2025 Environmental Risk Assessment - Milingimbi Wastewater Treatment Plant WDL 208-04

January 2025

PowerWater

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Abbreviations and Glossary

Abbreviation	Definition
ANZECC	Australian Water Quality Guidelines for Fresh and Marine Waters
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
Assessment endpoints	The explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes.
BOD	Biochemical oxygen demand
BUD	Beneficial Use Declaration – the uses of water specified in subsection 3 of the *Water Act* (1992)
BOM	Bureau of Meteorology
CSM	Conceptual site model
Cultural values	To provide water to meet aesthetic, recreational and cultural needs.
DLPE	Department of Lands, Planning and Environment (NT)
DO	Dissolved oxygen
E. coli	*Escherichia coli*
Ebb tide	A falling tide - the phase of the tide between high water and the succeeding low water.
Environmental Values	To provide water to maintain the health of aquatic ecosystems.
EPBC	Environment Protection and Biodiversity Conservation Act
ERA	Environmental risk assessment
ET	Equivalent Tenement – an average residential dwelling or house. Other developments are converted to an ET value by relating their average water demand (or sewage flow) to demand from one average house.
Flood tide	A rising tide - the phase of the tide between low water and the next high tide.
ICEGs	Indigenous Community Engineering Guidelines
kL	Kilolitre
Km	Kilometre
L	Litre
m	Metre
m^2	Square metre
Macrotidal estuary	Estuaries where the tidal range is in excess of 4 metres.
mg	Milligram
mL	Millilitre
NOx	Nitrogen oxides – the sum of nitrate and nitrite ionic species.
NT	Northern Territory

NTU	Nephelometric turbidity units
NT EPA	Northern Territory Environmental Protection Authority
PL	Primary lagoon
Risk characterisation	The culmination of the planning, problem formulation and analysis of predicted or observed adverse ecological effects related to the assessment endpoints.
Risk hypothesis	Assumptions made in order to evaluate logical or empirical consequences, or suppositions tentatively accepted to provide a basis for evaluation. They are used to test if an activity (e.g. contaminant discharges) has adverse effects on an assessment endpoint.
SL	Secondary lagoon
SOCs	Site of conservation significance
SPS(s)	Sewage pump station(s)
SS / TSS	Suspended solids / total suspended solids
TDS	Total dissolved solids – the portion of solids in wastewater that passes through a 2.0 micron filter.
TN	Total nitrogen
TP	Total phosphorous
TPWC	Territory Parks and Wildlife Conservation Act
WDL	Waste discharge licence
WwTP	Wastewater treatment plant. All facilities that treat wastewater disposed of to the sewerage system consisting primarily of sewage as well as stormwater inflow and infiltration. These facilities may include a range of different types of treatment technologies e.g. waste stabilisation ponds.
WSP(s)	Waste stabilisation pond(s)

Executive Summary

This desktop environmental risk assessment (ERA) provides an assessment of the risks associated with the discharge of secondary treated effluent from the Milingimbi wastewater treatment plant (WwTP) to Castlereagh Bay (Arafura Sea).

Based on this ERA and water quality data, there is limited evidence to suggest deleterious impacts on the environmental values identified for this receiving environment.

Risks to the assessment end-points, associated with the source, were assessed as having low to high risk rankings. These rankings were associated with the low discharge volumes into a tidal marine environment, while higher risk rankings were associated with impacts to cultural values including human health risks through primary and secondary contact and aquatic food safety.

The risk rankings may change as uncertainties associated with current assessments are addressed. A range of recommendations have been made in this risk assessment to address knowledge gaps and identify opportunities for improvement.

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1. Introduction

Power and Water operate the Milingimbi WwTP pursuant to Waste Discharge Licence (WDL) 208-04 issued on 11 July 2023. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to Castlereagh Bay (Arafura Sea).

Milingimbi is an island which forms part of the Crocodile Island Group, located approximately 500 m off the north coast of Central Arnhem Land in the Arafura Sea. It is approximately 440 km east of Darwin (Figure 1). Milingimbi has an estimated population of 1,288 (BushTel 2024). The Wastewater Treatment Plant (WwTP) is located approximately 439 m southwest of the Milingimbi township (Figure 2).

