ORANGEENVIRONMENTAL

Memorandum

Galilee Power Station - Response to SARA Advice Notice (4/11/2020)

To	Cameron Feltham c/- CJ Feltham Town Planning
From	Natasha McIntosh
CC	Nui Harris c/- Waratah Coal
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Ref	WC-GPS-MM001, Rev 1
Subject	Galilee Power Station - Response to SARA Advice Notice (4/11/2020)

Introduction

Following an application through the State Assessment and Referral Agency (SARA), subsequent Request for Information and response, a final request for information was provided by SARA on 4 November 2020 (Felicity Tate of SARA to Cameron Feltham, SARA reference: 2002-15561 SRA/ BRC reference: DA221920), hereafter referred to as the SARA Advice Notice.

The SARA Advice Notice related to eight issues for which SARA would like further information to progress the assessment. Orange Environmental and Phronis have undertaken further work to address the issues, and this memo outlines responses to these issues.

Response to Issues

1. Sewage Treatment

Issue:

The Environmental Assessment Report, prepared by Orange Environmental, dated 02-10- 2020, Document Ref: WC-GPS-RT01 and Revision 0 (EAR) states on page 31 that liquid waste from the sewage treatment plant will be utilised for landscaping. It also states on page 74 that effluent will be disposed of in the ash waste containment facility. This suggests that the application for ERA 63 may be considered a concurrence ERA under ERA 63(1)(a)(ii) of Schedule 2 in the Environmental Protection Regulation 2019 (EP Reg).

Action:

To demonstrate compliance with the Environmental Protection Act 1994 (EP Act) and State code 22 of the State Development and Assessment Provisions (SDAP):

a. confirm how sewage treatment plant effluent will be treated and disposed of
b. confirm the correct threshold of ERA 63(1)(a) of Schedule 2 in the EP Reg
c. propose treated effluent release limits to irrigation areas or to waters using the Model Operating Conditions for ERA 63 – Sewage Treatment for guidance in developing draft conditions, and can be found at https://environment.des.qld.gov.au/data/assets/pdf_file/0030/88419/pr-co-sewage-treatment.pdf.

Response:

The original response to SARA included both the landscape disposal by irrigation and disposal with the ash in the waste containment facility, although the overall strategy was not clear. As such, the sewerage strategy has been revisited and a detailed On-site Sewerage Design Report (OSSDR) prepared, as provided in Attachment A to this memo.

The report undertook an assessment of the existing environment including site soils and groundwater, determined the likely hydraulic loading and undertook water and nutrient mass balance modelling using MEDLI to determine the irrigation and wet weather storage sizes to contain all recycled water on the site, disposed of through land irrigation.

The report details that:

- All construction sewage waste will be transported off site by licensed transporters and disposed of off site in a licenced facility.
- An operational on-site sewage treatment plant will be installed, with a 30EP or 5kL/day capacity, and a 4,000 m^2 irrigation area, coupled with a 30 kL wet weather / irrigation storage tank.
- This triggers the threshold for ERA 63.1(a)(i), a non-concurrence ERA, namely:

  ERA63.1(a)(i) Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 – 100EP, if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.

- Sludge will be transported (by licensed transporters) and disposed of off site in a licenced facility.

2. Environmental Impact Assessment (EIS) documentation

Issue:

The response to the information request includes the following reports in relation to the Environmental Impact Statement (EIS), produced for the mining lease application (MLA) in 2013:

- Mine Site Creek Diversion and Flooding report
- Surface Water Impact Assessment of Longwall Mining Subsidence impact
- Mine Site Water Management System report
- Galilee Coal Project Groundwater Assessment report

The Material Change of Use (MCU) area was formally included in the MLA, however given the publication date and focus on coal mining within these reports, it is unclear how these relate to the operation of a power station in the MCU area and whether any of the conclusions contained within the reports would change with the differing activity on the site.

Action:

To demonstrate compliance with the EP Act and State code 22 of SDAP:

a. provide further clarification on the suitability and relevance of these reports for the construction and operation of a power station on the MCU site. If these documents are deemed unsuitable, provide additional information specific to the proposed development.

Response:

These reports are all relevant to the proposed construction and operation of a power station on the MCU site, as they provide relevant information directly used to respond to specific issues raised by

SARA in relation to flooding, subsidence, water supply and anticipated water quality (of input and waste waters). In particular:

- Mine Site Creek Diversion and Flooding report – this report provides detailed flood modelling over the power station site, which is relevant as it demonstrates that the power station site is outside of the Q100 (and Q1000) flood extent for both the developed and undeveloped (mine) scenarios. The assessment is relevant as it is based on physical features of the landscape and waterways which are not affected by the proposed power station (in terms of flooding). To demonstrate the flood immunity of the power station site, Figure D4 and Figure E4 of the Mine Site Creek Diversion and Flooding report were reproduced with the addition of the power station site as Figures 4-1 and 4-2 of the document WC-GPS-RT02-SARA Info Request, and hence the original Mine Site Creek Diversion and Flooding report was included so the veracity of Figures 4-1 and 4-2 could be checked if required.
- Surface Water Impact Assessment of Longwall Mining Subsidence impact – this report was included to show the extent of predicted mine subsidence, to directly respond to information request item 26. This report is directly relevant to explain the extent of nearby subsidence as a result of the mine. The report demonstrates that subsidence as a result of longwall mining will be localised to the longwall mine panels, as shown on Figure A4, which shows the predicted post-subsidence ground topography. The report demonstrates that the power station site will not be affected by any subsidence from the mine, being located at least 8 km distant from the extent of any subsidence.
- Mine Site Water Management System report – this report was included to clarify the expected quality of water sourced from the Galilee Coal Mine, as part of the response to issue 28, and so is directly relevant to the proposed power station.
- Galilee Coal Project Groundwater Assessment report – this report was included to clarify the expected quality of water sourced from the Galilee Coal Mine in relation to determining the major ion chemistry of RO brine, as part of the response to issue 28, and so is directly relevant to the proposed power station.

None of the conclusions reached in the aforementioned reports would be affected by the construction or operation of the power station.

3. Water

Issue:

The EAR states that the site is designed to be a no release site, however there is a clear risk of spills from the power station dams during wet weather events. The EAR states on page 99 that *"Monitoring of any releases from the site will be undertaken daily when releasing, both for the release itself, and both upstream and downstream in receiving waters in both the unnamed tributary to Saltbush Creek, and in Saltbush Creek itself."*

Given the application material states that the site has been designed as zero release site and no release points have been applied for, any releases conducted from the dams would be subject to investigation and potentially compliance action.

Action:

To demonstrate compliance with the EP Act and performance outcome PO4 and PO5 of State code 22 of SDAP:

b. consider the need for release points and amend the proposal accordingly (if required). A proposal to release contaminated water would need to include:
   i. an assessment of the environmental values of the receiving waters
   ii. a description of the receiving environment, including flow and background quality
   iii. proposed release and monitoring regime, including flow, quality, frequency and locations for dams and sediment dams (include maps and GPS coordinates)
   iv. the quantity of the proposed release (average, minimum and maximum daily discharge volume, and maximum hourly release/discharge rate) and whether the release will be continuous or intermittent
   v. identification of potential contaminants and expected concentrations (including range)
   vi. proposed treatment of contaminants prior to release
   vii. for a release of toxicants, the initial dilution provided by the discharge structure and the size of the mixing zone
   viii. details of any variation in quantity or quality of discharge released during wet weather events
   ix. proposed action plan for managing releases during wet weather events to prevent an unplanned/uncontrolled release
   x. response plan/contingency measures should the release not meet release criteria
   xi. the distance separating the receiving groundwater from any containment structure.

Further information can be found in the guideline Application requirements for activities with impacts to water https://environment.des.qld.gov.au/ data/assets/pdf file/0029/87851/era- gl-water-impacts.pdf. The technical guideline Wastewater releases to Queensland waters may also be of assistance and can be found at https://environment.des.qld.gov.au/data/assets/pdf file/0031/88636/pr-gl-wastewater-to-waters.pdf.

Response:

As discussed during the meeting with SARA officers, Waratah Coal and Orange Environmental of 5 November 2020, while the ash management system (and Drains Reclaim Dam / Sedimentation Dam 2) has been designed as a no release system other than for large events, the addition of licenced discharge points is required to control releases for those events. As such, a Water Release Strategy has been prepared and included as Attachment B to this memo, outlining three (3) proposed discharge points from the site.

The strategy clearly identifies these release points, and includes the following information and assessments:

- A description of the existing environment, including broad and local catchments and drainage features
- Environmental values of receiving waters
- Existing flows and water quality in receiving waters
- A description of the probability of release, based on site design – the Ash Runoff Water Dam is designed with a spill risk of less than 1% AEP; the Drains Reclaim Dam with a spill risk less than 5% AEP. Sedimentation Dams will be designed to relevant standards to settle out solids as required
- A controlled release strategy, based on water quality in dams and receiving waters, and flow rates in receiving waters (calculated based on calibrated environmental flow modelling), providing the rates of release – note that the assessment was conservative and the probability of releases lower than stated above. As such, specific characteristics of releases beyond these release rules coupled with the probabilities of release are difficult to provide before detailed design is underway.
- Identification of potential contaminants of concern and concentrations in dam waters – the variation in quantity or quality during wet weather is difficult to estimate, and a worst case approach has instead been adopted. Note however, that where a release does occur due to rainfall, further dilution would occur both before a release and during, due to ongoing rainfall necessitating the release
- Specification of dilution requirements and discussion of the mixing zone (expected to be very small due to turbulent mixing in a narrow creek also subject to high flows at the time)
- Contingency measures, including preventative (i.e. water management to avoid release, or controlled releases) and response measures (in the event of a non-compliant release)
- A description of the depth to groundwater across the site.

4. Groundwater

Issue:

The EAR provides a preliminary assessment consisting of a literature review in relation to the leaching potential of ash and potential contaminants of concern on page 79. The contaminants raised include aluminium, arsenic, boron, cadmium and selenium which were determined as having the potential (under these theoretical conditions) to exceed Australian & New Zealand Guidelines for Fresh & Marine Water Quality (2018) values for protection of aquatic ecosystems in leachate. The EAR states that leachability will be dependent on the actual combustion conditions in the boilers which will affect the way contaminants are incorporated into the ash and the structure of the ash particles themselves.

The final design of the Waste Containment Facility will also clearly influence the potential for seepage of contaminants into groundwater, particularly the use of composite lining within the ash storage cells and dams.

Given the above considerations will influence the final design, it is important for the risks of seepage to be considered and appropriately conditioned for in any environmental authority.

Action:

To demonstrate compliance with the EP Act and performance outcome PO4 and PO5 of State code 22 of SDAP:

a. propose a groundwater monitoring program which is commensurate to the site- specific risks of contaminant seepage from ash and water containment facilities, and which requires and plans for detection of any seepage of contaminants to groundwater as a result of storing contaminants, including:
    i. analysis of existing groundwater quality to establish a baseline
    ii. identification of the containment facilities for which seepage will be monitored
    iii. proposed bore locations, depths and frequency of monitoring which yield representative groundwater samples from at least the uppermost aquifer
    iv. proposed trigger parameters and concentration levels for early detection of contaminant releases
    v. proposed monitoring of background groundwater quality, with both hydraulically up-gradient bore(s) or background bore(s) that have not been affected by any release of contaminants to groundwater from the activity and hydraulically down gradient bore(s) of the activity
    vi. a rationale detailing the program conceptualisation including assumptions, determinations, monitoring equipment, sampling methods and data analysis
    vii. seepage trigger action response procedures for when trigger parameters or levels trigger the early detection of seepage.

Response:

A draft Groundwater Monitoring Program (GWMP) has been prepared and is included as Attachment C to this memo. The GWMP includes:

- A description of the existing environment, including geology and hydrogeological features and aquifers
- Environmental values of groundwater systems

- Existing surface water levels (pressure head) and water quality in groundwaters underlying the site
- Proposed locations of monitoring bores, including nested sites, and impact, down-gradient and background / up-gradient sites
- Identification of potential contaminants of concern, parameters to be monitored and the frequency of monitoring
- Existing baseline data has been provided, however baseline data collection has been proposed to obtain suitable baseline data to set trigger values. Given the background / up-gradient bores proposed, a before-after-control-impact style of program has been developed
- General sampling methods have been included, including preferred equipment and decontamination approaches
- Contingency measures have been included, outlining draft contingency response planning for seepage from dams.

5. Biodiversity

Issue:

The Vegetation and Flora Memo, prepared by Astrebla Ecological Services produced and dated January 2020 (Appendix F) involved vegetation ecological surveys of the MCU area undertaken in late 2019/2020. The surveys confirmed the vegetation findings of the Environmental Impact Statement (EIS) for the Galilee Coal Project mining lease application area (which included the MCU area). However, no ecological reporting has been provided to confirm the fauna findings of the EIS for the Galilee Coal Project within the MCU area.

Desktop assessments identified three fauna species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* and/or *Nature Conservation Act 1992*, which have been recorded within and around the study area for the Galilee Coal Project. These are the Koala (*Phascolarctos cinereus*), Squatter Pigeon (southern) (*Geophaps scripta scripta*) and Black-throated Finch (southern) (*Poephila cincta cincta*). Of these, only the Koala was detected during the fauna surveys for the Galilee Coal Project EIS. None of these species were recorded in the MCU area.

Action:

To demonstrate compliance with the EP Act and State code 22 of SDAP:

a. provide further information from any recent fauna surveys undertaken for the MCU area and immediate surrounds since the EIS for the Galilee Coal Project was completed
b. given the fauna species listed above are protected by both state and federal legislation, confirm what referrals have been undertaken with the federal government for assessment of these species.

Response:

a. provide further information from any recent fauna surveys undertaken for the MCU area and immediate surrounds since the EIS for the Galilee Coal Project was completed

As explained below, recent fauna habitat surveys and ecological reporting to confirm the fauna findings of the EIS for the Galilee Coal Project within the MCU area has been undertaken and was provided in the aforementioned Appendix F.

The approach to fauna assessments was to engage AustEcology, who had previously undertaken extensive work in and around the power station site as part of the Galilee Coal Project EIS, to undertake a fauna assessment for the power station based on their understanding of the site. The fauna assessment is provided as Appendix G (Fauna Assessment) to the Environmental Assessment Report. Specifically, Appendix G provides the findings of investigations into the potential impacts of the construction and operation of the Power Station upon threatened fauna and their habitat. The potential impacts are considered to be limited to noise and air emissions, as no clearing of any area considered to represent potential habitat to threatened fauna is proposed.

However, given the age of the Galilee Coal Project EIS work, it was considered prudent to undertake a site inspection to verify that the ecological values of the site remained unchanged from those detailed in the Galilee Coal Project EIS. The site inspection was undertaken by Astrebla Ecological Services and the results were detailed in the Vegetation and Flora Memo contained as Appendix F of the Environmental Assessment Report.

As explained in Section 1 of the Astrebla memo, their site inspection was “designed to confirm findings undertaken during previous extensive surveys” (page 1). Section 4 of the Astrebla report deals specifically with fauna habitat. Section 4 is reproduced in the box below (bold emphasis added). As can be seen from the below, as well as confirming the vegetation findings, Appendix F also confirm the fauna findings of the EIS for the Galilee Coal Project within the MCU area. Given these findings, it was not considered necessary to undertake further field surveys for fauna.

4. Fauna values

The MCU site contains primarily non-remnant vegetation and was not identified as containing any key habitat areas in the EIS. There is no remnant vegetation within the MCU disturbance footprint.

As part of the work to support the Material Change of Use Application and **the referral to the Commonwealth government**, an assessment has been undertaken addressing the potential impacts of noise and air emissions from the proposed Galilee Power Station upon fauna listed under the EPBC Act (AustEcology 2019).AustEcology had previously undertaken much of the fauna assessment for the EIS and their assessment makes reference to the findings of the field work undertaken for the EIS. As part of the assessment for the Power Station, the following work was undertaken:

•A number of threatened species were assessed in relation to their likelihood of occurrence on the MCU site,
•those considered likely or possible to occur were further assessed in relation to the potential for impacts as a result of air and noise emissions from the project.

The MCU area itself is not considered likely to support suitable habitat for any of the threatened species that could occur there. The AustEcology (2019) report makes the following observation regarding habitat values for fauna on the MCU site(page 32):

> *These relatively small remnant patches and linear bands, and the power plant infrastructure itself, are located within an extensive area of cleared pastoral land which does not support suitable remnant habitat for any of the threatened fauna species considered in this report.*

As such, the objective of this work with reference to fauna habitat, was to confirm that the habitat features of the MCU site, are still as previously described in the EIS, and as described in the AustEcology report. The field assessment did not reveal any new, or previously undescribed habitat features and demonstrated that the fauna habitat values of the MCU site correspond to those previously described in the EIS, and by AustEcology (2019).

b. given the fauna species listed above are protected by both state and federal legislation, confirm what referrals have been undertaken with the federal government for assessment of these species.

An EPBC referral to the Commonwealth Government has been prepared and will be lodged at the completion of the State approval process.

Appendix G, Fauna Assessment, was prepared to support the referral to the Commonwealth Government. As can be seen from Appendix G, 25 MNES fauna were selected for assessment in regard to their likelihood of occurrence relevant to the area surrounding the power station site. Of these, the assessment of likelihood concluded that 16 are known or considered either likely or possible to occur in the area surrounding the power station project area.

As mentioned above, there will be no direct impact to any fauna habitat as there will be no clearing. The project activities considered to have the potential to significantly impact upon threatened fauna are noise and air emissions.

The Fauna Assessment concludes that the predicted noise levels generated by construction activities and the operations would not generate a significant impact to any of the threatened or migratory fauna species assessed. Similarly, the Fauna Assessment concludes that the predicted emission levels generated by the proposed operations would not constitute a significant impact to threatened or migratory fauna species assessed.

These results of Appendix F and G will be discussed in the referral and it is considered that the proposed action is not likely to have a significant direct or indirect impact upon any listed threatened or migratory species.

6a. Ash Waste Containment Facility

Issue:

The EAR states on page 74 that several waste streams generated from the power station shall be treated and stored at the waste containment facility within the ash storage cells, these include:

- up to 620,000t/year of fly ash, economiser ash, boiler bottom ash
- coal rejects
- up to 240,000t/year of limestone/desulphurisation waste
- other power station waste products that include reverse osmosis brine rejects, sewage treatment plant effluent, water treatment plant sludges, ash fabric filter bags, waste ion exchange resins, coal and water laboratory waste, sediment dam waste, auxiliary cooling tower sludges, drain sediments, effluent from chemical cleans, boiler blowdown and other water mixed with the ash slurry, trace quantities of oils and hydrocarbons, and other solid or liquid wastes.

For some of the waste streams listed above, it is unclear the quality, quantity and composition anticipated.

Action:

To demonstrate compliance with the EP Act and performance outcome PO4, PO5 & PO6 of State code 22 of SDAP:

a. provide further details on the above waste streams (including quality, quantity and composition anticipated) and consider the new regulated waste classification and waste-related environmentally relevant activity (ERA) regulations.

Classification of the waste involves demonstrating what waste category it falls into and is done via sampling and testing. Given the power station is yet to be constructed, DES recommends reviewing the list of waste streams and determining the appropriate treatment, management and disposal measures in line with the waste categories outlined in section 43 of the Environmental Protection Regulation 2019. The guideline Overview of regulated waste categorisation (ESR/2019/4749) outlines the new waste classification system, management requirements and process for sampling and testing waste to demonstrate an appropriate risk-based category in accordance with section 43 of the EP Regulation and can be found https://environment.des.qld.gov.au/ data/assets/pdf file/0026/89333/era-is- categorising-regulated-waste.pdf. Note that any containers contaminated with waste can also be considered a regulated waste. Further information can also be found https://environment.des.qld.gov.au/management/waste/business/classification

Response:

A Waste Stream Characterisation has been prepared that addresses the following for each of the wastes listed above.

- Waste Name
- Form – liquid or solid
- Definition – a description of the source and general characteristics of the waste
- Classification – against the Environmental Protection Regulation 2019
- Quantity – the estimated annual generation rate

- Destination – a description of how the waste will be managed, including specific reference to the Waste hierarchy from the *Waste Reduction and Recycling Act 2011* (Qld).

This information is contained in Attachment D to this memo.

6b. Ash Waste Containment Facility

Issue:

The EAR states on page 74 that 240,000t/year of limestone/desulphurisation waste may be disposed of in the ash waste containment facility.

The report identifies that best practice boiler technology and flue gas desulphurisation technology can minimise the production and disposal of this hazardous waste by producing either gypsum, sulphuric acid or solid sulphur.

Action:

To demonstrate compliance with the EP Act:

a. when considering the final detailed design of the site, demonstrate that waste disposal aligns with the waste and resource management hierarchy outlined in section 9 of the *Waste Reduction and Recycling Act 2011* where the dispose option is only considered suitable when there is no viable alternative. This is also considered in s125(1)(l)(ii) of the *Environmental Protection Act 1994*. Review the waste management proposal and provide justification for disposal when there are alternative options.

Response:

Waratah Coal commits to using flue gas desulphurisation technology that will produce gypsum. There are three alternative methods of flue gas desulphurisation, of which, the method that produces gypsum is considered to be that which aligns best with the waste and resource management hierarchy outlined in section 9 of the *Waste Reduction and Recycling Act 2011*. Gypsum has beneficial reuse as a fertiliser, a constituent of cement, plaster of Paris, soil conditioner and as the main constituent in many forms of plasterboard and blackboard chalk.

7. Rehabilitation

Issue:

The Concept Design for the Galilee Power Station Rehabilitation Strategy (Appendix K) outlines an initial plan for rehabilitation for the site, however the report states on page 11 that a more detailed methodology will be developed during the detailed design phase.

Given factors such as ash compaction requirements for the ash waste containment facility, design of stormwater drainage structures, and a comprehensive surface and groundwater monitoring program is yet to be finalised, it is unclear what potential risks would require conditioning through an environmental authority (EA).

Action:

To demonstrate compliance with the EP Act:

a. propose potential EA conditions of the development that incorporate the following:
   i. final landform criteria (including slope criteria) and classifications
   ii. rehabilitation success criteria
   iii. decommissioning requirements and implementation of associated plans
   iv. monitoring regime for stormwater runoff from rehabilitated areas, leak detection/seepage of dams and/or regulated structures, surface water monitoring of dams/drains/regulated structures if required
   v. timeframes for progressive rehabilitation.

Further information can found in section 6 of the guideline Application requirements for activities with impacts to land

https://environment.des.qld.gov.au/_data/assets/pdf_file/0024/88008/era-gl-land-impacts.pdf.

Response:

As discussed during the meeting with SARA officers, Waratah Coal and Orange Environmental of 5 November 2020, some of these requirements are unable to be adequately determined at this point, prior to detailed design. In addition, reference to similar Environmental Authorities indicate that this level of detail is not generally included in the EA, although it is required of rehabilitation management plans.

As such, draft conditions have been prepared and are included as Attachment E, detailing:

- general rehabilitation requirements, including requirements to progressively rehabilitate disturbed areas to be safe, stable and non-polluting
- specific rehabilitation requirements relating to use of native vegetation, minimising erosion, controlling stormwater quality, minimising environmental nuisance and stable landforms
- specific requirements for development of a Progressive Rehabilitation Management Plan (PRMP) along with plan inclusions, along with rehabilitation required within 6 months of achieving final landforms in areas of the ash cells
- a requirement to update and submit a Final PRMP to the administering authority at least 2 years prior to decommissioning the project

- requirements for annual progress reporting, obtaining written agreements from landowners for infrastructure to remain, and a general requirement for rehabilitation to meet the satisfaction of the administrating authority.

In addition to the above, draft final rehabilitation requirements have been prepared, and are provided in Table 1 below. These could be included in the Environmental Authority, but an approach containing these within a living document (the PRMP) is sought as a more flexible solution to best achieve good rehabilitation outcomes for the site and in a way that is enforceable under the Environmental Authority.

Table 1. Final Rehabilitation Requirements

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
Waste Containment Facility	Safe to humans and wildlife	• Structurally safe. • No exposure to hazardous materials. • Site is safe now and for foreseeable future.	• Final landform surface is fully capped with benign material. • Safety assessment of landform. • Final slopes less than 10 degrees and erosionally and geotechnically stable. • Appropriate decommissioning.	• Certification by an appropriately qualified person in the Rehabilitation Report that slopes are safe and exhibit characteristics for long-term stability. • A risk assessment has been completed and risk mitigation measures have been implemented, as appropriate.
	Non polluting	• Waste affected water is contained on-site. • Surface water runoff results in no significant influence on neighbouring water quality. • No significant influence on groundwater beyond extent of facility. • Minimal sediment generation from wind/water erosion.	• Downstream surface water quality. • Groundwater quality.	• No degradation of water quality in surface or groundwaters outside the footprint of the waste containment facility over the post-mining monitoring period in the Final PRMP. • Runoff and seepage from rehabilitated landform of a quality which is unlikely to adversely impact known environmental values. • Dust and particulate matter from rehabilitated landforms comply with Condition X [EA air condition]. • Groundwater quality to remain similar to background variations. • Post contamination assessment complete on areas where notifiable activities occurred, and recommendations of assessment implemented.

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
	Stable	• Landform design achieves appropriate stability and erosion rates.	• Final landform slopes are less than 10 degrees and erosively and geotechnically stable, as monitored and determined by geotechnical engineer. • Engineered structures to control water flow and reduce soil loss. • Dimensions and frequency of erosion rills and gullies. • Vegetation cover sufficient to minimise erosion.	• Side slopes are no more than 10 Degrees. • Evidence that required contour banks, channel linings, surface armour, drop structures and other measures are in place and functioning. • Certification by a suitably qualified person that erosion activities are not greater than at comparable reference site. • Dimension and occurrence of rills and gullies (as recorded by a suitably qualified person) are no greater than at comparable reference site. • Evidence that vegetation type and density are of species suitable to the site and for erosion minimisation.
Dams	Safe to humans and wildlife	• All dam structures to be decommissioned (unless alternate post-operational land use identified and approved) • Contaminated sediments and/or materials to be disposed within the final landform surface and capped / contained • Landform shaped and rehabilitated to ensure no ponding or scouring potential	• Safety assessment of landform and • Appropriate decommissioning and rehabilitation.	• All infrastructure removed unless agreed in writing with the landholder and submitted to the administering authority. • Similar surrounding landform profile. • A risk assessment has been completed and risk mitigation measures have been implemented, as appropriate.

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
		• Structurally safe with no hazardous materials and safe for the foreseeable future.		• Landform design certified as meeting design requirements of rehabilitation.
	Non polluting	• Waste affected water is contained on-site. • Surface water runoff results in no significant influence on neighbouring water quality. • No significant influence on groundwater beyond extent of dam. • Minimal sediment generation from wind/water erosion.	• Downstream surface water quality. • Groundwater quality.	• Runoff and seepage from rehabilitated landform of a quality which is unlikely to adversely impact known environmental values. • Dust and particulate matter from rehabilitated landforms complies with Condition X [EA air condition]. • Groundwater quality similar to background variation.
	Stable	• Landform design achieves appropriate erosion rates.	• Engineered structures to control water flow • Appropriate rates of soil loss • Dimensions and frequency of erosion rills and gullies and • Vegetation cover sufficient to minimise erosion.	• Evidence that required contour banks, channel linings, surface armour, drop structures and other measures are in place and functioning • Certification by a suitably qualified person that erosion activities are not greater than at comparable reference site • Dimension and occurrence of rills and gullies (as recorded by a suitably qualified person) are no greater than at comparable reference site and • Evidence that vegetation type and density are of species suitable to the site and for erosion minimisation.

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
Infrastructure and roads	Safe to humans and wildlife	• Area safe for human and native species usage.	• Presence/absence of infrastructure and wastes	• All infrastructure removed unless agreed in writing with the landholder and submitted to the administering authority • Steep grades reduced and • Similar surrounding landform profile
	Non polluting	• No residual pollutants that could mobilise in environment.	• Soil sample result – salinity, hydrocarbon and metal levels.	• Post contamination assessment complete on areas where notifiable activities occurred, and recommendations of assessment implemented and • Runoff and seepage from rehabilitated landform will be of a quality which is unlikely to adversely impact known environmental values.
	Stable	• No erosion and sediment loss above surrounding area.	• Water turbidity in watercourses. • Sediment loss - visual inspection. • Presence of scouring or erosion, sediment plumes. • Percentage vegetative ground cover.	• Stable site with adequate cover and permanent drainage with no erosion issues.
All Rehabilitated Areas	Self-Sustaining	• Establish a sustainable vegetation cover. • Maintain species composition, diversity and structure. • Achieve final landuse of Low-intensity cattle grazing with pockets of tree vegetation	• Percentage vegetation cover per square metre. • Soil characteristics. • Presence and density of key plants species. • Structure of vegetation. • Weed and pest species presence, abundance and type.	• Restored landform ripped to nominal depth of 50-100 mm. • Topsoil and subsoils spread at suitable depths parallel to ripped contours: - Ash storage areas: 0.5m - Plant areas: 0.5m

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
				• Topsoil and subsoils replaced according to pre-mining mapped soil units with selective placement of more erodible soils on flatter areas, as appropriate. • No active areas of rill or gully erosion and drainage follows appropriate drainage paths. • Sown cover crop of perennial native vegetation or pasture mixes including short- and long-lived grasses and legumes. • Certification by a suitably qualified person that the density and presence of key species and vegetation cover is the same as at reference sites. • Area is certified as self-sustaining and has many of the attributes of the final landscape, including maintenance requirements (compared to surrounding analogue site). • Soil characteristics have been determined by a suitably qualified person as having acceptable levels of surface roughness, infiltration capacity, aggregate stability and surface condition as defined in the Australian Soil and Land Survey Handbook.

Area	Rehabilitation Goals	Rehabilitation Objectives	Indicators	Success Criteria
				• Established vegetative cover on slopes to at least 70 % cover. • Certification of no weed and pest species abundance identified in rehabilitation areas are no greater than at reference sites. • Evidence that weed and pest species management is occurring where appropriate.

Attachment A

On-site Sewerage Design Report

Galilee Power Station

On-Site Sewerage Design Report

Waratah Coal

WC-GPS-RT002, Rev 0

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ORANGE ENVIRONMENTAL

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Terms and Abbreviations

EP	equivalent persons
ERA	Environmentally Relevant Activity
FAR	Fixed Application Rate - approach to irrigation, which is triggered every n days, irrigating a fixed amount
GPS	Galilee Power Station
LAA	land application area
MCU Area	Material Change of Use, or the application, Area
MEDLI	Model for Effluent Disposal by Land Irrigation
OE	Orange Environmental Pty Ltd
OSSDR	On-Site Sewerage Design Report
SARA	State Assessment and Referral Agency
SBMP	Site Based Management Plan
STP	sewage treatment plant
SWD	Soil Water Deficit - approach to irrigation which is triggered by soil water deficit
Waratah Coal	Waratah Coal Pty Ltd

1 Introduction

1.1 Overview

Orange Environmental Pty Ltd (OE) were engaged by Waratah Coal Pty Ltd (Waratah Coal) to prepare this On-Site Sewerage Design Report (OSSDR) for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. Refer to Figure 1-1 for the site location, and Appendix A for the general arrangement plan.

This report has been prepared to clearly identify the proposed sewerage management scheme on the site, in response to queries raised by the State Assessment and Referral Agency (SARA) in their SARA advice notice - Monklands Road, Alpha (ref. 2002-15561 SRA, 4 November 2020), as part of the development application for approval of the project.

1.2 Scope

This OSSDR provides an assessment of the site for suitability for on-site sewerage disposal, including a site and soil assessment, land application area (LAA) sizing, general treatment and irrigation system requirements, and key management requirements.

This report has been prepared with reference to:

- AS/NZS 1547:2012 – On-site domestic wastewater management
- Plumbing & Drainage Act 2002 and supporting legislation
- The Queensland Plumbing & Wastewater Code (Queensland Government, 2019).

1.3 Description of the Development

Waratah Coal propose to develop the Galilee Power Station (the Power Station), a new ultra-supercritical coal fired power generation facility located in the Galilee Basin in Queensland, approximately 30 km to the north of Alpha. The Power Station involves the development of a 1,400 MW ultra-supercritical power station adjacent to Waratah Coal's Galilee Coal Project and will have the dual purpose of servicing the public network and providing the power needs for the Galilee Coal Project mine operations.

The Power Station Site covers an area of approximately 1,310 ha, described as the MCU Area (Material Change of Use Area). Within the 1,310 ha, 518 ha will be subject to disturbance in the form of land clearing and earthworks to facilitate the construction and operation of the Power Station.

The Power Station site will contain the following pieces of infrastructure (see Appendix A):

- Conveyors - Overland Conveyor (to bring coal into the Power Station site from the adjacent Galilee Coal Project); Plant Feed Conveyors (between the Coal Handling Plant and the Coal Bunkers)
- Coal Handling Plant – includes Coal Transfer Station; Coal Stacking Conveyor; Coal Stockpiles (sized for 12 weeks storage); Coal Reclaim Conveyors; Coal Stockpile Runoff Ponds
- Power Station – includes Coal Bunkers; Boilers and Turbine Hall; Air Cooled Condensers and Cooling Tower; Stack
- Flue Gas Desulphurisation - Limestone Silo; Limestone Prep Plant; Lime Injectors; Baghouse; Desulphurisation Plant

- Water Storage and Treatment - Raw Water Dams; Water treatment Plant; Service Water Tanks; Wastewater Ponds
- Ash Handling and Containment Facilities- Ash Silos; Pug Mill; Truck Loading
- Ancillary Infrastructure – Diesel Unloading and Storage; Hydrogen Store; Laboratory; Workshops; Storeroom; Fire Station; Administration Building; Amenities; Carpark; Lay Down Areas
- Power Transmission Infrastructure - Substation, Switchyards and Transmission Line (note that the Transmission line will form part of a separate approvals process)
- Waste Containment Facility (including associated drainage, Ash Runoff Water Dam and Sedimentation Dam 1).

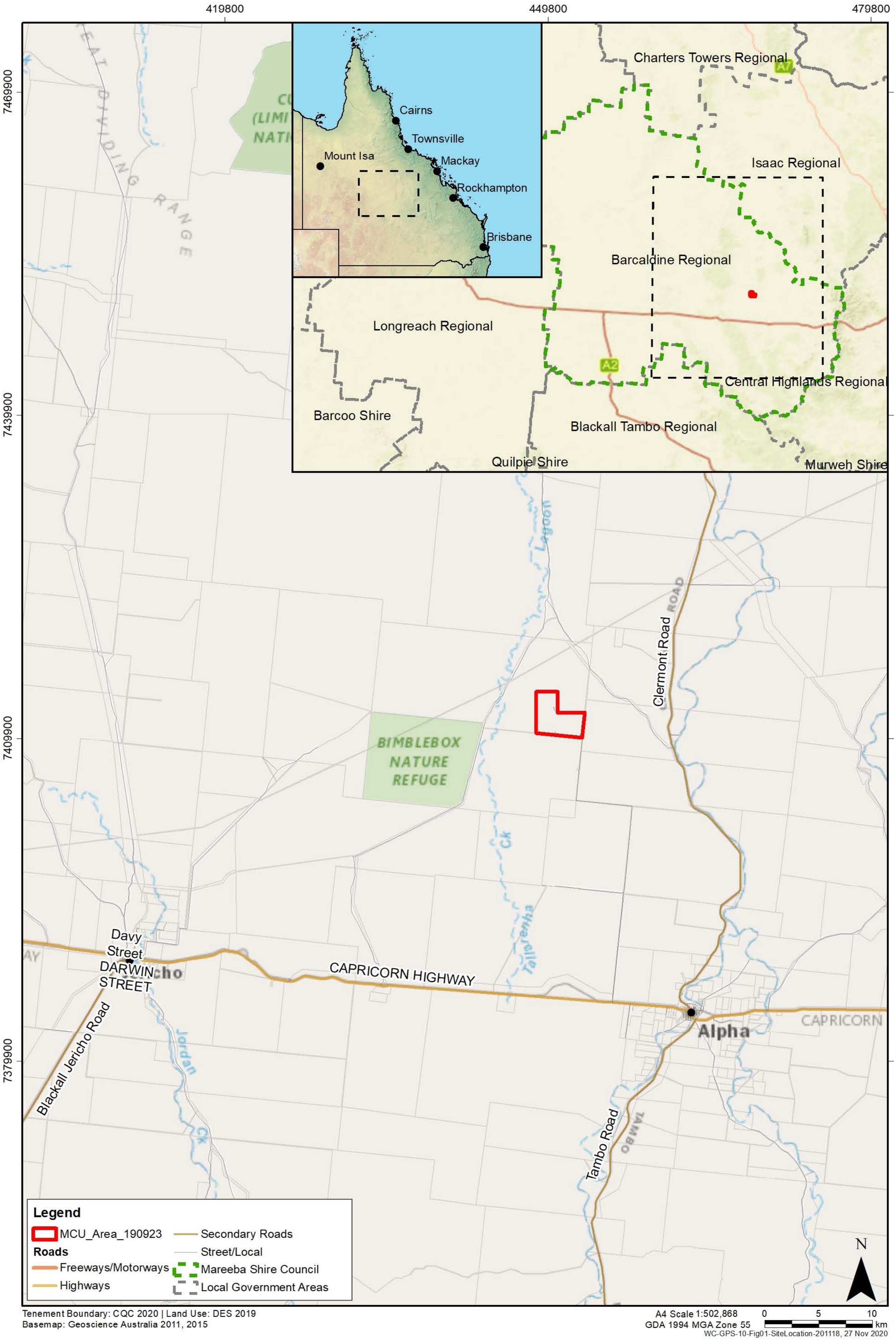

Figure 1-1. Site Location

2 Site and Soil Description

2.1 Geology

The surface geology of the area is dominated by unconsolidated sediments of Cainozoic (recent geological period) origin. The MCU area is comprised of Quaternary Alluvium in the western half of the site, described as alluvium of older plains comprising sand, gravel and soil; with rises of Early Permian Colinlea Sandstone over the eastern half of the site, comprising quartz and pebbly quartz sandstone, minor conglomerate and siltstone.

The regional geology is shown in Figure 2-1.

2.2 Soil Assessment

2.2.1 Published Soil Information

Soils are mapped at 1:100,000 in the Desert Uplands Strategic Land Resource Assessment (DUSLARA) mapping (Lorimer 2005) as shown in Figure 2-1. The bulk of the MCU area is mapped as the Joe Joe land system, described as a lateritised surface on gentle rises. Five soil map units are mapped over the MCU area in this land system, namely:

Joe Joe 1 (JJ1) – east of the ash dams, outside of the infrastructure area

> Upper slopes. Deep, red, loamy sand gradational soils. Low open woodlands, often in groves, of yellowjacket with occasional applejack. A diverse shrub layer is common and spinifex dominates the ground cover. Regional ecosystem 10.5.1 is predominant.

Joe Joe 2 (JJ2) – the ash dams and part of the ash ponds, eastern half of power station

> Crests and upper slopes. Shallow, red to yellowish brown texture contrast soils with sandy loam topsoils and an ironstone hardpan within 0.5m of the surface. Mid-tall open woodlands of silver-leaved ironbark with occasional ghost gum and poplar box. Regional ecosystem 10.7.11 is predominant, but significant areas of 10.5.5 are also present.

Joe Joe 3 (JJ3) – east of the ash dams, coming close to south-east corner of ash dams

> Scarps. Shallow, stony, red-brown gradational soils. An ironstone hardpan is often exposed. Mid-tall forests of lancewood and gummy spinifex provide a sparse ground cover. Regional ecosystem 10.7.3 is predominant.

Joe Joe 4 (JJ4) - Central MCU, east of infrastructure

> Lower slopes. Deep, texture-contrast profiles with sandy loam topsoils and yellowish-brown clayey subsoils. Tall woodlands of silver-leaved ironbark. Regional ecosystem 10.5.5 is predominant.

Joe Joe 6 (JJ6) – western section of MCU area, comprising half of ash dam and power station, and both western sediment dams

> Alluvial fans. Very deep, reddish-brown, uniform sandy loams overlie a buried clay soil. Woodlands of silver-leaved ironbark, poplar box and ghost gum. Regional ecosystem 10.5.5 is predominant, but significant areas of 10.3.12 are also present.

The bulk of the soils are therefore on slopes, with an approximately 700 m wide strip of alluvial fans running along the western boundary of the MCU area. Soils underlying the infrastructure comprises shallow stony soils on hardpan of ironstone at an average depth of less than 0.5m, with part of the infrastructure in the west over deep uniform sandy loams overlying a clay soil.

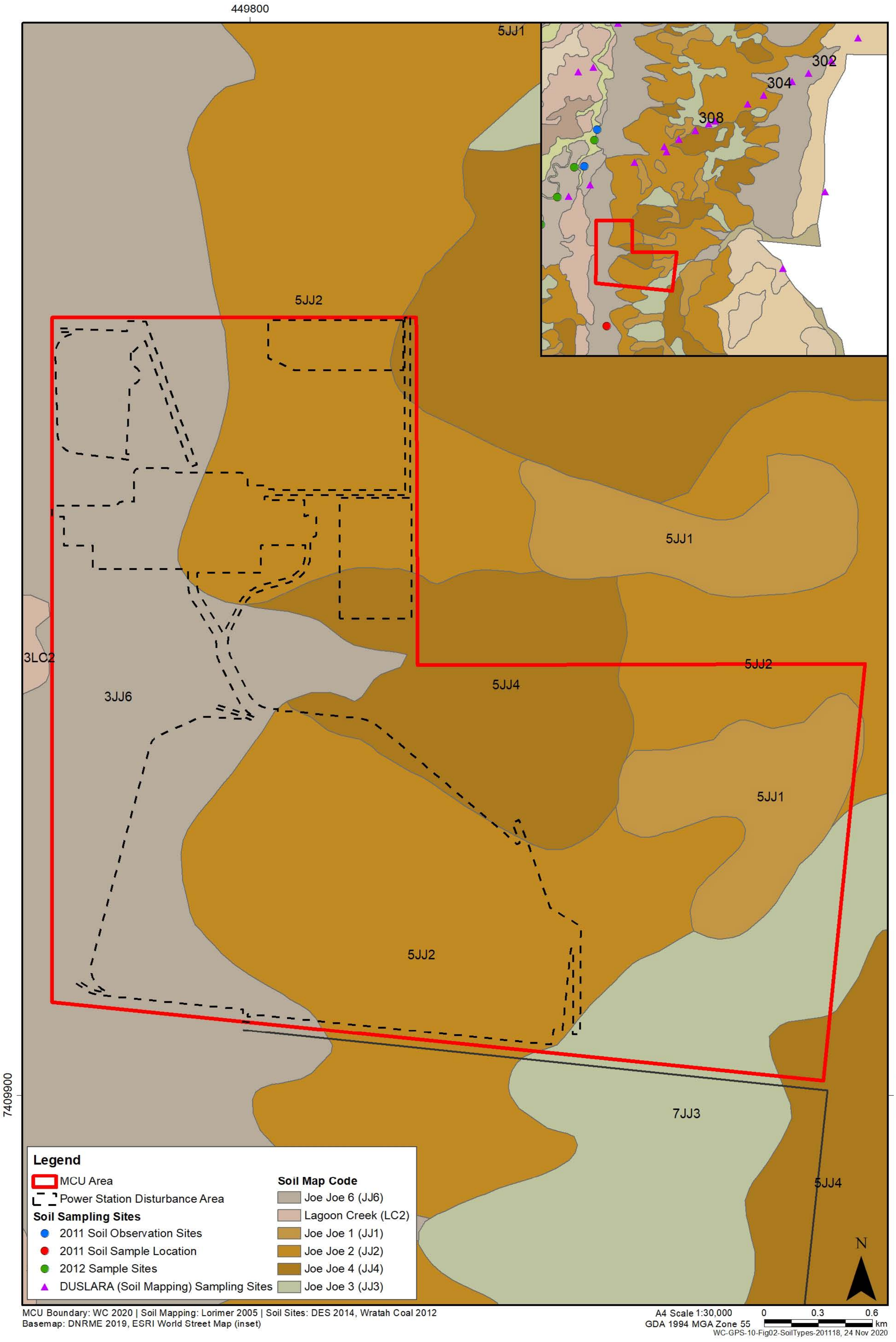

Figure 2-1. Soil map

Deep alluvial soils close to the power station and generally loamy topsoils would be expected to provide good application areas for land disposal.

