# 2025 Environmental Risk Assessment - Kalkarindji Wastewater Treatment Plant WDL 231-03

December 2025

PowerWater

# Document Details and History

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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 Kalkarindji wastewater treatment plant (WwTP) point to an unnamed tributary of Victoria River.

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 risk rankings. Low risk rankings were associated with low discharge volumes (with no discharge recorded 2023 - 2025) disposed of via irrigation near a freshwater creek environment. It is not expected that treated effluent discharged from the Kalkarindji WwTP will be detrimental to the nearby creek that flows into the Victoria River. Disposal of all effluent from the facility is likely to occur through irrigation and evaporation on site.

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 Kalkarindji WwTP pursuant to Waste Discharge Licence (WDL) 231-02 issued on 11 December 2021. This WDL allows for continuous discharge of secondary treated sewage effluent from an authorised discharge point to an unnamed tributary of Victoria River.

Kalkarindji is located in the Katherine region of the Northern Territory, 460 km south-west of Katherine, 779 km south of Darwin (Figure 1). Kalkarindji has an estimated population of 450 (BushTel, 2025). The Wastewater Treatment Plant (WwTP) is located approximately 355 m south of the Kalkarindji Township (Figure 2).


*Figure 1: Kalkarindji location (Google Earth, 2025)*

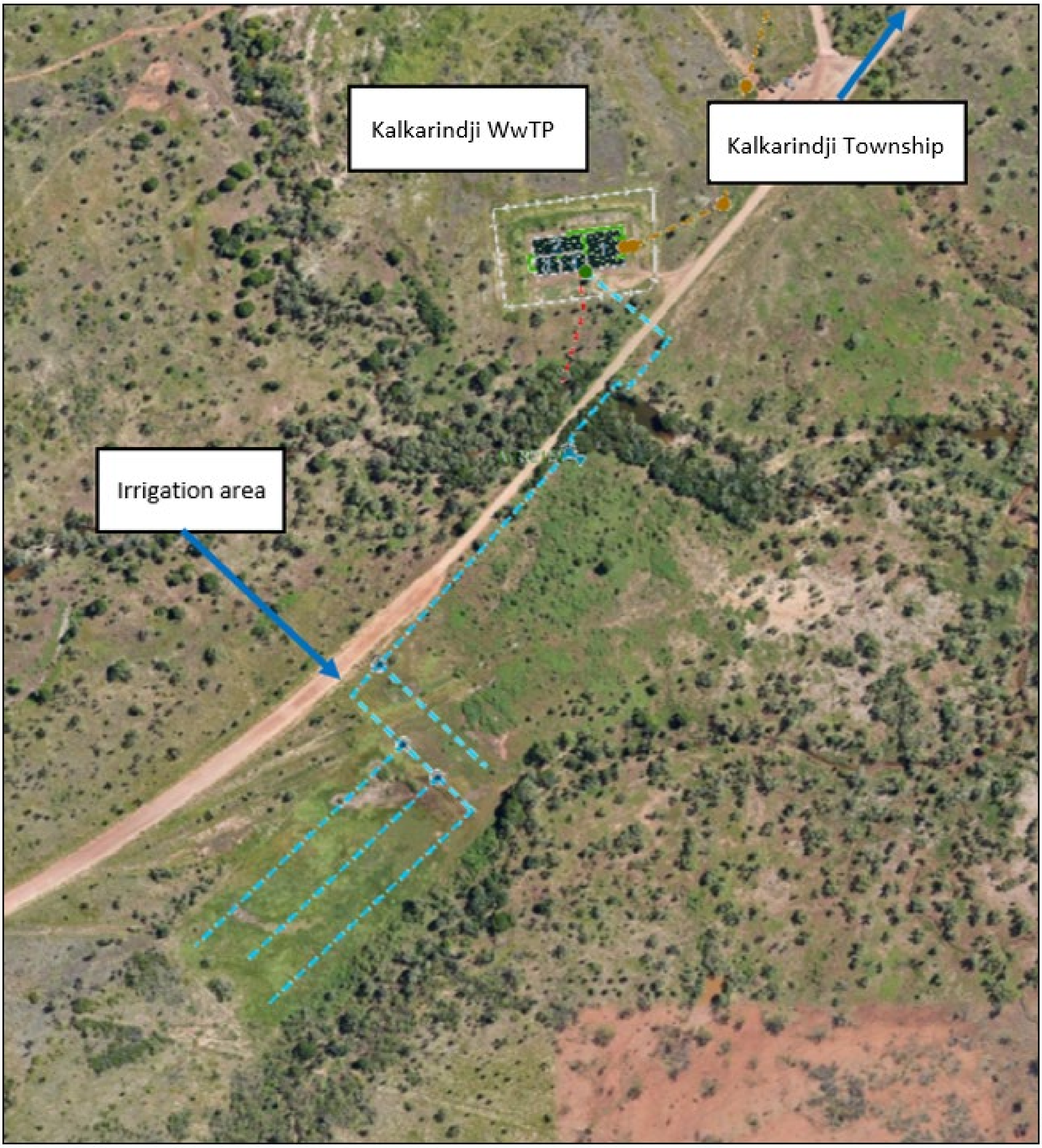


*Figure 2: Kalkarindji site layout including WwTP and Outfall (ArcFM, 2025)*

## 1.1 Background

Condition 32 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 11 December 2025.