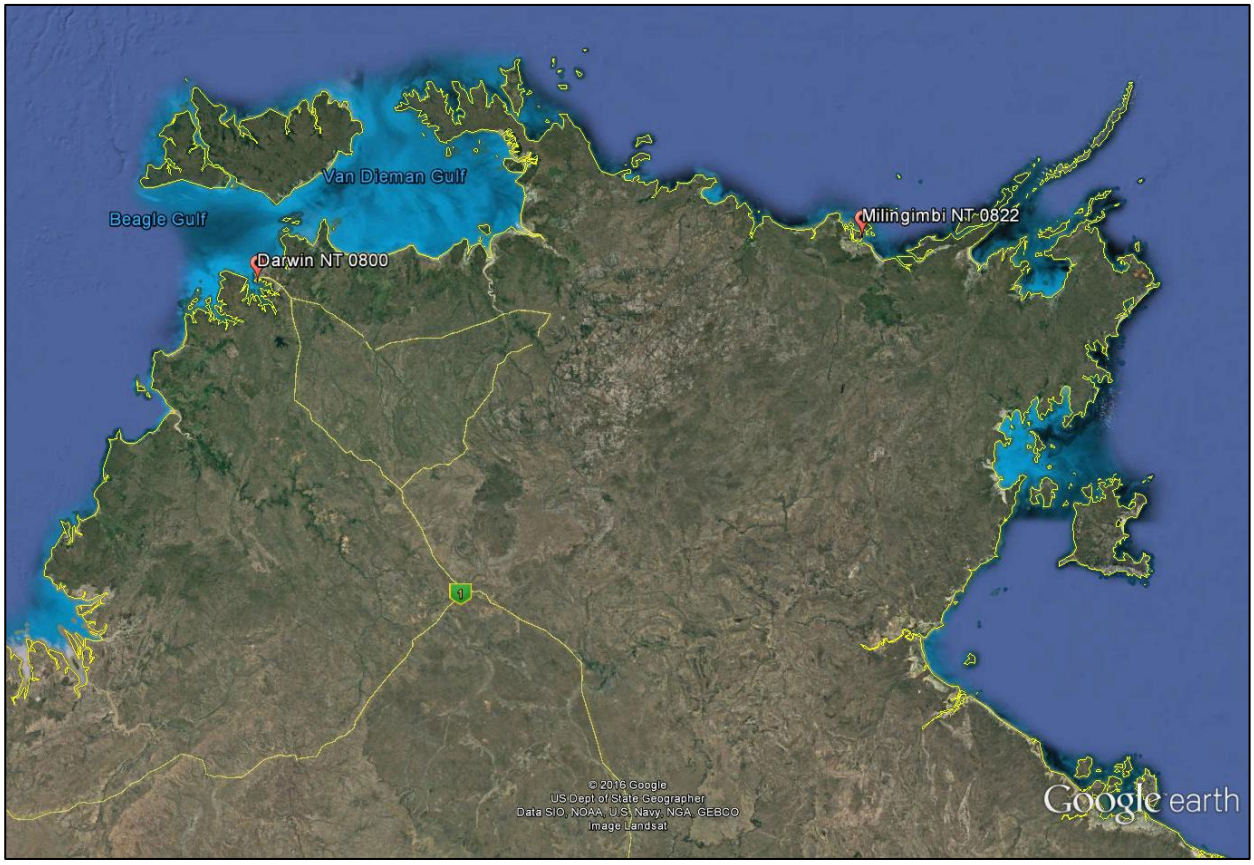

Figure 1: Milingimbi locality map (Google Earth 2016)

Figure 2: Milingimbi site layout including WwTP and outfall location (NT ILIS 2016)

1.1 Background

Condition 43 (Item 15) of this WDL requires Power and Water to submit to the Northern Territory Environment Protection Authority (NT EPA) an updated ERA for the Licenced Activity by 1 February 2025.

The ERA must:

i. be conducted with reference to a conceptual site model;

ii. characterise the impacts of discharge(s) on the relevant environmental values; and

iii. inform the development of a Performance Improvement Plan.

To be submitted at least 60 business days prior to the expiry date of this licence;

2. Risk Assessment Methodology

The purpose of the desktop ERA is to:

- identify assessment endpoints;
- characterise environmental risks associated with the facility; and
- initiate an ongoing iterative environmental risk process associated with ongoing operation of the facility.

The methodology employed has been adapted from ERAs completed by the Power and Water's Assurance Team and the Victorian EPA *Guidance for Environmental and Human Health Risk Assessment of Wastewater Discharges to Surface Waters* (VIC EPA 2023). The guidelines utilise a framework (Figure 3) consistent with current nationally and internationally accepted risk assessment approaches.

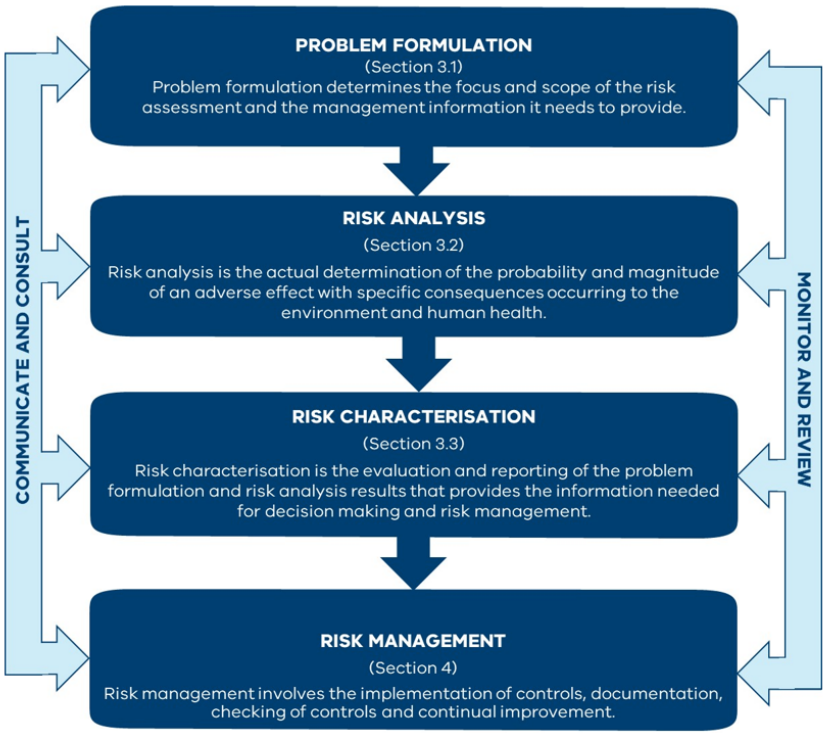

Figure 3: Risk Assessment framework for wastewater discharges to waterways (Victoria EPA, 2023)

2.1 Limitations

The following items have been identified as limitations associated with the preparation of this ERA:

- limited availability of inflow/outflow data;
- remoteness of communities impacting on the ability to understand systems due to costs, logistics and available expertise; and
- limited access to pond discharge points and surrounding environment due to climatic, safety and geographic factors.

3. Problem Formulation

The purpose of this ERA is to characterise the impacts of discharge on the relevant values and has been prepared with reference to section 1.1.

This problem is explored through the following:

- characterisation of the treated effluent discharged to the receiving environment;
- characterisation of the treated effluent discharge regime and subsequent dilution of treated effluent within receiving water; and
- identified values of receiving water and assessment endpoints representative of those values.

3.1 Milingimbi Wastewater Treatment Plant

The community utilises a gravity and pressure fed sewer reticulation system which drains raw sewage from the community to the WwTP (Figure 4). The Milingimbi WwTP utilises waste stabilisation pond technology to achieve secondary level treatment of sewage effluent. Based on current circumstances, the raw sewage is almost entirely domestic in nature with no chemicals added during the treatment process. The WwTP was constructed in August 1985 (Power and Water 2021). The ponds consist of a primary facultative pond which gravity feeds into two secondary maturation ponds.

