	
				EQC	Required Dilutions[(3)]	EQC	Required Dilutions[(3)]
Aluminium[(1)]	µg/l	5	13.88	N/A	N/A	0.5	27.8[(4)]
Chlorine	µg/l	500	28.97	4	7.24[(4)]	0.03	966[(4)]
Cadmium	µg/l	0.3	0.83	5	0.11	0.7	1.33
Chromium (III)[(6)]	µg/l	0.5	1.39	20	0.05	7.7	0.12
Chromium (VI)[(6)]	µg/l	0.5	1.39	20	0.05	0.14	9.93[(4)]
Copper	µg/l	0.5	1.39	3	0.36	0.3	4.63[(4)]
Lead	µg/l	5	13.88	6.6	5.55	2.2	90.9[(4)]
Mercury	µg/l	0.04	0.07	0.7	0.05	0.1	0.50
Nickel	µg/l	3.5	8.74	100	0.05	7	1.5
Silver	µg/l	5	13.89	1.8	7.72[(4)]	0.8	17.6[(4)]
Vanadium	µg/l	1.1	2.37	100	0.01	50	0.03
Zinc	µg/l	3.9	12.22	5	7.56	5	2.68
TRH / O&G	µg/l	0	1330	7	190	7	190
TDS	mg/l	37 700	57 436	39 500	11.0	39 400	11.6
Ntot	µg/l	147	5165	260	44.4	225	64.3
NOx (nitrate + nitrite)	µg/l	9.3	3616	16.6	494	12	1335.8
Ptot	µg/l	5.0	582	17.5	46.2	7.5	230.8
Filterable reactive phosphorus	µg/l	2.0	523.8	4.0	260.9	3.3	401.4
Faecal coliforms	CFU/100ml	2.25	15	14	1.09[(5)]	14	1.09[(5)]

Notes:

N/A = Not applicable

(1) *Aluminium is included for calculation at the High LEP boundary because of high concentrations in discharge. Not assessed for Moderate LEP boundary as no guideline value is available.*

(2) *Baseline concentrations as shown in Table 3.2, Table 3.3 and Table 3.4. A value of 50% of the reporting limit was used to calculate statistics where all measured values were below the reporting limit.*

(3) Required dilutions were calculated by dividing the difference between the maximum concentration at the final Waste Water sump outlet and ambient seawater concentrations by the difference between the EQC and ambient seawater concentrations.

(4) Baseline (or ½ LOR surrogate) higher than target EQC, adopt 0 for calculation of required dilutions.

(5) Only one dilution is required to meet the EQC for seafood consumption. The number of dilutions required is predicted to be achieved at the Moderate LEP boundary. This demonstrates social values (e.g. fishing, aquaculture, primary contact and secondary contact) for biological parameters are likely to be easily achieved at the Moderate LEP boundary and within the current exclusion zone. Disinfection processes at the WWTP will eliminate the majority of faecal coliforms from the treated Waste Water prior to discharge.

(6) Chromium speciation data was not available, so data represents total dissolved chromium, conservatively applied for both oxidative states.

4.6 Predicted Discharge Toxicity

The potential toxicity of the discharge waste water under typical conditions is determined by first comparing the predicted typical discharge constituents and the default EQC derived from ANZECC & ARMCANZ (2000) to identify the constituents with highest predicted risk of exceeding the guideline EQC; and, then, using the procedures outlined in ANZECC & ARMCANZ (2000), calculating the theoretical toxicity of a simple mixture of the highest risk constituents identified during the first step. This is not a definitive result, since this method is only valid for simple mixtures with five or less constituent toxicants. Since the current discharge contains more than five toxicants, direct toxicity assessment is preferable, as proposed in Section 6.2.4.

Synergistic effects of certain chemicals contained in a mixture can have greater toxicity than the additive effects of each chemical's individual toxicity while other mixtures may result in reduced toxicity (antagonism). Mixtures of metals can also cover the full range of antagonistic, additive or synergistic effects. The most common interaction for many chemicals is additivity, i.e. total toxicity is the sum of the toxicity of the individual components. Therefore, the total toxicity of a mixture (TTM) for simple mixtures of five or less constituents are calculated as follows:

$$TTM = \Sigma (C_i/WQG_i)$$

- Ci is the concentration of constituent i; and
- WQGi is the concentration of the guideline trigger value.

If TTM exceeds a value of one, the mixture has exceeded the water quality guideline. Further, if the aqueous concentration of *any* chemical in the mixture exceeds its guideline figure, then the water quality guidelines are automatically exceeded. To undertake the calculation, the five toxicants from Table 4.5 with an elevated risk of exceeding the EQC guideline values at the boundaries of the Moderate and High LEP zones can be chosen for inclusion in the mixture. TTM calculations for the boundaries of the Moderate and High LEP zones indicate that the predicted toxicity for the discharge is low (Table 4.6).

Background levels for copper, lead and silver were greater than the EQC at the High LEP boundary because of measured concentrations being below the LOR, and raw seawater concentration consequently being set to 50% of LOR at the LEP boundary. As such background concentrations were omitted from the calculation. Using five toxicants selected for the total toxicity calculation, a subset of those defined as toxicants by ANZECC & ARMCANZ (2000) (see Vol. 1, Chapter 3.4), the calculation indicated that the discharge does not present a significant potential toxicity, provided dilution estimates from the modelling are achieved.

Table 4.6: Total Toxicity of a Simple Mixture using Constituents of the Discharge with the Greatest Potential for Exceedance

Toxicant (µg/l)	Concentration at end of pipe	Concentration at moderate LEP (C_m)	Concentration at high LEP (C_h)	C_m/EQC_m	C_h/EQC_h
Dilution		**289**	**1458**		
Copper	1.39	0.0048	0.001	0.0016	0.0032
Lead	13.88	0.0480	0.010	0.0073	0.0043
Silver	13.89	0.0481	0.010	0.0267	0.0119
Zinc	12.22	0.0423	0.008	0.0018	0.0012
TRH / O&G	1330	4.6021	0.912	0.6574	0.1303
TTM (ratio)				0.6949	0.1509

5.0 TRIGGERS AND CONTINGENCY ACTIONS

5.1 Triggers

Trigger values are based on the modelling outputs and waste water characterisation described in Section 4.0, and are listed in Table 5.1. Trigger values are the designated values against which investigations and / or modifications will be initiated for system optimisation. Given that triggers and contingency actions apply to all three stages of commissioning, validation and operations they are described once, however the following summarises their application.

- Trigger Levels 1 and 2 apply to the commissioning stage
- Trigger Levels 1, 2 and 3 apply to the validation / EQVRP stage
- Trigger Levels 1 and 2 will be reviewed following the commissioning and validation stages, and may be revised via the DWER operating licence.

Commissioning and validation triggers were developed for assessing and managing performance, not compliance. Exceedance of the trigger does not represent failure to implement this Plan; rather, it indicates that a review of triggers or contingency options must be conducted.

5.1.1 Level 1

Level 1 trigger is an hourly average flow rate of 674 m^3/hr (Table 5.1) *over a minimum period of one hour.*

The average equivalent incoming flow rate to the final waste water sump before discharge is 276 m^3/hr for typical summer conditions and 248 m^3/hr for typical winter conditions. The anticipated combined waste water concentrations for average and instantaneous flow rate remain the same. Readings in excess of 674 m^3/hr (averaged over any given hour) at the 'end of pipe equivalent' will trigger an investigation to determine the cause.

5.1.2 Level 2

During the commissioning stage, Level 2 trigger values are based on a sampling frequency of once per week at the final waste water sump (i.e. onshore based triggers). During the validation stage, the sampling frequency will be coordinated with marine water quality monitoring (Table 6.1).

Level 2a triggers are based on the expected maximum concentrations in the combined waste water discharge (Table 5.1).

Results of monitoring at the final waste water sump will be used to compare against Level 2a trigger values. Level 2a trigger values are aligned to plant performance, are highly conservative and not aligned to environmental risk (except for NOx, see below). If the Level 2a trigger value is exceeded an investigation will be undertaken to determine if the plant facilities contributing to waste water flow to the final waste water sump are operating as designed and within specification.

Level 2b triggers are back-calculated from offshore EQC (Table 5.1).

Results of monitoring at the final waste water sump will be used to compare against Level 2b trigger values. Level 2b trigger values were back-calculated from the offshore EQC applying a conservative dilution factor derived from modelling. Level 2b triggers are set to be protective of the EQC of both the Moderate and High LEP boundaries (i.e. the most conservative of the two adopted). The calculation applied is as follows:

- Level 2b Trigger = [(Dilution x (EQC – Baseline)] + Baseline

Where a Level 2b trigger is reached during commissioning, there is a risk that the EQOs and LEPs will not be met. An investigation will be initiated to determine the cause of the trigger being reached, followed by implementing contingency management measures if the investigation indicates action is required to protect EQOs and LEPs.

5.1.3 Level 3

Level 3 trigger values are defined as EQC based on measurements of samples collected at the Moderate and High LEP boundaries during the validation stage only (Table 5.1).

Results from monitoring undertaken at each sampling location on the Moderate and High LEP boundary will be used to compare against the Level 3 trigger at the respective LEP boundary. The Moderate LEP Level 3 triggers are imposed on the boundary of the Low and Moderate LEP zones while the High LEP Level 3 triggers are imposed on the boundary of the Moderate and High LEP zones. Data collected from reference sites will be used to derive values for the reference 80th and 95th percentiles.

Should monitoring indicate that Level 3 trigger values are reached or exceeded, contingency management measures will be implemented. Monitored readings that reach Level 3 trigger values will be investigated and if this shows that the EQOs and LEPs are not being met, or are not likely to be met, Chevron Australia will report the findings to the CEO and the DWER as soon as practicable, but within five working days of receiving the results, along with a description of the management actions to be taken to meet the required level of environmental quality.

5.2 Contingency Management

In the event that the treatment systems and the permanent waste water outfall are unable to achieve the triggers during commissioning, validation or operations, contingency management actions will be evaluated and implemented. These will resolve issues under typical conditions and are dependent upon the constituent(s) of the combined waste water stream of concern and the risk posed. The specific constituent would be evaluated to determine if an appropriate contingency action is required, available and can practicably be implemented to resolve the abnormal conditions.