The ERA must:

*32.1 be conducted in reference to a conceptual site model;*

*32.2 characterise the impacts of discharge(s) on the relevant Environmental Values of the receiving environment;*

*32.3 assess the risk to groundwater and surface water;*

*32.4 inform the development of the Performance Improvement Plan and Consultation Plan Required in condition 32 and 33;*

*32.5 be submitted to the Administrating Agency every 2 years within 10 business days after each anniversary date of this licence; and*

*32.6 the Administrating Agency may require the licensee to revise, amend and resubmit the ERA.*

# 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.

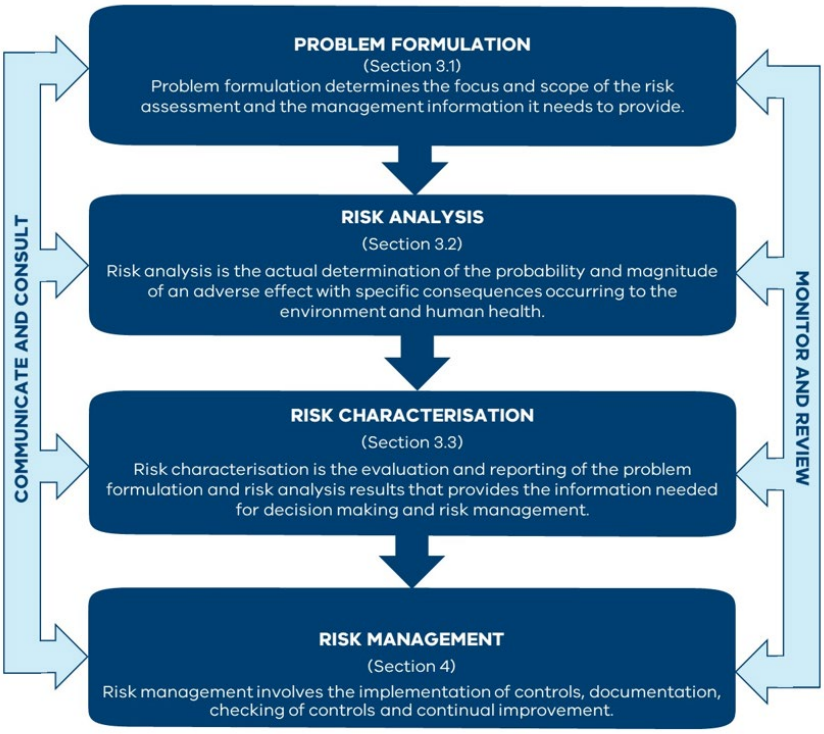


*Figure 3: Risk Assessment framework for wastewater discharges to waterways (Victoria EPA, 2023)*

## 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 Kalkarindji Wastewater Treatment Plant

The community utilises a pressure fed sewer reticulation system which pumps raw sewage from the community to the WwTP (Figure 4). The Kalkarindji 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 1986 (PWC 2021a). The ponds consist of one primary facultative pond which gravity feeds into the secondary maturation pond. The treated effluent is then fed into two tertiary maturation ponds, which can be bypassed if needed. Treated effluent is pumped to a nearby allocated irrigation area where the wastewater is discharged through impact sprinklers.

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 where required to remove accumulated solids and increase hydraulic performance, which may result in improved treatment performance. Desludging was last completed at Kalkarindji in 2019.

Prior to 2017, no regular wastewater monitoring was undertaken at the site, with no WDL in place. Regular wastewater monitoring commenced in January 2017, consistent with WDL 231-01. Samples of the final maturation pond outlet are currently conducted on a quarterly basis. Monitoring results are included in the PWC Annual Monitoring Report – Remote Community Waste Discharge Licences, a summary of the results is provided in Appendix 5, Table 7.

