Project Caymus - Environmental Monitoring Program

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Crowley Australia Pty Ltd
Project Caymus – Environmental Monitoring Program

Project Caymus
9 October 2024

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Jacobs Group (Australia) Pty Ltd

Level 2, Unit 10
25 Parap Road
Parap, NT 0820
PO Box 2145
Parap, NT 0804
Australia

T +61 8 8982 4800
F +61 8 8982 4840
www.jacobs.com

Contents

Appendices

Tables

Figures

1. Introduction

Crowley Australia (Crowley) as proponent for the Project Caymus Bulk Fuel Storage Facility was issued with an Environmental Approval under the *Environment Protection Act 2019* (EP Act) (EP2021/008-001) on 29 November 2021. The Approval was subsequently amended by variations to conditions 6(d), 11(i), 11(j) made pursuant to Section 65 of the EP Act. The Environmental Approval (EP2021/008-002) includes the following conditions related to environmental monitoring:

- Condition 7 – Monitoring and auditing
  - Condition 7 (a) Crowley to *design and implement a monitoring program, to the satisfaction of the CEO, which demonstrates compliance with condition 10g and 10l of the environmental approval.*
- Condition 10 – Marine environmental quality
  - Condition 10 (g) *Ensure that any stormwater that has the potential to be contaminated with hydrocarbons is retained on the premises and treated through an oily water separation device to a quality in accordance with Table 1 of Appendix 2 of this approval.*
  - Condition 10 (j) *Ensure any discharge of wastewater to the environment from the premises, after consideration of 10i, must:*
    - *Be controlled, such as through a pipe, in a manner that does not cause erosion*
    - *Be recorded, including details of the date, time discharge point location, name of the person monitoring the discharge, and the volume and rate of discharge; and*
    - *Be of a quality that meets 95% species protection for marine water under the Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), except as specifically authorised by another condition of this approval.*
  - Condition 10 (l) *The approval holder must conduct surface water and groundwater quality monitoring within the premises, in accordance with the monitoring program under conditions 7 that measures the parameters listed in Appendix 2.*

Crowley engaged Jacobs Group (Australia) Pty Ltd (Jacobs) to prepare an Environmental Monitoring Program to guide the ongoing environmental monitoring at site to ensure compliance with Conditions 7 and 10 (noted above).

1.1 Background

Project Caymus Bulk Fuel Storage Facility (referred to hereinafter as the site) is located on Lot 5720 west of the Railway Terminal on East Arm District, Northern Territory. The Environmental Approval covers the development and operation of a bulk aviation turbine (jet) fuel storage facility. Fuels permitted to be stored onsite include:

- JP-8 (Jet Propellant 8) - to meet the requirements of US Military Specification MIL-T- 83188D - North Atlantic Treaty Organisation (NATO) Code F34
- JP-5 (Jet Propellant 5) - to meet the requirements of US Military Specification MIL-PRF- 5624S Grade JP-5 - NATO Code F44

The Environmental Approval allows for:

- Construction of an access road
- Extension of an existing pipeline rack and pipeline
- Placement of 11 tanks in a tank farm, with a total storage capacity of 330 ML as follows
  - 4 x 30 ML tanks storing up to 111 ML of F34 (lower flash point (38°C) kerosene based jet fuel)
  - 7 x 30 ML tanks storing up to 190 ML of F44 (high flash point (>60°C) kerosene based jet fuel)
- Construction of a bunded area for the tank farm with concrete retaining walls and flooring designed to contain spills
- Unsealed paved areas outside of the tank farm to allow emergency and crane access

- Construction and operation of a common user facility incorporating:
  - a tanker loading gantry
  - park-up area for triple road tankers
  - warehouse and administration building
  - firewater system including tanks and pumps
  - oily water separation unit for treatment of collected stormwater

Fuel will be received and issued from ships berthed at East Arm Wharf via an extension to an existing pipeline rack and pipeline, and from triple road trains via a gantry. Figure 1-1 shows the site's location amongst the broader landscape and Figure 1-2 displays the arrangement of the site.

1.2 Existing Environment

The Northern Territory Environment Protection Authority identified two high value environmental elements which require focussed assessment and protection during the development and operation of the bulk fuel storage facility, namely the quality of the marine environment (discussed in Section 1.2.1) and air (currently being managed separately). Major threats to the marine environment include contamination leaving site via surface water and groundwater. The current understanding of surface water and groundwater on site is discussed in Section 1.2.3 and Section 1.2.4 respectively.

1.2.1 Surrounding Land Use

Land uses surrounding the site includes:

- North: Railway line, mangroves fronting Bleeser Creek.
- South: Natural mangrove environment and reclaimed land.
- East: Berrimah Freight Terminal, Darwin Railway Station, Berrimah Road (including the road over rail bridge), Berrimah Cattle Export yards, various industrial premises and vacant industrial lots.
- West: Global Resource Recovery, Vopak Terminal Darwin, Northern Cement Limited and conservation and natural environments.

1.2.2 Marine Environment

Darwin Harbour and its catchment covers approximately 3,230 km and extends south between Charles Point in the west and Gunn Point in the east. The area includes tributaries and estuarine areas of Cox Peninsula, West Arm, Middle Arm, East Arm and Shoal Bay. Several river systems drain to the estuary (Darwin, Blackmore, Elizabeth and Howard).

Darwin Harbour and its estuaries are fringed by mangroves, mudflats, reefs, and seagrasses and are home to dolphins, dugong, sea turtles, shorebirds and a large variety of fish. The harbour is classified as a tropical macro-tidal estuary with semi-diurnal tides which reach around 8 m, producing strong tidal movements which transport sediment within and across the harbour boundary.

The harbour has good water quality despite high turbidity levels. The fringing mangrove communities are largely undisturbed and remain generally healthy with present levels of development. The East Arm Peninsula is the centre of port services and development in Darwin Harbour, with large industry developments at East and Middle Arm Peninsulas.

East Arm receives urban stormwater runoff from the city of Darwin and a small volume of treated wastewater from the Berrimah plant into Bleesers Creek. Intact mangrove habitats remain along approximately half the coastline of the Peninsula.

Beneficial uses for marine surface water in the harbour have been declared under the Water Act 1992 for protection of the environment, culture, and aquaculture. Locally derived water quality objectives have been developed for some physico-chemical indicators and potential stressors. Guideline values for toxicant indicators are sourced from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

1.2.3 Surface Water

The Darwin region has a monsoonal climate, with a wet season lasting from November to April and the remainder of the year referred to as the dry season. During the transition from the dry season and throughout the wet season Darwin and surrounding areas experience many intense isolated, electrical and high rainfall storms. Darwin's mean annual rainfall of 1722.8 mm (Bureau of Meteorology data from Darwin Airport weather station (Station # 014015)) is highly seasonal varying from 1.1 mm in July to 431.3 mm in January.

The topography of the local area is relatively flat with the areas to the north and south of the site sloping towards the waterways / mangrove / mud flats, and slightly elevated areas to the east and west. Rainwater at the site and surrounding areas predominantly flows in earthen culvert drains prior to discharging into the local mangrove waters to the north. Some surface water can infiltrate through to ground. Surface water has the potential to flow onto the site from site from the eastern, and western boundaries. Onsite surface water that does not come into contact with fuel storage, transfer or containment areas is diverted through sediment control devices (Humeceptor), prior to discharge into the existing offsite culvert drains located at the eastern and western corners. Surface water that collects within the bunded area is discharged via an oil / water separator and is then discharge at the western corner of site (refer to Figure 1-2).

1.2.4 Groundwater

Darwin Harbour has a high tidal range with a maximum tidal range of around 8 m. The large tidal movement produces strong currents. Two high tides and two low tides are experienced daily, and the tidal range fluctuates over a lunar cycle. The following average tide data occurs in the Darwin Harbour area:

- Mean spring tide: 6.9 m (high) and 1.3 m (low).
- Mean neap tide: 5.0 m (high) and 3.2 m (low).