2.2.2 Site Specific Soils Information

A number of soil sample sites are located to the west of the MCU area, undertaken as part of the nearby Galilee Coal Project, with one site located in the JJ6 soil map unit (site SS52), described as a dark red/orange silty clay from 0 to 0.5m. A number of the DUSLARA project sites are also located, approximately 4 – 5 km north of the MCU area, within the same soil map units (JJ1, JJ2, JJ3, JJ4, JJ6), comprising:

- Soil unit JJ2 – site 304, comprising 120mm of dark reddish grey sandy loam over 310mm of reddish brown sandy clay over 320mm of strong brown light clay; pH 7; laboratory data as follows:
  - Surface: EC 0.01 dS/m; chloride 10mg/kg; total kjeldahl N 0.0575%; total kjeldahl P 0.0051%; ESP 1.3%; Exchangeable Ca (1.91), K (0.33), Mg (0.79), Na (0.04) meq/100g; CEC 3.07meq/100g; Ca:Mg ratio 2.41
  - Mid sandy clay: EC 0.02 dS/m; chloride 10mg/kg; total kjeldahl N 0.0691%; total kjeldahl P 0.0048%; ESP 1.77%; Exchangeable Ca (1.49), K (0.25), Mg (1.03), Na (0.05) meq/100g; CEC 2.82meq/100g; Ca:Mg ratio 1.44
  - Subsoil: EC 0.01 dS/m; chloride 10mg/kg; total kjeldahl N 0.0771%; total kjeldahl P 0.0057%; ESP 1.76%; Exchangeable Ca (1.63), K (0.11), Mg (2.16), Na (0.07) meq/100g; CEC 3.97meq/100g; Ca:Mg ratio 0.76
- Soil unit JJ4 – Site 308, comprising 230mm of brown to pale brown loamy sand over light grey light – medium clay; pH 5.5 – 6
- Soil unit JJ6 – Site 302, comprising 1.25m of sandy loam over medium clay; pH 6.5 – 7.

The above data confirm the general soil types found on the site, with the chemical information identifying soils as:

- Neutral to slightly acidic pH
- Low salinity and chloride
- Low phosphorous and moderate to low nitrogen
- Low ESP, indicating non-sodic soils
- Very low cation exchange capacity, with low calcium and low-moderate magnesium, but good exchangeable calcium percentage, high magnesium percentage, good potassium percentage, and low sodium percentage, and
- Good calcium : magnesium ratio for surface soils, diminishing as depth increases.

The general soil profile is described as a sandy loam (~100 – 200mm) over light – medium clay.

2.3 Local Climate

The project area has a sub-tropical continental climate and, in general, winter days are warm and sunny, and nights are cold. Mean monthly minimum temperatures range from 19°C in the summer to 7°C in the winter. The mean maximum temperatures range from 36°C in the hottest months and drop to 25°C in winter.

Average annual rainfall at the nearby Barcaldine Post Office (station 036007) (refer Figure 2-2) totals 500 mm, with average monthly rainfall of 75mm during the summer months, dropping to averages of 20mm during winter. Wetter periods, represented by the 90th percentile rainfall, show average monthly rainfalls of 170mm per month over summer and 57mm per month over winter, with a 90th percentile annual total of 823mm. Evaporation likewise peaks in summer, with an overall annual mean daily evaporation rate of 8.5mm/day, or 3,100mm per year, well above rainfall.

Wind direction in the area is predominantly easterly.

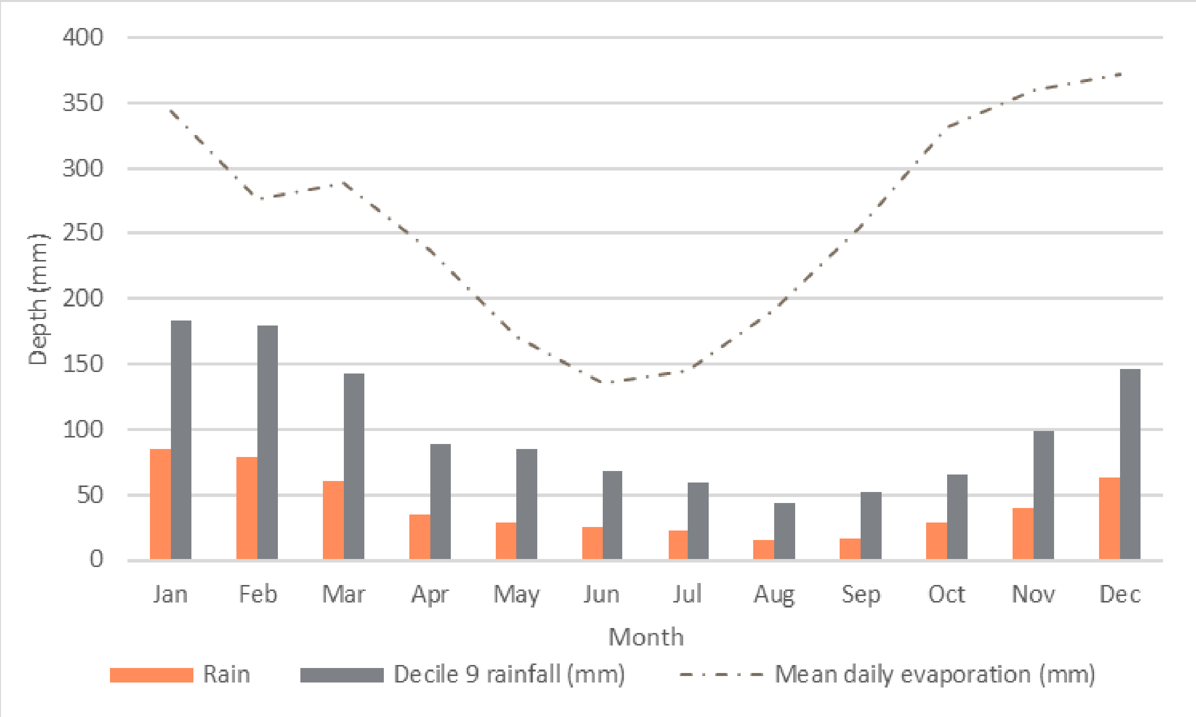

Figure 2-2. Average climatic conditions - Barcaldine Post Office (036007), evaporation from Longreach Aero (036031)

2.4 Site Summary

A summary of the key site characteristics, including key physical characteristics and a summary of the outcomes from the soil assessment above, is shown in Table 2-1

Table 2-1. Summary of site characteristics

Item	Details	Constraint Level	Mitigation
Landform	The landform over the site is described as level or very gently undulating plains (NRIC 1991). Localised mapping shows site elevations range between 390 in the south-east to 328 mAHD in the north-west of the MCU area. Western slopes are largely concave away from small ephemeral channels.	Minor	-
Slope	Very gently inclined (~1%)	Minor	-
Climate	Annual average rainfall of 500 mm, with summer dominated rainfall (December to March), with low rainfall months May to October, compared to annual average evaporation of 3,100 mm, exceeding average rainfall for all months.	Minor, though management required during wet years.	Adequate wet weather storage or diversion to waste water pond for inclusion in ash to avoid any overflows.
Exposure and Aspect	Aspect: westward Wind direction: predominantly easterly Shelter: minimal	Minor	-
Geology and Soils	Surface soils comprising sandy loams over light to medium clays, provide good vegetation growth medium, and some limitations to free downward movement of leachate. Laterite and shallow soils (~500mm) in areas.	Depth to Hardpan: Moderate Permeability: Minor	Irrigate to within hydraulic capacity of soils
Flooding	Located above 1 in 1000-year flood level (refer Engeny 2013)	Nil	-
Drainage	Two small ephemeral drainage gullies are located on the site, with drainage in the proposed LAA being overland flow, diverging ultimately to these drainage channels or to Saltbush Creek around 1 km west of the MCU area.	Minor	Maintain buffer to creeks and drainage lines
Erosion and Landslip	Given the low slopes on the project site, considered unlikely.	Minor	-
Surface rock outcrops	None identified (refer site photos from OE 2019)	Minor	-
Vegetation	Some remnant vegetation is identified on the site; however, the bulk has been cleared for cattle grazing.	Minor	Maintain buffer to remnant vegetation on-site
Groundwater	Seven registered groundwater bores are located within 5 km of the MCU area within the same alluvial geology with data on standing water level in three (RN36823, RN36835 and RN90144) recording it between 15.2 to 33 mbgl (refer Figure 2-3). Sampling of other bores further to the west also show water levels well below 10m depth. EC is recorded at 1,100 µS/cm at another bore (RN44468), and saltier in other bores in the area, other than Colinlea Sandstone.	Minor – unlikely to impact groundwater due to depth and expected to be saline underneath the potential LAAs.	-

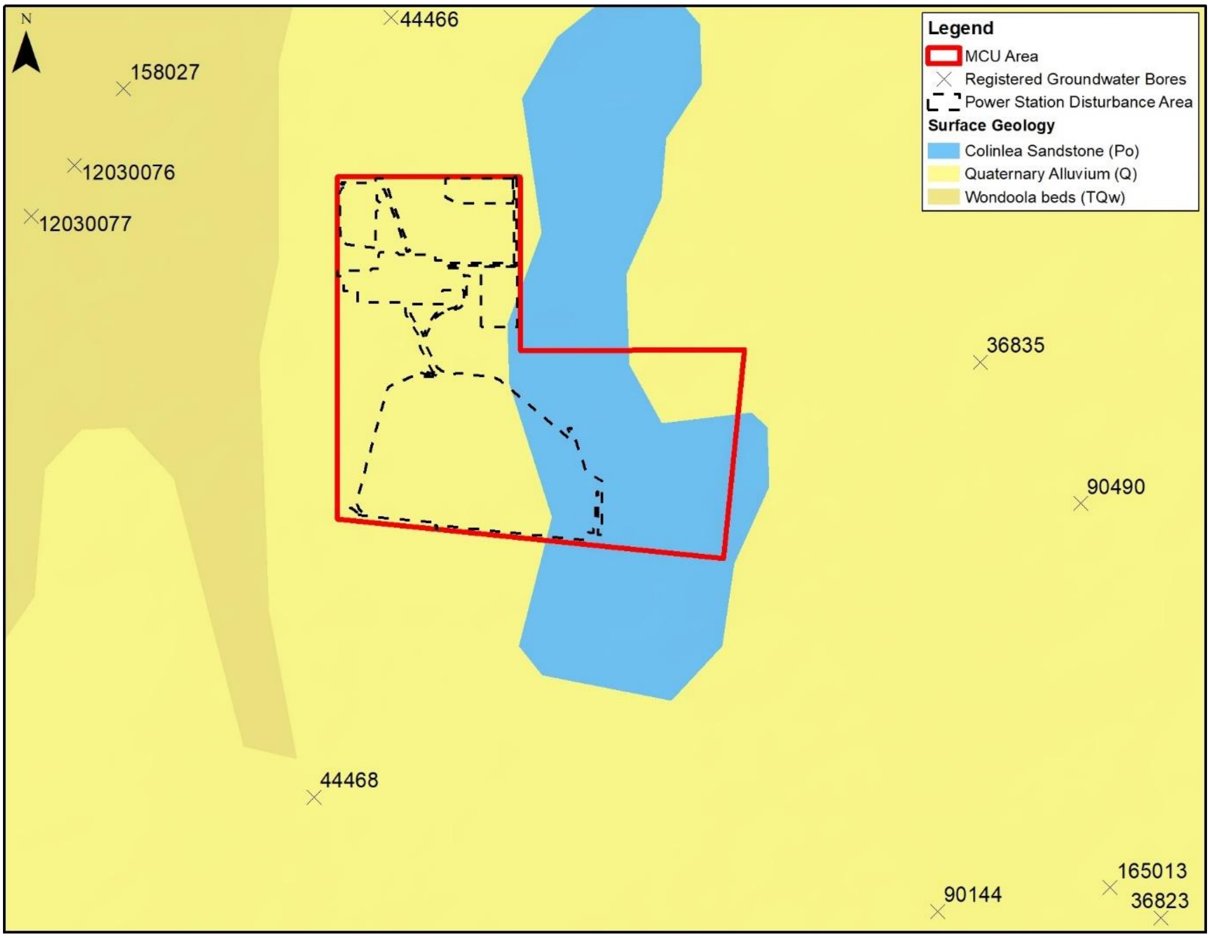

Figure 2-3. Groundwater bores in proximity to the project

3 Sewage Treatment Scheme

3.1 Hydraulic Loading

The project will involve the following estimated workforce:

- During construction, a variable workforce to a peak of up to 1,000
- During operations, a permanent workforce of 90 people, increasing up to ~100 for maintenance shutdowns.

Table 3-1. Estimated hydraulic loading

Stage	Persons	Flow (L/p/day)[1]	Flow (kL/day)
Construction	Up to 1,000	45	45
Operation	90 - 100	45	4.1 – 4.5

Table notes:
1 Rate for mining worker (toilet, urinal, basin, shower) from NSW Health (2001).

3.2 Sewerage Management

3.2.1 Construction Phase

During the construction phase, a highly variable workforce will be employed, with a workforce up to 1,000 persons at times, generating up to an estimated 45 kL/day. Temporary (pump out) ablution blocks will be utilised during the construction phase with sewage being disposed off-site at a licenced facility.

3.2.2 Operational Phase

During the operational phase, an on-site sewage treatment plant (STP) will be utilised on the site (likely a package plant or similar), along with disposal of treated recycled water via irrigation to an on-site LAA. Allowing for an additional 10% capacity, a sewage treatment plant designed to treat 5,000 L/day would be sufficient to manage the on-site workforce.

3.2.3 Accommodation

During both construction and operation, workers will be housed off-site – anticipated to be in the nearby mine construction and operation accommodation, which has been sized for 2,000 workers and has its own sewage treatment plant. No on-site accommodation will be provided.

3.3 Land Application Areas and Offsets

The location of the infrastructure relatively close to the plant, which provides opportunities to use the wastewater pond to avoid overflows, and to minimise overall drainage or pumping distances, coupled with the ability to restrict access and for reasonable offsets to LAAs (i.e. a low exposure scheme), a Class B level of treatment for recycled water quality is considered suitable. In terms of offsets to the LAA, the Queensland Recycled Water Guidelines (EPA, 2005) suggest an offset for Class B recycled water irrigation of 30 m, as a rule of thumb, and Queensland Health (2020) a 25 m spray drift offset for Class B recycled water.

The Queensland Plumbing and Wastewater Code (Queensland Government, 2019) likewise recommends an offset of 30 m for secondary quality recycled water to watercourses or drains, and bores used for human and or domestic consumption, and a 10 m offset to dwellings and recreation areas. However, that code is targeted towards smaller on-site effluent systems rather than larger scale irrigation schemes such as described here.

Given the above and the nature of the project site, the following conservative offsets to site features have been adopted, with potential effluent management areas (areas that could be used for the LAA) that comply with these offsets identified on Figure 4-1:

- 30 m to site boundaries, infrastructure and vegetation, and
- 50m from watercourses.

EPA Victoria's 'Recommended separation distances for industrial residual air emissions' (EPA Victoria 2013) provides a general offset for sewage treatment plants from sensitive land uses of $10n^{1/3}$, where n is the equivalent population. This provides for an offset of 31m. To allow for uncertainty, including unfavourable climatic conditions, an offset of 50m should be achieved between the plant and any sensitive uses.

3.4 Anticipated Recycled Water Quality

Table 3-2 summarises the anticipated recycled water quality for a Class C recycled water, sourced from a typical domestic effluent, based on experience with similar systems in Queensland, the *Public Health Regulation 2018* (Qld) and the Queensland Water Recycling Guidelines (EPA, 2005).

Table 3-2. Anticipated recycled water quality

Parameter	Anticipated Quality
pH	6.0 – 8.5
5-day Biochemical Oxygen Demand (BOD_5)	20 mg/L (median)
Total Suspended Solids	30 mg/L (median)
Electrical Conductivity (EC)	1,600 µS/cm
Total Nitrogen	45 mg/L (median)
Total Phosphorous	15 mg/L (median)
E.Coli	95^{th} %ile ≤100 cfu/100mL (over one year)

3.5 Licensing and Approvals

Given that the construction phase constitutes no release works, it does not constitute an Environmentally Relevant Activity (ERA) and no specific ERA approval or licence is required.

For the operational phase, the ERA for sewage treatment is based on the number of equivalent persons the plant is designed to treat. The *Environmental Protection Regulation 2019* (Qld) calculates equivalent persons (EP) based on the maximum of hydraulic capacity or phosphorous treatment capacity of the sewage treatment plant. Based on the operational flow of up to 4.5 kL/day, this is calculated as follows:

Based on hydraulic capacity: EP = V / 200 = 5,000 L / 200 = *25 EP*

where V = the volume in litres that can be treated in the STP per day

or

Based on phosphorous loading: EP = M / 2.5 = [(15 mg/L = 0.015g/L) × 5,000 L] / 2.5 = *30 EP*.

where M = the mass in grams of phosphorous in the influent that the works are designed to treat per day, assuming 15mg/L total phosphorous in the waste stream.

Therefore, the capacity of the operational treatment system for approval purposes will be the **30 EP**, and so triggers the threshold for ERA 63.1(a)(i), a non-concurrence ERA, namely:

ERA63.1(a)(i) Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 – 100EP, if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.

4 Risk Assessment

4.1 Overview

The sewage waste stream is sourced from ablution facilities, sinks and taps associated with worker use, and so would be expected to be a typical domestic sewage waste stream. As noted in Section 0, the STP will treat to a Class C recycled water standard.

4.2 Sensitive Receptors and Environmental Values

Within the MCU Area, the only mapped sensitive features are two non-perennial (i.e. ephemeral) watercourses, and Category B least concern vegetation. These flow into Saltbush Creek to the west, another non-perennial mapped watercourse.

One sensitive receptor (the Monklands homestead) is situated around 3 km west of the MCU boundary.

Refer to Figure 4-1 for the location of these features in relation to the site.

4.3 MEDLI Modelling

4.3.1 Overview

MEDLI (Model for Effluent Disposal by Land Irrigation) is a mass balance model incorporating a nutrient, salt and water budget approach to estimating the sustainability of land disposal systems. MEDLI v2.1.0.0 was used for this project.

Modelling was undertaken to determine whether the scheme could be operated sustainably in the long term, and was run for three key scenarios:

- no irrigation
- a Soil Water Deficit (SWD) approach, and
- a Fixed Application Rate (FAR) approach.

The model utilised a default MEDLI soil type to reflect the most limiting soil anticipated for the site – the shallow loamy soils over clay, represented by the 'Low Permeability Red Brown Earth'.

The key input parameters used are summarised in Appendix B1.

4.3.2 MEDLI Results

The model was run over a 50-year period – from January 1969 to December 2019 for the three scenarios described above. Table 4-1 summarises the results of the three scenarios, with a brief discussion of the main elements below the table. The full results from the modelling are provided in Appendices B2 (no irrigation), B3 (SWD approach) and B4 (FAR approach).

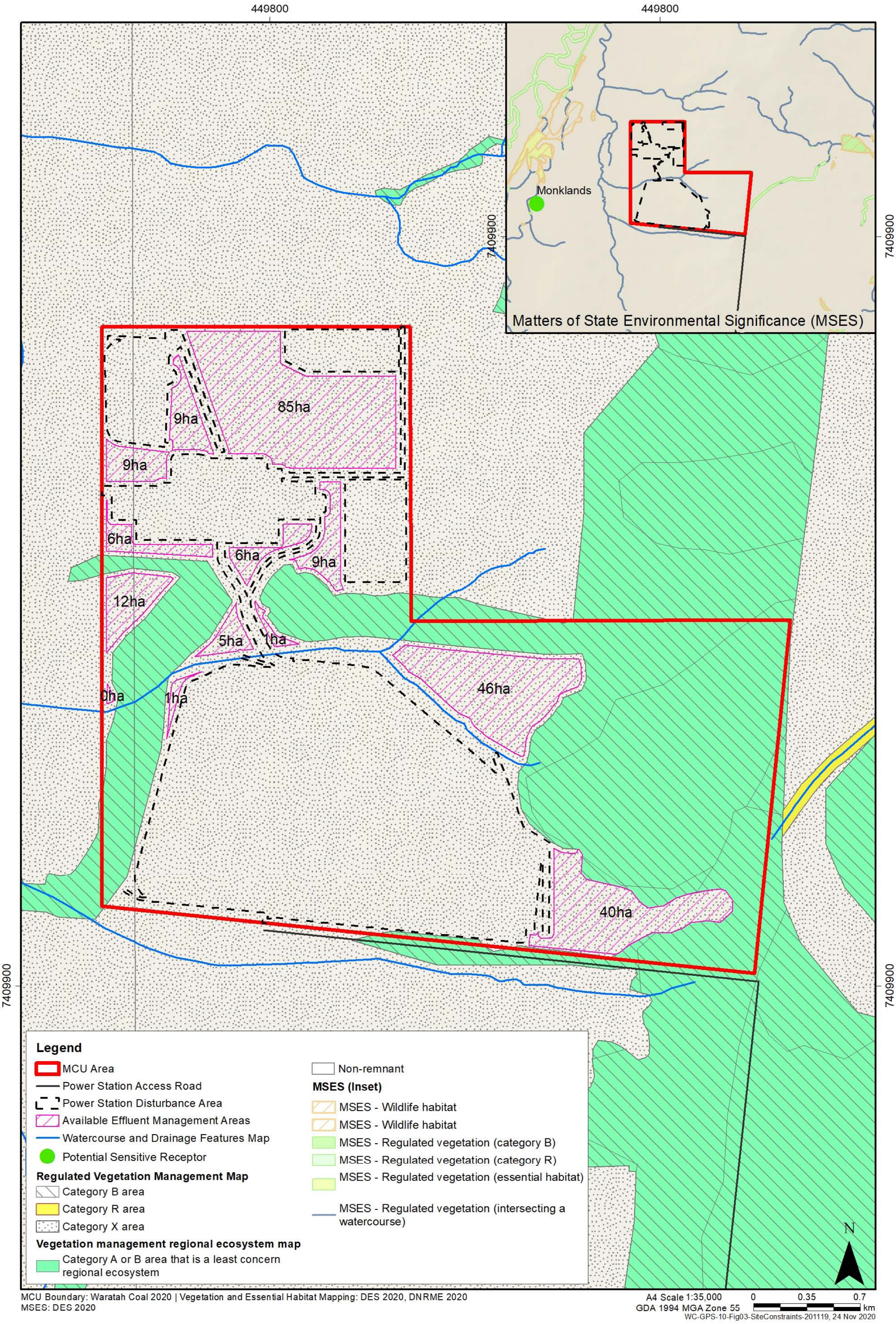

Figure 4-1. Sensitive Environmental Features

Table 4-1. MEDLI results

Parameter	Scenario 1 No Irrigation	Scenario 2 Soil Water Deficit (SWD) -	Scenario 3 Fixed Application Rate (FAR)
General			
Irrigation Trigger	-	Every 3 days	Every 3 days
Irrigation Depth	-	To Drained Upper Limit	6mm
Hydraulic Loading	5,000 kL/day		
Average irrigation rate	0 mm/day	1.2 mm/day	1.3 mm/day
Land application area	-	4,000 m^2	
Wet weather storage	-	30kL (100% drawdown)	
Reuse (%)	-	96%	100%
Water Balance (mm/yr)			
Rainfall	498.8		
Irrigation	0	438	456.6
Runoff	10.4	7.7	9.6
Irrigation Runoff	0	0	0
Drainage	67.4	143.8	162.9
Transpiration	145.1	784.5	767.8
Nutrient Application and Losses (kg/ha/yr)			
N irrigated (after volatilisation)	0	185.3	193.2
N removed by crop	37.9	246.5	253.9
N leached	0.92	0.68	0.80
P irrigated	0	65.7	68.5
P removed by crop	2.9	55.4	55.7
P leached	0.0700	0.1400	0.1600
P Storage Life (yr)	-	76.8	74.1
Nutrient Concentration in Deep Drainage (mg/L)			
Nitrogen	1.37	0.47	0.49
Phosphorous	0.10000	0.10000	0.10000
Salinity (t/ha/yr)			
Total salts added (rainwater + irrigation)	0.0	4.7	4.9
Salts removed by deep drainage	-	4.6	4.7
Yield reduction due to salinity	Nil	Nil	Nil
Summary			
Overflows - days / y	-	20	Nil
Overloading of land application area	-	Nil	Nil

Water Balance

The modelling shows that with a fixed rate approach, all of the recycled water can be irrigated on the proposed LAA without any overflows, with an average application rate of 1.3 mm/day. The soil water deficit approach provided 96% reuse efficiency but resulted in an average of 20 overflow days per year. The approach would therefore be to operate the plant on a fixed rate approach to ensure no overflows occur, and which the modelling shows has a similar outcome in terms of nutrient loads and leaching as the more conservative soil water deficit approach.

Note however that no overflows from the site would occur – any overflows would be directed to the on-site wastewater pond, which would be utilised within the ash conditioning and storage process, without releases to waters - in normal operating procedures (as outlined herein), no discharge to the wastewater pond is anticipated.

These scenarios resulted in decreases in runoff, due to better vegetation growth, and increases in transpiration and deep drainage. Given the depth to groundwater (in excess of 10m depth and likely 20m or more), the fact that nitrogen concentration in deep drainage has reduced (and nitrogen leaching has reduced), and that phosphorous has an estimated storage life in excess of 70 years, this increased deep drainage is not expected to result in impacts.

Nitrogen

The modelling indicated that more nitrogen is removed by the crop than was added in irrigation, due to the increased biomass as a result of the irrigation scheme. Compared to the no irrigation scenario, nitrogen leaching (both the mass and the concentration in deep drainage) reduces.

Overall, the modelling indicates that nitrogen leaching is not significant, and the scheme can be considered sustainable in terms of nitrogen.

Phosphorous

The modelling indicated that approximately 83% of the phosphorous added by irrigation was removed by the crop, with the amount of phosphorous leached increasing from 0.07 to 0.16 kg/ha/y, although the concentration in deep drainage remained the same (0.1 mg/L). Given that the model predicts a storage life of around 75 years (with a project life ~50 years), and that phosphorous would be expected to bind into the lower more clayey layers, phosphorous leaching is not anticipated to be an issue for the project. However, to ensure good soils for irrigation, soil testing should be undertaken, and amelioration (including balanced micro-nutrient application) undertaken as required.

Overall, the modelling indicates that phosphorous leaching, while increasing slightly, is not significant, with the bulk of the added phosphorous being taken up in the soil-vegetation system, and the scheme can be considered sustainable for the life of the project in terms of phosphorous.

Salinity

More salts were removed by drainage below the root zone than were added by irrigation and rainfall, and no yield reduction due to salinity was found.

4.4 Noise and Odour Amenity

The scheme will be located within the MCU area and with suitable offsets to on-site sensitive receptors to avoid nuisance noise and odour impacts to site workers. Given the nature of the site, the relatively small size of the treatment plant and LAA and large distances to the nearest sensitive receptors, no off-site impacts would be anticipated.

4.5 Summary

The modelling has shown that a fixed application irrigation approach, irrigating 6mm every 3 days can sustainably dispose of the treated recycled water over 4,000m^2 LAA, utilising a 30kL wet weather storage, without any overflows and without excessive leaching of nutrients or overloading of LAA soils.

Given the results of the nutrient leaching from the modelling and considering the proposed life of the project (~50 years), the scheme is sustainable in terms of nutrient loading, uptake and leaching. Soil testing and amelioration is recommended to ensure plant growth and soil stability and uptake can be protected into the long term.

Since there is ample space available, a second reserve LAA should be retained should the primary LAA require resting or replacement – this will be the same size as the primary (i.e. 4,000 m^2), although irrigation fitout is not required unless needed later in the project life.

Noise and odour amenity from a properly operated plant are not anticipated to be an issue given the adopted offsets, the nature of the site and size of the proposed scheme.

5 Design Summary

Table 5-1 summarises the key design considerations for the proposed scheme described in this report.

Table 5-1. Design considerations for sewerage scheme

Element	Description
General	
Sewage Treatment Plant	An on-site sewage treatment plant suitable to produce 'Class B' recycled water as defined in Section 3.4 of this report, along with a 30kL wet weather storage. An indicative location that satisfies the offset requirements is shown in Figure 5-1.
Safety	Erect appropriate signage complying AS1319-1994 'Safety Signs for the Occupational Environment' indicating that recycled water is not suitable for drinking or human exposure at every outlet from the treated recycled water distribution system. Signs shall be easily visible and maintained regularly.
Plumbing and drainage	Comply with all applicable plumbing requirements in particular to prevent cross-connections with drinking water pipes. Piping and fittings shall be installed, and colour coded in accordance with AS/NZS 1547, AS/NZS 3500 and AZ/NZS 1345. Any fittings/valves accessible by public must be appropriately secured to restrict access.
land application Area	
Location	The Effluent Management Areas shown in Figure 4-1 are suitable for the location of the LAA. Figure 5-1 shows indicative locations for the LAA, including an additional reserve area - an area the same size that could be utilised should the primary area require 'resting', and which should be retained as available although plumbing and irrigation fitout is not required. Any changes made must meet the offset requirements specified in Section 3.3.
Soil amelioration	Soil testing should be conducted prior to irrigation commencing, and soils conditioned as required based on the results and advice from an experienced agronomist.
Offsets and withholding periods	The following offsets shall be applied to the LAA: • 30 m to site boundaries, infrastructure and vegetation, and • 50m from watercourses. No access by humans or animals shall be allowed, or a withholding period applied before any access (at least 4 hours and until the area is dry). Persons may access the site within this holding time if required however appropriate PPE and vaccinations will be required, subject to a project specific risk assessment. No spray is to reach areas normally occupied by humans or animals. No cattle grazing on the disposal area is to be undertaken without first considering disease vectors and plant upgrades required (e.g. for helminths) which has not been considered herein.
Application and timing	Irrigation will be at a fixed rate, but able to be switched off in the case of rainfall occurring prior to or during irrigation, and the application rate must be able to be adapted to soil conditions to ensure over application does not occur.
Sprinkler application	Ensure even dispersion of recycled water over the LAA by surface spray irrigation, utilising coarse low throw spray heads suitable for use with effluent, that do not produce mist or aerosols. Spray must be contained inside the designated LAA. Install warnings complying with AS1319 or NZS/AS1319 at the boundaries of the designated area, clearly visible to property users, with wording such as 'Recycled Water - Avoid Contact- DO NOT DRINK'. Ensure the system used is disinfected to a suitable standard as outlined in AS1547.
Surface water drainage	Install upslope diversion drains to divert runoff water around LAAs.
Warning signs	Install prominent warning signs indicating that the area is being irrigated with treated effluent, to avoid contact with the water and not to drink it.

Element	Description
Management	
General	Do not drive or park vehicles on the LAA, and do not build structures or create shade on the LAA. Maintain diversion bunding to keep overland flow water from running across the LAA, where required. Regularly slash and remove excess grass from LAA. Do not allow trees or large vegetation to grow where roots may disrupt pipework. Ensure system is maintained in accordance with manufacturer's instructions, including routine flushing of irrigation pipework, and cleaning of filters where required.
Monitoring	Regular monitoring of the recycled water quality should be undertaken over the first year, until the plant has stabilised, and consistent recycled water quality achieved. Ongoing check monitoring should then be conducted, with the frequency increased where non-compliances are found. Weekly inspections of the treatment plant and irrigation area are to be conducted for excessive odour and noise, and for ponding or pooling of recycled water, or dead or excessively green patches on the LAA.
Site Based Management Plan	Implement a Site Based Management Plan (SBMP) to facilitate the effective management of the scheme. The SBMP is to be prepared consistent with the licence conditions, and best practice management.

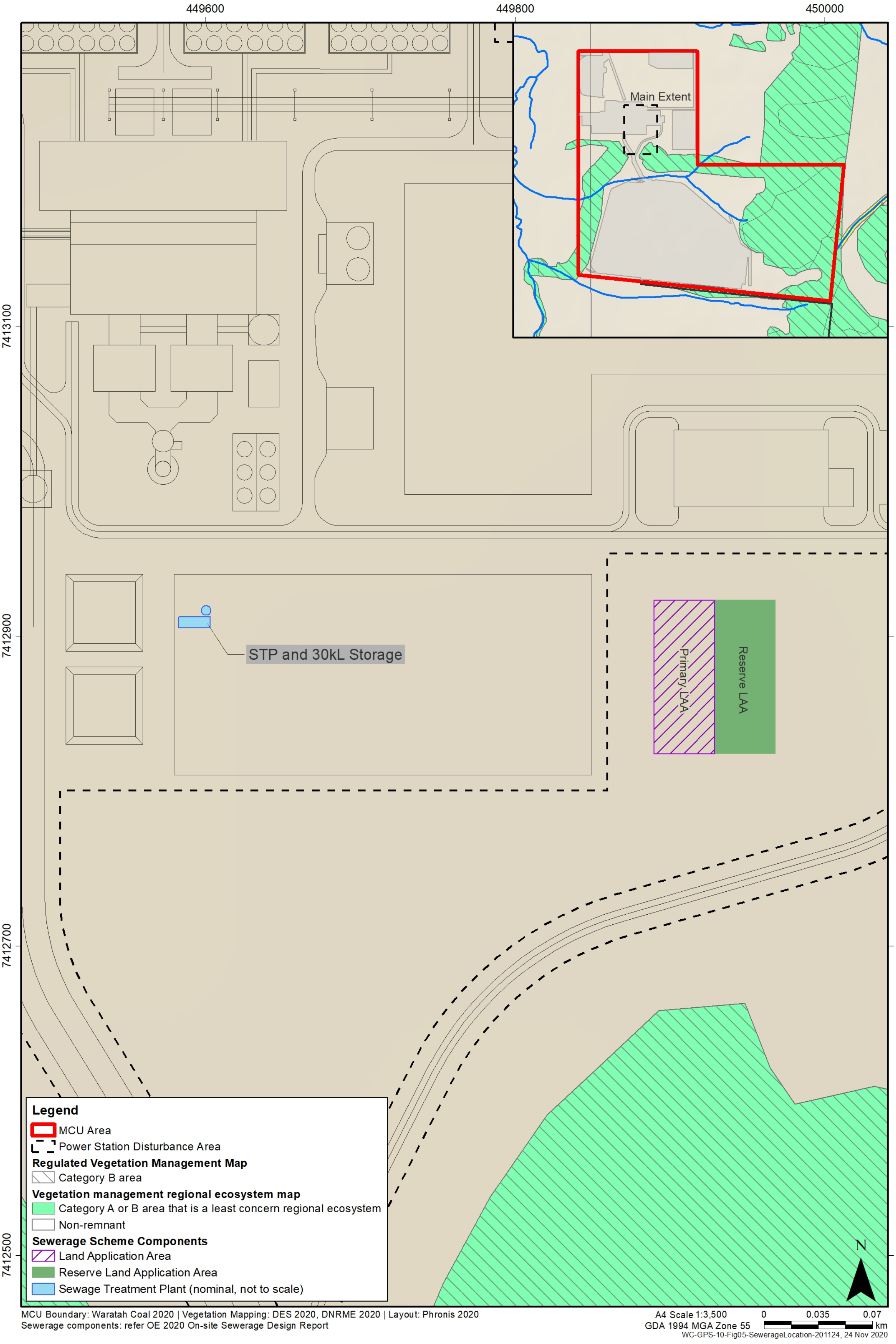

Figure 5-1. Location of key sewerage infrastructure (indicative)

6 Conclusions

This report has been prepared to support an application for development approval and Environmental Authority for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. The assessment described in this report included a description of the site and soils, assessment of key risks, calculation of hydraulic loading, licensing requirements, MEDLI nutrient and water balance modelling, and design summary for the recommended scheme.

The assessment found that the anticipated waste stream can be fully irrigated without overflow or overloading of soils with a 4,000m^2 LAA, utilising a 30kL wet weather storage. The available land on the site provides for suitable offsets to allow a 30EP or 5,000L/day Class B treatment plant to be utilised to support the scheme.

The scheme described in this report resulted in no overflows and can be operated sustainably in terms of nutrient loading, uptake and leaching. Soil testing and amelioration is recommended to ensure plant growth and soil stability and uptake can be protected into the long term.

Noise and odour amenity from a properly operated plant are not anticipated to be an issue given the adopted offsets, the nature of the site and size of the proposed scheme.

Detailed design is required for the plant and land disposal area, with design considerations provided in this report. Any design and construction should be undertaken in accordance with all relevant codes and standards, and by suitably qualified persons, generally in accordance with the recommendations made in this report. In particular, any deviations in design should result in emissions from the system that are the same or better than that proposed herein.

7 References

Engeny (2013). Mine Site Creek Diversion and Flooding, Galilee Coal Project SEIS Technical Report. Engeny Water Management, rev. 4, ref. M1700_005, 31 July 2013.

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EPA Victoria (2013). Recommended separation distances for industrial residual air emissions. Report no. 1518, March 2013.

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NSW Health (2001). Septic Tank and Collection Well Accreditation Guideline (Septic Tanks, Collection Wells, Septic Closets (Blackwater Tanks), Greywater Tanks, CED Pretreatment Tanks, and Sewage Ejection Pump Stations): Part 4, Location Government (Approvals) Regulation 1999. New South Wales Department of Health, December 2001.

OE (2019). Watercourse / Drainage Feature Determination Supporting Information. Orange Environmental Pty Ltd, Ref. WC-GCP-MM002, Rev 0, 20 December 2019.

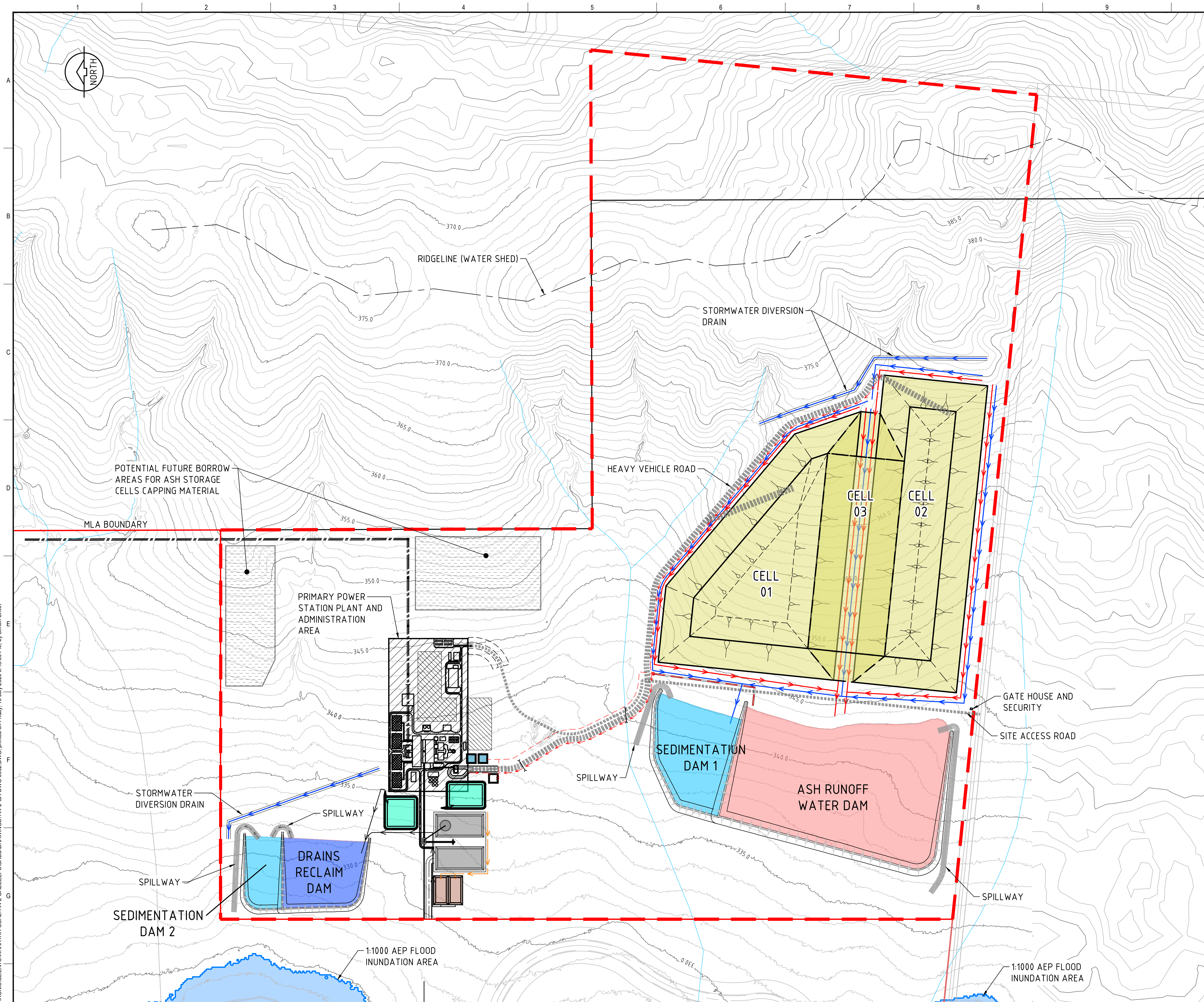
Queensland Government (2019). Queensland Plumbing and Wastewater Code Version 1: 2019. 26 March 2019

Queensland Health (2020). Guideline for low-exposure recycled water schemes. Accessed 19 November 2020 from https://www.health.qld.gov.au/public-health/industry-environment/environment-land-water/water/quality/recycled-water

Appendix A

Figures

144-2-GA-DWG-0002



LEGEND

- EXISTING CONTOURS (1.0m)
- SITE BOUNDARY
- STORMWATER DIVERSION DRAIN
- *CLEAN WATER DRAIN
- STORMWATER PIPELINE
- STORMWATER RISING MAIN
- *ASH RUNOFF WATER DRAIN
- DRAINS TO DRAINS RECLAIM DAM
- H.V. ROAD TABLE DRAIN/SW PIPELINE
- SITE ACCESS ROAD
- H.V. ROAD
- ASH STORAGE AREA

*REFER NOTE 1 ON DRG GA-DWG-0005

REV	DATE	BY	DESCRIPTION	CHK	APPD
F	10.07.20	SAS	MINOR AMENDMENTS	LC	SWN
E	15.06.20	GS	LEGEND REVISED	LC	SWN
D	27.05.20	GS	PRELIMINARY ISSUE	LC	SWN
C	18.12.19	CAG	PRELIMINARY ISSUE	LC	SWN
B	09.10.19	CAG	PRELIMINARY ISSUE	PB	SWN
A	04.10.19	SAS	PRELIMINARY ISSUE	PB	SWN

REFERENCE COORDINATION DRAWINGS

DESCRIPTION	DRAWING NO.	REV	CHK

SURVEY DATUM
HORIZONTAL DATUM: VERTICAL DATUM:

SCALES
0 100 200 400 600
Full Size 1:10000 ; Half Reduction 1:20000
SCALE (m)

A1 ORIGINAL
DO NOT SCALE THIS DRAWING
APPROVED
SIGNED:
DATE: RPEQ:

PHRONIS CONSULTING
Lvl 5 Bldg 2 50 McDougall St, Milton, Qld 4064
T (07) 3506 1100 Fax (07) 3229 8177
Website: www.phronis.com.au

CLIENT: Waratah Coal — THE NEW ENERGY IN COAL

PROJECT: GALILEE POWER STATION PROJECT
CONCEPT DESIGN

TITLE: GALILEE POWER STATION
CONCEPT DESIGN
SITE
LAYOUT PLAN

DRAWING STATUS: PRELIMINARY
NOT FOR CONSTRUCTION

DESIGNED:	CHECKED:	APPROVED:
LC	PB	SWN
PROJECT No: 144-2	DRAWN: CG	DATE: 26.09.19

DRAWING No: 144-2 - GA - DWG - 0002 REV: F

Appendix B

MEDLI Data

B1 – MEDLI Inputs

Table B1. MEDLI Inputs

Parameter	Value
Climate Data	Gridded SILO data from site -23.4ºS, 146.5E
Soil	Default MEDLI Low Permeability Red-Brown Earth – this matches approximately the texture profiles for the key area being investigated, being sandy loam over sandy clay over clay soils.
Crop	MEDLI default values for Rhodes grass, other than reduced rooting depth to 500 mm (accounting for lateritised shallow soils)
Waste Stream	Average daily flow rate of 5kL/day Total Nitrogen: 45mg/L Total Phosphorous: 15 mg/L Volatile Solids: 0 mg/L Total Solids: 1 mg/L TDS: 1,024 mg/L (1.6 dS/m)
Pond	30 kL, allowing for 6 days storage
Irrigation - fixed application rate approach	Trigger: every 3 days Irrigate: 6 mm
- soil water deficit approach	Trigger: 2 mm soil water deficit Irrigation: to 0 mm above Drained Upper Limit