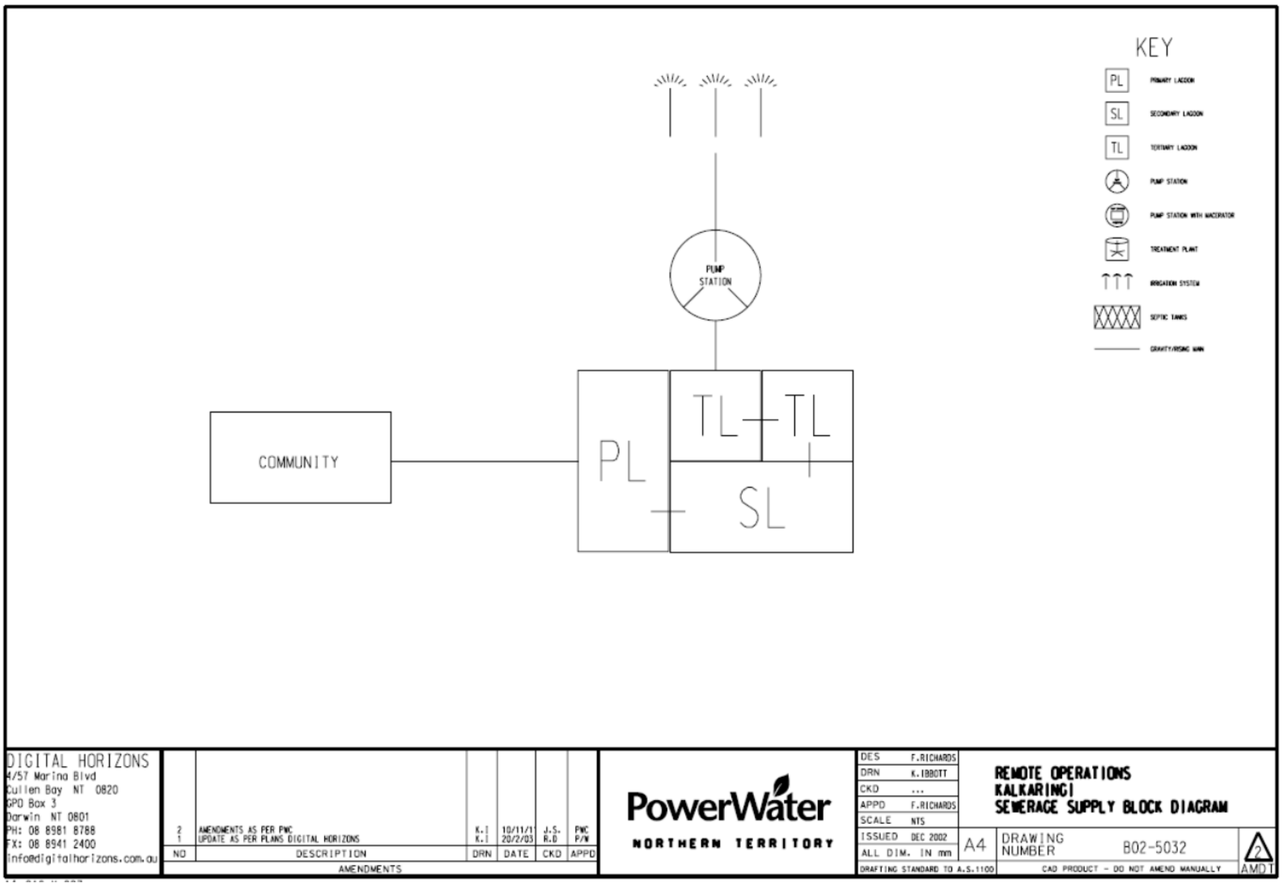


*Figure 4: Kalkarindji wastewater collection and treatment configuration*

## 3.2 Discharge Regime

Discharge from the facility occurs from a pump float system located in a concrete pit on Pond 4 (Figure 5). When the pond level rises, it causes the float within the concrete pit to rise and switch the irrigation system on automatically.

*Figure 5: Irrigation pump (PWC 2018)*

During discharge events, the irrigation system discharges effluent to an allocated irrigation paddock located across the road from the WwTP. A concrete spill way is situated on Pond 4 for overflows; however, overflows only occur when both pumps are malfunctioning.

A flow meter is installed at the Kalkarindji 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. As inflow data from flow meters is also not currently available, estimations have been utilised based on forecast sewage Equivalent Tenement (ET) flow, which may not accurately represent the inflow to outflow ratio on site (Appendix 3).

- Data indicates that there has been **no outflow** from Kalkarindji WwTP for the past two years (2024 and 2025).

Note that the volume of treated wastewater discharged to the environment varies annually with changes in seasonal 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.

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.

Wastewater monitoring at the Kalkarindji primary pond inlet commenced in January 2023. Over time, 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 median removal percentage at the Kalkarindji WSPs has been calculated using data collected from the most recent reporting period (i.e. 01/07/2024-30/06/2025).

Current median removal percentage:

- Biochemical Oxygen Demand (BOD): **26.9%**
- Free Ammonia (NH3-N): **66.8%**
- Total Nitrogen (TN): **40.7%**
- Total Phosphorus (TP): **19.6%**

The average log reduction for the pathogens indicator is:

- E. coli: **4 log reduction**

Note further monitoring data collection, statistical analysis and investigation of the cause of anomalies in the data is required to provide an accurate representation of pond performance in future risk assessments.

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) Appendix 1 (Figure 10), and water quality table Appendix 5 (Table 7).

## 3.4 Receiving Environment

The receiving environment consists of a locked and fenced irrigation paddock adjacent to the WwTP amongst tussock grassland and open woodland (DENR 2018). The irrigation area is approximately 21,000m2 in size. The sprinklers are above ground, running along 4 rows with minimal pooling observed (Figure 6; Figure 7) (PWC 2018).

