

Environmental Management Plan (EMP)

**For: Proof of Concept
Domesticated High Health Tiger Prawn Program**



Australia's National Science Agency

Location: 13 Muramats Road, East Arm, Darwin, NT

**Prepared By: CSIRO
Date: 04/11/2025**

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Glossary of Acronyms and Technical Words

AAPA – Aboriginal Areas Protection Authority

Statutory body responsible for protecting Aboriginal sacred sites in the Northern Territory.

ACDP – Australian Centre for Disease Preparedness

A CSIRO-operated facility supporting diagnostic testing and validation for aquatic animal diseases, including prawn pathogens.

Alkalinity

A measure of the buffering capacity of water; its ability to neutralise acids and maintain pH stability.

ANZECC/ARMCANZ

Australian water quality guidelines used as reference for environmental values and objectives.

BOD₅ – Biological Oxygen Demand (5-day)

The amount of oxygen consumed by microorganisms over five days as they decompose organic matter: an indicator of organic pollution.

CRAS – Closed Recirculating Aquaculture System

A water-efficient system where water is continuously filtered and reused, with minimal external exchange.

DSP – Discharge Sampling Point

A designated sampling location for treated water being released from the aquaculture facility.

EC – Electrical Conductivity

A measure of water's ability to conduct electricity, often used as a proxy for salinity or dissolved ions.

E. coli (*Escherichia coli*) - E. coli is a key microbial indicator under the ANZECC (2000) guidelines for assessing primary contact recreational water quality and effluent discharge compliance.

Enterococci - Enterococci counts are required for estuarine and marine receiving environments under ANZECC (2000) and NT EPA guidance, providing a reliable measure of microbiological water quality.

EMP – Environmental Management Plan

A document outlining environmental controls, mitigation strategies, and compliance measures for a project.

EPL – Environment Protection Licence

A licence issued under the Waste Management and Pollution Control Act 1998 to regulate pollution-generating activities.

HCMP – Hudson Creek Monitoring Point

Designated water quality monitoring locations upstream and downstream of the discharge point in Hudson Creek.

HH – High Health

Describes animals bred and maintained in controlled, pathogen-free environments to reduce disease risk.

NH₃-N – Ammonia-Nitrogen

A toxic form of nitrogen commonly found in aquaculture effluent; monitored due to its risk to aquatic life.

NO₂ – Nitrite

A nitrogen compound in the nitrogen cycle; toxic at high concentrations and indicative of incomplete nitrification.

NO₃ – Nitrate

A stable nitrogen compound resulting from nitrification; can promote algal growth in excess.

NOI – Notice of Intent

A formal document submitted to the NT EPA outlining a project's environmental risks and proposed management actions.

NT EPA – Northern Territory Environment Protection Authority

Regulatory body overseeing environmental assessment, monitoring, and compliance in the NT.

PSSA – Primary Storm Surge Area

An Area with a 1% Annual Exceedance Probability (AEP) of inundation during cyclone-related storm surge.

RAS Skid

A modular unit integrating key filtration, pumping, and disinfection systems for a Recirculating Aquaculture System.

SPF – Specific Pathogen Free

Refers to aquaculture stock certified free of certain harmful pathogens under strict breeding and testing regimes.

SSSA – Secondary Storm Surge Area

An area with a 0.1% AEP of inundation during severe cyclonic events, adjacent to PSSA zones.

TP – Total Phosphorus

The total concentration of phosphorus in a water sample, including both particulate and dissolved forms.

TN – Total Nitrogen

A measure of all nitrogen forms (organic and inorganic) present in water.

TSS – Total Suspended Solids

Particles suspended in water that may reduce water clarity and affect aquatic life.

Turbidity (NTU)

A measure of the cloudiness of water caused by suspended particles, reported in Nephelometric Turbidity Units.

UV Treatment

A disinfection method using ultraviolet light to inactivate bacteria, viruses, and protozoa in water.

WDL – Waste Discharge Licence

A licence required under the Water Act 1992 to legally discharge wastewater to receiving environments.

WQMP – Water Quality Monitoring Program

A monitoring plan that outlines sampling locations, parameters, trigger values, and compliance procedures.

WQOs – Water Quality Objectives

Standards and guidelines for acceptable water quality set by the NT EPA, particularly for Darwin Harbour zones.

WSSV – White Spot Syndrome Virus

A highly contagious viral pathogen affecting prawns and other crustaceans, requiring strict biosecurity controls.

Regulatory Referral Consideration

CSIRO has reviewed its obligations under the *Environment Protection Act 2019* and *Environment Protection Regulations 2020*, with particular consideration of NT EPA's *Guidance for Proponents on Referring a Proposal (2021)*.

Using the pre-referral screening tool (Appendix 1 of the guidance), it has been determined that the East Arm Proof of Concept project is **not likely to have a significant impact on the environment**, for the following reasons:

- The project will operate within an existing industrial precinct with no requirement for major land clearing, earthworks, or alteration to natural watercourses.
- Discharge volumes are low (maximum 40kL/day) and subject to multi-stage treatment before release, in compliance with *Darwin Harbour Water Quality Objectives* and to be regulated under a Waste Discharge Licence (WDL).
- The facility will house only local species (e.g., Black Tiger prawns, algae, polychaetes) and implements robust biosecurity, including physical containment and sterilisation of discharge.
- No threatened species or sensitive ecological communities are expected to be impacted by the proposed activities.
- Storm surge and flood risks have been assessed and are appropriately mitigated through site layout, equipment housing, and operational response plans.

CSIRO has concluded that formal referral under the *Environment Protection Act 2019* is not required. This position has been formed in response to NT EPA guidance and in consultation with internal environmental and regulatory staff.

Waste Discharge Licence Application

As the project is not considered to trigger referral under the *Environment Protection Act 2019*, CSIRO will proceed with an application for a **Waste Discharge Licence (WDL)** under the *Water Act 1992*. The discharge volumes are minor (less than 20kL per day on average) and will be subject to multi-stage treatment, including mechanical filtration, ozone sterilisation, settlement, aeration, and ultraviolet (UV) disinfection, prior to release to Hudson Creek on outgoing tide only.

The WDL process provides an appropriate regulatory framework for managing the controlled release of treated effluent and ensuring compliance with the Darwin Harbour Water Quality Objectives. CSIRO is committed to transparency and environmental stewardship and will include monitoring and reporting commitments in the WDL application consistent with the site's Water Quality Monitoring Program (WQMP).

1 Information

1.1 Proponent

CSIRO (Agricultural and Food).

- **Address:** 564 Vanderlin Drive Berrimah, Darwin, NT, Australia.
- **Postal Address:** PO Box address is Private Bag No 44, Winnellie NT 0822.

1.2 Project Site

Project Address: 13 Muramats Road, East Arm, Darwin, NT, Section 3245, the Hundred of Bagot.

1.3 Project Overview

Establishment of a High Health (HH) Black Tiger prawn program utilising a Closed Recirculating Aquaculture System (CRAS) for sustainable prawn aquaculture.

1.4 Scope

This EMP is drafted in accordance with the **NT EPA Guideline for the Preparation of an Environmental Management Plan, Version 1.0, May 2015**. This EMP covers the proposed Proof of Concept (POC) Prawn facility known within this document as East Arm 1 and East Arm 2 located on a small footprint within the 13 Muramats Road site, it does not include any other sections of that site and or any other operations that occur at the Muramats Road site.

1.5 Regulatory Approvals:

The project requires:

- a Waste Discharge Licence (WDL),
- a NT Fisheries Aquaculture Licence (application submitted as a Notice of Intent 10/10/2025).

1.6 Contact person for this project

Table 1: Contact details of nominated responsible person for this project

Name	Email	Phone
Adam Chapman, CSIRO Aquaculture officer	Adam.Chapman@csiro.au	0497 042 809

1.7 Associated Reference Documents

This document must be read in conjunction with:

- **Notice of Intent (NOI) – “East Arm NOI – October 2025”**
- **Water Quality Monitoring Program (WQMP) – “East Arm WQMP – October 2025”**

These documents collectively guide compliance under the NT EPA’s expectations.

2 Introduction

This document serves as the **Environmental Environment Plan (EMP)** for the CSIRO Proof of Concept (POC) project, intended for submission to Northern Territory Environmental Protection Agency (NT EPA).

The POC project, located at the East Arm site (13 Muramats Road, Darwin, NT), aims to establish a sustainable, High Health (HH) breeding program for Black Tiger prawns, with the goal of developing a domesticated population that is Specific Pathogen-Free (SPF) for targeted pathogens.

In alignment with the Darwin Harbour Water Quality Objectives (WQOs) established by the Northern Territory Environment Protection Authority (NT EPA), this EMP provides comprehensive details on project objectives, operational procedures, biosecurity protocols, and environmental management strategies.

This Environmental Management Plan (EMP) is supported by a site-specific Water Quality Monitoring Program (WQMP), developed concurrently with the Notice of Intent (NOI) to ensure consistency across operational, regulatory, and environmental safeguards. The EMP, WQMP, and NOI are aligned in their treatment of discharge volumes, sampling frequencies, trigger values, and monitoring site selection. Together, these documents form an integrated and cohesive management framework that supports compliance with the Darwin Harbour Water Quality Objectives and the requirements of the Waste Management and Pollution Control Act 1998.

3 Overview

CSIRO seeks to establish a Proof of Concept (POC) aquaculture project at 13 Muramats Road, East Arm, Darwin, NT.

This site, fully developed and located within an industrial area, zoned DV (Development), is leased from Mr. Barry Sandford, and is being conducted to advance the production of domesticated, High Health (HH) Black Tiger prawns (*Penaeus monodon*), a key initiative for sustainable aquaculture in Northern Australia. The project will utilise Closed Recirculating Aquaculture Systems (CRAS) wherever possible to maximise water efficiency and biosecurity.

Although the East Arm site is located within an industrial zone extensively modified by activities such as the continuous dredging of East Arm, Darwin Harbour, and nearby industrial operations, it is bordered to the east by mangroves. Mangroves are ecologically significant, playing a critical role in supporting biodiversity, stabilising coastal areas, and serving as nurseries for marine life. While the surrounding environment includes these important mangrove ecosystems, the East Arm site itself is fully developed and lacks any natural features of ecological sensitivity.

The industrial setting and existing infrastructure make this site an optimal location for the POC project, enabling CSIRO to fast-track critical research, refine Closed Recirculating Aquaculture Systems (CRAS) technology for prawn breeding programs, and minimise potential environmental impact. Furthermore, the project aims to support the development of a larger Aquaculture Research Centre (ARC) which may be developed with key stakeholders such as NT Fisheries at a later date on another site, contributing to the long-term goal of establishing a commercially viable and environmentally sustainable prawn farming industry across Northern Australia.

By leveraging the modified nature of the East Arm site and its alignment with industrial zoning, the project seeks to balance development objectives with the protection of adjacent ecologically sensitive areas, such as mangroves. Monitoring and management plans have been developed to ensure that these ecosystems remain unaffected by the project's activities.

Cultural and Heritage Significance

Located on Larrakia Country, the East Arm site holds significant cultural heritage value, reflecting the deep connections of the Larrakia Peoples with the land and waters. CSIRO is committed to respecting and protecting cultural sites, artifacts, and features central to the Larrakia Peoples' identity.

Consultation will be conducted in accordance with the EMP.

Environmental and Ecological Context

The East Arm site, while industrially developed, is situated near ecologically sensitive areas supporting diverse marine and terrestrial species. The project prioritises preserving the region's natural biodiversity, minimising disruption, and preventing negative environmental impacts. Adhering to sustainable practices and water quality management will help maintain the balance of nearby ecosystems.

Community and Economic Context

The POC project has the potential to bring significant benefits to local and regional communities, potentially creating job opportunities, promoting economic growth, and supporting First Nations inclusion, notably through alignment with the planned Mapurlarri prawn project on Bathurst Island. By incorporating First Nations expertise, providing training, and supporting local employment, the project promotes sustainable development that aligns with both economic and cultural priorities, contributing positively to Northern Australia's aquaculture sector and local communities.

4 Scope and Objectives

The scope of this EMP encompasses the development, implementation, and monitoring of environmental management strategies for the East Arm project. It addresses direct impacts, such as discharge management and biosecurity protocols, as well as indirect environmental impacts, including those on nearby ecosystems and communities.

The project will advance the sustainable aquaculture of High Health Black Tiger prawns by utilising CRAS technology to reduce environmental impacts, control water quality, and ensure biosecurity. It is expected to provide a base population of domesticated High Health, Specific pathogen-free Black Tiger prawn stock from which a more expansive breeding program can be developed.

4.1 Main Objectives:

4.1.1 Biosecurity:

Implement disease control through stringent biosecurity protocols, UV filtration, ozone disinfection, and pathogen screening.

4.1.2 Water Quality Management:

Minimise environmental impact through compliance with Darwin Harbour Water Quality Objectives (WQOs), specifically in the Upper Estuary region.

4.1.3 Sustainable Waste Management:

Control solid and liquid waste to protect surrounding ecosystems.

4.1.4 Community and Economic Benefits:

Develop sustainable aquaculture practices to support local job creation, training, and collaboration with all stakeholders.

4.2 Indirect Environmental Impacts and Mitigation:

4.2.1 Ecosystem Impacts:

The project's potential effects on adjacent mangrove ecosystems, including changes in nutrient dynamics and water flow patterns, will be mitigated by maintaining compliance with Darwin Harbour Water Quality Objectives and through regular ecological monitoring. This combined with low discharge volumes and disinfection of wastewater will ensure that any potential effects are mitigated.

4.2.2 Community Impacts:

Potential effects on local communities, such as odour or noise from operations, will be minimised through strict operational controls and the ability to address concerns proactively.

5 Site Ownership

5.1 Freehold Title

The site will be leased from the owner Mr Barry Sandford for a period of five years with an option to extend that period for an additional two to five years, depending on the development process for the ARC.

5.2 First Nations

CSIRO recognises the deep cultural significance of the lands and waters associated with the East Arm site in Darwin, located on Larrakia Country. CSIRO is committed to fostering respectful, meaningful partnerships with the Larrakia Peoples of Garramilla (Darwin).

CSIRO will engage with the Larrakia Peoples and provide them with an update on the project and the opportunities that it may provide to them, to their community and their people.

Image 1: Muramats Road in relation to Darwin

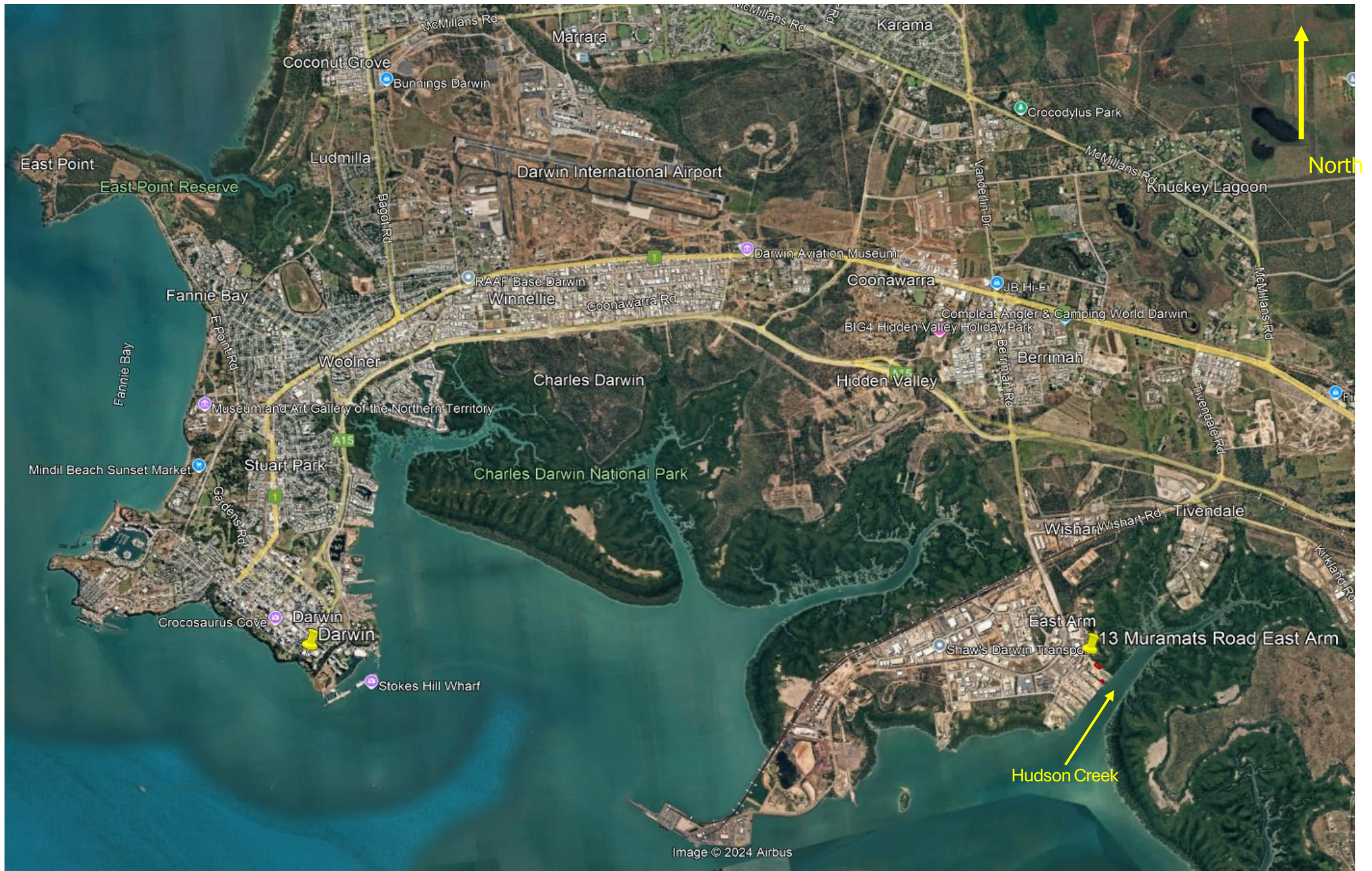


Image 2: 13 Muramats Road in relation to East Arm Industrial area



Image 3: Subject Site



Figure 1: Zoning and locality



6 Site Details

6.1 Location:

The site location is shown in Image 1 and Image 2, with details summarised in Table 2 below:

Table 2: Site Details

Latitude	-12.4771922
Longitude	130.9294776
Datum	GDA94
Street address	13 Muramats Road, East Arm, Darwin, NT
Lot/Section number	Section 3245
Town/Hundred	Hundred of Bagot

6.2 Site Size:

3 Muramats Road is a multi-use location with sections of the site operated by various companies. The site has a total land area of **approximately five hectares**.

- CSIRO will lease two small sections of the site previously operated by Monsoon Aquatics.
- These areas will be known as: **East Arm Area 1** and **East Arm Area 2**.

6.3 East Arm Area 1:

Consists of a section of the 13 Muramats Rd site measuring 80 x 27m, or **2160m²**

It currently contains:

- A main site shed measuring 16 x 27m, or approximately **430m²**.
- Attached Annex measuring 9 x 16m, or approximately **144m²**.
- A demountable office.

6.4 East Arm Area 2:

Consists of a section of the 13 Muramats Rd site measuring 52 x 20m, or **1040m²**.

It currently contains:

- Two shipping containers.
- An attached Annex between the shipping containers measuring 12 x 14m, or approximately **160m²**.
- A demountable office.

6.5 Zoning

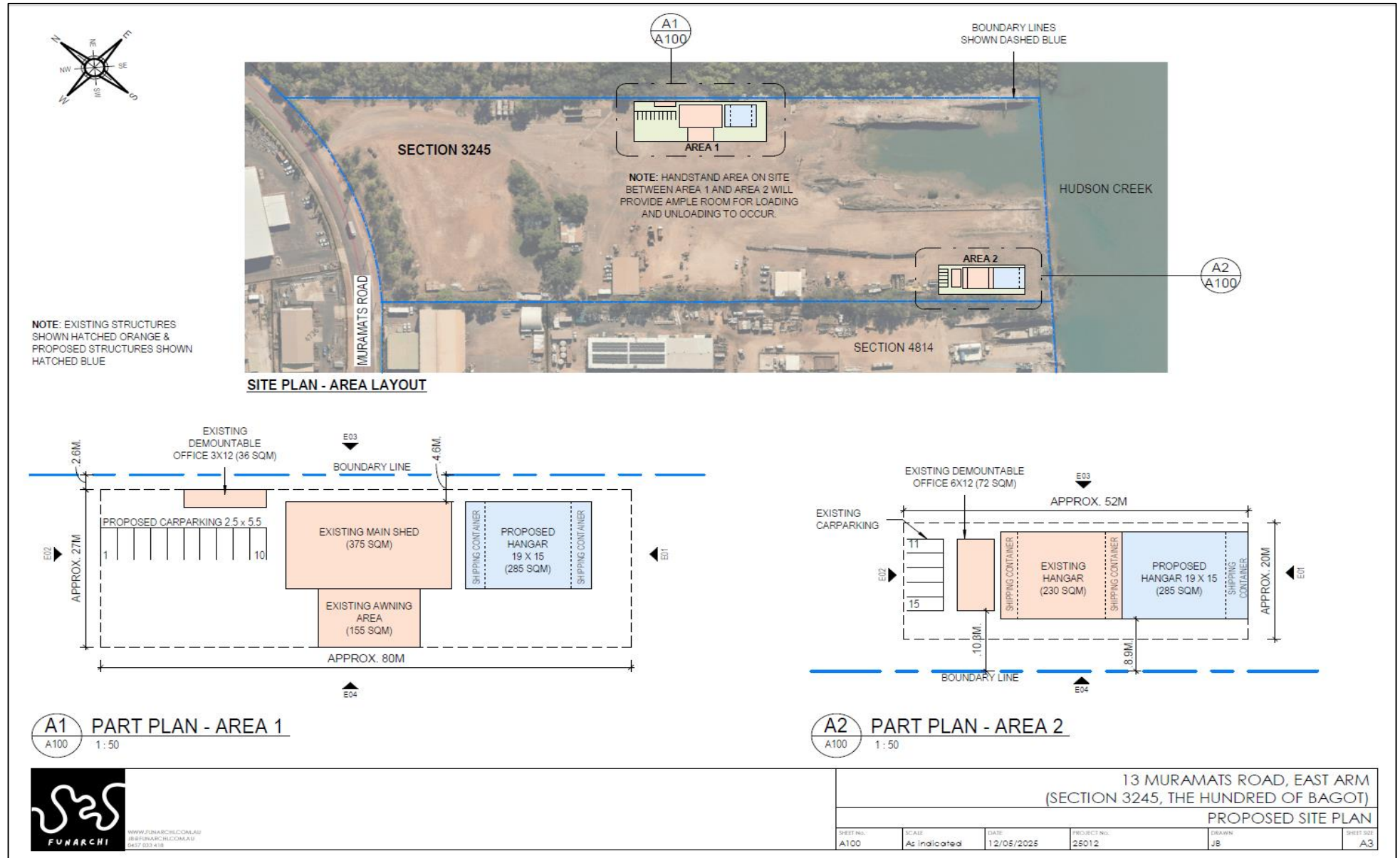
- The Site is zoned DV (development) – Similar to industry.
- As a research facility the land use is an “**undefined use**” and in this zone (and all zones) an Undefined use will be impact assessable and will require a development application.
- The project has applied for and received DA approval to operate (see appendages)

6.6 Neighbouring Property Land Use

The site is a multi-use facility with mechanics and pipeline construction facilities operating.