B2 – MEDLI Outputs – No irrigation

Enterprise: **WC-GPS Galilee Power Station**

Description:
Operational Phase - 5,000L/day, 45TN, 15TP

Client: **Waratah Coal**

MEDLI User: Marc Walker (EMCA)

Scenario Details:
No Irrigation

DESCRIPTION

Climate Data: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019 51 years, 0 days

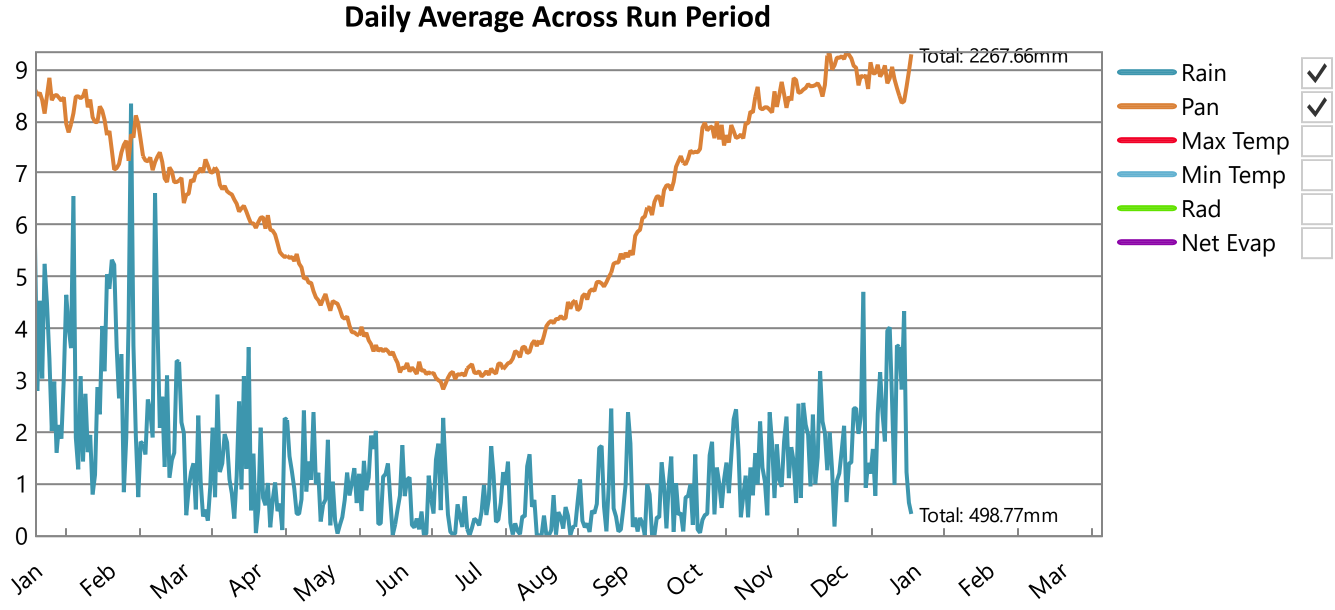
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	276	419	860
Pan Evaporation (mm/year)	1991	2318	2506

Climate Data:

Chart Table

Monthly Daily



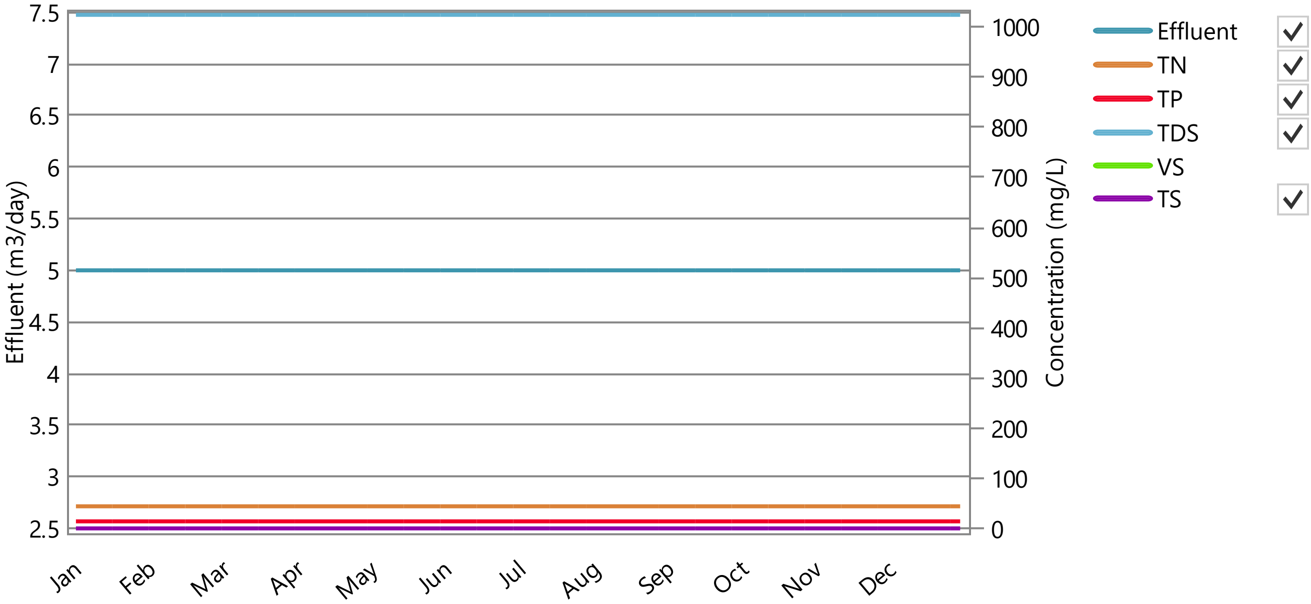
DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

■ Chart ☐ Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 1826.18 m3/year or 5.00 m3/day (Min-Max: 5.00 - 5.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

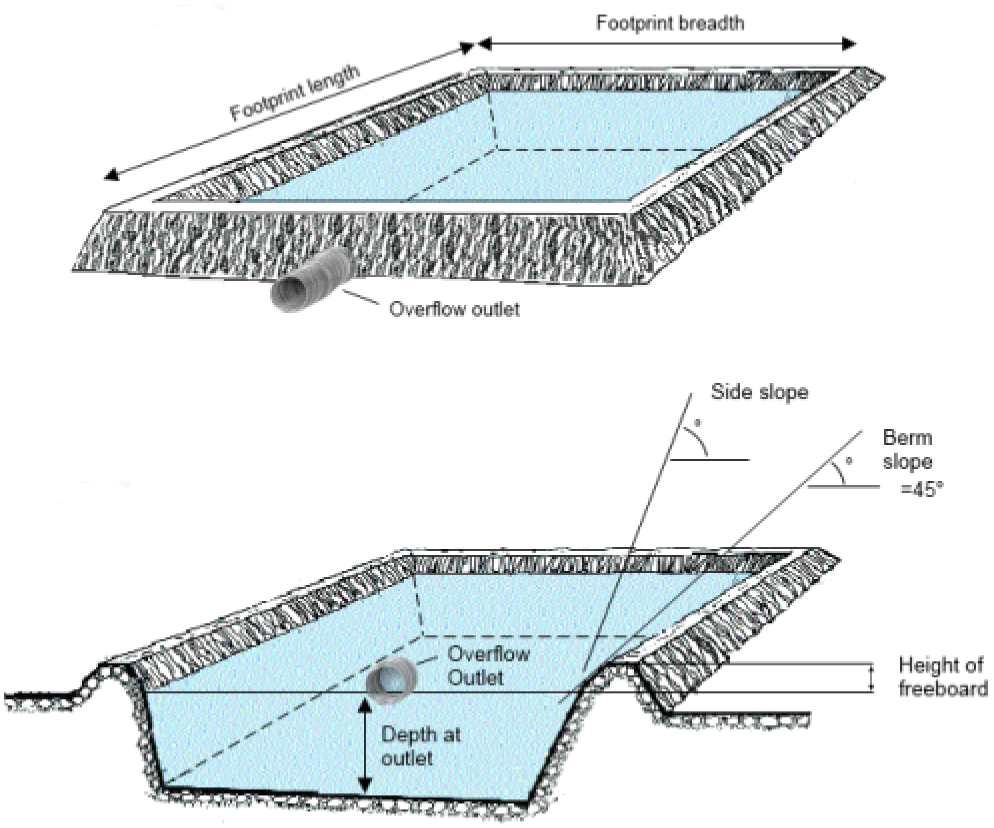
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	30.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	2.00
Maximum water surface area (m2)	15.00
Pond footprint length (m)	3.87
Pond footprint width (m)	3.87
Pond catchment area (m2)	15.00
Average active volume (m3)	30.00



Irrigation pump limits:

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate limit (ML/day)	0.00

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

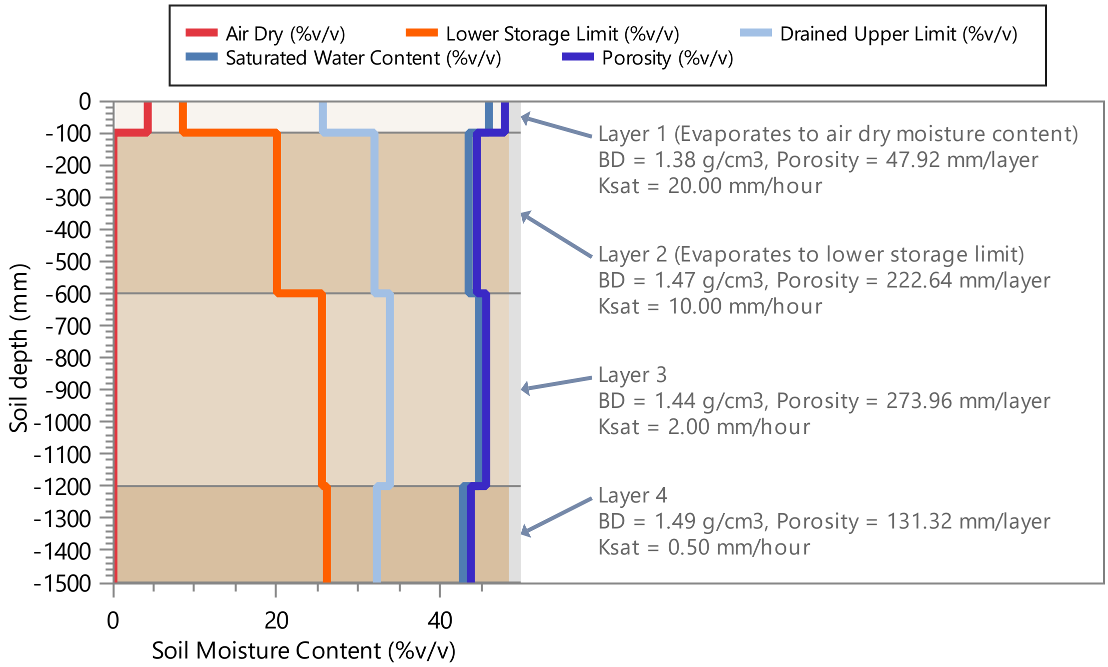
DESCRIPTION

Land: LAA

Area (ha): 0.40

Soil Type: Low Permeability Red Brown Earth, 1500.00 mm defined profile depth

Profile Porosity (mm)	675.85
Profile saturation water content (mm)	660.70
Profile drained upper limit (or field capacity) (mm)	486.00
Profile lower storage limit (or permanent wilting point) (mm)	341.30
Profile available water capacity (mm)	144.70
Profile limiting saturated hydraulic conductivity (mm/hour)	0.50
Surface saturated hydraulic conductivity (mm/hour)	20.00
Runoff curve number II (coefficient)	75.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Rhodes Grass Pasture - 500mm rooting

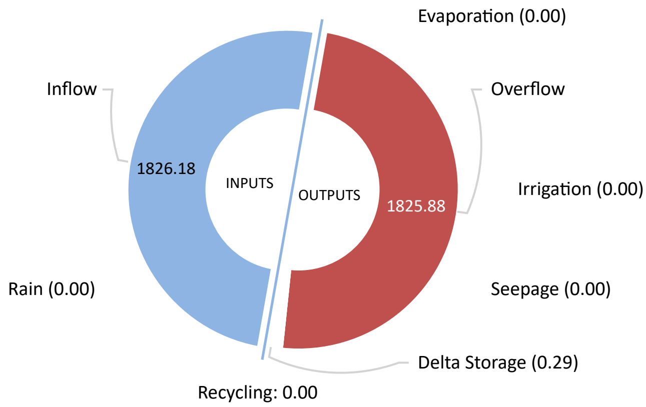
Average monthly cover (fraction) (minimum - maximum)	0.18 (0.07 - 0.34)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.9 x Pan coefficient 0.7)	0.63
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	500.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **30 m3**

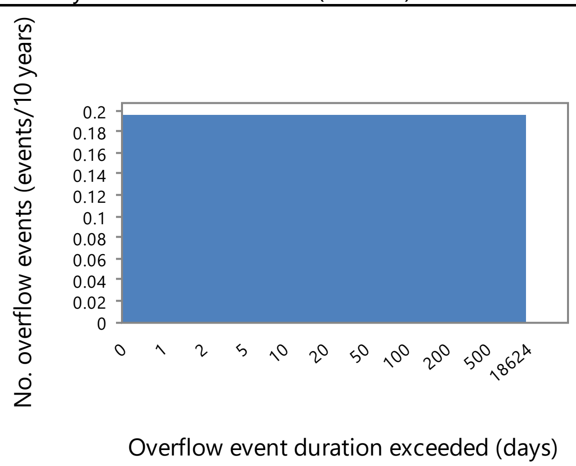
Pond System Water Balance (m3/year)

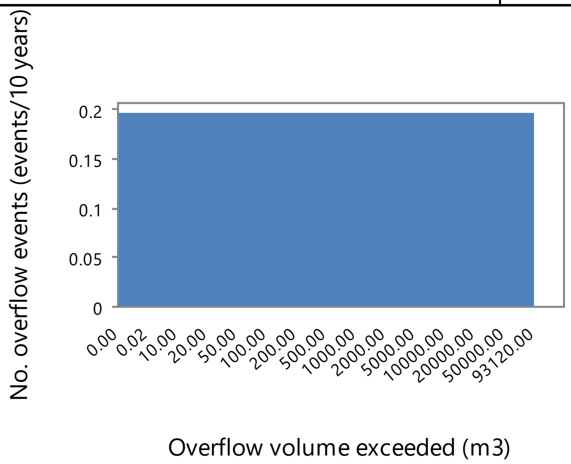


Name	Value
Rain	0.00
Inflow	1826.18
Recycling	0.00
Evaporation	0.00
Overflow	1825.88
Irrigation	0.00
Seepage	0.00
Delta Storage	0.29

Overflow Diagnostics

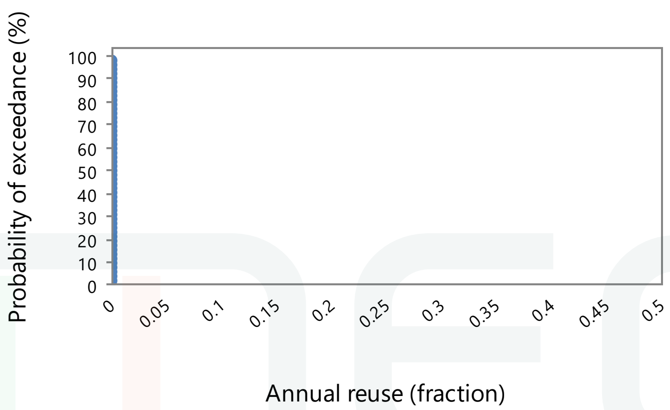
Volume of overflow (m3/year)	1825.88
No. days pond overflows (days/year)	365.18
Average duration of overflow (days)	18624.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% reuse (fraction)	0.00





Export plot

Export plot



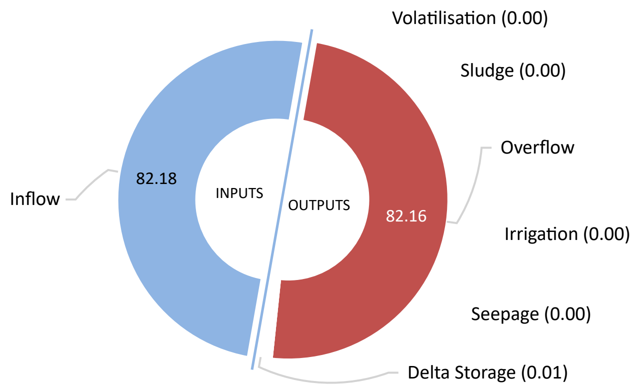
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

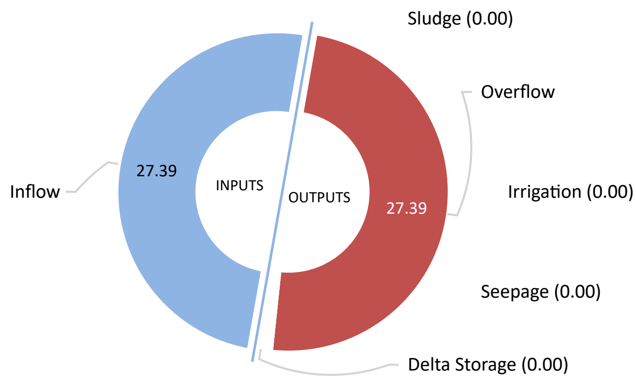
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



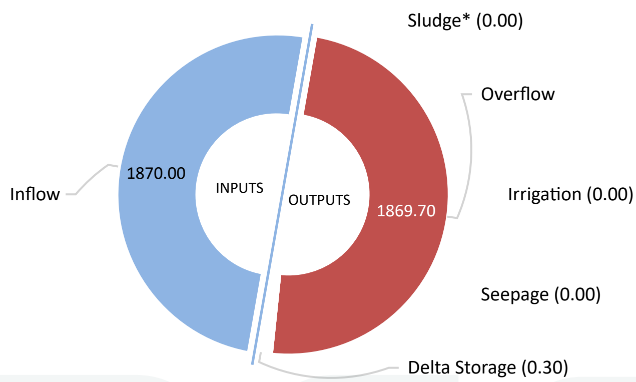
Name	Value
Inflow	82.18
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	82.16
Irrigation	0.00
Seepage	0.00
Delta Storage	0.01

Phosphorus Balance (kg/year)



Name	Value
Inflow	27.39
Recycling	0.00
Sludge	0.00
Overflow	27.39
Irrigation	0.00
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	1870.00
Recycling	0.00
Sludge*	0.00
Overflow	1869.70
Irrigation	0.00
Seepage	0.00
Delta Storage	0.30

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	45.00
Average phosphorus concentration of pond liquid (mg/L)	15.00
Average salinity of pond liquid (dS/m)	1.60

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	45.00
Final phosphorus concentration of pond liquid (mg/L)	15.00
Final salinity of pond liquid (dS/m)	1.60

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	0.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	0.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	0.00
Average phosphorus concentration of irrigation water (mg/L)	0.00
Average salinity of irrigation water (dS/m)	0.00

Irrigation Diagnostics (No effluent irrigation occurred!):

Proportion Days Irrigation Turned Off (fraction)	1.00 (Hence no irrigation!)
Proportion of days maximum irrigation rate set to zero (fraction)	1.00 (Hence no irrigation!)
Proportion of Days irrigation occurs (fraction)	0.00

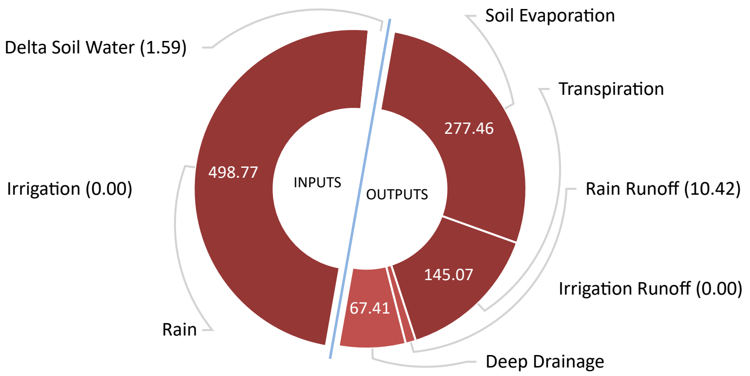
PERFORMANCE

Land Performance - Soil Water

Paddock: LAA, 0.4 ha
Soil Type: Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

Land Water Balance (mm/year):

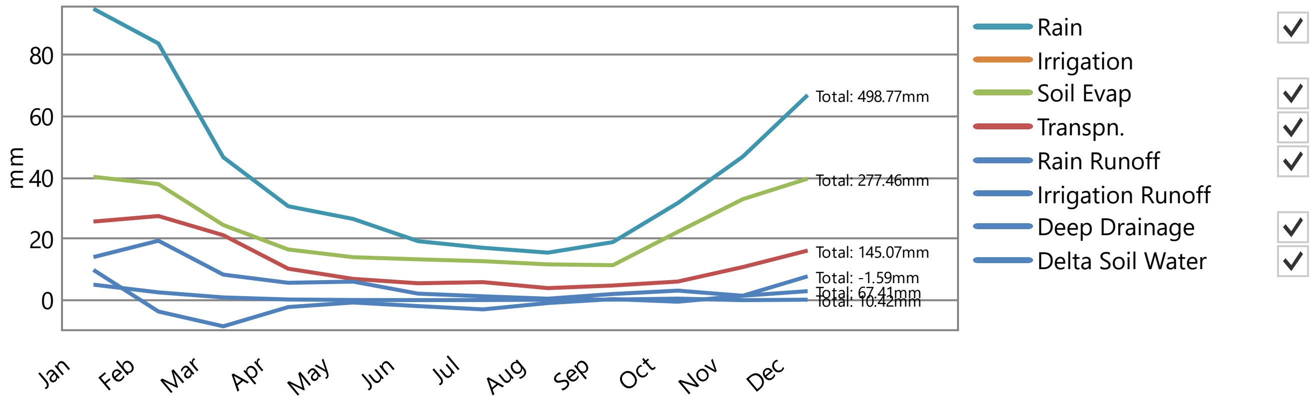
■ mm/year ☐ % Total inputs



Name	Value
Rain	498.77
Irrigation	0.00
Soil Evaporation	277.46
Transpiration	145.07
Rain Runoff	10.42
Irrigation Runoff	0.00
Deep Drainage	67.41
Delta Soil Water	-1.59

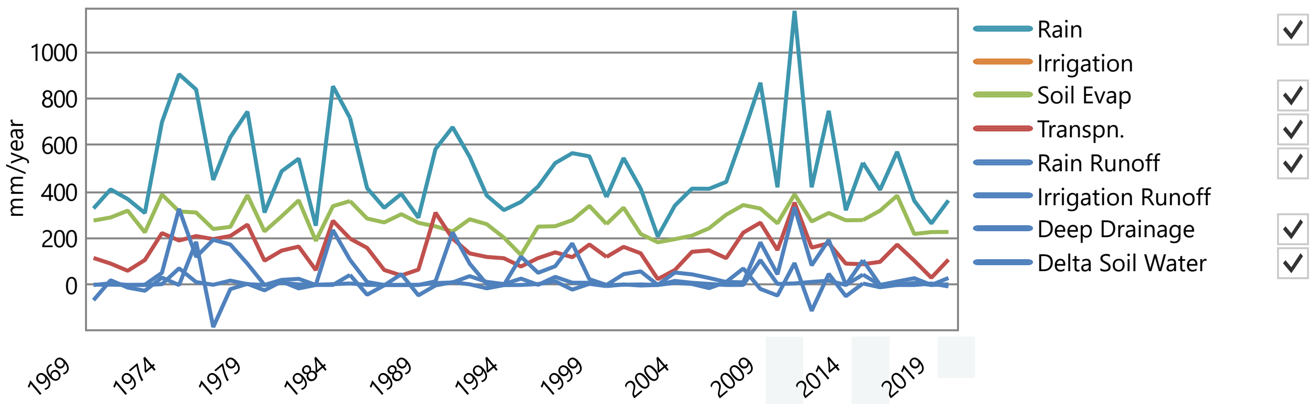
Average Monthly Totals (mm):

■ Chart ☐ Table



Average Annual Totals (mm/year):

■ Chart ☐ Table



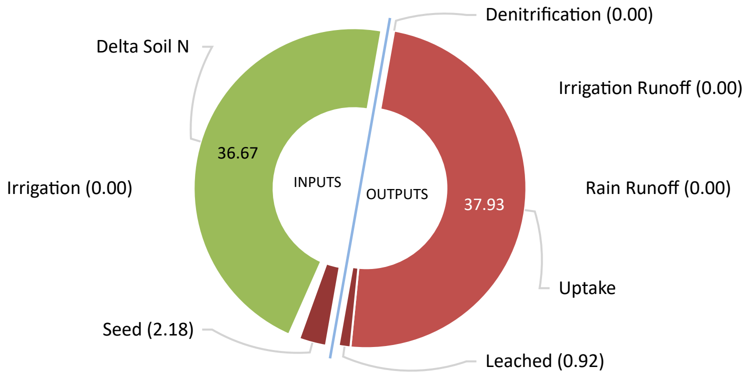
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

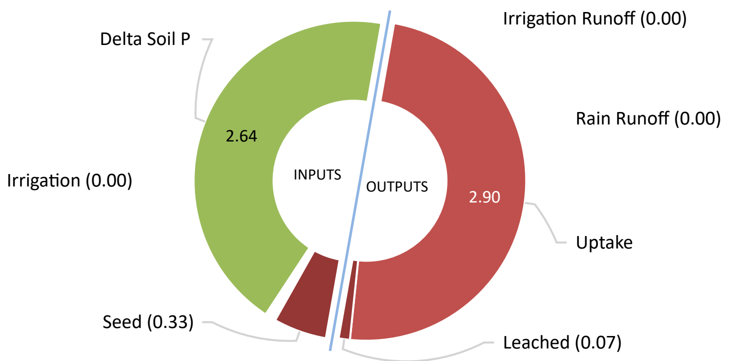
Irrigation ammonium volatilisation losses (kg/ha/year): 0.00
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.30

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	2.18
Irrigation	0.00
Denitrification	2.38E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	37.93
Leached	0.92
Delta Soil N	-36.67

Land Phosphorus Balance (kg/ha/year)



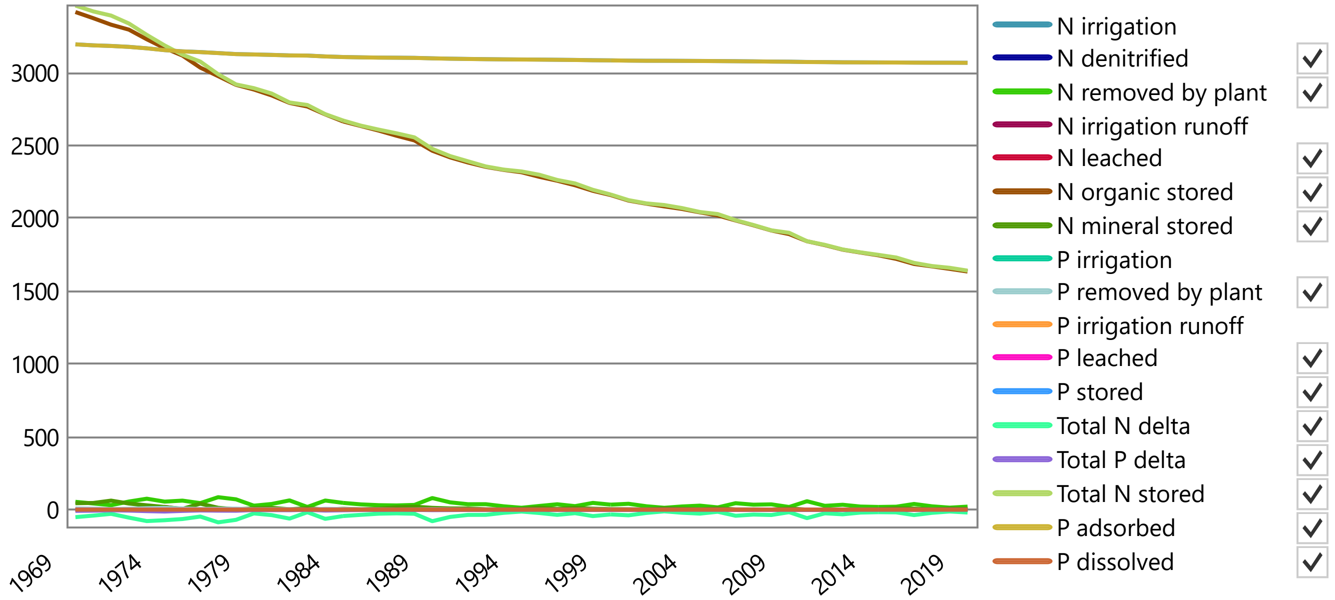
Name	Value
Seed	0.33
Irrigation	0.00
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	2.90
Leached	0.07
Delta Soil P	-2.64

PERFORMANCE

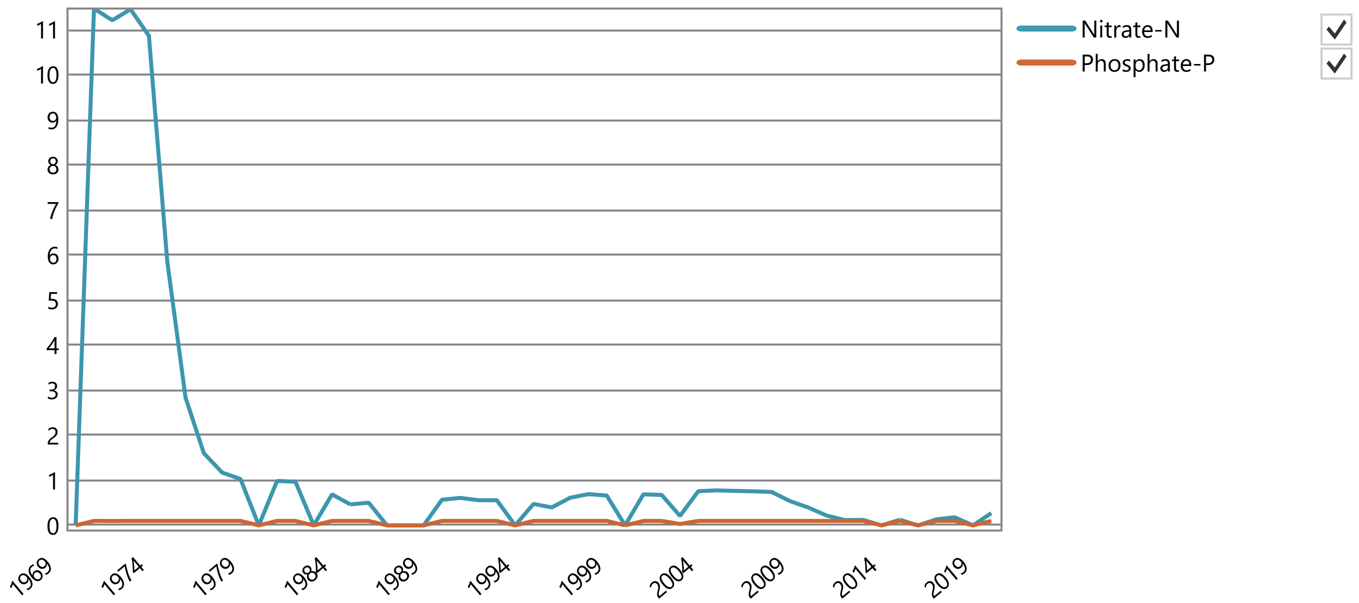
Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: LAA, 0.4 ha **Soil Type: Low Permeability Red Brown Earth**

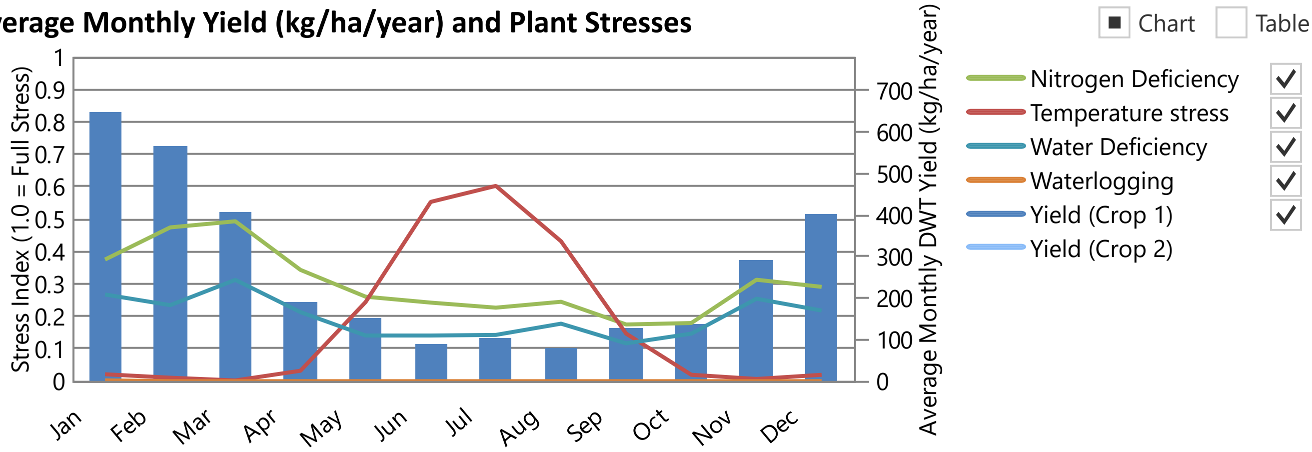
Plant: Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	3320.43 (1046.57 - 6753.94)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.18 (0.07 - 0.34)
Average monthly root depth (mm) (minimum - maximum)	125.39 (62.29 - 215.15)

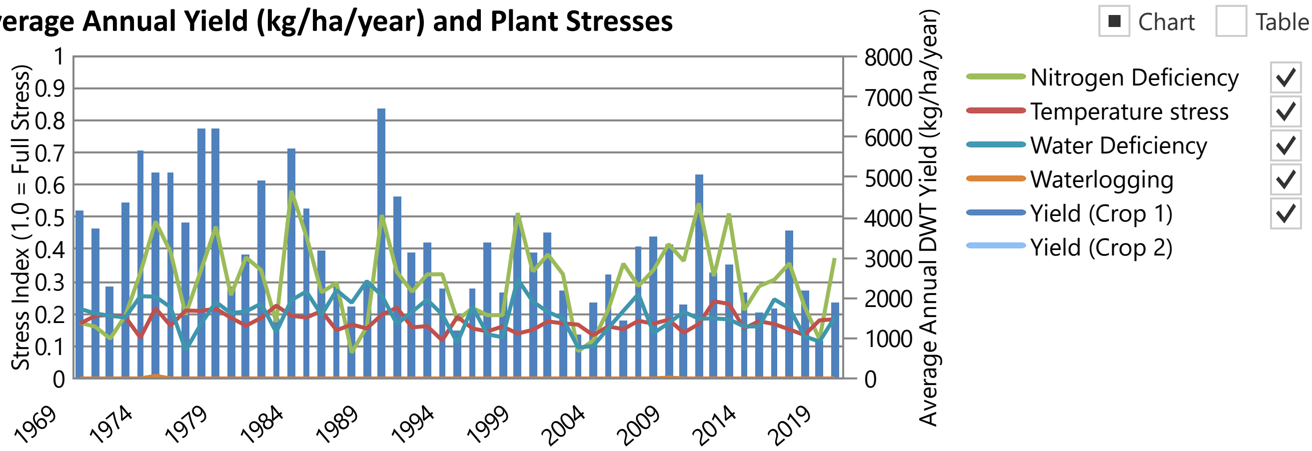
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	37.93 (13.17 - 85.93)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	2.90 (0.43 - 12.54)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.002)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 0.02 (normal), 3.63 (forced by crop death due to nitrogen stress (0.33), water stress (3.29))

No. days without crop/year (days/year): 173.88 due to frosting (0.86), temperature stress - not frost (1.51), water stress (171.51)

PERFORMANCE

Land Performance

Paddock: **LAA, 0.4 ha** **Soil Type**: **Low Permeability Red Brown Earth**

Plant: **Continuous Rhodes Grass Pasture - 500mm rooting**

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

Soil Salinity:

Average Infiltrate Salinity (dS/m)	0.03

Insufficient deep drainage to run steady state salinity calculations.

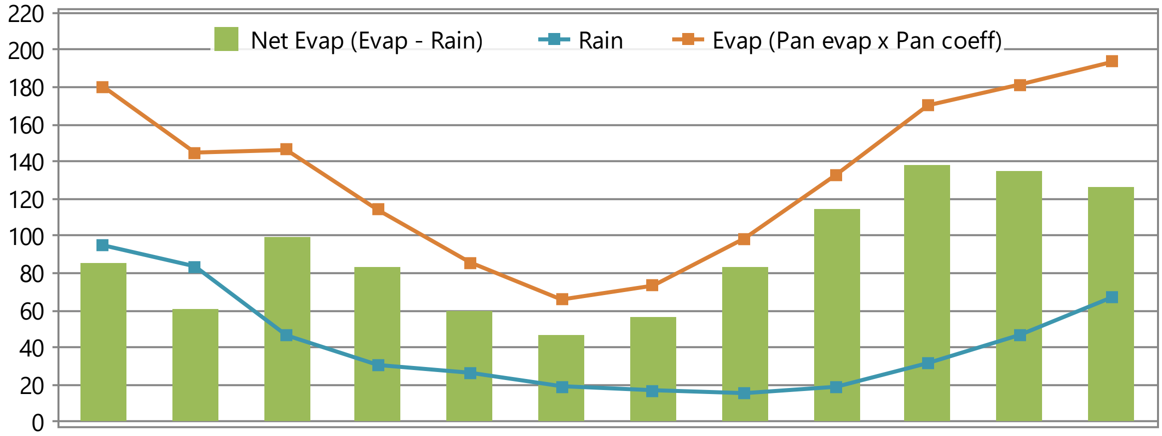
DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Averaged Historical Climate Data Used in Simulation (mm)

Location: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019   51 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Evap	180.3	144.9	146.3	113.9	85.9	65.9	73.3	98.8	133.0	170.3	181.4	193.5	1587.4
Net Evap	85.3	61.1	99.6	83.3	59.4	46.6	56.2	83.3	114.1	138.6	134.6	126.6	1088.6
Net Evap/day	2.8	2.2	3.2	2.8	1.9	1.6	1.8	2.7	3.8	4.5	4.5	4.1	3.0

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Pond System: 1 closed storage tank

New Generic System - 1826.18 m3/year or 5.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

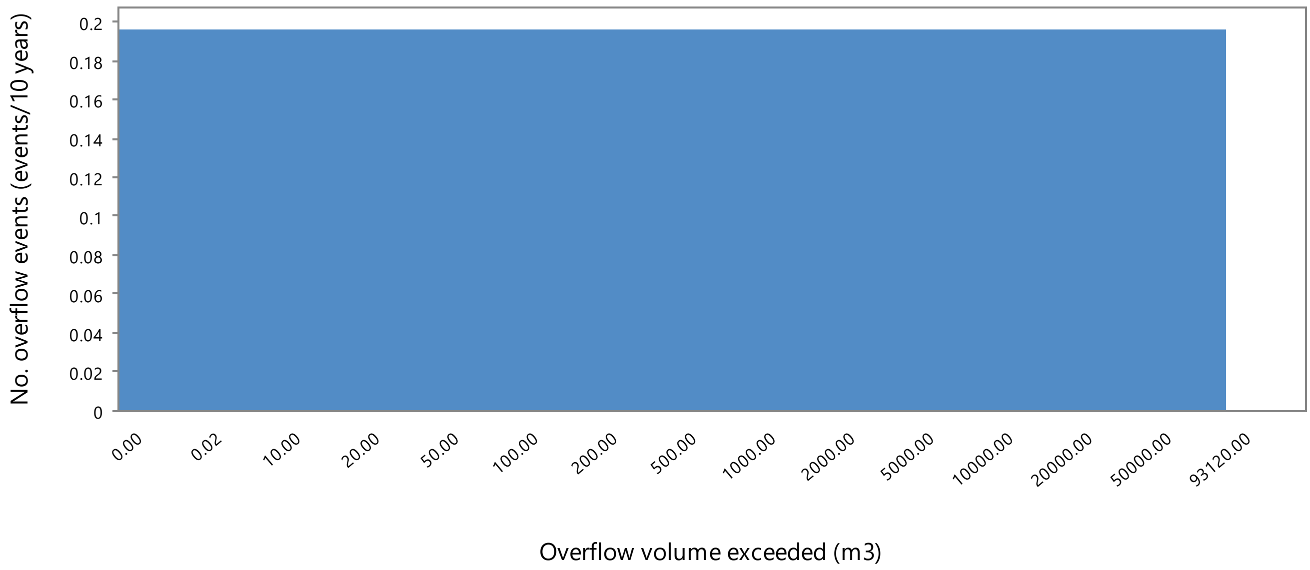
Last pond (Wet weather store): 30.00 m3

Theoretical hydraulic retention time (days)	6.00
Average volume of overflow (m3/year)	1825.88
No. overflow events per year exceeding threshold* of 0.02 m3 (no./year)	0.02
Average duration of overflow (days)	18624.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% effluent reuse (fraction)	0.00
Average salinity of last pond (dS/m)	1.60
Salinity of last pond on final day of simulation (dS/m)	1.60
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

■ Chart ☐ Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Irrigation Information

Irrigation: 0.4 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	0.00	0.00
Total nitrogen applied (kg)	0.00	0.00
Total phosphorus applied (kg)	0.00	0.00
Total salts applied (kg)	0.00	0.00

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	1.00

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 2.00 mm and rainfall is less than or equal to 0.10 mm
Irrigate up to a soil water content of drained upper limit plus 0.00 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil Evap	40.2	37.9	24.5	16.6	14.1	13.4	12.7	11.7	11.4	22.3	33.0	39.7	277.5
Transpn.	25.7	27.5	21.2	10.3	7.0	5.6	5.9	4.0	4.8	6.1	10.8	16.2	145.1
Runoff	5.1	2.6	1.0	0.3	0.1	0.1	0.1	0.2	0.2	0.6	0.1	0.2	10.4
Drainage	14.1	19.4	8.4	5.7	6.1	2.2	1.3	0.5	2.1	3.2	1.5	3.0	67.4
Delta	9.9	-3.6	-8.5	-2.2	-0.7	-1.9	-3.0	-0.9	0.4	-0.5	1.5	7.8	-1.6

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	0.00
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	37.93
Average annual soil nitrogen removed by denitrification (kg/ha/year)	2.38E-03
Average annual soil nitrogen leached (kg/ha/year)	0.92
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.92
Soil organic-N kg/ha (Initial - Final)	3456.00 - 1634.41
	54.60 - 5.93
Average nitrate-N concentration of deep drainage (mg/L)	1.37
Max. annual nitrate-N concentration of deep drainage (mg/L)	11.47

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	0.00
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	2.90
Average annual soil phosphorus leached (kg/ha/year)	0.07
Dissolved phosphorus (kg/ha) (Initial - Final)	0.49 - 0.31
Adsorbed phosphorus (kg/ha) (Initial - Final)	3201.01 - 3066.49
Average phosphate-P concentration in rootzone (mg/L)	0.02
Average phosphate-P concentration of deep drainage (mg/L)	0.10
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.10
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.00 mg/L (years)	0.00

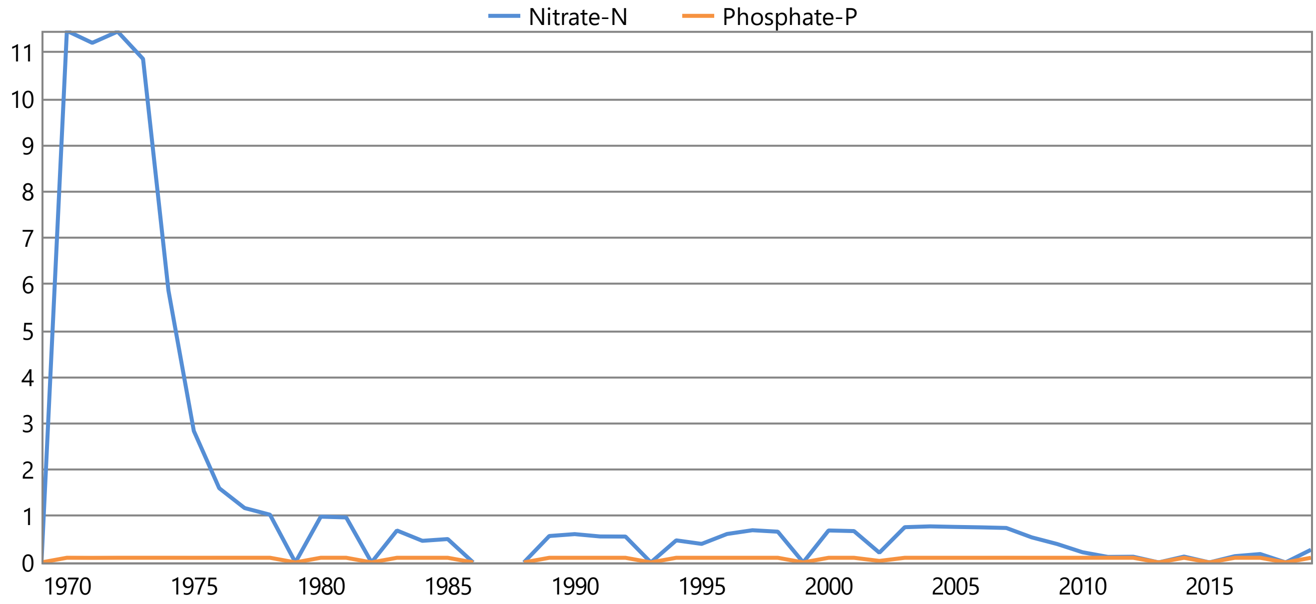
DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

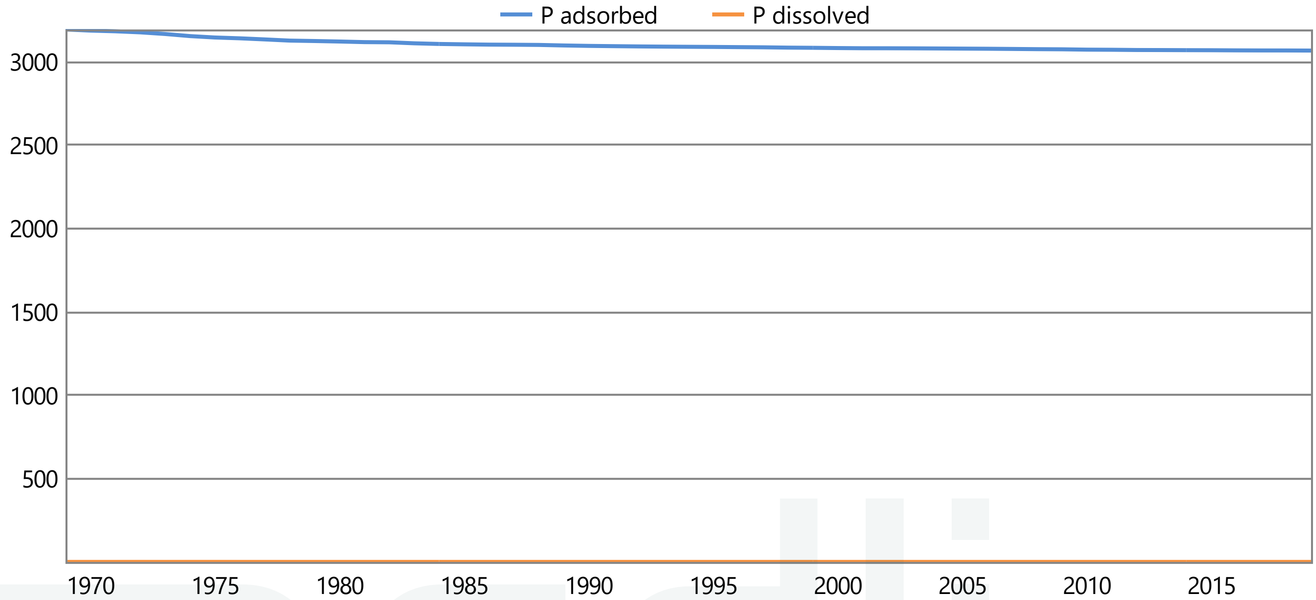
Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Plant Performance: LAA: 0.4 ha

Average Plant Performance (Minimum - Maximum): Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	3320.43 (1046.57 - 6753.94)
Average monthly plant (green) cover (fraction)	0.18 (0.07 - 0.34)
Average monthly crop factor (fraction)	0.11 (0.05 - 0.21)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	125.39 (62.29 - 215.15)
Average number of normal harvests per year (no./year)	0.02 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of crop deaths per year (no./year)	3.63 (2.00 - 8.00)
Average number of crop deaths for last five years only (no./year)	3.60
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.30 (0.08 - 0.58)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.10)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.60 (0.31 - 0.84)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.20 (0.12 - 0.31)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	173.88

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Insufficient deep drainage to run steady state salinity calculations.