A majority of wastewater from the community flows from septic tanks with water quality in the pond system looking very clean in comparison to other WwTPs, with minimal surface scum or gross pollutants observed (Figure 8). It is believed that local kids sometimes play in the irrigation spray and the ponds to catch ducks (PWC 2018). Public access to the WwTP area is likely as it is located on the side of a main community road. Currently the gate requires maintenance at the irrigation area.

A small creek is located 400 m east of the disposal area which feeds into the Victoria River 1 km away. Due to the low estimated discharge volumes, run off from the irrigation area is not expected to reach the creek as the gradient is relatively flat within the area (NT ILIS 2018). During the wet season, overflow from the irrigation area may drain into this area towards the Victoria River. It was noted that the ponds occasionally overflow approximately every 5 years. During extreme wet weather the area is prone to flooding, with the river rising to the location of the ponds in 2001, 2008 and 2023 (PWC 2025).

The receiving environment is considered to have experienced minor disturbance due to proximity to the community and a number of vehicle tracks within the area, the disposal area has been cleared (PWC 2018). This area may have occasional visitors, but is not commonly used by local community members for recreation. Fishing occurs downstream of the Victoria River along the bridge, with minimal swimming occurring due to the presence of crocodiles (Figure 9).

*Figure 6: Irrigation disposal area in Wet Season (PWC 2018)*

*Figure 7: Irrigation disposal area in Dry Season (PWC 2021)*

*Figure 8: Minimal surface scum observed at ponds (PWC 2018)*

*Figure 9: Area of Victoria River downstream of WwTP (PWC 2018)*

Kalkarindji is not located within a site of conservation significance, however five threatened fauna species (NR MAPS 2025) have been recorded in proximity to the ponds. 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 Kalkarindji WwTP.*

| Common name | Species name | National Status (EPBC) | NT Status (TPWC) |
|---|---|---|---|
| Plants | | | |
| Nil | - | - | - |
| Vertebrates | | | |
| Australian Bustard | *Ardeotis australis* | - | NT |
| Mitchell's Water Monitor | *Varanus mitchelli* | - | VU |
| Buff-sided Robin | *Poecilodryas cerviniventris* | - | NT |
| Pictorella Mannikin | *Heteromunia pectoralis* | - | NT |
| Purple-crowned Fairy-wren | *Malurus coronatus coronatus* | EN | VU |

EN – Endangered, VU – Vulnerable, NT – Near Threatened

## 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, Figure 10) 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 Kalkarindji WwTP*

| Values | Receptors | |
|---|---|---|
| **Cultural (Recreational Water Quality)** | Humans | Fishing |
| **Cultural (Aesthetics)** | Humans | Visible water quality<br>Sacred sites |
| **Environment (Aquatic Ecosystem Protection)** | Aquatic | Fish<br>Turtles<br>Crocodiles |
| | Terrestrial | Wading birds<br>Invertebrates (water insects)<br>Mammals<br>Reptiles |
| | Plants | Native vegetation |

*Table 3. Screening level risk assessment for key indicator and stressors associated with Kalkarindji 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 |
| 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 Kalkarindji WwTP is 19.0mg/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 Kalkarindji WwTP is 8.3mg/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 Kalkarindji WwTP is 1,000/100ml. 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 endpoint 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 2 (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 2 (Figure 11).