5.2.1 Contingency Measures

There are a number of potential contingency measures which may be used in response to trigger level exceedances for the commissioning, validation and operational stages. In the event of an exceedance requiring intervention, the first step would likely be to determine if the cause of the exceedance relates to design or operating parameters (such as the design model itself, monitoring errors, discharge rates/volumes, met-ocean conditions).

Subject to the outcomes of the investigation a combination of the following corrective actions may be implemented:

- Redirecting waste water to temporary storage on site for later recirculation/recycling through the WWTP(s).
- Evaluate and adjust the flow process and rates.
- Change management and treatment of waste water (e.g. isolating a particular stream of concern and other modifications to WWTP[s] operations depending on the test results).
- Injecting seawater into the final waste water sump to achieve further dilution.
- Transport by a licensed controlled waste contractor for treatment off site at an approved licensed facility.

- Caustic solution dosing.
- Inspection of pumps, in-line analyser(s) and alarms, and waste water monitors, deployment of maintenance / production specialists and use stocked spares to rectify process upsets.

Design options such as:

- Modify existing equipment/facilities (e.g. adding an additional treatment method[s] for the constituent[s] of concern, replacing a particular treatment[s] with other equivalent or improved techniques).
- Addition of another processing train[s] to the WWTP[s] (subject to approval).
- Modifying or relocating the diffuser (subject to approval under Condition 13.1).

If a design option(s) is selected, an assessment of the risk that the triggers will not be met (including possible additional modelling) will be conducted to determine if proposed corrective actions are likely to address the attainment or exceedance of the trigger value(s). In the event that a design option is required to resolve the abnormal conditions relevant approval applications will be submitted as appropriate.

Table 5.1: Triggers for Contingency Management of the Permanent Onshore Facilities Waste Water Discharges

Waste Water Constituents	Units	Trigger Values				
		Level 1	Level 2a[1]	Level 2b[1]	Level 3[2] (EQVRP Stage Only)	
					Moderate LEP Boundary	High LEP Boundary
Toxicants						
Aluminium	µg/L	Flow rate during discharge > 674 m^3/hr (hourly average)	13.88	729[3]	Impact median > reference 95th percentile	0.5 & impact median > reference 80th percentile
Chlorine	µg/L		28.97	44[3]	4	0.03
Cadmium	µg/L		0.83	36[4]	5	0.7
Chromium (III/VI)	µg/L		1.39	5636[5] / 204[3]	20	7.7 / 0.14
Copper	µg/L		1.39	437[3]	3	0.3
Lead	µg/L		13.88	467[5]	6.6	2.2
Mercury	µg/L		0.07	1.4[4]	0.7	0.1
Nickel	µg/L		8.74	5107[5]	100	7
Silver	µg/L		13.89	520[3]	1.8	0.8
Vanadium	µg/L		2.37	28 583	100	50
Zinc	µg/L		12.22	322	5	5
Hydrocarbon (TRH)	µg/L		1330	2023	7 & impact median > reference 95th percentile	7 & impact median > reference 80th percentile
aMDEA	µg/L		1[6]	1445	5[7]	5[7]
Physical and Chemical Parameters						
TDS	mg/L	Flow rate during discharge > 674 m^3/hr (hourly average)	57 436	N/A[10]	39 500 & impact median > Reference 95th percentile	39 400 & impact median > reference 80th percentile
Ntot	µg/L		5165	32 804	260 & impact median > reference 95th percentile	225 & impact median > reference 80th percentile
NOx (nitrate + nitrite)	µg/L		3616	2119[10]	16.6 & impact median > reference 95th percentile	12 & impact median > reference 80th percentile
Ptot	µg/L		582	3618	17.5 & impact median > reference 95th percentile	7.5 & impact median > reference 80th percentile

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Waste Water Constituents		Units	Trigger Values				
			Level 1	Level 2a(1)	Level 2b(1)	Level 3(2) (EQVRP Stage Only)	
						Moderate LEP Boundary	High LEP Boundary
Filterable reactive phosphorus		µg/L		523.8	580	4.0 & impact median > reference 95th percentile	3.3 & impact median > reference 80th percentile
Chlorophyll-a		µg/L		N/A(9)	N/A(9)	1.4 & impact median > Reference 95th percentile	1.4 & impact median > reference 80th percentile
pH		-		6-9	N/A(10)	Impact median not between reference 5th and 95th percentiles	Impact median not between reference 20th to 80th percentiles
Temperature		°C		31.9	N/A(10)	Impact median > reference 95th percentile	Impact median > reference 80th percentile
Turbidity		NTU		40.91	N/A(10)	Impact median > reference 95th percentile	Impact median > reference 80th percentile
DO Saturation		%		84%	N/A(10)	60% (spot sample ≤ 0.5 m from seafloor) 80% (median at any site ≤ 0.5 m from seafloor)	60% (spot sample ≤ 0.5 m from seafloor) 90% (median at any site ≤ 0.5 m from seafloor)
Microbiological Parameters							
Environmental Quality Guideline	Faecal coliforms	CFU/100 mL	Flow rate during discharge > 674 m³/hr (hourly average)	15	3398	14 & 90th percentile > 21	
	Enterococci	org/100 mL		N/A(10)	57 800	Impact 95th percentile > 200	
	Toxic Algae / Algal Biotoxins	cells/L		N/A(9)	N/A(9)	Alexandrium = 100 (*A. acatenella, A. catenella, A. cohorticula, A. fundyense, A. lusitanucum, A. minitum, A. ostenfeldii, A. tamiyavanachi, A. tamarense*)	
						Dinophysis = 500 (*D. acuta, D. fortii, D. norvegica*)	
						Dinophysis = 3000 (*Dinophysis acuminata*)	
						Prorocentrum = 500 (*P. lima*)	
						Gymnodinium = 1000 (*Gymnodinium catenatum*)	
						Karenia = 1000 (*K. brevis*, *K. brevis*-like, *K. mikimotoi*)	

Waste Water Constituents		Units	Trigger Values				
			Level 1	Level 2a(1)	Level 2b(1)	Level 3(2) (EQVRP Stage Only)	
						Moderate LEP Boundary	High LEP Boundary
						Pseudonitzchia = 250,000 (*P. australis, P. pungens, P. turgidula, P. fraudulenta, P. delicatissima, P. pseudodelicatissima*)	
						Pseudonitzchia = 100 (*Gonyaulax* cf. *Spinifera*)	
						Pseudonitzchia = 500 *Protoceratium reticulatum* (*Gonyaulax grindley*)	
	Nuisance organism	-		N/A(9)	N/A(9)	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae and sewage fungus not present in excessive amounts.	

Notes:

N/A = Not applicable

(1) Level 2 trigger values will be measured from samples taken at the final waste water sump (or equivalent).

(2) Level 3 trigger values are based on the EQC for the Moderate and High LEP boundaries which were derived from a combination of ANZECC & ARMCANZ (2000), or OEPA (2017) and/or are based on the percentile values detected at reference sites during the EQVRP only.

(3) Baseline (or ½ LOR surrogate) higher than target EQC, adopt 0 as baseline for Level 2b calculation.

(4) Level 2b trigger based on EQC for Low LEP (refer to Table 3.2), given that the parameter is a bio-accumulating toxicant (i.e. no dilutions applied).

(5) Baseline result below LOR, ½ LOR surrogate adopted as baseline value for Level 2b calculation.

(6) aMDEA is not expected to enter the final waste water sump, therefore any detection triggers investigation. 1 µg/L trigger set based upon commercial laboratory LOR.

(7) Level 3 trigger derived from a literature obtained lowest observed effect concentration (LOEC) of 0.5 mg/L (Brooks, 2008) and a safety factor (100).

(8) Level 2b trigger for NOx is more conservative than Level 2a (see Section 4.5).

(9) No level 2 triggers as the constituent is not expected in the discharge.

(10) No level 2b trigger, given a back-calculation from the offshore EQC was not possible (due to no fixed value or otherwise).

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6.0 MONITORING PLAN

This section describes the monitoring approach applicable to the commissioning, validation and operations stages.

6.1 Commissioning

A commissioning period is required to enable the waste water facilities and RO plant to be gradually brought “online”, and for the operation of the waste water facilities to be optimised for all input streams. Commissioning is taken to mean wet commissioning of all plant, facilities or associated infrastructure resulting in discharges via the permanent outfall outlined in this plan. The end of the commissioning period will be determined when engineering and monitoring confirm typical conditions have been achieved. The duration of the commissioning period will not exceed three months post-introduction of the final waste water stream into the final waste water sump.

Management of the permanent onshore facilities waste water discharge during commissioning is focused on staggered start-up and optimisation of the permanent waste water treatment and discharge facilities following construction. Relevant triggers and contingency management measures provide direction and recommendations for achieving EQOs and associated LEPs as described in Schedule 2 (MS 873).

6.1.1 Waste Water Discharge Monitoring

During commissioning, waste water discharge samples will be collected from the final waste water sump on a weekly basis, as detailed in Table 6.1. Samples collected will be sent to a National Association of Testing Authorities (NATA) accredited laboratory for evaluation of relevant water quality parameters. Water samples will be taken for biological and chemical analyses in accordance with the laboratory specifications for the constituents. Readings for pH, salinity (by conductivity), temperature, turbidity and dissolved oxygen will be taken *in situ*, with salinity measurements converted to a TDS equivalent for comparison with EQC.

6.2 Validation: Effluent Quality Validation and Reporting Plan (EQVRP)

The purpose of the EQVRP is to assess modelling predictions against the EQC set out in Section 3.0 and to achieve EQOs as outlined in MS 873. The EQVRP has been designed to deliver outcomes for the objectives outlined in Condition 13-12 of MS 873 and Condition 44a of EPBC 2008/4679 and will be undertaken once typical conditions have been achieved. To deliver these outcomes, the EQVRP comprises the following four components:

1. Waste water discharge monitoring to characterise the waste water from the final waste water sump. (Section 6.2.1)
2. EQC validation monitoring at the boundaries of the Moderate and High LEP zones to test water quality against the Moderate and High EQC[1] (Section 6.2.2)
3. Whole Effluent Toxicity (WET) testing to evaluate the toxicity of the discharge, and (Section 6.2.4)
4. Assessment to determine if EQC and dilution requirements need to be revised based on the results of the EQVRP (Section 6.2.5)

[1] the Moderate LEP EQC and/or Level 3 triggers are imposed on the boundary of the Low and Moderate LEP zones while the High LEP EQC and/or Level 3 triggers are imposed on the boundary of the Moderate and High LEP zones

6.2.1 Waste Water Discharge Monitoring

Samples will be collected from the final waste water sump as detailed in Table 6.1. Samples are collected to characterise the combined waste water composition to evaluate the inputs supplied for the modelling. Results will be used in combination with the marine water quality sampling and WET testing to assess that the EQC are being achieved at the boundaries of the Moderate and High LEP zones.