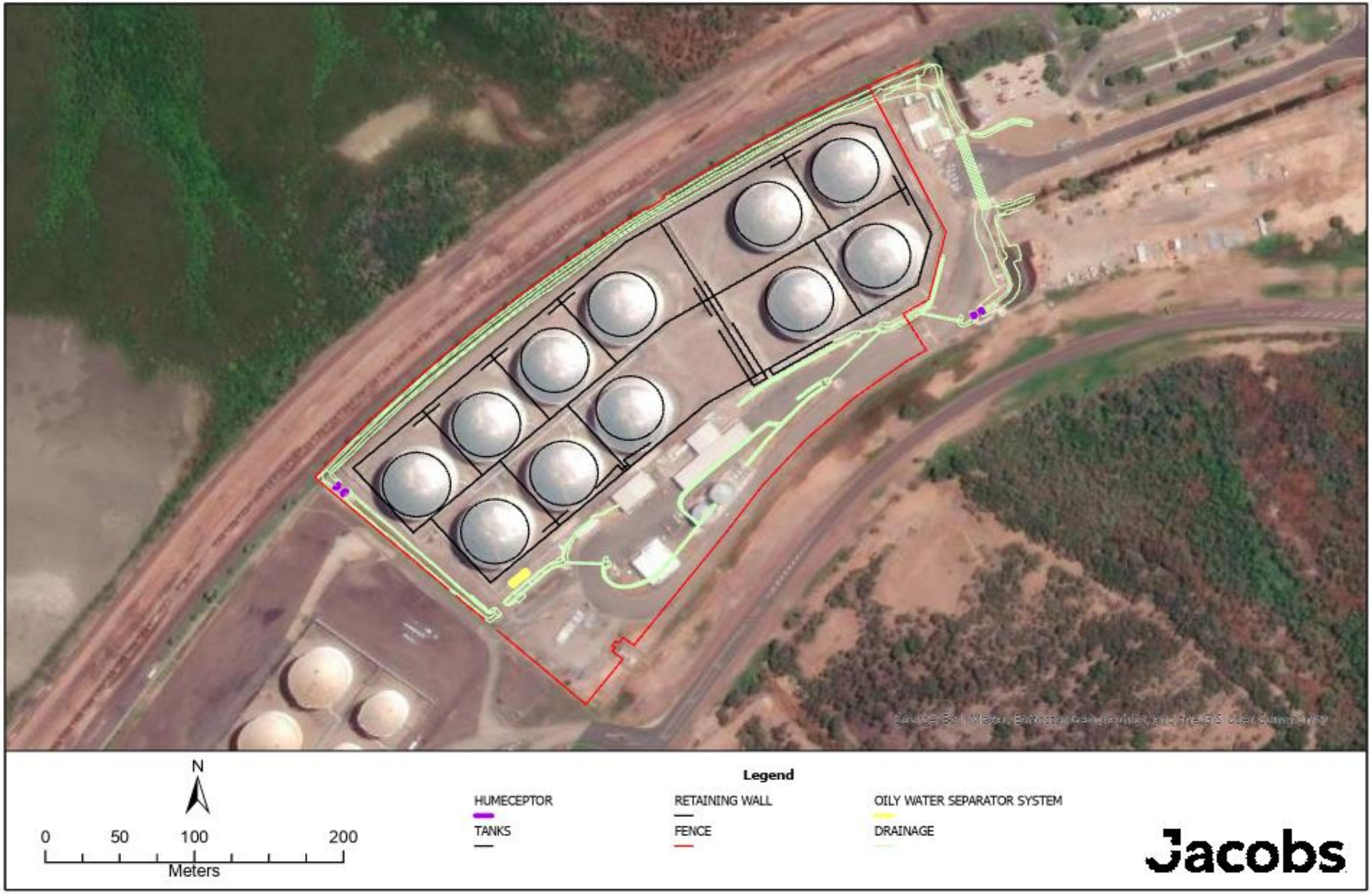
Groundwater immediately surrounding the Port of Darwin is heavily influenced by tidal change and sea water ingress.

Previous investigations identified groundwater level to be roughly 1-3m below surface at the end of wet season. Nearshore groundwater levels are likely to be influenced by tides. Groundwater levels are also likely to fluctuate seasonally. The investigations also found elevated concentrations of several potential contaminants of concern in groundwater, including perfluorooctanesulfonic acid (PFOS), ammonia, copper, lead, nickel, and zinc. These substances are associated with the import of fill material, local historical land use and naturally elevated background concentrations.

Groundwater flowing under the site is expected to be contiguous with the mangrove / marine waters, with the directions likely to change with tide and season. Significant differences in groundwater salinity and acidity were recorded in previous investigations suggesting that water across the site is not well connected.

Figure 1-1 Location and extent of site

Figure 1-2 Site Layout



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

2. Monitoring Locations

To achieve compliance with the requirements of the Environmental Approval, groundwater and surface water sampling locations have been nominated (refer to Table 2-1). The proposed locations are positioned to provide coverage of site and to assess potential contamination entering and leaving site. Access to each of the proposed locations was confirmed via site inspection.

Table 2-1 Monitoring Locations

Monitoring Location	Description	Location
Groundwater[1]		
MW01	To assess groundwater quality at north-eastern corner.	130.8991289°E 12.4758364°S
MW02	To assess groundwater quality at western boundary. Located in line with historic groundwater well.	130.8998101°E 12.4766313°S
MW03	To assess groundwater quality at southern corner. Located in line with historic groundwater well.	130.9006545°E 12.4772755°S
MW04	To assess groundwater quality at northeastern corner.	130.9014379°E 12.4763992°S
MW05	To assess groundwater quality at the northern corner. Located in line with historic groundwater well.	130.9022694°E 12.4755001°S
MW06	To assess groundwater quality at the western boundary.	130.9032933°E 12.4748627°S
Surface water		
SW01	To assess quality of water entering northern drain from northeastern humeceptor and upgradient drain.	130.8990183°E 12.4759881°S
SW02	To assess water quality entering site from Vopak plot.	130.9001602°E 12.4769129°S
SW03	To assess quality of water entering southern swale.	130.9009746°E 12.4773278°S
SW04	To assess quality of runoff water from nearby hardstand areas.	130.9031965°E 12.4748127°S
SW05	To assess water quality entering northeastern drain discharged from northeastern industrial area.	130.9052148°E 12.4735162°S
SW06	To assess water quality before being discharged into the marine environment	130.9027185°E 12.4734557°S
SW07[2]	To assess water pooling in southern swale.	130.9019306°E 12.4759968°S
SW08[2]	To assess water draining from railway area into northern drain.	130.9010365°E 12.4742508°S
Wastewater Discharge		
DIS01	To validate that any wastewater that has the potential to be contaminated with hydrocarbons has been treated by the oil water separation device.	130.9027365°E 12.4733493°S
DIS02	To assess water quality leaving the northeastern humeceptor (designed to remove TSS from water) and subsequently the site.	130.8990730°E 12.4760292°S

Notes:

1. Prior to construction a DSI (CDM Smith, 2021) was completed at the site, this included the construction of three groundwater wells across the site. These wells were subsequently removed during construction at site. It is proposed to reinstall these wells (to allow for comparison of pre-construction data with current data), and additionally three well locations have been proposed to allow for additional site coverage. It is understood that the proposed spatial distribution of groundwater wells across the site will facilitate the detection of any potential groundwater contamination that may arise from site operations, such as product leakage from storage tanks, spills during product transfer, or from general site operations.
2. Potential for surface water to never be present at location, allowance has been made to sample if water is present.