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

### 4.1.1 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 Kalkarindji WwTP discharge.*

| Hypothesis | Consequence | | Likelihood | | 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 2024-2025 sampling data, Kalkarindji WwTP BOD discharge quality is 19.0 mg/L. PWC data indicates nil discharge from Kalkarindji WwTP for the past two years, however the estimated flow rates (Appendix 3), evapotranspiration rates (Appendix 4) and dilution ratio (Appendix 5) from the 2023 Environmental Risk Assessment suggests that, in the event that discharge occurs and effluent leaves the irrigation paddock and reaches into Victoria River, the estimated dilution volume ratio between the effluent and receiving environment is 1:12,281 (Appendix 5).<br><br>The estimated evapotranspiration rate indicates that the irrigation paddock experiences as annual water evapotranspiration of approximately 67,200 kL with a daily average of approximately 184.10 kL. During a discharge event, the estimated mean outflow rate is 140 kL per day. This indicates that all treated irrigation would most likely evaporate into the immediate area, suggesting any observed oxygen demand would be absorbed by the environment. | Insignificant | Based on the estimated flow rates, evapotranspiration rates and dilution ratio, PWC considers that the likelihood of oxygen depletion in receiving environmental waters may be rare. Ongoing sampling will assist to characterise discharge quality. | Rare | Low |
| Free ammonia is resulting in **toxicity to aquatic organisms** in water and sediments. | Toxicity to aquatic organisms may only be applicable to localised invertebrate populations and sediment dwelling organisms at immediate discharge area. 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 sprinkler irrigation discharge to ground. The distance to the creek and further to the Victoria River may provide a buffer from any impacts associated with free ammonia in the discharge. The creek is mainly formed from runoff during the wet season which will provide additional dilution. Therefore, PWC considers that the likelihood of toxicity to aquatic organisms in water and sediments is rare. Ongoing sampling will assist to characterise discharge quality. | Rare | 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. | PWC data indicates nil discharge from Kalkarindji WwTP for the past two years. As such, Kalkarindji WwTP has not contributed nutrients (total nitrogen and phosphorus) to the receiving environment in recent years, and estimated outflow rates indicate the effects of nutrients within discharge into the paddock area would be minor. No eutrophication/ algal blooms or scums were observed within the river, which is an indicator or excess nutrient loads. | Minor | Stressor not typically observed with such low discharge volumes via irrigation. Nutrients are likely to filter out into soil within immediate discharge area. Discharge may only reach the creek during the wet season when rainfall occurs. The river has continuous flow in the wet season which would provide a buffer from nuisance plant growth in extreme circumstances (PWC 2018). Based on the sampling results to date, PWC considers that the likelihood of nuisance plant growth as the result of the WwTP would be unlikely. Ongoing sampling will assist to characterise discharge quality. | Unlikely | Low |
| **Cultural/ Human Health** | | | | | |
| BOD is leading to odours resulting in the **reduction of amenity** in the receiving environment. | Access to the discharge point is possible but limited by a gate. Children visit the area to play, but there are minimal other cultural beneficial uses of the receiving environment. It is assumed recreation activities occur closer to the bridge on Buntine Highway nearer to the community. | Minor | Stressor not typically observed with such low discharge volumes. There is potential that discharge may reach the creek during the Wet Season when significant surface water may already be present. No evidence of odours during inspection of discharge area and recreational use of the receiving area not observed. Any odours would be limited to immediate discharge point, with the bridge being 1.4 km across ground and an additional 800 m south down river of the irrigation area, PWC considers that the likelihood of reduction in amenity from BOD is unlikely. | Unlikely | Low |
| 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. | Minimal cultural beneficial uses of the receiving environment observed. Very low levels of nutrients in discharge (data indicates nil discharge to receiving environment for the past two years). There is potential for discharge into the receiving environment in the Wet Season. In the Dry season effluent would evaporate into immediate area. | Minor | Stressor not typically observed with low discharge volumes via irrigation. Toxic blooms would not be a concern during extreme wet weather events with high flow rates in the river. PWC considers that the likelihood of toxicant exposure is rare. | Rare | Low |
| Nutrients are resulting in the **reduction of amenity** of receiving environment through **reduction in water clarity**, objectionable **discolouration** and **odours**. | Minimal cultural beneficial uses of the receiving environment, on rare occasions the public may access the immediate discharge site. However, Access should be limited to employees by a gate. | Minor | Stressor not typically observed with such low discharge volumes to ground. Good water clarity was observed at the ponds during inspection. Nutrient levels in sampling results are low. PWC considers that the likelihood of reduction in amenity from nutrients is unlikely. | Unlikely | Low |

| | | | | | |
|---|---|---|---|---|---|
| Pathogens are leading to the **contamination of water** resulting in a public health risk through primary and secondary contact recreation. | The receiving environment is 1.4 km to the river, and a further 800 m distance downstream to the bridge where most recreation occurs. Sampling results suggest minimal pathogen risk in diluted waters. | Moderate | Based on the rare occasion that secondary contact recreation and cultural uses of the river may occur, the distance for filtration from the immediate discharge point and the river, and the occurrence of crocodiles during the Wet Season, PWC considers that the likelihood of the illness from pathogen exposure is rare. | Rare | Low |

# 5. Summary

The ERA found that the identified values of the nearby tributary of the Victoria River at risk from the Kalkarindji WwTP discharge were environmental and cultural.

PWC consider there are minimal key stressors identified that posed a risk to these values, with all consequences considered to be unlikely.

The ERA process has determined that the discharge from the Kalkarindji WwTP poses low risk to the identified values of the receiving area. The influence of the discharge on the receiving environment is considered sustainable given the frequency of discharge events and as effluent is evaporated during dry weather, and heavy dilution rates would occur in the wet season. Based on this ERA and modelled 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, PWC make the following recommendations:

- continue monitoring quality of wastewater discharged to the environment;
- assess pond performance;
- incorporate recommendations into future Performance Improvements Plans;
- investigate options to accurately quantify the volume of treated wastewater discharged to the environment;
- conduct a site visit to verify frequency of discharge events; and
- update the ERA and CSM based on new information and additional wastewater quality data.