There is no gross pollutant screening, grit removal, maceration or storm flow separation located on the inlet to the pond system. The majority of the removal process for gross pollutants and other entrained materials is via sedimentation to sludge layers or entrapment in concentrated surface scums that can be physically removed. Desludging of the WSPs is conducted periodically to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. Last desludge date is unknown.

Monthly wastewater monitoring occurred from three sample sites (pond 1 inlet, pond 2 inlet and pond 2 outlet) for a period of 6 years from 2012 – 2018. WDL wastewater monitoring commenced in September 2015, consistent with WDL 208. Samples of the secondary pond outlet for the purpose of the WDL are currently collected on a monthly basis. Monitoring results are included in the *Power and Water Annual Monitoring Report – Remote Community Waste Discharge Licences,* a summary is provided in Appendix 4, Table 7.

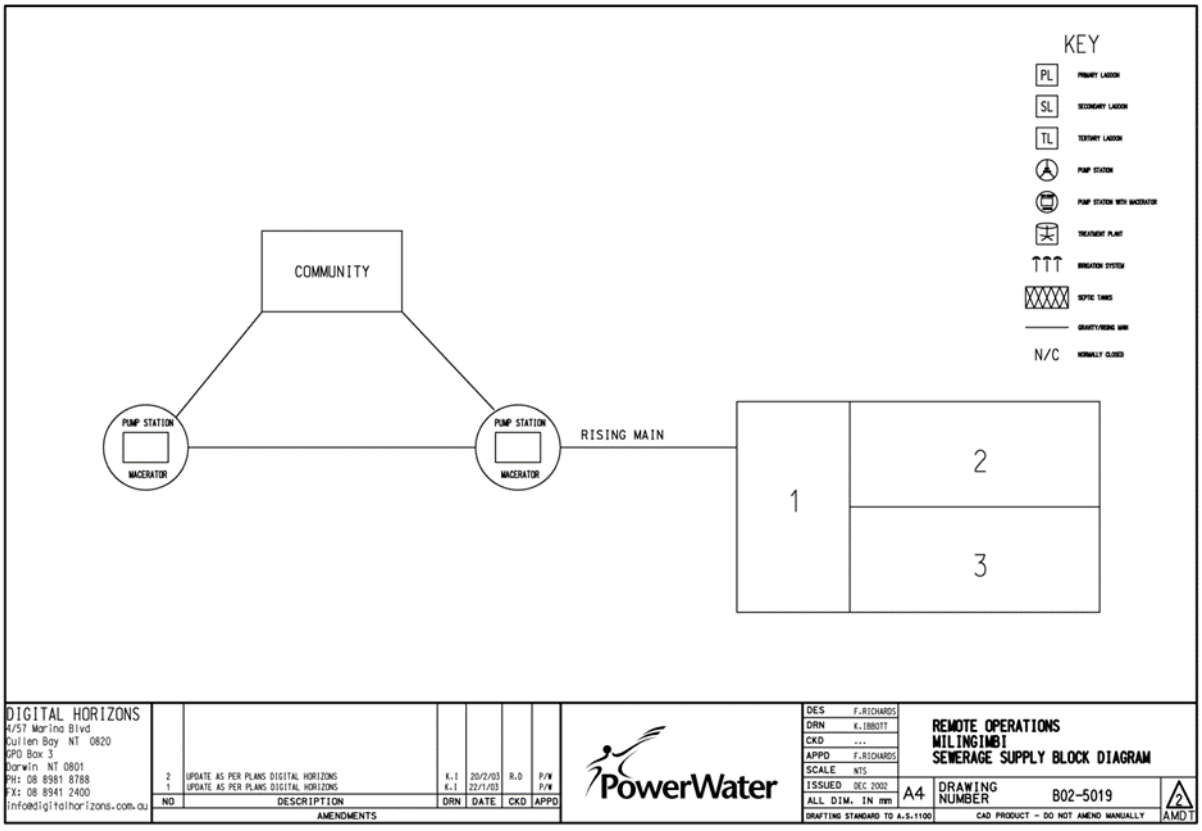

Figure 4: Milingimbi wastewater collection and treatment configuration.

3.2 Discharge Regime

Discharge from the facility occurs from an outfall located in the tertiary maturation pond to the sea. Discharge occurs all year round to the Arafura Sea through the littoral mangrove zone of a small tidal estuary.

A flow meter is installed at the Milingimbi discharge point; however, currently this data set contains inconsistencies, reducing confidence in the data statistics. Further data collation and assessment is required over a longer-term to provide more accurate measurements in future risk assessments.

In the interim the annual water balance will continue to be utilised until the metered data is available. The annual water balance is estimated based on forecast sewage Equivalent Tenement (ET) flow, which may not accurately represent the inflow to outflow ratio on site.

The estimated mean outflow from Milingimbi WwTP is **419.4 kL/day**

Note that the volume of treated wastewater discharged to the environment varies seasonally with changes in evaporation and rainfall.

3.3 Pond Performance

WSPs offer a low input, cost effective form of wastewater treatment that is particularly applicable in higher temperature environments with sufficient available land area. While the inputs are low, because it is largely driven by solar energy, the processes are no less complex and are largely controlled by the appropriate design and maintenance of the pond system to achieve the treatment performance required.

Wastewater monitoring at the Milingimbi primary pond inlet commenced in June 2012. This data will provide an accurate characterisation of the raw effluent entering the waste stabilisation pond system, and an indication of treatment performance.

Pond treatment performance can be measured at remote community sites utilising mean biochemical oxygen demand (BOD) removal performance and mean predicted *E.coli* disinfection performance. The results are a reduction in concentration levels from the primary pond inlet to the final pond outlet.

The mean removal percentage at the Milingimbi WSPs has been calculated using data collected following the submission of the previous Environmental Risk Assessment and includes data from August 2022 to January 2025:

- Biochemical Oxygen Demand (BOD): **45%**
- Free Ammonia (NH_3-N): **7%**
- Total Nitrogen (TN): **7%**
- Total Phosphorus (TP): **-7.4%**

The average log reduction for the pathogens indicator is:

- *E. coli:* **0.8 log reduction**

Further monitoring data, statistical analysis and investigation is required to verify these results.