Figure 2-1 Map of groundwater monitoring bore

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Figure 2-2 Map of Surface Water Sampling Location

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Figure 2-3 Discharge Location

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

3. Assessment Criteria (trigger values)

The environmental approval states that water discharged from the premises is to be of a quality that meets the "95% species protection for marine water under the Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), except as specifically authorised by another condition of this approval."

In accordance with this, the adopted trigger levels will be based off the ANZG (2018)[1] marine water guidelines, targeting the parameters listed in Appendix 2 of EP2021/008 – 002. In accordance with similar facilities located within Darwin Harbour, a range of other parameters have also been recommended for monitoring.
Where the ANZG marine water guidelines does not provide criteria or the guideline considers the 95% protection level is inappropriate, trigger levels have been sourced by using:

- Guideline Values for the Protection of Aquatic Ecosystems – Upper Estuary Water Quality objectives Darwin Habour Region (DNRETAS, 2010)
- The 99% protection levels given in the guidelines for contaminants considered to be bioaccumulative (e.g. PFAS compounds, PAH compounds, cadmium)
- The ANZG (2018) guidelines do not provide criteria for TPH (C10 – C36). For this analyte, the Dutch Intervention Guideline (RIVM, 2000) for mineral oil (600 ug/L) will be adopted.

The sampling frequency and water quality parameters to be analysed is recommended in EP2021/008 – 002. Table 1, Appendix 2 of the environmental approval. This was adopted as a minimum requirement for the proposed monitoring program. Additional water quality parameters have been nominated for several sample locations the frequency of sampling at some locations has also been increased to provide a better characterisation of water quality during the startup phase of the project (refer to Table 3-1).

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[1] Where available the most up to date Australian & New Zealand Guidelines for Fresh and Marine Water Quality guidelines have been adopted.

3.1 Water Quality Objectives

The below table (Table 3-1) presents the proposed water quality objectives.

Table 3-1 Surface Water Quality Objectives

Parameter	Units	Sampling Type					
		Surface Water		Wastewater Discharge		Groundwater	
		Trigger Value	Frequency	Trigger Value	Frequency	Trigger Value	Frequency
Field Parameters							
pH	-	7.0-8.5[1]	Quarterly	7.0-8.5[1]	Weekly during any discharge	7.0-8.0[1]	Quarterly
Electrical conductivity	µS/cm	NA	Quarterly	NA	Quarterly	NA	Quarterly
Total suspended solids	mg/L	30[1]	Quarterly	30[1,5]	Weekly during any discharge	30[1]	Quarterly
Turbidity	NTU	4	Quarterly	4	Quarterly	NA	Quarterly
Dissolved oxygen	DO% saturation	80-100	Quarterly	80-100	Quarterly	80-100	Quarterly
Temperature	ºC	NA	Quarterly	NA	Quarterly	NA	Quarterly
Environmental Indicators[3]							
Ammonia nitrogen (NH3-N)	µg/L	20	Quarterly	20	Quarterly	20	Quarterly
Dissolved reactive phosphorous (PO4-P)	µg/L	10	Quarterly	10	Quarterly	10	Quarterly
Chlorophyll-a	µg/L	4	Quarterly	4	Quarterly	4	Quarterly
Biological oxygen demand	mg/L	NA	Quarterly	NA	Quarterly	NA	Quarterly
Total Recoverable Hydrocarbons	mg/L	10[1]	Quarterly	10[1]	Weekly during any discharge	10[1]	Quarterly
Total nitrogen	µg/L	300	Quarterly	300	Quarterly	300	Quarterly
Total phosphorus	mg/L	30	Quarterly	30	Quarterly	30	Quarterly
E.coli	MNP/100ml	200	Quarterly	200	Quarterly	200	Quarterly
Enterococci	MNP/100ml	50	Quarterly	50	Quarterly	50	Quarterly
Metals[2,4]							

Parameter	**Units**	**Sampling Type**					
		Surface Water		**Wastewater Discharge**		**Groundwater**	
		Trigger Value	Frequency	Trigger Value	Frequency	Trigger Value	Frequency
Arsenic	µg/L	NA	Quarterly	NA	Quarterly	NA	Quarterly
Cadmium	µg/L	0.7	Quarterly	0.7	Quarterly	0.7	Quarterly
Chromium (CrIII)	µg/L	27	Quarterly	27	Quarterly	27	Quarterly
Chromium (CrVI)	µg/L	4.4	Quarterly	4.4	Quarterly	4.4	Quarterly
Copper	µg/L	1.3	Quarterly	1.3	Quarterly	1.3	Quarterly
Iron	µg/L	NA	Quarterly	NA	Quarterly	NA	Quarterly
Lead	µg/L	4.4	Quarterly	4.4	Quarterly	4.4	Quarterly
Manganese	µg/L	NA	Quarterly	NA	Quarterly	NA	Quarterly
Mercury	µg/L	0.4	Quarterly	0.4	Quarterly	0.4	Quarterly
Nickel	µg/L	70	Quarterly	70	Quarterly	70	Quarterly
Silver	µg/L	1.4	Quarterly	1.4	Quarterly	1.4	Quarterly
Zinc	µg/L	8.0	Quarterly	8.0	Quarterly	8.0	Quarterly
BTEXN[2,4]							
Benzene	µg/L	700	Quarterly	700	Quarterly	700	Quarterly
Ethyl Benzene	µg/L	80	Quarterly	80	Quarterly	80	Quarterly
Toulene	µg/L	180	Quarterly	180	Quarterly	180	Quarterly
m-Xylene	µg/L	75	Quarterly	75	Quarterly	75	Quarterly
o-Xylene	µg/L	350	Quarterly	350	Quarterly	350	Quarterly
p-Xylene	µg/L	200	Quarterly	200	Quarterly	200	Quarterly
Polyclyclic aromatic hydrocarbons[2,4]							
Anthracene	µg/L	0.01	Quarterly	0.01	Quarterly	0.01	Quarterly
Benzo(a) pyrene	µg/L	0.1	Quarterly	0.1	Quarterly	0.1	Quarterly
Fluoranthene	µg/L	1.0	Quarterly	1.0	Quarterly	1.0	Quarterly
Naphthalene	µg/L	50	Quarterly	50	Quarterly	50	Quarterly

Parameter	**Units**	**Sampling Type**					
		Surface Water		**Wastewater Discharge**		**Groundwater**	
		Trigger Value	Frequency	Trigger Value	Frequency	Trigger Value	Frequency
Phenanthrene	µg/L	0.6	Quarterly	0.6	Quarterly	0.6	Quarterly
TPH[2]							
TPH C10-C14	µg/L	600	Quarterly	600	Quarterly	600	Quarterly
TPH C15-C28	µg/L	600	Quarterly	600	Quarterly	600	Quarterly
TPH C29-C3	µg/L	600	Quarterly	600	Quarterly	600	Quarterly
TPHC6-C9	µg/L	600	Quarterly	600	Quarterly	600	Quarterly
TPH C10-C14	µg/L	NA	Quarterly	NA	Quarterly	NA	Quarterly
PFAS[2]							
PFOS	µg/L	0.13	Quarterly	0.13	Quarterly	0.13	Quarterly
PFOA	µg/L	220	Quarterly	220	Quarterly	220	Quarterly

Notes:

1. Values taken from Table 1 Appendix 2 of environmental approval EP2021/008 – 001
2. Parameters required by Table 2 Appendix 2 of environmental approval EP2021/008 – 002 for groundwater monitoring.
3. Trigger Values taken from Darwin Harbour Water Quality Objectives (DNRETAS, 2010)
4. Values taken from Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
5. TSS values at the DIS01 (Oil Water Separator) may potentially be higher during large discharge events. TSS values recorded at the DIS01 will be compared to those recorded at the DIS02 (northeastern humeceptor), to ensure TSS values are below trigger values before leaving site.

4. Description of Works

The following is the proposed monitoring program. Jacobs considers a staged approach for the collection of environmental data to be the most suitable sampling design. An outline of the staged approach summarised in Table 4-1.