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# Appendices

| Number | Title |
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| Appendix 1 | Kalkarindji Conceptual Site Model |
| Appendix 2 | Power and Water Risk Matrix |
| Appendix 3 | Estimated flow rates for Kalkarindji WwTP |
| Appendix 4 | Estimated Evapotranspiration rates |
| Appendix 5 | Water quality and estimated dilution Ratio for Kalkarindji WwTP |

## Appendix 1 – Kalkarindji Conceptual Site Model

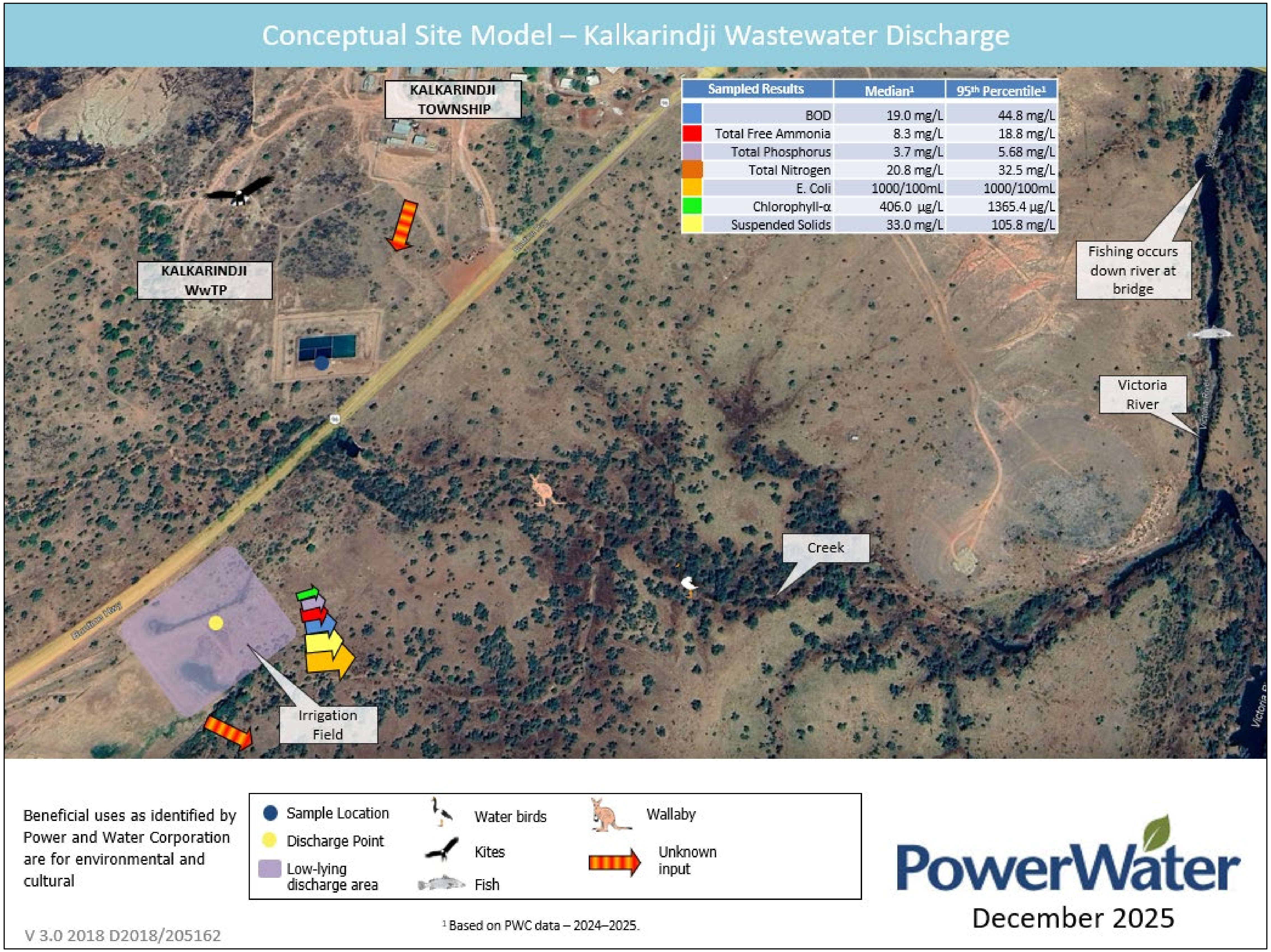


*Figure 10: Conceptual site model for the Kalkarindji WwTP.*

## Appendix 2 – 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** | A near miss incident without injury or illness. | An incident resulting in a minor injury or illness and first-aid treatment applied. | An incident or illness that requires medical treatment*<br>***Notes:**<br>Medical treatment is defined as treatment by a medical professional at a medical facility.<br>Treatment at a worksite by a paramedic is a first aid injury unless they are transported to a medical facility | Hospitalisation (24hrs or greater); and/or long-term permanent disabling effects on human health or exceedance of chemical exposure with acute health impacts. | ▪ One or more fatalities; and/or<br>▪ One or more persons seriously injured (includes long term disabling effect); and/or<br>▪ Fatalities or widespread hospitalisation of many customers. |
| **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.<br>▪ Civil action, fines and/or civil penalties (refer to Financial definition) | ▪ Notification to regulator required.<br>▪ Regulator/external auditor non-conformance or request for further explanation<br>▪ Functional breach of obligation, procedure or policy.<br>▪ Civil action, fines and/or civil penalties (refer to Financial definition) | ▪ Regulator/ external auditor issues improvement notice, multiple non-conformances or provisional improvement notice.<br>▪ Systemic breach of obligation, procedure or policy.<br>▪ Civil action, fines and/or civil penalties (refer to Financial definition) | ▪ Regulator issues notices, corrective action order and/or penalties<br>▪ Order to stop work<br>▪ Multiple provisional improvement notices, prohibition notice.<br>▪ Civil action, fines and/or civil penalties (refer to Financial definition) | ▪ Successful criminal prosecution imprisonment of Power and Water director and/or officer.<br>▪ Royal Commission, parliamentary or other government inquiry,<br>▪ Loss of licence to operate.<br>▪ 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<br>▪ Isolated community or individual issue-based concern; and/or<br>▪ Localised employees dissatisfaction which is managed by normal business processes; | ▪ Occasional once-off negative media attention; and/or<br>▪ Localised community impacts and customer concerns; and/or<br>▪ Localised employees dissatisfaction which requires human resources in resolution; | ▪ Brief adverse media attention and/or<br>▪ Community/customer condemnation; and/or<br>▪ Limited, localised loss of confidence by the community; and/or<br>▪ Reduced confidence of key stakeholders<br>▪ Localised employees dissatisfaction with localised impacts to service delivery | ▪ Prolonged adverse media attention and/or<br>▪ Community/ customer condemnation; and/or<br>▪ Prolonged, widespread community/ customer loss of confidence; and/or<br>▪ Confidence of key stakeholders damaged<br>▪ Widespread dissatisfaction and loss of confidence by employees resulting in temporary service delivery | ▪ Sustained adverse media attention and/or<br>▪ Community/customer condemnation; and/or<br>▪ Sustained community/ customer loss of confidence; and/or<br>▪ Loss of stakeholder confidence in Board and/or<br>▪ Management; and/or<br>▪ 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.