Waste water discharge monitoring will be scheduled concurrently with marine water quality surveys so the water quality of the discharge stream can be compared against water quality around the outfall. Waste water samples will be collected and analysed at a NATA accredited laboratory.

6.2.2 Marine Water Quality Monitoring

Marine water quality monitoring involves sampling of nearshore marine waters with distance from the outfall, at the designated LEP boundaries and at reference locations. The purpose of the marine water quality monitoring is to:

a) Confirm that the EQC are being met at the boundaries of the Moderate and High LEP zones. These samples will be assessed against Level 3 triggers in Table 5.1.
b) Evaluate dilutions being achieved at the Moderate and High LEP boundaries under typical conditions, and hence validate the model predictions, using a combination of;
    a. waste water discharge monitoring data
    b. marine water quality monitoring data
    c. dye testing data

6.2.2.1 Sampling Events

Marine water quality monitoring will be undertaken consistent with the guidelines in ANZECC & ARMCANZ (2000). Sample collection in the marine environment will not be initiated until discharge conditions are representative of typical conditions.

Samples will be collected from impact and reference sites across five sampling events over approximately 6 days[2], designed to test different tidal cycles and discharge sequences where practicable. For each sampling event, the prevailing current direction will be identified and the coordinates, depth, time and date of each sample will be noted.

Based on the data collected Chevron Australia will determine if a second EQVRP stage is required to account for seasonality given that EQC have been set to be applied year round based on percentiles from a complete calendar year data set. A second EQVRP stage will be implemented:

a) to account for seasonality if it is inferred by comparison against baseline data that EQOs may not be met due to seasonal variation.
b) where significant changes to waste water discharge characteristics or outfall design have occurred, in order to re-validate the achievement of EQOs.

6.2.2.2 Impact Sites

A down-current gradient approach will be employed and samples representing impact sites will be collected at approximately:

[2] LNG tanker presence at the PLF may limit the ability to conduct monitoring and collect appropriate samples over consecutive days, therefore the program may be delayed or adjusted if a tanker is berthed.

- 0 m
- 25 m
- 50 m
- 70 m (boundary of the Low and Moderate LEP zones)
- 100 m
- mid-way point between the Moderate and High LEP boundary
- boundary of the Moderate and High LEP zones, and
- 2000 m from the outfall.

*Note: transect sampling will be undertaken to map dilution gradients. Only samples collected at the Moderate and High LEP boundaries will be used for comparison against the EQC and/or Level 3 triggers.

An example of this methodology is shown in Figure 6.1. Samples collected from each of the eight impact sites (in the prevailing current direction) will be taken 1.0 m below the surface and 0.5 m above the sea floor. For sites on the Moderate and High LEP boundaries, samples will be taken at two additional depths between the surface and sea-floor sample points. Replicate samples will be taken at all monitored depths and for all sites (i.e. four samples per impact site or eight samples per impact site on the Moderate and High LEP boundary).

Samples collected at impact sites will be sent to a NATA accredited laboratory for analysis. In addition, *in situ* probe based sampling (salinity, pH, Chlorophyll-a, temperature, turbidity and DO) (refer to Table 6.1) will be recorded throughout the water column at all impact sites to facilitate further identification of stratification.

6.2.2.3 Reference Sites

Three reference sites will be sampled during each of the five gradient sampling event. Replicate samples will be taken 1.0 m below the surface and 0.5 m above the sea floor at each reference site and sent to a NATA accredited laboratory for analysis. *In situ* probe based sampling (refer to Table 6.1) will also be recorded throughout the water column at all reference sites.

Reference sites will be selected and located in consideration of the recommendations made by ANZECC & ARMCANZ (2000) and the OEPA (EPA 2017) as follows:

- Representative - same bio-geographic and climatic region as the impact sites
- Bathymetry, substrate and hydrodynamics of the reference site should be similar to the impact sites
- Independent - should be sufficiently distant from the impact sites to avoid disturbances in the impact sites affecting the reference site - current assumption is that reference sites are more than 1000 m up-current from the outfall
- Reference sites are located approximately 100 m apart on an axis perpendicular to the direction of current
- Reference sites will be located up-current of the marine outfall diffuser.

Background constituent concentrations recorded at reference sites at any location during monitoring are likely to be dependent on the physical (e.g. meteorological, oceanographic, depth), biological (e.g. abundance and movement of organisms) and anthropogenic (e.g. upstream nutrient input from Ashburton River) conditions present at the time of sampling. Using these reference site locations allows for the calculation of temporal and spatial statistics for the assessment of potential impact.

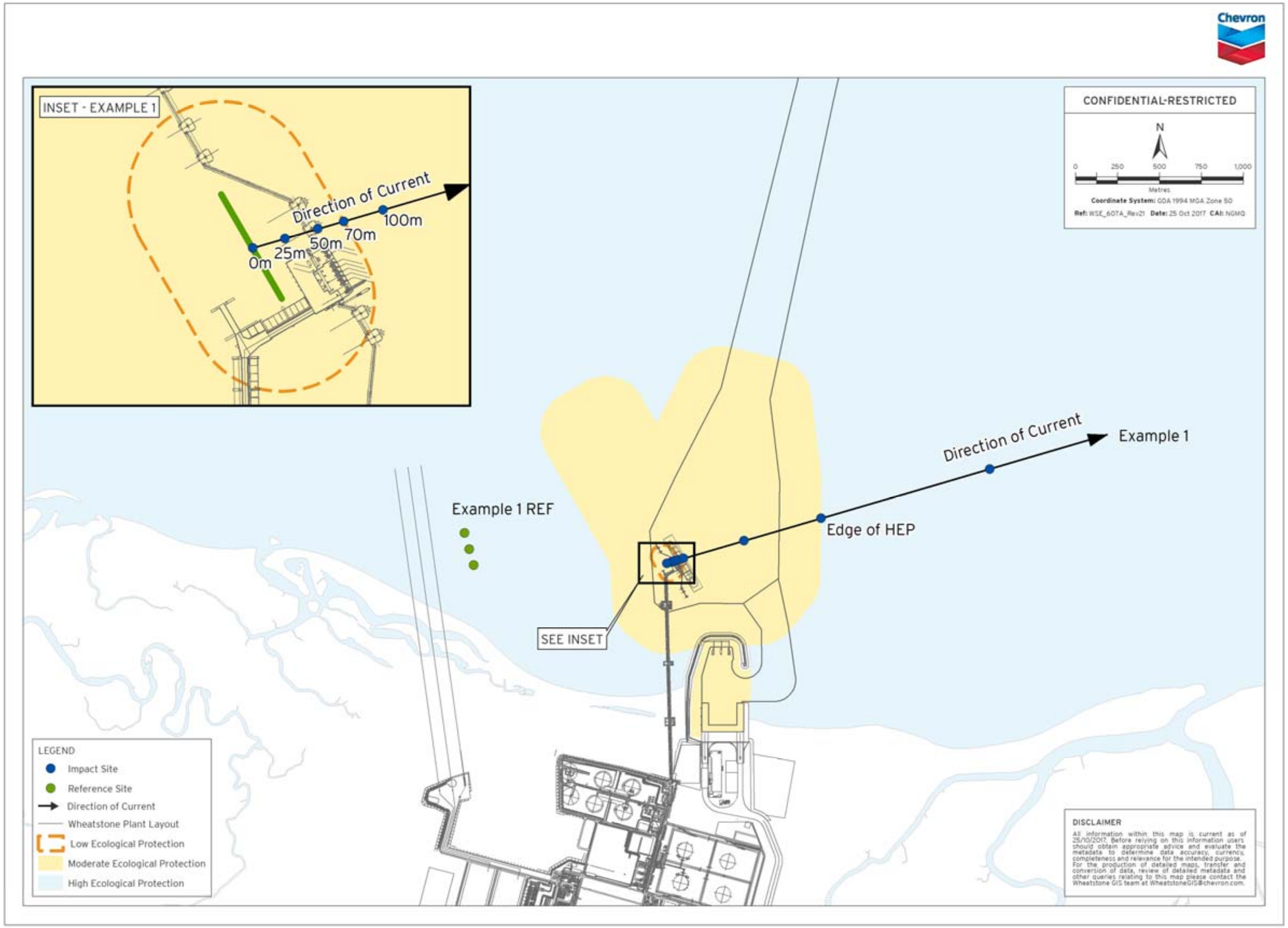

Figure 6.1: Approximate Locations of Impact and Reference Monitoring Sites (EQVRP)

6.2.2.4 Data Analysis

Achievement of the EQC and the prescribed levels of ecological protection will be assessed by comparing the impact site data with the EQC guideline triggers for the Moderate and High LEP boundaries, reported in Table 3.2, Table 3.3 and Table 3.4.

The value for each constituent will be derived using either the median (nutrients and physical stressors) or the 95th percentile (toxicants and bacteriological indicators) from impact site data at each LEP boundary location (given they all represent samples collected in the direction of the current) and for each depth (i.e. 5 data points collected over approximately 6 days, used to derive a median or 95th percentile value for comparison to the EQC guideline triggers for the Moderate and High LEP boundaries). Impact site data below the LOR will be replaced by a numerical surrogate equal to 50% of the respective LOR (as per ANZECC & ARMCANZ, 2000).

Gradient data will be plotted to produce a dilution curve, showing a change from water directly at the discharge location (high concentrations/levels) to that at the 2000 m location (low concentrations/levels). Gradient plots will be used to identify the distance from the outfall at which water quality reaches background concentrations.