Table 4-1 Outline of Monitoring Program

Sampling Phase	Description
Stage 1 – Development of Groundwater monitoring network	
Construction of monitoring wells	Includes the installation, development, and survey of groundwater monitoring wells, concurrently with the collection of soil samples (to be used in Pre-Operations Environmental Report).
Stage 2 - Environmental Monitoring	
Pre-Operations Environmental Investigation	Collection of environmental data ▪ Includes the collection of groundwater and surface water samples prior to the operation of site. ▪ Assessment is required across the Site to reflect the previous commercial/industrial use of the site. This investigation will cover a broad range of contaminants in both soils and groundwater to reflect the ongoing use of the Site and adherence to the environmental approval EP2021/008-001. Environmental data will support the development of appropriate responses to detections during the implementation of the environmental monitoring program. This will also be informed by historical data previously collected from the site and surrounding areas. Jacobs propose one environmental monitoring event to be conducted prior to site being operational. Soil, groundwater and surface water data collected will be paired with results displayed in CDM Smith (2021) to create a monitoring report. This data will help form the understanding of the onsite background environmental conditions prior to commissioning of the site.
Ongoing quarterly Groundwater and Surface water monitoring	Environmental Monitoring – Quarterly The approach will be to design the monitoring program to incorporate a number of surface water sampling locations that discharge offsite and representative upgradient locations. The program will also include temporal sampling to capture seasonal variance. Groundwater and surface water will be collected from across the site and sent for chemical analysis. An allowance for quarterly monitoring has been made, but it is understood due to seasonal variations there is unlikely to be surface water onsite during the dry season. A quarterly technical memorandum will be produced displaying this data and an Annual Environmental Monitoring Report will collate the four memorandums and comment on trends.

Sampling Phase	Description
	It is proposed that the ongoing monitoring program is reviewed after the first year of monitoring is complete.
Wastewater Discharge Monitoring	Wastewater discharge samples will be collected directly from the oily water separator and the northeastern humeceptor, for chemical analysis, weekly during discharge events.
Annual Environmental Monitoring Program Review and Update	Undertake a yearly review of the environmental monitoring program to ensure it is capturing all the required information and determine if changes are required to the sampling plan. If the review finds changes are required, these will be presented to the EPA for approval before implementation.

5. Sampling Plan and Methodology

This section outlines the proposed sampling and analytical program for the collection of environmental data.

5.1 Stage 1 - Construction of new wells

Jacobs proposes setting up a groundwater monitoring network within the site premise, facilitating the groundwater quality monitoring required by the environmental approval.

5.1.1 Site Visit

The site inspection will include a walk over to identify suitable access for drill rigs and locations for groundwater monitoring wells to be installed. Specifically, the site inspection will include the following tasks:

- Document site facilities and key site features (including drainage features)
- Identify evidence of potential contamination including discoloured or oil staining on the ground surface, or notable odours.
- Identify surface water on or adjacent to the Site (if any) and potential discharge points for surface water runoff.
- Visual inspection of integrity of hard stand areas.
- Identify land uses of the immediate surrounds.
- Confirm drilling/sampling locations for the intrusive investigations and potential constraints to sampling in particular areas.

The site inspection may be undertaken by Jacobs during the service location.

5.1.2 Underground Service Clearance

Underground services pose a risk for intrusive investigations. To maximise safe working and minimise the potential for service strikes, the following approach is proposed:

- Acquisition and review of site specific utility plans from Crowley, where available.
- Collection and review of Before You Dig plans
- Utilities clearance of each proposed borehole location by a suitably accredited underground service locator using ground penetrating radar (GPR) and electromagnetic tools.
- Moving the borehole locations a safe distance from services.
- Where the density of underground services precludes the attainment of a safe distance from borehole locations, clearance of each proposed location will be carried out manually (hand auger) to ‘clear’ proposed borehole locations to the required target depth.

The service locating and clearance of each proposed groundwater monitoring well location will be completed under the supervision of a suitably qualified environmental scientist or engineer from Jacobs, in advance of the drill rig / excavator mobilising to site.

5.1.3 Borehole drilling/Groundwater Well Installation

Jacobs intends to advance six boreholes which will subsequently be converted into groundwater water monitoring wells. The wells will be progressed at locations where historical wells have been decommissioned, and additional locations to ensure coverage of onsite groundwater. Description of the groundwater sampling locations is given in Table 2-1 and are presented in Figure 2-1.

It is proposed that the six groundwater wells be installed to a maximum depth of 6 mbgl (this is in line with the depth of historic wells and is considered appropriate to classify potential contamination migrating from above ground fuel storage tanks) or excavation method refusal (whichever is shallower).

The initial drilling will follow the below methodology:

- Boreholes will be progressed using non-destructive drilling or hand-auger for the top.
- Bores will then be progressed to a target depth of 6m or excavation method refusal (whichever is shallower).
- Boreholes will be drilled using auger methods to V bit refusal/target depths.
- Soil samples will be collected at approximately 0.1 – 0.2 m bgl, 0.5 mbgl, 1.0 m bgl and 1 m intervals thereafter to the base of each sample location. Six soil samples are to be collected per borehole.
- Samples will be conducted following general procedures outlined in Appendix A.
- Soils will be logged according to Jacobs SOP for Soil and Rock Description, which is in general accordance with Australian Standard AS1726-2017.

Boreholes will then be converted into groundwater wells, installed in general accordance with the 'Minimum Requirements for Water Bores in Australia' (Version 4, National Uniform Drillers Licensing Committee, 2020). As a minimum, the installation of all groundwater wells will include:

- Construction of the well using 50mm UPVC casing and screen, packed with 8/16 (or finer) grade filter pack sand to a minimum of 0.5m above the well screen, and grouting of the borehole annulus to a minimum of 0.3m below the ground surface using pre-hydrated cement-bentonite grout.
- Allowance has been made for the wells to be completed with a 'monument' style headwork that will sit approximately 500mm above the ground, set in concrete, and fitted with adjustable well plugs.
- Wells will be screened from 1mbgl to the base, to ensure groundwater does not enter the well from over the screen.
- Coordinates and casing heights for each well location will be surveyed by a licenced surveyor.

5.1.4 Well Development

Following construction groundwater wells will be developed abiding by the following methodology:

- Development should be performed as soon as it is practical after the well is installed, but no sooner than 24 hours after grouting is completed, to reduce risk of collapsing screen or annulus materials.
- The wells will be developed via air-lift, Waterra® foot valve techniques or bailing to remove inputs from the drilling process and excess sediment from the monitoring well.
- A minimum of three well volumes of water will be removed to ensure fresh formation water enters the wells.
- Groundwater generated through well development is proposed to be retained on site unless visual and olfactory assessment indicate potential contamination. In which case purged water will be placed in drums for storage and off-site disposal at a later stage by a licenced contractor.

5.2 Stage 2 – Environmental Monitoring

Environmental monitoring will include groundwater, surface water and wastewater discharge monitoring. It will be broken up into an initial monitoring event prior to site being operational (pre-operations monitoring event) and ongoing monitoring post commissioning of site.

5.2.1 Groundwater Monitoring

Jacobs will to take groundwater samples from six locations over five monitoring events (one pre-operation event and four ongoing monitoring events). The groundwater investigation aims to assess the site's ongoing compliance with the environmental approval.

Groundwater monitoring will be conducted in accordance with the following methodology.