- The area is a multi-use “undefined use” with multiple freight and petroleum facilities nearby.

Image 4: Area 1 & 2, 13 Muramats Road



7 Regulatory Compliance Context

This section provides an overview of the key Commonwealth and NT environmental and heritage legislation relevant to the project, as well as key approvals, licences and or permits received or required to proceed.

7.1 Commonwealth

7.1.1 Environment Protection and Biodiversity Conservation (EPBC) Act 1999

The EPBC Act is the Australian Government's key environmental legislation administered by the Commonwealth Department of the Environment and Energy (DoEE). Approval under the EPBC Act may be required for any proposed action likely to have a significant impact on a matter protected by that Act. The environment assessment and approvals process of the EPBC Act aims to protect Matters of National Environmental Significance (MNES), as well as the environment in general where actions are proposed that will take place on or will affect Commonwealth land, and/or where Commonwealth agencies are proposing to take an action.

7.1.2 Native Title Act 1993

This Act provides legal recognition of the rights and interests of Aboriginal people over land and water. It regulates development on Aboriginal land and sets out the processes to be followed when negotiating with Traditional Owners (TOs) for access to Aboriginal land and the grant of titles over that land.

The site is not located on land subject to native title claim and therefore, the Native Title Act (1993) does not apply.

7.2 Northern Territory

The primary NT approvals required for the project are a Development Permit under the Planning Act 1999; and a Waste Discharge Licence under the Waste Management Pollution Control Act 1998 (WMPC Act).

7.2.1 Planning Act 1999

The proposed land use is classified as "undefined use" and in this zone (and all zones) an Undefined use will be impact assessable and will require a development application. (Development Permit received see appendages).

7.2.2 Waste Management Pollution Control Act 1998

Under the Waste Management and Pollution Control Act 1998, a Waste Discharge Licence (WDL) is required for activities involving the discharge of waste to the environment, particularly into water bodies such as creeks, rivers, or marine environments. The WDL sets enforceable conditions to ensure that discharges are appropriately managed to minimise environmental harm.

CSIRO will apply for a WDL to authorise the controlled discharge of treated effluent from its aquaculture research facility at East Arm. The WDL will be tailored to reflect the scale, location, and environmental risk profile of the operation and is expected to be issued in Q4 2025.

A WDL typically includes:

- **Licence Holder Details:** The entity responsible for compliance with the licence.
- **Authorised Discharge Parameters:** Including discharge location, volume limits, timing (e.g. outgoing tide only), and water quality thresholds.
- **Monitoring and Reporting Requirements:** Regular testing and submission of discharge water quality data to the NT EPA.

- **Incident Notification Procedures:** Requirements for reporting environmental incidents or non-compliance.
- **Licence Duration and Renewal Conditions.**

CSIRO acknowledges and will operate in accordance with the **General Environmental Duty** under **Section 12 of the Waste Management and Pollution Control Act 1998**, which requires that all reasonable and practicable measures are taken to prevent pollution and minimise environmental harm. The WDL application and associated Environmental Management Plan (EMP) demonstrate CSIRO's commitment to meeting these obligations.

7.2.3 Water Act

Provides for the investigation, allocation, use, control, protection and management of surface water and groundwater resources, as well as the administrative process for licensing these activities. The Act also prescribes some areas to be Water Control Districts in order to regulate the investigation, use, control, protection and allocation of water resources. Water Control Districts are generally proclaimed in areas where there is a need for close management of water resources to avoid stressing groundwater reserves, river flows or wetlands.

A water extraction licence is not required for this project (feedback NT Gov). (see appendages)

7.2.4 Other approvals, permits and licences

Other key approvals, permits and licences that may be required under NT Government legislation are summarised in Table 3.

Table 3: Other Relevant NT legislation

Legislation	Relevance to project
Work Health and Safety (National Uniform Legislation) Act (NT)	Aims to promote health and safety in the workplace, including storage, handling and notification related to hazardous chemicals, including maintenance of a hazardous chemical register. There are no specific licencing requirements relevant to this project. However, all chemicals to be used on-site must be stored and handled accordingly,
NT Fisheries Act	An aquaculture licence is required for operations and expected approval within 4–6 months of lease initiation. (NOI submitted Oct 2025)

7.3 Consideration of the Environment Protection Act 2019 (NT)

The proponent has reviewed its obligations under the Environment Protection Act 2019 and Environment Protection Regulations 2020, in accordance with the NT EPA's published guidance: "Referring a Proposal to the NT EPA (2022)". Using the screening tool provided in Appendix 1 of the guidance, the proponent has determined that the project is unlikely to trigger referral requirements due to the limited footprint, low predicted environmental impact, and absence of identified matters of national or significant environmental concern.

The NT EPA has reviewed the EMP, WQMP, and NOI and advised that they did not identify matters that indicate a referral should be made but recommended that the proponent formally document this assessment process. Should any future expansion or material change to the activity be proposed, CSIRO will reassess its referral obligations and consult with NT EPA as necessary.

8 Documentation and Compliance Verification

8.1 Objective

To ensure that all EMP actions are in alignment with Northern Territory regulations, enhancing accountability and maintaining comprehensive compliance across environmental and operational standards.

8.2 Compliance Checklist

The following checklist cross-references each EMP section with applicable NT regulations and guidelines. This table serves as a record of compliance, making it easier to verify adherence and streamline regulatory reporting.

Table 4: Compliance Checklist

EMP Section	NT Regulation/Guideline	Compliance Action
Water Management (section 13.1)	Waste Discharge Licence	Monitoring and reporting of water quality
Effluent Discharge Management (section 13.14 & WQMP)	Waste Management and Pollution Control Act, ANZECC Guidelines	Adherence to discharge limits, reporting to NT EPA
Solid Waste Management (section 13.6)	NT Environmental Protection Act, Waste Management and Pollution Control Act	Waste segregation, recycling efforts, licensed disposal
Biosecurity Management (section 13.13)	Fisheries Act, Aquatic Pest and Disease Control Program	Treatment protocols, monitoring, NT Fisheries reporting
Exotic Species Management (section 13.9)	Fisheries Act, Biosecurity Guidelines	Treatment and containment measures, NT Fisheries consultation
Noise Management (section 13.3)	NT Noise Guidelines	Monitoring and complaint response
Air and Odour Management (section 13.4)	NT Environmental Protection Act	Control measures, complaint response
Fire Management (section 13.10)	NT Fire and Emergency Management Act	Fire prevention, evacuation drills, coordination with NT Fire
Light Management (section 13.5)	NT Planning and Environmental Protection Authority Recommendations	Downward lighting, complaint response
Stakeholder Engagement and Communication (section 17)	Public and Environmental Duty as per NT Environmental Protection Act	Regular stakeholder updates, issue resolution
Environmental Risk Assessment (section 21)	NT Environmental Protection Act, Waste Management and Pollution Control Act	Following all aspects of the approved EMP

8.3 Verification Process

1. Annual External Review:

- Submit this checklist as part of the annual EMP report to NT EPA, NT Fisheries, and other relevant stakeholders for verification.
- Ensure compliance actions reflect current NT standards, confirming all sections meet or exceed regulatory expectations.

9 Environmental Context

The site has a mix of hard stand and gravel topped earth with stable coastal soils and provides access to year-round clean saline water, which is crucial for aquaculture.

Key Points regarding Geology and Hydrology

- Operations **will not draw on and or release water** to groundwater aquifers.
- CSIRO will utilise current infrastructure located at the site with **no additional permanent structures** to be developed.
- Water will be sourced from Hudson Creek, an offshoot creek of the East Arm of Darwin Harbour.
- There will be no additional stormwater and or diversion drains established.

9.1 Hydrology and Coastal and Marine Environments

Table 5: Climate, Rainfall and Temperature Darwin, Northern Territory

Month	Avg Max Temp (°C)	Avg Min Temp (°C)	Avg Rainfall (mm)	Avg Humidity (%)
January	31.8	25.3	426.2	79
February	31.4	25.3	369.5	81
March	31.8	25.0	315.7	80
April	32.6	24.1	101.5	74
May	32.0	21.8	21.7	67
June	30.6	19.6	1.6	63
July	30.6	19.3	1.0	61
August	31.2	20.5	3.1	61
September	32.2	23.0	15.3	66
October	33.2	25.0	71.7	72
November	33.3	26.0	140.5	76
December	32.5	26.0	252.2	78
Avg	31.7 (°C)	23.5 (°C)	176 mm (2114 mm annual)	71.1%

9.1.1 Hudson Creek Geology

The "Geotechnical Investigations: East Arm Stage 1B and 2A Industrial Subdivision Incorporating Muramats Road Subdivision" report (NT EPA.NT.gov.au) provides detailed insights into the soil composition of the East Arm area. The subsurface profile is generally characterised by marine sediments overlying weathered rock. Specifically, the investigation identified up to 1 metre of very soft marine mud or a combination of sand and mud in certain areas. In the southern part of the site, a mixture of marine mud, sand, and gravel-sized coral fragments was encountered. Underlying these sediments, weathered rock formations, including phyllite and meta-siltstone, were observed. The depth of these overburden soils varies across the site, with some areas exhibiting up to 3.2 metres of overburden. These findings are crucial for informing construction practices, particularly concerning foundation design and earthworks, to ensure structural stability and environmental compliance.

9.1.2 Darwin Harbour Geology

The Darwin Harbour area is characterised by Permian siltstones and sandstones, which form the foundational bedrock of the region. During the Last Glacial Maximum (approximately 19,000 to 23,000 years ago), the harbour and adjacent areas were exposed to subaerial conditions due to lower sea levels, leading to significant geological formations and sediment deposits. (Researchgate.net)

9.1.3 Darwin Harbour Hydrology

Darwin Harbour experiences a monsoonal tropical climate with distinct wet and dry seasons. The wet season, from October to March, contributes the majority of the annual rainfall, leading to increased freshwater input into the harbour's tributaries, including Hudson Creek. The harbour is macrotidal, with tidal ranges reaching up to 7.8 meters, resulting in complex and strong tidal currents that influence water movement and sediment distribution within the estuarine systems. The region's hydrology is also influenced by its extensive mangrove systems, which play a crucial role in nutrient cycling and provide habitats for various marine species. These mangroves contribute to the nitrogen-limited nature of the harbour, serving as primary producers and supporting the overall ecological balance. (CDU.edu.au).

9.1.4 Groundwater

As highlighted previously, the project will not draw on and or release to groundwater aquifers.

The "**Geotechnical Investigations: East Arm Stage 1B and 2A Industrial Subdivision Incorporating Muramats Road Subdivision**" report provides insights into the groundwater conditions of the East Arm area. The investigation revealed that groundwater levels vary across the site, with depths ranging from approximately 2.5 to 4.0 metres below the existing ground surface. These fluctuations are influenced by tidal movements, given the site's proximity to Darwin Harbour. The report also notes that the groundwater is generally brackish, reflecting the saline conditions of the adjacent marine environment. (NT EPA.gov.au)

9.2 Flora and Fauna

This project will be primarily contained indoors, and all of the areas of operations will occur on an area that has been cleared and developed for over 20 years. The project acknowledges that the East Arm area supports a diverse range of flora and fauna, including extensive mangrove forests, intertidal mudflats, and seagrass beds, which provide critical habitats for marine and bird species. Mangrove ecosystems play a key role in coastal stability and serve as breeding and nursery grounds for many fish and crustacean species.

9.3 Significant sites or features (East Arm)

The East Arm area in Darwin, Northern Territory, is notable for several significant features and sites:

- **East Arm Wharf:** A deepwater port facility that serves as a critical hub for maritime trade in northern Australia (approximately 5kms from the site).
- **World War II Heritage Sites:** The area includes historical sites such as the WWII Quarantine Anti-Aircraft Battery Site, which is recognised for its unique design and historical significance.
- **Catalina Aircraft Wrecks:** The waters around East Arm contain wrecks of Catalina flying boats from World War II, serving as underwater cultural heritage sites.

None of these sites will be effected by this project.

9.4 Site History and Surrounding Land Uses

13 Muramats Road, East Arm, is located within the East Arm Industrial Precinct—an area zoned for logistics, warehousing, and industrial activities. It lies near key infrastructure including the East Arm Wharf, rail connections, and major transport routes. Surrounding properties are similarly used for industrial purposes. The site has a history of commercial use and was most recently occupied by **Monsoon Aquatics**, which operated a coral collection and wholesale business. CSIRO intends to utilise the existing sheds previously used by Monsoon Aquatics for its Proof of Concept aquaculture program.

9.5 Land Suitability

The land and current infrastructure is considered suitable (with some minor additions) for this project. The project will seek a Development Application (or clarification) due to its Research nature.

10 Farm Layout and Design

The East Arm site will be divided into two primary sections known as **East Arm 1** and **East Arm 2**, each designed for specific aquaculture functions and equipped with the necessary infrastructure for prawn maturation, larval rearing, and biosecure operations. Both sections are optimised for Closed Recirculating Aquaculture Systems (CRAS), ensuring biosecurity and efficient water use.

10.1 East Arm Area 1:

- Total Area: **2160 m²**, with a **442 m²** main shed and a **160 m²** awning.

10.1.1 Main Shed and Algal Tanks

Main Shed Components: (disinfection footbaths and component specific tools will separate each section)

- **Maturation:** 8 x 10,000-litre conical tanks arranged in two sets of four, each connected to a skid-mounted recirculating unit that includes a primary microstraining filter (60 microns), protein skimmer, biological filter, and bag filter.
- **Larval Rearing:** 12 x 700-litre tanks, divided into three groups of four, these will be stand-alone units with aeration.
- **Nursery Rearing:** 12 x 700-litre tanks, divided into three groups of four, these will be stand-alone units with aeration.
- **Spawning & Hatching:** 12 x 100-litre tanks designated for the spawning and hatching of prawn larvae.
- **Post-Larval Rearing:** 3 x 5,000-litre parabolic tanks designed for rearing post-larval prawns.

Awning Area:

- **Algal Production:** 12 x 1000-litre algal tanks under the awning for supporting the prawn rearing process by supplying phytoplankton to juveniles, complete with aeration and associated plumbing.
- **Artemia:** 3 x 75 litre conical based Artemia tanks to produce food for juvenile prawns.

10.1.2 East Arm 1: Water Management Systems

A new Hangar (12 x 15m) will be installed at the East Arm area 1 site to provide shade for raw and treated water prior to use within the facility and to protect filtration systems and electrical equipment associated with the water treatment. Additionally, this hangar will have two shipping containers within its design to provide storage for equipment and or housing for automated electrical services. This Hangar is not a permanent structure and can be removed from site at the end of the project.

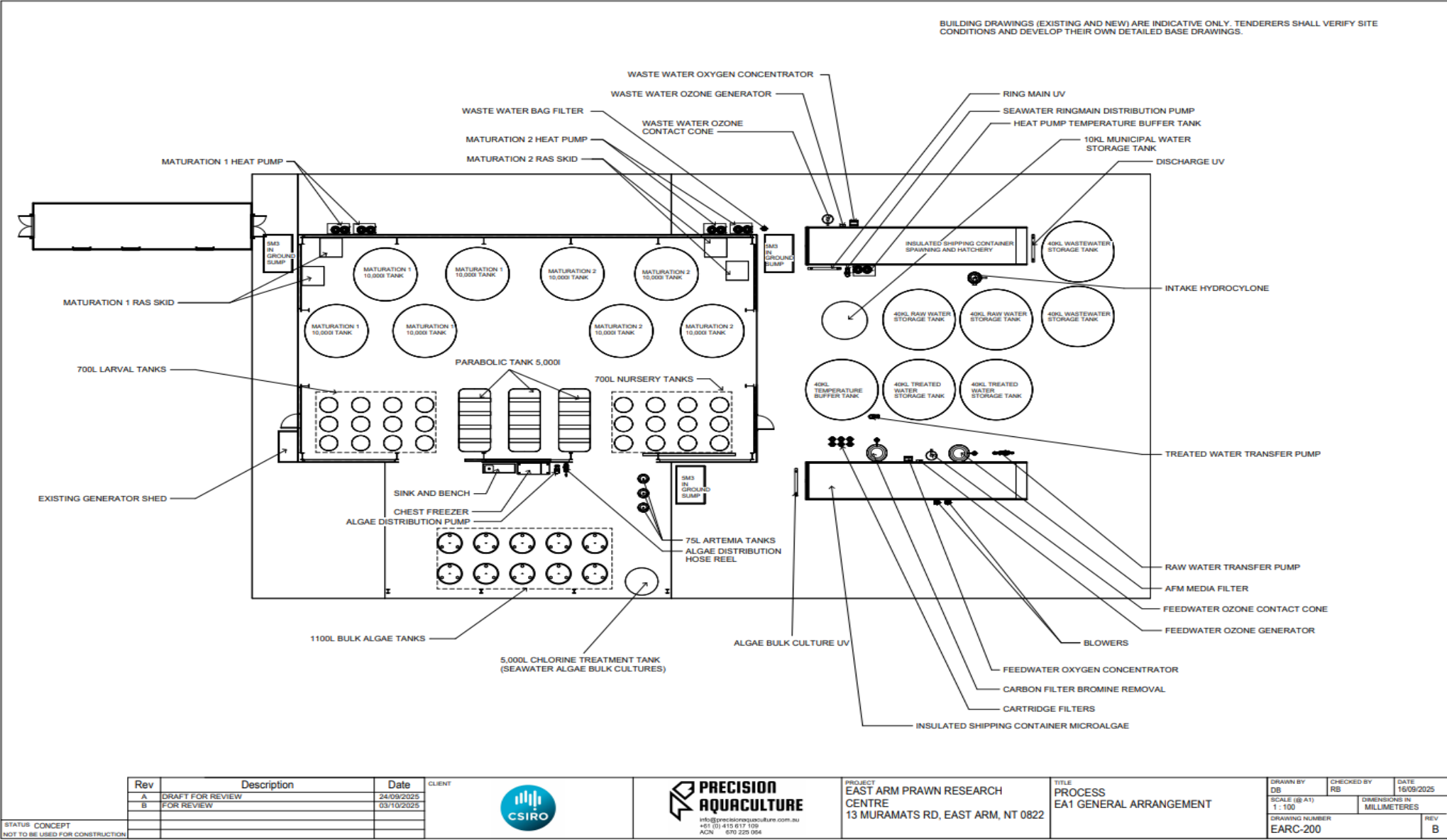
Water Intake & Treatment:

- Course filtration, media filtration, settlement, disinfection, storage and post storage UV disinfection.

Water Effluent Management:

- Sump pumps, bag filters, Ozone disinfection, wastewater storage, UV disinfection post storage.

Figure 2: East Arm 1 – General Arrangement



10.2 East Arm 2:

As with East Arm area 1, East Arm Area 2 will be expanded to include an additional Hangar and two additional 10 metre shipping container (not permanent structures).

The additional Hangar will provide shade and protection for raw and treated water and associated treatment equipment.

- Total Area: **1020m²**, including four 10m shipping containers and a 2 x 15m x 12m hangars.

10.2.1 Stock Assessment

Stock Assessment (SA1 and SA2):

- Each Stock Assessment area includes 20 x 100-litre tanks for isolated holding of new stock entering the program. Its will be equipped with chillers, UV filtration, and air/water plumbing.

10.2.2 Polychaetes

The SA1 and SA2 systems will be rarely utilised and therefore East Arm Area 2 will primarily be utilised as a growing area for Polychaetes (marine worms used as prawn Broodstock food).

10.2.3 East Arm Area 2 water systems

Hangar Area External:

- **SA1 & SA 2 Wastewater Management:** Sump pumps, bag filters, and wastewater storage ensure efficient waste management and environmental compliance.
- **Water Storage:** UV and filtered water will be transferred to storage tanks in this area (2 x 20kL).

10.2.4 East Arm Area 2: Water Management Systems

As highlighted in 3, the current Hangar located onsite will be utilised for Quarantine, Polychaete production and an office area. An additional Hangar will be installed to provide protection for raw water, treated water and associated water treatment equipment and electrical.