6.2.2.5 Rhodamine Dye Study

Dye dilution testing using a rhodamine dye tracer will be undertaken to confirm modelling assumptions. A known concentration of dye is injected into the combined waste water stream at the final waste water sump at a precise flow rate. The diluted concentration of fluorescence is measured downstream in the marine environment with the use of appropriate instrumentation. Rhodamine dye is highly fluorescent and can therefore be detected in very low concentrations. Sampling for dye fluorescence will be undertaken at the time of the first gradient sampling event. Early results of the dye tracer study will inform the design of the remaining sampling program (i.e. sampling design has some flexibility to be adjusted based on the results of the dye test).

6.2.3 Monitoring Parameters, Sampling Method and Frequency

Table 6.1 outlines the monitoring parameters and frequency for the combined waste water discharge monitoring at the final waste water sump, impact sites and reference sites.

Table 6.1: Monitoring Parameters, Sampling Method and Frequency

Sampling Parameter	Monitoring at the Final Waste Water Sump	Marine Water Quality Monitoring at Impact (Moderate & High LEP boundaries) & Reference Sites(1)
Toxicants		
Chlorine	Grab sample: Weekly during commissioning and coordinated with marine water quality monitoring during the EQVRP stage	Grab Samples(2)
Aluminium		
Cadmium		
Chromium (III/VI)		
Copper		
Lead		
Mercury		
Nickel		
Silver		
Vanadium		
Zinc		
Hydrocarbon (TRH)		
aMDEA		
Physical and Chemical Parameters		
TDS(3)	Grab sample: Weekly during commissioning and coordinated with marine water quality monitoring during the EQVRP stage	Grab Samples(2)
Ntot		
NOx (nitrate + nitrite)		
Ptot		
Filterable reactive phosphorus		
Chlorophyll-a		
pH(3)	Grab sample: Weekly during commissioning and coordinated with marine water quality monitoring during the EQVRP stage	*In situ*(2)
Temperature(3)		
Turbidity(3)		
DO Saturation		
Flow rate and volume(3)	Continuous	N/A
Biological Parameters		
Faecal coliform	Grab sample: Weekly during commissioning and coordinated with marine water quality monitoring during the EQVRP stage	Grab Samples(2)
Enterococci		
Algal biotoxins	N/A	

Notes:

N/A = Not applicable

(1) *Marine Water Quality Monitoring at impact and reference sites will be required during the EQVRP stage only.*
(2) *Samples will be collected per Section 6.2.2.*
(3) *Continuous (in situ) sampling will be undertaken where practicable or appropriate.*

6.2.4 Whole Effluent Toxicity Testing

WET testing will be conducted on samples taken from the final waste water sump during the EQVR period to evaluate toxicity of the combined waste water discharge. Results of sampling during the commissioning period will be used to inform the selection of a discharge scenario where the resulting effluent sample is considered representative of the most likely worst-case condition (and includes UMF and UF backwash).

In addition to the sampling and analyses outlined in Table 6.1, further detailed chemical composition analyses will be conducted coincident with WET testing to provide information which may assist in diagnostics, including the origin of the toxic effect if/where appropriate. This may also assist by providing information on constituents which were not anticipated based on the review of contaminants of concern as identified in Table 3.2, Table 3.3 and Table 3.**4**. This suite of tests will be conducted at a NATA accredited laboratory, and will nominally include a range of hydrocarbon suites, constituents of the backwash water and a 'scan for unknowns' to evaluate against a reference database of chemical signatures.

WET testing involves exposing organisms to different concentrations of an effluent and measuring the effect on the test organisms' ability to survive, grow and reproduce. The WET testing program is anticipated to involve two aspects:

1. Determining the actual toxicity of the discharge during operation of the outfall by:
    a. Range finding test: to determine if the combined waste water at the outfall is toxic and, if so, the concentration range relevant for further testing
    b. Toxicity testing, involving derivation of either EC_{50} or IC_{50}, and the No Observed Effect Concentration (NOEC) values for the combined waste water
2. Determining the number of dilutions required to achieve each relevant level of ecological protection:
    a. Results will be evaluated by assessing the species sensitivity distribution using a suitable statistical software package (e.g. BurrliOZ, Campbell et al. 2000) to determine the dilutions required to achieve each relevant level of ecological protection

EC_{50} is the concentration that produces 50% of the maximum possible effect, derived from regression analysis of toxicity data. IC_{50} is derived similarly to the EC_{50} values where a concentration produces 50% inhibition of biological function. WET testing will be undertaken on a minimum of five locally relevant species from four different taxonomic groups using the recommended protocols from ANZECC & ARMCANZ (2000).

The waters of the Project area are at the Southern extent of Australia's western coastline considered to represent tropical waters as classified by IMCRA 4.0 (Commonwealth of Australia, 2006). The biodiversity of species in this area is predominantly tropical but includes the northern extent of the ranges of some temperate species. WET testing is therefore proposed to include mostly tropical species from a range of trophic levels (primary producer, herbivore and carnivore), using chronic (predominantly) tests for toxicity.

Proposed tests and locally relevant species to be used in the WET testing for this Plan are listed below, although other locally relevant species will be used if these species are unavailable:

1. 72-hr (chronic) marine algal growth inhibition test using *Nitzschia closterium.*
2. 48-hr (chronic) larval development using the milky oyster *Saccostrea echinata.*
3. 72- hr (chronic) larval development test using the sea urchin *Heliocidaris tuberculata*.

4. 48-hr (acute) toxicity test using the copepod *Parvocalanus crassirostris.*
5. 7-day (chronic) larval fish imbalance and biomass (dry weight) test using pink snapper *Pagrus auratus* or yellowtail kingfish *Seriola lalandi*.

A description of each WET testing method listed above, along with the method that the testing is based on, are provided in Appendix C. Samples for WET testing will be taken in accordance with the sampling kit and instructions provided by the laboratory undertaking the ecotoxicological analysis.

6.2.5 Revision to EQC & Dilution

The outcomes of the WET testing program (Section 6.2.4) will be used to revise the EQC and hence the number of dilutions required at each LEP boundary (Section 4.4) as prescribed by Ministerial Condition 13-12(iv). Revised EQC will be derived following WET testing by assessing the species sensitivity distribution using a suitable statistical software package (e.g. BurrliOZ, Campbell et al. 2000), in order to be protective of the relevant levels of ecological protection.

6.3 Post EQVRP Operations

Following the EQVRP stage[3] (Section 5.2.1) a licence, required under Section 56 of the EP Act, must be obtained prior to operating the facility (as described in the Part V Works Approval). A licence application is proposed to be submitted concurrently with the EQVR (Section 7.1), however there will be a period between the completion of the EQVRP stage and when a licence is granted by the DWER.

Chevron Australia will continue to manage, monitor and report (if required) waste water discharges in accordance with the commissioning requirements of the Plan (Section 6.1) until such time a licence to operate is granted by the DWER. The EQVR, and/or consultation with DWER, may also be used to reassess the monitoring requirements and frequency during this period.

6.4 Operations

Operational monitoring and management will be managed under the Part V operating licence. A revised list of potential contaminants of concern (to be monitored onshore) will be derived based on an assessment of the risk posed by each contaminant as identified by the EQVR. Conservative onshore targets will be derived in order to ensure ongoing achievement of the EQOs and LEPs and will be documented in the EQVR along with guidance for ongoing monitoring and management to support the Part V licensing process.

Onshore targets will be set to be protective of EQC in the marine environment by applying a dilution factor derived from the results of the EQVRP per the modified formula following Zaker et al. (2001):

Onshore target = ((Dilution x (Existing Offshore Target – Baseline)) + Baseline

If the composition of a discharge changes significantly under typical conditions from that described in Section 4.0, the requirement for additional validation monitoring will be reviewed and relevant monitoring will be performed as necessary.

[3] The EQVRP stage will be considered complete once marine monitoring (validation) has concluded.

7.0 REPORTING

This section provides a framework for external reporting to regulatory authorities relevant to this Plan, including scheduled and unplanned reporting.

7.1 Effluent Quality Validation Report

In accordance with MS 873 Condition 13-12(v) and Condition 44 (EPBC 2008/4469), Chevron Australia is required to submit a waste water discharge report to the DWER and the Commonwealth Minister for the Environment within six months[4] of commissioning of a discharge or within six months of any significant change in composition of a discharge, including any management actions necessary to achieve the EQOs and LEPs established through MS 873 Condition 13-1 and described in MS 873 Schedule 2.

Consistent with MS 873 Condition 13-15, in the event that monitoring undertaken as part of the EQVRP (Section 6.0) indicates that the EQOs and LEPs established through conditions 13-1, and described in Schedule 2, are not being met, or are not likely to be met, a report of the findings of this monitoring will be provided to the CEO and the DWER as soon as practicable, but within five working days of receiving the results, along with a description of the management actions to be taken to meet the required level of environmental quality.

7.2 Annual Compliance Reporting

A State and Commonwealth annual Compliance Assessment Report (CAR) are required by MS 873 Condition 4 and EPBC 2008/4469 Condition 3 respectively. Both reports assess compliance against Ministerial Conditions within the compliance reporting period being 31 August to 30 August of each compliance year, with each CAR due by the 30 November of each year. As part of the preparation of the annual CARs, Chevron Australia will assess its compliance status against this Plan, which will be guided by the action table provided in Appendix A.

The Compliance Assessment Plan requires that the Project CARs shall be made publicly available within one month of being submitted to the DWER. A copy of the most recent annual CAR will be placed on the Chevron Australia website until the subsequent annual CAR is placed on the website. Annual CAR's from previous years will be made publicly available on request for the life of the Project.

7.3 Non-compliance Reporting

MS 873 Condition 4-5 requires that any potential non-compliance, relevant to this Plan, will be reported to the CEO of the DWER within seven working days of that potential non-compliance being known. EPBC 2008/4469 Condition 3 requires non-compliance with this Plan to be reported to DOTEE at the time the CAR is published on Chevron Australia's website.

[4] Chevron Australia will submit an EQVR to the DWER within 6 months of the completion of marine water quality monitoring.