The ponds ultimately provide a centralised treatment barrier that prevents direct contamination of the receiving environment and have an important role in the protection of both environmental and public health.

For the scope of this risk assessment, wastewater quality monitoring data collected at the final pond discharge point to the receiving environment are illustrated on the conceptual site model (CSM) in Appendix 1 and water quality table (Table 7).

3.4 Receiving Environment

Castlereagh Bay is a bay of the Arafura Sea which surrounds Milingimbi Island. Castlereagh Bay tides are semi-diurnal and have a mean spring and neap tidal range of 1.8 m (BOM 2016).

The receiving environment consists of tidal mudflats and coastal waters. The coastline is vegetated with Darwin woolybutt (*Eucalyptus miniata*), stringybark (*Eucalyptus tetradonta*), Melaleuca species and with a spear grass *(Saga* spp.) understorey and seaward mangrove assemblages (Power and Water 2005).

The receiving environment is considered to have experienced minor disturbance (Power and Water 2010) due to the cultural uses of the area and weed species such as hyptis (*Hyptis suaveolens*) and snakeweed (*Stachytarpheta* spp) are evident beside the sewage pond compound.

Milingimbi is located within the boundaries of the Castlereagh Bay and Associated Islands site of conservation significance number 19 (Appendix 2) and contains eight threatened marine and near shore species. The conservation status for these species listed under the Territory Parks and Wildlife Conservation Act 2000 (TPWC) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) are summarised below in Table 1.

Table 1: Conservation status of species at risk from the area surrounding the Milingimbi WwTP.

Common name	Species name	National Status (EPBC)	NT Status (TPWC)
Plants			
Australian Arenga Palm	*Arenga australasica*	VU	-
Vertebrates			
Emu	*Dromaius novaehollandiae*	-	VU
Partridge Pigeon	*Geophaps smithii*	VU	VU
False Water-rat	*Xeromys myoides*	VU	-
Yellow-spotted Monitor	*Varanus panoptes*	-	VU
Flatback Turtle	*Natator depressus*	VU	DD
Green Turtle	*Chelonia mydas*	VU	NT
Olive Ridley Turtle	*Lepidochelys olivacea*	EN	VU

CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, DD – Data Deficient

3.5 Screening Level Risk Assessment

A screening level risk assessment is used to determine if a risk to the assessment end-point exists that should be further investigated. It is a method for prioritising risks and minimising effort in assessing low risks. Table 3 provides a summary of the screening level risk assessment.

Risk hypotheses for the stressors identified in the conceptual site model (CSM) Appendix 1 are defined with respect to their potential effects on the identified values of the receiving environment.

The identified values of the receiving environment are summarised below in Table 2.

Table 2: Identified values of receiving environment at risk from the Milingimbi WwTP

Values	Receptors	
Cultural/ Human Health	Humans	Fishing Shellfish harvesting Mangrove worms Swimming/wading Visible water quality Sacred sites
Environment	Marine	Fish Turtles Mud Crabs
	Terrestrial	Shorebirds Waterbirds Seabirds
	Plants	Mangroves

Table 3. Screening level risk assessment for key indicator and stressors associated with Milingimbi WwTP discharge.

Indicator (water quality parameter)	Stressor (change to indicator)	Risk Hypothesis		Assessment end-points		Scope of this desktop ERA	Further investigation required?
		ENVIRONMENTAL	CULTURAL	ENVIRONMENTAL	CULTURAL		
Gross pollutants	Presence and accumulation of gross pollutants from influent carried through to effluent	That gross and micro-scale pollutants are ingested by biota resulting in death of animals and environmental degradation.	That gross pollutants are resulting in the reduction of visual amenity in the receiving environment.	To maintain the presence of biota in the environment.	To maintain the visual amenity of the environment.	The WwTP is considered a relatively effective barrier to gross pollutant entry to the receiving environment. This is due to the settling out to sludge layers and accumulation on pond surface where gross pollutants are physically removed as required. No evidence of gross pollutant accumulation during visual monitoring of discharge site (qualitative discharge criteria). No further investigation necessary at this stage.	No
Electrical conductivity	Decrease in salinity from freshwater input to marine environment	That freshwater inputs are leading to impacts on biota less tolerant of lower salinities resulting in loss of biodiversity.		To maintain biodiversity in the environment.		Significance of freshwater inputs are considered low with respect to discharge volumes and natural freshwater inputs within the region. Mangroves are also at the interface of terrestrial and marine environments and can tolerate freshwater inputs (Power and Water 2015a, Power and Water 2015b). No further investigation necessary at this stage.	No
Organic matter	Increase in BOD, decrease in DO	That BOD is leading to oxygen depletion in the environment resulting in loss of biota (e.g. fish kills) and changes to ecosystem structure.	That BOD is leading to odours resulting in the reduction of amenity in the receiving environment.	To maintain the presence of biota in the environment.	To maintain oxygen levels in the environment sufficient to prevent production of odours.	The median concentration of BOD in the discharge of Milingimbi WwTP is 31 mg/L. As BOD is present in the discharge, it is determined at a screening level that a risk is present and further investigation is necessary.	Yes
Nutrients (nitrogen and phosphorus)	Increase in nutrient concentrations	That nutrients are leading to nuisance plant growth (e.g. phytoplankton blooms) resulting in oxygen depletion; displacement of endemic species; diminished light availability; release of toxins; and changes to ecosystem structure.	That nutrients are resulting in the reduction of amenity of receiving environment through reduction in water clarity, objectionable discolouration and odours; toxic blooms that are a public health risk; and blooms of toxin producing species whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	To maintain nutrient levels so that the levels of primary production do not have an adverse impact on ecosystem structure.	To maintain the amenity of the environment.	As nutrients are present in the discharge, it is determined at a screening level that a risk is present and further investigation is necessary.	Yes
Toxicants	Increase in free ammonia concentration	That free ammonia is resulting in toxicity to aquatic organisms in water and sediments.		To maintain the presence of biota in the environment.		The median concentration of free ammonia in the discharge of Milingimbi WwTP is 19.0 mg/L. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes
Pathogens	Presence of *E. coli*		That pathogens are leading to the contamination of water resulting in primary and secondary contact; recreation a public health risk; and accumulation in shellfish resulting in the consumption of shellfish a public health risk.		To maintain that pathogens from municipal wastewater are not increasing the risk of illness via primary and secondary contact recreation and consumption of shellfish.	The median pathogen concentration in the discharge of Milingimbi WwTP is 216,880 MPN/100mL. At a screening level it is determined that a risk is present and further investigation is necessary.	Yes

4. Risk Analysis and characterisation

4.1 Power and Water Risk Management Framework

Power and Water has adopted a qualitative risk assessment methodology aligned to the Australia/New Zealand Standard *"AS/NZ 4360: Risk Management"*. This process is used to assess and manage activities that have potential to cause environmental harm.