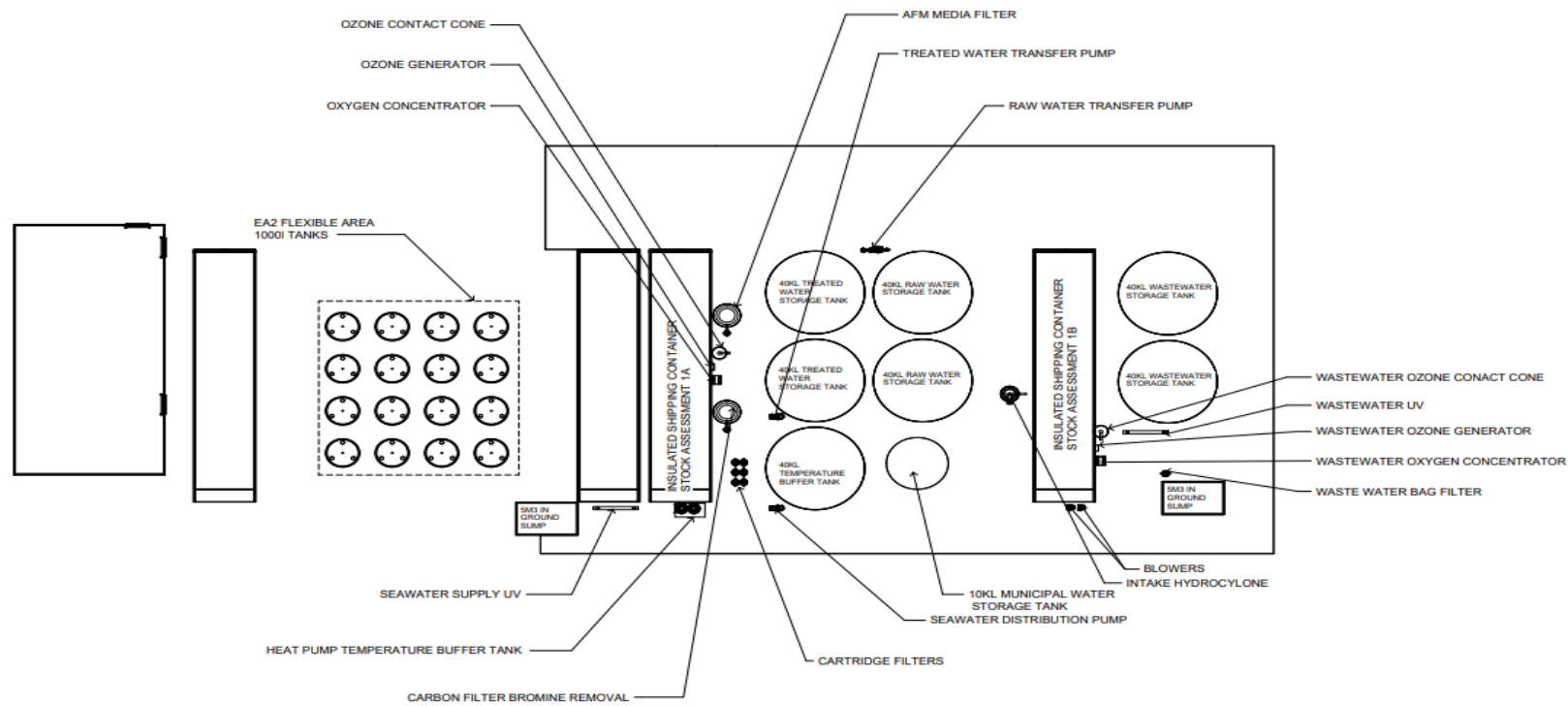
Water Intake & Treatment:

- Course filtration, media filtration, settlement, disinfection, storage and post storage UV disinfection.

Water Effluent Management:

- Sump pumps, bag filters, Ozone disinfection, wastewater storage, UV disinfection post storage.

Figure 3: East Arm 2 – General site arrangement



Rev	Description	Date	CLIENT		 PRECISION AQUACULTURE info@precisionaquaculture.com.au +61 (0) 410 417 109 ACN 670 220 064	PROJECT EAST ARM PRAWN RESEARCH CENTRE 13 MURAMATS RD, EAST ARM, NT 0822	TITLE PROCESS EA2 GENERAL ARRANGEMENT	DRAWN BY DB	CHECKED BY RB	DATE 16/09/2025
A	DRAFT FOR REVIEW	24/09/2025						SCALE (B/A) 1 : 100	DIMENSIONS IN MILLIMETERS	
B	FOR REVIEW	03/10/2025						DRAWING NUMBER EARC-210	REV B	
STATUS: NOT USED NOT TO BE CONCEPT FOR CONSTRUCTION										

11 Operational Process

The project at East Arm focuses on developing and implementing High Health (HH) prawn breeding through advanced Closed Recirculating Aquaculture Systems (CRAS). Due to the Intellectual Property (IP) involved, only a summary of each operational section will be provided. The process includes stock assessment, pathogen testing, biosecure rearing, and precise water quality management. However, some operational details are withheld to protect CSIRO's proprietary methodologies.

11.1 Stock sourcing

Black Tiger prawn (BTP) stock will be sourced exclusively from local waters in the Northern Territory, which are known for their reliability in supplying high-quality broodstock. Northern Territory-sourced BTP are currently the primary spawners used in Australian prawn farming, setting benchmarks for health and performance in the industry.

By using locally-sourced stock, the project eliminates the risk of introducing foreign pathogens typically associated with interstate transport, such as those found in prawn stocks from Queensland and northern NSW. This local sourcing approach significantly mitigates biosecurity risks, as the prawns will only potentially carry pathogens already present in Northern Territory waters, which are well understood and managed.

Key Benefits:

1. **Reduced Biosecurity Risks:** Sourcing stock locally minimises the potential for introducing diseases from other regions.
2. **Simplified Stock Assessment Procedures:** With only local pathogens expected, protocols can be streamlined to stock assessment level, focusing on known and controlled disease profiles relevant to the Northern Territory.
3. **Sustainable Practice:** Utilising local stocks supports the sustainable development of the Northern Territory's aquaculture industry by reducing reliance on interstate sources, providing a continued and sustained biosecurity reduction.

By focusing on Northern Territory broodstock, the project aligns with CSIRO's commitment to biosecurity, helping to establish a secure, sustainable, and locally resilient Black Tiger prawn farming industry in Northern Australia.

11.2 Primary Stock Assessment

Upon arrival, locally-sourced Black Tiger prawn stock will be moved into Stock Assessment Area 1 (SA1) for a brief assessment period of 7-14 days. SA 1 is a climate-controlled, sealed within a shipping container, recirculating system with minimal water exchange, specifically designed to maintain optimal environmental conditions and biosecurity whilst isolating and assessing the health of incoming stock. This system will allow for a rapid evaluation of the broodstock's overall health, characteristics, and suitability for the POC project.

Key Procedures:

1. **Health Assessment:** During their time in SA 1, the broodstock will undergo visual inspections to detect any signs of disease or health issues. This includes monitoring for physical deformities, unusual behaviours, and general vitality. Since the stock is locally sourced, the risk of encountering foreign pathogens is minimised, streamlining this assessment phase and reducing the need for complex health protocols typically associated with interstate or international stock

2. **Low-Impact Assessment:** SA1 is designed for a quick and efficient assessment process that aligns with best practices for locally sourced stock. The controlled conditions and low water exchange within the recirculating system provide a stable environment, which helps minimise stress on the stock and supports a rapid acclimatisation process. Assessment protocols will focus on monitoring and isolating any potential issues unique to local pathogens, allowing a simplified approach compared to higher-risk, interstate imports.

By sourcing stock locally, the project reduces biosecurity risks and enables a low-impact assessment phase in SA1, facilitating a more efficient transition to the next stage of assessment and rearing. This approach supports both the health and sustainability of the Northern Territory's prawn aquaculture operations.

11.3 Secondary Stock Assessment

Following initial assessment in SA 1, Black Tiger prawn stock will be transferred to Stock Assessment Area 2 (SA2) for a more comprehensive health evaluation over a 30–60 day period. SA 2 is a climate-controlled, recirculating system with minimal water exchange, designed to maintain consistent environmental conditions and minimise stress on the stock during this in-depth analysis phase. This stage focuses on detecting specific pathogens, ensuring that only healthy, disease-free stock are cleared for integration into the East Arm 1 facility.

Key Procedures:

1. **Advanced Health and Disease Screening:** In SA 2, broodstock undergo pathogen screening to identify any diseases that may not have been detectable in the initial assessment. This includes both visual and laboratory-based testing to verify the presence of common pathogens associated with Black Tiger prawns. The comprehensive diagnostics are tailored to local pathogen profiles, further enhancing biosecurity by focusing on regional disease threats.
2. **Controlled Environmental Conditions:** The climate-controlled, low water exchange system within SA 2 provides a stable environment that reduces external contamination risks and limits the potential spread of any undetected pathogens. These controlled conditions allow for accurate disease analysis while maintaining optimal prawn health, which is essential for reliable assessment results.
3. **Disinfection of wastewater:** All water discharging from the stock assessment will be disinfected using Ozone to 650-850mV to ensure the breakdown of pathogens. If discharge volumes are low (as expected) the site may utilise chlorine additions rather than ozone. Chlorine would be dosed at 100ppm and allowed to disinfect under aeration for 12 hours before discharge.
4. **Clearance for Facility Use:** Only stock that pass all health assessments and are free from known diseases will be approved for transfer to the East Arm 1 facility. This clearance process is critical to maintaining the biosecurity integrity of the POC project, ensuring that all stock introduced into the main production system are verified as healthy and pathogen-free.

The SA 2 assessment phase represents a higher level of biosecurity, enabling the project to thoroughly verify the health of locally sourced Black Tiger prawns before their introduction to the main rearing system. This approach aligns with CSIRO's commitment to a biosecure and sustainable aquaculture process, reinforcing the integrity of the entire facility.

11.4 Larval

The larval rearing process for Black Tiger Prawns includes three main stages: Nauplius, Zoea, and Mysis, each requiring specific conditions.

1. **Nauplius Stage** (1–2 days): Newly hatched larvae do not feed but rely on their yolk reserves. They are kept in well-aerated tanks with stable salinity (30–35 ppt) and temperature (28–30°C).
2. **Zoea Stage** (3–4 days): At this stage, larvae begin feeding on microalgae like *Chaetoceros* or *Isochrysis*. The tanks maintain similar water parameters, with daily water exchanges of 10–20% to ensure water quality. Microalgae density is kept around 50,000–100,000 cells/mL to support larval feeding. CSIRO will trial CRAS during this stage to reduce water exchange.
3. **Mysis Stage** (3–4 days): Larvae now resemble shrimp and consume both microalgae and live feeds, such as *Artemia* nauplii. Daily water exchanges increase to 20–30%, and careful monitoring of ammonia and pH levels is essential. CSIRO will trial CRAS during this stage to reduce water exchange.

Throughout these stages, larvae are reared in conical based tanks with gentle aeration, providing optimal conditions for development. This setup ensures appropriate oxygenation, minimises larval stress, and maintains feed availability, supporting their growth until they reach the post-larvae stage.

11.5 Post Larval

The Post-Larval (PL) stage is a critical phase in Black Tiger prawn development, where newly hatched prawns are transitioned from the larval to juvenile stage. During this stage, PL prawns are moved to tanks with carefully controlled conditions that support their rapid growth and adaptation to a structured diet. The focus is on providing high water quality and balanced nutrition to ensure healthy development as they prepare for the on-growing phase.

Key Points:

1. **Water Quality Management:** Conditions such as salinity, pH, ammonia and oxygen levels are monitored and adjusted to meet the specific needs of post-larval prawns, which are particularly sensitive to environmental changes.
2. **Nutrient-Rich Feeding:** Post-larvae are fed a protein-rich diet that includes live (*Artemia* nauplii) or formulated feeds tailored for this stage. These diets are designed to support rapid growth and build the immune systems of young prawns.
3. **Health Monitoring:** Regular health assessments are conducted to monitor growth rates and identify any signs of disease or developmental issues. Adjustments to the environment or diet are made as needed to ensure optimal survival and growth.

The post-larval stage is essential for developing robust prawn stock, as it establishes the foundation for strong, disease-resistant prawns ready for the on-growing phase.

11.6 On-growing

The on-growing stage in a Black Tiger prawn facility focuses on the growth and development of juvenile prawns to a size suitable for the maturation phase. During this stage, prawns are housed in specialised tanks where conditions such as water quality, temperature, and salinity are carefully monitored and maintained to optimise growth.

Regular feeding schedules provide a balanced diet formulated for rapid and healthy growth, typically including high-protein feeds and specialised supplements to support shell development and overall health.

Key Points:

1. **Water Quality Management:** Parameters like ammonia, nitrite, nitrate, pH, and dissolved oxygen are continuously monitored to ensure an ideal environment, minimising stress and promoting consistent growth.
2. **Feeding Protocols:** Prawns receive nutrient-rich feed several times daily to meet the high metabolic demands of this growth phase, with feed quantities adjusted based on prawn size (biomass) and activity.
3. **Growth Monitoring:** Regular size assessments are conducted to track prawn growth rates, enabling adjustments to feed and water conditions as needed.

11.7 Maturation

In the maturation stage, adult prawns are prepared for reproduction. This stage involves conditioning the prawns to maximise their reproductive potential through tailored diets (such as Polychaetes), enhanced water quality, and specific environmental conditions. Prawns are housed in broodstock tanks with controlled lighting and temperature settings to mimic natural conditions and stimulate maturation.

Key Points:

1. **Enhanced Feeding Regime:** Prawns are provided with a specialised diet high in essential nutrients, such as omega-3 fatty acids and vitamins, to improve gonadal development and reproductive health. To reduce the potential of pathogen introduction, feed will consist of a combination of:
 - Polychaetes grown onsite
 - And cold water sourced frozen Mussels (NZ) and Squid (Southern Victoria)
2. **Water Quality Enhancement:** Water quality is maintained at optimal levels, with increased filtration and oxygenation to support the health of mature prawns, which are more sensitive to environmental stressors. These measures minimise the potential for disease outbreaks during this critical stage.
3. **Environmental Stimulation:** Controlled lighting cycles and temperature adjustments help simulate seasonal changes, encouraging natural spawning behaviours.

By ensuring high-quality local feed sourcing, robust water quality management, and precise environmental controls, the maturation phase promotes the health and readiness of Black Tiger prawns for breeding. These measures support the facility's overall productivity, biosecurity, and sustainability.

11.8 Algae production

In a Black Tiger prawn hatchery, algal production plays a crucial role in the early stages of prawn development, providing a natural food source for larvae and supporting overall health. Algae such as *Chaetoceros*, *Nannochloropsis*, and *Isochrysis* species are commonly cultivated in controlled environments and introduced to larval rearing tanks to improve water quality and meet the nutritional needs of the prawns. Each species brings unique benefits to the larvae, enhancing their growth and survival rates.

Key Aspects of Algal Production:

1. **Cultivation:** Algae are grown in separate tanks or bags under specific light and temperature conditions to optimise growth. Nutrients are added to the culture to sustain high-density algal growth, ensuring a steady supply for the hatchery.
2. **Nutritional Role:** Algae provide essential fatty acids, vitamins, and other nutrients that support the development of larval prawns. Specifically, *Isochrysis* is rich in omega-3 fatty acids, such as DHA,

which is vital for the immune system and growth of larvae. Together, these algae support the larvae's growth, survival, and resilience to stress.

3. **Feeding Protocols:** Algal production is carefully timed to meet the demand of the hatchery's larval phases, with fresh algae introduced daily. The density and volume of algae added are adjusted based on the number and developmental stage of the prawns, ensuring optimal nutrient availability.

The algal production system is an essential component of the project at East Arm, where it supports sustainable, biosecure prawn rearing. By integrating algae grown onsite into the diet, the hatchery can reduce reliance on external feed sources and promote a balanced, natural diet during the critical early life stages of Black Tiger prawns.

11.9 Artemia production

Artemia (brine shrimp) are commonly used in prawn hatcheries in Australia, especially for the larval stages of Black Tiger prawns. Artemia nauplii, which are the newly hatched larvae from Artemia cysts, are ideal for feeding prawn larvae due to their small size and high nutritional content. They provide essential fatty acids, proteins, and other nutrients that promote the growth and health of prawn larvae. The nauplii are typically used in the early stages, as they are easily digestible and meet the specific dietary needs of young prawns, providing a boost to survival and growth rates.

11.9.1 Summary of Artemia Production in the POC Setting

In the project, Artemia production will be integrated to provide live feed during the initial stages of prawn development. Here's how the process generally works:

1. **Hatching and Cultivation:** Artemia cysts will be hatched in dedicated tanks with sterilised saline water. The cysts are typically incubated under controlled light and aeration conditions to encourage hatching, producing nauplii within 24 hours. The hatching water's salinity, pH, and temperature are closely managed to maximise nauplii output.
2. **Nutritional Enhancement:** After hatching, Artemia nauplii are typically fed with enriching diets that are bioencapsulated with additional nutrients, such as essential fatty acids, to boost their nutritional value. This enrichment process enhances the nauplii's nutritional profile, particularly when they are used for more intensive larval rearing phases. While not always essential, this step ensures that the nauplii provide optimal nutrition for developing larvae in high-intensity aquaculture settings.
3. **Feeding Protocols:** The nauplii are then harvested and introduced to larval rearing tanks in controlled quantities. This provides a fresh, high-protein feed source that meets the immediate dietary needs of the prawns during their vulnerable early life stages, supporting rapid growth and higher survival rates.

By incorporating an on-site Artemia production system, the project ensures a reliable, high-quality source of live feed for the hatchery, reducing reliance on imported supplies and supporting the development of robust prawn larvae. This system also enables CSIRO to control the quality and nutritional profile of the Artemia fed to their prawns, which can lead to healthier and more resilient stock for future aquaculture initiatives in Australia

11.10 Polychaetes

In Australian prawn hatcheries, polychaetes (marine worms) are a crucial feed source for broodstock, especially during the maturation phase. Rich in proteins, omega-3 fatty acids (such as DHA), and essential

amino acids, polychaetes significantly enhance reproductive health and egg quality in Black Tiger prawns. CSIRO has been actively involved in research on polychaetes, focusing on sustainable cultivation methods and optimising their nutritional profile for aquaculture use.

11.10.1 Polychaete Production in the POC Setting

For the project at East Arm, on-site polychaete production will support a reliable and biosecure feed supply for prawn broodstock, aligning with CSIRO's sustainable aquaculture goals.

This process includes:

1. **Cultivation:** Polychaetes will be locally sourced from Charles Darwin University (CDU) and then reared in dedicated tanks with sediment substrates that replicate their natural habitats. These tanks will be located in an area remote from the prawn rearing systems, minimising biosecurity risks. Environmental conditions such as salinity and temperature will be carefully regulated to optimise growth and health. *Marphysa* species, commonly cultivated for this purpose, will benefit from nutrient-rich diets to enhance their omega-3 and protein content, ensuring their suitability as a high-quality feed source.
2. **Nutritional Benefits:** Polychaetes provide essential fatty acids and proteins that improve prawn broodstock spawning success. Their nutrients contribute to healthier, more viable eggs, enhancing overall hatchery productivity and supporting the long-term health of the prawn population.
3. **Reducing Biosecurity Risk:** By sourcing polychaetes locally and producing on-site, the project reduces the need for wild-caught polychaetes or the introduction of external sources into the facility, thereby minimising potential biosecurity risks. This controlled approach prevents the risk of introducing pathogens or contaminants that may accompany wild-caught or externally sourced polychaetes.
4. **Complete separation of Polychaetes from prawn systems:** Polychaetes will be housed in a separate system with biosecurity protocols utilised such as separate RAS with footbaths and section only equipment. There will be physical barriers (walls and doors) between the SA1 and SA2 quarantine sections and the Polychaete production.

On-site production of polychaetes enables CSIRO to maintain a strict biosecure environment. This strategy aligns with the project's commitment to biosecurity and sustainable aquaculture practices, ensuring a safe, high-quality feed supply for prawn broodstock without compromising the health of the stock.

11.11 Water Supply and Discharge

Hudson Creek, a tidal creek on the northern shore of East Arm in the Darwin Harbour region, will serve as the primary water source. As part of the local catchment, Hudson Creek and nearby waterways contribute to Darwin Harbour's ecological dynamics, characterised by macro-tidal variations that influence water flow, salinity, and quality.

Situated near Darwin's industrial zone, Hudson Creek benefits from high tidal flushing, maintaining good water quality and making it a practical choice for the POC's aquaculture systems. Locally-sourced Black Tiger prawns will be exclusively used to reduce the risk of foreign pathogens. Additionally, water from Hudson Creek will undergo filtration and disinfection to ensure it meets stringent biosecurity and health standards required for successful operations at the East Arm facility.

11.11.1 Water extraction volumes

The East Arm site will be equipped with two separate water intake pipes, one located at Area 1, and one located at Area 2. Each will have a pump and a series of filtration and disinfection systems capable of

extracting 40KL per hour from Hudson Creek. During the commissioning of the system these systems will extract an anticipated 80KL per day until all systems are full and operating.

CSIRO have been operating a CRAS prawn maturation trial at Bribie Island for a period of over 12 months with zero water exchange across that period. Utilising that information but realising that trials of CRAS on early stages of prawn life cycle may require refining the project estimates that the:

Expected daily use on average will = 20KL per day.

11.11.2 System Volumes

This is a boutique research project with a low volume of internal system (tank) water.

11.11.2.1 East Arm Area 1

- Internal water volumes of tanks = **120 KL**
- **80 KL** of Raw water storage (Raw = unfiltered/undisinfected)
- **120 KL** of Filtered water storage (Filtered = Filtered and disinfected)
- **80 KL** of Filtered and disinfected wastewater storage (awaiting discharge on outgoing tide)
- Total capacity of water **East Arm Area 1 = < 450 Kilolitres** (0.45 megalitres)

11.11.2.2 East Arm Area 2

- Internal water volumes of tanks (Stock Assessment 1, 2 and Polychaetes) = **45 KL**
- **80 KL** of Raw water storage (Raw = unfiltered/undisinfected)
- **120 KL** of filtered water storage (Filtered = Filtered and disinfected)
- **80 KL** of Filtered and disinfected wastewater storage
- Total capacity of water East Arm Area 2 = **< 350 Kilolitres** (<0.35 megalitres)

Total water capacity for the East Arm site = 800 KL (0.8 megalitres)

11.11.3 Intake water treatment (both areas)

Water will be drawn from Hudson Creek during periods of high tides >4.8m. This will provide CSIRO with clean water from the incoming tide.