8.0 REFERENCES

ANZECC (1997). Australian Guidelines for Sewerage Systems: Effluent Management. Canberra.Australian and New Zealand Environment and Conservation Council, Canberra, ACT

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, National Water Quality Management Strategy Paper 4, Canberra, ACT

API Management Pty Ltd (2010). API West Pilbara Iron Ore Project - Stage 1 Desalination Discharge Management Plan. API Management Pty Ltd, Perth, WA, Australia

Brecken-Folse JA, Mayer FL, Pedigo LE, Marking LL (1994). Acute toxicity of 4-nitrophenol, 2,4-dinitrophenol, terbufos and trichlorfon to grass shrimp (*Palaemonetes* spp.) and sheepshead minnows (*Cyprinodon variegatus*) as affected by salinity and temperature. Environmental Toxicology and Chemistry 13: 67-77

Brooks, S (2008). CO_2 and Amines: The Toxicity of Selected Amines and Secondary Products to Aquatic Organisms, a Review. Norwegian Institute for Water Research. Oslow, Norway

Campbell E, Palmer MJ, Shao Q, MStJ W, D W (2000). BurrliOZ: A computer program for calculating toxicant trigger values for the ANZECC and ARMCANZ water quality guidelines., Perth, WA

Chevron Australia (2010). Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project: Technical Appendices Q6, Q7, R1, S1, T1, U1, V1, and W1, July 2010

Chevron Australia (2013). Construction Onshore Facilitites Waste Water Discharge Plan. Document Number: WS0-0000-HES-PLN-CVX-000-00096-000

Commonwealth of Australia (2006). A guide to the integrated marine and coastal regionalisation of Australia Version 4.0. Canberra, Australia, Department of the Environment and Heritage

Das, S. and B. K. Sahu (2005). "Interaction of pH with mercuric chloride toxicity to penaeid prawns from a tropical estuary, East Coast of India: enhanced toxicity at low pH." Chemosphere 58(9): 1241-1248

Denton, G. R. W. and C. Burdon-Jones (1982). "The influence of temperature and salinity upon the acute toxicity of heavy metals to the banana prawn *Penaeus merguiensis* (de Man)." Chemistry in Ecology 1: 131-143

Department of Environment (2004). State Water Quality Management Strategy No. 6. Department of Environment, SWQ 6, Perth, WA

Department of Environment (2006). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Perth, WA, Department of Environment: 50

DHI (2013). Wheatstone Downstream Numerical Modelling Assessment of Construction-phase Outfall Discharge and Intake Recirculation

DHI (2015). Revised Numerical Modelling Assessment of Permanent Outfall Discharge and Intake Recirulation

Ecotox Services Australia (2005). Toxicity Test Fact Sheets - <www.ecotox.com.au>

Environmental Protection Authority – *See EPA*

EPA (2011). Wheatstone Development - Gas Processing, Export Facilities and Infrastructure, Shire of Ashburton and Roeburne. Ministerial Statement 873. Environmental Protection Authority, Perth, WA

EPA (2016). Technical Guidance – Protecting the Quality of Western Australia's Marine Environment. Environmental Protection Authority, Perth, WA

EPA (2017). Environmental Quality Criteria Reference Document for Cockburn Sound (2017). Environmental Protection Authority, Perth, WA

Florence, T. M. and J. L. Stauber (1986). Toxicity of copper complexes to the marine diatom *Nitzschia closterium*. Aquatic toxicology 8(1): 11-26

Geffard O, Budzinski H, His E, Seaman MNL, Garrigues P (2002). Relationships between contaminant levels in marine sediments and their biological effects on embryos of oysters, *Crassostrea gigas*. Environmental Toxicology and Chemistry 21: 2310-2318

Government of Western Australia (2003). State Water Quality Management Strategy, Implementation Plan: Status Report, SWQ 2. Perth, WA, Water and Rivers Commission

Hogan AC, Stauber JL, Pablo F, Adams MS, Lim RP (2005). The Development of Marine Toxicity Identification Evaluation (TIE) Procedures Using the Unicellular Alga *Nitzschia closterium*. Archives of Environmental Contamination and Toxicology 48: 433-443

McKim JM (1977). Evaluation of Tests with Early Life Stages of Fish for Predicting Long-Term Toxicity. Journal of the Fisheries Research Board of Canada 34: 1148-1154

MScience (2011). Wheatstone LNG Development: Water Quality Characterisation and Parameter Calibration. Unpublished Report to URS Australia Pty Ltd by MScience Pty Ltd, MSA134R9, Perth, WA

MScience (2013). Wheatstone LNG Development: Water Quality Around the Proposed Nearshore Outfall. Unpublished Report to Chevron Australia by MScience Pty Ltd, MSA188R1, Perth, WA

Negri AP, Bunter O, Jones B, Llewellyn L (2004). Effects of the bloom-forming alga *Trichodesmium erythraeum* on the pearl oyster *Pinctada maxima*. Aquaculture 232: 91-102

NHMC (2008). Guidelines for Managing Risks in Recreational Water. National health and Medical Research Council, Canberra

Pearce AF, Buchan S, Chiffings T, D'Adamo N, Fandry C, Fearn P, Mills D, Phillips R, Simpson C (2003). A review of the oceanography of the Dampier Archipelago. In: Wells FE, Walker DI, Jones DS (eds) Proceedings of the Twelfth International Marine Biological Workshop: The Marine Flora and Fauna of Dampier, Western Australia. Vol.1. Western Australian Museum, pp 13-50

Peerzada, N. and C. Dickinson (1989). "Metals in oysters from the Arnhem Land coast, Northern Territory, Australia." Marine Pollution Bulletin 20(3): 144-145

SKM (2012). Chevron Wheatstone Water Quality Measurement Programme: Twelve Monthly Baseline Water Quality Measurement Report: 15/05/2011 – 21/05/2012 Unpublished Report by Sinclair Knight Merz for Chevron Australia, Perth, WA

Smith R, Krazzoi R, Doyle C, Stauber J, Bacher J, Mueller J (2004). Evaluation of methods of water and effluent toxicity testing. Evaluation Report. Brisbane Water, Brisbane, QLD, Australia

Stauber, J. (1995). Toxicity testing using marine and freshwater unicellular algae. Australasian Journal of Ecotoxicology 1: 15-24

URS (2010). Wheatstone Project – Characterisation of the Marine Environment. Chevron Australia P/L

van Dam RA, Harford AJ, Houston MA, Hogan AC, Negri AP (2008). Tropical tarine toxicity testing in Australia: A review and recommendations. Australasian Journal of Ecotoxicology 14: 55-88

Wenziker K, McAlpine K, Apte S, Masini R (2006). Background Quality for Coastal Marine Waters of the North West Shelf, Western Australia, North West Shelf Joint Environmental Management Study Technical Report 18

APPENDICES

TABLES

Appendix A Action Table

Section		Actions	Timing
Background			
1.3	Environmental Approvals	Amendments to State and Commonwealth environmental approval requirements may be made from time to time and if so will be reflected in the next revision of this Plan.	As required
1.5	Review, Approval and Revision	Chevron Australia will review and revise the Plan to address changes in environmental risks, environmental performance and changes in business conditions when required.	As required
		MS 873 condition 24-1 requires that Chevron may only implement an amendment to this Plan from the date of the amendment. Significant amendments may only be implemented from the date of approval of the amendment by the CEO.	
		This Plan is submitted prior to application for any works approval from the DWER and informs the construction and commissioning process. Ongoing management of discharges will be managed via the operating licence once issued. In the event of any difference or inconsistency between this Plan and works approval/licence documents, the works approval/licence documents will apply.	
		In accordance with Condition 5 of EPBC 2008/4469, if Chevron Australia wishes to undertake activities associated with the discharge of waste water from the permanent onshore facilities otherwise than in accordance with the provisions of this Plan, the activity shall not commence until the Commonwealth Minister has approved the varied plan.	
1.6	Public Availability	The approved Plan will be made publicly available on Chevron Australia's website within one month of approval (EPBC 2008/4469 Condition 8) unless otherwise agreed to in writing by the Minister for the Department of the Environment and Energy (DOTEE).	As required
Triggers and Contingency Actions			
5.1	Triggers	Trigger Levels 1 and 2 will be reviewed following the commissioning and validation stages, and may be revised via the DWER operating licence.	Commissioning & EQVRP stages
5.1.1	Level 1	Level 1 trigger is an average hourly flow rate of 674 m^3/hr (Table 5.1) over a minimum period of one hour. The average equivalent incoming flow rate to the final waste water sump before discharge is 276 m^3/hr for typical summer conditions and 248 m^3/hr for typical winter conditions. The anticipated combined waste water concentrations for average and instantaneous flow rate remain the same. Readings more than 674 m^3/hr (averaged over any given hour) at the 'end of pipe equivalent' will trigger an investigation to determine the cause.	All stages

Section		Actions	Timing
5.1.2	Level 2	Level 2 triggers are based on waste water monitoring concentrations at the end of pipe equivalent (Table 5.1). During the commissioning and EQVRP stages, Level 2 trigger values are based on a sampling frequency of once per week at the final waste water sump (i.e. onshore based triggers). During the validation stage, the sampling frequency will be coordinated with marine water quality monitoring (Table 6.1).	All stages
5.1.2	Level 2a	Results of monitoring at the final waste water sump will be used to compare against Level 2a trigger values (Table 5.1). If the Level 2a trigger value is exceeded an investigation will be undertaken to determine if the plant facilities contributing to waste water flow to the final waste water sump are operating as designed and within specification.	All stages
5.1.2	Level 2b	Results of monitoring at the final waste water sump will be used to compare against Level 2b trigger values. Where a Level 2b trigger is reached during commissioning, there is a risk that the EQOs and LEPs will not be met. An investigation will be initiated to determine the cause of the trigger being reached, followed by implementing contingency management measures if the investigation indicates action is required to protect EQOs and LEPs.	All stages
5.1.3	Level 3	Results from monitoring undertaken at each sampling location on the Moderate and High LEP boundary will be used to compare against the Level 3 trigger at the respective LEP boundary. Data collected from reference sites will be used to derive values for the reference 80th and 95th percentiles. Should monitoring indicate that Level 3 trigger values are reached or exceeded, contingency management measures will be implemented. Monitored readings that reach Level 3 trigger values will be investigated and if this shows that the EQOs and LEPs are not being met, or are not likely to be met, Chevron Australia will report the findings to the CEO and the DWER as soon as practicable, but within five working days of receiving the results, along with a description of the management actions to be taken to meet the required level of environmental quality.	EQVRP stage
5.2	Contingency Management	In the event that the treatment system and permanent waste water outfall are unable to achieve the triggers during commissioning, validation or operations, contingency management actions will be evaluated and implemented. These will resolve potential long-term issues under typical conditions and are dependent upon the constituent(s) of the combined waste water stream is of concern and the risk posed. The specific constituent would be evaluated to determine if an appropriate contingency action is required, available and can practicably be implemented to resolve the abnormal conditions.	All stages
5.2.1	Contingency Management	There are a number of potential contingency measures which may be used in response to trigger level exceedances for the commissioning, validation and operational stages. In the event of an exceedance requiring intervention, the first step would likely be to determine if the cause of the exceedance relates to design or operating parameters (such as the design model itself, monitoring errors, discharge	All stages