<br>▪ 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<br>▪ Loss of water supply >2 hrs and <= 6 hours in any remote community<br>▪ 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<br>▪ Loss of water supply >6 and <=12 hours in any remote community<br>▪ 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<br>▪ 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<br>▪ Complete loss of water supply (>24 hours) in any urban or remote community. |
| **Project delivery** | **Cost** - <1% of the original approved business case budget (P50)<br>**Time** – Insignificant time increase<br>**Scope** – Scope decrease barely noticeable<br>**Quality** – quality degradation barely noticeable | **Cost** - 1-2.5% of the original approved business case budget (P50)<br>**Time** - <5% time increase<br>**Scope** – Minor areas of scope affected<br>**Quality** – Only very demanding applications are affected | **Cost** - 2.5-10% of the original approved business case budget (P50)<br>**Time** – 5-10% time increase<br>**Scope** – Major areas of scope affected<br>**Quality** – quality reduction requires sponsor approval | **Cost** - 10-20% of the original approved business case budget (P50)<br>**Time** – 10-20% time increase<br>**Scope** – scope reduction unacceptable to sponsor<br>**Quality** – quality reduction unacceptable to sponsor | **Cost** - >20% of the original approved business case budget (P50)<br>**Time** - >20% time increase<br>**Scope** – project end term is effectively useless<br>**Quality** – Project end item is effectively useless |

##### 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 5: Power and Water likelihood, risk ranking, actions and reporting matrix*

## Appendix 3 – Estimated flow rates for Kalkarindji WwTP

It has been estimated/ observed that the ponds have not discharged in recent years; however, if discharge were to occur, the previous discharge estimations have been utilised below.

Assumptions:

Raw wastewater flow rate based on ICEG (2017) forecast sewage ET flow of 850 L/day and estimated total sewer ET for Kalkarindji of 119.13 (PWC 2021a).

Rainfall catchment estimates based on mean monthly rainfall for all available years from Bureau of Meteorology (BOM) and total pond surface area (1,674 m2) (Louey-Gung 2011). Rainfall data was obtained using the Wave Hill weather station (station number 14840) located approximately 29.8 km away.

Rainfall and evaporation estimates are based on mean monthly values for all available years from BOM and total pond surface.

Flow rates are summarised in the table below (Table 6).

*Table 6: Estimated average annual flows.*

| Month | Actual Inflow kL/d | Rainfall kL/d | Evaporation kL/d | Total outflow kL/d |
|---|---|---|---|---|
| January | 147 | 8 | 10 | 145 |
| February | 147 | 10 | 10 | 147 |
| March | 147 | 6 | 10 | 143 |
| April | 147 | 1 | 10 | 138 |
| May | 147 | 0 | 10 | 137 |
| June | 147 | 0 | 10 | 137 |
| July | 147 | 0 | 10 | 137 |
| August | 147 | 0 | 10 | 138 |
| September | 147 | 1 | 10 | 138 |
| October | 147 | 1 | 10 | 138 |
| November | 147 | 3 | 10 | 140 |
| December | 147 | 6 | 10 | 143 |
| **Mean** | **147** | **3.17** | **10** | **140** |

## Appendix 4 – Evapotranspiration Estimates

**Water evapotranspiration from a 21,000 Square Meter area of land**

The calculation begins by determining the total water evapotranspired from a 21,000 square meter area of land with a point potential evapotranspiration rate of 3200 mm per year (BOM).