To ensure the health of the prawns and prevent the introduction of waterborne pathogens from Hudson Creek, a comprehensive raw water treatment process will be implemented. This multi-stage process includes:

- **Primary 100-Micron Screening:** Raw water drawn from Hudson Creek will first pass through a 100-micron screen, removing large debris and suspended particles that could harbor harmful organisms.
- **Sand or Media Filtration:** After primary screening, the water will undergo sand or media filtration. This process further refines the water by filtering out finer particulate matter, which may carry bacteria, protozoa, or other harmful microorganisms.
- **Ozone treatment (Pre - Storage):** Prior to storage, the intake water will undergo ozone treatment at a rate of 0.5mg/L for 10 minutes or to 650-850mV to ensure that any potential contamination that may have occurred during storage is fully neutralised.
- **Water Storage:** After ozone treatment, the water will be stored in aerated storage tanks (aeration will assist in biological stabilisation and prevent stagnation). The tanks will be monitored to ensure that water quality remains consistent before use in the aquaculture systems.

- **UV Treatment (Post Storage):** On delivery to the facility, the filtered water will then be treated with ultraviolet (UV) light to neutralise any remaining pathogens and or ozone. UV treatment effectively kills or inactivates bacteria, viruses, and parasites by disrupting their DNA, rendering them unable to reproduce or cause infection.

This comprehensive treatment process ensures that all water entering the facility is free from harmful pathogens, significantly reducing the risk of disease transmission to the stock from the environment. By using advanced filtration and sterilisation techniques, the project will effectively prevent waterborne pathogens from entering the aquaculture system and ensure the biosecurity of the prawns.

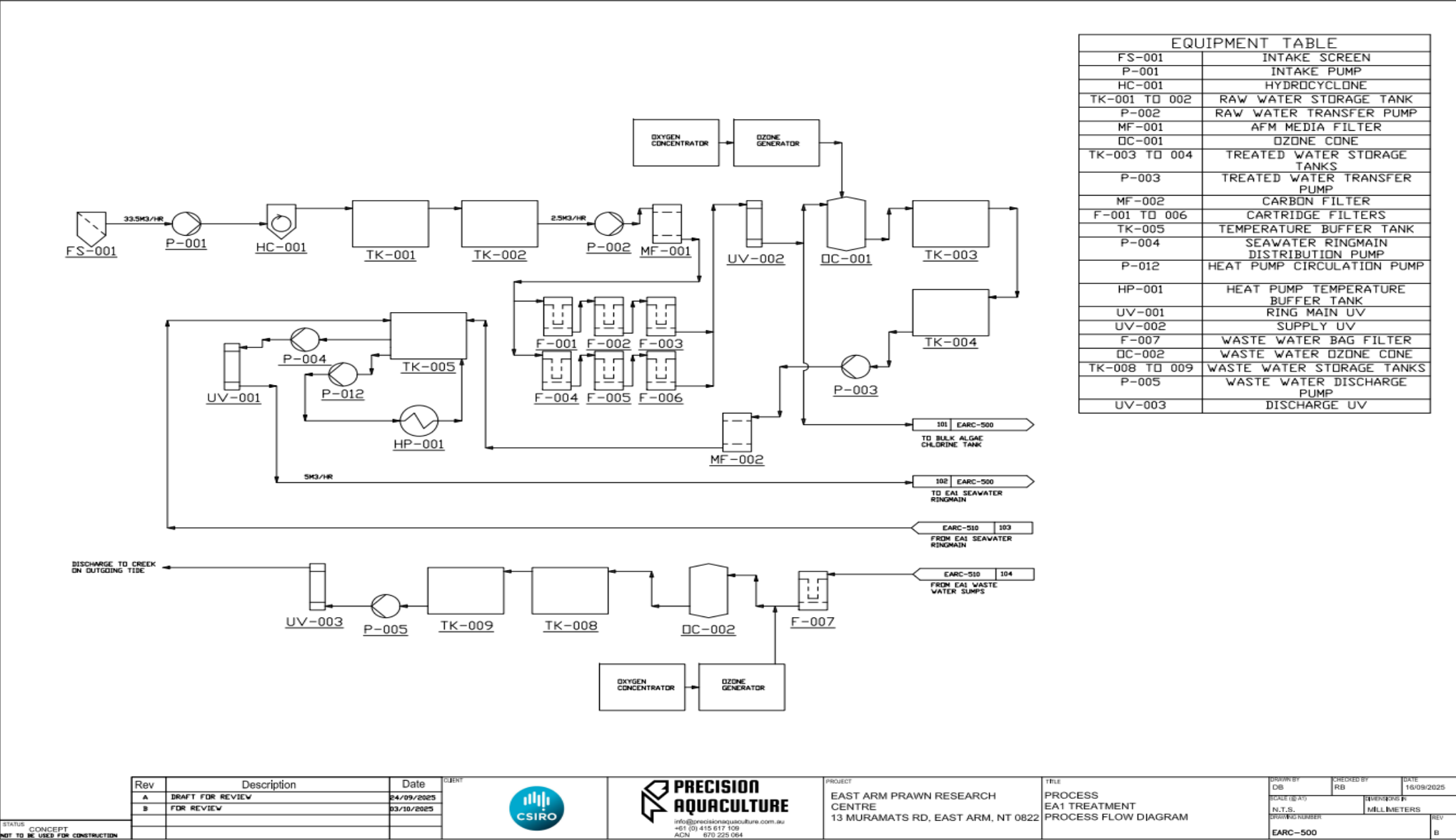
11.11.4 Waste water treatment process - EA1 & EA2

- **Primary Screening:** Wastewater discharged from both facilities will first pass through a 50-micron filter bag, removing large debris and suspended solids that could harbour harmful organisms or otherwise impact the receiving environment in Hudson Creek.
- **Ozone Treatment (Pre-Treatment):** Post filtration, waste water will undergo ozonation at a concentration of approximately 0.5 mg/L for 10 minutes, or until achieving an oxidation-reduction potential (ORP) of 650–850 mV. This step ensures that any potential microbial contamination is effectively neutralised.
- **Settlement:** Following primary screening and ozonation the water will be directed to two 40 kL settlement tanks, where finer particulate matter will be allowed to settle out under quiescent conditions. This process further clarifies the water prior to ultraviolet disinfection and discharge.
- **Ultraviolet (UV) Treatment (Post-Storage):** After settlement, the clarified and ozonated water will be passed through UV sterilisation units prior to discharge. UV treatment inactivates bacteria, viruses, and protozoan parasites by damaging their nucleic acids, thereby preventing replication and infection.

Summary: This multi-stage treatment train—comprising mechanical filtration, oxidation, sedimentation, and UV sterilisation—ensures that all water leaving the facility is effectively free of harmful pathogens and suspended solids. The process significantly reduces any potential for disease transmission between the environment and cultured stock, thereby safeguarding both biosecurity and the receiving waterways of Darwin Harbour.

See the process Flow Diagram on the following page for additional information (figure 4)

Figure 4: EA1 and EA2 – Process Flow Diagram



11.11.5 Expected Discharge Water Quality and Volumes

Basis of Estimates

Predicted wastewater volumes and nutrient concentrations for the East Arm Proof-of-Concept (POC) facility are based on data obtained from CSIRO's ongoing *Closed Recirculating Aquaculture System (CRAS)* trials at Bribie Island, Queensland. These trials have successfully demonstrated the maturation of tiger prawns within a zero-discharge system over a 12-month operational period while maintaining stable and acceptable water quality. The East Arm facility will operate using comparable technology and management practices, and will further refine CRAS methodologies across quarantine, spawning, larval rearing and maturation systems.

11.11.5.1 Anticipated Wastewater Volumes

The proponent anticipates that wastewater generation during normal operations will remain low, with:

- **Average daily discharge:** less than 20 kL per day; and
- **Peak discharge:** up to 40 kL per day during short periods of peak activity.

All wastewater volumes will be monitored, recorded, and reported annually as part of the site's Environmental Management Program to ensure transparency and compliance with relevant regulatory requirements.

11.11.5.2 Expected Wastewater Quality

Representative nutrient and solids concentrations derived from Bribie Island CRAS trials are as follows:

- **Total Nitrogen (TN):** ≈ 27 mg/L (equivalent to 0.54 kg/day at 20 kL/day)
- **Total Phosphorus (TP):** ≈ 7.6 mg/L (≈ 0.15 kg/day)
- **Biochemical Oxygen Demand (BOD₅):** ≈ 3 mg/L
- **Total Suspended Solids (TSS):** ≈ 13 mg/L

These results indicate low nutrient and organic loads, consistent with effective biological filtration and solids removal within closed-loop systems.

11.11.5.3 Progressive Reduction Strategy

Consistent with CSIRO's ongoing technology development program, discharge volumes and nutrient loads are expected to decrease over time through:

- Expansion of CRAS operation across additional culture stages.
- Enhanced biofiltration, nutrient recovery and real-time water-quality control; and
- Increased internal water recycling and disinfection prior to reuse.

By 2027, the proponent aims to achieve **minimal water exchange** consistent with zero-discharge performance demonstrated at Bribie Island, thereby ensuring best-practice environmental performance and protection of the receiving environment.

Table 6 on the following page, highlights the estimated wastewater volumes and key nutrient concentrations.

Table 6: Estimated discharge volumes and key parameter Total Nitrogen and Total Phosphorous loads

Year	Month	Days in Month	Estimated Discharge Volume (kL) (month)	Total Nitrogen Load (kg) (month)	Total Phosphorus Load (kg) (month)
2026	January	31	620	16.74	4.74
2026	February	28	560	15.12	4.28
2026	March	31	620	16.74	4.74
2026	April	30	570	15.39	4.36
2026	May	31	589	15.9	4.51
2026	June	30	570	15.39	4.36
2026	July	31	559.55	15.11	4.28
2026	August	31	559.55	15.11	4.28
2026	September	30	541.5	14.62	4.14
2026	October	31	531.57	14.35	4.07
2026	November	30	514.42	13.89	3.94
2026	December	31	531.57	14.35	4.07
2027	January	31	504.99	13.63	3.86
2027	February	28	456.12	12.32	3.49
2027	March	31	504.99	13.63	3.86
2027	April	30	464.27	12.54	3.55
2027	May	31	479.74	12.95	3.67
2027	June	30	464.27	12.54	3.55
2027	July	31	455.76	12.31	3.49
2027	August	31	455.76	12.31	3.49
2027	September	30	441.06	11.91	3.37
2027	October	31	432.97	11.69	3.31
2027	November	30	419	11.31	3.21
2027	December	31	432.97	11.69	3.31
2028	January	31	411.32	11.11	3.15
2028	February	28	371.52	10.03	2.84
2028	March	31	411.32	11.11	3.15
2028	April	30	378.15	10.21	2.89
2028	May	31	390.75	10.55	2.99
2028	June	30	378.15	10.21	2.89
2028	July	31	371.22	10.02	2.84
2028	August	31	371.22	10.02	2.84
2028	September	30	359.24	9.7	2.75
2028	October	31	352.66	9.52	2.7
2028	November	30	341.28	9.21	2.61
2028	December	31	352.66	9.52	2.7

Table 7: Summary of key goals and aspects of the proposal

Aspect	Goal	Planned Outcome
East Arm site	Establish a High Health domesticated Tiger Prawn population in the Northern Territory	One of the key plans of the proposal is the establishment of a High Health, domesticated Tiger prawn population which can form the base of long-term special breeding programs to improve Tiger Prawn growth, feed conversion, climatic tolerances and disease resistance.
Locally sourced stock	Use locally sourced Tiger prawn stock	The project plans to use locally sourced Tiger prawns to reduce pathogen risk with accessing interstate stock and also have stock with local climatic tolerances. The planned outcome is no new pathogens detected and a healthy locally sourced broodstock population suited to NT conditions.
Closed Recirculating Aquaculture System	Utilising advancements made in Bribie Island trials – further trial other stages of prawn growth in a CRAS.	To develop a multi stage (breeding, nauplii and larval) CRAS facility that reduces water exchange to a minimum (<1% of system volume). This will further enhance aquaculture demonstrating that CRAS facilities can be placed virtually anywhere.
Supply prawn larvae to potential NT growout trials	To be able to produce prawn larvae for stocking year round to provide prawns for ongoing trials in the NT	To provide high health, locally sourced stock to potential aquaculture trials and or projects year round. Currently stock can only be sourced from interstate and only during the NT Wet season which is not the prime time for prawn farming in the NT
Support Indigenous aquaculture	That the project will assist CSIRO's goal of establishing aquaculture within Indigenous communities across northern Australia.	CSIRO have established a close relationship with Tiwi Islands Ranku Clan and wish to support them in their endeavour to develop a prawn farm on country. CSIRO wish to further expand relationships with other Clans to assist them in developing aquaculture on country.
Establish a local Polychaete pathogen free population onsite for Broodstock feed	To find a suitable Polychaete species that can be used as a high protein, high nutrient source for the NT Broodstock population.	Develop a CRAS method for the growing of locally sourced Polychaetes to supply food for the broodstock. Currently the only Polychaetes available for prawn broodstock are interstate and therefore have a high biosecurity risk to the operation if brought into the NT. The outcome would be to have a fully domesticated local species grown.
Train staff in CRAS technology and pathogen free, domesticated prawn management	CSIRO wish to expand the project in future years to provide a larger genetic diversity through additional families included.	To train NT staff in the CRAS technology and other aspects of the project as a staff base for an expanded breeding program at a later date.
Transfer all of the above	To develop protocols and procedures for all of the above to deliver the outcome of CRAS in a complete tiger prawn program	The East Arm site is seen as a starting point for Black Tiger prawn production in the NT. It will allow CSIRO to develop CRAS technology to transfer to another larger site such as an Aquaculture research centre. The East Arm Proof of concept will allow CSIRO to be able to clearly develop costs for any proposed expansion and transfer fully trained staff to the larger site.

Table 8: Results from CRAS sampling Bribie Island 28/11/23 – 12/12/2024 (mg/L)

Date of Sample	Alkalinity (CaCO ₃)	BOD5	TOC	TSS	Ammonia as N	NOX	Phosphate as P	Organic N as N	TKN as N	Organic P as P	TN as N	TP as P
29/11/2023	116	3	1.2	14	0.19	0.88	0.34	0.36	0.55	0.13	1.43	0.48
13/12/2023	107	3	4.1	10	0.13	11.3	1.68	0.07	0.2	0.05	11.5	1.68
1/3/2024	92.8	3	6.9	14	0.14	26.3	3.01	0.53	0.67	0.05	27	3.53
2/7/2024	84.9	3	7.6	11	0.05	26.7	3.74	1.84	1.89	0.59	28.6	4.33
2/14/2024	82.9	3	7.4	27	0.05	25.4	3.87	0.88	0.88	0.05	26.2	3.87
3/11/2024	142		8.9	14	0.05	37.1	5.29	0.42	0.42	0.19	37.6	5.48
4/10/2024	103		13.2	12	0.07	38.8	6.3	8.49	8.56	1.35	47.4	7.65
5/15/2024	99.1	3	13.7	12	0.05	60.4	9.63	5.51	5.51	0.12	65.9	9.75
6/12/2024	128		15.4	13	0.09	71.9	9.28	1.48	1.57	0.57	73.4	9.85
7/10/2024	140		18.3	10	0.25	85.8	10.9	1.71	1.71	1.14	87.6	12.1
8/9/2024	191	3	16.5	12	0.14	44.4	11.3	3.45	3.59	0.05	48	11.3
9/24/2024	146		10.9	16	0.35	15.9	7.28	0.66	0.66	0.28	16.6	7.56
10/16/2024	130		13	16	0.5	16.9	8.3	1.08	1.08	0.05	18	8.3
11/21/2024	152	3	12.1	10	0.05	16	8.3	3.3	3.35	0.43	19.4	8.73
12/12/2024	123		13	16	0.05	15.4	7.81	0.83	0.83	0.2	16.3	8.01

Table 9: Summary of results Bribie Island CRAS 28/11/23 – 12/12/2024 and potential nutrient loads reporting to Hudson Creek

Parameter	Sampling events	Maximum mg/L	Median mg/L	Loading at 20KL/day (median)
Alkalinity (CaCO ₃)	15	191	123	2.46 kg
Biological Oxygen Demand (BOD5)	8	3	3	0.06 kg
Total Organic Carbon (TOC)	15	18.3	12.1	0.242 kg
Total Suspended Solids (TSS)	15	27	13	0.26 kg
Ammonia as N (NH ₃)	15	0.35	0.09	0.0018 kg
NOX (Nitrate + Nitrite)	15	85.8	26.3	0.526 kg
Phosphate as P (Dissolved P)	15	11.3	7.28	0.1456 kg
Organic N as N	15	8.49	1.08	0.0216
Total Kjeldahl Nitrogen (TKN) as N	15	8.56	1.08	0.0216
Organic Phosphorous as P	15	1.35	0.19	0.0038
Total Nitrogen as N	15	87.6	27	0.54
Total Phosphorus as P	15	12.1	7.65	0.153

*Please note in regards to Alkalinity that typically marine saltwater has an Alkalinity range of between 125 – 175mg/L

Figure 5: East Arm area 1: (roof and verandah and side wall removed)

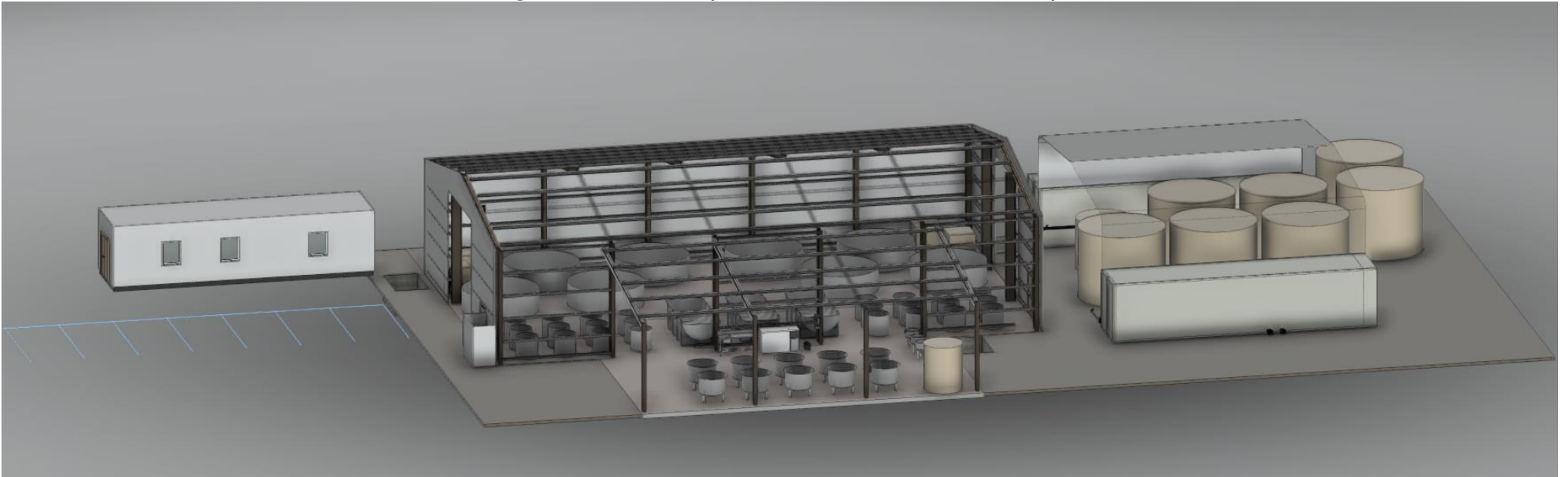
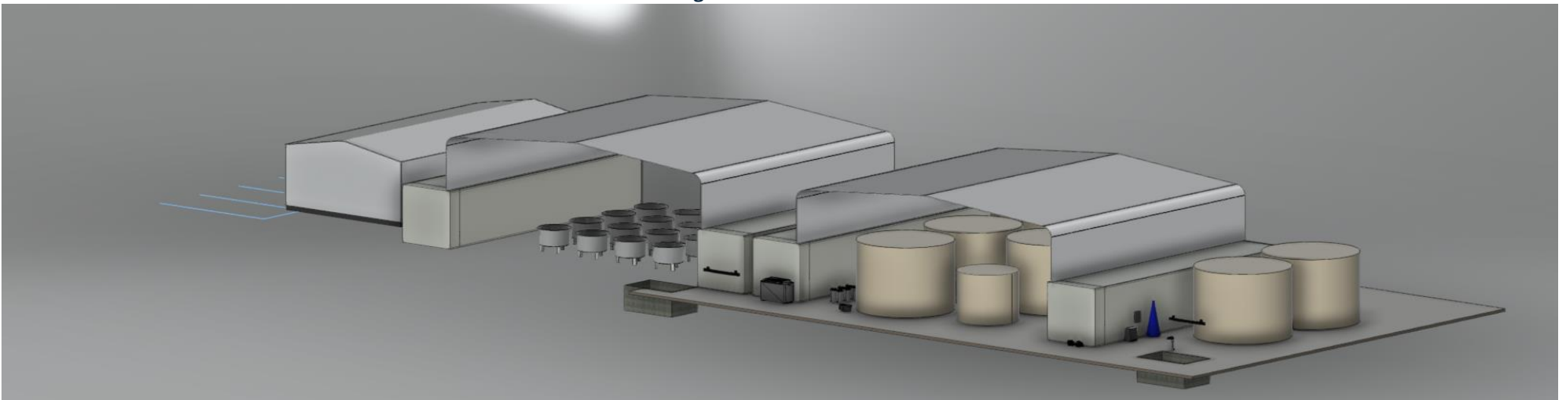


Figure 6: East Arm area 2



12 Water Quality Monitoring

A Water Quality Monitoring Program (WQMP) for the project at East Arm has been developed to meet the Darwin Harbour Water Quality Objectives (WQOs) set by the NT EPA. The WQMP outlines a robust monitoring framework designed to track key water quality indicators and nutrient levels, with an emphasis on ensuring compliance and protecting the estuarine environment. The project will secure “Baseline” samples prior to operations to provide some form of background data. The project will attempt to secure 3 months of “Baseline” data samples before operations begin, depending on site access.