The first step in the ERA process is to identify the aspects (problem formulation i.e. discharge of treated wastewater) (section 2.0) and corresponding potential impacts associated with each assessment end-point identified in the screening level risk assessment as seen in Table 3.

This methodology is based on knowledge of the existing environment and incorporates site specific environmental factors into the analysis of the potential impacts. An assessment of each impact is analysed for likelihood and consequence.

The categories and associated rankings for environmental impact consequences are shown in Appendix 3 (Table 5). The likelihood of an event occurring and a risk score for each potential impact is determined by combining likelihood with consequence results as seen in Appendix 3 (Figure 7).

Low to medium risks can typically be managed by routine procedures and integration into management plants, while high to extreme risks require senior management attention, immediate action or more detailed research and management planning.

3.1.1 Risk assessment for key indicators and stressors identified in screening level assessment.

Table 4: Risk assessment for key environmental and cultural assessment endpoints associated with Milingimbi WwTP discharge.

Hypothesis	Consequence		Likelihood	Inherent	Risk Ranking
Environmental					
BOD is leading to oxygen depletion in the environment resulting in **loss of biota** and **changes to ecosystem structure**.	Based on the 2023-2024 monitoring data, Milingimbi WwTP median BOD discharge quality is 31 mg/L. The estimated dilution volume ratio between effluent (419.4 kL/d) and the receiving environment has been conservatively calculated as 1:0:98 in the direct vicinity of the discharge point with further subsequent dilution (Appendix 4). Suggesting any observed oxygen demand would be absorbed by the environment.	Moderate	Stressor not typically observed with such small discharge volumes and dilution experienced in receiving waters. Likelihood greater during low tide where there are short-term flushing constraints however unlikely to be sustained. Power and Water considers that the likelihood of oxygen depletion in the receiving environment is unlikely. Further investigations and site inspections are required to determine if changes to ecosystem structure is discharge influenced.	Unlikely	Medium
Free ammonia is resulting in **toxicity to aquatic organisms** in water and sediments.	Based on the 2023-2024 monitoring data, Milingimbi WwTP free ammonia discharge quality is 19 mg/L. One of the most visible means by which toxicity presents in an aquatic ecosystem is through the occurrence of fish kills. No fish kills reported to date.	Minor	Stressor not typically observed with such small discharge volumes and dilution experienced in receiving waters. Based on the sampling results to date, Power and Water considers that the likelihood of toxicity to aquatic organisms in water and sediments is unlikely. Concentrations of free ammonia are elevated at Milingimbi in comparison to other remote WwTPs, however it is assumed that daily tidal flushing within the immediate discharge area reduces toxicity to aquatic organisms.	Unlikely	Low
Nutrients are leading to **nuisance plant growth resulting** in oxygen depletion; displacement of endemic species; diminished light availability; release of toxins; and changes to ecosystem structure.	Based on the 2023-2024 monitoring data, Milingimbi WwTP contributes 6.5 and 1.0 tonnes/year of total nitrogen and phosphorus respectively.	Moderate	Based on the sampling results to date, Power and Water considers that the likelihood of nuisance plant growth in the receiving environment is possible due to the immediate discharge area being a mangrove forest. Ongoing sampling and site inspections will assist to characterise discharge quality.	Possible	Medium
Cultural					
BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment.	The coastline is identified as having cultural beneficial uses for primary and secondary recreation. The immediate discharge site is located above the low-level tide point however public access is restricted due to mud and thick mangrove vegetation.	Moderate	Stressor not typically observed with rapid dilution and efficient coastal flushing. Likelihood greater during extreme low tide where there are short-term flushing constraints however unlikely to be sustained. No evidence of odours during monitoring of discharge location at final pond (qualitative discharge criteria). Milingimbi BOD concentrations are considered low strength (Power and Water 2021). Power and Water considers that the likelihood of reduction in amenity from BOD is unlikely.	Unlikely	Medium
Nutrients are resulting in the **reduction of amenity** of receiving environment through **reduction in water clarity**, objectionable **discolouration** and **odours**.	The coastline is identified as having cultural beneficial uses for primary and secondary recreation. The immediate discharge site is located above the low-level tide point however public access is restricted due to mud and thick mangrove vegetation.	Moderate	Stressor not typically observed with rapid dilution and efficient coastal flushing. No evidence of reduction in water clarity, objectionable discolouration of receiving water or odours during monitoring of discharge site (qualitative discharge criteria). Power and Water considers that the likelihood of reduction in amenity from nutrients is unlikely.	Unlikely	Medium
Nutrients are resulting in **toxic blooms** that are a public health risk; and **blooms of toxin producing species** whereby the toxins bio-accumulate in shellfish and fish ingested by humans.	The coastline is identified as having cultural beneficial uses for primary and secondary recreation including exposure through swimming and exploratory wading. Collection and consumption of marine species such as shellfish, crabs, mangrove worms, turtles and other fish are known to occur within the area.	Major	Based on the primary and secondary contact recreation and cultural uses of the coastline, Power and Water considers that the likelihood of toxicant exposure is possible. Signage is located at the discharge point to warn community members of the discharge location and risks to public health.	Possible	High
Pathogens are leading to the **contamination of water** resulting in a public health risk through primary and secondary contact recreation.	The coastline is identified as having cultural beneficial uses for primary and secondary recreation including exposure through swimming and exploratory wading.	Moderate	Based on the secondary contact recreation and cultural uses of the coastline, Power and Water considers that the likelihood of the illness from pathogen exposure is possible.	Possible	Medium
Pathogens are leading to **accumulation in shellfish** resulting in a public health risk through the consumption of shellfish.	Collection and consumption of shellfish are known to occur within the area (Michels Warren Munday 2012).	Major	Based on the cultural uses of the coastline, Power and Water considers that the likelihood of the illness from pathogen exposure through the consumption of shellfish is possible.	Possible	High

5. Summary

The ERA found that the identified values of Castlereagh (Arafura Sea) at risk from the Milingimbi WwTP discharge were environmental and cultural/ Human Health.