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

This is a Dryland scenario
No effluent irrigation has occurred!
Full run chosen

B3 – MEDLI Outputs – Fixed Application Rate Approach

Enterprise: **WC-GPS Galilee Power Station**

Description:
Operational Phase - 5,000L/day, 45TN, 15TP

Client: **Waratah Coal**

MEDLI User: Marc Walker (EMCA)

Scenario Details:
Fixed Application Rate Approach - irrigate 6mm every 3 days

DESCRIPTION

Climate Data: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019 51 years, 0 days

Climate Statistics:

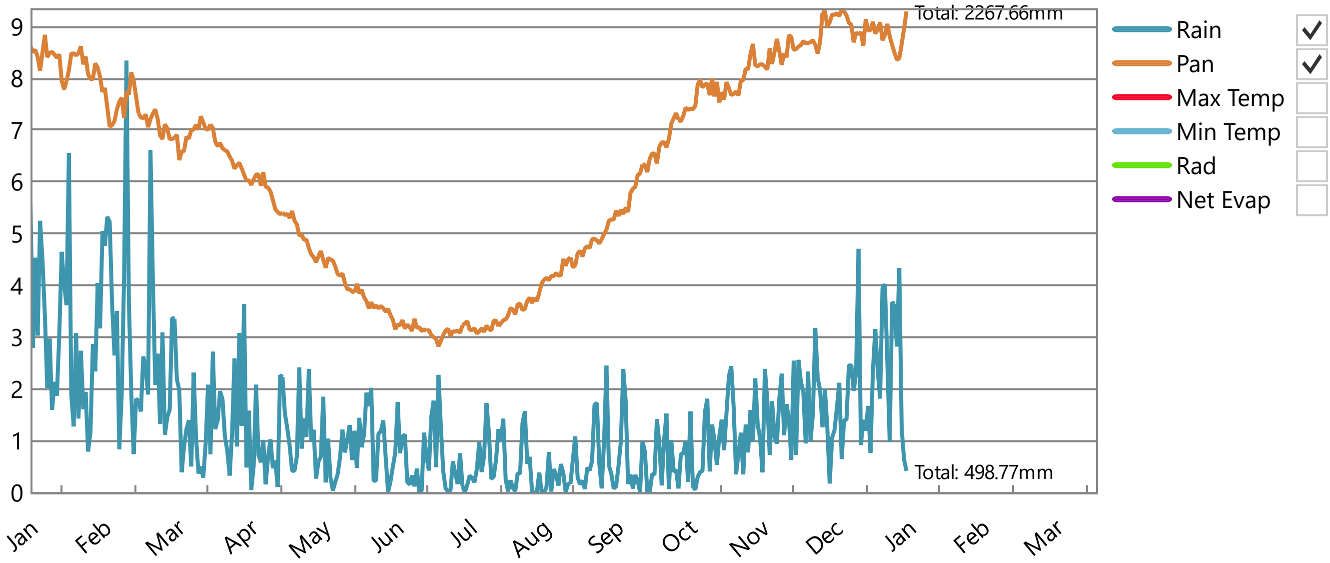
	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	276	419	860
Pan Evaporation (mm/year)	1991	2318	2506

Climate Data:

■ Chart ☐ Table

☐ Monthly ■ Daily

Daily Average Across Run Period



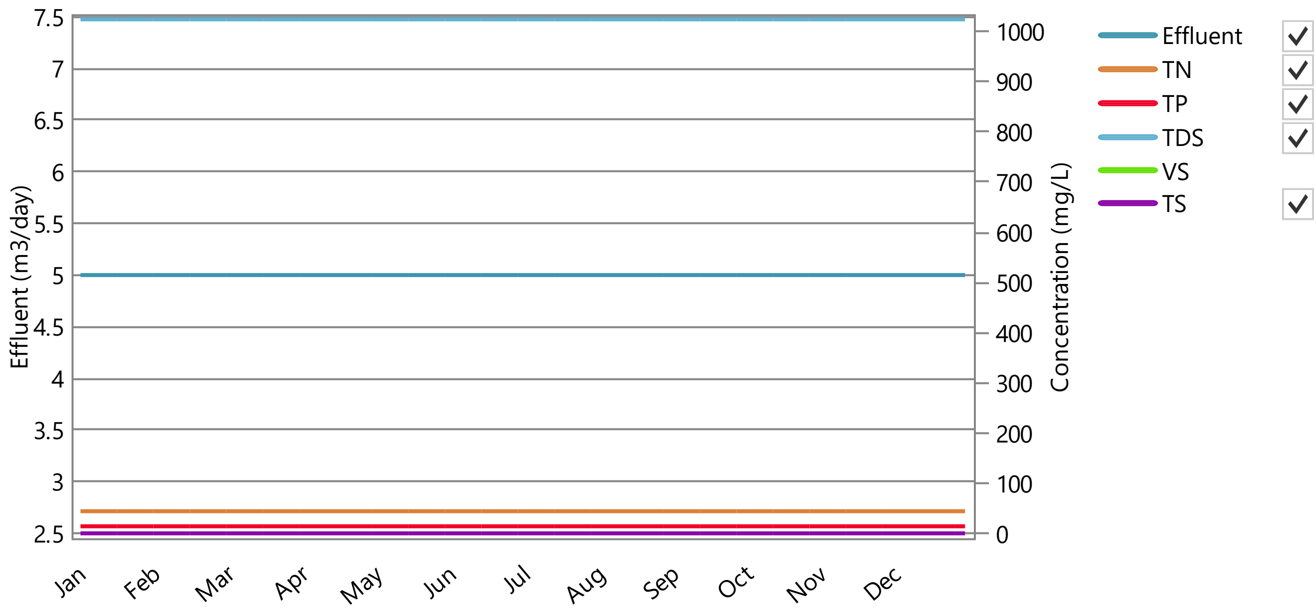
DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

Chart Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **1826.18 m3/year** or 5.00 m3/day (Min-Max: 5.00 - 5.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

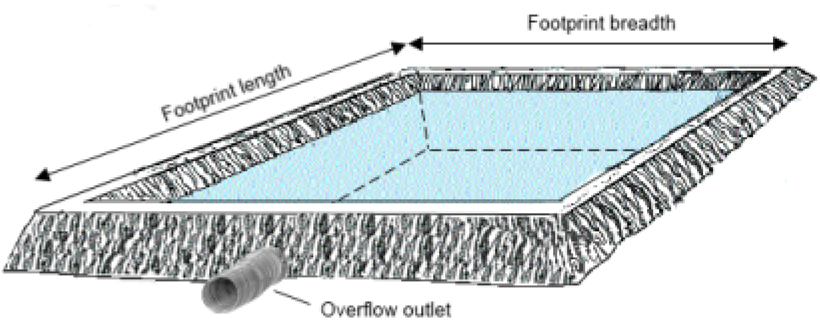
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

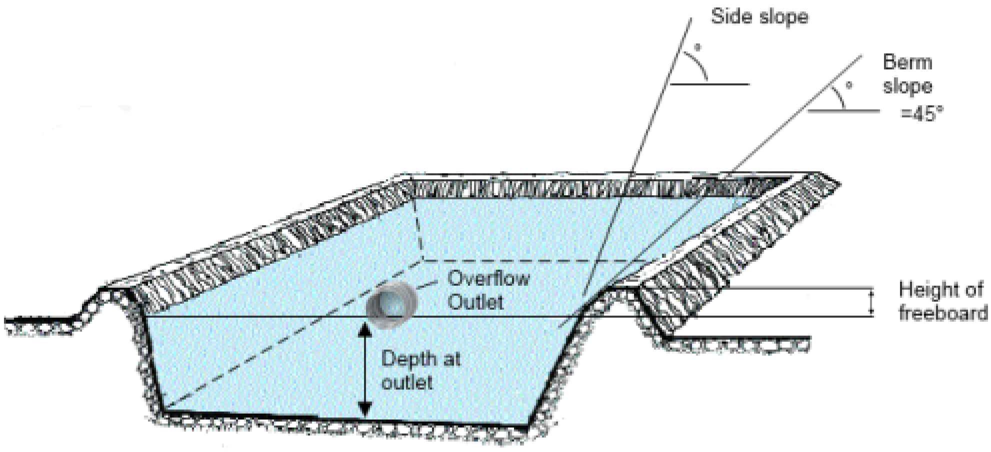
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	30.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	2.00
Maximum water surface area (m2)	15.00
Pond footprint length (m)	3.87
Pond footprint width (m)	3.87
Pond catchment area (m2)	15.00
Average active volume (m3)	5.00





Irrigation pump limits:

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump limit	As scheduled

Shandying water:

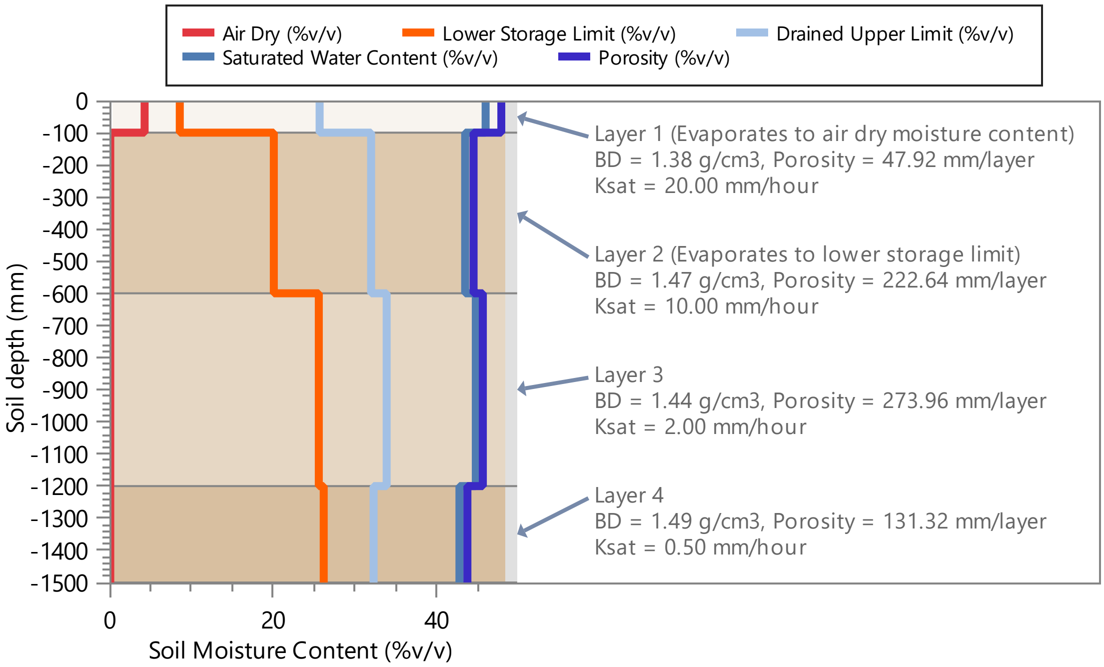
Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

Land: LAA

Area (ha): 0.40

Soil Type: Low Permeability Red Brown Earth, 1500.00 mm defined profile depth

Profile Porosity (mm)	675.85
Profile saturation water content (mm)	660.70
Profile drained upper limit (or field capacity) (mm)	486.00
Profile lower storage limit (or permanent wilting point) (mm)	341.30
Profile available water capacity (mm)	144.70
Profile limiting saturated hydraulic conductivity (mm/hour)	0.50
Surface saturated hydraulic conductivity (mm/hour)	20.00
Runoff curve number II (coefficient)	75.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Rhodes Grass Pasture - 500mm rooting

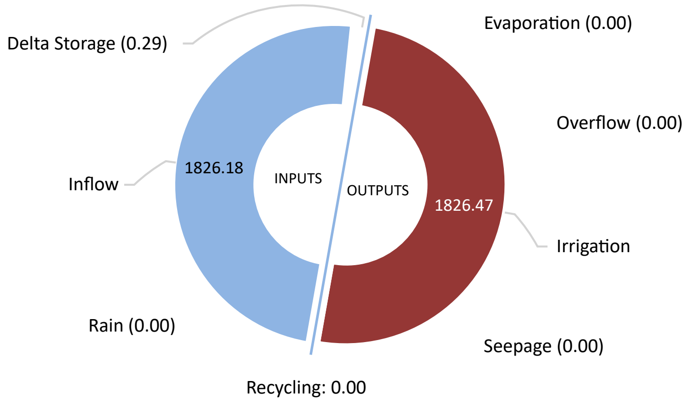
Average monthly cover (fraction) (minimum - maximum)	0.70 (0.65 - 0.75)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.9 x Pan coefficient 0.7)	0.63
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	500.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **30 m3**

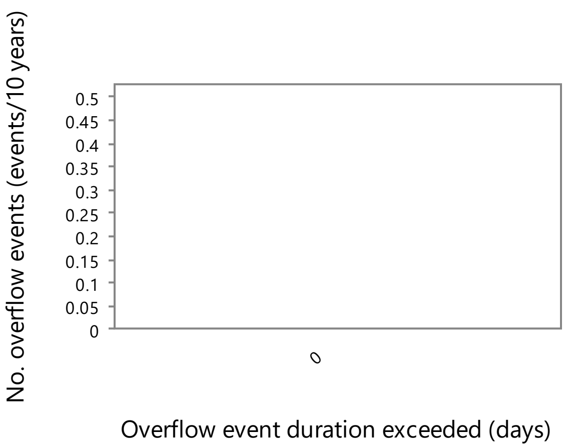
Pond System Water Balance (m3/year)



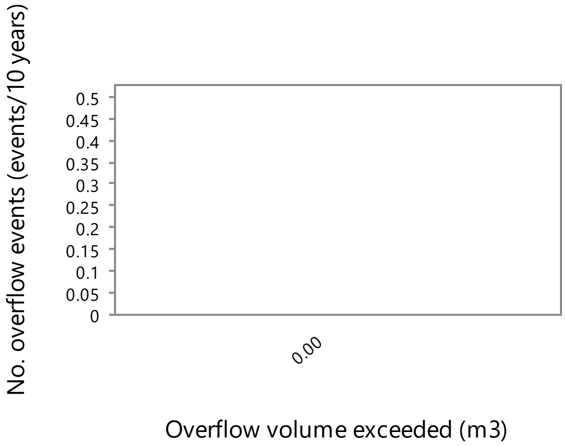
Name	Value
Rain	0.00
Inflow	1826.18
Recycling	0.00
Evaporation	0.00
Overflow	0.00
Irrigation	1826.47
Seepage	0.00
Delta Storage	-0.29

Overflow Diagnostics

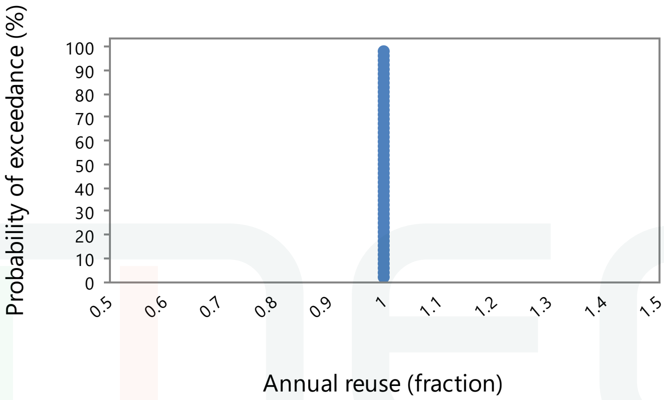
Volume of overflow (m3/year)	0.00
No. days pond overflows (days/year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00



Export plot



Export plot



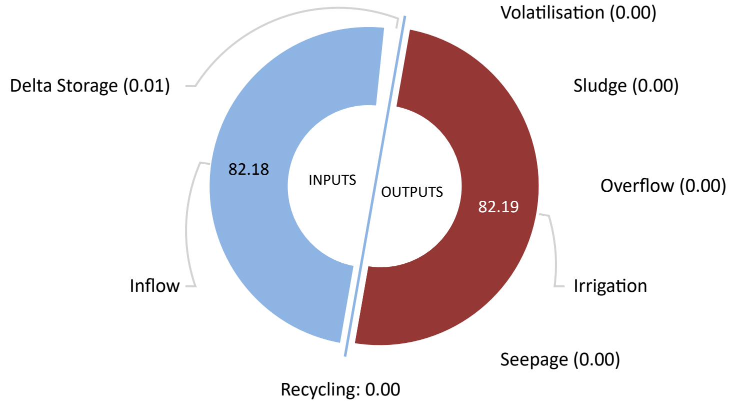
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

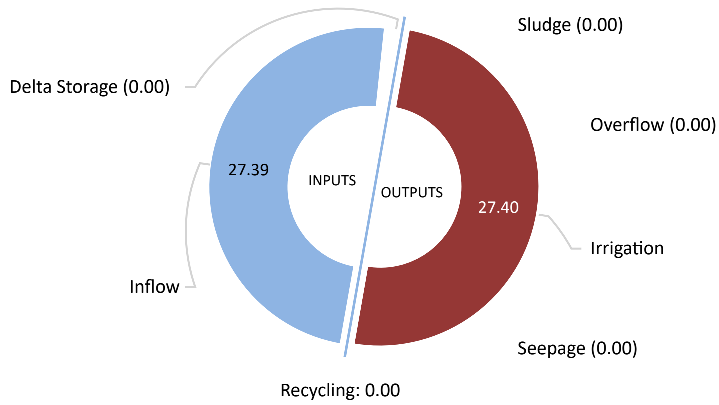
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



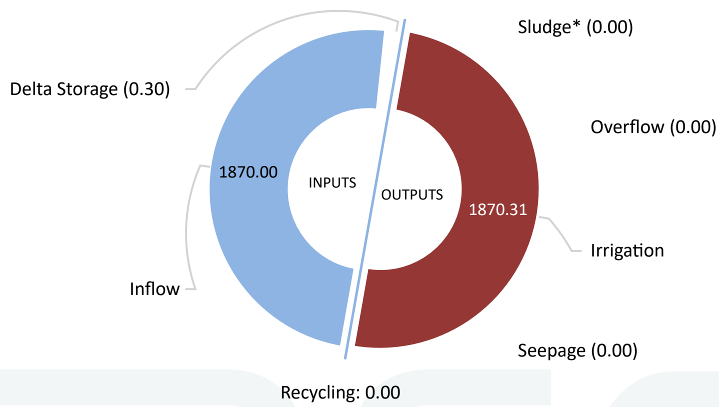
Name	Value
Inflow	82.18
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.00
Irrigation	82.19
Seepage	0.00
Delta Storage	-0.01

Phosphorus Balance (kg/year)



Name	Value
Inflow	27.39
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	27.40
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	1870.00
Recycling	0.00
Sludge*	0.00
Overflow	0.00
Irrigation	1870.31
Seepage	0.00
Delta Storage	-0.30

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	45.00
Average phosphorus concentration of pond liquid (mg/L)	15.00
Average salinity of pond liquid (dS/m)	1.60

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	N.D.*
Final phosphorus concentration of pond liquid (mg/L)	N.D.*
Final salinity of pond liquid (dS/m)	N.D.*

* Not determined. Pond is empty.

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	1826.47
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	1826.47
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	45.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	42.30
Average phosphorus concentration of irrigation water (mg/L)	15.00
Average salinity of irrigation water (dS/m)	1.60

Irrigation Diagnostics:

Proportion Days Irrigation Turned Off (fraction)	0.67
Proportion of Days irrigation occurs (fraction)	0.33

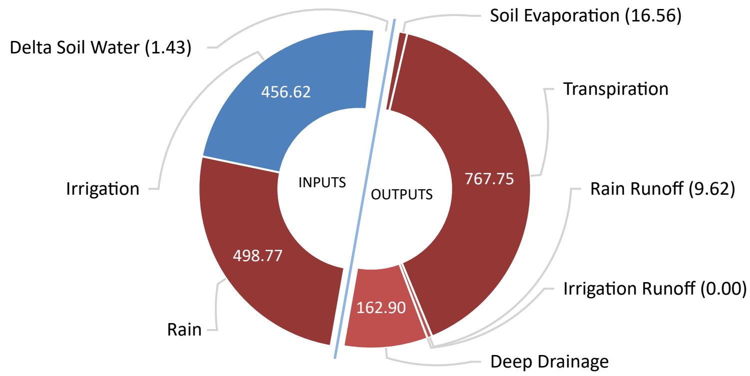
PERFORMANCE

Land Performance - Soil Water

Paddock: LAA, 0.4 ha
Soil Type: Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

Land Water Balance (mm/year):

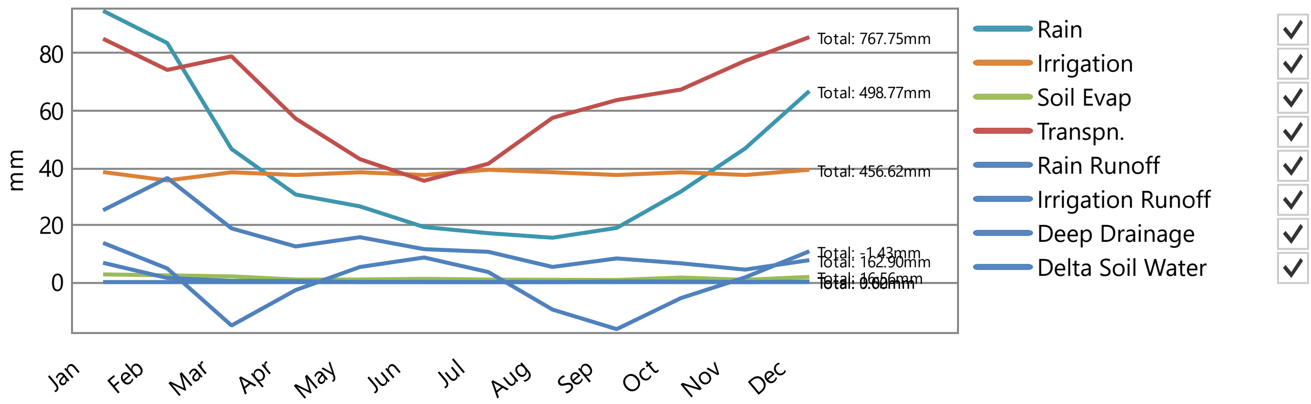
■ mm/year ☐ % Total inputs



Name	Value
Rain	498.77
Irrigation	456.62
Soil Evaporation	16.56
Transpiration	767.75
Rain Runoff	9.62
Irrigation Runoff	0.00
Deep Drainage	162.90
Delta Soil Water	-1.43

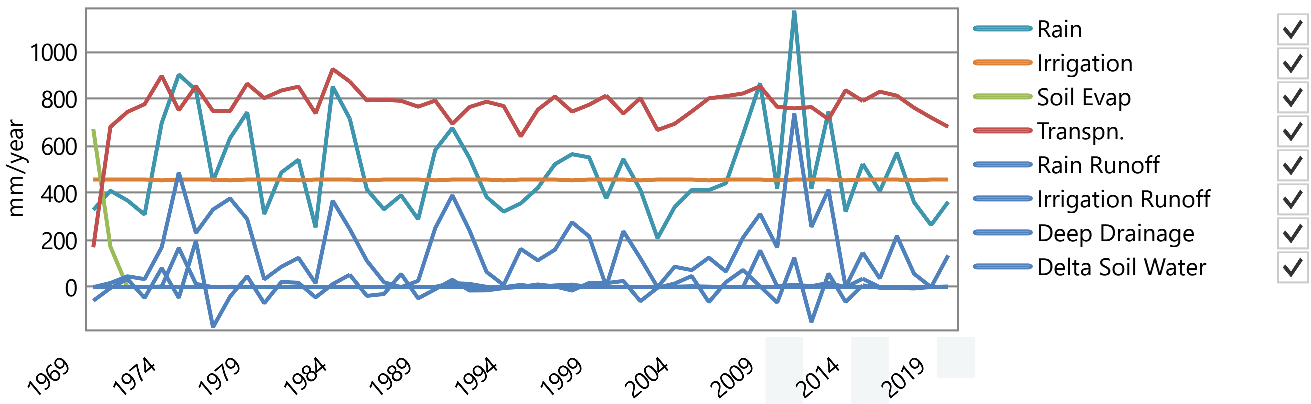
Average Monthly Totals (mm):

■ Chart ☐ Table



Average Annual Totals (mm/year):

■ Chart ☐ Table



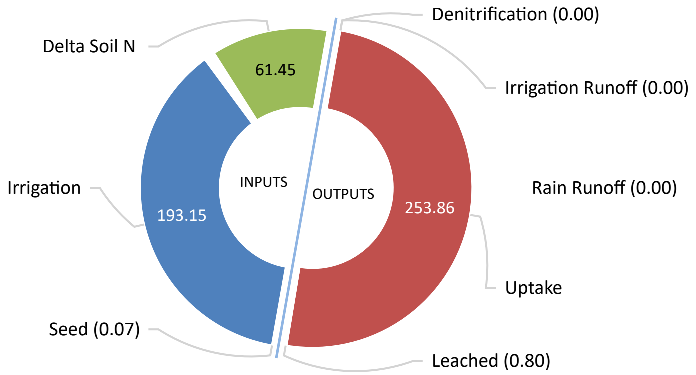
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

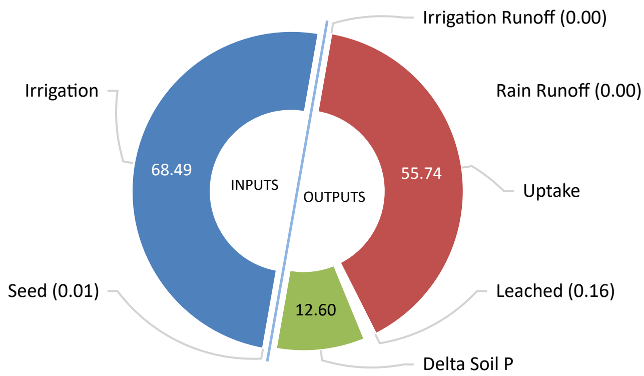
Irrigation ammonium volatilisation losses (kg/ha/year): 12.33
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.30

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.07
Irrigation	193.15
Denitrification	4.52E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	253.86
Leached	0.80
Delta Soil N	-61.45

Land Phosphorus Balance (kg/ha/year)



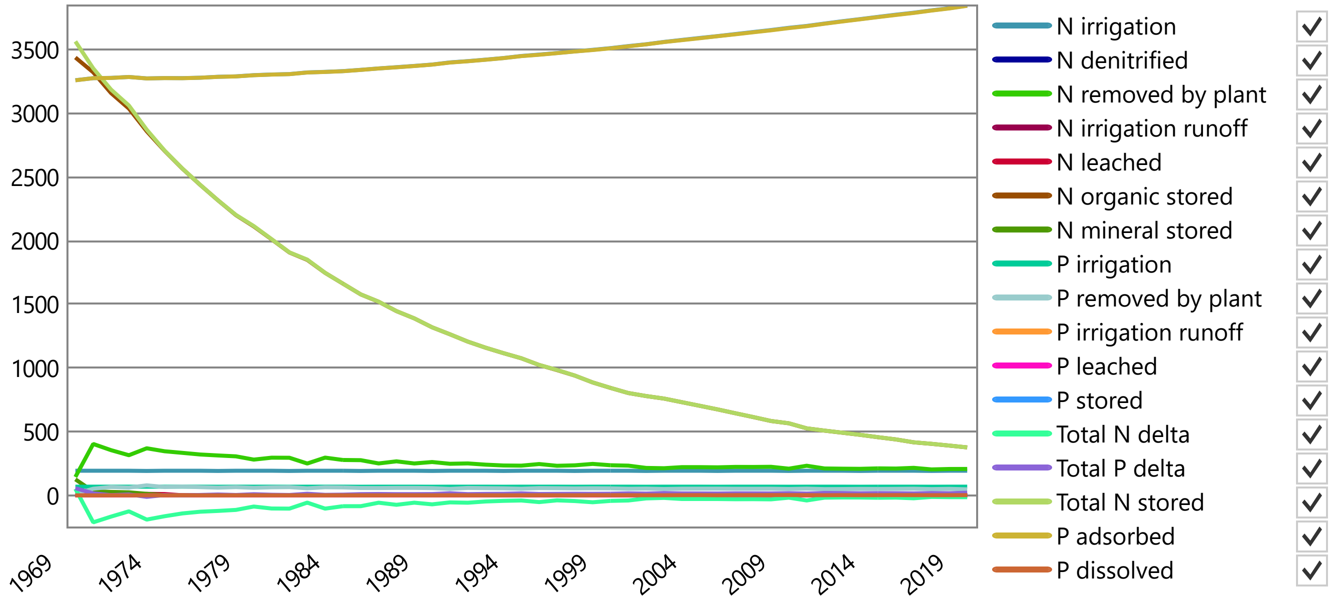
Name	Value
Seed	0.01
Irrigation	68.49
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	55.74
Leached	0.16
Delta Soil P	12.60

PERFORMANCE

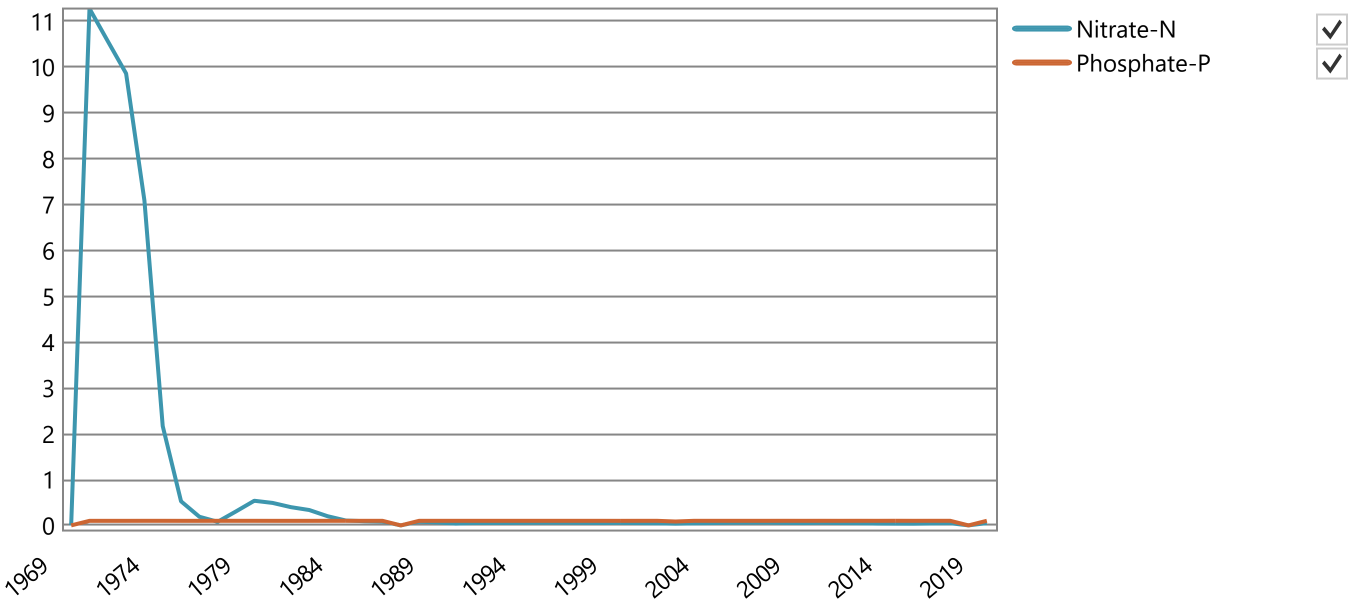
Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: LAA, 0.4 ha **Soil Type: Low Permeability Red Brown Earth**

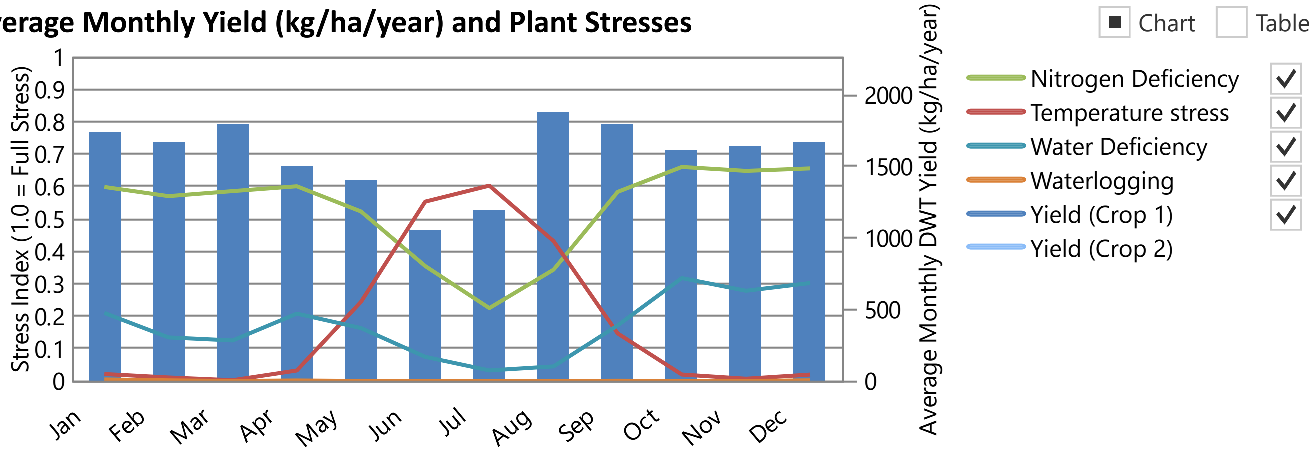
Plant: Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	19002.37 (7570.53 - 26724.85)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.70 (0.65 - 0.75)
Average monthly root depth (mm) (minimum - maximum)	492.12 (489.69 - 495.68)

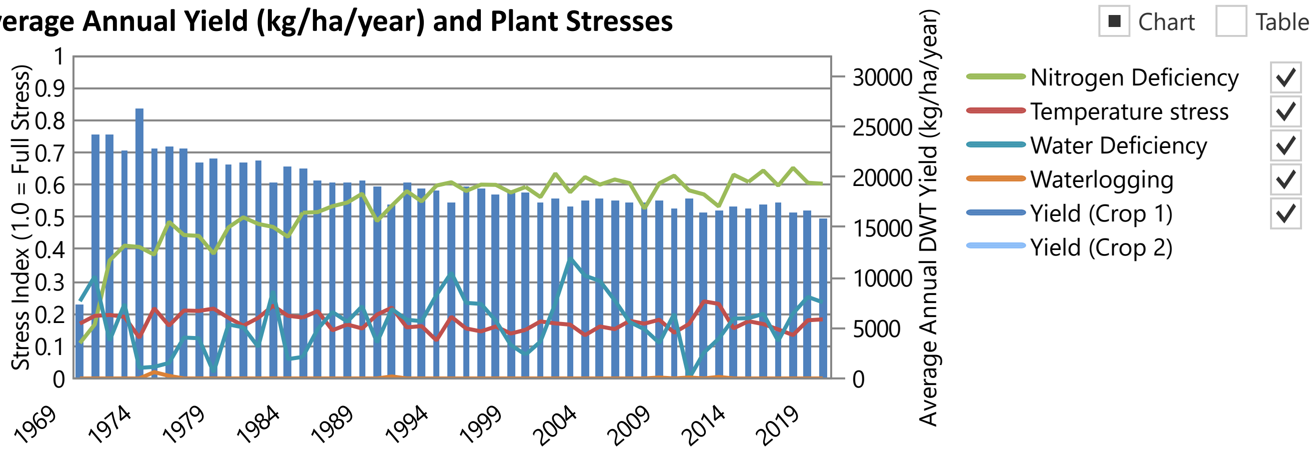
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	253.86 (144.69 - 403.62)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	55.74 (12.63 - 79.14)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.003 (0.002 - 0.003)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 3.27 (normal), 0.10 (forced by crop death due to water stress (0.10))
No. days without crop/year (days/year): 2.76 due to water stress (2.76)

PERFORMANCE

Land Performance

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

Plant: Continuous Rhodes Grass Pasture - 500mm rooting

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

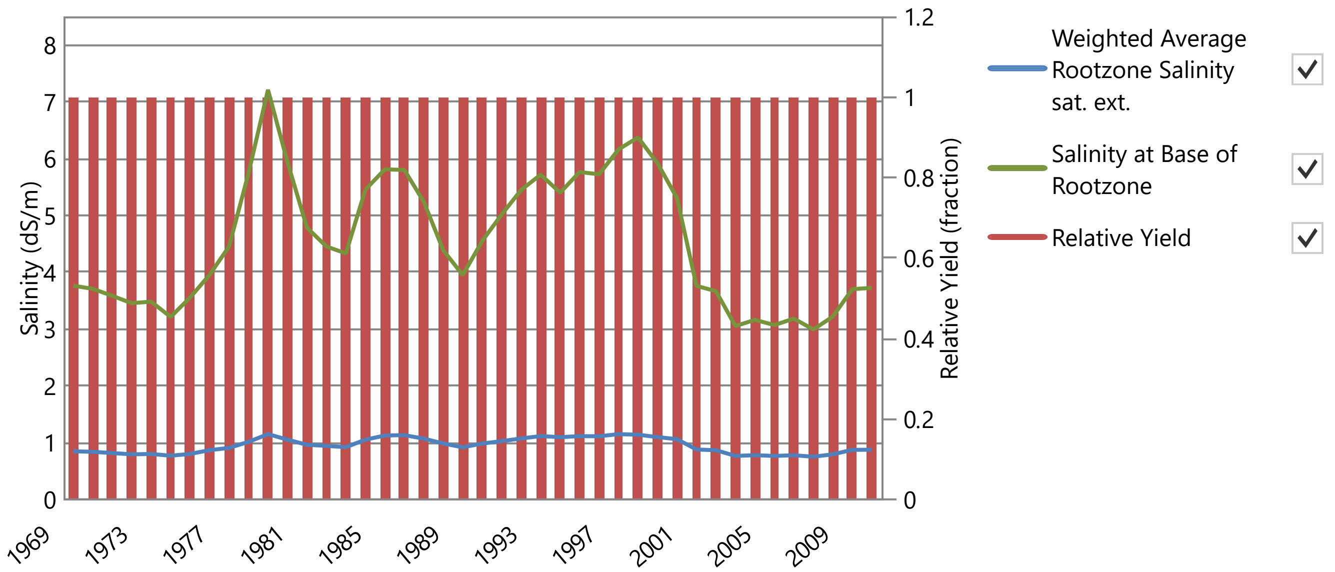
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.78
Salt added by rainfall (kg/ha/year)	93.92
Average annual effluent salt added & leached at steady state (kg/ha/year)	4769.68
Average leaching fraction based on 10 year running averages (fraction)	0.38
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.95
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	4.55
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

■ Chart ☐ Table

All values based on 10 year running averages

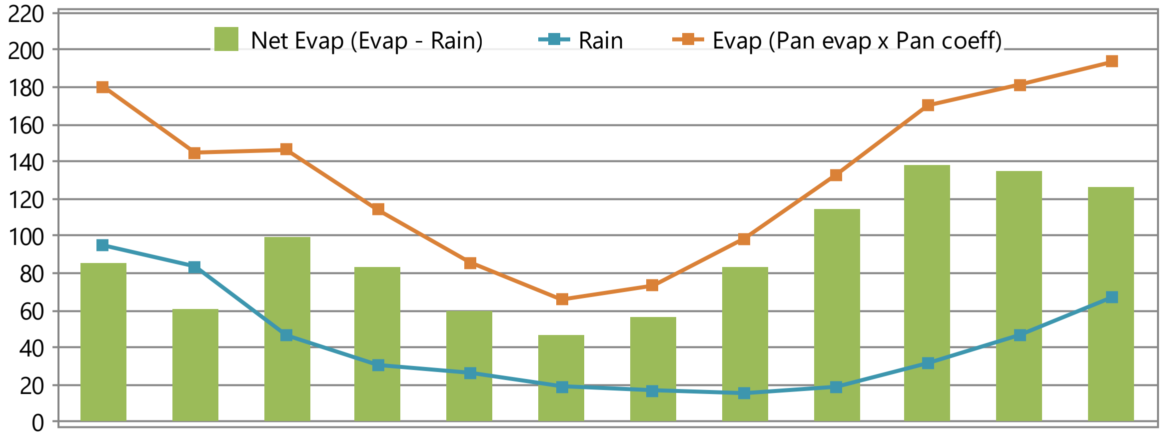


Sustainability Diagnostics: WC-GPS Galilee Power Station

Averaged Historical Climate Data Used in Simulation (mm)