<table>
<tr><th colspan="2">Section</th><th>Actions</th><th>Timing</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>rates/volumes, met-ocean conditions). Subject to the outcomes of the investigation a combination of the following corrective actions may be implemented:
• Redirecting waste water to temporary storage on site for later recirculation/recycling through the WWTP(s).
• Evaluate and adjust the flow process and rates.
• Change management and treatment of waste water (e.g. isolating a particular stream of concern and other modifications to WWTP[s] operations depending on the test results).
• Injecting seawater into the final waste water sump to achieve further dilution.
• Investigate available options for reuse.
• Transport by a licensed controlled waste contractor for treatment off site at an approved licensed facility.
• Caustic solution dosing.
• Inspection of pumps, in-line analyser(s) and alarms, and waste water monitors, deployment of maintenance / production specialists and use stocked spares to rectify process upsets.
Design options such as:
• Modify existing equipment/facilities (e.g. adding an additional treatment method[s] for the constituent[s] of concern, replacing a particular treatment[s] with other equivalent or improved techniques).
• Addition of another processing train[s] to the WWTP[s] (subject to approval).
• Modifying or relocating the diffuser (subject to approval under Condition 13.1).</td><td></td></tr>
<tr><td>If a design option(s) is selected, an assessment of the risk that the triggers will not be met (including possible additional modelling) will be conducted to determine if proposed corrective actions are likely to address the attainment or exceedance of the trigger value(s). In the event that a design option is required to resolve the abnormal conditions relevant approval applications will be submitted as appropriate.</td><td>All stages</td></tr>
<tr><td colspan="4">Monitoring Plan</td></tr>
<tr><td>6.1</td><td>Commissioning</td><td>The end of the commissioning period will be determined when engineering and monitoring confirm typical conditions have been achieved. The duration of the commissioning period will not exceed three months post-introduction of the final waste water stream into the final waste water sump.</td><td>As required</td></tr>
</table>

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Section		Actions	Timing
6.1.1	Commissioning - Waste Water Discharge Monitoring	During commissioning, waste water discharge samples will be collected from the final waste water sump on a weekly basis, as detailed in Table 6.1. Samples collected will be sent to a National Association of Testing Authorities (NATA) accredited laboratory for evaluation of relevant water quality parameters.	Commissioning
6.2	Effluent Quality Validation Reporting Plan	The EQVRP has been designed to deliver outcomes for the objectives outlined in Condition 13-12 of MS 873 and Condition 44a of EPBC 2008/4469 and will be undertaken once typical conditions have been achieved.	EQVRP stage
6.2.1	Validation - Waste Water Discharge Monitoring	Waste water discharge samples will be collected from the final waste water sump as detailed in Table 6.1. Samples are collected to characterise the waste water composition to evaluate the inputs supplied for the modelling and provide assessment of ecotoxicity (WET Testing). Results will be used in combination with the marine water quality sampling and WET testing to predict the number of dilutions to assess that the EQC are being achieved at the boundaries of the Moderate and High LEP zones.	EQVRP stage
		Waste water discharge monitoring will be scheduled concurrently with marine water quality surveys so the water quality of the discharge stream can be compared against the impact on the environmental water quality around the outfall. Analysis of the combined waste water will either be conducted *in situ* with water quality sensors or samples will be collected and sent to a NATA accredited laboratory.	
		Marine water quality monitoring involves sampling of nearshore marine waters with distance from the outfall, at the designated LEP boundaries and at reference locations. The purpose of the marine water quality monitoring is to; a) Confirm that the EQC are being met at the boundaries of the Moderate and High LEP zones. These samples will be assessed against Level 3 triggers in Table 5.1. b) Evaluate dilutions being achieved at the Moderate and High LEP boundaries under typical conditions, and hence validate the model predictions, using a combination of; a. waste water discharge monitoring data b. marine water quality monitoring data c. dye testing data	
6.2.2.1	Marine Water Quality Monitoring – Sampling Events	Marine water quality monitoring will be undertaken consistent with the guidelines in ANZECC & ARMCANZ (2000). Sample collection in the marine environment will not be initiated until discharge conditions are representative of typical conditions.	EQVRP stage
		Samples will be collected from impact and reference sites across five discrete sampling events over approximately 6 days, designed to test different tidal cycles and discharge sequences as practicable.	

Section		Actions	Timing
		For each sampling event, the prevailing current direction will be identified and the coordinates, depth, time and date of each sample will be noted.	
		Based on the data collected, Chevron Australia will determine if a second EQVRP stage is required to account for seasonality, given that the EQC were derived based on percentiles from a complete calendar year data set and developed to be applied year-round. A second EQVRP stage will be implemented to account for seasonality if it is inferred by comparison against baseline data that EQOs may not be met due to seasonal variation. Where significant changes to waste water discharge characteristics or outfall design have occurred, a second EQVRP stage will be required to re-validate the achievement of EQOs.	
6.2.2.2	Marine Water Quality Monitoring – Impact Sites	Samples of impact sites will then be collected down current using a gradient approach at approximately 0 m, 25 m, 50 m, 70 m (boundary of the Low and Moderate LEP zones), 100 m, mid-way point between the Moderate and High LEP boundary, boundary of the Moderate and High LEP zones and 2000 m from the outfall. Examples of sampling impact sites via a gradient approach is shown in Figure 6.1.	EQVRP stage
		Samples of each constituent collected from each of the eight impact sites (in the prevailing current direction) will be taken 1.0 m below the surface and 0.5 m above the sea floor. For sites on the Moderate and High LEP boundaries, samples will be taken at two additional depths between the surface and sea-floor sample points. Replicate samples will be taken at all monitored depths and for all sites (i.e. four samples per impact site or eight samples per impact site on the Moderate and High LEP boundary).	
		Samples collected at impact sites will be sent to a NATA accredited laboratory for analysis. In addition, *in situ* probe based sampling (salinity, pH, Chlorophyll-a, temperature, turbidity and DO) (refer to Table 6.1) will be recorded throughout the water column at all impact sites to facilitate further identification of stratification.	
6.2.2.3	Marine Water Quality Monitoring – Reference Sites	Three reference sites will be sampled during each gradient sampling event. Replicate samples will be taken 1.0 m below the surface and 0.5 m above the sea floor at each reference site (total of six reference samples per sampling event) and sent to a NATA accredited laboratory for analysis. *In situ* probe based sampling (refer to Table 6.1) will also be recorded throughout the water column at all reference sites.	EQVRP stage
		Reference sites will be selected and located in consideration of the recommendations made by ANZECC & ARMCANZ (2000) and the OEPA (EPA 2017) as follows: ♦ Representative - same bio-geographic and climatic region as the impact sites ♦ Bathymetry, substrate and hydrodynamics of the reference site should be similar to the impact sites	

Section		Actions	Timing
		♦ Independent - should be sufficiently distant from the impact sites to avoid disturbances in the impact sites affecting the reference site - current assumption is that reference sites are more than 1000 m up-current from the outfall ♦ Reference sites are located approximately 100 m apart on an axis perpendicular to the direction of current ♦ Reference sites will be located up-current of the marine outfall diffuser.	
6.2.2.4	Marine Water Quality Monitoring – Data Analysis	Achievement of the EQC and the prescribed levels of ecological protection will be assessed by comparing the impact site data with the EQC guideline triggers for the Moderate and High LEP boundaries, reported in Table 3.2, Table 3.3 and Table 3.4. The value for each constituent will be calculated using either the median (nutrients and physical stressors) or the 95th percentile (toxicants and bacteriological indicators) from impact site data at each LEP boundary location (given they all represent samples collected in the direction of the current) and for each depth. [i.e. 5 data points (collected over approximately 6 days) used to derive a median or 95th percentile value for comparison to the EQC guideline triggers for the Moderate and High LEP boundaries]. Impact site data below the LOR will be replaced by a numerical surrogate equal to 50% of the respective LOR (as per ANZECC & ARMCANZ, 2000). Gradient data will be plotted to produce a dilution curve, showing a change from water directly at the discharge location (high concentrations/levels) to that at the 2000 m location (low concentrations/levels). Gradient plots will be used to identify the distance from the outfall at which water quality reaches background concentrations.	EQVRP stage
6.2.2.5	Marine Water Quality Monitoring – Rhodamine Dye Study	Dye dilution testing using a rhodamine dye tracer will be undertaken to confirm modelling assumptions. A known concentration of dye is injected into the combined waste water stream at the final waste water sump at a precise flow rate. The diluted concentration of fluorescence is measured downstream in the marine environment with the use of appropriate instrumentation. Rhodamine dye is highly fluorescent and can therefore be detected in very low concentrations. Sampling for dye fluorescence will be undertaken at the time of the first gradient sampling event. Early results of the dye tracer study will inform the design of the remaining sampling program (i.e. sampling design has some flexibility to be adjusted based on the results of the dye test).	EQVRP stage
6.2.4	Whole Effluent Toxicity Testing	WET testing will be conducted on samples taken from the final waste water sump during the EQVR period to evaluate the toxicity of the combined waste water discharge. Results of sampling during the commissioning period will be used to inform the selection of a discharge scenario where the resulting effluent sample is considered representative of the most likely worst-case condition (and includes UMF and UF backwash).	EQVRP stage