12.1 Sampling Locations and Frequency

Water quality samples will be collected from the following four designated monitoring points (as defined in the WQMP Section 7.3.1):

- **DSP EA1:** Discharge Sampling Point 1 – Outlet pipe from main shed (East Arm 1)
- **DSP EA2:** Discharge Sampling Point 2 – Outlet pipe from hangar (East Arm 2)
- **HCMP US:** Hudson Creek Monitoring Point Upstream – collected during discharge and 2 hours before low tide
- **HCMP DS:** Hudson Creek Monitoring Point Downstream – collected 1 hour after discharge commences and 2 hours before low tide

Sampling at these points provides a clear assessment of discharge characteristics, allowing for accurate comparison with background water quality data and enabling the evaluation of any influence from site operations.

12.2 Field and Laboratory Sampling Integration

To achieve efficient and comprehensive monitoring, the WQMP combines weekly field analysis with monthly laboratory sampling and analysis. Weekly field analysis at the discharge points provides immediate insights into water quality parameters entering the environment, while monthly laboratory testing by a NATA-certified facility validates field data and ensures accuracy for regulatory reporting. This combined approach allows for timely detection and management of potential environmental impacts.

Weekly field sampling will be conducted at DSP EA1 and DSP EA2 using handheld multiparameter sensors to measure:

- Temperature, Salinity, DO (% saturation), pH, Turbidity (NTU), Ammonia (NH₃-N), NO_x, and Chlorophyll-a (Chl-a)

Monthly laboratory analysis (WQMP Section 7.3.2) by a NATA-accredited facility will assess:

- Total Nitrogen (TN), Total Phosphorus (TP), Biological Oxygen Demand (BOD₅), Total Suspended Solids (TSS), and Chlorophyll-a

12.3 Trigger Levels and Adaptive Management

The WQMP defines trigger levels for key water quality indicators in alignment with the Darwin Harbour Water Quality Objectives (Upper Estuary zone) (see WQMP Section 7.4). These values represent early-warning thresholds for potential environmental harm.

Trigger Values:

- NO_x (Nitrate + Nitrite): 20 µg/L
- Chlorophyll-a: 4 µg/L

- Dissolved Oxygen (DO): Minimum 80% saturation
- Ammonia (NH₃-N): 20 µg/L
- Filterable Reactive Phosphorus (FRP): 5 µg/L

Adaptive Response Protocol:

If any of the above parameters exceed their respective trigger values:

- Immediate notification will be made to the NT EPA
- Repeat sampling will be undertaken to confirm exceedance
- Investigations will be initiated to identify potential causes, including operational activity reviews
- Weekly laboratory sampling will be conducted at all relevant points until values return to within acceptable limits

This adaptive management framework ensures responsive and proportionate monitoring. Parameters that consistently present no environmental risk may be phased out with NT EPA agreement, while additional parameters may be added if required by regulatory bodies or based on environmental observations.

12.4 Onsite Testing Equipment

Onsite testing equipment, including portable monitoring units, will be used for real-time assessments of nutrient levels and other water quality parameters. Although these units may not match the detection limits of NATA-certified laboratory analysis, they provide valuable, timely insights that allow for early detection of potential environmental risks. Monthly laboratory testing supports these results with more precise data, ensuring a thorough approach to water quality management.

12.5 Data Documentation and Reporting

All sampling data—collected through both field and laboratory analyses—will be entered into a centralised CSIRO database. Data will be reviewed on a monthly basis to detect trends, evaluate performance against trigger values, and inform any adaptive responses required under the Water Quality Monitoring Plan (WQMP).

Sampling Schedule:

- Field sampling will be conducted weekly if discharge occurs during that week
- Laboratory analysis will be conducted monthly, but only if discharge has occurred within that month

Annual reports will be submitted to the **NT EPA** and **NT Fisheries**, summarising:

- Compliance with trigger values and monitoring outcomes
- Total nutrient discharge loads (e.g. TN and TP)
- Details of any trigger exceedances and corrective actions taken
- Any updates to monitoring methods or parameters

In accordance with the **WQMP Section 8.1**, a comprehensive review of the monitoring framework will be conducted after two years of operations, allowing the program to be refined. Parameters showing consistent compliance with no environmental relevance may be phased out, while new indicators may be introduced based on regulatory recommendations or site performance.

These documentation and reporting procedures ensure full transparency, enable continuous improvement, and uphold CSIRO's commitment to environmental stewardship and compliance with the **Darwin Harbour Water Quality Objectives**.

13 Environmental Aspects and Controls

The East Arm site will operate under a site-specific EMP (this document) that encompasses all aspects of environmental management. This will include provisions for Traffic Management, Light, Noise Control, Odour Mitigation, Waste and Wastewater Management. The EMP is designed to ensure the site's operations align with both environmental sustainability and community expectations.

CSIRO acknowledges that the EMP will require approval from the relevant regulatory bodies, and post approval, any non-compliance with the EMP or regulatory standards will necessitate adjustments to site operations. This proactive approach ensures that the project meets all environmental and legal requirements while minimising any potential impact on the surrounding environment and local community.

13.1 Water Management

Refer to the Water Quality Management Program for detailed information.

13.1.1 Water Quality Objectives:

The project aligns with Darwin Harbour's Upper Estuary Water Quality Objectives (WQOs) to protect the estuarine environment. Key guideline parameters include:

- **Dissolved Oxygen (% saturation): 80–100%**
- **Chlorophyll-a (µg/L): Less than 4**
- **NOx N (µg/L): Less than 20**
- **Ammonia as N (µg/L): Less than 20**
- **Filterable Reactive Phosphorus (µg/L): Less than 10**

These objectives serve as benchmarks for assessing the environmental impact of the discharge, ensuring compliance with local and national standards for estuarine ecosystem health.

13.1.2 Water Use and Discharge:

- **Saltwater Source:** Water for site operations is sourced from Hudson Creek and undergoes a multi-stage filtration and UV/Ozone sterilisation process to ensure pathogen control and water quality. The CRAS is designed to limit intake volume and maximise internal water reuse, significantly reducing overall water demand.
- **Municipal (freshwater):** Freshwater for the project will be used as general drinking water and general cleaning. The Muramats site has an existing shared public type ablutions block, CSIRO staff will utilise these. The CSIRO sites will operate with 2-4 staff and freshwater use is expected to be <1,000 litres per day.
- **Discharge Management:** Wastewater discharge is managed through controlled release points to Hudson Creek, timed with outgoing tides. This approach reduces the risk of backflow and dilution effects, protecting water quality in surrounding areas. Discharge volumes and characteristics will be continually monitored to meet WDL requirements and to prevent degradation of local water quality.

The project does not expect any detection of operations to be found during sampling based on the low volume of expected discharge and considerable immediate dilution.

13.1.3 Wastewater Quality Monitoring:

To comply with WDL and maintain environmental standards, the project implements a dual-tiered monitoring program:

- **Weekly Field Sampling:** Sampling is conducted at two designated discharge points (East Arm Area 1 and Area 2). Parameters monitored include temperature, pH, dissolved oxygen, salinity, and nutrient levels. This field data provides a real-time understanding of water quality at discharge points and enables immediate action if deviations are detected.
- **Monthly Laboratory Testing:** Monthly samples are sent to a NATA-certified laboratory for detailed analysis of key water quality indicators, including pH, filterable reactive phosphorus, total nitrogen, chlorophyll-a, and Total Suspended Solids. Results from these analyses are compiled into internal monthly reports, which are reviewed internally and submitted to NT EPA on request, ensuring full transparency and regulatory compliance. Sampling will be conducted at Four sites, the two discharge outlets (during discharge) an upstream sample and a downstream environmental sample taken 30 minutes post discharge commencing.
- **Performance Indicators:** Key water quality indicators are maintained within the WQOs and per conditions contained within the WDL. Exceedances trigger immediate corrective actions and reporting to NT EPA.

13.1.4 Corrective Actions:

If the effluent from the operation failed to meet the WQOs and trigger limits were exceeded at the Hudson creek monitoring sites which were directly related to the project. CSIRO would implement:

- **Enhanced Wastewater Treatment:** CSIRO if required, could extend wastewater storage and treatment times for effluent by installing additional post treatment storage tanks with aeration, combined and additional biological filtration.
- **Regulatory Reporting:** Any non-compliance incidents are documented and reported to NT EPA for further guidance on corrective measures

13.1.5 Water Quality Exceedance Reporting Protocol

If water quality indicators exceed regulated thresholds, NT EPA notification is required as follows:

1. Identify Exceedance:

- Assess whether the parameter exceedance represents a risk to waterway health or is outside permitted limits.

2. Evaluate Reporting Requirements:

NT EPA Reporting Threshold: Exceedance incidents must be reported if:

- They involve significant nutrient or chemical pollution (e.g., high nitrogen or phosphorus levels).
- They have visibly impacted Hudson Creek or other water bodies (e.g., causing visible changes like algal blooms or turbidity).
- They pose a risk of serious or material environmental harm.

3. Notification Process:

- Contact NT EPA as soon as possible, but no later than 24 hours after identifying the exceedance.

- Submit a Section 14 Incident Report Form or Online Pollution Report, detailing the nature of the exceedance and initial corrective actions. If necessary, contact the Pollution Hotline at 1800 064 567.

4. Documentation and Follow-Up:

- Log the exceedance in the project's incident register, detailing actions taken and preventive measures.
- Complete a full incident report for NT EPA and implement any recommended additional corrective actions.

13.2 Traffic Management

13.2.1 Traffic Objective

To maintain traffic levels consistent with existing operations and minimise any potential impacts on local infrastructure and road users.

13.2.2 Traffic expectations

The site is located within an established industrial precinct with sufficient road infrastructure to support light industrial traffic volumes. Access to the site is primarily via Muramats Road, connecting to Cochrane Road and Berrimah Road, which is the main thoroughfare for the East Arm Industrial area. This setup provides efficient access to major transport routes, minimising the need for traffic through residential or sensitive areas.

Anticipated Traffic Movements:

- **Daily:** Approximately two passenger vehicles or utility vehicles (utes/4WDs) are expected to visit the site for routine operations.
- **Weekly:** One small to mid-sized truck (less than 12 tonnes) is anticipated for delivery and pick-up of materials or products.

Traffic volume is expected to remain minimal, with no significant increase anticipated over current levels, as the site is leased from a similar operator with comparable vehicle requirements. The majority of traffic will occur between 6 am and 6 pm, aligning with typical industrial operation hours and minimising potential impacts on peak traffic times. This scheduling approach is intended to prevent disruptions to local traffic flow and maintain efficient access for neighbouring businesses.

Table 10: Estimated Traffic Movements to the East Arm site.

Vehicle Type	Weekly Movements	Annual Movements
Passenger (cars/utes/4wds)	14	728
Light Truck (<12 tonnes)	1	52

13.2.3 Traffic Corrective Actions

While corrective actions are not expected to be necessary, the following measures could be implemented if traffic volumes unexpectedly increase, or impact is observed:

- **Carpooling Initiatives:** Encouraging carpooling among staff to reduce vehicle numbers.
- **Scheduled Deliveries:** Setting specific days or times for truck deliveries to further control traffic patterns and minimise congestion.

This proactive approach to traffic management ensures minimal disruption to surrounding businesses and maintains safe and efficient access to the site.

13.3 Noise Management

13.3.1 Noise Objective

To minimise noise impacts on the surrounding community and ensure compliance with Northern Territory industrial noise guidelines, maintaining operations within acceptable noise limits for both industrial and residential standards.

13.3.2 Noise Expectations

The East Arm site will operate within the Northern Territory's industrial noise limit of 70 dB(A). However, CSIRO anticipates that operational noise will remain within the more stringent residential limits, set at <45 dB(A) during the day (7 am – 10 pm) and <35 dB(A) at night (10 pm – 7 am), at distances measured from nearby sensitive receptors. Although the site is in an industrialised area with no known sensitive receptors in proximity, CSIRO is committed to proactive noise management to prevent potential disturbances.

Operational Noise Control Measures:

- **Equipment Use:** Noisy equipment will be restricted to daylight hours and, where feasible, operated within enclosed spaces to reduce noise emissions.
- **Continuous Monitoring:** Noise levels will be periodically monitored to ensure compliance with residential standards, particularly if site operations intensify or if new equipment is introduced.

Table 11: Anticipated noise levels from East Arm facility

Period	Expected dB(A) at sensitive receptor
7am – 10pm	< 45 dB(A)
10pm – 7am	< 35 dB(A)
Maximum	< 70 dB (A) as per industrial guidelines

13.3.3 Noise Complaint Response Protocol

1. Receive Complaint:

- Log the complaint in the complaints register.
- Identify specific concerns, including time of day and source of noise (if possible).

2. Investigate and Measure:

- Conduct an immediate on-site assessment of noise levels.
- Use noise monitoring equipment to confirm if levels exceed residential or industrial limits.

3. Implement Corrective Actions:

- Operational Adjustments: Modify or reschedule equipment use if noise exceeds limits.
- Expert Consultation: If noise persists, consult a noise expert to recommend additional control measures.

4. Report and Document:

- Record the actions taken and results in the complaints register.
- Update the incident report if further mitigation actions were required.

13.4 Odour Management

13.4.1 Odour Objective

To prevent and minimise any odour emissions from operations at the East Arm site, ensuring that activities do not impact surrounding areas.

13.4.2 Odour Sources and Controls

Two potential sources of odour have been identified: composting of solid waste and temporary storage of wastewater. These are managed through specific controls to prevent unpleasant odours from affecting the site's surroundings. The system is designed to operate indoors or under controlled conditions that prevent odour emissions. Regular maintenance and sealed storage reduce the risk of odour generation. Should complaints arise, CSIRO will investigate promptly under its complaints register and response procedures.

1. Composting (Odours)

Source: Small volumes of organic waste (less than 7 kg per week) from aquaculture operations, including uneaten food and filtration sludge.

- **Controls:** Two sealed composting units are used on-site, following industry standards for controlled composting. The composting process combines waste with sawdust (1:3 ratio) to maintain an optimal carbon-to-nitrogen balance, effectively controlling microbial activity and reducing odours. Units are stored in a shaded area and kept sealed to prevent pest attraction and odour release.
- **Post-Processing:** Once fully decomposed (after 60 days), the composted material is transported to CSIRO's Berrimah facility for reuse in gardens, supporting sustainable practices.
- **Excess Waste Management:** Any waste exceeding compost capacity will be bagged, frozen, and disposed of at a municipal waste facility, in line with environmental regulations.

2. Wastewater Storage (Odours)

Source: Temporary on-site storage of wastewater before discharge.

- **Controls:** Wastewater is stored in an enclosed polyethylene tank with a breather pipe, which releases potential odours at a height of 4 metres to minimise ground-level impact. Aeration of the tank prevents anaerobic conditions that could cause odours.

13.4.3 Odour Complaint Response Flowchart

In the event of an odour complaint, CSIRO will implement the following response protocol:

1. Receive Complaint:

- Log the complaint in the complaints register.
- Gather details from the complainant, including the time of day, nature of the odour, and any suspected source.

2. Investigate and Identify Source:

- Conduct an on-site inspection to assess odour levels and identify the source.
- Check composting units and wastewater storage for any irregularities (e.g., improper sealing or aeration issues).

3. Implement Corrective Actions:

- **Composting Adjustments:** Adjust the composting ratio, sealing practices, or storage conditions if odour originates from composting.

- **Aeration and Tank Checks:** If odour is from wastewater storage, check and adjust aeration levels or ensure the breather pipe is functioning correctly.
- **Additional Controls:** If needed, increase the frequency of waste removal or transport excess waste offsite.

4. Report and Document:

- Document the investigation, corrective actions, and outcomes in the complaints register.
- Follow up with the complainant to inform them of actions taken and verify if the issue has been resolved.

5. Review and Improve:

- Review odour management practices if complaints persist or new sources are identified.
- Implement improvements as needed to ensure ongoing control and reduction of odour emissions.

13.5 Light Management

13.5.1 Light Objective

To minimise light pollution from site operations, ensuring compliance with best practices for industrial lighting while reducing any potential impact on the surrounding environment.

13.5.2 Light Controls

The East Arm project is located within an industrial area with existing external lighting infrastructure. However, to minimise light pollution, CSIRO has implemented specific lighting controls:

- **Downward-Angled Lighting:** All external lights are directed downward to reduce skyglow and outward spill, minimising light pollution in the area.
- **Focused Illumination:** Lighting is concentrated on operational areas only, ensuring that non-operational spaces are not unnecessarily illuminated, which enhances efficiency and reduces potential impacts on nearby areas.
- **Shielding Measures:** Lighting fixtures are shielded or angled away from any potential sensitive receptors, although none are currently identified within this industrial zone.

These practices align with best practices for industrial lighting design and meet NT EPA recommendations for minimising environmental impacts related to industrial lighting.

13.5.3 Regulatory Compliance

While the Northern Territory does not have specific legislation solely addressing light pollution, CSIRO's lighting strategy aligns with NT EPA and local planning recommendations. By controlling light spill and focusing illumination on essential areas, the project supports NT guidelines to preserve local amenity and prevent unnecessary light pollution.

13.5.4 Light Corrective Actions

In the event of a verified complaint regarding lighting, CSIRO will collaborate with the complainant to resolve the concern. Actions may include adjusting lighting angles, reducing intensity, or implementing additional shielding to manage light levels effectively. All lighting-related complaints and corrective actions will be documented in the complaints register (see section 15.5).

13.5.5 Light Complaint Response Flowchart

In the event of a verified lighting complaint, CSIRO will follow the steps below to investigate and resolve the issue:

1. Receive Complaint:

- Log the complaint in the complaints register.
- Record details such as time, nature of the complaint, and location of any perceived light disturbance.

2. Investigate and Identify Source:

- Conduct an on-site inspection to determine if light levels exceed expected operational standards.
- Review lighting angles, shielding, and focus areas for compliance with current controls.

3. Implement Corrective Actions:

- **Adjust Lighting Angles:** Modify the angle of lights to further reduce spill if light is affecting surrounding areas.
- **Reduce Intensity:** Lower light intensity if operational requirements allow, decreasing overall light emission.
- **Enhance Shielding:** Add or modify shielding to focus illumination on specific areas and prevent unnecessary light spill.

4. Report and Document:

- Document all investigation findings and corrective actions taken in the complaints register.
- Follow up with the complainant to explain the steps taken and confirm whether the issue has been resolved to their satisfaction.

5. Review and Improve:

- Evaluate lighting controls periodically to identify any areas for improvement.
- Implement further adjustments or innovations in lighting technology to reduce light pollution over time.

13.6 Solid Waste Management

13.6.1 Solid Waste Objectives

To minimise solid waste generation, promote recycling, and protect the environment through effective waste management practices that reduce bio-waste and mitigate nutrient pollution.

13.6.2 Sources of Solid Waste

Solid waste generated at the East Arm site is categorised as follows:

- **Bio-Waste:** Tank biological debris, including organic material and suspended solids from aquaculture systems and mortalities.
- **General Waste Streams:** Includes materials such as cardboard, paper, and staff-generated waste, which will be managed internally or through licensed waste disposal companies.

13.6.3 Management Procedures

13.6.3.1 Bio-Waste Disposal

Composting and Disposal: Where feasible, bio-waste will be composted on-site using sealed composting units in line with NT waste management standards. Non-compostable waste is securely stored and disposed of via municipal waste facilities.

13.6.3.2 General Waste Disposal

Storage and Collection: General waste is stored in appropriate bins on-site and collected weekly for disposal through licensed waste management services, ensuring compliance with local environmental standards.

13.6.3.3 Performance Indicators

Recycling and Waste Reduction: Progress is tracked annually, with performance indicators focusing on increased recycling rates and a year-over-year reduction in waste volume.

13.6.4 Solid Waste Incident Response Flowchart

In the event that solid waste management practices do not meet performance targets or negatively impact environmental quality, CSIRO will follow these steps:

1. Identify Waste Issue:

- Review waste logs to determine if waste volumes exceed targets or if disposal methods fall short of standards.
- Inspect bio-waste composting units and general waste storage areas for any signs of improper handling or containment.

2. Investigate Cause:

- Identify if increased waste volumes are due to operational changes, storage issues, or insufficient recycling efforts.
- Determine if any specific waste materials are contributing disproportionately to excess volumes or environmental risks.

3. Implement Corrective Actions:

- **Process Adjustments:** Modify waste collection, storage, or disposal processes to manage excess volumes or non-compliance. For instance:
 - Increase frequency of waste removal for compost units or general waste bins.
 - Adjust waste segregation practices to ensure proper disposal.
- **Enhanced Recycling Efforts:** Initiate additional recycling or composting measures to reduce waste volumes, such as:
 - Introducing new waste separation protocols.
 - Educating staff on waste reduction practices.

4. Report and Document:

- Record the issue, investigation findings, and corrective actions taken in the waste management log.
- If environmental impacts are significant, report to NT EPA and document actions for regulatory compliance.

5. Monitor and Review:

- Conduct follow-up inspections to ensure corrective actions effectively manage waste and meet performance indicators.
- Implement periodic reviews to assess waste management practices and identify further opportunities for improvement.

13.7 Weed Management

A review of the NT Weeds Database identified the presence of Class A and B declared weeds in the area, including Gamba Grass (*Andropogon gayanus*) and Prickly Acacia (*Vachellia nilotica*). CSIRO will implement weed monitoring and control in accordance with the Weeds Management Act 2001 and statutory weed management plans. Measures include:

- Regular inspections of project areas.
- Targeted treatment of any declared weed species.
- Compliance with best practice weed hygiene protocols to prevent spread.

13.7.1 Weed Management Objective

To maintain a weed-free environment on the leased site, ensuring that operations are not impacted by invasive species and that weed growth is controlled in line with environmental best practices.

13.7.2 Weed Management Controls

The East Arm site is fully developed with hard surfaces, including gravel, bitumen, and concrete, which naturally limit weed growth. However, CSIRO will proactively manage any weed growth within the leased area by implementing the following controls:

- **Regular Inspections:** Routine site inspections to identify and address any emerging weed growth promptly.
- **Chemical Treatment:** Use of approved chemical treatments to remove and control weeds, applying treatments in line with environmental guidelines to prevent impact on surrounding areas.