Location: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019   51 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Evap	180.3	144.9	146.3	113.9	85.9	65.9	73.3	98.8	133.0	170.3	181.4	193.5	1587.4
Net Evap	85.3	61.1	99.6	83.3	59.4	46.6	56.2	83.3	114.1	138.6	134.6	126.6	1088.6
Net Evap/day	2.8	2.2	3.2	2.8	1.9	1.6	1.8	2.7	3.8	4.5	4.5	4.1	3.0

DIAGNOSTICS

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Pond System: 1 closed storage tank

New Generic System - 1826.18 m3/year or 5.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

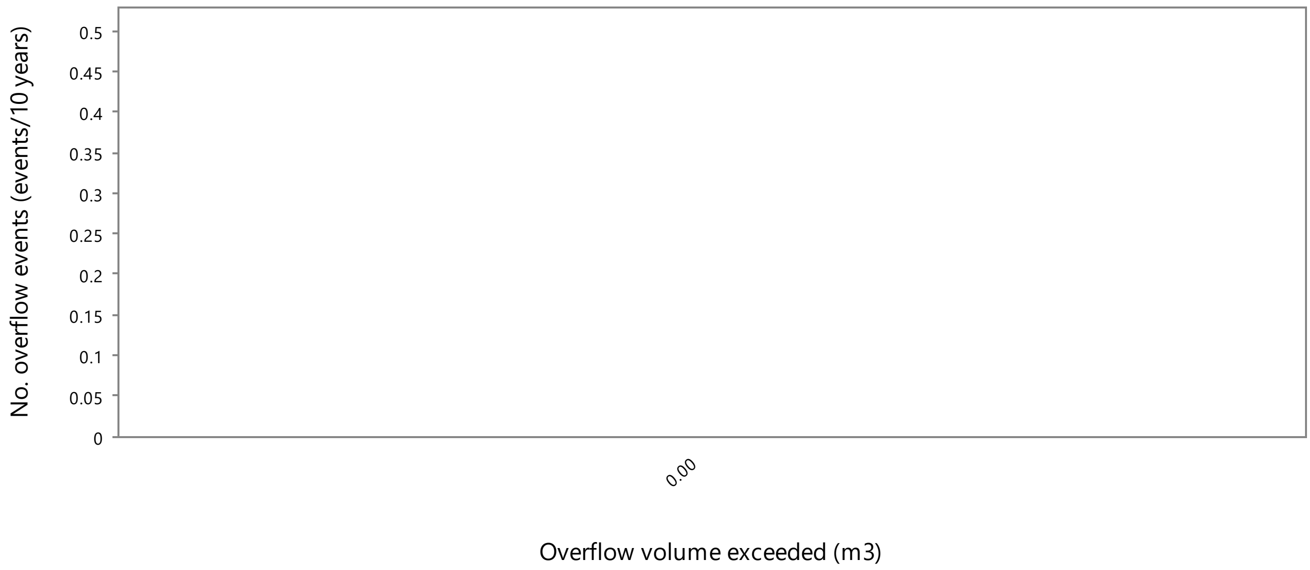
Last pond (Wet weather store): 30.00 m3

Theoretical hydraulic retention time (days)	6.00
Average volume of overflow (m3/year)	0.00
No. overflow events per year exceeding threshold* of 0.02 m3 (no./year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	1.60
Salinity of last pond on final day of simulation (dS/m)	1.60
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

■ Chart ☐ Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Irrigation Information

Irrigation: 0.4 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	1826.47	4566.18
Total nitrogen applied (kg)	77.26	193.15
Total phosphorus applied (kg)	27.40	68.49
Total salts applied (kg)	1870.31	4675.76

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	0.67
Proportion of Days irrigation occurs (fraction)	0.33

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Irrigation triggered every 3 days
Irrigate a fixed amount of 6.00 mm each day
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Irrigation	38.5	35.6	38.5	37.5	38.5	37.5	39.3	38.5	37.5	38.5	37.5	39.3	456.6
Soil Evap	2.7	2.3	2.0	0.9	0.9	1.1	0.9	0.8	0.7	1.6	0.8	1.8	16.6
Transpn.	85.2	74.3	79.1	57.2	43.1	35.5	41.5	57.5	63.7	67.4	77.5	85.8	767.7
Rain Runoff	6.7	1.4	0.4	0.3	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.2	9.6
Irr. Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	25.2	36.4	18.8	12.5	15.7	11.5	10.6	5.3	8.3	6.6	4.4	7.7	162.9
Delta	13.7	4.8	-15.2	-2.8	5.3	8.6	3.5	-9.6	-16.5	-5.6	1.6	10.8	-1.4

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	193.15
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	253.86
Average annual soil nitrogen removed by denitrification (kg/ha/year)	4.52E-03
Average annual soil nitrogen leached (kg/ha/year)	0.80
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.80
Soil organic-N kg/ha (Initial - Final)	3456.00 - 376.57
	54.60 - 0.16
Average nitrate-N concentration of deep drainage (mg/L)	0.49
Max. annual nitrate-N concentration of deep drainage (mg/L)	11.28

Soil Phosphorus Balance

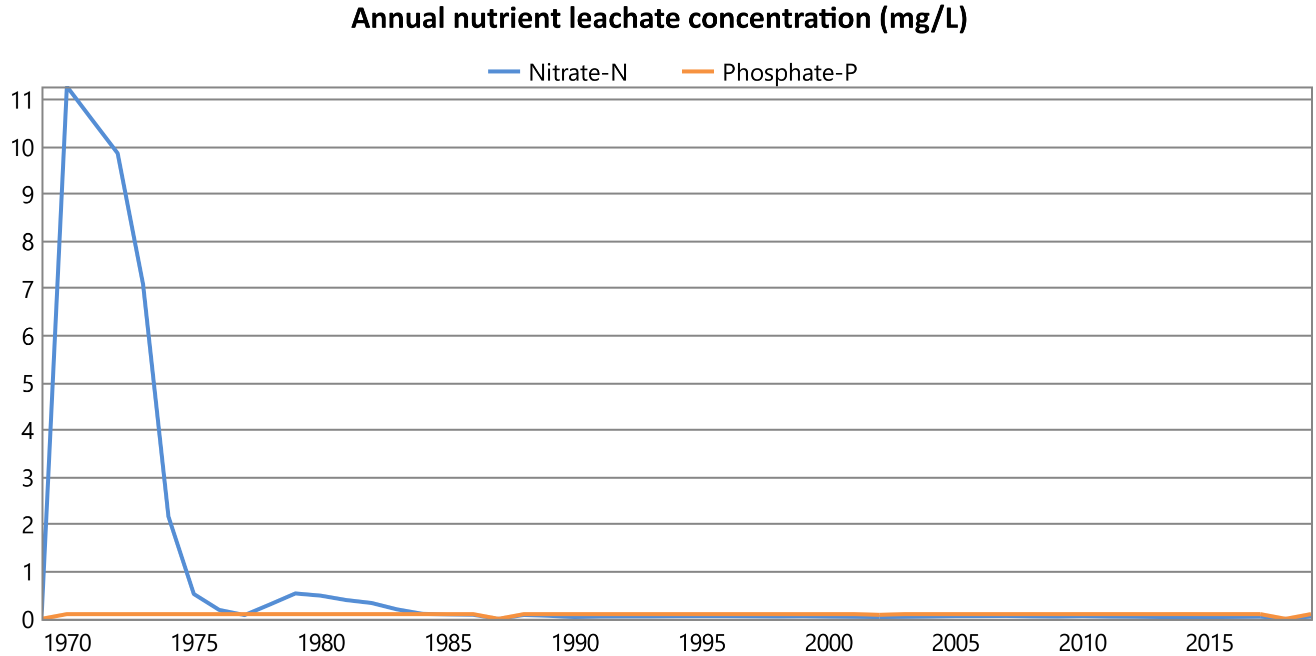
Average annual effluent phosphorus added (kg/ha/year)	68.49
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	55.74
Average annual soil phosphorus leached (kg/ha/year)	0.16
Dissolved phosphorus (kg/ha) (Initial - Final)	0.49 - 2.02
Adsorbed phosphorus (kg/ha) (Initial - Final)	3201.01 - 3842.13
Average phosphate-P concentration in rootzone (mg/L)	0.75
Average phosphate-P concentration of deep drainage (mg/L)	0.10
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.10
Design soil profile storage life based on average infiltrated water phosphorus concn. of 7.24 mg/L (years)	74.06

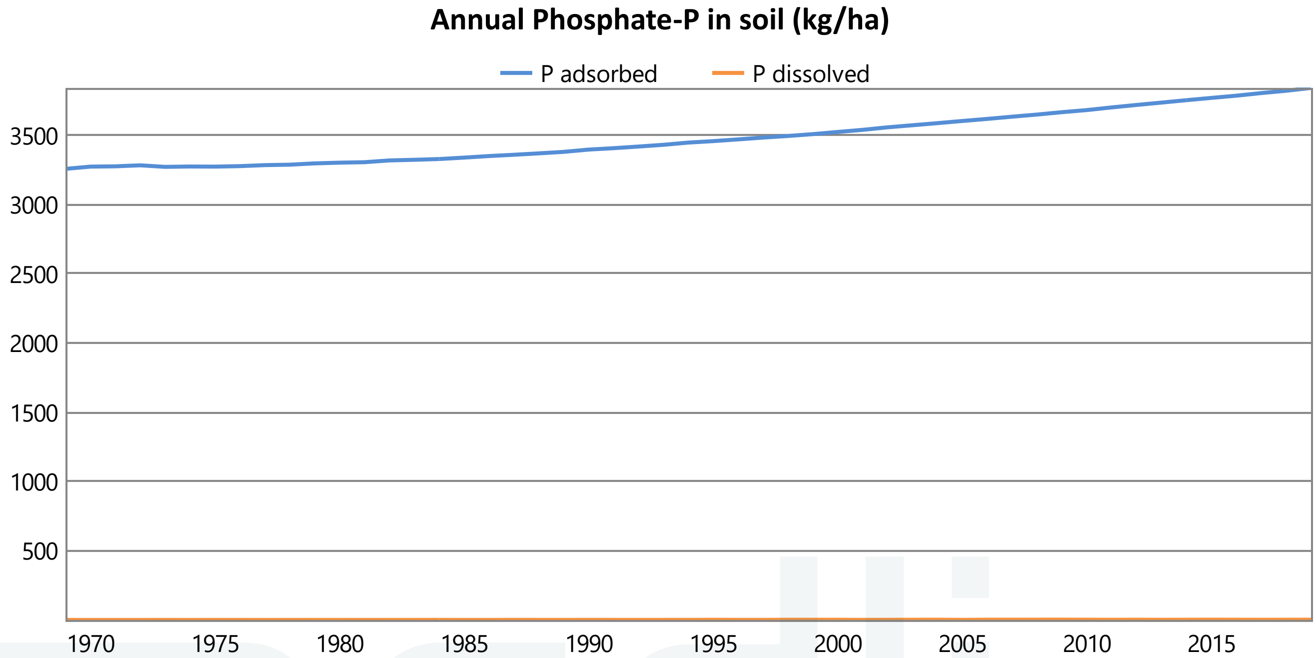
DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation





DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Plant Performance: LAA: 0.4 ha

Average Plant Performance (Minimum - Maximum): Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	19002.37 (7570.53 - 26724.85)
Average monthly plant (green) cover (fraction)	0.70 (0.65 - 0.75)
Average monthly crop factor (fraction)	0.44 (0.41 - 0.47)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	492.12 (489.69 - 495.68)
Average number of normal harvests per year (no./year)	3.27 (0.00 - 5.00)
Average number of normal harvests for last five years only (no./year)	3.00
Average number of crop deaths per year (no./year)	0.10 (0.00 - 4.00)
Average number of crop deaths for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.53 (0.11 - 0.65)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.10)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.60 (0.31 - 0.84)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.17 (0.03 - 0.32)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	2.76

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.78
Salt added by rainfall (kg/ha/year)	93.92
Average annual effluent salt added & leached at steady state (kg/ha/year)	4769.68
Average leaching fraction based on 10 year running averages (fraction)	0.38
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.95
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	4.55
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

B4 – MEDLI Outputs – Soil Water Deficit Approach

Enterprise: WC-GPS Galilee Power Station

Description:
Operational Phase - 5,000L/day, 45TN, 15TP

Client: Waratah Coal

MEDLI User: Marc Walker (EMCA)

Scenario Details:
Soil Water Deficit Approach - irrigate when SWD reaches 2mm, up to DUL

DESCRIPTION

Climate Data: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019 51 years, 0 days

Climate Statistics:

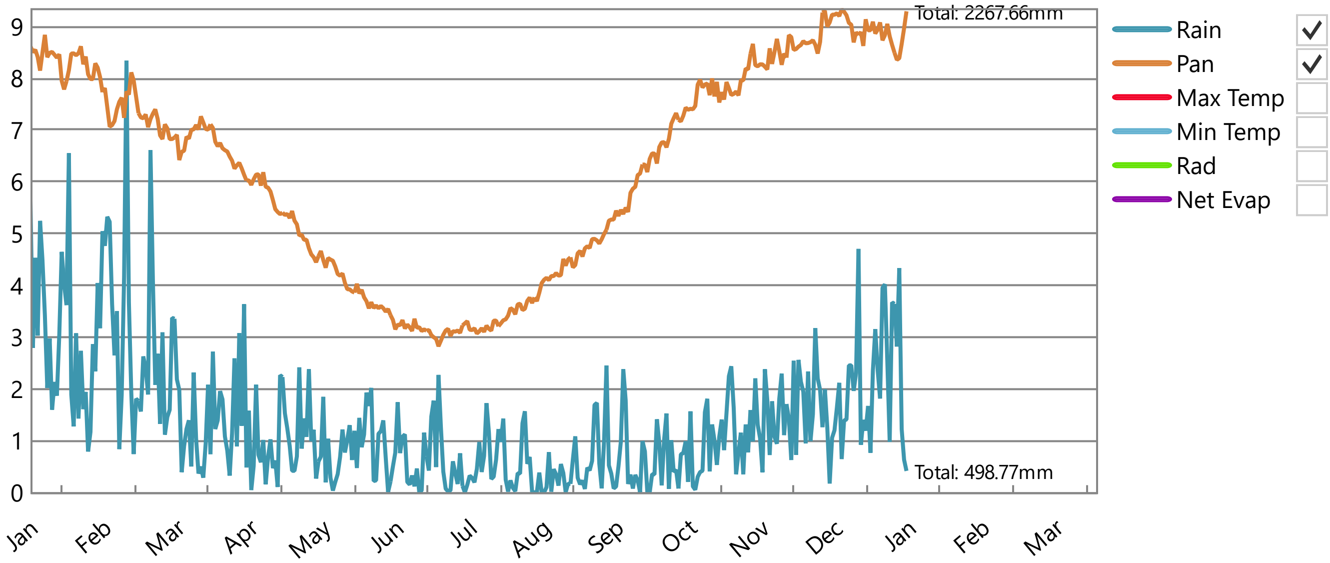
	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	276	419	860
Pan Evaporation (mm/year)	1991	2318	2506

Climate Data:

■ Chart ☐ Table

☐ Monthly ■ Daily

Daily Average Across Run Period



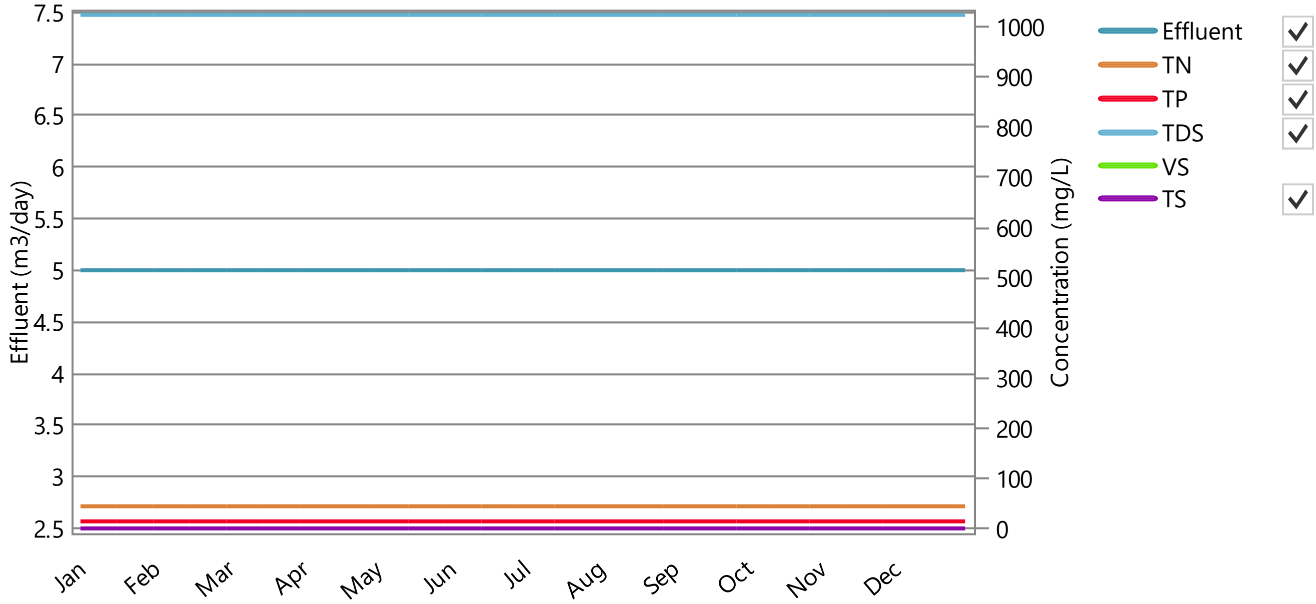
DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

■ Chart ☐ Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **1826.18 m3/year** or 5.00 m3/day (Min-Max: 5.00 - 5.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

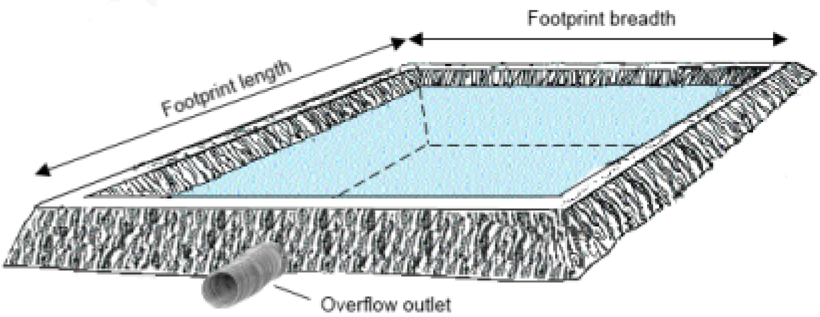
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

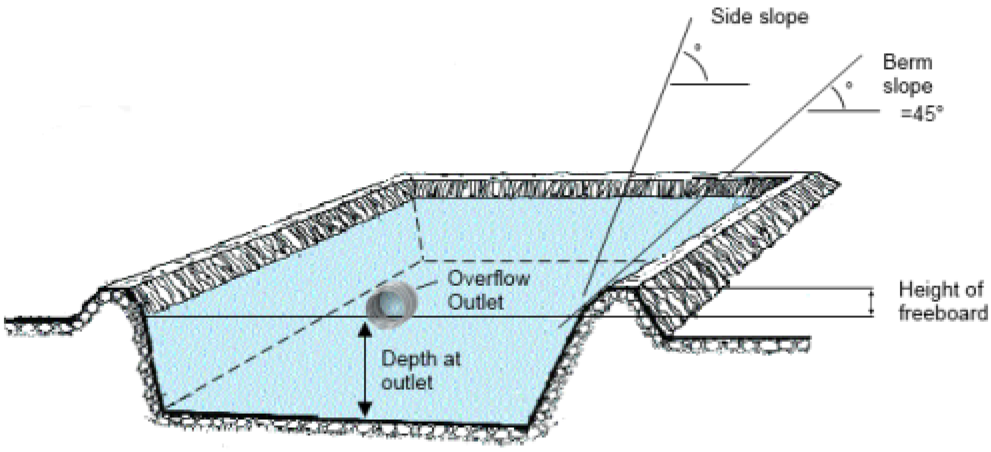
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	30.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	2.00
Maximum water surface area (m2)	15.00
Pond footprint length (m)	3.87
Pond footprint width (m)	3.87
Pond catchment area (m2)	15.00
Average active volume (m3)	4.21





Irrigation pump limits:

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump limit	As scheduled

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

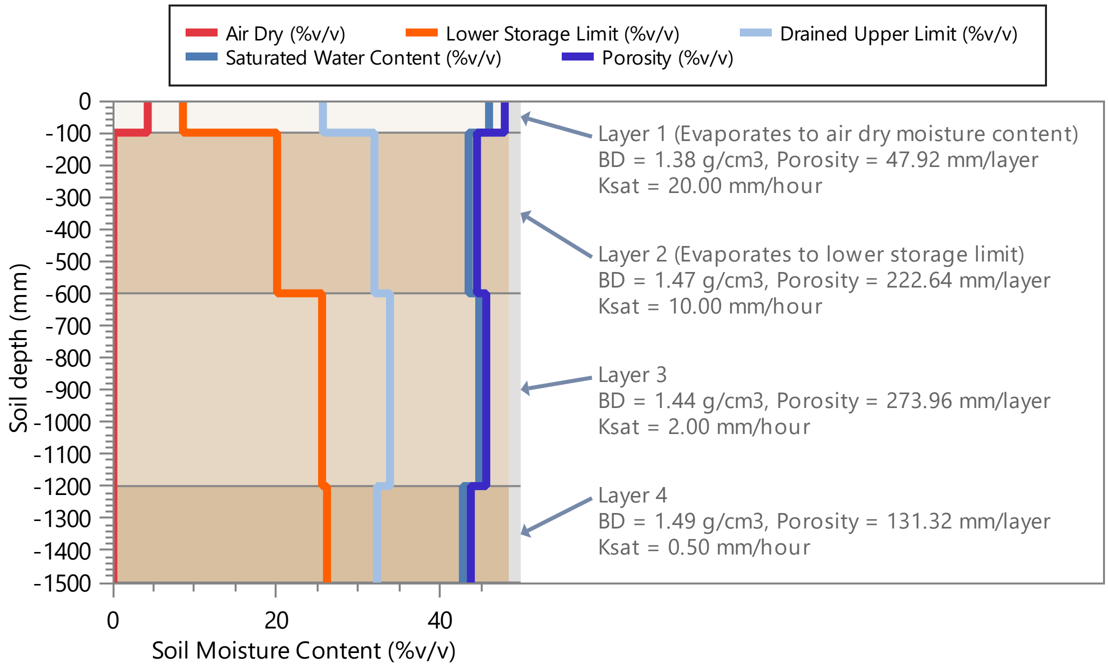
DESCRIPTION

Land: LAA

Area (ha): 0.40

Soil Type: Low Permeability Red Brown Earth, 1500.00 mm defined profile depth

Profile Porosity (mm)	675.85
Profile saturation water content (mm)	660.70
Profile drained upper limit (or field capacity) (mm)	486.00
Profile lower storage limit (or permanent wilting point) (mm)	341.30
Profile available water capacity (mm)	144.70
Profile limiting saturated hydraulic conductivity (mm/hour)	0.50
Surface saturated hydraulic conductivity (mm/hour)	20.00
Runoff curve number II (coefficient)	75.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Rhodes Grass Pasture - 500mm rooting

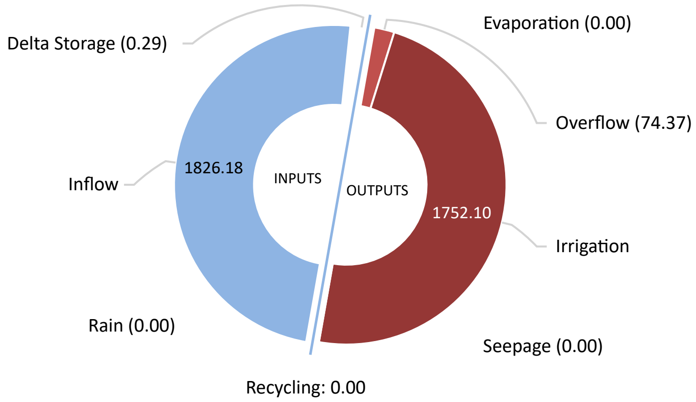
Average monthly cover (fraction) (minimum - maximum)	0.71 (0.65 - 0.76)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.9 x Pan coefficient 0.7)	0.63
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	500.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **30 m3**

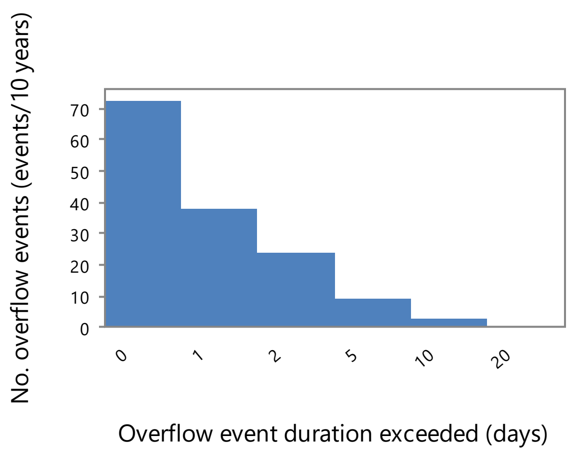
Pond System Water Balance (m3/year)

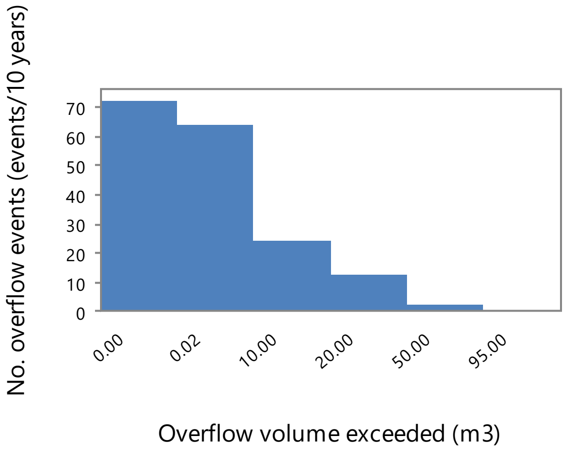


Name	Value
Rain	0.00
Inflow	1826.18
Recycling	0.00
Evaporation	0.00
Overflow	74.37
Irrigation	1752.10
Seepage	0.00
Delta Storage	-0.29

Overflow Diagnostics

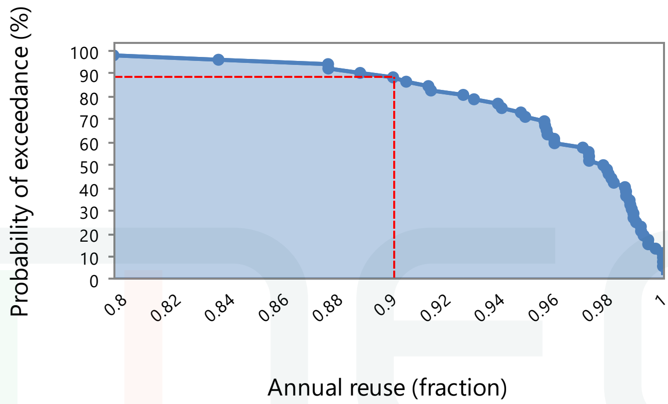
Volume of overflow (m3/year)	74.37
No. days pond overflows (days/year)	20.29
Average duration of overflow (days)	2.81
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.96
Probability of at least 90% reuse (fraction)	0.88





Export plot

Export plot



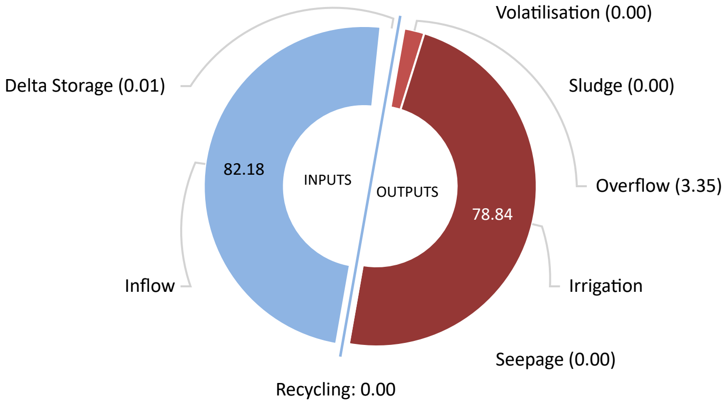
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

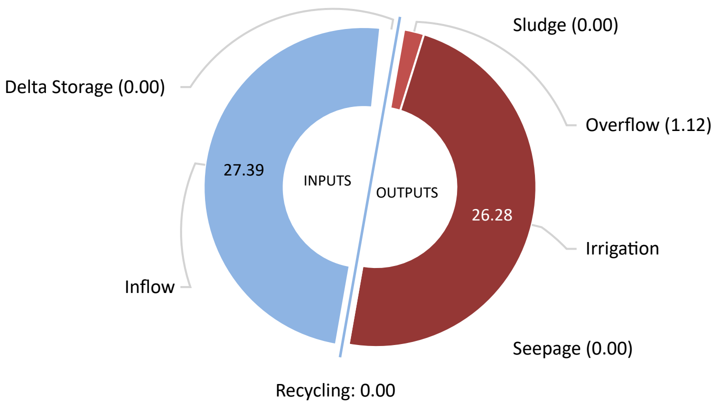
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



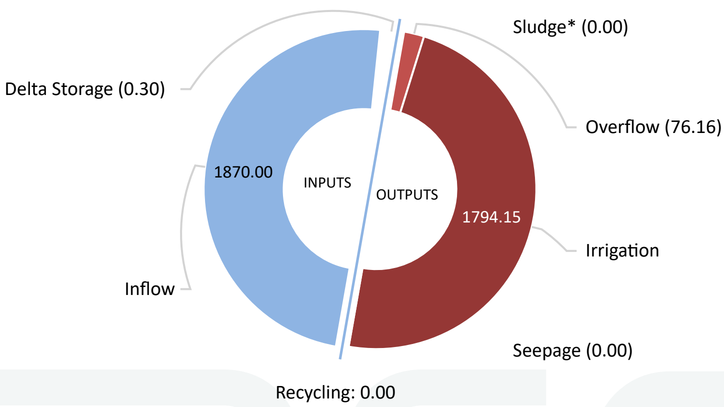
Name	Value
Inflow	82.18
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	3.35
Irrigation	78.84
Seepage	0.00
Delta Storage	-0.01

Phosphorus Balance (kg/year)



Name	Value
Inflow	27.39
Recycling	0.00
Sludge	0.00
Overflow	1.12
Irrigation	26.28
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	1870.00
Recycling	0.00
Sludge*	0.00
Overflow	76.16
Irrigation	1794.15
Seepage	0.00
Delta Storage	-0.30

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	45.00
Average phosphorus concentration of pond liquid (mg/L)	15.00
Average salinity of pond liquid (dS/m)	1.60

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	45.00
Final phosphorus concentration of pond liquid (mg/L)	15.00
Final salinity of pond liquid (dS/m)	1.60

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	1752.10
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	1752.10
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	45.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	42.30
Average phosphorus concentration of irrigation water (mg/L)	15.00
Average salinity of irrigation water (dS/m)	1.60

Irrigation Diagnostics:

Proportion of Days rain prevents irrigation (fraction)	0.15
Proportion of Days water demand too small to trigger irrigation (fraction)	0.07
Proportion of Days irrigation occurs (fraction)	0.78

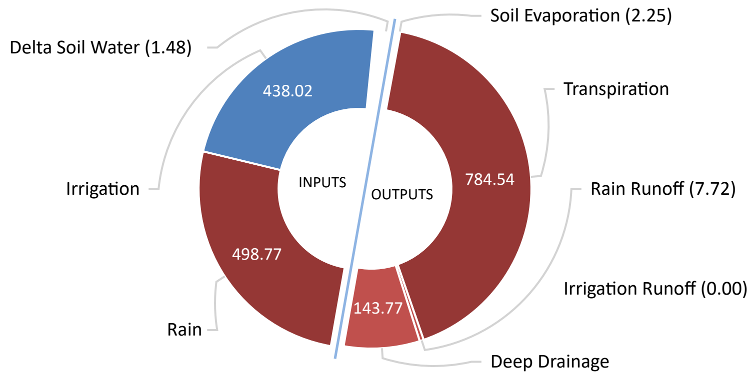
PERFORMANCE

Land Performance - Soil Water

Paddock: LAA, 0.4 ha
Soil Type: Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

Land Water Balance (mm/year):

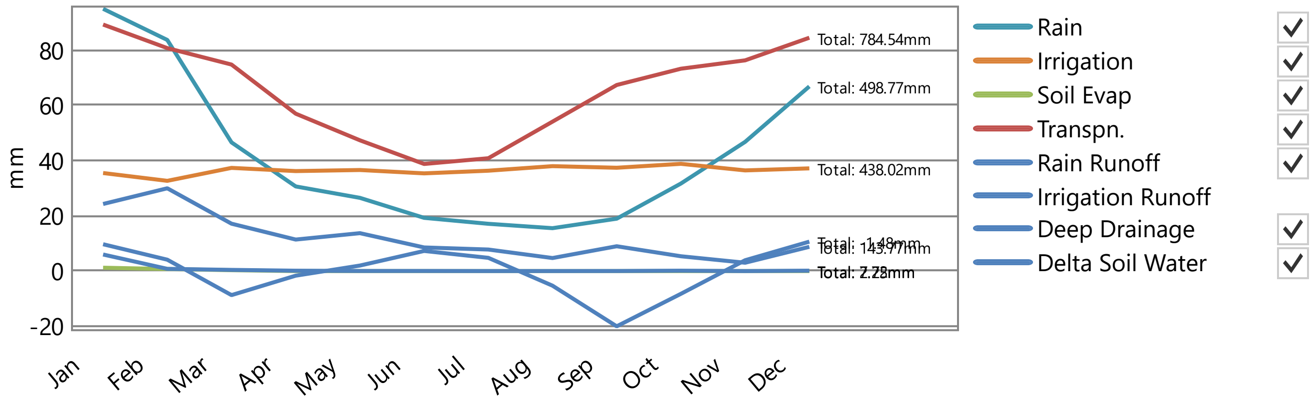
■ mm/year ☐ % Total inputs



Name	Value
Rain	498.77
Irrigation	438.02
Soil Evaporation	2.25
Transpiration	784.54
Rain Runoff	7.72
Irrigation Runoff	0.00
Deep Drainage	143.77
Delta Soil Water	-1.48

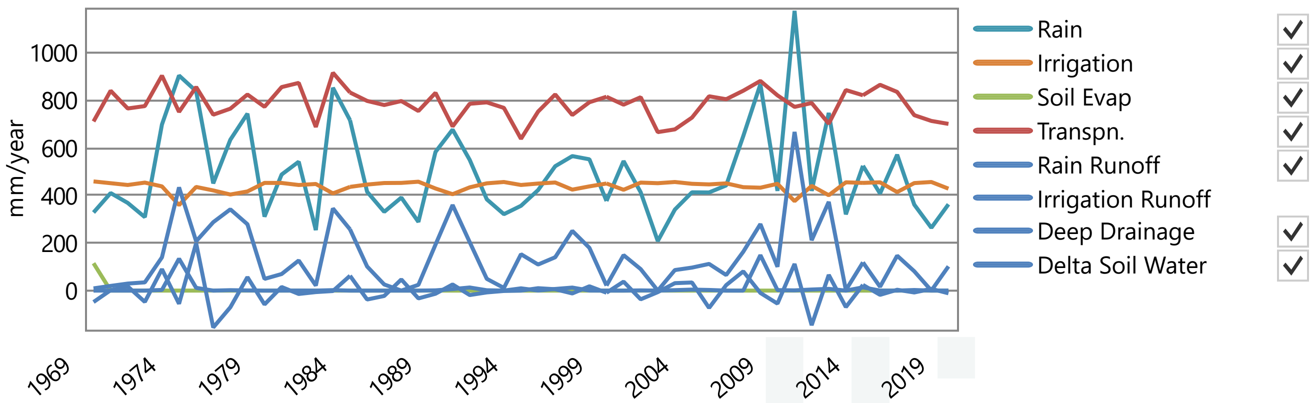
Average Monthly Totals (mm):

■ Chart ☐ Table



Average Annual Totals (mm/year):

■ Chart ☐ Table



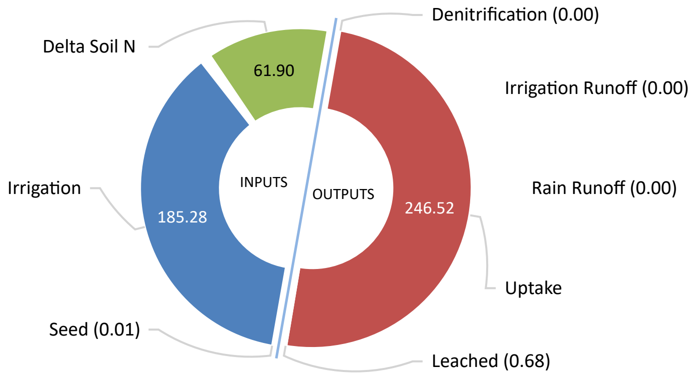
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

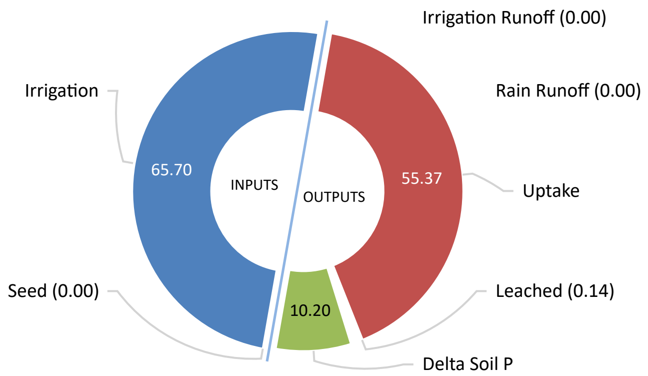
Irrigation ammonium volatilisation losses (kg/ha/year): 11.83
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.30

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.01
Irrigation	185.28
Denitrification	3.22E-04
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	246.52
Leached	0.68
Delta Soil N	-61.90

Land Phosphorus Balance (kg/ha/year)



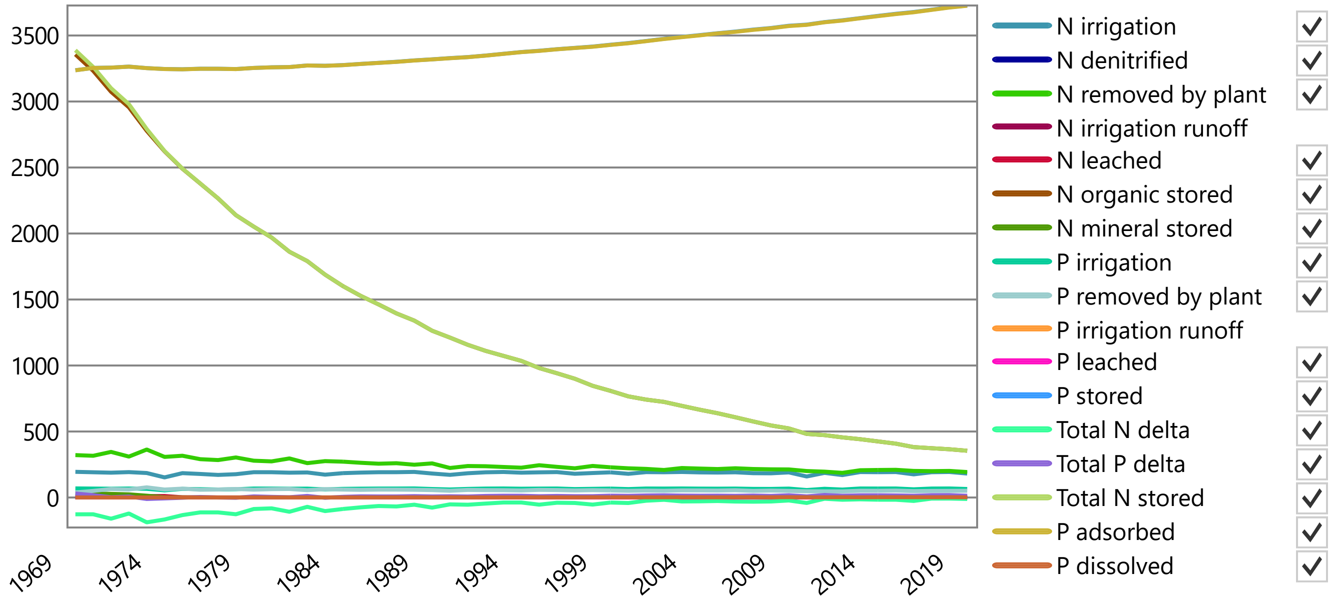
Name	Value
Seed	1.76E-03
Irrigation	65.70
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	55.37
Leached	0.14
Delta Soil P	10.20

PERFORMANCE

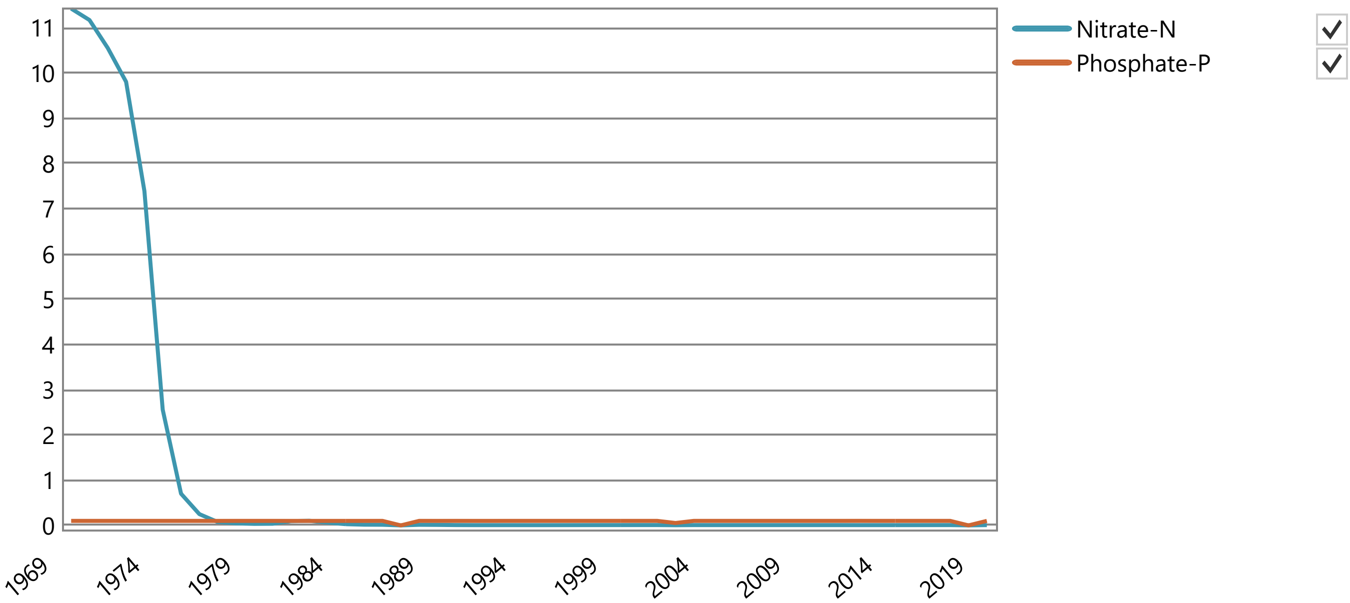
Land Performance - Soil Nutrient

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

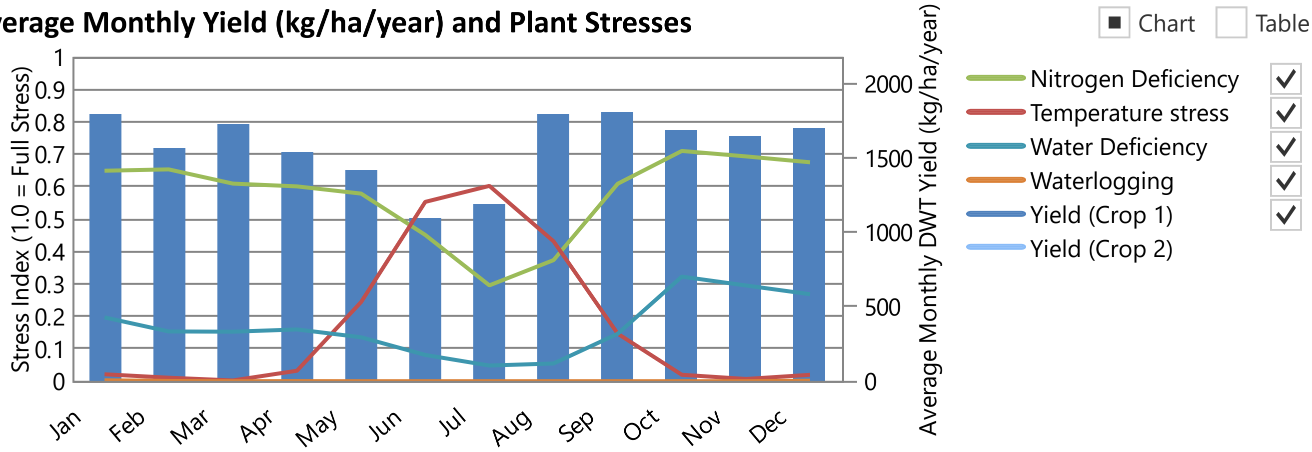
Plant: Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	18982.83 (15402.24 - 25910.88)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.71 (0.65 - 0.76)
Average monthly root depth (mm) (minimum - maximum)	499.37 (495.19 - 500.00)