Section		Actions	Timing
		In addition to the sampling and analyses outlined in Table 6.1, further detailed chemical composition analyses will be conducted coincident with WET testing to provide information which may assist in diagnostics, including the origin of the toxic effect if/where appropriate. This may also assist by providing information on constituents which were not anticipated based on the review of contaminants of concern as identified in Table 3.2, Table 3.3 and Table 3.4. This suite of tests will be conducted at a NATA accredited laboratory, and will nominally include a range of hydrocarbon suites, constituents of the backwash water and a 'scan for unknowns' to evaluate against a reference database of chemical signatures.	
		WET testing will be undertaken on a minimum of five locally relevant species from four different taxonomic groups using the recommended protocols from ANZECC & ARMCANZ (2000).	
		Proposed tests and locally relevant species to be used in the WET testing for this Plan are listed below, although other locally relevant species will be used if these species are unavailable: 1. 72-hr (chronic) marine algal growth inhibition test using *Nitzschia closterium.* 2. 48-hr (chronic) larval development using the milky oyster *Saccostrea echinata.* 3. 72- hr (chronic) larval development test using the sea urchin *Heliocidaris tuberculata*. 4. 48-hr (acute) toxicity test using the copepod *Parvocalanus crassirostris.* 5. 7-day (chronic) larval fish imbalance and biomass (dry weight) test using pink snapper *Pagrus auratus* or yellowtail kingfish *Seriola lalandi*.	
		A description of each WET testing method listed above, along with the method that the testing is based on, are provided in Appendix C. Samples for WET testing will be taken in accordance with the sampling kit and instructions provided by the laboratory undertaking the ecotoxicological analysis.	
6.2.5	Revision to EQC & Dilution	The outcomes of the WET testing program (Section 6.2.4) will be used to revise the EQC and hence the number of dilutions required at each LEP boundary (Section 4.4) as prescribed by Ministerial Condition 13-12(iv). Revised EQC will be derived following WET testing by assessing the species sensitivity distribution using a suitable statistical software package (e.g. BurrliOZ, Campbell et al. 2000), in order to be protective of the relevant levels of ecological protection.	EQVRP stage
6.3	Post EQVR Operations	Following the EQVRP stage* (Section 5.2.1) a licence, required under Section 56 of the EP Act, must be obtained prior to operating the facility (as described in the Part V Works Approval). A licence application is proposed to be submitted concurrently with the EQVR (Section 7.1), however there will be a period between the completion of the EQVRP stage and when a licence is granted by the DWER. *The EQVRP stage will be considered complete once marine monitoring (validation) has concluded.	Post- EQVRP stage & Pre-Operations

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Section		Actions	Timing
		Chevron Australia will continue to control, manage, monitor and report (if required) waste water discharges in accordance with the commissioning requirements of the Plan (Section 6.1) until such time a licence to operate is granted by the DWER. The EQVR, and/or consultation with DWER, may also be used to reassess the monitoring requirements and frequency during this period.	
6.4	Operations	Operational monitoring and management will be managed under the Part V licence. A plan describing ongoing operational monitoring and management will be prepared to support the licence application.	Operations
		Operational monitoring and management will be managed under the Part V operating licence. A revised list of potential contaminants of concern (to be monitored onshore) will be derived based on an assessment of the risk posed by each contaminant as identified by the EQVR. Conservative onshore targets will be derived in order to ensure ongoing achievement of the EQOs and LEPs and will be documented in the EQVR along with guidance for ongoing monitoring and management to support the Part V licensing process.	
		Onshore targets will be set to be protective of EQC in the marine environment by applying a dilution factor derived from the results of the EQVRP per the modified formula following Zaker et al. (2001): Onshore target = ((Dilution x (Existing Offshore Target – Baseline)) + Baseline.	
		If the composition of a discharge changes significantly under typical conditions from that described in Section 4.0, the requirement for additional validation monitoring will be reviewed and relevant monitoring will be performed as necessary.	
Reporting			
7.1	Effluent Quality Validation Report	In accordance with MS 873 Condition 13-12(v) and Condition 44 (EPBC 2008/4469), Chevron Australia is required to submit a waste water discharge report to the DWER and the Commonwealth Minister for the Environment within six months* of commissioning of a discharge or within six months of any significant change in composition of a discharge, including any management actions necessary to achieve the EQOs and LEPs established through MS 873 Condition 13-1 and described in MS 873 Schedule 2. *Chevron Australia will submit an EQVR to the DWER within 6 months of the completion of marine water quality monitoring.	EQVRP stage & Operations
		In accordance with Condition 44 (EPBC 2008/4469), Chevron Australia is required to submit an onshore facilities waste water discharge report to the Commonwealth Minister for the Environment.	
		Consistent with MS 873 Condition 13-15, in the event that monitoring undertaken as part of the EQVRP (Section 6.0) indicates that the EQOs and LEPs established through conditions 13-1, and described in Schedule 2, are not being met, or are not likely to be met, a report of the findings of this monitoring will be provided to the CEO and the DWER as soon as practicable, but within five working days of	EQVRP stage

Section		Actions	Timing
		receiving the results, along with a description of the management actions to be taken to meet the required level of environmental quality.	
7.2	Annual Compliance Reporting	As part of the preparation of the annual CARs, Chevron Australia will assess its compliance status against this Plan, which will be guided by the action table provided in Appendix A.	As required
		The Compliance Assessment Plan requires that the Project CARs shall be made publicly available within one month of being submitted to the DWER. A copy of the most recent annual CAR will be placed on the Chevron Australia website until the subsequently annual CAR is placed on the website. Annual CAR's from previous years will be made publicly available on request for the life of the Project.	
7.3	Non-compliance Reporting	MS 873 Condition 4-5 requires that any potential non-compliance, relevant to this Plan, will be reported to the CEO of the DWER within seven working days of that potential non-compliance being known.	As required
		EPBC 2008/4469 Condition 3 requires non-compliance with this Plan to be reported to DOTEE at the time the CAR is published on Chevron Australia’s website.	

Appendix B Modelling Results

Overview

Table A 1, Table A 2, Table A 4 and Table A 5 included in this appendix provide the number of dilutions to meet the EQO. They also show waste water discharge concentrations along with predicted concentrations of modelled constituents for two simulations representing typical summer and winter ambient and operating conditions, respectively. As described in Section 4.1, the two simulations each of one month duration represent differing character of the intake seawater and differing requirements and operations of the permanent waste water treatment and discharge facilities over a year. The results show that all four selected constituents meet their respective environmental target concentrations at the boundaries of the Moderate and High LEP zones, with the exception of situations where the ambient concentration is already at or above stipulated target concentration.

Table A 3 and Table A 6 show the highest mean and maximum concentrations for selected relevant constituents at the seawater intake location for the two simulations. They also show Percentage Exceedance which is calculated as the percentage time that the instantaneous concentration is below the lower bound or above the upper bound over the entire duration of the simulation. The predicted concentrations at the intake show that both the mean and temporal max values are within the acceptable range at the intake, with the exception of Ntot for which the imposed summer ambient concentration is itself above the maximum design value for the desalination plant. No degradation in the performance of the onshore facilities is anticipated due to any seawater intake recirculation.

Table A 1: Simulation 1 Results at Moderate LEP Boundary - Typical Summer Conditions

Waste Water Constituent	Seawater Intake Concentration (C_{amb}), (mg/L)	Waste Water Discharge Concentration Range (C_{eff0}), (mg/L)		Moderate Ecological Protection Boundary					
				Max median Concentration(1) at Moderate LEP Boundary (C_{effm}), (mg/L)	EQC for Moderate LEP Boundary (C_{crm}), (mg/L)	Range of Dilutions Required to Meet EQC at Moderate LEP Boundary (D_{crm})(2)		Effective Dilution over 28 Days at Moderate LEP Boundary (D_{effm})(2)	Below EQC (YES/NO)
		Min	Max			Min	Max	Median	
TDS	34 900	27 303	45 809	34 903	39 500	N/A	3	3895	YES
Ntot	0.24	1.5	2.8	0.240	0.260	63	128	6244	YES
Ptot	0.0075	0.15	0.31	0.0075	0.0175	15	31	6480	YES
O&G TSE	0.0	0.60	1.33	0.005	0.007	86	190	289	YES

Notes:

(1) Median Concentration is calculated as the median value of the model results over the entire duration of the simulation (28 days). For O&G TSE the 95th percentile is used instead of the median.

(2) $D_{crm} = (C_{eff0} – C_{amb})/(C_{crm} – C_{amb})$; $D_{effm} = (C_{eff0} – C_{amb})/(C_{effm} – C_{amb})$.

Table A 2: Simulation 1 Results at High LEP Boundary - Typical Summer Conditions

Waste Water Constituent	Seawater Intake Concentration (C_{amb}), (mg/L)	Waste Water Discharge Concentration Range (C_{eff0}), (mg/L)		High Ecological Protection Boundary					
				Max median Concentration(1) at High LEP Boundary (C_{effh}), (mg/L)	EQC for High LEP Boundary (C_{crh}), (mg/L)	Range of Dilutions Required to Meet EQC at High LEP Boundary (D_{crh})(2)		Effective Dilution over 28 Days at High LEP Boundary (D_{effh})(2)	Below EQC (YES/NO)
		Min	Max			Min	Max	Median	
TDS	34 900	27 303	45 809	34 901	39 400	N/A	3	> 10 000	YES
Ntot(3)	0.24	1.5	2.8	0.240	0.225	N/A	N/A	> 10 000	NO
Ptot(3)	0.0075	0.15	0.31	0.0075	0.0075	N/A	N/A	> 10 000	NO
O&G TSE	0.0	0.60	1.33	0.001	0.007	86	190	1458	YES

Notes:

(1) *Median Concentration is calculated as the median value of the model results over the entire duration of the simulation (28 days). For O&G TSE the 95th percentile is used instead of the median.*

(2) $D_{crh} = (C_{eff0} - C_{amb})/(C_{crh} - C_{amb})$; $D_{effh} = (C_{eff0} - C_{amb})/(C_{effh} - C_{amb})$.