These measures ensure that the leased area remains clear of invasive species, supporting site safety and operational efficiency.

13.7.3 Weed Corrective Actions

In the event that weeds become problematic or extend beyond expected levels, CSIRO will implement corrective actions, which may include:

- **Increased Treatment Frequency:** Adjusting the frequency of chemical treatments or inspections to prevent further spread.
- **Alternative Treatment Methods:** Implementing alternative or enhanced treatment methods if chemical applications alone do not effectively control weed growth.

This approach to weed management maintains site integrity, supports environmental protection, and aligns with CSIRO's commitment to responsible site maintenance.

13.8 Soil Management and Erosion Control

13.8.1 Soil Management Objective

To maintain soil stability and prevent erosion throughout the project by utilising existing infrastructure and minimising soil disturbance.

13.8.2 Development Activities

No soil disturbance is anticipated as the project will primarily use existing infrastructure. Soil stability will be regularly monitored (visually), and if any issues arise, CSIRO will consult with soil management experts to implement appropriate mitigation measures.

13.8.3 Erosion Prevention

Due to the low risk of soil disruption, additional erosion control measures are not initially planned. However, if future site modifications or development activities occur, CSIRO will:

- **Reassess Soil Integrity:** Conduct a re-evaluation of soil stability and erosion risks.
- **Implement Erosion Controls:** Introduce necessary control measures, if required, following expert consultation and obtaining appropriate approvals.

Routine inspections will monitor for signs of erosion, and any issues will be addressed with expert guidance to ensure stability and prevent sediment runoff.

13.8.4 Acid Sulfate Soils

No excavation or disturbance of natural soils is currently proposed; however, CSIRO acknowledges the potential risk of encountering acid sulfate soils in the region. Should future works involve disturbance, Chromium Reducible Sulphur (CRS) testing will be conducted in line with the National Acid Sulfate Soils Guidance. If acid sulfate soils are detected, an Acid Sulfate Soil Management Plan (ASSMP) will be developed in accordance with the Queensland and WA technical manuals. This plan would include CRS results, lime requirements, treatment methods, and monitoring protocols.

13.9 Exotic Species Management

13.9.1 Exotic Species Management Objective

To prevent the introduction and spread of exotic species within the site's aquaculture operations, safeguarding native ecosystems and maintaining compliance with biosecurity standards.

13.9.2 Exotic Species Controls

To minimise the risk of introducing exotic species through water intake, CSIRO has implemented a multi-stage water treatment process:

- **Screening:** Intake water undergoes initial screening to remove large particles and potential organisms.
- **Filtration:** Water is then filtered through sand and media filters to capture finer particles and organisms.
- **UV and Ozone Treatment:** A final stage of ultraviolet (UV and Ozone) sterilisation is applied to neutralise any remaining microorganisms, ensuring biosecurity within the aquaculture system.

These layered controls significantly reduce the risk of exotic species entering the site's systems and impacting local biodiversity.

13.9.3 Exotic Species Incident Response Flowchart

In the event that a suspected exotic species is identified within the intake or system water, CSIRO will follow the steps below:

- 1. Identify Potential Exotic Species:**
 - Confirm the presence of the suspected species in the intake or system water.
 - Isolate affected tanks or systems immediately to prevent further spread.
- 2. Notify and Liaise with NT Fisheries:**
 - Contact NT Fisheries for guidance on species identification and biosecurity risk assessment.
 - Provide NT Fisheries with samples and preliminary data to assist in identifying the species.
- 3. Implement Eradication Measures:**

- Follow Expert Guidance: Implement any recommended eradication methods from NT Fisheries, including additional UV treatment, filtration adjustments, or removal of affected stock.
- Increase Treatment Levels: Adjust UV or other treatment processes to ensure complete neutralisation of potential threats.
- Isolate and Quarantine: Quarantine any affected systems or equipment to prevent cross-contamination with unaffected areas.

4. Document and Report:

- Log all actions, findings, and communications with NT Fisheries in the project's incident register.
- Complete an incident report detailing corrective actions and outcomes and submit it to relevant regulatory authorities if required.

5. Review and Preventive Measures:

- Assess existing controls and identify any necessary improvements to prevent future occurrences.
- Enhance staff training on early detection and response to exotic species as part of continuous improvement in biosecurity.

13.10 Fire Management

13.10.1 Fire Management Objective

To ensure a safe working environment by implementing fire prevention and response measures, minimising fire risks, and preparing staff for effective response in case of a fire.

13.10.2 Fire Risk Assessment

Due to the developed nature of the site, with limited vegetation and expansive hard surfaces such as concrete and bitumen, the risk of grass or vegetation fires is low. However, internal fire prevention and preparedness measures are in place to protect personnel, equipment, and infrastructure, whilst noting that the buildings are industrial steel, and no insulation is in place further limiting the risk of fire spreading.

13.10.3 Fire Prevention and Preparedness Controls

- **Fire Extinguishers:** Fire extinguishers will be strategically placed throughout the site, clearly marked and regularly inspected in line with safety standards.
- **Fire Alarms:** Fire Alarms will be strategically placed throughout the site and regularly inspected.
- **Signage:** Appropriate signage will indicate fire extinguisher locations and emergency exits, ensuring visibility and easy access for all staff.
- **Fire Warden:** A designated fire warden from the site staff will oversee fire safety, conduct regular inspections, and lead drills and emergency procedures.
- **Fire Drills:** Fire drills will be conducted twice yearly to ensure all staff are familiar with evacuation routes, extinguisher use, and emergency protocols.
- **Training:** Site staff will receive regular fire safety training, including extinguisher handling and emergency response procedures.

13.10.4 Fire Incident Response Flowchart

In the event of a fire, CSIRO will follow the steps below to ensure prompt, safe, and effective response.

1. Detect Fire:

- Fire alarms sound to alert staff.
- Fire warden or any staff member identifies the location and type of fire.

2. Activate Emergency Procedures:

- Alert Personnel: Immediately announce the fire and begin evacuation.
- Contact Emergency Services: Dial 000 to notify fire services if the fire is beyond internal control.
- Evacuate Site: Fire warden leads staff to designated assembly points, following marked evacuation routes.

3. Contain the Fire (If Safe to Do So):

- Use Fire Extinguishers: Trained staff may use fire extinguishers if the fire is small and manageable.
- Secure Hazards: Turn off any equipment or systems that could fuel the fire (e.g., power supplies, gas lines).

4. Conduct a Headcount at Assembly Point:

- Confirm that all personnel have evacuated safely.
- Report missing persons to the fire warden or emergency services.

5. Post-Incident Review:

- Conduct a debriefing with all staff to assess the effectiveness of the response.
- Document the incident, including response actions, issues faced, and areas for improvement.

6. Implement Corrective Actions:

- Address any recommendations from emergency services or staff feedback.
- Update fire safety protocols if necessary and ensure any equipment is repaired or replaced as required.

13.11 Fuel and Chemical Storage and Spills

The need for chemical and fuel storage is considered minimal at the East Arm site and will primarily consist of general household cleaners and disinfectants and is anticipated to remain <20 litres. Fuel will be stored onsite within chemical storage units <100 litres of fuel is anticipated to be stored onsite primarily for emergency back-up generators.

13.11.1 Fuel and Chemical Storage Objective

To safely manage and store small quantities of chemicals and fuel on-site, ensuring compliance with safety standards and minimising risks to personnel and the environment. Chemicals are purchased from approved suppliers and stored in locked units that have a warning sign appropriate to the hazardous chemicals being stored. Chemicals are stored near to their area of use, inside chemical storage units.

At each of these locations, there is spill containment equipment, and hard-copy safety data sheets (SDSs) for the chemicals stored. Incompatible chemicals will be kept separate, and the storage units are banded, where required. Hard-copy SDSs are also held at the site office and electronic copies on file.

Staff who regularly handle and use chemicals are required to complete CHEMCERT training. The East Arm Training Matrix records the staff who have completed the training, and which staff still need to complete the training.

The East Arm Chemical Register lists all chemicals used and stored on-site and includes information on the storage location, chemical brand, volume, active constituent, common use, supplier and link to the SDS

13.11.2 Storage and Handling Controls

Given the limited amount of chemicals used on-site, the following controls will be implemented to ensure safe storage and handling:

- **Secure Storage:** All chemicals and fuel will be stored in designated, clearly labelled cabinets specifically designed for chemical and fuel storage. These cabinets will meet industry standards for containment and ventilation.
- **Labelling and Identification:** Each chemical container will be properly labelled with contents, handling instructions, and hazard symbols to ensure safe and correct usage by all staff.
- **Material Safety Data Sheets (MSDS):** MSDS documents for all stored chemicals and fuels will be maintained in two locations: in the storage area and within the office, allowing for easy access and inspection by staff or regulatory bodies as needed.

13.11.3 Fuel and Chemical Safety Corrective Actions

In the event of a spill or other safety issue, corrective actions will include:

- **Immediate Containment:** Any spills will be contained using spill kits, which are readily available near storage areas. Trained personnel will manage the spill according to MSDS guidelines.
- **Notification and Documentation:** Incidents will be documented and reported, and staff will be briefed on any updated procedures following an incident.
- **Review and Improvement:** Post-incident reviews will assess handling and storage practices, with adjustments made to prevent future occurrences.

These storage and handling practices ensure that fuel and chemicals are managed in a safe and compliant manner, reducing risks to personnel, property, and the environment.

13.11.4 Spill Containment Response Flowchart

Objective: Quickly isolate, contain, and safely dispose of hazardous spills to prevent environmental contamination.

Spill Containment Flowchart

- 1. Identify the Spill:**
 - Determine the type and volume of the spilled substance.
 - Notify the site supervisor.
- 2. Isolate the Area:**
 - Evacuate any personnel in the immediate vicinity.
 - Use barriers or signage to prevent entry into the contaminated area.
- 3. Contain the Spill:**
 - Retrieve the nearest spill kit (located near fuel storage and discharge points).
 - Use absorbent materials to encircle and contain the spill.
 - For liquid spills, use diking materials to prevent spread.
- 4. Assess Need for Additional Resources:**
 - If the spill is large or highly hazardous, contact local emergency services.
 - Deploy additional spill kits if required.
- 5. Determine Reporting Requirement:**

NT EPA Reporting Threshold: The spill must be reported to NT EPA if it:

- Involves contaminants such as hydrocarbons, pesticides, or other hazardous chemicals.
- Has reached a waterway, including drains.

- Has spread more than three metres or extends beyond the premises.

Reporting Process: If the spill meets any of these conditions, notify NT EPA as soon as possible, but within 24 hours of awareness. Complete a Section 14 Incident Report Form or submit an Online Pollution Report via the NT EPA portal. Contact the **Pollution Hotline at 1800 064 567** if needed.

6. Clean-Up and Disposal:

- Collect all contaminated materials (e.g., absorbents, used PPE) in approved disposal containers.
- Arrange for proper disposal through a licensed waste management provider.

7. Report and Document:

- Log the incident in the site's incident register.
- Complete a detailed incident report and include corrective actions taken.
- Notify NT EPA if the spill exceeds reportable thresholds.

13.12 Flood and Storm Surge Management

The East Arm site is partially located within mapped Primary and Secondary Storm Surge Areas (PSSA and SSSA) (see image 8) as designated by the Northern Territory Government. These zones represent areas that may be subject to inundation during severe cyclonic events and associated storm surges. While portions of the site's existing infrastructure fall within these zones, the overall flood and surge risk is considered manageable due to the elevated positioning of core infrastructure and the application of targeted mitigation strategies developed in accordance with regional risk assessments and environmental best practice.

To ensure operational resilience and safeguard the site against extreme weather events, including cyclones and coastal flooding, CSIRO has adopted a range of preventative and responsive measures. These strategies are designed to minimise disruption to research activities, prevent asset damage, and ensure the safety of personnel and aquaculture stock. The following controls and protocols are in place to actively manage this risk profile:

13.12.1 Objective

To safeguard the site, equipment, and stock from potential flood and storm surge impacts, minimising risks to operational continuity and ensuring the safety of personnel and assets.

13.12.2 Site Controls and Mitigation Measures

- **Enclosed Equipment Storage:** Equipment is stored within enclosed sheds, providing protection against water ingress and minimising the risk of flood damage.
- **Use of Local Species:** Only locally adapted aquaculture species (e.g., tiger prawns, algae, and polychaetes) are maintained on site. These species are suited to regional conditions, reducing the risk of biodiversity impacts if a storm surge affects the site.
- **Drainage Maintenance:** Routine inspection and maintenance of on-site drainage infrastructure helps ensure proper water flow and limits flood accumulation.

13.12.3 Response Measures for Severe Weather Events

- **Monitoring and Early Notification:** Weather alerts issued by the Bureau of Meteorology will be closely monitored. In the event of a severe storm warning, site personnel will be notified immediately.

- **Equipment and Stock Relocation:** If storm surge risk is elevated, portable equipment and essential stock will be relocated to elevated ground outside of flood zones or transferred to the CSIRO Berrimah facility.
- **Emergency Activation:** Drainage pumps will be activated as needed, and non-essential staff will follow evacuation procedures. Essential personnel may shelter on-site if evacuation is not viable.
- **Post-Event Recovery:** Once the event has passed, site inspections will be conducted, and any damage or operational impacts will be documented and addressed promptly.

These measures ensure that, despite being partially located within mapped surge zones, the East Arm facility can operate safely and respond effectively to storm surge events.

Image 5: Extent of PSSA and SSSA on site



13.13 Biosecurity Management

13.13.1 Biosecurity Objective

To maintain a high standard of biosecurity throughout the site, protecting stock and preventing the spread of disease, which is critical to the success of the East Arm Proof of Concept project.

13.13.2 Biosecurity Controls

Biosecurity is central to all operations at the East Arm site. CSIRO has implemented a comprehensive range of measures to prevent the introduction and spread of pathogens, ensuring the health and safety of stock and the surrounding environment:

- **Water Filtration and Treatment:** Intake water is processed through multiple stages, including screening, sand and media filtration, UV and Ozone treatment (and or chlorine), to neutralise potential pathogens before entering the facility.
- **Foot Baths and Equipment Separation:** Foot baths are positioned at strategic points throughout the facility, with all personnel required to disinfect footwear upon entering specific areas.

Additionally, equipment is designated for specific zones within the facility to prevent cross-contamination.

- **Stock sourcing:** all stock for the project will be sourced from the Northern Territory removing the risk of disease transfer from other areas.
- **Zoned Facility Layout:** The facility is divided into two distinct sections for biosecurity management:
- **Stock Assessment Areas:** All incoming stock undergoes rigorous health assessments and disease detection in Stock Assessment Area 1 (SA-1) and Stock Assessment Area 2 (SA-2). Stock is isolated in these zones until they pass all required health checks.
- **Main Facility:** Only stock verified as Specific Pathogen Free can enter the main aquaculture system, reducing biosecurity risks and maintaining the integrity of the entire facility.
- **Discharge Water Filtration and Treatment:** Discharge water is processed through multiple stages, including screening to 50 micron, UV and Ozone treatment, to neutralise potential pathogens exiting the facility.

13.13.3 Biosecurity Monitoring and Disease Detection

Ongoing biosecurity monitoring is integral to facility operations:

- **Regular Stock Assessments:** All stock is screened for diseases at various stages, with any signs of disease leading to immediate isolation and further testing.
- **Environmental Monitoring:** Routine monitoring of water quality parameters supports early detection of potential biosecurity risks and ensures water treatment systems are functioning effectively.

13.13.4 Biosecurity Incident Response Flowchart

In the event of a suspected biosecurity breach or disease outbreak, CSIRO will follow the steps below:

1. **Identify and Isolate:**
 - **Detect Symptoms:** Signs of disease or abnormal stock behaviour are reported immediately.
 - **Immediate Isolation:** Affected stock is moved to isolation zones to prevent potential spread.
2. **Initiate Testing and Diagnosis:**
 - Conduct additional tests to identify and confirm the pathogen or biosecurity threat.
 - Collaborate with on-site biosecurity staff to determine the severity and potential spread.
3. **Implement Enhanced Sanitation:**
 - **Disinfection Protocols:** Increase disinfection of affected areas, using enhanced footbath procedures and equipment separation.
 - **Equipment Quarantine:** Isolate or disinfect any equipment used in contaminated zones.
4. **Notify NT Fisheries:**
 - Contact NT Fisheries for guidance on containment or eradication strategies, providing preliminary findings and sample data.
 - Follow NT Fisheries' recommendations for any specialised containment or eradication measures.
5. **Eradicate and Control:**
 - **Execute Eradication Measures:** Based on NT Fisheries' recommendations, apply further control measures, such as increased filtration, additional UV treatment, or removal of affected stock.
 - **Intensify Monitoring:** Increase frequency of environmental and stock assessments to monitor effectiveness of containment actions.

6. Document and Report:

- Log the incident in the biosecurity incident register, detailing the cause, actions taken, and outcomes.
- Complete a detailed incident report, including follow-up actions, and submit it to NT Fisheries and relevant regulatory bodies.

7. Review and Update Protocols:

- Assess biosecurity protocols to identify potential improvements, such as enhanced screening or additional monitoring points.
- Update staff training on disease detection and response to prevent future breaches.

13.14 Effluent/Discharge Management

13.14.1 Effluent Management Objective

To manage and treat all effluent and discharge in a way that protects local water quality, aligns with Darwin Harbour WQOs, and complies with NT EPA guidelines, as outlined in the WQMP.

13.14.2 Effluent and Discharge Controls

Effluent management at the East Arm site incorporates multiple stages of treatment and monitoring, ensuring that discharge meets environmental standards and minimises impact on surrounding waters:

- **Water Treatment:** Effluent is generated from the CRAS units in low volumes, typically as backflush water from filters and or low volume water exchanges. This water will pass through a **50-micron filter** bag and then will be pumped and treated with **ozone to 650-850mV** before storage in an aerated tank for discharge.
- **Controlled Discharge Timing:** Discharge is carefully timed with outgoing tides to promote dilution and reduce potential impacts on nearby sensitive estuarine ecosystems. Discharge volumes will be managed to stay within an approved WDL requirements, as stipulated by NT EPA.
- **Monitoring Program:** A dual-tiered monitoring program, as detailed in the WQMP, is in place to track water quality parameters at discharge points:
 - **Weekly Field Sampling:** Conducted to monitor real-time water quality, assessing parameters such as pH, temperature, dissolved oxygen, salinity, and nutrients.
 - **Monthly Laboratory Testing:** Samples are analysed by a NATA-certified lab to check for compliance with WQOs, focusing on indicators like Filterable Reactive Phosphorus, Total Nitrogen, chlorophyll-a, and Total Suspended Solids.

13.14.3 Discharge Water Quality

Water quality monitoring will be undertaken during discharge in accordance with the East Arm Water Quality Monitoring Plan (WQMP). This plan outlines the monitoring sites, sampling frequency, parameters measured, and methods used to ensure compliance with regulatory requirements from the NT EPA and NT Fisheries. The monitoring program enables the assessment of any potential impacts on the receiving environment, specifically Hudson Creek.

CSIRO has trialled a portion of the proposed East Arm system at its Bribie Island facility, operating for over 12 months under CRAS conditions. This has generated a reliable dataset that supports accurate prediction of discharge water quality at the East Arm site. Predicted discharge values are summarised in Table 13.

Table 12: Predicated discharge water quality East Arm sites 1 & 2

Parameter	Maximum Bribie Island trials mg/L	Predicated Discharge Quality
Alkalinity (CaCO ₃)	191	< 200 mg/L
Biological Oxygen Demand (BOD ₅)	3	< 4 mg/L
Total Organic Carbon (TOC)	18.3	< 20 mg/L
Total Suspended Solids (TSS)	27	< 30 mg/L
Ammonia as N (NH ₃)	0.35	< 0.40 mg/L
NOX (Nitrate + Nitrite)	85.8	< 90 mg/L
Phosphate as P (Dissolved P)	11.3	< 12 mg/L
Organic N as N	8.49	< 9 mg/L
Total Kjeldahl Nitrogen (TKN) as N	8.56	< 9 mg/L
Organic Phosphorous as P	1.35	< 1.5 mg/L
Total Nitrogen as N	87.6	< 90 mg/L
Total Phosphorus as P	12.1	< 12.5 mg/L
*Please note predicated discharge water quality may be influenced by background incoming water concentrations		

In accordance with the WQMP (Section 7.5), the East Arm project will:

- Use purpose-built taps at DSP EA1 and DSP EA2 to collect undiluted discharge samples prior to environmental release
- Monitor water quality in real-time using field sensors for key indicators (e.g., DO, pH, salinity, turbidity, NH₃-N, NO_x)
- Discharge only during outgoing tides, with operations ceasing two hours prior to tide change
- **Maintain nutrient loads within the following limits:**
 - Total Nitrogen (TN): ≤ 0.54 kg/day (based on 20 kL/day discharge)
 - Total Phosphorus (TP): ≤ 0.153 kg/day

This approach ensures the discharge is managed responsibly, with protective measures that align with water quality objectives for the Upper Estuary zone of Darwin Harbour.

13.14.4 Performance Indicators

Effluent quality is assessed against the **Darwin Harbour Water Quality Objectives (WQOs)** and **ANZECC (2000) Guidelines**, with specific **performance indicators** and **trigger limits** applied at the **Compliance Point – HCMPDS** in accordance with the approved Water Quality Monitoring Program (WQMP).

Performance Indicators include:

- **Compliance with nutrient and turbidity standards:**

Concentrations of Total Nitrogen (TN > 0.250 mg/L), Total Phosphorus (TP > 0.020 mg/L), Filterable Reactive Phosphorus (FRP > 0.010 mg/L), Ammonia (NH₃-N > 0.020 mg/L), and NO_x > 0.020 mg/L, as well as Total Suspended Solids (TSS > 0.010 mg/L) and Chlorophyll-a > 0.002 mg/L, must remain within the specified trigger values at the compliance point.

- **Compliance with pH limits:**

pH must remain within the acceptable range of 7.0 – 8.5 pH units at the compliance point.