Well purging and gauging:

- Standard water levels (SWL) and depth to the base of the monitoring well will be measured at each monitoring well location using an electronic interface probe. The interface probe will be decontaminated between each location using demineralised water.
- A low flow micropurge pump equipped with new dedicated low density polyethylene tubing will be used to purge each well. The tubing inlet will be placed approximately at the mid-point of the top of groundwater and at the bottom of the well. Groundwater head will be monitored for drawdown using an electronic interface probe. Where use of a micropurge is not possible due to shallow groundwater levels, a low flow peristaltic pump will be used.
- The low flow micropurge groundwater sampling and peristaltic pumps will have flow control to minimise drawdown and allow general field quality parameters to stabilise during purging. During purging, standing water levels will be measured to gauge drawdown and allow for the adjustment of pumping rates.
- Field parameters including pH, conductivity, dissolved oxygen, redox potential, and temperature will be recorded during purging using a calibrated water quality meter fitted with a flow-through-cell.
- Purge water will be passed through a flow cell fitted with a water quality meter until field parameters stabilised as follows:
  - ± 10% or less than 0.5 mg/L for dissolved oxygen;
  - ± 5% for electrical conductivity:
  - ± 0.1 for pH units;
  - ± 10 mV for redox potential; and
  - ± 0.2 °C for temperature.
  - Turbidity will be visually assessed.

Groundwater generated through well purging will be collected for disposal offsite.

Well sampling:

- All samples are to be collected using new sterile nitrile gloves for each sample. Gloves are to be changed between the collection of each sample.
- Samples will be collected using disposable single use high-density polyethylene (HDPE) bladders and tubing or other single use disposal materials (dependant on the sampling technique selected).
- Samples will be field filtered using 0.45 μm filters for dissolved metals analysis. All samples will be collected using laboratory supplied containers.
- When PFAS is included in the analysis schedule, specific Teflon free sample containers will be used to collect water for PFAS analysis.
- Care will be taken to minimise disturbance of the sample to avoid aeration by minimising the distance between the outlet tubing from the pump/s and the container and tilting the container so that discharge will flow gently down the inner walls of the sample container.
- Any reusable sampling equipment will be decontaminated between sampling locations using triple wash procedure (Liquinox solution wash, followed by tap water rinse, then deionised water rinse).
- Rinsate samples will be collected from decontaminated reusable sampling equipment.

- General sampling procedures are further detailed in Appendix A.

5.2.2 Surface Water Monitoring

Jacobs intends to take surface water samples from up to eight different locations over five sampling events (one pre-operations monitoring event and four quarterly events). It is understood due to seasonal variability that surface water may not be present during the dry season, hence will only be collected when surface water is present. The surface water monitoring aims to determine surface water quality in addition to collating initial data for trend analysis (ongoing management).

Surface water monitoring will be conducted in accordance with the following procedure:

- Surface water samples will be collected as grab samples.
- Samples (where there is sufficient water to do so) will be collected using an extendable sampling pole where it is assessed to be safer than sampling directly by hand. The sample will be collected from approximately 0.5m below the surface.
- Specific containers will be used to fill all other containers as necessary. This process will be repeated until all sample containers for each location are filled or until the location is dry. No containers will be re-used between sample locations. All samples will be collected using laboratory supplied containers. Specific Teflon free sample containers will be used to collect surface water samples for PFAS analysis.
- A description of the surface water monitoring location and condition will be documented (photographs to be included).
- Field pH, specific conductivity, dissolved oxygen, redox potential and temperature will be recorded with a calibrated water quality meter at each surface water sample location. Turbidity will be visually assessed.
- Any reusable sampling equipment will be decontaminated between sampling locations using triple wash procedure (Liquinox solution wash, followed by tap water rinse, then deionised water rinse).
- Rinsate samples will be collected from decontaminated reusable sampling equipment.
- General sampling procedures are further detailed in Appendix A.

5.2.3 Wastewater Discharge Monitoring

Wastewater discharged from the discharge from the points detailed in

Figure 2-3 are required to be monitored on a weekly basis during discharge events. Once the site is operational, Jacobs intends to conduct the first two (2) rounds of sampling and then train operational staff to conduct future sampling events.

Wastewater discharge monitoring will be conducted in accordance with the following procedure:

- Wastewater discharge samples are proposed to be collected directly from the oily water separator and from the northeastern humeceptor, for chemical analysis, to assess water quality. Location detailed in Table 2-1 and
- Figure 2-3.
- Samples will be collected as grab samples.
- Field pH, specific conductivity, dissolved oxygen, redox potential and temperature will be recorded with a calibrated water quality meter at each surface water sample location. Turbidity will be visually assessed.
- Samples will be collected on a weekly basis (when discharge occurs) and includes duplicate and triplicate samples for QAQC (data quality assessment). Samples will be collected as per QAQC sampling procedures in the EMP.
    - 1 samples per week per nominated location when the oily water separator is discharging to the drainage line.
- The following details will be recorded at the time of sampling:

- Date
- Time
- Discharge point location
- Name of person monitoring the discharge
- Volume and rate of discharge

5.3 Sampling Nomenclature

The sample nomenclature used will be in accordance with Table 5-1.

Table 5-1 Sampling nomenclature

Sample Type	Sample ID
Borehole	BH0X_ZZ-ZZ_DDMMYYYY
Groundwater	GW0X_ZZ-ZZ_DDMMYYYY
Surface Water	SW0X_ZZ-ZZ_DDMMYYYY
Wastewater Sample	DIS0X_ZZ-ZZ_DDMMYYYY

0X – location identifying number starting from 01 and continuing sequentially.

ZZ-ZZ – denoted the depth that the sample has been collected in metres below ground level for borehole and test pit samples (top of sampling interval)

DDMMYYYY – date of sample collection

5.4 Analytical Schedule

Laboratory analysis will be undertaken at a National Association of Testing Authorities (NATA) accredited laboratory.

The proposed analytical schedule is detailed in the below **Table 5-2**.

Table 5-2 Proposed analytical schedule

Media	Number of locations	Number of sampling events	Number of samples to analyse	Analysis
Soil	6	1	36 primary samples 4 duplicates 4 triplicates	▪ Total Recoverable Hydrocarbon (TRH) C6-C40 ▪ Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene (BTEXN) ▪ Poly-aromatic Hydrocarbons (PAH) ▪ Phenols ▪ 15 Heavy metals ▪ Organochlorine (OC) and Organophosphate (OP) Pesticides ▪ Polychlorinated biphenyl (PCB) ▪ pH_f/pH_{fox} ▪ Chromium reducible sulfur (CrS)
Groundwater	6	1 baseline 4 ongoing monitoring events	30 primary samples 5 duplicates 5 triplicates	▪ TRH/BTEXN/PAH/ Heavy metals ▪ NEPM Water Suite: Ca, Mg, Na, K, pH, EC, Cl, F, SO4, Alkalinity,

Media	Number of locations	Number of sampling events	Number of samples to analyse	Analysis
				Hardness & Total Dissolved Solids (TDS)(Calc), Nitrate, Nitrite, Ammonia, Reactive Phosphorus, Total Phosphorous & Nitrogen, Total Kjeldahl Nitrogen (TKN) ▪ Per-and Polyfluoroalkyl Substances (PFAS)
Surface water	5	1 baseline 4 ongoing monitoring events	25 primary samples 5 duplicates 5 triplicates	▪ TRH/BTEXN/PAH/8 metals ▪ NEPM Water Suite: Ca, Mg, Na, K, pH, EC, Cl, F, SO4, Alkalinity, Hardness & Total Dissolved Solids (TDS)(Calc), Total Suspended Solids (TSS), Nitrate, Nitrite, Ammonia, Reactive Phosphorus, Total Phosphorous & Nitrogen, Total Kjeldahl Nitrogen (TKN) ▪ Per-and Polyfluoroalkyl Substances (PFAS)
Discharge water	1	Up to 25	25 primary samples 3 duplicates 3 triplicates	▪ TRH/BTEXN ▪ TSS