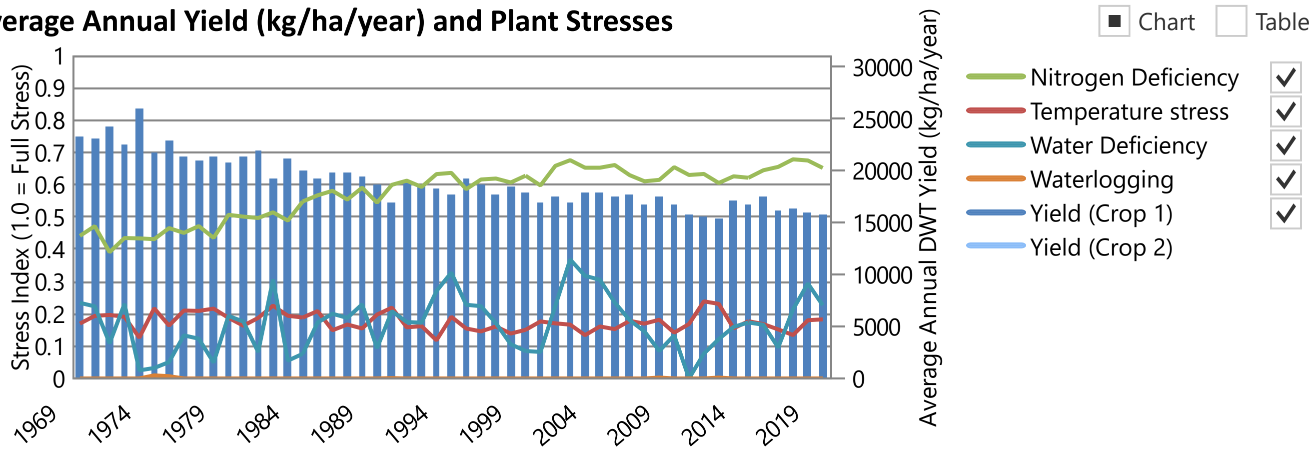
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	246.52 (186.56 - 362.87)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	55.37 (38.32 - 76.78)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.003 (0.002 - 0.003)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 3.29 (normal)
No. days without crop/year (days/year): 0.00

PERFORMANCE

Land Performance

Paddock: LAA, 0.4 ha **Soil Type**: Low Permeability Red Brown Earth

Plant: Continuous Rhodes Grass Pasture - 500mm rooting

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

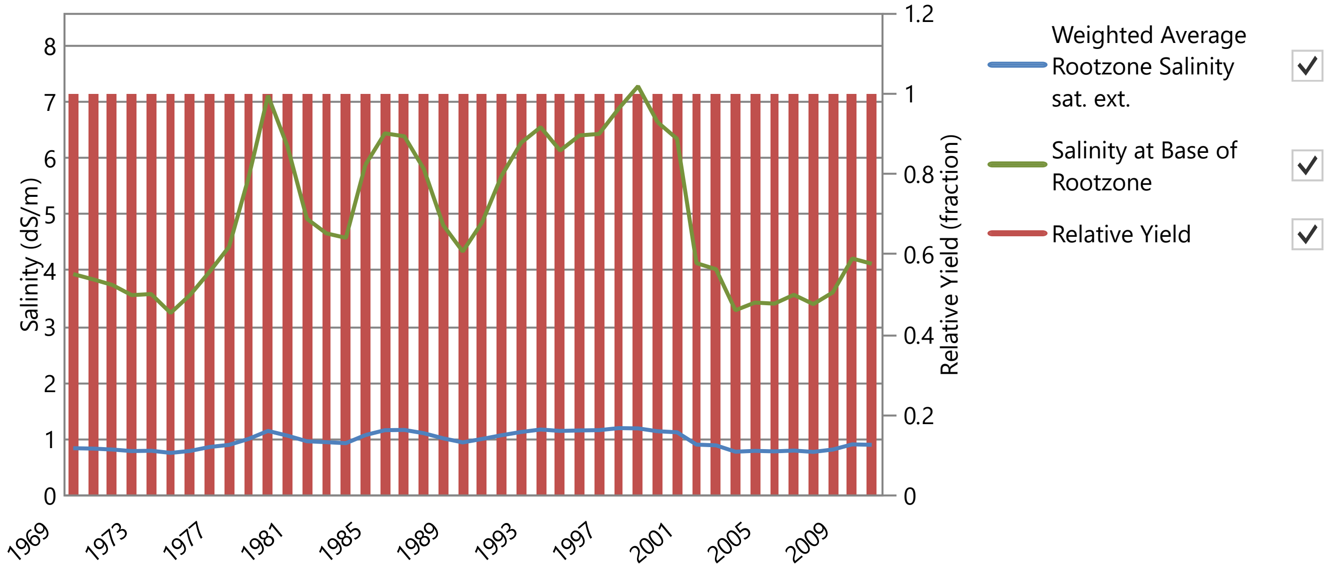
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.76
Salt added by rainfall (kg/ha/year)	94.28
Average annual effluent salt added & leached at steady state (kg/ha/year)	4579.65
Average leaching fraction based on 10 year running averages (fraction)	0.36
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.97
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	4.94
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

■ Chart ☐ Table

All values based on 10 year running averages



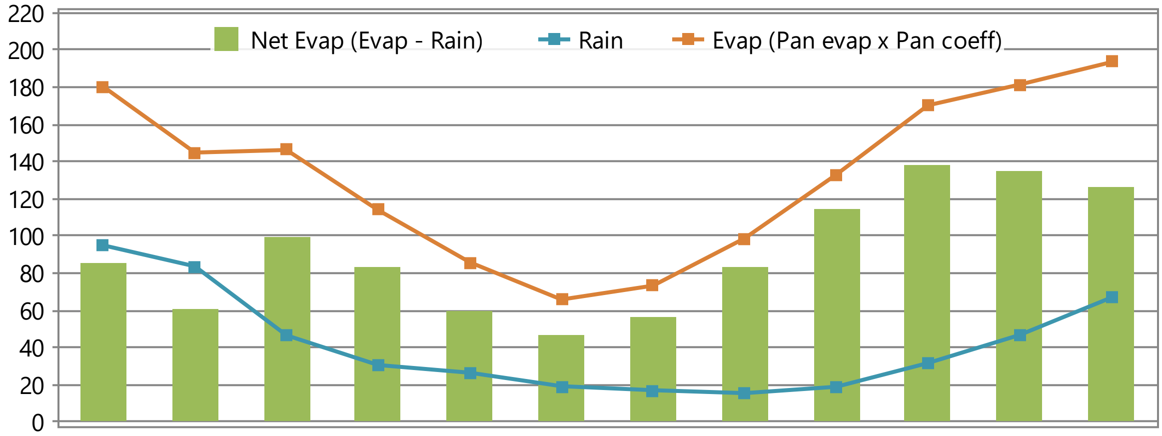
DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Averaged Historical Climate Data Used in Simulation (mm)

Location: Near Alpha Qld -23.4_146.5, -23.4°, 146.5°

Run Period: 01/01/1969 to 31/12/2019 51 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Evap	180.3	144.9	146.3	113.9	85.9	65.9	73.3	98.8	133.0	170.3	181.4	193.5	1587.4
Net Evap	85.3	61.1	99.6	83.3	59.4	46.6	56.2	83.3	114.1	138.6	134.6	126.6	1088.6
Net Evap/day	2.8	2.2	3.2	2.8	1.9	1.6	1.8	2.7	3.8	4.5	4.5	4.1	3.0

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Pond System: 1 closed storage tank

New Generic System - 1826.18 m3/year or 5.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	45.00 (45.00 - 45.00)	82.18 (82.12 - 82.35)
Total Phosphorus	15.00 (15.00 - 15.00)	27.39 (27.37 - 27.45)
Total Dissolved Salts	1024.00 (1024.00 - 1024.00)	1870.00 (1868.80 - 1873.92)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	1.00 (1.00 - 1.00)	1.83 (1.82 - 1.83)

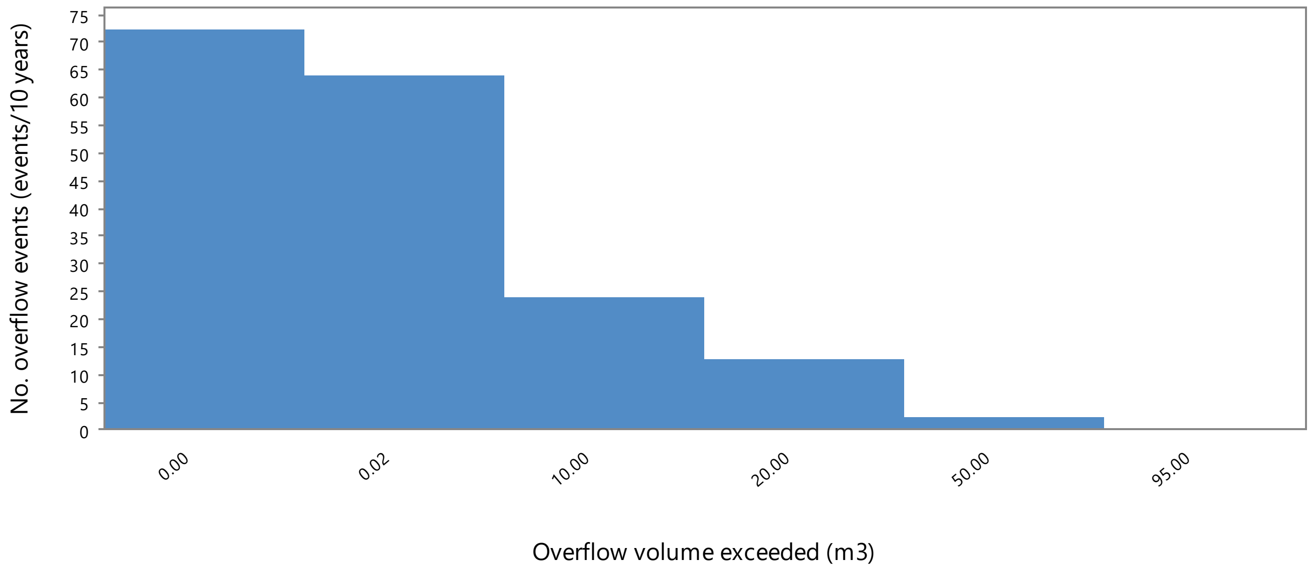
Last pond (Wet weather store): 30.00 m3

Theoretical hydraulic retention time (days)	6.00
Average volume of overflow (m3/year)	74.37
No. overflow events per year exceeding threshold* of 0.02 m3 (no./year)	6.39
Average duration of overflow (days)	2.81
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.96
Probability of at least 90% effluent reuse (fraction)	0.88
Average salinity of last pond (dS/m)	1.60
Salinity of last pond on final day of simulation (dS/m)	1.60
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

■ Chart ☐ Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Irrigation Information

Irrigation: 0.4 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	1752.10	4380.24
Total nitrogen applied (kg)	74.11	185.28
Total phosphorus applied (kg)	26.28	65.70
Total salts applied (kg)	1794.15	4485.37

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is prevented when triggered (fraction)	0.15
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.07
Proportion of Days irrigation occurs (fraction)	0.78

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 2.00 mm and rainfall is less than or equal to 0.10 mm
Irrigate up to a soil water content of drained upper limit plus 0.00 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Low Permeability Red Brown Earth, 64.70 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	95.0	83.7	46.6	30.7	26.5	19.3	17.1	15.5	19.0	31.7	46.8	66.9	498.8
Irrigation	35.5	32.7	37.4	36.2	36.6	35.4	36.3	38.0	37.4	38.8	36.5	37.2	438.0
Soil Evap	1.2	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
Transpn.	89.3	80.8	74.8	57.0	47.4	38.8	40.9	54.1	67.4	73.3	76.3	84.5	784.5
Runoff	6.0	0.8	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	7.7
Drainage	24.3	30.0	17.2	11.4	13.7	8.5	7.8	4.7	9.0	5.4	3.0	8.8	143.8
Delta	9.7	4.1	-8.7	-1.7	2.0	7.3	4.8	-5.3	-20.0	-8.2	3.9	10.7	-1.5

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	185.28
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	246.52
Average annual soil nitrogen removed by denitrification (kg/ha/year)	3.22E-04
Average annual soil nitrogen leached (kg/ha/year)	0.68
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.68
Soil organic-N kg/ha (Initial - Final)	3456.00 - 353.63
	54.60 - 0.03
Average nitrate-N concentration of deep drainage (mg/L)	0.47
Max. annual nitrate-N concentration of deep drainage (mg/L)	11.42

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	65.70
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	55.37
Average annual soil phosphorus leached (kg/ha/year)	0.14
Dissolved phosphorus (kg/ha) (Initial - Final)	0.49 - 1.53
Adsorbed phosphorus (kg/ha) (Initial - Final)	3201.01 - 3719.99
Average phosphate-P concentration in rootzone (mg/L)	0.63
Average phosphate-P concentration of deep drainage (mg/L)	0.10
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.10
Design soil profile storage life based on average infiltrated water phosphorus concn. of 7.07 mg/L (years)	76.75

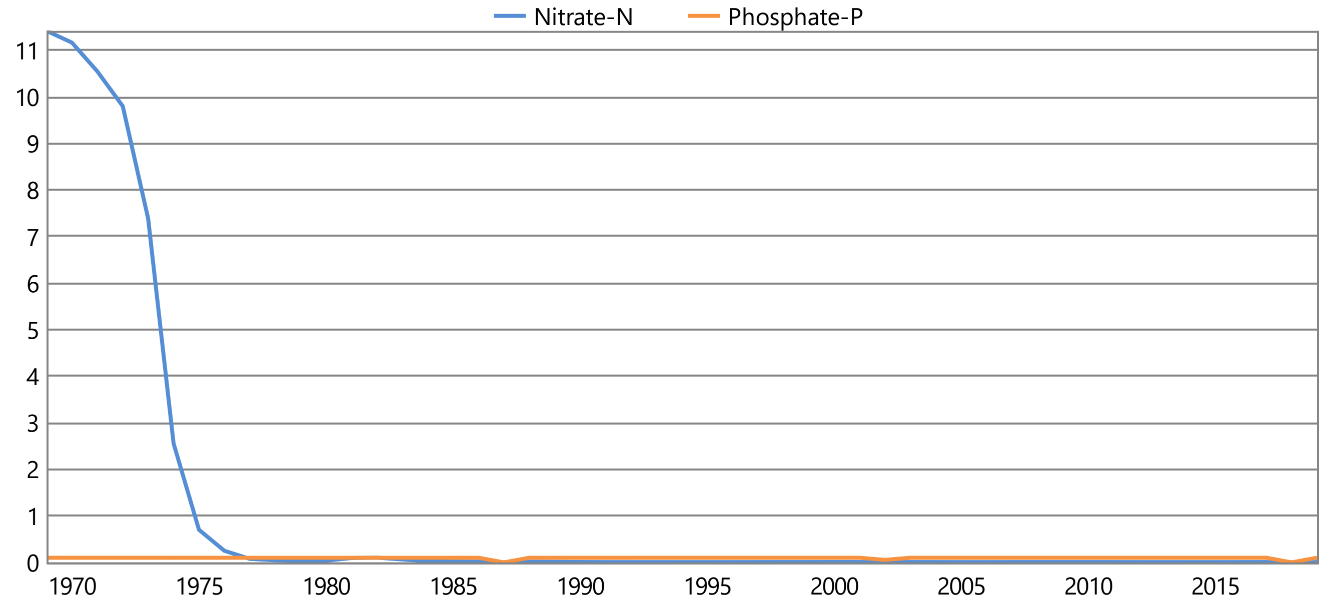
DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

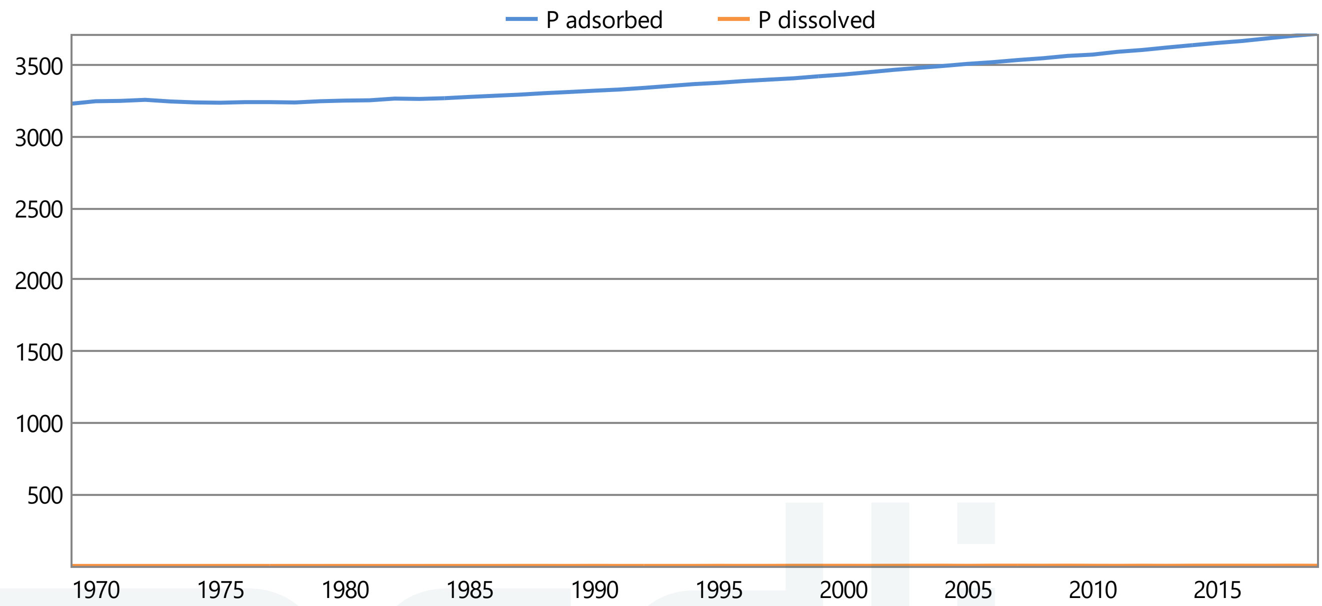
Paddock Land: LAA: 0.4 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: WC-GPS Galilee Power Station

Paddock Plant Performance: LAA: 0.4 ha

Average Plant Performance (Minimum - Maximum): Continuous Rhodes Grass Pasture - 500mm rooting

Average annual shoot dry matter yield (kg/ha/year)	18982.83 (15402.24 - 25910.88)
Average monthly plant (green) cover (fraction)	0.71 (0.65 - 0.76)
Average monthly crop factor (fraction)	0.44 (0.41 - 0.48)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	499.37 (495.19 - 500.00)
Average number of normal harvests per year (no./year)	3.29 (2.00 - 4.00)
Average number of normal harvests for last five years only (no./year)	2.80
Average number of crop deaths per year (no./year)	0.00 (0.00 - 0.00)
Average number of crop deaths for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.57 (0.39 - 0.68)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.10)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.60 (0.31 - 0.84)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.17 (0.05 - 0.32)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	0.00

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.76
Salt added by rainfall (kg/ha/year)	94.28
Average annual effluent salt added & leached at steady state (kg/ha/year)	4579.65
Average leaching fraction based on 10 year running averages (fraction)	0.36
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.97
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	4.94
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

Attachment B

Water Release Strategy

Galilee Power Station

Water Release Strategy

Waratah Coal

WC-GPS-RT003, Rev 0

7-Dec-2020

Document Properties

Project Title:	Galilee Power Station
Report:	Water Release Strategy
Prepared for (Client):	Waratah Coal
Document Ref:	WC-GPS-RT003
Date:	7-Dec-2020
Revision:	0
Author:	Marc Walker
Contact Details:	Orange Environmental Pty Ltd +61 417 791 061 admin@orangeenvironmental.com.au
Suggested Reference:	Orange Environmental (2020). Galilee Power Station, Water Release Strategy. Orange Environmental Pty Ltd. Report Ref. WC-GPS-RT003. Revision 0, 7-Dec-2020.

Document Control

Revision	Description	Issued By	Approved	Date
0	FINAL	MW	NM	7-Dec-2020

Contents

Appendices

Figures

Tables

Terms and Abbreviations

µg/L	Microgram per litre
µS/cm	Microsiemens
AEP	Annual Exceedance Probability
Al	Aluminium
APET	aerial potential evapotranspiration
ARWD	Ash Runoff Water Dam
AWBM	Australian Water Balance Model
AWQG	Australian Water Quality Guidelines
B	Boron
Cd	Cadmium
DRD	Drains Reclaim Dam
DSA	Design Storage Allowance
DUSLARA	Desert Uplands Strategic Land Resource Assessment
EA	Environmental authority
EC	Electrical conductivity
ERA	Environmentally Relevant Activity
ESS	Extreme Storm Surge
g/s	Grams per Second
ha	hectares
HEV	High Ecological Value
Hg	Mercury
km	Kilometres
LDMG	Local Disaster Management Group
m	Metres
m3/s	cubic metres per second, or kL/s
mbgl	Metres below ground level
MCU Area	Material Change of Use, or the application, Area
MD	Moderately Disturbed
mg/L	Milligrams per litre
ML	Megalitres (1,000,000L)
mm	Millimetres
MW	Megawatts
NTU	Nephelometric Turbidity Unit
OE	Orange Environmental Pty Ltd
Pb	Lead
PCoC	Potential Contaminants of Concern
pH	Scale used to specify the acidity or basicity of an aqueous solution
RO	Reverse osmosis

SARA	State Assessment and Referral Agency
SMD	Slightly-Moderately Disturbed
Waratah Coal	Waratah Coal Pty Ltd
WCF	Waste Containment Facility
WQOs	Water quality objectives
Zn	Zinc

1 Introduction

1.1 Overview

Orange Environmental Pty Ltd (OE) were engaged by Waratah Coal Pty Ltd (Waratah Coal) to prepare this Water Release Strategy for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. Refer to Figure 1-1 for the site location, and Appendix A for the general arrangement plan.

This report has been prepared to assess the existing surface water environment and outline the proposed release strategy for conditioning of authorised releases and release points from the project, in response to queries raised by the State Assessment and Referral Agency (SARA) in their SARA advice notice - Monklands Road, Alpha (ref. 2002-15561 SRA, 4 November 2020), as part of the development application for approval of the project.

1.2 Scope

This plan provides an assessment of the receiving environment – namely Saltbush Creek and its tributaries on-site – and a proposed release strategy, including flow-based release rules, contingency measures and a monitoring program.

1.3 Description of the Development

Waratah Coal propose to develop the Galilee Power Station (the Power Station), a new ultra-supercritical coal fired power generation facility located in the Galilee Basin in Queensland, approximately 30 km to the north of Alpha. The Power Station involves the development of a 1,400 MW ultra-supercritical power station adjacent to Waratah Coal's Galilee Coal Project and will have the dual purpose of servicing the public network and providing the power needs for the Galilee Coal Project mine operations.

The Power Station Site covers an area of approximately 1,310 ha, described as the MCU Area (Material Change of Use Area). Within the 1,310 ha, 518 ha will be subject to disturbance in the form of land clearing and earthworks to facilitate the construction and operation of the Power Station.

The Power Station site will contain the following pieces of infrastructure (see Appendix A):

- Conveyors - Overland Conveyor (to bring coal into the Power Station site from the adjacent Galilee Coal Project); Plant Feed Conveyors (between the Coal Handling Plant and the Coal Bunkers)
- Coal Handling Plant – includes Coal Transfer Station; Coal Stacking Conveyor; Coal Stockpiles (sized for 12 weeks storage); Coal Reclaim Conveyors; Coal Stockpile Runoff Ponds
- Power Station – includes Coal Bunkers; Boilers and Turbine Hall; Air Cooled Condensers and Cooling Tower; Stack
- Flue Gas Desulphurisation - Limestone Silo; Limestone Prep Plant; Lime Injectors; Baghouse; Desulphurisation Plant
- Water Storage and Treatment - Raw Water Dams; Water treatment Plant; Service Water Tanks; Waste Water Ponds
- Ash Handling and Containment Facilities- Ash Silos; Pug Mill; Truck Loading

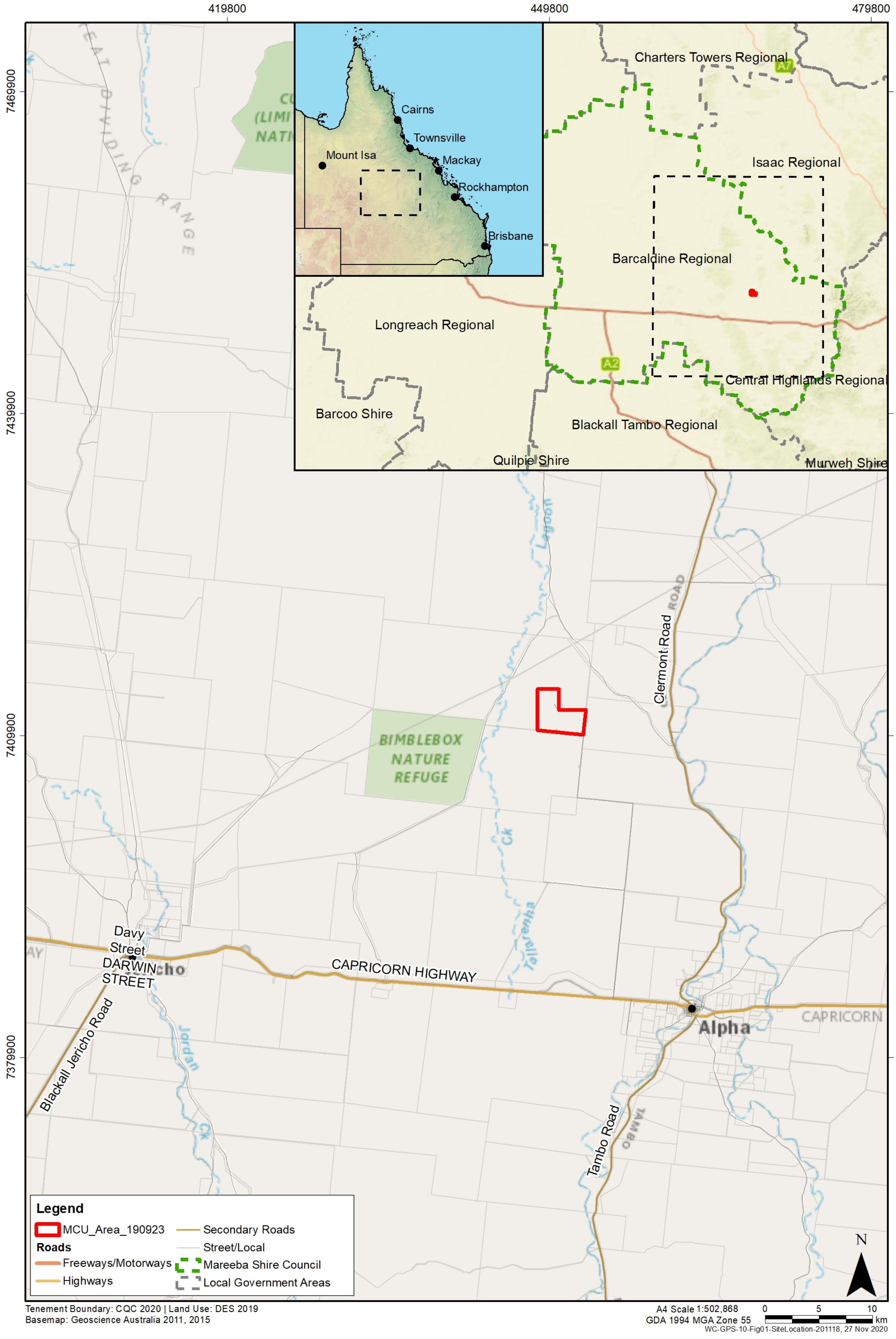


Figure 1-1. Site Location

- Ancillary Infrastructure – Diesel Unloading and Storage; Hydrogen Store; Laboratory; Workshops; Storeroom; Fire Station; Administration Building; Amenities; Carpark; Lay Down Areas
- Power Transmission Infrastructure - Substation, Switchyards and Transmission Line (note that the Transmission line will form part of a separate approvals process)
- Waste Containment Facility (including associated drainage, Ash Runoff Water Dam and Sedimentation Dam 1).

2 Existing Environment

2.1 Local Climate

The project area has a sub-tropical continental climate and, in general, winter days are warm and sunny, and nights are cold. Mean monthly minimum temperatures range from 19°C in the summer to 7°C in the winter. The mean maximum temperatures range from 36°C in the hottest months and drop to 25°C in winter.

Average annual rainfall at the nearby Barcaldine Post Office (station 036007) (refer Figure 2-1) totals 500 mm, with average monthly rainfall of 75mm during the summer months, dropping to averages of 20mm during winter. Wetter periods, represented by the 90th percentile rainfall, show average monthly rainfalls of 170mm per month over summer and 57mm per month over winter, with a 90th percentile annual total of 823mm. Evaporation likewise peaks in summer, with an overall annual mean daily evaporation rate of 8.5mm/day, or 3,100mm per year, well above rainfall.

Wind direction in the area is predominantly easterly.

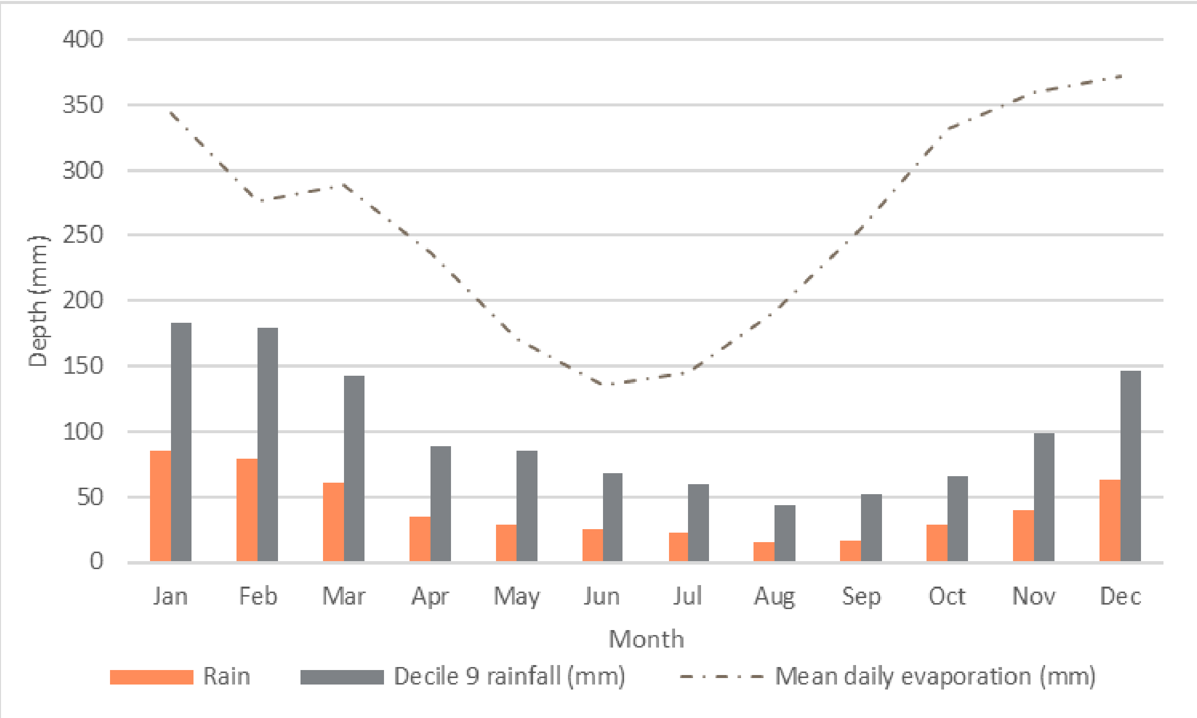


Figure 2-1. Average climatic conditions - Barcaldine Post Office (036007), evaporation from Longreach Aero (036031)

2.2 Geology and Soils

The surface geology of the area is dominated by unconsolidated sediments of Cainozoic (recent geological period) origin. The MCU area is comprised of Quaternary Alluvium in the western half of the site, described as alluvium of older plains comprising sand, gravel and soil; with rises of Early Permian Colinlea Sandstone over the eastern half of the site, comprising quartz and pebbly quartz sandstone, minor conglomerate and siltstone.

Soils are mapped at 1:100,000 in the Desert Uplands Strategic Land Resource Assessment (DUSLARA) mapping (Lorimer 2005), with the bulk of the MCU area mapped as the Joe Joe land system, described as a lateritised surface on gentle rises. The bulk of the soils are therefore on slopes, with an approximately 700 m wide strip of alluvial fans running along the western boundary of the MCU area. Soils underlying the infrastructure comprises shallow stony soils on hardpan of ironstone at an average depth of less than 0.5m, with part of the infrastructure in the west over deep uniform sandy loams overlying a clay soil.

2.3 Receiving Waters and Catchments

2.3.1 Catchments

The project is located within the Sandy Creek sub-catchment of the Belyando River sub-basin within the Burdekin River basin, part of the North East Coast Drainage Division (refer Figure 2-2). The Belyando Catchment is predominantly low relief floodplain with wide braided channels and alluvial plains, predominantly agricultural land with cattle grazing on natural vegetation.

The project site drains to Saltbush Creek, approximately 1 km west of the MCU boundary, which flows north, joining into Lagoon Creek approximately 10 km north. Lagoon Creek flows in a northerly direction downstream of the project before joining with Sandy Creek which discharges into the Belyando River 70 km downstream.

The major creeks and sub-catchments in proximity to the project are shown in Figure 2-3.

The waters of the Burdekin Basin have not been scheduled under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (Qld) as yet, however the Queensland Government has published the *Draft environmental values and water quality guidelines: Burdekin River Basin fresh and estuarine waters* (Newham et al 2017), based on information in or supporting the Burdekin Basin water quality improvement plan (NQ Dry Tropics 2016), and other relevant mapping layers including protected estate layers and landuse mapping.

The documents above divided the Burdekin River basin into 6 river sub-basins, and 48 sub-catchments, with the project located within the Upper Burdekin Basin. The project is located within the Sandy Creek freshwaters sub-catchment (number 27) – including Lagoon and Sandy Creeks. Receiving water types in the Sandy Creek sub-catchment are defined in Newham et al (2017) as freshwaters (and would be considered upland freshwater under the Queensland Water Quality Guidelines, QWQG, EHP 2013).

Areas of Slightly Disturbed (SD) and High Ecological Value (HEV) waters are identified upstream and well downstream of the project area. The management intent for the remaining areas, including receiving waters for the project, would be considered as Moderately Disturbed (MD) as a consequence of the surrounding land use for cattle grazing, although as noted by Engeny (2013a), the biological communities are thought to remain in a healthy condition and ecosystem integrity is likely to be largely retained. The management intent for receiving waters is therefore Slightly-Moderately Disturbed (SMD) as defined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the Australian Water Quality Guidelines (AWQG), ANZG 2018).

The management intent for SMD waters is to maintain/achieve the relevant water quality guidelines (Newham et al 2017; ANZG 2018).

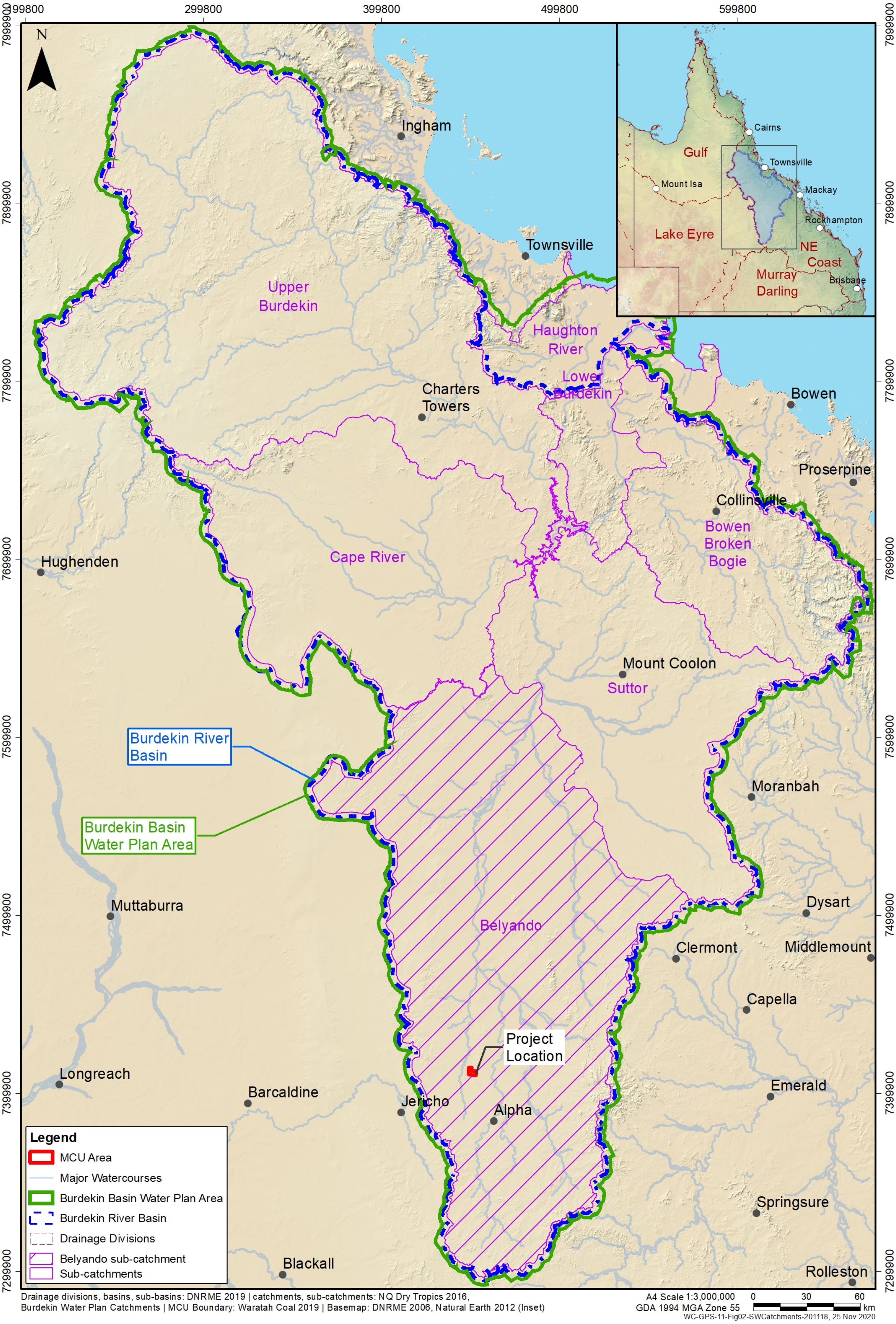


Figure 2-2. Surface Water Catchments

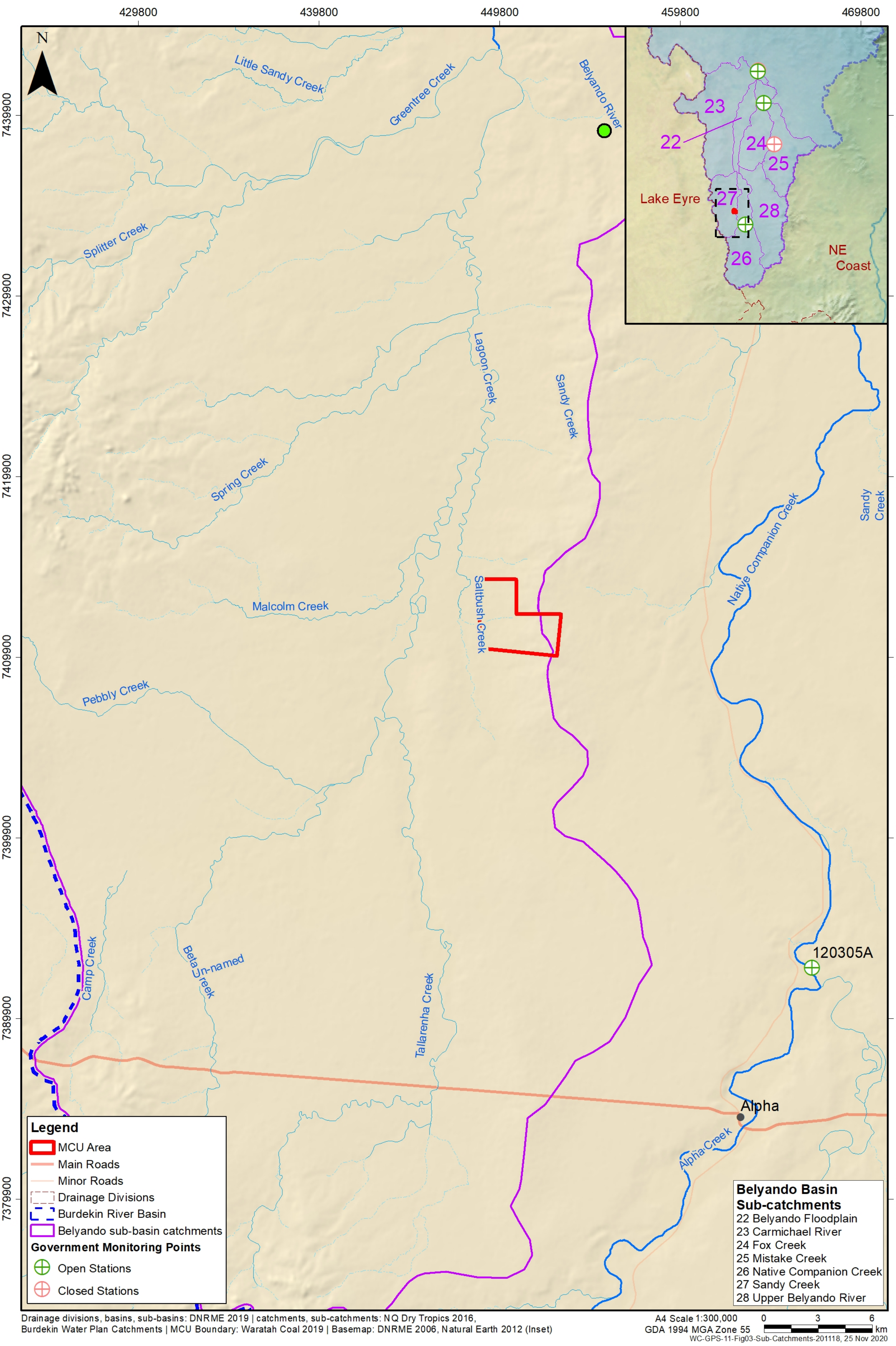


Figure 2-3. Major watercourses and sub-catchments

2.3.2 On-site Drainage Features and Receiving Waters

The site is very gently sloped westwards at ~1% towards Saltbush Creek. Two small ephemeral drainage gullies are located on the site nominally draining into Saltbush Creek:

- A mapped watercourse under the *Water Act 2000* (Qld) draining through the centre of the project area, terminating in a farm dam, with runoff further west appearing to be unchanneled overland flow without a defined channel in evidence. The mapped course of this drainage line does not correspond well to the available aerial and topographical information and has been corrected to the available data in Figure 2-4.
- An unmapped drainage line running through the northern part of the MCU area, draining into the proposed Drains Reclaim Dam / Sedimentation Dam 2 stormwater diversion drain. A watercourse determination has found this to be a 'Drainage Feature' under the *Water Act 2000* (Qld), and therefore not a defined Watercourse (OE 2019). The drainage gully can be identified up to the location of the proposed dams, at which point it disappears into a large open depression where water pools during rain periods, described in OE (2019) as an indistinct 'delta' comprising two ill-defined channels without consistency, alternating between very small and shallow channels reminiscent of cattle tracks, to areas with no identifiable channel.