- **Compliance with bacterial standards:**

Microbiological indicators must not exceed:

– **E. coli:** ≥ 200 CFU/100 mL (or MPN/100 mL)

– **Enterococci:** ≥ 50 CFU/100 mL

Exceedances indicate potential faecal contamination and require investigation in accordance with the Trigger Action Response Plan (TARP).

- **Regular reporting and review:**

All laboratory results are compiled and reported monthly to the NT EPA to ensure ongoing transparency, compliance, and adaptive management of discharge quality.

13.14.5 Effluent Incident Response Flowchart

If effluent discharge fails to meet water quality objectives, CSIRO will implement the following response steps:

1. **Identify Exceedance:**

- Review monitoring data to confirm which parameter(s) exceed specified limits.
- Verify whether the exceedance is linked to a process or operational change.

2. **Implement Immediate Corrective Actions:**

- **Adjust Treatment:** Increase aeration, apply additional filtration, or extend wastewater storage time to improve discharge quality.
- **Delay Discharge:** If possible, delay discharge until the outgoing tide to maximise dilution and mitigate impact.

3. **Increase Monitoring Frequency:**

- **Enhanced Sampling:** Increase sampling frequency to closely track water quality at discharge points until levels return to compliance.
- **Real-Time Monitoring:** Implement real-time monitoring if feasible to capture any ongoing fluctuations.

4. **Notify and Consult with NT EPA:**

- **Report Non-Compliance:** Notify NT EPA as soon as the exceedance is confirmed.
- **Request Guidance:** Consult with NT EPA for additional corrective measures or actions as needed.

5. **Document and Report:**

- Record details of the exceedance, corrective actions taken, and monitoring results in the incident log.
- Submit a detailed report to NT EPA, including findings, actions, and follow-up measures.

6. **Review and Update Procedures:**

- **Evaluate Controls:** Assess current effluent controls and adjust as needed to prevent future exceedances.
- **Update Staff Training:** Ensure all relevant personnel are updated on new procedures or changes in discharge management practices.

13.15 Other Controls

Although no earthworks or open construction activities are planned, CSIRO will monitor for nuisance dust as a precaution. If dust-generating activities such as the external loading of organic materials occur, appropriate suppression measures (e.g., water spraying) will be implemented to minimise off-site impacts.

13.16 Complaints Management and Register

The project at East Arm is committed to maintaining open communication with the community and addressing any concerns that may arise during operations. To facilitate this, a Complaints Register will be established and maintained throughout the duration of the project.

13.16.1 Complaints Handling Procedure:

- **Receiving a Complaint:** If a complaint is received, it will be formally recorded in the Complaints Register, noting details such as the complainant's contact information, the nature of the complaint, and the date and time of the issue.
- **Complaint Acknowledgment:** The complainant will receive an acknowledgment of their complaint within 24 hours of its receipt, outlining the steps that will be taken to investigate and resolve the issue.
- **Investigation:** CSIRO will conduct an internal investigation to determine the cause of the complaint. This may involve reviewing operational procedures, conducting site inspections, or consulting with external experts, such as noise or environmental specialists, depending on the nature of the complaint.
- **Action and Resolution:** Once the cause of the complaint has been identified, corrective actions will be implemented to resolve the issue. The complainant will be informed of the actions taken to address their concerns.
- **Follow-Up:** CSIRO will follow up with the complainant within an agreed timeframe to ensure that the issue has been resolved to their satisfaction.

13.16.2 Complaints Register Contents:

The Complaints Register will include:

- Date and time of the complaint
- Complainant's contact details
- Description of the complaint (e.g., noise, odour, environmental impact)
- Details of the investigation conducted
- Actions taken to resolve the issue
- Follow-up communication with the complainant

The register will be reviewed regularly to ensure ongoing compliance with environmental management protocols and to identify any patterns that may require longer-term corrective actions. Any complaints will be noted within the Annual Report.

Table 13: Summary of Environmental Aspects, objectives, controls and corrective Actions

Environmental Aspect	Objective	Controls	Corrective Actions
Water Management	Maintain water quality in line with Darwin Harbour WQOs.	CRAS for reuse, filtration, UV treatment, weekly sampling, and monthly lab testing.	Additional filtration, increased monitoring, and regulatory reporting.
Traffic Management	Minimise traffic impact on local infrastructure and maintain safe access.	Limited vehicle use, scheduling of delivery times.	Implement carpooling, adjust delivery schedules to minimise congestion.
Noise Management	Operate within NT noise guidelines and minimise community disturbance.	Equipment restrictions, regular noise monitoring.	Modify equipment usage, engage a noise expert, and document complaints.
Odour Management	Prevent and control odour emissions.	Sealed compost units, aeration of wastewater tanks, and shaded storage.	Adjust compost or aeration, work with complainants, and document responses.
Light Management	Minimise light pollution and comply with best practices for industrial lighting.	Downward-angled lights, operational area focus, shielding measures.	Adjust angles, reduce intensity, add shielding as needed.
Solid Waste Management	Minimise waste and maximise recycling, ensuring environmental protection.	Composting bio-waste, scheduled disposal of general waste, and recycling tracking.	Increase recycling, adjust waste disposal procedures.
Weed Management	Maintain a weed-free environment to support site operations.	Routine inspections, chemical treatments where necessary.	Increase treatment frequency, use alternative treatment methods as needed.
Soil Management	Prevent soil erosion and maintain soil stability.	Regular monitoring, limited site disturbance, erosion control for future modifications.	Implement erosion control, reassess soil integrity if disturbed.
Exotic Species	Prevent introduction of exotic species and protect native ecosystems.	Screening, sand and media filtration, UV and ozone sterilisation, liaison with NT Fisheries for eradication.	Implement eradication as advised by NT Fisheries, adjust protocols as required.
Fire Management	Ensure fire safety for personnel and property, minimise fire risk.	Fire extinguishers, signage, designated fire warden, regular drills, staff training.	Evacuate, coordinate with emergency services, conduct post-incident review.
Fuel and Chemical Storage	Safely store and manage limited chemicals and fuel to reduce risks.	Labelled cabinets, secure storage, accessible MSDS documentation.	Contain spills, report incidents, and review safety procedures.
Flood and Storm Surge	Protect site equipment and stock from flooding or storm surge impacts.	Enclosed storage, stock resilience, drainage maintenance, weather monitoring.	Inspect and repair damage, secure equipment, assess environmental impacts.
Biosecurity	Maintain biosecurity and prevent disease spread within site operations.	Multi-stage water treatment, footbaths, equipment separation, zoned facility for stock assessment and disease monitoring.	Isolate affected stock, intensify disinfection protocols, consult NT Fisheries.
Effluent Discharge	Manage effluent to meet water quality standards and minimise environmental impacts.	CRAS treatment, controlled discharge timing, dual-tier monitoring (weekly and monthly).	Enhance treatment, increase monitoring, consult with NT EPA for additional measures.

14 Effects of the Development

14.1 Local and Regional Benefits:

CSIRO's project at East Arm is seen as essential for advancing aquaculture in Northern Australia, establishing a reliable supply of high-quality, pathogen-free prawn stock tailored to Northern Territory conditions. CSIRO is collaborating with the Ranku Clan on the Tiwi Islands to assess the feasibility of low-input prawn farming. This collaboration includes ongoing trials at Barramundi Adventures in Berry Springs, now in its third year, focused on sustainable, low-cost farming methods. However, a significant challenge has been the limited availability of Post-Larval (PL) prawns at optimal farming times. Currently, PL stock must be sourced from Queensland at the start of the Wet Season, facing quarantine requirements due to biosecurity risks and growth issues related to reduced salinity and elevated temperatures.

The HH prawn project at East Arm will provide a consistent local supply of high-quality prawns, eliminating the need for interstate sourcing and reducing disease risks. This project supports Northern Territory aquaculture and enables local producers, including those on the Tiwi Islands, to access dependable, disease-free prawn stock. CSIRO aims to stimulate regional economic growth, create local jobs, and contribute to a sustainable aquaculture sector, potentially revitalising prawn farming opportunities throughout the Northern Territory.

14.2 Future Benefits

If the project at East Arm proves successful, it will lay the groundwork for a large-scale HH prawn breeding facility (CSIRO's planned Aquaculture Research Centre). This expansion would provide substantial benefits to the Northern Territory by establishing a reliable HH prawn supply, reducing reliance on interstate stock, and enhancing regional biosecurity.

A full-scale HH project at the proposed ARC would create numerous employment opportunities for local residents in aquaculture and support industries. Additionally, key personnel from CSIRO's Bribie Island operations are expected to relocate, bringing valuable expertise to bolster the region's aquaculture capabilities. This initiative positions Northern Australia as a leader in sustainable aquaculture, driving economic growth, supporting long-term industry development, and advancing CSIRO's aquaculture research objectives in the region.

14.3 Environmental Benefits:

The East Arm project aims to advance aquaculture in Northern Australia while minimising environmental impact. By researching and implementing Closed Recirculating Aquaculture Systems, the project seeks to significantly reduce water use across Australia's aquaculture industry. CRAS enables enhanced water recycling and treatment within a controlled system, reducing the need for large volumes of water exchange. This approach conserves water and allows precise control over water quality and promotes healthier prawn stock. Insights gained from these trials will inform sustainable practices and CRAS technology that can be applied nationwide, increasing environmental efficiency in the aquaculture industry.

The project will also explore bacterial enhancement techniques, focusing on specific bacterial assemblages to improve water treatment processes. These techniques are expected to enhance wastewater quality by breaking down organic waste and removing harmful compounds before discharge. Such advancements can serve as a model for sustainable aquaculture, benefiting the industry with a reduced environmental footprint, improved biosecurity, and more efficient water management practices. Through these trials, CSIRO aims to elevate sustainable aquaculture standards across Australia.

15 Decommissioning and Rehabilitation Plan

Following the conclusion of CSIRO's lease, all equipment installed for the project will be dismantled and relocated to CSIRO's Berrimah site at 564 Vanderlin Drive, Berrimah, or to the proposed ARC project.

This transfer includes all modular and specialised equipment associated with the Closed Recirculating Aquaculture Systems, as well as biosecurity and water treatment systems developed during the project.

No earthworks or modifications to the existing landscape will be conducted, ensuring the natural and built environments remain undisturbed.

The building and infrastructure at the 13 Muramats Road site will remain the property of the Owner.

By relocating these assets, CSIRO will maximise resource use, supporting the long-term objectives of the Aquaculture Research Centre.

16 Emergency Response and Incident Management

16.1 Emergency Response Objective

To ensure a prompt and effective response to any incident that may arise on-site, protecting personnel, stock, and the surrounding environment. CSIRO's emergency response strategy is designed to minimise impact, swiftly contain incidents, and restore safe operations.

16.2 Incident Response Protocols

Comprehensive response protocols are in place to handle various types of incidents, with specific procedures for containment, notification, and corrective actions. Key protocols include:

16.2.1 Spill Management:

- **Containment and Isolation:** In the event of a chemical or fuel spill, on-site personnel will isolate the affected area immediately and use spill kits located near storage and discharge points.
- **Clean-Up and Disposal:** Trained staff will contain the spill using absorbent materials, and all contaminated materials will be disposed of per NT waste management regulations.
- **Ventilation and Safety:** If required, affected areas will be ventilated to reduce potential hazards, and additional protective equipment will be provided for clean-up personnel.
- **Notification:** Incidents involving significant spills will be reported to relevant authorities, with follow-up assessments conducted to prevent recurrence.

16.2.2 Disease Outbreaks:

- **Isolation and Increased Treatment:** If a disease outbreak is suspected, affected tanks will be immediately isolated to prevent cross-contamination. UV treatment levels will be increased as an initial containment measure.
- **Notification and Disposal:** CSIRO will notify NT Fisheries and the Berrimah Vet lab promptly, ensuring appropriate biosecurity protocols are followed for safe disposal of affected stock. All bio-waste from diseased stock is treated as biohazardous and disposed of according to strict biosecure waste protocols.
- **Additional Sanitation:** Enhanced disinfection measures will be implemented across the facility, and equipment will be quarantined or disinfected to avoid further spread.

16.2.3 Water Quality Exceedance:

- **Increased Monitoring and Sampling:** If water quality parameters exceed Trigger limits, immediate additional sampling will be conducted to assess changes and identify root causes.
- **Adjustments to Discharge and Treatment:** Discharge timing will be modified to align with outgoing tides, reducing impact on local waters. Treatment levels, including filtration and aeration, will be adjusted to improve effluent quality.
- **Regulatory Reporting:** Exceedances will be reported to NT EPA, with a summary of corrective measures implemented to bring discharge back within limits.

16.3 Incident Documentation and Reporting

All incidents, whether minor or significant, are meticulously recorded in the project's incident log. The following reporting practices will be in place to ensure accountability and transparency:

- **Annual Reporting:** Summaries of all incidents, responses, and corrective actions will be included in reports to the NT EPA, documenting both immediate and follow-up measures taken.
- **Corrective Action Documentation:** Each incident report outlines specific corrective actions, and any procedural adjustments made to prevent similar incidents in the future.
- **Continuous Improvement:** Post-incident reviews assess response effectiveness, and lessons learned are integrated into future response protocols. Adjustments are made to emergency procedures based on insights from these reviews.

16.4 Training and Drills

To maintain preparedness, CSIRO conducts regular emergency response training and drills:

- **Annual Spill Response Drills:** Spill response drills are conducted annually, ensuring that all personnel are familiar with containment procedures, spill kit usage, and notification protocols.
- **Disease Outbreak Simulation:** Disease outbreak simulations help staff practice isolation procedures, sanitation protocols, and effective communication with NT Fisheries.
- **Water Quality Exceedance Protocol Review:** Response protocols for water quality exceedances are reviewed biannually, ensuring that staff are prepared to act swiftly in case of discharge issues.

These protocols and training measures ensure that the site maintains a high level of emergency readiness, safeguarding the environment, stock, and personnel from potential incidents and minimising any impact on surrounding areas.

17 Stakeholder Engagement and Communication

17.1 Stakeholder Engagement Objective

To maintain transparent, respectful, and continuous communication with all stakeholders, including the local community, Larrakia Peoples, Ranku Clan, and regulatory bodies, ensuring that the project aligns with cultural values, regulatory standards, and environmental commitments.

17.2 Community and Cultural Engagement

CSIRO acknowledges the cultural significance of the East Arm area to the Larrakia Peoples. Engaging meaningfully with the community and respecting traditional cultural practices are integral components of the project's operations. Key engagement practices include:

- **Regular Meetings with the Larrakia Land Council:** Scheduled meetings provide updates on project activities, ensuring transparency and fostering a respectful, collaborative partnership.
- **Regular Meetings with the Ranku Clan:** CSIRO sees this as an opportunity to enhance the potential for success at the proposed Prawn Farm in Ranku on the Tiwi Islands. The Clan will receive project updates and be welcomed to visit the site.
- **Adherence to Cultural Protocols:** Cultural protocols and practices will be followed at all stages of project implementation, particularly during site modifications, construction, or activities intersecting with culturally significant areas or practices.
- **Open Communication Channels:** CSIRO ensures that the Larrakia Peoples and local community have accessible channels for feedback, concerns, or further information regarding project operations.
- **School Visits:** Leveraging CSIRO's existing "Aquariums in Classrooms" project, students will be invited to visit the prawn research facility, offering educational insights into sustainable aquaculture practices.

17.3 Regulatory Reporting

CSIRO is committed to ongoing regulatory communication and reporting to ensure full compliance with environmental and operational standards. Regular reporting provides NT EPA, NT Fisheries, and community stakeholders with detailed project updates:

- **Bimonthly meeting with NT Fisheries:** CSIRO currently engage with NT Fisheries on a Bimonthly basis, this is expected to continue post the East Arm sites establishment.
- **Annual EMP Report:** A comprehensive report will be submitted annually to NT EPA, detailing adherence to EMP objectives, including water quality, waste management, and corrective measures. This transparent overview will also be shared with community representatives.

17.4 Communication and Feedback Mechanisms

To promote continuous, open communication, CSIRO has established structured feedback processes ensuring timely responses to concerns and fostering continuous improvement:

17.4.1 Quarterly Stakeholder Feedback Sessions:

CSIRO will offer stakeholder opportunities to multiple stakeholders to attend Quarterly feedback sessions.

- **Participants:** NT EPA, NT Fisheries, Larrakia Land Council, Ranku Clan, and community representatives.
- **Format:** Virtual or in-person meetings to discuss updates, gather feedback, and identify areas for improvement.
- **Documentation:** Meeting minutes are recorded, noting key feedback, issues, and planned actions.

17.4.2 Issue Resolution Process:

- **Complaints Register:** All stakeholder concerns are logged in a register, regularly reviewed to track resolutions.
- **Investigation and Response:** Each complaint is investigated promptly, with corrective actions implemented. Updates on resolutions are shared with the complainant.
- **Reporting:** Complaints and resolutions are included in annual reports to NT EPA.

17.5 Stakeholder Engagement Review

To maintain effective stakeholder relationships, CSIRO will conduct periodic reviews of its engagement practices:

- **Annual Stakeholder Engagement Review:** Evaluates the effectiveness of community and cultural engagement efforts, identifying areas for improvement to enhance transparency and collaboration.
- **Feedback Integration:** Insights and recommendations from stakeholders are integrated into project practices and the EMP, ensuring operations remain responsive to community needs and expectations.

17.6 Additional Key Stakeholders

NT Fisheries:

- Bi-monthly meetings are held to discuss project progress, address regulatory concerns, and ensure alignment with compliance standards.
- NT Fisheries receives regular updates and reports, fostering collaboration on sustainable aquaculture practices.

Charles Darwin University (CDU):

- CDU is a key stakeholder, and CSIRO aims to strengthen this relationship by engaging students in site visits and collaborative learning opportunities.
- These interactions will provide practical education in aquaculture and environmental sustainability, enhancing CDU's academic programs while promoting community engagement.

18 Performance Review and Adaptive Management

18.1 Performance Management Objective

To ensure that the EMP remains effective, relevant, and responsive to changing conditions, CSIRO will implement ongoing performance reviews and adaptive management practices. This approach allows for continuous improvement, ensuring that the project meets environmental, regulatory, and community expectations over time.

18.2 Annual EMP Review

An annual review of the EMP is conducted to evaluate the effectiveness of current management practices and to incorporate any new data, incidents, or regulatory requirements. Key components of the review include:

- **Effectiveness Assessment:** Analysis of EMP measures based on monitoring data, incident reports, and stakeholder feedback, determining which practices are effectively meeting performance objectives.
- **Regulatory Compliance Check:** Verification that all EMP actions align with current NT EPA and NT Fisheries guidelines, ensuring that compliance remains up-to-date.
- **Documentation of Adjustments:** Any changes to the EMP, including refined protocols, new control measures, or corrective actions based on review outcomes, are documented in an annual report shared and approved with regulatory bodies.

18.3 Adaptive Sampling Strategy

CSIRO applies an adaptive approach to sampling, adjusting frequency and parameters in response to seasonal and environmental conditions that may influence project impacts. This strategy includes:

- **High-Risk Period Adjustments:** Sampling frequency and parameter sensitivity may be increased during high-risk periods, such as the wet season, to account for potential shifts in water quality from nutrient runoff.
- **Event-Triggered Sampling:** Additional sampling may be conducted following significant events (e.g., heavy rainfall, discharge exceedances) to ensure that immediate environmental impacts are monitored and managed effectively.
- **Data-Driven Modifications:** Sampling protocols are adjusted based on findings from ongoing monitoring, allowing CSIRO to proactively respond to emerging patterns and environmental trends.

18.4 Continuous Improvement

CSIRO is committed to continuous improvement in environmental management, drawing from lessons learned, stakeholder feedback, and best practices in aquaculture and environmental stewardship.

Continuous improvement actions include:

- **Incorporating Feedback:** Lessons from incident responses, community feedback, and regulatory reviews are systematically integrated into EMP practices, refining operational procedures.
- **Adopting Best Practices:** As aquaculture and environmental management best practices evolve, CSIRO reviews and incorporates new techniques or technologies to enhance project sustainability and reduce environmental impact.

- **Routine Staff Training:** Regular training sessions ensure that staff are aware of updates to EMP procedures and are equipped to implement adaptive strategies effectively.

18.5 Performance and Management Review Documentation

All performance reviews and adaptive management changes are documented to support regulatory compliance and internal accountability:

- **Annual Performance Report:** A comprehensive report summarising annual review outcomes, adaptive management adjustments, and continuous improvement actions will be submitted to NT EPA and other relevant bodies.
- **Corrective Action Log:** Corrective actions and updates based on the adaptive sampling strategy or incident feedback are recorded, ensuring traceability and transparency.
- **Stakeholder Update:** Key findings and changes from performance reviews are communicated to stakeholders, reinforcing CSIRO's commitment to proactive environmental management.

These performance review and adaptive management processes allow the EMP to evolve alongside project needs, enhancing environmental outcomes and maintaining a high standard of operational excellence.

19 Supporting Documents

- East Arm Water Quality Monitoring Program
- Notice of Intent for East Arm POC Site

20 Additional Permits

- **Aquaculture Licence:** Required for operations and expected approval within **4–6 months** of lease initiation. – NOI submitted to NT Fisheries 10/10/25
- **Development Permit – received October 2025**
- **AAPA site search report – completed**

21 Environmental Risk Assessment

The operational activities of the East Arm POC have been considered through an environmental aspects and impacts register, which assesses the environmental risks. The likelihood and consequence categories adopted are provided in Table 15 and Table 16 and were combined (Likelihood multiplied by Consequence) to derive an overall risk rating using the matrix in Table 17. The environmental aspects and impacts register is included as Table 18.