The key stressors that posed a risk to these values were the presence and accumulation of gross pollutants from influent carried through to effluent; decrease in salinity; increase in BOD; increase in nutrient concentrations; increase in free ammonia concentration and the presence of *E. coli*.

The ERA process has determined that the discharge from the Milingimbi WwTP poses a low to high risk to the identified values of the receiving waterway. The influence of the discharge on the receiving environment is considered sustainable given the low discharge volumes and rapid dilution of nutrients and pathogens at the outfall. Based on this ERA and water quality data, there is limited evidence to suggest deleterious impacts to the receiving environment.

All risk rankings have considerable uncertainties attached to the assessments. The risk rankings may change as uncertainties associated with current assessments are addressed.

Based on the ERA process and outcomes, Power and Water make the following recommendations:

- continue monitoring quality of wastewater discharged to the environment;
- incorporate recommendations into future Performance Improvements Plans;
- implement options to accurately quantify the volume of treated wastewater discharged to the environment; and
- update the ERA and CSM based on new information and additional wastewater quality data.

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Appendices

Number	Title
Appendix 1	Milingimbi Conceptual Site Model
Appendix 2	Map of Castlereagh Bay and Associated Islands Site of Conservation Significance
Appendix 3	Power and Water Risk Matrix
Appendix 4	Water quality and estimated dilution Ratio for Milingimbi WwTP

Appendix 1 – Milingimbi Conceptual Site Model

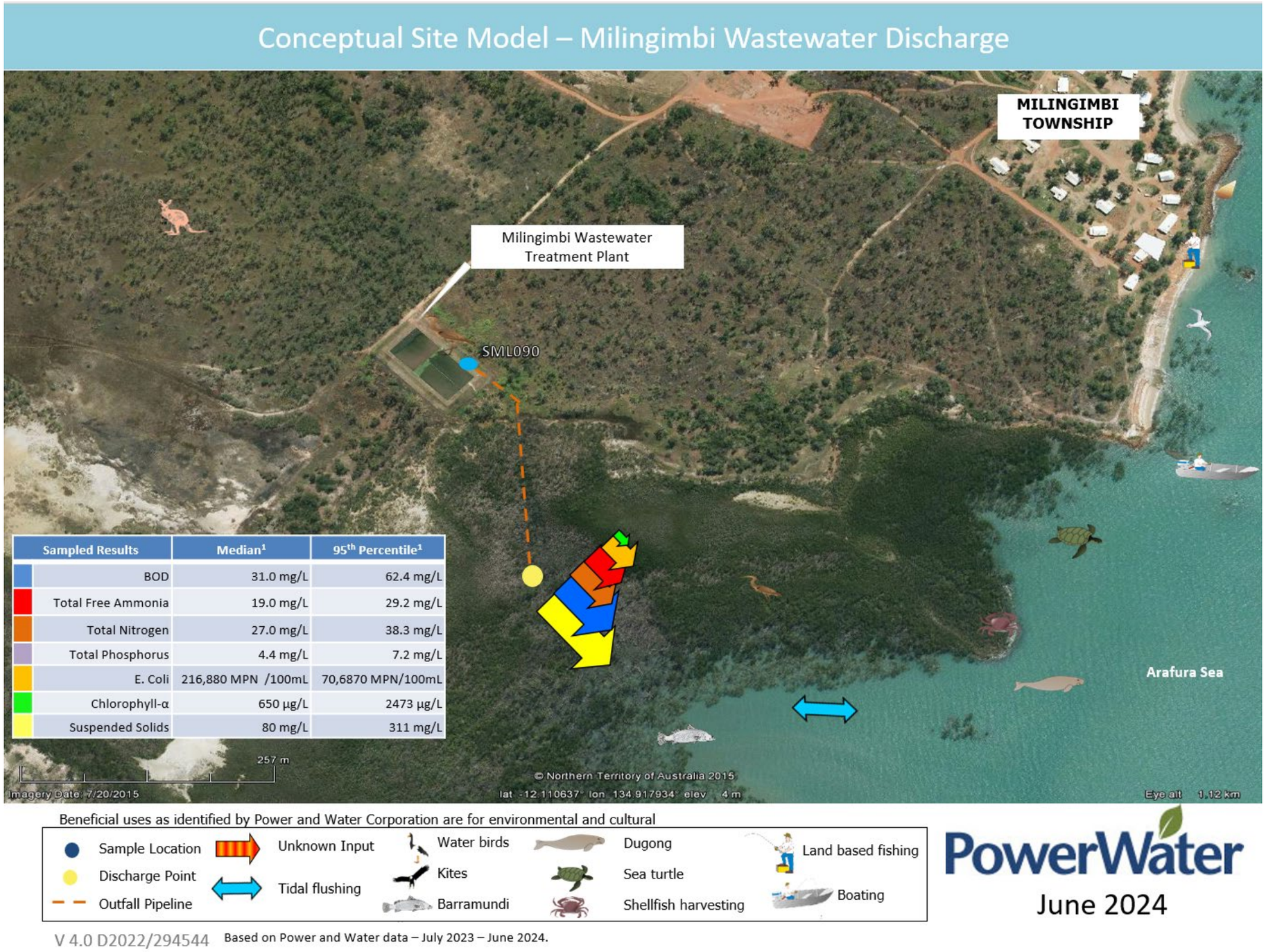

Figure 5: Conceptual site model for the Milingimbi WwTP.