Table 5-3 Proposed QA analytical schedule

Media	Number of samples to analyse	Analysis
Soil	4 duplicates 4 triplicates	▪ Total Recoverable Hydrocarbon (TRH) C6-C40 ▪ Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene (BTEXN) ▪ Poly-aromatic Hydrocarbons (PAH) ▪ Phenols ▪ 15 Heavy metals ▪ Organochlorine (OC) and Organophosphate (OP) Pesticides ▪ Polychlorinated biphenyl (PCB) ▪ pH_{f}/pH_{fox} ▪ Chromium reducible sulfur (CrS)
Groundwater	5 duplicates 5 triplicates	▪ TRH/BTEXN/PAH/Phenols/8 metals ▪ NEPM Water Suite: Ca, Mg, Na, K, pH, EC, Cl, F, SO4, Alkalinity, Hardness & Total Dissolved Solids (TDS)(Calc), Nitrate, Nitrite, Ammonia, Reactive Phosphorus, Total Phosphorous & Nitrogen, Total Kjeldahl Nitrogen (TKN)

Media	Number of samples to analyse	Analysis
		▪ Per-and Polyfluoroalkyl Substances (PFAS)
Surface water	5 duplicates 5 triplicates	▪ TRH/BTEXN/PAH/Phenols/8 metals ▪ NEPM Water Suite: Ca, Mg, Na, K, pH, EC, Cl, F, SO4, Alkalinity, Hardness & Total Dissolved Solids (TDS)(Calc), Nitrate, Nitrite, Ammonia, Reactive Phosphorus, Total Phosphorous & Nitrogen, Total Kjeldahl Nitrogen (TKN) ▪ Per-and Polyfluoroalkyl Substances (PFAS)
Discharge water	3 duplicates 3 triplicates	▪ TRH/BTEXN ▪ TSS
Laboratory prepared trip blank/ trip spike	One blank/spike per batch of samples submitted to the laboratory	▪ BTEX.
Rinsate blank - soil	One per day per matrix where decontaminated equipment is used	▪ Total Recoverable Hydrocarbon (TRH) C6-C40 ▪ Benzene, Toluene, Ethylbenzene, Xylene, Naphthalene (BTEXN) ▪ Poly-aromatic Hydrocarbons (PAH) ▪ Phenols ▪ 15 Heavy metals ▪ Organochlorine (OC) and Organophosphate (OP) Pesticides ▪ Polychlorinated biphenyl (PCB)
Rinsate blank - Water	One per day per matrix where decontaminated equipment is used	▪ TRH/BTEXN/PAH/Phenols/8 metals ▪ NEPM Water Suite: Ca, Mg, Na, K, pH, EC, Cl, F, SO4, Alkalinity, Hardness & Total Dissolved Solids (TDS)(Calc), Nitrate, Nitrite, Ammonia, Reactive Phosphorus, Total Phosphorous & Nitrogen, Total Kjeldahl Nitrogen (TKN) ▪ Per-and Polyfluoroalkyl Substances (PFAS)

5.5 Sampling quality assurance / quality control

To ensure the field investigations and analyses are undertaken in a manner that enables the collection and reporting of reliable data, the following quality assurance / quality control (QAQC) samples will be collected.

Table 5-4 QAQC sampling nomenclature

QAQC Sample type	Sample ID
Blind duplicate	QC1XX_DDMMYY
Split duplicate	QC2XX_DDMMYY
Rinsate	QC3XX_DDMMYY

Trip blank	QC5XX_DDMMYY
Trip spike	QC6CC_DDMMYY

XX – sequential number independent of sample or matrix type

5.5.1 Field duplicates

Blind replicate samples will be provided by the collection of two environmental samples from the same location. These samples will be preserved, stored, transported, prepared and analysed in an identical manner.

5.5.2 Field splits

Split samples provide a check on the analytical proficiency of the laboratories. Split samples will be provided by the collection of two environmental samples from the same location. These samples will be preserved, stored and transported in an identical manner. The split samples will be analysed by the secondary laboratory.

5.5.3 Rinsate blanks

Rinsate blanks are collected from decontaminated field equipment using laboratory-supplied water. The purpose of the rinsate blanks are to detect potential cross-contamination associated with using the same equipment at multiple sampling locations. Rinsate will be conducted at the end of each field day.

5.5.4 Trip blanks and spikes

Trip blanks consist of laboratory-supplied purge water and clean sand. The purpose of trip blanks are to detect potential contamination during sample transport. Trip spikes are laboratory prepared samples used to determine whether loss of volatiles has occurred during sample transport. These samples will be kept within an insulated container during sampling activities and will bot be opened in the field. Trip blanks and trip spikes will be analysed at the laboratory for the standard suite as per the CoPC. Trip blanks and trip spikes will be submitted with every batch of soil and water samples delivered to the respective primary laboratory.

5.5.5 Laboratory control

Laboratory methods used by the laboratory are suitable for environmental contaminant analysis based on established internationally recognised procedures. The individual testing samples will conduct an assessment of the laboratory QC program and will also be independently reviewed and assessed by Jacobs. All laboratory QA/QC results will be documented with the laboratory certificates of analysis.

6. Reporting

Reporting will be conducted throughout the monitoring program. In general reporting will consist of the following:

- On receipt of laboratory results, Jacobs will review the analysis results, including QA/QC of data and undertake a trigger assessment. The trigger assessment will be completed to ascertain whether an exceedance against the proposed trigger values has occurred.
- Results will be verified by assessing whether the results are within natural variability (background levels). The natural variability will be based on relevant publications and background sampling results where available. Where the results are found to be higher than the natural variability range, an investigation into the potential cause will need to be undertaken.
- If exceedances of the trigger values are observed then Crowley will be notified within 12 hours, who will then subsequently notify the EPA.

6.1 Pre-operations Monitoring Report

Following the completion of the pre-operations monitoring fieldworks and receipt of all laboratory results, a monitoring report will be prepared. The report will present all data collected including field observations and laboratory test results. The following will be included in the report:

- A description of field works completed, including field observations
- Discussion on departures from this EMP (if any)
- Tabulated analytical results and field records
- Borelogs and groundwater well construction information
- A summary of the QA/QC data obtained and an assessment of the QA/QC results in comparison to the data quality indictors outlined in this EMP
- An assessment of the laboratory analytical results relative to the adopted site assessment criteria
- Comment on the soil analytical results relative to commercial / industrial land use criteria (human health and protection of ecosystems) and exposure risk to site workers
- Comment on the groundwater and surface water analytical results relative to the environmental approval.
- Comparison of results with the CDM Smith DSI (2021).
- Laboratory certificates

6.2 Quarterly Technical Memorandums

Factual summary reports are to be prepared at the completion of each quarterly monitoring event and an annual detailed monitoring report (incorporating all monitoring undertaken across the site for the annual monitoring period).

Some of the below elements may be covered by a direct reference to this EMP within the monitoring report.

6.2.1 Summary Reports

- The quarterly factual summary reports will include the following information:
- Detail that the quarterly monitoring program was undertaken in accordance with the EMP or provides discussion of departures from the EMP
- Discussion on the suitability of the use of the data in accordance with the quality control plan detailed in the EMP

- Discussion on the results of the monitoring program including field observations, in-situ water quality results, groundwater heights and flow direction, samples / compounds exceeding the adopted investigation levels
- Brief discussion on results which may represent potential immediate exposure risks to on-site and/or off-site receptors
- Recommendations (where required) to further investigate and/or manage immediate risks identified
- Site figures including exceedance figures
- Analytical tables detailing results against the adopted site assessment criteria
- Laboratory certificates
- Groundwater and surface water monitoring field sheets

6.2.2 Annual monitoring reports

Annual detailed monitoring reports will include the following information:

- Executive summary
- An introduction to the monitoring program, including background that details the history and context of monitoring which has been undertaken at the site to date
- The objectives and scope of works of the monitoring program, including the methodologies applied to the collection of groundwater and surface water
- The laboratory analysis plan detailing the analysis that was undertaken for each sample and the field and laboratory QA/QC program that was implemented
- QA/QC assessment of the field and laboratory QA/QC program and analytical results, as well as an assessment of the data quality indicators (DQI). A summary of the investigation levels (ecological based) will be applied to analytical sample results to evaluate groundwater and surface water quality. Analytical results will be screened against the adopted investigation levels.
- Results detailing the findings of the groundwater and surface water monitoring including groundwater gauging, intrinsic water quality (groundwater and surface water), and a summary of the analytical results and exceedances of the investigation levels. A trend assessment will also be included where results (exceeding the investigation levels) obtained during the annual monitoring period will be compared against historical results (where sufficient data is available) to provide an assessment of long term water quality and the effectiveness of the improvement works in reducing the offsite migration of contaminated water from the site.
- Concluding statements outlining the results of the groundwater and surface water monitoring, an assessment of the sites compliance with the environmental approval and overall risk of exposure to receptors from contamination sourced from the site (where identified).
- Recommendations (where required) to further assess the results of the monitoring program, risks to receptors and the performance of the site at complying with the environmental approval EP2021/008-002.