(3) *The constituent meets the target concentration, with the exception of situations where the ambient concentration is already at or above the target concentration.*

Table A 3: Simulation 1 Results at the Seawater Intake - Typical Summer Conditions

Waste Water Constituent	Seawater Intake Concentration (mg/L)	Waste Water Discharge Concentration Range (mg/L)	Temporal Mean Concentration(2) at Intake location (mg/L)	Temporal Max Concentration(2) at Intake location (mg/L)	Lower Bound of Design Concentration Range for Intake (mg/L)	Upper Bound of Design Concentration Range for Intake (mg/L)	Percentage Exceedance(3) below Lower Bound	Percentage Exceedance(3) above Upper Bound
TDS(1)	34 900	27 303 to 45 809	34 903	34 941	34 500	39 700	0	0
Ntot(1)(4)	0.24	1.5 to 2.8	0.240	0.257	0	0.2	0	100
Ptot1	0.0075	0.15 to 0.31	0.00755	0.00948	0	0.01	0	0
O&G TSE(1)	0.0	0.60 to 1.33	0.0	0.009	0	100	0	0

Notes:

(1) Raw Sea Water Intake data taken from mean March 2011 values in “Wheatstone LNG Development: Outfall Baseline Report - Water Quality around the Proposed Nearshore Outfall”, Report No. MSA188R1, 30 January 2013 (MScience 2013).

(2) Temporal Mean and Max Concentrations are calculated for a time series containing the vertical maximum concentration at each output time step at the location of the intake.

(3) Percentage Exceedance is calculated as the percentage time that the instantaneous concentration is above the upper bound over the entire duration of the simulation (28 days).

(4) The summer ambient Ntot concentration is already above max design value for the desalination plant and therefore the Ntot predicted concentration does not meet the acceptable design range at the intake.

Table A 4: Simulation 2 Results at Moderate LEP Boundary - Typical Winter Conditions

Waste Water Constituent	Seawater Intake Concentration (C_{amb}), (mg/L)	Waste Water Discharge Concentration Range (C_{eff0}), (mg/L)		Moderate Ecological Protection					
				Max median Concentration(1) at Moderate LEP Boundary (C_{effm}), (mg/L)	EQC for Moderate LEP Boundary (C_{crm}), (mg/L)	Range of Dilutions Required to Meet EQC at Moderate LEP Boundary (D_{crm})(2)		Effective Dilution over 28 Days at Moderate LEP Boundary (D_{effm})(2)	Below EQC (YES/NO)
		Min	Max			Min	Max	Median	
TDS(3)	39 500	31 772	57 436	39 500	39 500	N/A	N/A	> 10 000	NO
Ntot	0.16	1.5	5.2	0.160	0.260	14	51	> 10 000	YES
Ptot	0.005	0.16	0.58	0.0050	0.0175	13	46	> 10 000	YES
O&G TSE	0.0	0.11	0.42	0.001	0.007	16	60	539	YES

Notes:

(1) Median Concentration is calculated as the median value of the model results over the entire duration of the simulation (28 days). For O&G TSE the 95th percentile is used instead of the median.

(2) $D_{crm} = (C_{eff0} - C_{amb})/(C_{crm} - C_{amb})$; $D_{effm} = (C_{eff0} - C_{amb})/(C_{effm} - C_{amb})$.

(3) The constituent meets the target concentration, with the exception of situations where the ambient concentration is already at or above the target concentration.

Table A 5: Simulation 2 Results at High LEP Boundary - Typical Winter Conditions

Waste Water Constituent	Seawater Intake Concentration (C_{amb}), (mg/L)	Waste Water Discharge Concentration Range (C_{eff0}), (mg/L)		High Ecological Protection					
				Max median Concentration(1) at High LEP Boundary (C_{effh}), (mg/L)	EQC for High LEP Boundary (C_{crh}), (mg/L)	Range of Dilutions Required to Meet EQC at High LEP Boundary (D_{crm})(2)		Effective Dilution over 28 Days at High LEP Boundary (D_{effh})(2)	Below EQC (YES/NO)
		Min	Max			Min	Max	Median	
TDS	39 500	31 772	57 436	39 500	39 400	154	N/A	>10 000	NO
Ntot(3)	0.16	1.5	5.2	0.160	0.225	21	78	> 10 000	YES
Ptot(3)	0.005	0.16	0.58	0.0050	0.0075	62	230	> 10 000	YES
O&G TSE	0.0	0.11	0.42	0.0	0.007	16	60	1987	YES

Notes:

(1) *Median Concentration is calculated as the median value of the model results over the entire duration of the simulation (28 days). For O&G TSE the 95th percentile is used instead of the median.*

(2) *Dcrh = (Ceff0 – Camb)/(Ccrh – Camb); Deffh = (Ceff0 – Camb)/(Ceffh – Camb).*

(3) *The constituent meets the target concentration, with the exception of situations where the ambient concentration is already at or above the target concentration.*

Table A 6: Simulation 2 Results at the Seawater Intake - Typical Winter Conditions

Waste Water Constituent	Seawater Intake Concentration (mg/L)	Waste Water Discharge Concentration Range (mg/L)	Temporal Mean Concentration(2) at Intake location (mg/L)	Temporal Max Concentration(2) at Intake location (mg/L)	Lower Bound of Design Concentration Range for Intake (mg/L)	Upper Bound of Design Concentration Range for Intake (mg/L)	Percentage Exceedance(3) below Lower Bound	Percentage Exceedance(3) above Upper Bound
TDS(1)	39 500	31 772 to 57 436	39 501	39 533	34 500	39 700	0	0
Ntot(1)	0.16	1.5 to 5.2	0.161	0.166	0	0.2	0	0
Ptot(1)	0.005	0.16 to 0.58	0.00506	0.00566	0	0.01	0	0
O&G TSE(1)	0.0	0.11 to 0.42	0.0	0.0	0	100	0	0

Notes:

(1) Raw Sea Water Intake data taken from mean March 2011 values in “Wheatstone LNG Development: Outfall Baseline Report - Water Quality Around The Proposed Nearshore Outfall”, Report No. MSA188R1, 30 January 2013 (MScience 2013).

(2) Temporal Mean and Max Concentrations are calculated for a time series containing the vertical maximum concentration at each output time step at the location of the intake.

(3) Percentage Exceedance is calculated as the percentage time that the instantaneous concentration is above the upper bound over the entire duration of the simulation (28 days).

Appendix C Whole Effluent Toxicity Testing Methods

WET Testing of Permanent Onshore Facilities Waste Water Discharges

Test / Species / Method		Notes
1.	72-hour microalgal growth inhibition *Nitzschia closterium* USEPA Method 1003.0 and Stauber et al., 1996 for the National Pulp Mills Research Program	A 72-hr growth test using the diatom *Nitzschia closterium* is the most extensively-used marine microalgal test in Australia. *N. closterium* is both benthic and planktonic and is widely distributed in Australian coastal waters (Stauber, 1995). This test utilises the temperate clone of alga which has been used in many ecotoxicological assessments and is sensitive to a wide range of metals, organic compounds and whole effluents (Florence and Stauber, 1986; Hogan et al., 2005; Stauber, 1995). The test is usually undertaken on a range of concentrations of a test material, e.g. 100, 50, 25, 12.5 and 6.3% effluent. At the end of the exposure period, algae cell yield is determined.
2.	48-hour larval abnormality tropical milky oyster - *Saccostrea echinata* Krassoi et al., 1996 for the National Pulp Mills Research Program	Many oyster species are of great ecological and economic importance in Australia, in particular *Saccostrea commercialis* (Smith et al., 2004), *Pinctada maxima* (Negri et al., 2004) and *Saccostrea echinata* (Peerzada and Dickinson, 1989). In northern Australian waters the black-lip oyster (*S. echinata*) are wild-harvested from rocky foreshore areas (van Dam et al. 2008). The vast majority of toxicity studies using oysters have assessed larval development and/or growth, endpoints that have provided one of the most rapid and sensitive toxicity tests (Geffard et al., 2002). The current test examines the effect of a range of concentrations of test material on the larval development of *S. echinata* from zygote to D-veliger stage, reached 48 hours after fertilisation. The test follows the standard ASTM protocol developed for North American bivalve species.
3.	72-hour larval development sea urchin *Heliocidaris tuberculata* APHA Method 8810D and Simon and Laginestra, 1997	The temperate sea urchin (Echinoderm), *Heliocidaris tuberculata*, has become widely used in toxicity testing programs in Australia, with fertilisation (1-hr exposure) and larval development (72-hr exposure) being the major endpoints measured (as summarised by Smith et al., 2004). Although a temperate species, *H. tuberculata* has been used in the past for toxicity testing in the Pilbara (API Management Pty Ltd, 2010) and is sensitive to saline effluent, making it suitable for the current discharges. This test involves exposing developing urchin embryos to the test material for 72 hours. The test is usually undertaken on a range of concentrations of a test material, e.g. 100, 50, 25, 12.5 and 6.3% effluent. At the end of the exposure period, the numbers of normally developed and abnormal larvae are counted.

Test / Species / Method		**Notes**
4.	48-hr acute toxicity copepod *Parvocalanus crassirostris* Rose et al., 2006	*Parvocalanus crassirostris* is a copepod species with known distribution in the tropical inshore waters of Western Australia. Copepods are important secondary producers in marine environments and are the natural prey for whales, seabirds, other crustaceans and larvae of most fishes. The acute toxicity test uses mainly laboratory reared copepods (juvenile) and based on the protocol for the tropical copepod *Acartia sinijensis* (Rose et al., 2006) with some modifications. The test is usually undertaken on a range of concentrations of a test material, e.g. 100, 50, 25, 12.5 and 6.3% effluent. At the end of the exposure period, the number of non-immobilised copepods is recorded.
5.	7-day Fish Imbalance and growth test Larval Marine Fish (subject to availability) USEPA Method 1004.0 USEPA 2002	Fish are the primary vertebrate component in aquatic systems and, as such, have comprised an integral part of toxicity assessments (Smith et al., 2004), with the early life stages of fish considered to be the most sensitive to toxicant exposure (McKim, 1977). The choice of species will be limited to either Australasian snapper (*Pagrus auratus*) or yellowtail kingfish (*Seriola lalandis*). These species are considered locally relevant and have been used regularly for toxicity assessments. In Australia, fry of these species are available from specialist commercial hatcheries. The test is usually undertaken on a range of concentrations of a test material, e.g. 100, 50, 25, 12.5 and 6.3% effluent. This test involves exposing fish larvae to the test material for 7 days. The fish are monitored daily for signs of distress or imbalance and the number of surviving and apparently healthy fish recorded. At the termination of the test the fish are euthanased, then dried at 60°C for 24 hours and then weighed.