The formula used is:

$$Total\ Point\ Potential\ Evapotranspired\ (EvaT) = \frac{Annual\ Point\ Potential\ EvaT\ Rate\ x\ Land\ Area}{1000}$$

Given an evapotranspiration rate of 3200 mm/year and a land area of 21,000 square meters, the total water evapotranspired is calculated to be approximately 67200 kilolitres.

To understand the daily water volume evapotranspired, the formula:

$$Average\ Daily\ Water\ Volume\ Evapotranspired = \frac{Total\ Water\ Evapotranspired}{Number\ of\ Days\ in\ a\ Year}$$

Using 365 days in a year, the daily water volume evapotranspired is approximately 184.10 kilolitres per day.

In summary, the 21,000 square meter land experiences an annual water evapotranspiration of approximately 67,200 kilolitres, with a daily average of around 184.10 kilolitres.

It is important to note that point potential evapotranspiration is the evapotranspiration that would take place, under the condition of unlimited water supply, from an area so small that the local ET effects do not alter local air mass properties. It is assumed that latent and sensible heat transfers within the height of measurement are through convection only. For example, this represents the evapotranspiration which would occur from small irrigated fields with a never-ending water inflow, surrounded by unirrigated land. Point potential ET may be taken as a rough preliminary estimate of evaporation from small water bodies such as farm dams and shallow water storages (BOM).

## Appendix 5 - Water quality and estimated dilution Ratio for Kalkarindji WwTP

Treated wastewater is discharged via irrigation into a designated disposal area (irrigation paddock). Discharge occurs when pond 4 reaches the level required to switch the irrigation system on automatically. During discharge events, the average discharge rate is estimated at approximately 140 kL/day into the irrigation paddock.

Data from 'An Assessment of the Physical and Ecological Condition of the Victoria River and its Major Tributaries' (NTG 2004) was used to estimate a dilution ratio in the event effluent reaches Victoria River. This dilution ratio will be applied to all relevant water quality parameters to assess the potential influence of effluent discharge if it reaches Victoria River. This estimated dilution ratio represents a worst-case scenario, considering effluent discharge coming into contact with the river during dry or no-rain conditions.

**Information Source:**

**Average River Flow:** Data was from 'An Assessment of the Physical and Ecological Condition of the Victoria River and its Major Tributaries' (NTG 2004).

**Victoria River Flow Volume Calculation:**
The 24-hour flow volume of a river with a flow rate of 19.9 cubic meters per second is calculated using the formula:

Flow Volume (cubic meters) = Flow Rate (cubic meters per second) × Time (seconds)
With 86,400 seconds in 24 hours, the calculation is:
Flow Volume = 19.9 cubic meters/second × 86,400 seconds
Flow Volume ≈ 1,719,360 cubic meters
Since 1 cubic meter is equal to 1 kilolitre, the flow volume is also ≈ 1,719,360 kilolitres.

**Dilution Ratio Calculation:**
The dilution ratio is calculated when a solute of 140 kilolitres' is mixed with the river water.

Dilution Ratio (R) = Volume of Solvent (river water) / Volume of Solute
With a solvent volume of 1,719,360 kilolitres and a solute volume of 140 kilolitres, the calculation is:
Dilution Ratio = 1,719,360 kilolitres / 140 kilolitres
Dilution Ratio ≈ 1:12,281
This means for every part of the solute, there are approximately 12,281 parts of the solvent.

*Table 6: Summary of 2024-2025 Kalkarindji water quality results*

| Sample Location/Asset: SKJ090 (Pond 4 Outlet) | |
|---|---|
| **Indicator** | **Median** |
| Physio-chemical Parameters | |
| pH (pH units) | 8.64 |
| Electrical Conductivity (uS/cm) | 1,100.0 |
| Dissolved Oxygen (% Saturation) | 91.0 |
| Turbidity (NTU) | 27.0 |
| Total Suspended Solids (mg/L) | 33.0 |
| Biological Parameters | |
| Biochemical Oxygen Demand (mg/L) | 19.0 |
| Chlorophyll-a (ug/L) | 406.0 |
| Nutrient Parameters | |
| Ammonia (Total as N – NH3-N) (mg/L) | 8.3 |
| Total Nitrogen (mg/L) | 8.5 |
| Oxidised Nitrogen (NOx) (mg/L) | 0.2 |
| Total Phosphorus (mg/L) | 3.7 |
| Pathogen Indicators | |
| Escherichia coli Log10(*E. coli*/100mL) | 3 |
| Enterococci Log10(Enterococci/100mL) | 3 |

## Contact

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PowerWater