Another mapped watercourse is defined immediately south of the waste containment facility, along and outside of the MCU boundary.

Given the small ephemeral nature of the drainages on site, particularly the ill-defined channels downstream of the spillway locations, the receiving waters for the project are taken as the waters of Saltbush Creek.

Site drainage, along with receiving waters, contributing catchments, proposed release and assessment points are shown in Figure 2-4.

2.3.3 Surface Water Monitoring

No information is available on the water quality within the on-site drainage features. However, data is available for nearby creeks as part of the nearby Galilee Coal Project, and the broader mine related assessments in the region for other projects. The available surface water monitoring data is as follows:

- Surface flow gauging station - Site 120305A, Native Companion Creek at Violet Grove, in operation since December 1967 to the present, collecting water quality, stream flow records and daily rainfall.
- Monitoring as part of the nearby Galilee Coal Project, initially conducted between October 2009 and September 2012, with an ongoing monitoring program being conducted since 2019. Given the ephemeral nature of the waterways, this is an event-based program. Of the 21 sites monitored, three are located downstream of the project within Saltbush Creek:
  - WQ41 (new), located ~2.8 km downstream from the project, comprising 3 events between November 2019 and March 2020
  - WQ47, located ~3.6 km downstream from the project, comprising one event with water, and a further 3 dry events (no water in the creek), between November 2019 and March 2020
  - Site 04, located ~6.8 km downstream from the project, comprising 10 events over 11 years.

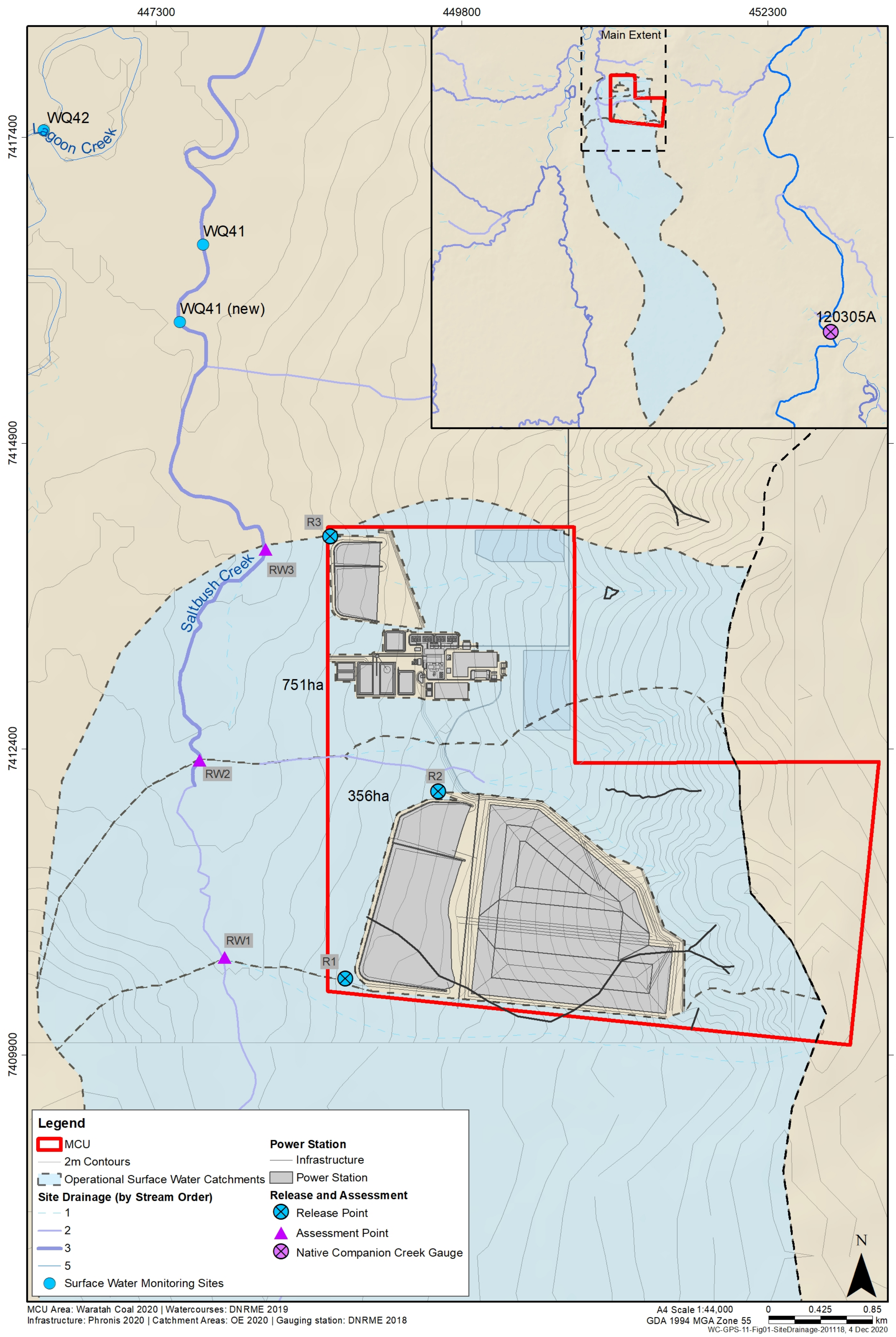


Figure 2-4. Discharge locations and relevant upstream catchments and assessment points

Given these sites are relatively close and represent the same watercourse, the results can be combined averaging out some of the values on the same events, for a total of 10 events. As noted in the Queensland Water Quality Guidelines (QWQGs, EHP 2013), 18 or more samples are recommended for development of trigger values, however 8 or more sample events are suitable for development of interim trigger values. Interim trigger values have been derived from these sites and presented in Section 2.3.5.

2.3.4 Environmental Values

Newham et al (2017) provided draft EVs for the Sandy Creek sub-catchment, summarised in Table 2-1.

Table 2-1. Draft Environmental Values

Symbol	Environmental Value	Sandy Creek
	Aquatic ecosystems (SMD)	✓
	Irrigation	
	Farm supply	
	Stock water	✓
	Aquaculture	
	Human consumer	
	Primary recreation	
	Secondary recreation	
	Visual recreation	✓
	Drinking water	
	Industrial use	
	Cultural and spiritual values	✓

2.3.5 Potential Contaminants of Concern

The Potential Contaminants of Concern (PCoC) related to water discharges from the site relate mainly to runoff from ash contaminated areas, as well as to a lesser extent contamination from hydrocarbons and similar general operational contaminants. The key potentially contaminating activities in relation to water quality are as follows:

- Production, treatment and storage of ash, with runoff collected by the Ash Runoff Water Dam
- Generation of brine reject and evapoconcentration in water dams
- Runoff from rehabilitated ash storage cells and other disturbed or hardstand areas of the site
- Runoff from coal storage and handling operations, and other potential wastes washed off from the plant area
- On-site sewerage scheme
- Chemical storage

Note that chemical stores are self-contained and bunded, and so PCoCs from these sources are not further considered. Where a leak or spill occurs, cleanup will be undertaken immediately to contain the spill, and if required monitoring specific to the spill will be conducted.

Based on an analysis of worst case leaching from the ash (using a highly conservative approach based on the likely maximum solubility, maximum leaching rates and the expected maximum concentration in the ash – Phronis 2020, included in Appendix C), and the other activities on the site the following PCoC and relevant indicators have been identified for the project:

- Physico-chemical:
  - pH, salinity (as EC), dissolved oxygen
  - Turbidity, total suspended solids
  - Sodium, sulfate, fluoride
- Nutrients (likely minor):
  - Total nitrogen and phosphorous
- Metals and metalloids:
  - Ash related – aluminium, arsenic, boron, cadmium, selenium
  - Others which should be considered – chromium, copper, lead, manganese, mercury, molybdenum, nickel, zinc
- Hydrocarbons (likely minor):
  - Total Recoverable Hydrocarbons

2.3.6 Water Quality Objectives / Trigger Values

Newham et al (2017) provided draft Water quality guidelines for the Spring Creek sub-catchment. The AWQGs (ANZG, 2018) recommend as the normal approach using the 80th percentile of reference-site data, or 20th percentile of reference-site data for stressors that cause problems at low concentrations, such as oxygen, for SMD waters.

WQOs / Trigger Values from Newham et al (2017) are shown in Appendix B, compared to trigger values calculated from the available data, using 20th and 80th percentiles. Toxicant levels are taken from the AWQGs for slightly to moderately disturbed waters.

Table 2-2 provides the calculated medians from the available monitoring data for Saltbush Creek (refer Section 2.3.3) along with the adopted interim trigger values for each, based on the PCoCs identified in Section 2.3.5.

Table 2-2. Water quality medians and trigger values for Saltbush Creek

Parameter	Units	Median	Interim Trigger Value[1]
Phys-chem			
pH	pH units	7.2	6.5 – 8.5
Dissolved Oxygen Saturation	%	43	85 - 110#
Electrical Conductivity (EC)	µS/cm	120	95 – 165#
Turbidity	NTU	27.4	≤370 (event); ≤265 (baseflow)
Total Suspended Solids	mg/L	11	≤250 (event); ≤205 (baseflow)
Sulfate as SO_4^{2-}	mg/L	<1	<1#
Sodium	mg/L	8	≤12#
Fluoride	mg/L	<0.1	2
Nutrients and Biological			
Total Nitrogen	µg/L	1,350	≤2,100#
Total Phosphorous	µg/L	145	≤270
Metals and Metalloids			
Aluminium	µg/L	530	800#
Arsenic	µg/L	2	13 (As V) 24 (As III)
Boron	µg/L	<50	370
Cadmium	µg/L	<0.1	0.2
Chromium	µg/L	<1	1 (Cr VI) 3.3 (Cr III)
Copper	µg/L	1	2.0#
Lead	µg/L	<1	3.4
Manganese	µg/L	60	1900
Mercury	µg/L	<0.1	0.06 (inorganic)
Molybdenum	µg/L	<1	34
Nickel	µg/L	1.5	11
Selenium	µg/L	<10	5 (total) 11 (Se IV)
Zinc	µg/L	<5	8
Total Recoverable Hydrocarbons			
C6-C9	µg/L	<20	<20#
C10-C36	µg/L	223	460#

Table notes:

1 Interim Trigger Values adopted from Newham et al (2017), unless denoted with a # (site specific values used), in which case the 80th percentile, or the 20th to 80th percentile for ranges (e.g. pH, dissolved oxygen) are used.

as noted in '1' above, denotes site specific trigger value

2.4 Catchment Flows

To enable the effective assessment of flows within receiving waters for the project, the runoff characteristics of Saltbush Creek at the proposed discharge points was assessed. This was calculated using the Australian Water Balance Model (AWBM) model – a catchment water balance model used to estimate daily runoff based on rainfall and evapotranspiration. Rainfall and evapotranspiration (after Boughton & Chiew 2003) were obtained from the 0.05 degree gridded daily rainfall and evapotranspiration data from the SILO website (https://www.longpaddock.qld.gov.au/silo/), using Moreton's wet aerial potential evapotranspiration (APET).

The AWBM parameters were initially set based on calibrated data from an earlier assessment by Engeny (2013b). The model underestimated the flows from the gauging station based on the current dataset and so, while the average soil water store was retained as per Engeny (2013b), the three partitioned soil water stores and the partial areas were set based on the default settings for AWBM described in Boughton & Chiew (2003). This resulted in a good fit to the data, particularly for the larger events, and so further calibration was not undertaken.

The adopted AWBM parameter values are shown in Table 2-3, and a comparison of the modelled and gauged runoff flow duration curves is shown in Figure 2-5.

Table 2-3. AWBM Input Parameters

Parameter	Value (Natural – modified from Engeny 2013b)
C1 (mm)	25
C2 (mm)	252
C3 (mm)	505
A1	0.134
A2	0.433
A3	0.433
BFI	0.4
K_b	0.8
K_s	0

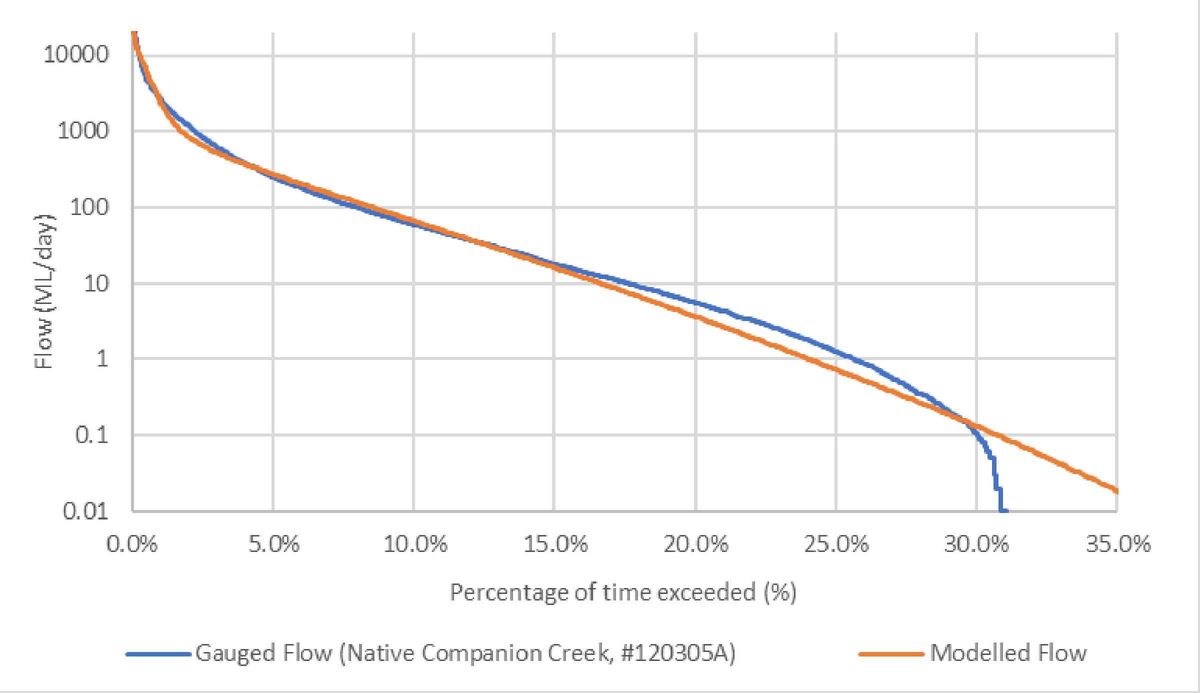


Figure 2-5. Comparison of gauged vs modelled flow duration curves using AWBM

The Annual Exceedance Probability (AEP) for modelled catchment runoff as mm/day was estimated using the Annual Maximum (and plotting position) method described in Chapter 3 of Australian Rainfall and Runoff (Kuczera & Franks, 2019), as shown in Figure 2-6. A Log-Pearson Type III model was fitted, providing the flow values shown in Table 2-4, based on the methods outlined in Kuczera & Franks (2019).

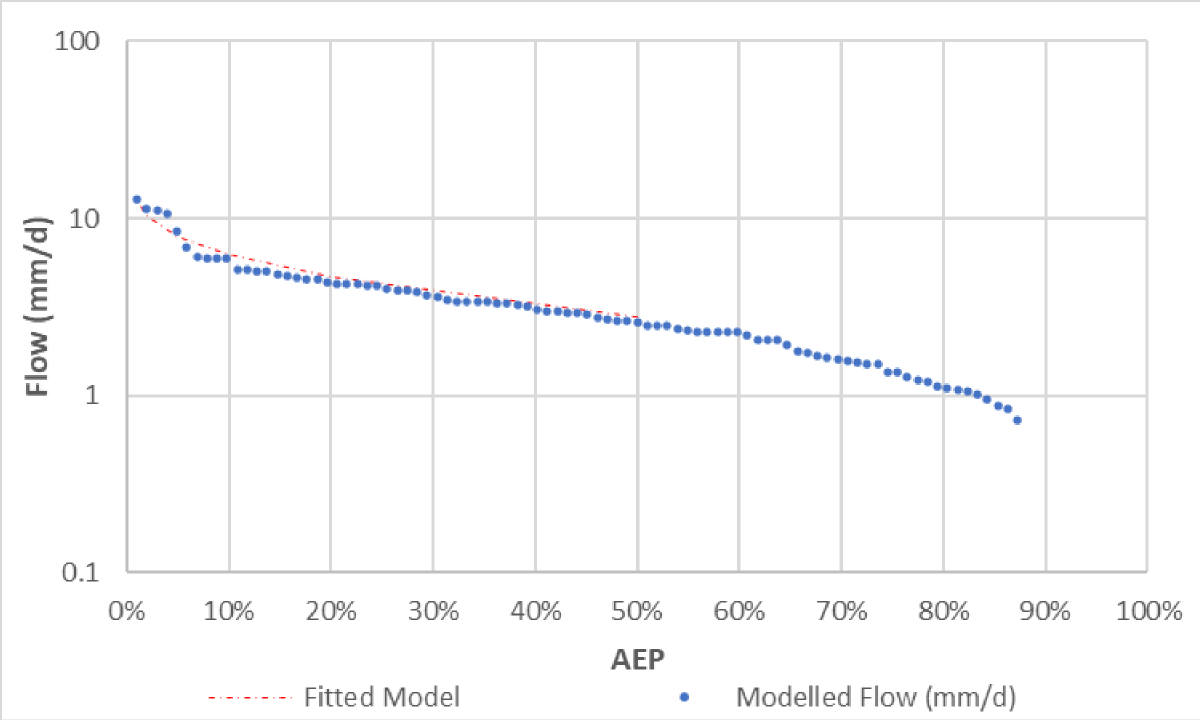


Figure 2-6. Probability Plot of flow (as mm runoff from AWBM) against AEP

Table 2-4. Runoff and AEP table for modelled flows

ARI[1]	AEP	Average Daily Runoff (mm/day)
2	50%	2.77
5	20%	4.71
10	10%	6.24
20	5%	7.90
50	2%	10.32
100	1%	12.36

Table notes:

1 Average Recurrence Interval

Further examination of the daily runoff (ML/day) against peak daily flow (m^3/s) at the Native Companion Creek gauging station after Boughton & Hill (1997) found the following relationship for peak daily flow (as m^3/s) from daily average flow (as ML/day):

- Peak Daily Flow (m^3/s) = 0.0255 x MeanDailyFlow $(ML/day)^{0.9435}$ ($r^2 = 0.96$).

2.5 Water Users

A search of the Queensland Government Water Entitlement Viewer found no water entitlements or licences in proximity to the project (the nearest is some 95 km downstream).

2.6 Flooding

The site is located above the 0.1% AEP (1 in 1000-year ARI) flood level (refer Engeny 2013c).

2.7 Vegetation

Some remnant vegetation is identified on the site however the bulk has been cleared for cattle grazing.

2.8 Groundwater

Seven registered groundwater bores are located within 5 km of the MCU area within the same alluvial geology with data on standing water level in three (RN36823, RN36835 and RN90144) recording it between 15.2 to 33 mbgl (refer Figure 2-3). Sampling of other bores further to the west also show water levels well below 10m depth. EC is recorded at 1,100 µS/cm at another bore (RN44468), and saltier in other bores in the area, other than Colinlea Sandstone which is relatively fresh.

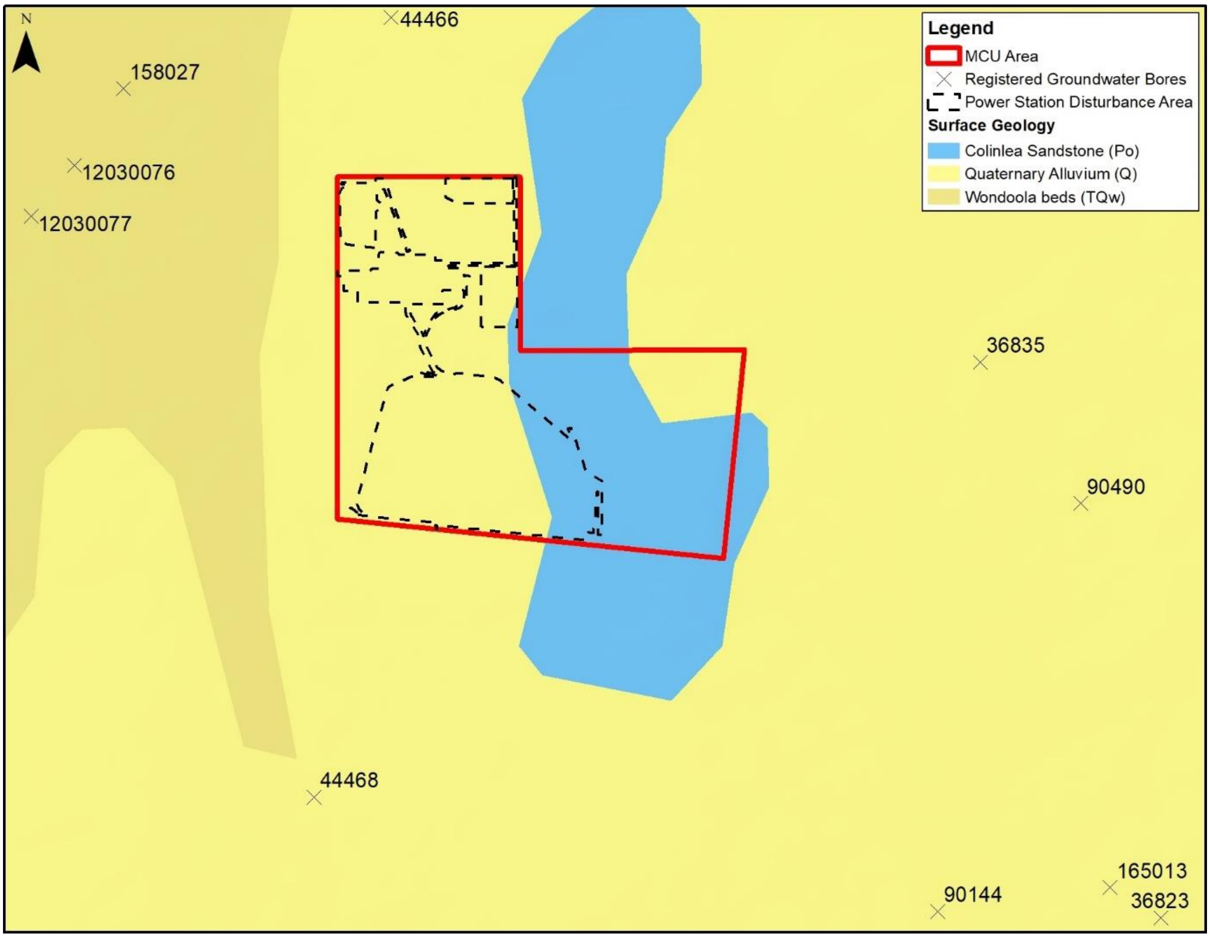


Figure 2-7. Groundwater bores in proximity to the project

3 Assessment of Releases

3.1 Proposed Releases

The project includes a number of dams and ponds for water management on the site, three of which – the Ash Runoff Water Dam, Sedimentation Dam 1 and Sedimentation Dam 2 – could potentially discharge off-site, although due to the design of the system, only in extreme climatic conditions for the ARWD and Sedimentation Dam 2. Sedimentation Dam 1 will drain the relatively clean rehabilitated ash cells.

The proposed release points are shown in Figure 2-4, as follows:

- R1 – spillway discharge from the Ash Runoff Water Dam, potentially contaminated with runoff from active areas of the ash cells and the heavy vehicle road, and flowing down to Saltbush Creek by way of a small low point in the terrain (initially overland flow)
- R2 – spillway discharge from Sedimentation Dam 1, containing clean diversion water and runoff water from capped and rehabilitated ash dam areas, flowing to a small tributary to Saltbush Creek, and then into Saltbush Creek itself to the west, approximately 2 km downstream from where the R1 discharge comes into Saltbush Creek
- R3 – spillway discharge from Sedimentation Dam 2, containing runoff from the power station plant area, including coal stockpiles, and flowing into Saltbush Creek, approximately 2.1 km downstream from where the R2 discharge enters the creek.

Figure 2-4 also shows:

- Assessment points for each discharge location, representing the nearest point in the receiving waters for each discharge (RW1, RW2 and RW3)
- The upstream contributing catchments calculated for each of the assessment points.

Using the flows for selected AEPs defined in Section 2.4, catchment runoff was estimated as summarised in Table 3-1 for a range of larger AEP events. Given that any discharges would preferably be controlled and likely not short duration, the average daily flow (as ML/day) has been adopted for assessment purposes.

Table 3-1. Estimated runoff

Release Point	Assessment Point	Upstream Catchment Area (ha)	AWBM Flow Statistics (ML/day)			
			1% AEP	2% AEP	5% AEP	10% AEP
R1	RW1	14,143	1,748	1,460	1,117	883
R2	RW2	15,298	1,891	1,580	1,208	955
R3	RW3	15,693	1,940	1,620	1,240	980

Sedimentation Dams 1 and 2 are considered relatively clean, and will primarily require settlement of suspended solids before release. Sedimentation Dam 1 will drain from rehabilitated areas of the ash storage dams, and will be designed to suitable standards (such as IECA 2008; DECC 2008), including release limits as summarised in Section 3.3.

Sedimentation Dam 2 provides secondary containment for the Drains Reclaim Dam (DRD), which has been designed with a spill risk of less than 5% AEP (or 1 in 20-year ARI) (Phronis 2020). Given it has almost no other external catchment, the actual overflow frequency will be similar to the DRD – that is, a spill risk of less than the 5% AEP (or 1 in 20-year ARI).

The Ash Runoff Water Dam has been designed to have a spill risk of less than the 1% AEP event (or 1 in 100-year ARI) (Phronis 2020). This dam potentially contains the highest potential for contaminants of the three dams that discharge off-site, and so will be subject to flow-based discharge rules.

Assuming that the larger storm events occur only in the wet season, the above translates directly to a probability of overflow of less than 5% per year for Sedimentation Dam 2, and less than 1% per year for the Ash Runoff Water Dam (Sedimentation Dam 1 will meet relevant receiving water quality criteria for release, as will Sedimentation Dam 2). In reality, as the levels of the ARWD, DRD and Sedimentation Dam 2 will generally be maintained at less than 20% capacity during average weather conditions, the probability of overflow of these dams is lower.

The spill containment risk is achieved by minimising operational dam levels and ensuring that the Design Storage Allowance for regulated dams is available at the start of each wet season. Contingency measures for pre-wet season and wet season high level dam management are provided in Section 4.

3.2 Estimated Release Water Quality

Based on the constituents in the ash, their leaching characteristics, and estimated proportion ending up in ash runoff water, the anticipated worst-case concentrations of contaminants in the Ash Runoff Water Dam are summarised in Table 3-2 (after Phronis 2020), along with the receiving water median and trigger value for each contaminant, as detailed in Section 2.3.6. As can be seen, for these contaminants, the required dilution ratio is 19 x to achieve receiving water trigger values after release. For an added factor of safety, a minimum dilution ratio of 20 x has been adopted.

Table 3-2. Concentration of contaminants expected in ARWD

Analyte	Units	Maximum concentration likely in ARWD	Maximum likely discharge concentration	Median background concentration in receiving waters	Adopted Trigger Value for receiving waters	Dilution required to meet trigger value[2]
Aluminium	mg/L	3	0.6	0.53	0.8	-
Arsenic	mg/L	1	0.2	0.002	0.013	18
Boron	mg/L	4	0.8	0.05[1]	0.37	2
Cadmium	mg/L	0.010	0.002	0.0001[1]	0.0002	19
Mercury	mg/L	0.0002	0.00004	0.0001[1]	0.00006	-
Lead	mg/L	0.010	0.002	0.001[1]	0.0034	-
Selenium	mg/L	0.400	0.080	0[1]	0.005	16
Zinc	mg/L	0.300	0.060	0.005[1]	0.008	18

Table notes:

1 Median is less than the limit of reporting, and so the limit of reporting has been used as a worst case. However, for selenium, the background data is <0.010, higher than the trigger value. It has instead been set at 0 to allow an estimate of dilution requirements to be made.

3.3 Controlled Release Rules - ARWD

Based on the anticipated dilution requirements identified in Section 3.2 using a conservative estimation of concentrations in the Ash Runoff Water Dam, and using the flows estimated in Section 3.1, flow based release rules can be developed.

To enable more flexible management, Table 3-3 provides Controlled Release Rules in units of g/s per m^3/s in receiving waters – that is, a target that is calculated based on concentrations in the dam and receiving water flow. This allows for a relatively simple way to take into account recent water quality data in determining suitable discharge rates to protect receiving waters. The permissible flow rate will be the minimum flow rate calculated after taking each individual contaminant into account using the following formula:

$$\text{Discharge Rate } (m^3/s) = \frac{\text{ReceivingWaterFlow } (m^3/s) \times \text{DischargeCriteria (Table 3-3)}}{\text{Dam Quality (mg/L or µS/cm EC)}}$$

Table 3-3. Proposed Controlled Release Rules - ARWD

Parameter	Units	Discharge Criteria
Electrical Conductivity	µS/cm per m^3/s in receiving waters	51
Sulfate as SO_4	g/s per m^3/s in receiving waters	0.49
Aluminium		0.30
Arsenic		0.011
Boron		0.27
Cadmium		0.00010
Mercury		0.000020
Lead		0.0010
Selenium		0.0047
Zinc		0.0032

It is proposed that this table is used in circumstances where recent testing has been undertaken to accurately assess the concentration of each specific contaminant in the Ash Water Runoff Dam.

Long term data will be used to develop flow-based Quick Release Criteria that can be used quickly if needed, without monitoring being conducted prior to release. These Quick Release Criteria are provided in Table 3-4 based on existing worst case ARWD water quality estimates and current receiving water median concentrations and trigger values.

Table 3-4. Proposed Quick Release Criteria - ARWD

Flow condition, Saltbush Creek[1]	Receiving water flow required for discharge (m^3/s)	Maximum release rate (m^3/s)[2]	Discharge Limits[3]
Low Flow	1	0.05	EC: <1,065 µS/cm SO_4: <20 mg/L Al: <0.6 mg/L As: <0.2 mg/L B: <0.8 mg/L Cd: <0.002 mg/L Hg: <0.00004 mg/L Pb: <0.002 mg/L Se: <0.08 mg/L Zn: <0.06 mg/L
Medium Flow	11	0.55	
High Flow	14	0.7	
Very high flow	18	0.9	
Flood flow	22	1.1	
High flood flow	>22	Maintain min. 20 x dilution	

Table notes:

1 Based on flow guidance from DES (2017) and where: low flow intended for temporary periods after periods of significant flow (e.g. due to ongoing emergency release prior to forecast further rainfall); medium flow = 10% AEP event; high flow = 5% AEP event; very high flow = 2% AEP event; flood flow = 1% AEP event; high flood flow = nominal above 1% AEP flood event.

2 Based on achieving 20 x dilution

3 From Table 3-2 'maximum likely discharge concentration'. Parameters are EC = Electrical Conductivity, SO_4 = Sulfate; Al = Aluminium; As = Arsenic; B = Boron; Cd = Cadmium; Hg = Mercury; Pb = Lead; Se = Selenium; Zn = Zinc. All metals and metalloids are dissolved fractions.

The above Controlled Release Rules and Quick Release Criteria provide for suitable dilution to ensure receiving water quality remains within the interim trigger values. Releases to the ephemeral waterways on-site will be made to the lower portion of defined drainage channels, and substantial mixing is anticipated to occur prior to waters entering Saltbush Creek.

A lower dilution ratio will be achieved for the on-site drainage prior to entering Saltbush Creek, however since it is not a defined natural watercourse channel at the discharge point, there are limited aquatic values in that location to protect.

Due to turbulence associated with flow conditions within the channel, given that any releases would only be associated with rare and large flow events, any mixing zone is anticipated to be very small, and would be expected to meet the requirements of the Department of Environment and Science's 'Technical Guideline: Wastewater release to Queensland waters' (DES 2016) of within three stream widths from the point it enters Saltbush Creek.

Given the rare nature of controlled releases, fixed through-wall release pipes are not proposed. Instead, over-wall syphon pipes or pumps would be used. As an indication, subject to detailed design, 6 x PE siphon pipes of 300mm to 350mm internal diameter would be expected to be suitable for the releases required from the ARWD.

3.4 Spillway Discharges

The dam spillways have been designed (as required) for large events. Assuming the DSA is full (i.e. water level is at the spillway crest), then based on preliminary spillway sizing another 50% AEP event in the ARWD could be expected to result in an uncontrolled spill in the order of 2.2 – 3.1 m^3/s, going up to 8 – 12 m^3/s for the 1% AEP event. However, the probability of this occurring is very low – this would require a wet season filling up the DSA, and then subsequent rainfall overtopping the spillway.

Should an uncontrolled release occur, the above would indicate that the flow-based release criteria outlined in Table 3-4 could be met for smaller subsequent events, and for larger events, the additional dilution would increase the allowable discharge. In reality, the above rates show the need to undertake controlled releases to avoid an uncontrolled release occurring, should this be required, although overall any releases from the ARWD are low probability events.

Release rates for the DRD and Sedimentation Dam 2 is similar to that calculated for the ARWD above.

3.5 Water Release Limits – Sedimentation Dams

For the Sedimentation Dams 1 and 2, no flow based release limits are proposed (or required) given the nature of their source catchments, other than for EC, which has a limit based on the receiving water trigger value, or a dilution based target adopting that for the ARWD in Section 3.3.

Release limits are provided in Table 3-5.

Table 3-5. Proposed release criteria – Sedimentation Dams 1 and 2

Parameter	Units	Discharge Criteria
pH	pH units	6.5 – 8.5[1]
Electrical Conductivity (EC)	µS/cm	165[2] OR As per Table 3-3 for EC
Turbidity	NTU	Derive site specific relationship between turbidity and total suspended solids for early warning
Total Suspended Solids	mg/L	<50[3]
Sulfate as SO_4^{2-}	mg/L	<1[2]

Table notes:

1 From both the interim trigger values in this report and the Queensland State Planning Policy July 2017 (Appendix 2, Table A Construction phase – stormwater management design objectives)

2 From the interim trigger values in this report

3 Based on achievable release limits for suspended solids from sediment basins (Appendix 2, Table A Construction phase – stormwater management design objectives, Queensland State Planning Policy July 2017)

4 Contingency Measures

The below sections outline preventative and response / contingency actions in relation to control of water volume and quality within the site dams, in order to minimise off-site releases and exceedances of water quality of release waters.

4.1 Preventative Actions

If dam levels are trending very high prior to the start of the wet season (e.g. due to unusually very high rain events during the spring period / early onset of the wet season) and high rainfall events occur during the wet season, preventative actions and associated trigger levels will be initiated to reduce the dam levels and minimise the risk of a large uncontrolled discharge via the spillways at the R1 and R3 release points. These are listed as follows.

Trigger Level 1: Dams have sufficient capacity to fully contain the wet season containment Design Storage Allowance (DSA) (1% AEP for ARWD and 5% AEP for DRD) at nominal start of the wet season on 1 November.

Actions:

- Continue monitoring
- No response required

Trigger Level 2: Exceedance of the level for wet season containment Design Storage Allowance (DSA) (1% AEP for ARWD and 5% AEP for DRD) at nominal start of the wet season on 1 November, or trend levels during August to October indicating likely exceedance.

Actions:

- Activation of additional evaporation sprays at the Waste Containment Facility (WCF).
- Mobilisation and activation of Evaporation bowers at the WCF and DRD.
- Transfer of water from DRD to ARWD, subject to available capacity in ARWD.

Trigger Level 3: Exceedance of the level for Extreme Storm Surge (ESS) allowance (72-hour duration) [1% AEP for ARWD and 10% AEP for DRD) at any time.

Actions:

- Continuation of actions as per Trigger Level 1.
- Implementation of RO treatment of the ARWD water, utilising any spare capacity of the RO plant at the PS, to allow for additional water reuse at the PS.
- Controlled water release via siphons or pumps, subject to adequate flows within Saltbush Creek for dilution.

4.2 Response/Contingency Measures should the release not meet release criteria

The storage allowances intended to contain extreme rainfall events (i.e. wet season containment DSA and ESS allowance (72-hour duration)) will significantly reduce contaminant concentrations prior to any spillway overtopping. However, in the unlikely event that a water release occurs from the ARWD at release point R1 that does not meet minimum dilution rates, such as a large spillway discharge during an extreme rainfall event greater than dilution requirements downstream as per Section 3, the following response/contingency measures will be implemented.

Notification

Notification of the following key persons / organisations:

- The Local Disaster Management Group (LDMG) [Note: Managed by the Barcaldine Regional Council]
- Downstream landowners and/or residents within 10 km downstream of the dam spillway and/or likely to be affected by the water release.
- Notify regulatory bodies of the release not meeting release criteria under the EA, including:
  - Department of Environment and Science.
  - Barcaldine Regional Council.

Water discharge rate logging and quality sampling

Logging of water release flows via water levels at the spillway and water quality sampling at the spillway should begin within three hours after release starts and continue every three hours until the release has stopped.

Receiving water quality sampling

Monitoring will be conducted as outlined in Section 5.

Remedial options

Subject to review of surface water and groundwater quality sampling and extent of any contamination, the following remediation options may be considered.

- Release of good quality water (from mine dewatering operations) from the Power Station raw water dams down Saltbush Creek to achieve the minimum dilution rates as per the release criteria. The water quality of the water within the raw water dams is to be confirmed as suitable prior to release to Saltbush Creek.

4.3 Contingency Response Plan

An emergency management plan will be developed for the site, to include contingency measures and a preventative action plan. This will include the above information, plus further detail on operational specifics.

5 Monitoring

The monitoring program will involve the following key components:

- Monitoring of all releases at the release points – daily for in-situ parameters, and every 3 days (at the start of the release and once every 3 days thereafter) for laboratory parameters, namely:
  - Daily: pH, EC, turbidity
  - 3-daily: TSS, SO_4^{2-}, total and dissolved metals (Al, As, B, Cd, Hg, Pb, Se, Zn).
- Monitoring of Saltbush Creek, upstream and downstream of where the release points enter Saltbush Creek (upstream of point RW1, downstream of point RW3, and two more locations up to a minimum 10 km downstream):
  - Monthly during flows to build the baseline dataset, until at least 18 data points have been collected. Thereafter twice per year
  - Following an initial release, within 24 hours or as soon as safe access can be achieved
  - 3-daily thereafter while releasing, where safe access can be achieved
  - Monitor all parameters listed in Table 2-2, including total and dissolved metals. Where a significant change between upstream to downstream occurs (>10% change), undertake testing of on-site storages to determine if the source is project related.
- Monitoring of the quality in all site dams:
  - Weekly for in-situ parameters, until water quality can be shown to be stable, after which time monitoring reduced to monthly
  - Quarterly for other parameters listed in Table 3-3 until it can be shown that water quality is stable, after which monitoring can be conducted every 6 months.

6 Conclusions

This report has been prepared to support an application for development approval and Environmental Authority for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. The assessment described in this report included an assessment of the existing environment; potential contaminants of concern; receiving water environmental values, water quality objectives and trigger values; catchment flows; proposed release regime; contingency measures and monitoring program for releases.

The assessment identified interim trigger values to adopt for the project receiving waters, and controlled release rules that can be utilised to undertake controlled releases to minimise uncontrolled spillway overflows. The anticipated water quality and dilution achieved using the release rules ensures that receiving water quality can be maintained within the identified trigger values.

Overall, the proposed controlled releases and monitoring will ensure that receiving water quality is protected, and uncontrolled releases are minimised, to avoid and minimise the potential for environmental harm to occur.