Appendix 2 – Castlereagh Bay and Associated Islands Site of Conservation Significance

Figure 6: Castlereagh Bay and Associated Islands site of conservation significance map (NRETAS, 2008).

Appendix 3 – Power and Water Risk Matrix

Table 5: Power and Water risk consequence table.

CONSEQUENCES

The consequence (impact or outcome) associated with a risk is assessed using the following criteria:

RISK CONSEQUENCE TABLE					
Category	**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Health and safety	**Physical**: A near miss incident without injury or illness. **Psychosocial*:** No treatment needed from a health professional. *Notes: Psychosocial harm relates to the factors in the design or management of work that increases the risk of work-related stress and can lead to psychological or physical harm.	**Physical:** An incident resulting in a minor injury or illness, and first-aid treatment applied. **Psychosocial**: Reduced ability to perform tasks, no professional treatment needed.	**Physical:** An incident resulting in an injury or illness requiring medical treatment*. **Psychosocial:** Reduced ability to perform tasks, likely needs ongoing support from a health professional. *Notes: Medical treatment relates to treatment by a medical professional at a medical facility. Treatment at a worksite by a paramedic is a first aid injury, unless they are transported to a medical facility.	**Physical:** A serious incident: ▪ Requiring hospitalisation (24hrs); and/or ▪ Resulting in long-term permanent disabling; or ▪ Exceeding of chemical exposure with acute health impacts. **Psychosocial:** Serious psychological treatment needed, reduced ability to perform tasks.	**Physical:** A serious incident resulting in any one or more of the following: ▪ One or more fatalities; ▪ One or more persons seriously injured (includes long-term disabling effect); ▪ Widespread hospitalisation of members of the public or Power and Water's workforce. **Psychosocial**: Inability to perform tasks, ongoing extensive psychological treatment.
Financial **(Impact on EBITDA)**	Loss less than $500K.	Impact between $500K and $5M.	Impact between $5m and $25m.	Impact between $25m and $50m.	Impact greater than $50m.
Legal/ regulation	▪ Individual breach of obligation, procedure or policy. ▪ Civil action, fines and/or civil penalties (refer to Financial definition)	▪ Notification to regulator required. ▪ Regulator/external auditor non-conformance or request for further explanation ▪ Functional breach of obligation, procedure or policy. ▪ Civil action, fines and/or civil penalties (refer to Financial definition)	▪ Regulator/ external auditor issues improvement notice, multiple non-conformances or provisional improvement notice. ▪ Systemic breach of obligation, procedure or policy. ▪ Civil action, fines and/or civil penalties (refer to Financial definition)	▪ Regulator issues notices, corrective action order and/or penalties ▪ Order to stop work ▪ Multiple provisional improvement notices, prohibition notice. ▪ Civil action, fines and/or civil penalties (refer to Financial definition)	▪ Successful criminal prosecution imprisonment of Power and Water director and/or officer. ▪ Royal Commission, parliamentary or other government inquiry, ▪ Loss of licence to operate. ▪ Civil action, fines and/or civil penalties (refer to Financial definition)
Environmental	Localised low level damage controlled but no remedial action required.	Localised low level damage controlled and remedied with minimal resources.	Widespread temporary damage with extended resources to remedy.	Long-term detrimental effect on environment and once controlled results in minor permanent damage.	Substantial permanent damage to widespread and sensitive areas.
Reputation	▪ No media attention; and/or ▪ Isolated community or individual issue-based concern; and/or ▪ Localised employees dissatisfaction which is managed by normal business processes;	▪ Occasional once-off negative media attention; and/or ▪ Localised community impacts and customer concerns; and/or ▪ Localised employees dissatisfaction which requires human resources in resolution;	▪ Brief adverse media attention and/or ▪ Community/customer condemnation; and/or ▪ Limited, localised loss of confidence by the community; and/or ▪ Reduced confidence of key stakeholders ▪ Localised employees dissatisfaction with localised impacts to service delivery	▪ Prolonged adverse media attention and/or ▪ Community/ customer condemnation; and/or ▪ Prolonged, widespread community/ customer loss of confidence; and/or ▪ Confidence of key stakeholders damaged ▪ Widespread dissatisfaction and loss of confidence by employees resulting in temporary service delivery	▪ Sustained adverse media attention and/or ▪ Community/customer condemnation; and/or ▪ Sustained community/ customer loss of confidence; and/or ▪ Loss of stakeholder confidence in Board and/or ▪ Management; and/or ▪ Widespread dissatisfaction by employees resulting in sustained service delivery and industrial action
Customer **(Impact due to disruption to services)**	▪ No loss of supply. Issues rectified with corrective action. ▪ Loss of water supply <= 2 hours in any urban or remote community	▪ An event resulting in loss of a single residential feeder for 15 to 30 minutes ▪ Loss of water supply >2 hrs and <= 6 hours in any remote community ▪ Loss of water supply in urban area, restored within expected timeframes (<=4 hours)	▪ An event resulting in loss of a single to multiple zone substations for up to 3 hours ▪ Loss of water supply >6 and <=12 hours in any remote community ▪ Loss of water supply in urban area outside of expected timeframes (> 4 hours and <=12 hours).	▪ An event resulting in loss of a single to multiple zone substations affecting CBD, town centres, commercial, and emergency services lasting up to 6 hours ▪ Loss of water supply >12 hours < =24 hours in any urban area or remote community.	▪ An event resulting in loss of a single to multiple zone substations affecting CBD, town centres, commercial, and emergency services lasting > 6 hours ▪ Complete loss of water supply (>24 hours) in any urban or remote community.