6.3 Operational Discharge Monitoring letters

Jacobs will provide the following reporting in regard to the Operational Discharge Monitoring:

- Weekly Operational Discharge Monitoring letter reports will be submitted 2 weeks following completion of monitoring (allowance for receipt of laboratory analysis).
- Letter report will include details of sample location observations, laboratory analysis undertaken and a discussion of the results, including comparisons against EPA assessment criteria / trigger values.

  - It should be noted that the oil water separators main purpose is to remove potential hydrocarbons in the discharge water, and the humeceptor removes suspended solids. Results from both of these locations will be compared with the assessment criteria to ensure compliance.
- Proposed delivery time is contingent on receiving analysis from laboratories within two weeks of the completion of the survey. Additional time may be required for reporting if there are delays in the provision of laboratory results.

7. References

Australian and New Zealand Governments and Australian State and Territory Governments - Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Water Quality Guidelines) 2018 (ANZWQG, 2018)

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Northern Territory Environment Protection Authority (June 2017) Northern Territory Contaminated Land Guideline, Version 1.0. (NT EPA, 2017)

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Appendix A. Sampling Protocols

A.1 General sampling procedures

The following general sampling procedures are to be adopted during the sampling program.

Table 7-1. Summary of general sampling procedures

	Summary
Field Records	At each sample location the following general information are to be recorded on field forms and retained for reporting purposes. ▪ Unique sample identification number ▪ Date of sample collection ▪ Weather conditions ▪ Initials of the sampling personnel ▪ Designation as to the type of sample (groundwater, soil, duplicate, rinsate etc.) ▪ Sample containers ▪ Collection method ▪ Any other relevant comments on sample appearance (odour, colour, sheen, filtering, preservation, etc.) Photographs are to be recorded where necessary.
Groundwater	Additionally, the following specific information is to be recorded during groundwater level dipping and sampling and surface water sampling (as applicable): ▪ Standpipe diameter and stick-up ▪ Total depth of well and thickness of sediment at the base of the well (if present) ▪ Depth to water and depth to NAPL (if present) ▪ Purging and sampling methodology for sampled wells ▪ Purged volume and purging time for sampled wells ▪ Depth to water after purging for sampled wells ▪ Depth to water after sampling ▪ Observable condition of surface water (e.g. presence of sheen, odour, turbidity, flow etc.) ▪ Field water quality parameter readings (temperature, pH, turbidity, redox potential, electrical conductivity and dissolved oxygen) recorded during purging and sampling of groundwater wells and sampling at surface water locations.
Surface water	Surface water sample collection method: ▪ Surface water samples will be collected by submerging the laboratory supplied sample containers (non-preserved containers only), with the top of the container facing down to a depth of just below (nominal 5cm) the surface of the water. Once fully submerged, the containers will be tilted up to allow water to flow into the container. Once filled the sample containers will be lifted out of the water where the sample volume will then be transferred into all preserved and non-preserved containers required to be filled for each location. ▪ Where direct access to the surface water sampling location is constrained (e.g., steep embankments, vegetation, elevated discharge point) an extendable sampling pole will be used. Using the sampling pole, the sample containers, where applicable, will be lowered into water with the top of the containers facing down. Once fully submerged, the containers will be tilted up to allow water to flow into the container. Once filled the sample containers will be lifted out of the water where the sample volume will then be transferred into all preserved and non-preserved containers required to be filled for each location.
Soil	Soil sample collection method:

[redacted]	▪ A Jacobs representative will be present during all borehole works and will be responsible for handling, collection, preservation and submission of all soil samples as part of the soil investigation. ▪ To provide an indication of potential organic volatile contaminants within soil, discrete, select soil samples will also be obtained at regular depth intervals, placed in a zip lock plastic bag, and screened for volatile organic compounds (VOC) using a photo-ionisation detector (PID). Samples will be submitted to ALS (primary laboratory) and Eurofins MGT (secondary laboratory). ▪ All samples are to be collected using new sterile nitrile gloves for each sample. Gloves are to be changed between the collection of each sample. Where hand or reusable (e.g. hand auger) tools are used, the sample is to be collected from the decontaminated tool. The samples will be placed into laboratory supplied containers (glass jar and PFAS fee jar) and/or zip lock bag. The glass jars are to be completely filled with minimal headspace. ▪ Field duplicate and triplicate samples will be collected. ▪ A description of each sampling location is to be recorded in the field logs and photographs are to be taken of each sampling location.

A.2 Decontamination

Strict hygiene procedures will be applied throughout the project in accordance with Jacobs SOPs to assure sample integrity and quality are achieved. Reusable equipment include hand augers, trowels, interface probes and groundwater and surface water sampling.

Samples can be contaminated with PFAS from a range of products, including new clothing, footwear, PPE and treated fabric and water-resistant products, sunscreen, polytetrafluoroethylene (PTFE) materials (such as Teflon, sampling containers with PTFE-lined lids, stickers and labels, inks, drilling fluids, decontamination solutions and reusable freezer blocks. These should not be work or used during any stage of sampling (at site, during transport etc.)

Field consumables and decontamination detergents (e.g. Liquinox or equivalent) are to be PFAS free.

Handling

The following should be applied:

- Sampling personnel should wash their hands with plain soap and rinse thoroughly in tap water
- Use laboratory supplied sample containers suitable for requested analysis LOR requirements, typically polypropylene or HDPE
- Avoid use of sampling consumables and reusable monitoring equipment that may contain PTFE (PTFE based compositions including Teflon)
- Ensure that Teflon coated materials and aluminium foil do not come into contact with the sample
- Chemical or gel-based cooling products are not to be used to keep samples cool.
- Recommended equipment for groundwater sampling includes low flow methods using silicon and/or HDPE tubing.
- Consumable sampling equipment is not to be reused

All non-dedicated sampling and measurement equipment is to be decontaminated prior to use for sampling, then before and after each use.

The decontamination procedures for reusable equipment is to comprise the following:

- Remove visible foreign matter (if present) by brushing and/or wiping

- Scrub with brushes and cleaning solution (e.g. Liquinox or equivalent mixed with potable water)
- Potable water rinse
- Deionised water rinse.

A.3 Sample storage and transportation

Samples are to be kept secure and cool in insulated containers containing ice for preservation in the field and during transport to the laboratory.

To reduce the potential influence of ice melt water, where PFAS analysis is being undertaken, sample containers are to be placed in a separate sealed bag and placed in the cooler containing ice. Ice melt water will be removed daily, and new ice will be added. The insulated container will be sealed with tape / security seals prior to being transported to the testing laboratory.

Samples are to be transported to the laboratories using chain of custody (CoC) documentation. Insulated containers filled with samples are to be security sealed, with glass containers packed to prevent breakage.