Table 14: Likelihood categories

Level	Descriptor	Likelihood Description
1	Remote	Low chance of occurrence, but not impossible
2	Rare	May occur in exceptional circumstances
3	Unlikely	Uncommon, but has been known to occur
4	Possible	Possible occurrence
5	Occasional	May occur on occasion
6	Likely	It is expected to occur

Table 15: Consequence Description

Level	Descriptor	Score	Consequence Description
0	Negligible	0	Insignificant impact. Unlikely to be measurable at the scale to receiving environment (i.e. ecosystem/community/stock) against natural background variability
1	Minor	1-6	Possibly detectable but minimal impact on receiving environment ecosystem structure/function or dynamics.
2	Moderate	7-12	Maximum appropriate/acceptable level of impact (e.g. minor erosion)
3	Severe	13-20	This level will result in wider and longer-term impacts occurring to receiving environment (e.g. silt entering a waterway and smothering mangroves).
4	Major	21-25	Very serious impact with relatively long time frame likely to be needed to restore to an acceptable level
5	Catastrophic	26-30	Widespread and permanent/irreversible damage to receiving environment will occur - unlikely to ever be fixed (e.g. extinctions)

Table 16: Risk matrix

Consequence							
Likelihood		Negligible (0)	Minor (1)	Moderate (2)	Severe (3)	Major (4)	Catastrophic (5)
	Likely (6)	Negligible	Minor (6)	Moderate (12)	Severe (18)	Major (24)	Catastrophic (30)
	Occasional (5)	Negligible	Minor (5)	Moderate (10)	Severe (15)	Major (20)	Major (25)
	Possible (4)	Negligible	Minor (4)	Moderate (8)	Moderate (12)	Severe (16)	Major (20)
	Unlikely (3)	Negligible	Minor (3)	Minor (6)	Moderate (9)	Moderate (12)	Severe (15)
	Rare (2)	Negligible	Minor (2)	Minor (4)	Minor (6)	Moderate (8)	Moderate (10)
	Remote (1)	Negligible	Minor (1)	Minor (2)	Minor (3)	Minor (4)	Minor (5)

Table 17: Environmental aspects and impacts register

Activity	Aspect	Potential Impact	Background Information and assumptions	Likelihood	Consequence	Risk Score	Controls	Relevant Documents	Likelihood	Consequence	Risk Score
Filling and replenishing tanks	Extraction of saltwater from Hudson Creek	Reduction of environmental flows in Hudson Creek	The project is estimating an average water intake of 20KL per day. With all water used returned to the Hudson creek.	1	0	minor (1)	Extract water within permitted volumes and rates	Water extraction licence (not required)	0	0	Minor (0)
Discharging to Hudson's creek	Discharge of nutrient rich water into Hudson creek	Reduction in water quality downstream of discharge point (addition of nutrients) and subsequent impacts on aquatic ecosystem health downstream if the discharge point	The project will operate at low stocking rates and has completed extensive trials of the proposed system at its Bribie Island site. The main components of the discharge will be ammonia, nitrogen and phosphorous.	3	3	Minor (6)	Discharge will operate via gravity from a 60mm discharge pipe which will provide low flow and ample dispersal of nutrients. Water quality within the system is carefully managed and no spikes in nutrient concentrations are expected to occur as the system is highly monitored	Water Quality Monitoring Plan The project will be required to report annually.	1	1	Minor (2)
Storage and use of chemicals, hydrocarbons and hazardous substances	Spills of chemicals, hydrocarbons or hazardous substances	Contamination of soils and/or water on site and/or Hudson creek as a result of uncontrolled spills. Potential reduction of water quality and/or impacts to aquatic health.	All refuelling (only minor volumes for power backup generator) will be conducted in bunded designated areas. Fuel storage volumes <110 litres within bunded generator shed. Other chemicals (chlorine) in volumes of less than 4 litres in chemical storage cabinet.	3	3	Minor (6)	Training and site inductions provided to all employees in the appropriate handling and storage of chemicals and hazardous substances. All products will be stored in accordance with AS:1940(2004) and NOHSC:1015 (2001), including bunding or self-bunded containers. All fuels are stored in bunded areas or within equipment. Spill kits will be onsite, adequately sized and stocked to respond to a spill if required. All staff will be trained in the use of spill kits. Safety Data Sheets (SDS) will be kept onsite and in storage areas for all products. Chemical register is kept up to date for all chemicals, their volumes and storage locations. Routine site inspections on all chemicals and hazardous goods containers. Robust incident reporting system/culture. Conduct water sampling as per the Water Quality Monitoring Plan	Environmental Management Plan (Spill response plan) Refuelling procedures Chemical register and SDSs Water Quality Monitoring Plan Water Quality Database	2	2	Minor (4)
Composting	Composting of low volumes of solid wastes with sealed compost bins	Odours, leakage and/or rodents attracted.	Waste is estimated at <1kg per day in the form of uneaten feeds. The project wishes to compost this for reuse in gardens	3	3	Minor (6)	Careful management of carbon (sawdust to waste at a ratio of 3/1) Excessive volumes of wastes will be frozen and disposed of to a municipal waste facility. If odour occurs all waste will be frozen and disposed and compost stopped.	Environmental Management Plan Compost section	2	2	Minor (4)

Emergency Flooding Event	Flooding of site either through storm surge or stormwater runoff	Potential biosecurity risk of stock entering environment. Stock genetics entering wild stock	All stock are contained with elevated tanks within a shed. All wastewater is held in sealed tanks. Stock are sourced locally. Disease potentially entering ecosystem	4	4	Moderate (8)	Stock have been sourced locally and therefore genetic impact on wild stocks is negligible. Stock are pathogen tested, and internal UV keeps pathogen load low. Volumes of wastewater stored onsite is <161KL at low nutrient concentrations	EMP biosecurity section Water Quality Monitoring Plan Water Quality Database	2	2	Minor (4)
Biosecurity	Disease from stock onsite entering the ecosystem causing an outbreak in wild stock	Potential that stock onsite cause and outbreak in wild stocks. Potential that a new disease is transferred from interstate to the NT	All stock will be sourced from NT waters, significantly reducing the potential of a new pathogen entering the system. All stock are health checked and assessed for pathogens before entering main system All wastewater is treated with ozone before release	4	5	Moderate (9)	All stock will be sourced from NT waters, significantly reducing the potential of a new pathogen entering the system. Stock enter into a stock assessment process with waste water disinfected and pathogens tested. All wastewater is treated with ozone before release.	EMP biosecurity section Water Quality Monitoring Plan Water Quality Database	2	2	Minor (4)

Table 18: Environmental Management Summary

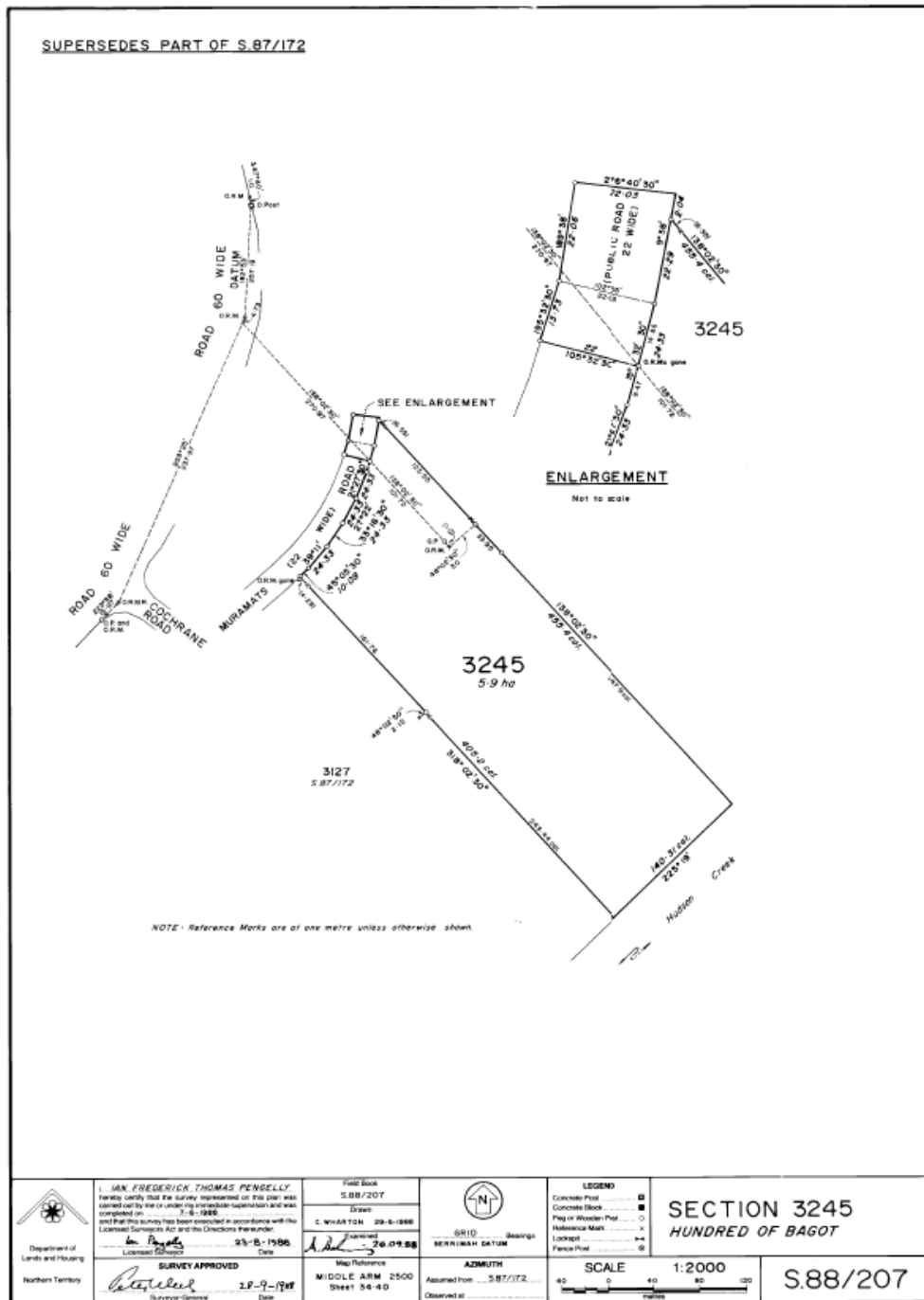
Aspect	Potential Impact	Objective/ Outcome	Management action	Target /performance indicators	Monitoring	Corrective actions and contingencies	Reporting and record-keeping
Filling and replenishing tanks	Reduction of environmental flows in Hudson Creek	The project is estimating an average water intake of 20KL per day. With all water used returned to the Hudson creek.	- Extract water within permitted volumes - Meter and monitor extraction volumes weekly to ensure volumes are within permit.	No exceedance to permit limits Continued reduction in volumes utilised across time	Weekly meter reading and internal monthly reporting. Annual reports	If estimated volume of 20KL/Day is exceeded for an extended period, discuss with team and modify management to improve results.	All water use will be recorded and maintained within the CSIRO database and reported at minimum annually to stakeholders
Discharging to Hudson's creek	Reduction in water quality downstream of discharge point (addition of nutrients) and subsequent impacts on aquatic ecosystem health downstream if the discharge point	No observable impact noticeable either visually and or within the water quality monitoring program	Daily and weekly internal analysis of wastewater for key parameters. Follow conditions of any WDL and or permit. Compare downstream environmental sampling to Trigger values.	No exceedance of Trigger values downstream of site. No complaints or impact on the public.	Weekly internal field sampling and monthly laboratory analysis	If water quality fails to meet the standards of CSIRO and or NT EPA. CSIRO will upgrade the water treatment system until compliant.	Monthly internal reports and annual reports to EPA.
Storage and use of chemicals, hydrocarbons and hazardous substances	Contamination of soils and or water on site and or Hudson creek as a result of uncontrolled spills.	No contamination of soils and or water caused by spills during site operations or staff.	Training and site inductions provided to all employees in the appropriate handling and storage of chemicals and hazardous substances. All products will be stored in accordance with AS:1940(2004) and NOHSC:1015 (2001), including bunding or self-bunded containers.	No indication of spills of chemicals or hazardous substances. Any spill of stored product is	Regular inspections of chemical and hazardous substance storage areas through	Review storage and handling practices for chemicals and hazardous substances. Increase the amount of bunding and containment for chemical	Incident reporting records Internal audits Water Quality Database • Reporting is undertaken through, the Monitoring Report

	Potential reduction of water quality and/or impacts to aquatic health.		All fuels are stored in bunded areas or within equipment. Spill kits will be onsite, adequately sized and stocked to respond to a spill if required. All staff will be trained in the use of spill kits. Safety Data Sheets (SDS) will be kept onsite and in storage areas for all products. Chemical register is kept up to date for all chemicals, their volumes and storage locations. Routine site inspections on all chemicals and hazardous goods containers. Robust incident reporting system/culture.	contained and remediated through the spill response procedure. No leaks from equipment.	operational activities. Water quality performance will be monitored through the WQMP	and hazardous substance storage areas. Increase the number, capacity or type of spill kit materials.	and the Annual Return as per WDL conditions.
Composting	Odours, leakage and or rodents attracted.	Waste is composted with no noticeable odour. No leaks from composting No rodents observed	Careful management of carbon (sawdust to waste at a ratio of 3/1) Excessive volumes of wastes will be frozen and disposed of to a municipal waste facility. If odour occurs all waste will be frozen and disposed and compost stopped.	No odour No leaks No rodents	Visual and nasal assessment by staff. If odour is identified staff to notify management.	If offensive odours are occurring, compost will be removed from site and all waste will be frozen going forward	Any complaints will be mentioned within annual reports.
Emergency Flooding Event	Potential biosecurity risk of stock entering environment. Stock genetics entering wild stock	No Stock entering the ecosystem due to flood events and if they did due to a catastrophic event, they would cause no harm.	Stock have been sourced locally and therefore genetic impact on wild stocks is negligible. Stock are pathogen tested, and internal UV keeps pathogen load low.	EMP biosecurity section Water Quality Monitoring Plan Water Quality Database	Weather monitoring through wet season Visual monitoring during storm events.	If a emergency flooding event was to occur with some form of notice. Some stock could be removed to higher ground to preserve the project. All remaining stock could be humanly euthanised. (typically completed in ice water slurry).	Any escape from the site due to flooding will be reported to NT EPA and NT Fisheries asap. An incident report will be completed as per the EMP.
Biosecurity	Potential that stock onsite cause and outbreak in wild stocks. Potential that a new disease is transferred from interstate to the NT	No non NT pathogens entering the ecosystem from the facility	All stock will be sourced from NT waters, significantly reducing the potential of a new pathogen entering the system. Stock enter into a stock assessment process with waste water disinfected and pathogens tested. All wastewater is treated with ozone before release.	Low levels of pathogens found in wastewater, with all pathogens endemic to the NT	Pathogen monitoring will be conducted monthly to ensure pathogen loads are acceptable	Increase mV of Ozone dose. Increase UV contact time Introduce Chlorine dosing of wastewater	Any pathogen identified that appears to be of concern will be reported to NT Fisheries immediately.

Figure 7: Site Survey Plan 13 Muramats Road

Viewed at 11:11:58 on 21/11/2017

Survey Plan S 88/207



Page 1 of 1.

Figure 8: Search certificate 13 Muramats Road

Date Registered: 15/09/2016

Volume 813 Folio 942

Duplicate Certificate as to Title issued? No

SEARCH CERTIFICATE

Section 3245 Hundred of Bagot from plan(s) S 88/207

Area under title is 5 hectares 9000 square metres

Owner:

Sandford Pty Ltd (ACN 009 599 606)

of PO Box 240, Berrimah NT 0828

Registered Date	Dealing Number	Description
		Previous title is Volume 773 Folio 280
29/01/2013	789117	Lease to Sea Swift (NT) Pty Ltd - part - expiring 17/01/2018
End of Dealings		

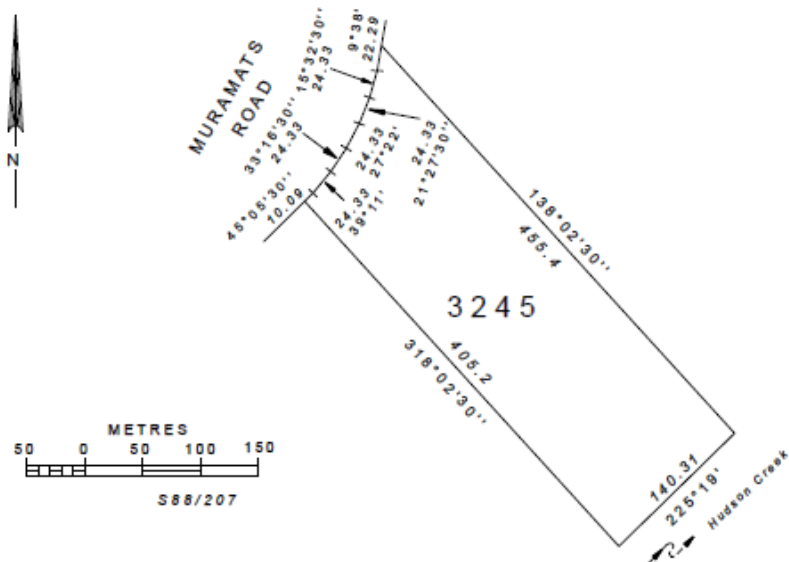


Figure 9: AAPA search abstract 13 Muramats Road East Arm, section 3245, Hundred of Bagot

Our File: RI2024/805
In Reply Please Quote: 202411944

CSIRO
PMB 44
WINNELLIE, NT, 0822

ATTENTION: Adam Chapaman
RE: Abstract of Records - 13 Muramats Road, East Arm, Darwin Section 3245, Hundred of Bagot NT
Australia - 202411944

On 22nd October 2024 the Aboriginal Areas Protection Authority (the **Authority**) received your application for an abstract of records under regulation 7 of the *Northern Territory Aboriginal Sacred Sites Regulations 2004* (NT) (the **Regulations**).

The contents of this letter and the enclosed map comprise the abstract which is hereby provided to you for the purposes of regulation 7(3). I advise, in accordance with regulation 7(3)(a), that for the parcel of land the subject of this abstract:

- i. there are currently no registered sacred sites located on the parcel of land;
- ii. there are currently no recorded sacred sites located on the parcel of land;
- iii. there are currently no restricted work areas in the parcel of land which are provided for in Authority Certificate;

The map enclosed provides an overview of any registered or recorded sacred sites and restricted work areas described above. The information provided to you in this abstract is for information purposes only and cannot be relied upon as an exhaustive list of sacred sites in the area. There may be other sacred sites in the parcel of land of which the Authority is not yet aware.

A person is only permitted to enter and remain on a sacred site, carry out works on a sacred site, or make use of a sacred site in accordance with an Authority Certificate granted by the Authority (refer ss22 and 25 of the Act, also see ss34 and 35). Should you desire to do any of these things please make an application for an Authority Certificate. Further information about this process can be found here – <https://www.ntlis.nt.gov.au/aapa-online/auth/login>. Undertaking any of these acts without an Authority Certificate puts you at risk of prosecution under the Act (refer ss33-35). This abstract does not protect you in any way for your acts and is not an Authority Certificate.

The current Act and Regulations can be found online here - <https://legislation.nt.gov.au/>. Please ensure you are familiar with the legislation, particularly the offences in relation to sacred sites and the processes involved for obtaining an Authority Certificate if and when you require one.

Further information concerning abstracts and requests for information from the Authority can be found in the frequently asked questions (**FAQs**) which can be found online here– <https://www.aapant.org.au/faq>.

The cost of providing the information set out in this letter and the attached map is \$32 (GST inclusive if applicable) and an invoice will be issued to you by the Department of Corporate and Digital Development.

If you have any queries, please do not hesitate to contact the Registrar via email through enquiries.aapa@aapant.org.au or (08) 8999 4356.

Yours sincerely,



Wendy Forscutt
REGISTRAR
23rd October 2024

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All mail to Darwin GPO



**Aboriginal Areas
Protection Authority**
protecting sacred sites across the territory

Figure 10: Response from Water Resources Division – Re water extraction permit

RE: Surface water extraction query (Saltwater Hudson Creek)

 Andrew Applegate <Andrew.Applegate@nt.gov.au> on behalf of Water L
 To  Chapman, Adam (A&F, Darwin)
 Cc  Water Licensing

Tue 27/05/2025 1:06 PM

 This sender Andrew.Applegate@nt.gov.au is from outside your organization.
 Follow up. Start by Tuesday, 27 May 2025. Due by Tuesday, 27 May 2025.
 You forwarded this message on 27/05/2025 1:42 PM.

You don't often get email from waterlicensing@nt.gov.au. [Learn why this is important](#)

Hello Adam,

Apologies for the delay in getting back to you.

I've reviewed the supporting documents you provided, and based on the proposed extraction point, a water extraction licence will not be required.

Under the *Water Act 1992*, a licence is only required for the extraction of water from groundwater or from surface water within a defined waterway. As Darwin Harbour is not classified as a waterway under the Act, the proposed take from this location does not fall under licensing requirements.

Let me know if you need anything further or would like to discuss this in more detail.

Cheers,

Andy Applegate

A/Manager Water Licensing
 Water Resources Division
 Department of Lands, Planning and Environment
 Northern Territory Government

Floor 3, Goyder Centre, 25 Chung Wah Terrace, Palmerston City
 PO Box 496, Palmerston, NT 0831

P: +61 8 8999 3641
 E: Andrew.Applegate@nt.gov.au

Figure 11: Copy of Development Permit

NORTHERN TERRITORY OF AUSTRALIA
<i>Planning Act 1999 - sections 54 and 55</i>
DEVELOPMENT PERMIT DP2025/0181
DESCRIPTION OF LAND THE SUBJECT OF THE PERMIT Section 03245 Hundred of Bagot 13 MURAMATS RD, EAST ARM
APPROVED PURPOSE To use and develop the land for the purpose of part change of use (undefined) for the purpose of an aquaculture research facility, in accordance with the attached schedule of conditions and the endorsed plans.
VARIATIONS GRANTED Clause 3.7 (LSSS – Land Subject to Storm Surge) and Clause 5.6.1 (Setbacks and Building Design Requirements in Zones LI, GI and DV) of the Northern Territory Planning Scheme 2020.
BASE PERIOD OF THE PERMIT Subject to the provisions of sections 58, 59 and 59A of the <i>Planning Act 1999</i> , this permit will lapse two years from the date of issue.
 Digitally signed by AMIT MAGOTRA Date: 2025.10.06 11:01:03 +09'30' AMIT MAGOTRA Delegate of the Minister for Lands, Planning and Environment 06 October 2025