LIKELIHOOD

The likelihood of a risk occurring is assessed using the following scale:

(E) Almost certain	Event is expected to occur on a regular basis. One or more times per annum.	Not applicable
(D) Likely	An event is expected to occur from time to time. Once every 1 – 3 years	Probability of occurring is greater than 33%
(C) Possible	An event should occur at some time. Once every 4 – 10 years.	Probability of occurring is greater than 10% and up to and including 33%
(B) Unlikely	An event could occur at some time. Once every 11 to 30 years	Probability of occurring is greater than 3% and up to and including 10%
(A) Rare	An event not expected but possible. Less than once in 30 years	Probability of occurring is up to and including 3%

RISK RATING

Consequences and Likelihood

Likelihood	Consequence: Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Almost certain (E)	Medium	High	Very High	Extreme	Extreme
Likely (D)	Low	Medium	High	Very High	Extreme
Possible (C)	Low	Low	Medium	High	Very High
Unlikely (B)	Low	Low	Medium	High	High
Rare (A)	Low	Low	Low	Medium	Medium

ACTIONS AND REPORTING

	Low	Medium	High	Very High	Extreme
Escalation (new risk or reassessment)	Reported through risk review process.	Reported through risk review process.	Reported to executive general manager	Reported to CEO / Executive Leadership Team as soon as practicable.	Reported to Board Chair as soon as practicable.
Reporting to ARMC	Not applicable.	Not applicable.	To be reported to Audit and Risk Management Committee on a quarterly basis.	To be reported to Audit and Risk Management Committee on a quarterly basis.	Exception reporting as soon as practicable.
Tolerance	Tolerable unless otherwise determined by management.	Tolerable unless otherwise determined by management.	Tolerance to be determined by executive general manager.	Tolerance to be determined by CEO / Executive Leadership Team.	Tolerance to be determined by Board.
Risk monitoring	Reporting frequency to be annual.	Reporting frequency as per related business process.	Status to be reported to executive general manager at each business unit management meeting. Reporting frequency to be quarterly.	Status to be reported to each ELT. Reporting frequency to be quarterly	Status reported to each Board meeting. Reporting frequency to be quarterly

Note: "Escalation" refers to the escalation of **risks** (i.e. events that could happen in future) not **incidents** (events that have happened). Escalation of incidents is covered by the *HSE Incident and Investigation Management Procedure (CONTROL0070)*.

Figure 7: Power and Water likelihood, risk ranking, actions and reporting matrix.

Appendix 4 – Water quality and estimated dilution Ratio for Milingimbi WwTP

A model-based prediction of Milingimbi outfall dilution was undertaken based on the method outlined by Wood, Bell and Wilkinson (1993). The model utilises site parameters such as outfall flowrate, water and wastewater temperature, outfall diameter and depth of ocean above outfall to predict the outfall plume dilution in the vicinity of the discharge point due to buoyancy led mixing.

The following parameter values were used:

Table 6: Basis for estimating outfall dilution.

Parameters		Minimum	Maximum	Unit
Depth of Ocean Above Outfall[1]	z	0	1.8	m
Outfall Flowrate[2]	Q	0.0047	0.0049	m^3/s
Wastewater Temperature[3]	T_{wwater}	22	32	^oC
Ocean Temperature[4]	T_{ocean}	23.6	33.1	^oC
Outfall Diameter	d_p	0.10		m

[1] No definitive information of tide heights above outfall pipe are available; limits chosen are considered to be conservative assumptions.
[2] As per estimated flowrate from the 2023 – 2024 monitoring report.
[3] Based on average air temperatures at site.

[4] Based on monthly average sea temperatures provided by Australian Bureau of Meteorology.

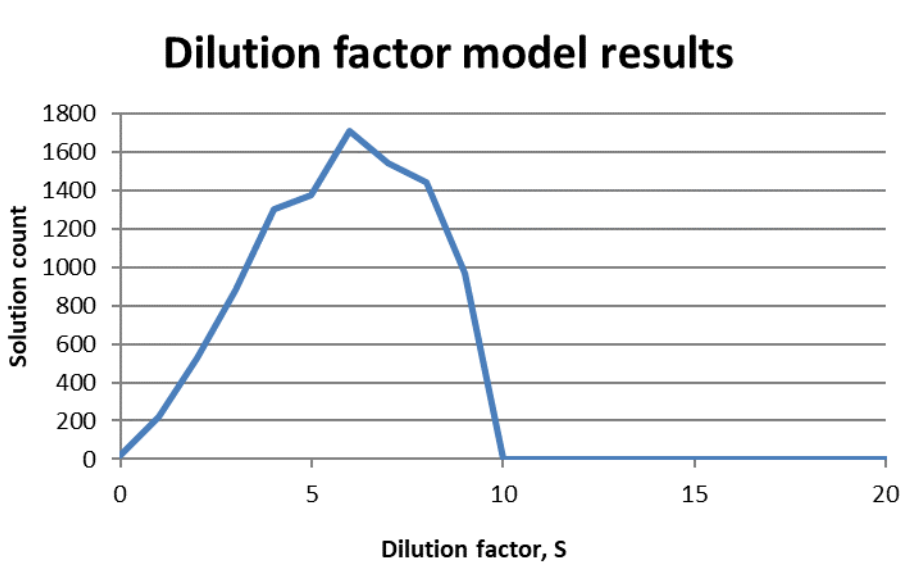

Figure 8: Monte Carlo dilution factor distribution results for Milingimbi WwTP and Arafura Sea.

Table 7: Summary of 2023-2024 Milingimbi water quality results

Sample Location/Asset: SML090 (Pond 3 Outlet)	
Indicator	**Median**
Physio-chemical Parameters	
pH (pH units)	7.25
Electrical Conductivity (uS/cm)	920
Dissolved Oxygen (% Saturation)	10
Turbidity (NTU)	4.4
Total Suspended Solids (mg/L)	80
Biological Parameters	
Biochemical Oxygen Demand (mg/L)	31
Chlorophyll-a (ug/L)	650
Nutrient Parameters	
Ammonia (Total as N – NH3-N) (mg/L)	19
Total Nitrogen (mg/L)	27
Oxidised Nitrogen (NOx) (mg/L)	0.1
Total Phosphorus (mg/L)	4.4
Pathogen Indicators	
Escherichia coli Log10(*E. coli*/100mL)	5.34
Enterococci Log10(Enterococci/100mL)	3.0

[1] No definitive information of tide heights above outfall pipe are available; limits chosen are considered to be conservative assumptions.
[2] As per Table 7.
[3] Based on average air temperatures at site.
[4] Based on monthly average sea temperatures provided by Australian Bureau of Meteorology.

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