A.4 Chain of custody documentation

Standard CoC procedures will be used for each set of samples. A minimum of one CoC will be provided for each laboratory. The following information must be clearly written on each CoC:

- Laboratory name
- Samplers name
- Date sampled
- Sample identification code
- Sample type
- Requested analyses
- Date delivered to the laboratory
- Name and signature of person relinquishing sample control to the laboratory or courier, including date and time
- Name and signature of person who received samples from the sampler
- All subsequent changes in sample control
- Requested laboratory turnaround time.

The original CoC record must accompany the samples to the laboratory, with a copy signed by the person who collected the samples and the courier to be retained.

A.5 Storage and disposal of excess soil and groundwater

It is proposed to retain drilled soil and the purged water on site unless visual and olfactory assessment indicate potential contamination. In which case, drilled soil and purged water will be placed in drums for storage and off-site disposal at a later stage by a licenced contractor.

A.6 Data acceptance criteria

Quality control parameters will be assessed against the Data Acceptance criteria presented in Table 7-2.

Should data be found to deviate outside the acceptable criteria, further consideration shall be provided to identify potential causes, implication of any such deviations on the integrity of the dataset and the reliability of any conclusions made based on the dataset in question.

Table 7-2 Data Quality Indicators

Element	Data Quality Indicator (DQI)	Objectives	Acceptance Criteria
Field QAQC			
Standard procedures	Precision Accuracy Representativeness Completeness	▪ All sampling undertaken by suitably qualified and experienced Jacobs personnel ▪ Adherence to the relevant Jacobs Work Instructions or Standard Operating Procedure, including record keeping	▪ No deviation from standard procedure, unless deviation provides greater certainty and is reported ▪ All appropriate field records kept and maintained
Sample collection, preservation, handling, and analysis	Accuracy Representativeness	▪ All analysis within holding times ▪ Samples collected in appropriate containers for the analysis with suitable preservation applied upon collection ▪ Samples received at the laboratory in good condition, appropriately chilled and chain of custody intact	▪ Use of laboratory supplied sample containers ▪ Preservation and storage of samples chilled in insulated containers and transported to laboratories under chain of custody documentation. ▪ Samples received at laboratory appropriately chilled (<5°C) with ice. Samples remain not waterlogged and in separate bags to ice. ▪ Samples extracted and analysed within holding times relevant for the sample matrix. ▪ Use of NATA accredited laboratories for all analysis undertaken
Decontamination	Precision Accuracy Representativeness Comparability	▪ Prevention of cross-contamination between sampling locations ▪ Collection and analysis of rinsate blanks from reusable sampling equipment	▪ Decontamination using a triple wash system for all reusable equipment prior to sampling and between sampling locations. ▪ Collection of rinsate blanks from reusable sampling equipment at a rate of 1 per day, per matrix.
Collection of field quality control samples	Precision Comparability	▪ Field quality control sampling in accordance with AS 4482.1 – 2005	▪ Collection of blind replicate samples for analysis by the primary laboratory at a rate of ≥10%.

Element	Data Quality Indicator (DQI)	Objectives	Acceptance Criteria
			▪ Collection of split duplicates for analysis by the secondary laboratory at a rate of ≥10%. ▪ Collection of trip blanks and trip spikes at a rate of one per laboratory batch per sample matrix. ▪ Collection of rinsate blanks from reusable equipment at a rate of one per day when sampling equipment may contact multiple samples and/or multiple sample locations.
Calibration	Precision Representativeness	▪ Calibration of field measuring equipment as specified by the manufacturer and retention of calibration records.	▪ Daily check of equipment against known standards. ▪ Calibration of equipment if observed to be outside of acceptable range from standard. ▪ Calibration of field measuring equipment at the rate specified by the manufacturer. ▪ Calibration records for each event.
Data handling	Comparability Completeness	▪ Appropriate labelling of sampling containers ▪ Central database of correct field and laboratory data.	▪ Labelling of sample containers to include a unique sample identification number, date of collection, sampler's initials, and project number. ▪ Field data and laboratory reports undergo secondary check.
Intra-and inter-lab duplicate samples	Precision Comparability	▪ To ensure the primary data is reliable and fit for purpose. ▪ The assessment of blind replicate and split samples is undertaken by calculating the Relative Percent Difference (RPD) of the replicate or split concentration compared with the original sample concentration. ▪ The RPD is defined as: $RPD = 100 \times \frac{(X1 - X2)}{average}$	▪ Analysed for the same analytes as the primary sample. ▪ Typical RPDs are noted in AS 4482.1-2005 as between 30 – 50%. Higher RPDs may be acceptable for heterogeneous material or where concentrations are close to the LOR (i.e. less than 10 times the LOR).

Element	Data Quality Indicator (DQI)	Objectives	Acceptance Criteria
		Where, X1 and X2 are the concentration of the original and replicate samples.	
Trip blanks	Precision Accuracy Representativeness	▪ Ensure that cross contamination has not occurred from sampling equipment, sampling procedure, or during storage and transport of samples.	▪ Analytical result < LOR.
Trip spikes	Precision Accuracy Representativeness	▪ Ensure that volatile compound loss has not occurred during sample transport and storage.	▪ The trip spike is analysed after returning from the field and the % recovery of the known spike is calculated (70%-130%).
Rinsate samples	Precision Accuracy	Ensure that cross contamination has not occurred from sampling equipment, sampling procedure, or during storage and transport of samples.	Each rinsate sample is analysed for compounds included in the primary sample analysis. Analytical result < LOR.
Laboratory QA/QC			
Analytical methods	Precision Accuracy Comparability Repeatability	▪ NATA accredited methods used for all analyses undertaken.	▪ Primary and secondary laboratories NATA accredited methods for all analyses undertaken.

Element	Data Quality Indicator (DQI)	Objectives	Acceptance Criteria
Analysis of laboratory QA/QC samples	Precision Accuracy	▪ Laboratory QAQC samples are undertaken at a rate according to their NATA accreditation.	▪ Analysis of laboratory method blanks at a rate of one per 20 samples or one per batch, whichever is greater. ▪ Analysis of laboratory duplicates at a rate of one per 20 samples. ▪ Analysis of matrix spikes at a rate specified by the laboratory for each analyte. ▪ Analysis of laboratory control samples at a rate of one per sample batch ▪ Analysis of surrogate spikes at a rate specified by the laboratory for each analyte.
Laboratory duplicates	Precision	▪ To ensure precision of the analysis method and replicability of analysis due to potential sample heterogeneity. ▪ Assessment as per blind replicates and split samples	▪ One laboratory duplicate per process batch or two laboratory duplicates if the process batch exceeds 10 samples. ▪ Acceptance criteria for laboratory duplicates results as per laboratory quality control report.
Surrogates/ PFAS Extracted Internal Standards Matrix spike recoveries Laboratory Control Samples	Accuracy	▪ Matrix Spikes used to assess the effect of the matrix on the accuracy of the analytical method used and Laboratory Control Samples to evaluate matrix interference by comparison with matrix spikes. ▪ Surrogates and PFAS Extracted Internal Standards are added at the extraction stage in order to verify method effectiveness ▪ Assessment is undertaken by determining the percent recovery of the known spike or addition to the sample. ▪ The % Recovery is defined as: $\% Recovery = 100 \times \frac{C - A}{B}$	▪ One matrix spike sample per process batch. ▪ One laboratory control sample per process batch. ▪ Acceptance criteria for surrogates, matrix spike recoveries and laboratory control samples as per laboratory quality control report.

Element	Data Quality Indicator (DQI)	Objectives	Acceptance Criteria
		Where: A = concentration of analyte determined in the original sample B = added concentration C = calculated concentration	
Method blanks	Accuracy	▪ To assess potential bias introduced by the laboratory analytical method for a relevant analyte. A method blank assesses the component of the analytical result introduced from laboratory equipment. ▪ Each blank is analysed as per the original samples.	▪ Analytical result < LOR