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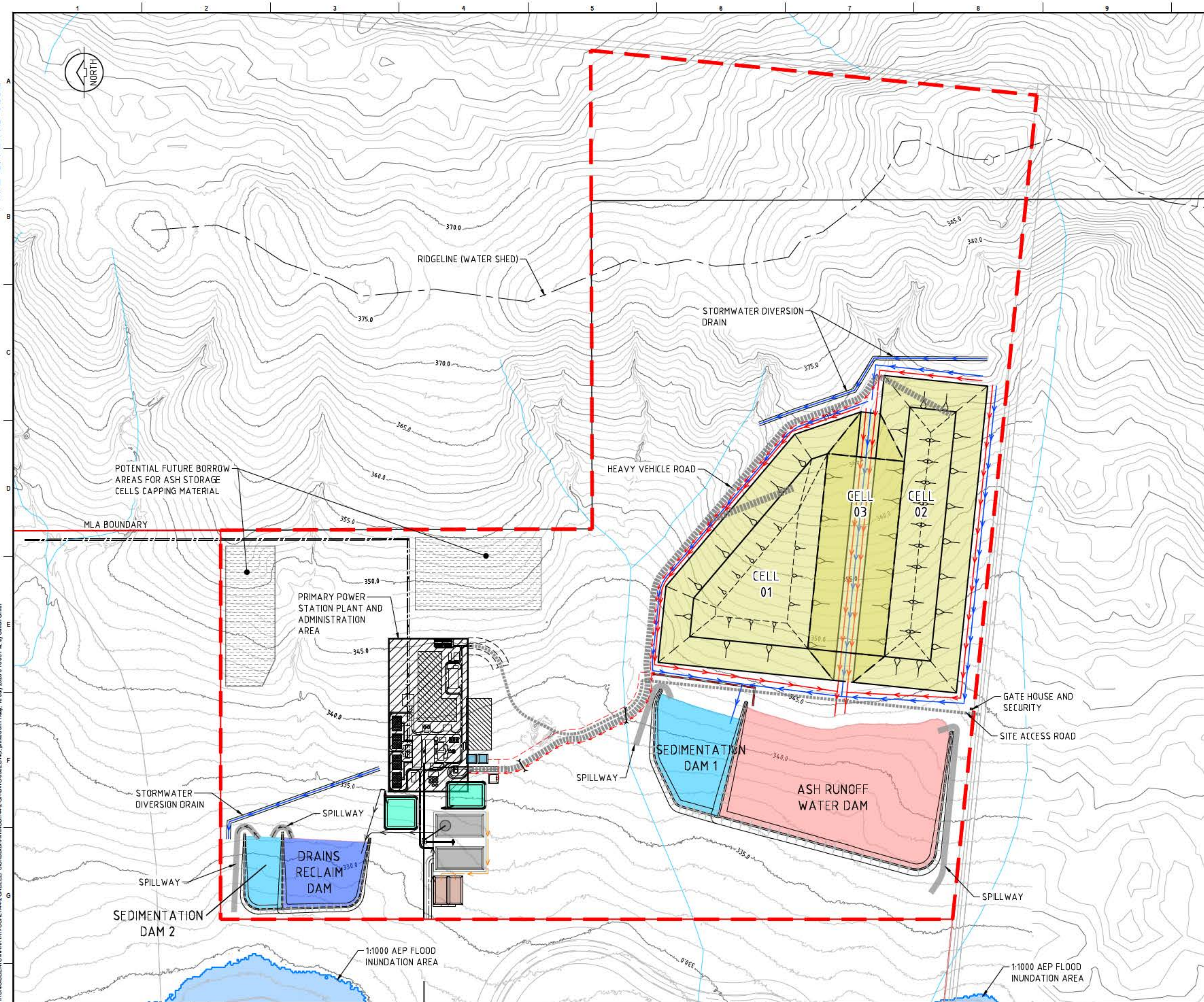
Appendix A

Figures

144-2-GA-DWG-0002



LEGEND

- EXISTING CONTOURS (1.0m)
- SITE BOUNDARY
- STORMWATER DIVERSION DRAIN
- *CLEAN WATER DRAIN
- STORMWATER PIPELINE
- STORMWATER RISING MAIN
- *ASH RUNOFF WATER DRAIN
- DRAINS TO DRAINS RECLAIM DAM
- H.V. ROAD TABLE DRAIN/SW PIPELINE
- SITE ACCESS ROAD
- H.V. ROAD
- ASH STORAGE AREA

*REFER NOTE 1 ON DRG GA-DWG-0005

REV	DATE	BY	DESCRIPTION	CHK	APPD
F	10.07.20	SAS	MINOR AMENDMENTS	LC	SWN
E	15.06.20	GS	LEGEND REVISED	LC	SWN
D	27.05.20	GS	PRELIMINARY ISSUE	LC	SWN
C	18.12.19	CAG	PRELIMINARY ISSUE	LC	SWN
B	09.10.19	CAG	PRELIMINARY ISSUE	PB	SWN
A	04.10.19	SAS	PRELIMINARY ISSUE	PB	SWN

REFERENCE COORDINATION DRAWINGS

DESCRIPTION	DRAWING NO.	REV	CHK

SURVEY DATUM

HORIZONTAL DATUM | VERTICAL DATUM

SCALES

0 100 200 400 600

Full Size 1:10000 ; Half Reduction 1:20000
SCALE (m)

A1 ORIGINAL
DO NOT SCALE THIS DRAWING

APPROVED

SIGNED

DATE | RPEQ

PHRONIS CONSULTING
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Website: www.phronis.com.au

CLIENT: Waratah Coal — THE NEW ENERGY IN COAL

PROJECT: GAL LEE POWER STATION PROJECT CONCEPT DESIGN

TITLE: GALILEE POWER STATION CONCEPT DESIGN SITE LAYOUT PLAN

DRAWING STATUS: PRELIMINARY — NOT FOR CONSTRUCTION

DESIGNED	CHECKED	APPROVED
LC	PB	SWN

PROJECT No	DRAWN	DATE
144-2	CG	26.09.19

DRAWING No: 144-2 - GA- DWG-0002 REV: F

Appendix B

Water Quality Trigger Values

Table B1. WQO / Trigger Values for Sandy Creek sub-catchments

Parameter	Newham et al (2017)[1]		Draft Trigger Values – Saltbush Creek[2]
	Baseflow: <36 m^3/s (gauge 120301B[3])	Event Flow: >36 m^3/s (gauge 120301B)	
Flow (m^3/s)	<36 m^3/s	>36 m^3/s	High (event) flows (90^{th} %ile at Native Companion Creek gauge)[5]: > 0.7 m^3/s average daily flow
Aquatic Ecosystem Protection, Sandy Creek (Belyando River sub-basin waters - all sub-basin waters not named below)			
pH	6.5–8.5 [b]	6.5–8.5 [b]	6.5 – 8.5
Dissolved Oxygen (% saturation)	85–110 [b]	Id	85 – 110[4]
Conductivity (µS/cm)	190-305-550 [a]	95-135-240 [a]	165[#] (n = 10)
Turbidity (ntu)	55–105–265 [a]	100-165-370 [a]	≤370 (event); ≤265 (baseflow)
Suspended Solids (mg/L)	25–60–205 [a]	40-110-250 [a]	≤250 (event); ≤205 (baseflow)
Sulfate (mg/L as SO42-)	2-4-8 [a]	1–2–3 [a]	<1[#] (n = 8)
Sodium (mg/L)	-	-	≤12[#] (n = 8)
Fluoride (mg/L)	2[6]		2
Ammonia N (µg/L)	-	-	≤200[#] (n = 8)
Ammonium N (µg/L)	10–20–60 [a]	7-10-20 [a]	-
Oxidised N (µg/L)	10–30–100 [a]	<5-10-25 [a]	≤25 (event); ≤100 (baseflow)
Total N (µg/L)	600–855–1265 [a]	705-790-980 [a]	≤2,100[#] (n = 8)
Filterable Reactive P (µg/L)	5-10-40 [a]	20-45-70 [a]	≤70 (event); ≤40 (baseflow)
Total P (µg/L)	70–130–270 [a]	160-195-270 [a]	≤270
Chlorophyll-a (µg/L)	6-8-20 [a]	Id	≤20
All fresh waters: Toxicants [c]			
Newham et al (2017) – refer to Table B2. Toxicants in water: refer to AWQG volume 1 section 3.4 'water quality guidelines for toxicants' (including tables 3.4.1, 3.4.2, and Figure 3.4.1), and AWQG volume 2 (section 8). AWQG values for the MD level of protection typically correspond to protection of 95% species (in a small number of cases where bioaccumulation may occur, the AWQG recommends 99% species protection level). Toxicants in sediments: refer to AWQG volume 1 section 3.5 'sediment quality guidelines' (including Table 3.5.1, Figure 3.5.1), and AWQG volume 2 (section 8)			
Freshwaters: Stock water			
Newham et al (2017) As per AWQG, including median faecal coliforms <100 organisms per 100 mL. For total dissolved solids and metals, refer to Tables 16 and 17 of Newham et al (2017), based on AWQG. For other indicators, such as cyanobacteria and pathogens, see AWQG.			
Freshwaters: Visual Recreation			
Newham et al (2017) As per NHMRC (2008), including: recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life. cyanobacteria/algae—refer NHMRC (2008) and Table 18 of Newham et al (2017).			
Freshwaters: Cultural and spiritual values			
Protect or restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans			

Table notes:

1 WQGs for indicators are shown as a range of 20th, 50th and 80th percentiles to be achieved (e.g. 3–4–5), lower and upper limits (e.g. pH: 7.2–8.2), or as a single value (e.g. <15). For single value guidelines, medians of test data are compared against the draft guideline (refer Newham *et al* (2017) for more details).
2 Adopting trigger values from the guideline values presented by Newham et al (2017), unless denoted with a # (site specific values used), in which case the 80th percentile, or the 20th to 80th percentile for ranges (e.g. pH, DO) are used.
3 Belyando River at Gregory Development Road
4 Site specific dissolved oxygen is lower (range 30 – 70% saturation), however this is considered very low, and indicative of ephemeral conditions. Monitoring for dissolved oxygen should assess upstream / downstream values for change to ensure low dissolved oxygen does not occur due to site operations when background levels are high.
5 After Newham et al (2017), taking the 90th percentile daily average flow from the nearest gauging station (Native Companion Creek, gauge #120305A).
6 Stock watering Environmental Value, from Newham et al (2017)
a Derived from local datasets
b Queensland Water Quality Guidelines (regional guidelines) and/or data
c AWQG (ANZECC & ARMCANZ, 2000)
id insufficient data
\# as noted in '2' above, denotes site specific trigger value
* Newham *et al* (2017) assessed high flow conditions based on the 90th percentile of daily mean flows, representing the 10% of days with the highest recorded flows. For local reference data: Low Flow: 25 – 2038 samples, depending on the parameters, on 1171 different sample dates between 1970 – 2015; High Flow: 19 – 483 samples, depending on parameter, on 364 different sample dates between 1970 – 2015; both sourced from AMCI, Adani, Desert Channels, JCU, Project Hydstra

Table B2. Water quality trigger values for toxicants

Parameter	Newham et al (2017)[1]	Draft Trigger Values – Saltbush Creek[2]
Sandy Creek (Belyando River sub-basin fresh waters, Toxicants)		
Dissolved metals and metalloids		
Aluminium (µg/L)	55 (pH > 6.5) 0.8 (pH < 6.5)[LR]	800[#] (n = 6)
Arsenic (µg/L)	13 (As V) 24 (As III)	13 (As V) 24 (As III)
Boron (µg/L)	370	370
Cadmium (µg/L)	0.2	0.2
Chromium (µg/L)	1 (Cr VI) 3.3 (Cr III)[LR]	1 (Cr VI) 3.3 (Cr III)[LR]
Cobalt (µg/L)	1.4[LR]	1.4[LR]
Copper (µg/L)	1.4	2.0[#] (n = 6)
Iron (µg/L)	300[LR]	1,760
Lead (µg/L)	3.4	3.4
Manganese (µg/L)	1900	1900
Mercury (µg/L)	0.06 (inorganic)[99]	0.06 (inorganic)[99]
Molybdenum (µg/L)	34[LR]	34[LR]
Nickel (µg/L)	11	11
Selenium (µg/L)	5 (total)[99] 11 (Se IV)[LR]	5 (total)[99] 11 (Se IV)[LR]
Silver (µg/L)	0.05	0.05
Uranium (µg/L)	0.5[LR]	0.5[LR]
Vanadium (µg/L)	6[LR]	6[LR]
Zinc (µg/L)	8	8
Total Recoverable Hydrocarbons		
C6-C9	<20	<20[#]
C10-C36	<100	460[#]

Table notes:
1 from ANZG (2018) for slightly to moderately disturbed waters (95% protection, 99% for some elements as recommended by ANZG 2018 (and Newham et al 2017)), other than hydrocarbons, from DES (2017)

2 Adopting trigger values from the guideline values presented by Newham et al (2017), unless denoted with a # (site specific values used), in which case the 80th percentile is used

as noted in '2' above, denotes site specific trigger value

LR Low reliability value from ANZG (2018)

99 Refers to the use of the 99% protection level as recommended by ANZG (2018) for slightly-moderately disturbed waters for this analyte

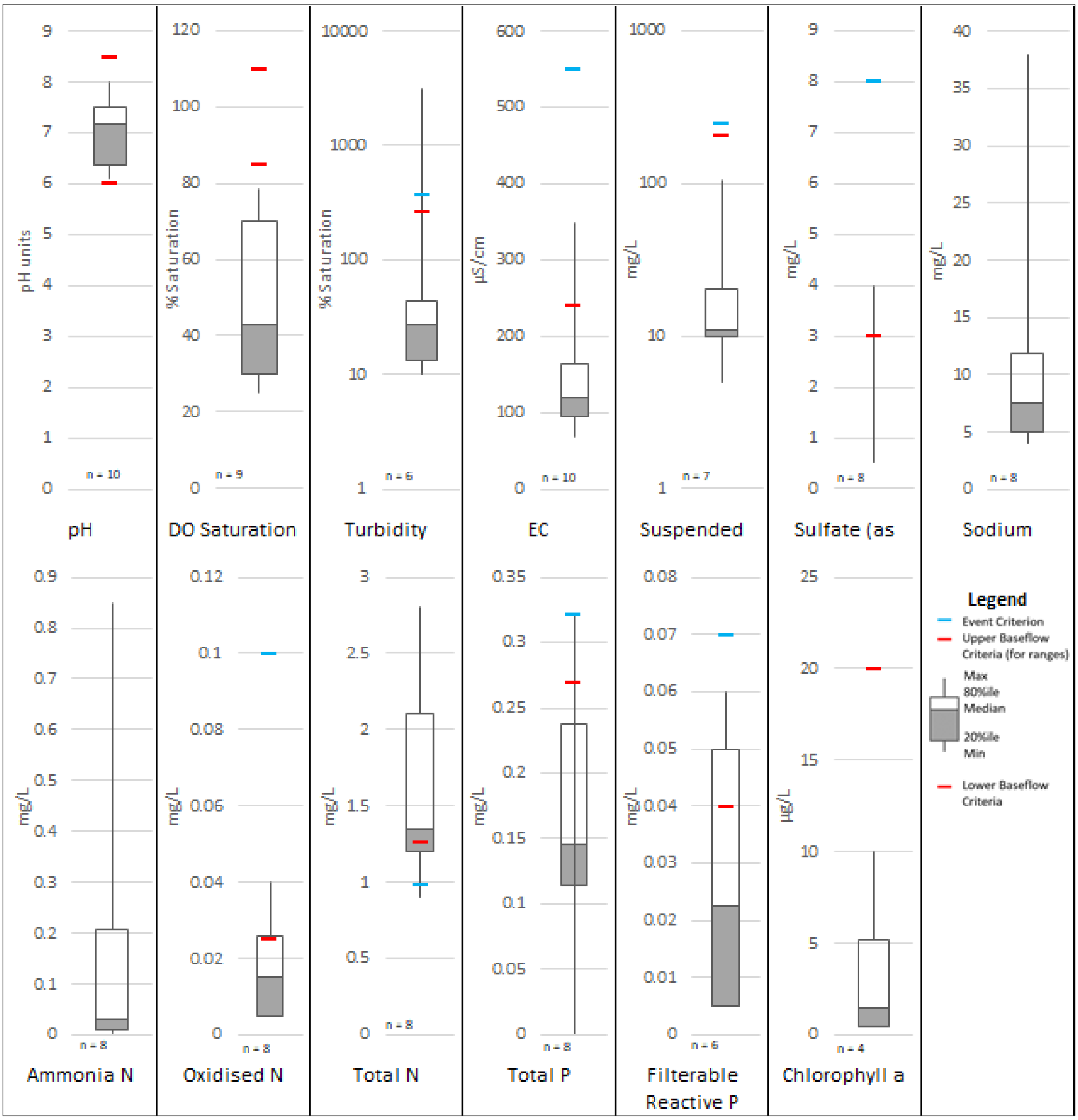

Figure B1. Boxplots of key analytical results from baseline monitoring

Appendix C

Phronis (2020b) Report - ARWD Water Quality

Galilee Power Station

SARA Response

ARWD Water Quality

Document Ref: 144-2-RPT007-aj

Revision: A - DRAFT

PHRONIS CONSULTING

DOCUMENT CONTROL STATUS

Revision Record

Revision	Date	Purpose
A	27/11/20	Draft for review (Client Review)

Review

	Name	Date	Signature
Prepared by:	A Just	25/11/20	
Reviewed by:	L Capel	27/11/20	
Approved by:			

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1 ASH DISPOSAL

1.1 Ash disposal process and infrastructure

The Waste Containment Facility is proposed to be located on the southern side of the Power Station Site and incorporates the following infrastructure.

- Ash Storage Cells 1, 2 & 3;
- Ash Runoff Water Dam (ARWD);
- Sedimentation Dam 1 (adjacent to the ARWD);
- Ash Runoff Water Drains;
- Clean Water Drains;
- Heavy Vehicle Road;
- Stormwater Diversion Drain 1; and
- Ground water monitoring bores installed to monitor for any seepage of contaminants from the Ash Storage Cells or ARWD.

The ash disposal process will involve conditioning the ash with a controlled quantity of water sourced from various waste streams, mainly comprising the reject stream from the RO plant, but also some other streams such as runoff and leachate recycled from the ash cells. This will bring the moisture content of the ash to approximately 20% by weight, at which point the ash is more easily handled but still below the saturation level such that there would not be any free-draining water present in the mix.

The Galilee Power Station Waste Containment Facility, including the Ash Storage Cells, Ash Runoff Water Dam (ARWD) and Sedimentation Dam 1, is planned to be located above the 1:1000 AEP flood level, in a geologically stable area, protected from overland flow. It will therefore not be subject to inundation or contact with significant volumes of water. Some infiltration by rainwater is likely to occur in the active areas during and after emplacement, with the likely infiltration rate decreasing after completion of each cell and application of the capping material which will encourage evaporation, transpiration through vegetation, and runoff.

Any runoff from ash cell surfaces prior to capping, and any leachate produced from the ash cells, will be separated from clean runoff and directed to the ARWD. The ARWD standard operating procedures will be targeted to keep the dam level at <20% of full capacity during average weather conditions, mainly through reuse of the water for ash conditioning or dust suppression. The freeboard comprising the remaining 80% of ARWD capacity will therefore be available to contain runoff during significant rain events, up to a 1:100 AEP event, without the need to spill.

1.2 ARWD water quality assessment

1.2.1 Potential for Leaching of Toxic Substances from the Ash

A preliminary assessment of the potential leaching of substances from the ash in the Ash Storage Cells was undertaken.

Because the ash placed in the cells is not saturated, and rainfall infiltration is minimised to the greatest extent possible, any substances present in the water (e.g. salt rejected from the RO plant, substances leached from the ash) is expected to largely remain within the ash once it has been placed in the cells. In the event of significant infiltration due to a major or sustained rain event, some of this water may become displaced and generate leachate, which will be collected in the ARWD. Runoff from the active ash cell and heavy vehicle road that has been in contact with ash will also be collected in the ARWD.

The ARWD will be managed to operate normally at only 20% capacity, leaving 80% of the capacity as a compartment to handle the additional flow resulting from up to a 1:100 AEP wet season period and/or storm event without spilling. In normal operation, water from the dam that does not evaporate will be returned to the conditioning plant to mix with more ash. Some concentration of contaminants will occur during dry weather, but this will be accompanied by a decrease in operating volume, so that the total contaminant load is expected to remain largely constant.

During a major rain event, inflows are expected to exhibit relatively low levels of contaminants, having been generated by surface flows across rather than through the ash, with large volumes involved so that any substances leached from the surface of the ash will be significantly diluted. Thus it is expected that, in the event that the ARWD reaches 100% capacity and is about to spill, the concentration of contaminant species will be no more than 20% of normal levels in the dam.

A review of over 90 publications on the leaching behaviour of coal fly ash by Izquierdo and Querol in 2012 provides a useful overview of the potential for mobilisation of contaminants in ash in the absence of any actual samples of Galilee Power Station ash to allow testing. A summary of some of the findings of this review relating to the main priority pollutant species found in the Galilee coal ash, is provided in Table 1.1.

Ash is typically an alkaline material as a result of the presence of a number of different metal oxides. As a result, the pH of the water present in the ash is likely to be above 7. However, the concentration of alkaline metal oxides, especially CaO, in the Galilee coal ash is at the low end of the typical range, and the Ca and S concentrations are comparable, so pH is most likely to be in the range 8-9 (Izquierdo and Querol, 2012).

Toxicity Characteristic Leaching Procedure testing has not been undertaken on ash samples from the Galilee product coal to try to quantify the leachability of contaminants, and is in any case not particularly relevant as it is undertaken under acidic conditions that are not likely to be representative of the ash storage. Leachability will be dependent on the actual combustion conditions in the boilers which will affect the way contaminants are incorporated into the ash and the structure of the ash particles themselves, but the objectives of the ash disposal procedures being used are all directed at minimising the opportunity for leaching to occur.

Using the assessment by Izquierdo and Querol of typical solubility values and the fraction of ash components that might leach under conditions that would apply at the Galilee PS, a conservative estimate of the maximum concentration of toxic species in leachate can be derived. The data are not available for all elements of interest, but where representative numbers are given, the maximum likely concentration of each element has been estimated based on both the solubility curves and the leachability. It has been assumed that this leaching process involves only the 20% water added to the ash before placement, or any subsequent infiltration that might subsequently displace the original water. In practice, the quantity of leachable material will slowly decline so that the concentration of each element remaining in the ash and going into solution is likely to fall over time for any given parcel of ash. The solubility and leachability values are given as a guide only, so that the estimated concentrations are at best only estimates. The actual concentration of any species present in the water in contact with ash is a complex function dictated by the chemistry of the ash and all the interacting species present in solution, together with the pH of the water.

To provide a check of these estimates, levels of the species of interest in the water from some typical ash dams for which data are available have been reviewed. Where there is consistent evidence that the levels of an element in actual ash dams is significantly different from the estimated values, the largest value that is reported regularly has generally been adopted as more realistic. (Although this process did not have enough data available to undertake a rigorous analysis, it is estimated that values selected in this way probably represent the 70th or 80th percentile in most cases).

1.2.2 Likely characteristics of water in ARWD

pH

The review by Izquierdo and Querol indicates that for ash with the calcium and sulfur concentrations identified in Galilee coal, a pH in the range of 8-9 is expected. Typical available ash dam measurements show pH mainly in the range 8-9, with the extremes in the range from 7.1 – 11.7 which are likely to be the result of significant rainfall diluting the dam contents and extended drought periods allowing concentration of the water. The most probable pH range appear to be 7.5-9.0. In this range the solubility curves for potential contaminants in the ARWD are relevant, but must be treated with caution as the interactions of species cannot be predicted.

Dissolution of species

Izquierdo and Querol provide a survey of sources covering the likely maximum concentration of species in water that is in contact with ash, and the maximum percentage of any species that is expected to leach from the ash matrix. The former provides an upper limit to the concentration that is expected in ash dam water. The maximum percentage of a species that can typically be leached from ash, together with ash analyses for Galilee ash, has been used to estimate the maximum concentration in the water incorporated with the ash. To do this, it is assumed that the relevant fraction of the species present in the ash is dissolved into the water and that this water is subsequently flushed from the ash by infiltration of additional water. The additional water will generally dissolve less of each species as the remaining quantity decreases.

Aluminium

The solubility of Al is very pH dependent. The maximum solubility of Al within the likely pH range is expected to be approximately 10 mg/L. The maximum leachable fraction is not clear from Izquierdo and Querol, but appears unlikely to exceed 10%. The maximum concentration in leachate is therefore likely to be limited to 10 mg/L. Concentrations in the one ash dam that could be found where Al has been monitored has not exceeded 6 mg/L (as a single extreme reading), and typically only 2 mg/L, with averages significantly lower, <1 mg/L. A maximum likely concentration of 3 mg/L has been adopted.

Arsenic

The maximum solubility of As within the likely pH range is expected to be approximately 1 mg/L. The maximum leachable fraction is not expected to exceed 10%, so that the maximum possible concentration if this occurred would be 8 mg/L. Other ash dams show much lower concentrations, up to 0.1 mg/L. A conservative maximum likely concentration of 1 mg/L has been adopted.

Boron

The maximum solubility of B within the likely pH range is not quoted by Izquierdo and Querol, but they note that the leachable fraction is usually very high. The maximum concentration in leachate could therefore be as high as 1590 mg/L. However, typical concentrations in existing ash dams do not appear to exceed 4-6 mg/L. A maximum likely concentration of 4 mg/L has been adopted.

Cadmium

The concentration in Galilee ash is quite low. The maximum solubility of Cd within the likely pH range is expected to be approximately 0.01 mg/L. The maximum leachable fraction is not expected to exceed 10%, so that the maximum possible concentration would be 0.01 mg/L. Other ash dams show very low levels of Cd, typically <0.0002 mg/L. A conservative maximum concentration of 0.01 mg/L has been adopted.

Mercury

The concentration of Hg in Galilee ash is very low (consistent with ash generally). The maximum solubility of Hg is usually very low, and within the likely pH range is expected to be <0.0002 mg/L. The maximum leachable fraction is also typically very low, and a maximum concentration of 0.0002 mg/L has been adopted.

Lead

The maximum solubility of Pb within the likely pH range is expected to be quite low, <0.01 mg/L. The maximum leachable fraction is also low, not expected to exceed 1%, so that the maximum possible concentration if this occurred would be 5 mg/L. Other ash dams show much lower concentrations, up to 0.004 mg/L. A maximum likely concentration of 0.01 mg/L has been adopted based on the maximum solubility.

Selenium

The maximum solubility of Se within the likely pH range is expected to be 1-2 mg/L. The maximum leachable fraction is estimated to be in the range 10-50%, so that the maximum possible concentration if this occurred would be 30 mg/L. Other ash dams show much lower concentrations, up to 0.4 mg/L in a few samples from one dam, but usually not exceeding 0.2 mg/L. A maximum likely concentration of 0.4 mg/L has been adopted based on the maximum concentration seen in some other ash dams, but this is likely to be conservative.

Zinc

The maximum solubility of Zn within the likely pH range is expected to be typically 0.02 mg/L, although Izquierdo and Querol report a wide range of values. The maximum leachable fraction is estimated to be only 0.2%, so that the maximum possible concentration if this occurred would be 2 mg/L. Other ash dams show concentrations up to 0.4 mg/L as very infrequent outliers, but most frequently 0.1-0.2 mg/L and occasionally 0.05-0.1 mg/L. A maximum likely concentration of 0.02 mg/L has been adopted based on the likely maximum solubility in the expected pH range and distribution of observed concentration in actual ash dams.

Table 1.1: Concentration of contaminants expected in ARWD

Element	Likely maximum solubility mg/L	Maximum fraction likely to be extracted from ash (%)	Concentration in Galilee ash mg/kg	Estimated maximum possible concentration mg/L	Typical maximum concentration in other ash dams mg/L	Adopted maximum concentration likely in ARWD µg/L	Maximum likely discharge concentration µg/L	Dilution required to meet ANZECC guideline	ANZ guidelines (2018) ‡ µg/L
Aluminium	10	10	170,000 (as Al)	10	3	3,000	600	11	55
Arsenic	1	15	10.8	1	0.1	1,000	200	8	24 (As III); 13 (As IV)
Boron	ND*	65	489	1590	4	4,000	800	2	370
Cadmium	0.01	10	0.3	0.01	0.0002	10	2	10	0.2
Mercury	<0.0002	Very low	0.2	0.0002	ND*	0.2	0.04	-	0.6
Lead	<0.01	1	91	0.01	0.004	10	2	-	3.4
Selenium	1-2	50	12.7	2	0.4	400	80	16	5 (99% protection)
Zinc	0.02	0.2	200	0.02	0.3	300	60	8	8

‡ 95% species protection level in fresh aquatic ecosystems (except as noted)
ND* No data available

1.2.3 Likely characteristics of ARWD water discharged to the environment

As previously noted, the operating level in the ARWD will be targeted at <20% during average weather conditions so that a dilution factor of 5 will typically be achieved before water is spilled due to an extreme rain event. The concentration of contaminants in spilled ARWD water is shown in Table 1.1. In the event that a controlled release is required (for example, to increase freeboard in the dam in anticipation of a major rain event), release would not be initiated unless the ARWD level had already risen substantially above 20% as a result of previous rain events, and similar concentrations to those in spilled water would be present. It would also be possible to test the dam ahead of any release to confirm that the concentration of contaminants would not exceed guideline values in the receiving waters.

In the event of a leak from the ARWD as a result of a punctured liner, the concentration is likely to be the adopted maximum concentration shown in Table 1.1.

1.3 Prevention of environmental harm arising from discharges

1.3.1 Discharges to surface waters

Table 1.1 shows the concentrations of various contaminant species that have been identified in Galilee coal ash, together with an estimate of the concentration of those species that might exist in any leachate that might be generated from the ash cells. The table also shows the current toxicant default guideline values (DGVs) for protection of aquatic ecosystems (typically 95% protection level) published by Water Quality Australia (2018). These guideline values have been selected as the most relevant to the receiving waters which do not normally provide stock watering, domestic supply or irrigation.

Spills and controlled releases of water from the ARWD will occur only as a result of significant rainfall events, typically events exceeding 1:100 AEP, or during a lesser event expected to culminate in such a major event where a reduction in the dam level is considered necessary to provide additional storage volume for safety during a subsequent event. In all these instances, the catchment for the receiving waters will already be experiencing a similar event involving large flows with large dilution factors.

In addition to the large dilution that will occur in the receiving waters, any release will be of relatively short duration. Whilst this might result in a brief exposure to toxicants for any aquatic species present, it will not result in long term exposures or opportunity for significant uptake of chronic toxicants, and the probability of significant environmental harm will consequently be small. There is potential for some contamination of sediments, but the large flows involved are likely to ensure that most toxicant species remain in suspension and are quickly carried downstream where further dilution is likely to occur.

Table 1.1 shows the dilution factors likely to be required in the receiving waters to achieve the DGVs. The maximum dilution required is 16 times to reduce Se levels to the DGV (noting that this is the default value for 99% protection). The estimated AWBM flow statistics for a 1:100 AEP event in the Saltbush Creek diversion is 1478 ML/d or average of 20.2 m^3/s. At a flow rate of 1.1 m^3/s over the spillway (above the 1% AEP to fill the dam) a dilution rate of creek water to ARWD water of 18:1 is provided. During very rare rainfall events significantly less than 1% AEP, large releases could occur through the spillway. At these large creek flows, the flow regime in the creek will be highly turbulent, so that mixing will be rapid and the mixing zone, in which there may be areas where the DGV might be intermittently exceeded, will be short. During very rare rainfall events significantly less than 1% AEP, large releases could occur through the spillway. During these events a large flooding event would be expected in Saltbush Creek providing significant dilution.

It is also noted that if the construction of the diversion of Lagoon Creek and Saltbush Creek (including the diversion of Lagoon Creek into the active channel of Saltbush Creek) is carried out as planned prior to year one of mine operations, this will provide significantly more stream flow for dilution.

For a planned release, the release rate will be under the control of the operator (using valves, pump speed or capacity, siphons or similar control devices), so that flows can be matched to maintain sufficient dilution at all times to prevent the DGVs being exceeded.

1.3.2 Potential Seepage to groundwater

The designs of the ash disposal cells and the ARWD are intended to prevent any fugitive seepage to groundwater. An impermeable synthetic liner (PE or similar) will be installed over a compacted clay base of the ash cells to provide two layers of protection against seepage. A clay base or clay base plus synthetic liner, subject to detailed design, will be provided for the ARWD. An extensive network of groundwater monitoring bores will be established around the cells and ARWD to establish the background levels of any indicator contaminants in the natural groundwater and to detect any signs of changes in concentration of these species down-gradient of the cells and ARWD. The monitoring bores will also provide confirmation of the direction of groundwater flow and depth to the first aquifer that might be impacted by any seepage.

Due to the relatively constrained site, with limited distance between the ash cells, ARWD and boundaries, a compromise is required between the distance of bores from potential sources of seepage and the spacing of bores, in order to minimise the risk of missing any plume that might form.

A baseline groundwater quality monitoring program will be established ahead of the first use of the ash cells and the ARWD. This is required to ascertain both the concentration of naturally occurring species in the groundwater before any potential for contamination, and the natural variability of the concentration of those species.

A full analysis of the typical Galilee PS ash will identify chemicals of concern that might impact groundwater in the event of any seepage in the ash cell or dam liner systems, or a spill that infiltrates any shallow aquifers.

A statistical examination of the background data will enable suitable trigger conditions to be determined and revised from time-to-time, based on the background concentrations and the concentration of those species present in the dam and ash cell leachate. Ahead of such an analysis, it is proposed that a 20% change in background concentration outside the long-term mean ± 1 standard deviation, could be used to trigger additional sampling and testing and, if confirmed, further follow-up action, including reporting of a possible breach of conditions.

Any statistical change in the long term trend (i.e. a change in the slope of any trend line) would also be a suitable trigger.

Subsequent to the commencement of operations, once the trend in the concentration of relevant species in the ARWD has been established, the sensitivity of groundwater to any seepage can be determined and suitable absolute trigger levels set in addition to the statistical triggers proposed above.

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Attachment C

Draft Groundwater Monitoring Program

Galilee Power Station

Groundwater Monitoring Plan

Waratah Coal

WC-GPS-RT004, Rev 0

4-Dec-2020

ORANGEENVIRONMENTAL

Document Properties

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ORANGE ENVIRONMENTAL

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Terms and Abbreviations

ARWD	Ash Runoff Water Dam
EC	Electrical Conductivity
EV	Environmental Values
GAB	Great Artesian Basin
MCU	Material Change of Use
OE	Orange Environmental Pty Ltd
PCoC	Potential Contaminants of Concern
SARA	State Assessment and Referral Agency
SMD	Slightly-Moderately Disturbed (receiving waters)
Waratah Coal	Waratah Coal Pty Ltd
WQO	water quality objectives
µS/cm	Microsiemens
ha	Hectare (10,000 square metres)
km	Kilometres
m	Metres
mbgl	Metres below ground level
mg/L	Milligrams per litre
mm	Millimetres
pH	Scale used to specify the acidity or basicity of an aqueous solution

1 Introduction

1.1 Overview

Orange Environmental Pty Ltd (OE) were engaged by Waratah Coal Pty Ltd (Waratah Coal) to prepare this Groundwater Monitoring Plan for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. Refer to Figure 1-1 for the site location, and Appendix A for the general arrangement plan.

This report has been prepared to assess the existing groundwater environment and outline the proposed monitoring program for the project, in response to queries raised by the State Assessment and Referral Agency (SARA) in their SARA advice notice - Monklands Road, Alpha (ref. 2002-15561 SRA, 4 November 2020), as part of the development application for approval of the project.

1.2 Scope

This plan provides an assessment of the surrounding groundwater environment and a proposed monitoring program, including baseline and background monitoring bores, and seepage monitoring for the ash cells and Ash Runoff Water Dam (ARWD).

1.3 Description of the Development

Waratah Coal propose to develop the Galilee Power Station (the Power Station), a new ultra-supercritical coal fired power generation facility located in the Galilee Basin in Queensland, approximately 30 km to the north of Alpha. The Power Station involves the development of a 1,400 MW ultra-supercritical power station adjacent to Waratah Coal's Galilee Coal Project and will have the dual purpose of servicing the public network and providing the power needs for the Galilee Coal Project mine operations.

The Power Station Site covers an area of approximately 1,310 ha, described as the MCU Area (Material Change of Use Area). Within the 1,310 ha, 518 ha will be subject to disturbance in the form of land clearing and earthworks to facilitate the construction and operation of the Power Station.

The Power Station site will contain the following pieces of infrastructure (see Appendix A):

- Conveyors - Overland Conveyor (to bring coal into the Power Station site from the adjacent Galilee Coal Project); Plant Feed Conveyors (between the Coal Handling Plant and the Coal Bunkers)
- Coal Handling Plant – includes Coal Transfer Station; Coal Stacking Conveyor; Coal Stockpiles (sized for 12 weeks storage); Coal Reclaim Conveyors; Coal Stockpile Runoff Ponds
- Power Station – includes Coal Bunkers; Boilers and Turbine Hall; Air Cooled Condensers and Cooling Tower; Stack
- Flue Gas Desulphurisation - Limestone Silo; Limestone Prep Plant; Lime Injectors; Baghouse; Desulphurisation Plant
- Water Storage and Treatment - Raw Water Dams; Water treatment Plant; Service Water Tanks; Waste Water Ponds
- Ash Handling and Containment Facilities - Ash Silos; Pug Mill; Truck Loading

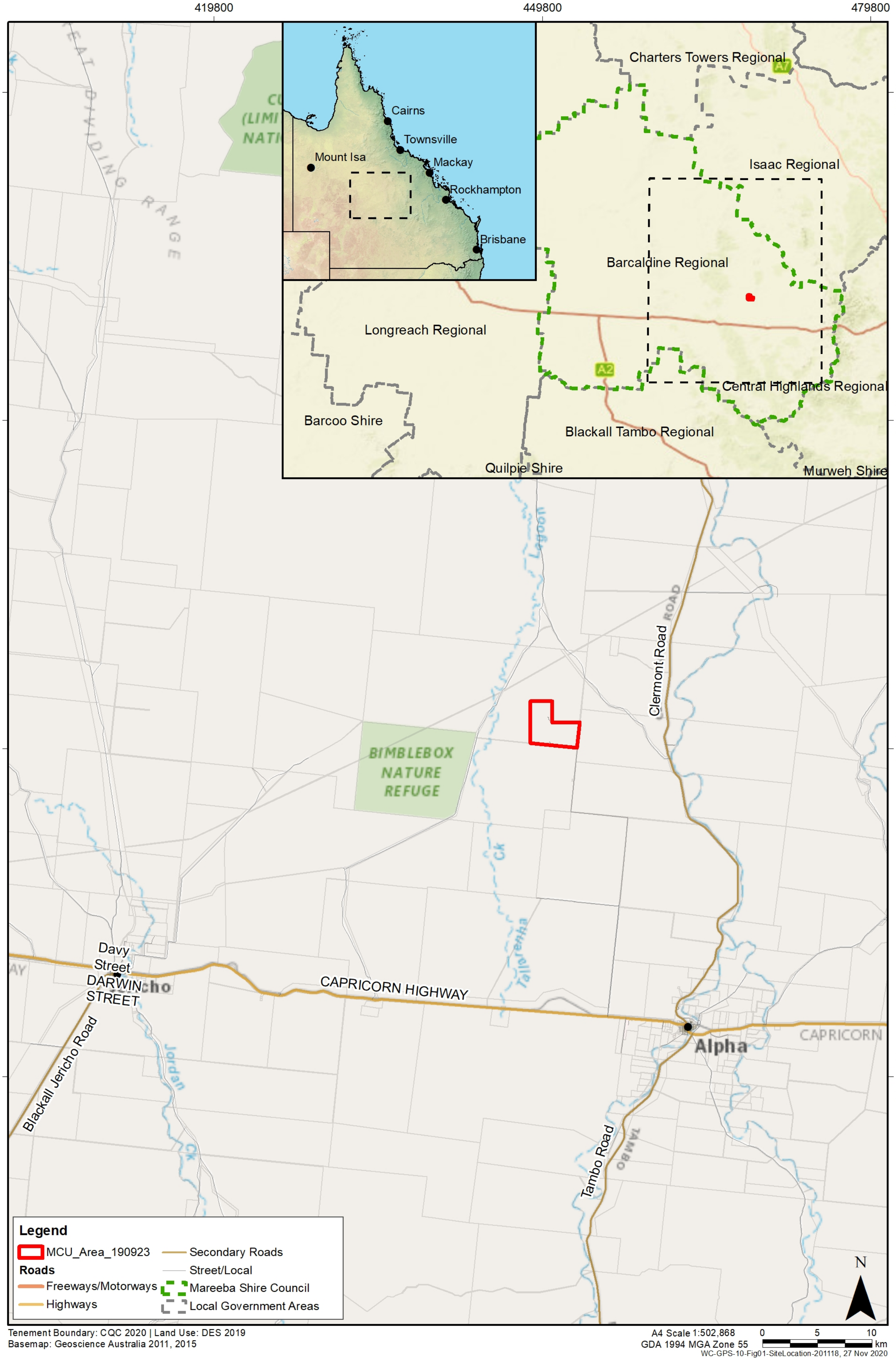


Figure 1-1. Site Location

- Ancillary Infrastructure – Diesel Unloading and Storage; Hydrogen Store; Laboratory; Workshops; Storeroom; Fire Station; Administration Building; Amenities; Carpark; Lay Down Areas
- Power Transmission Infrastructure - Substation, Switchyards and Transmission Line (note that the Transmission line will form part of a separate approvals process)
- Waste Containment Facility (including associated drainage, Ash Runoff Water Dam and Sedimentation Dam 1)
- Plant drainage system, including Drains Reclaim Dam (DRD) and Sedimentation Dam 2.

2 Existing Environment

2.1 Local Climate

The project area has a sub-tropical continental climate and, in general, winter days are warm and sunny, and nights are cold. Mean monthly minimum temperatures range from 19°C in the summer to 7°C in the winter. The mean maximum temperatures range from 36°C in the hottest months and drop to 25°C in winter.

Average annual rainfall at the nearby Barcaldine Post Office (station 036007) (refer Figure 2-1) totals 500 mm, with average monthly rainfall of 75mm during the summer months, dropping to averages of 20mm during winter. Wetter periods, represented by the 90th percentile rainfall, show average monthly rainfalls of 170mm per month over summer and 57mm per month over winter, with a 90th percentile annual total of 823mm. Evaporation likewise peaks in summer, with an overall annual mean daily evaporation rate of 8.5mm/day, or 3,100mm per year, well above rainfall.

Wind direction in the area is predominantly easterly.

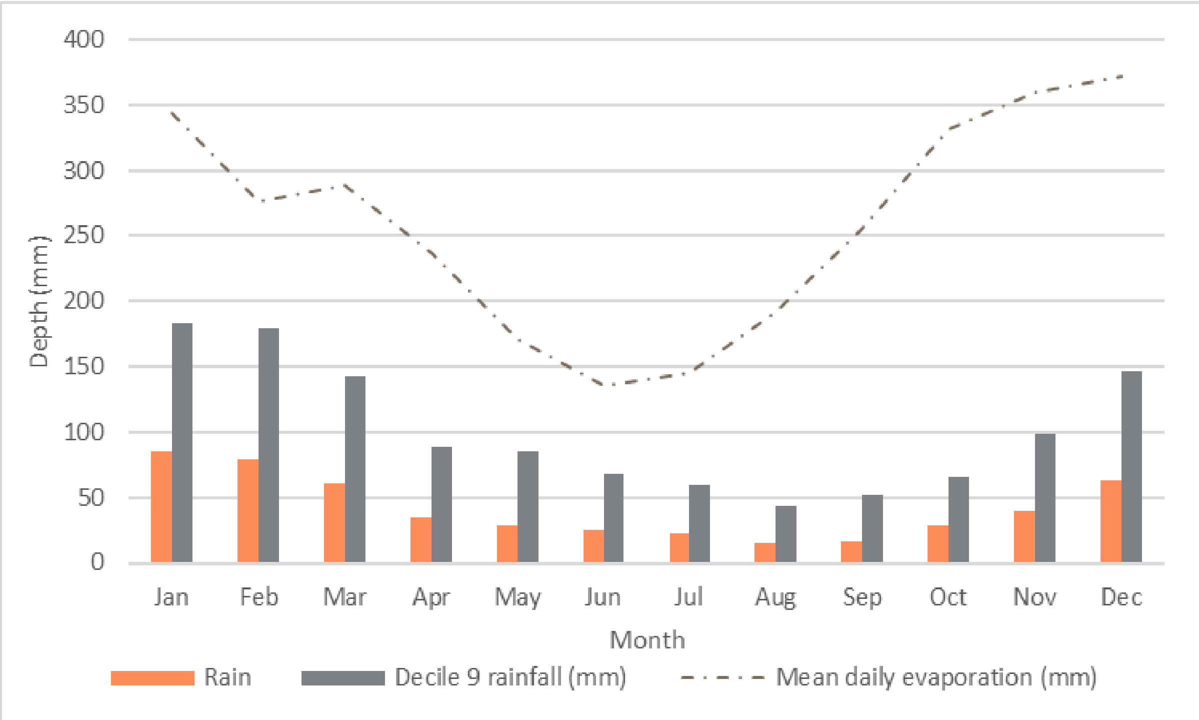


Figure 2-1. Average climatic conditions - Barcaldine Post Office (036007), evaporation from Longreach Aero (036031)

2.2 Geology

The Project is situated within the Galilee Basin, a Permian geological basin in central Queensland located west of the Surat Basin and immediately east of part of the GAB drainage basin. The Galilee Basin is a large intra-cratonic basin filled with mostly fluviatile sediment. It covers about 250,000 km^2 of central Queensland and is connected to the Bowen Basin over the Springsure Shelf (south-east of Alpha).

The site is located on the side of a very gently sloping ridge running north-south, comprising Late Carboniferous to Permian Colinlea sandstone and Joe Joe Group outcropping through surrounding Tertiary sediments on hills and ridges, and Quaternary alluvial plains in the west of the MCU area, with Cainozoic (Pleistocene and Quaternary) channel sediments around drainages further west.

This is shown in Figure 2-2.

Beneath the Cainozoic sediments are weathered remnant Tertiary volcanogenic material, Triassic sedimentary sequences and Permian coal measures (including the Colinlea Sandstone and Joe Joe strata), all of which dip down to the west.

The soil descriptions and available bore data from the adjacent Galilee Coal Project (refer OE 2020a) indicate the Colinlea Sandstone to be around 50 – 70m deep, with Joe Joe lateritised (and weathered) sediments and Cainozoic sediments overlaying the bulk of the site.

2.3 Hydrogeology

The hydrogeological regime of the Project area and surrounds comprises three main groundwater systems:

- Shallow groundwater systems comprising Quaternary alluvial groundwater systems of channel fill deposits associated with various drainages, and tertiary water tables
- underlying Permian strata of low yielding sandstone, low permeability siltstone and moderately permeable coal seams, and
- Great Artesian Basin (GAB) basal aquitard and overlying aquifers to the west.

The GAB aquitard and aquifers are located well to the west of the project, and are not relevant to site operations. Based on the geological mapping, the shallow Quaternary alluvial groundwater systems are potentially located in the west of the site, and may underlie the dams, with the Tertiary water tables making up the bulk of the site, and Permian sandstones underlying all of the site at various depths, anticipated at 50 – 70 m deep.

2.3.1 Alluvial and Tertiary Aquifers

Groundwater flow and water table patterns within the shallow alluvial aquifer were identified by Heritage Computing (2013) as reflecting topographic levels with the containment of alluvium within the principal drainage pathways. These are to a large degree independent of the underlying Permian hard rock fractured aquifers although contribution from these deeper aquifers may occur where and if upward leakage occurs. In most cases a perched water table is expected in the alluvium. It is likely that the alluvium has a role in supplying recharge to the underlying Permian strata as well as contributing to baseflow of surface water features after high flows by releasing water from bank storage.

The water table in the tertiary sequence, away from alluvial deposits, rests at approximately 20 – 60m deep, reflecting topography with localised mounding under hills and rises, and representing the regional water table, with reduced levels in proximity to alluvial areas.

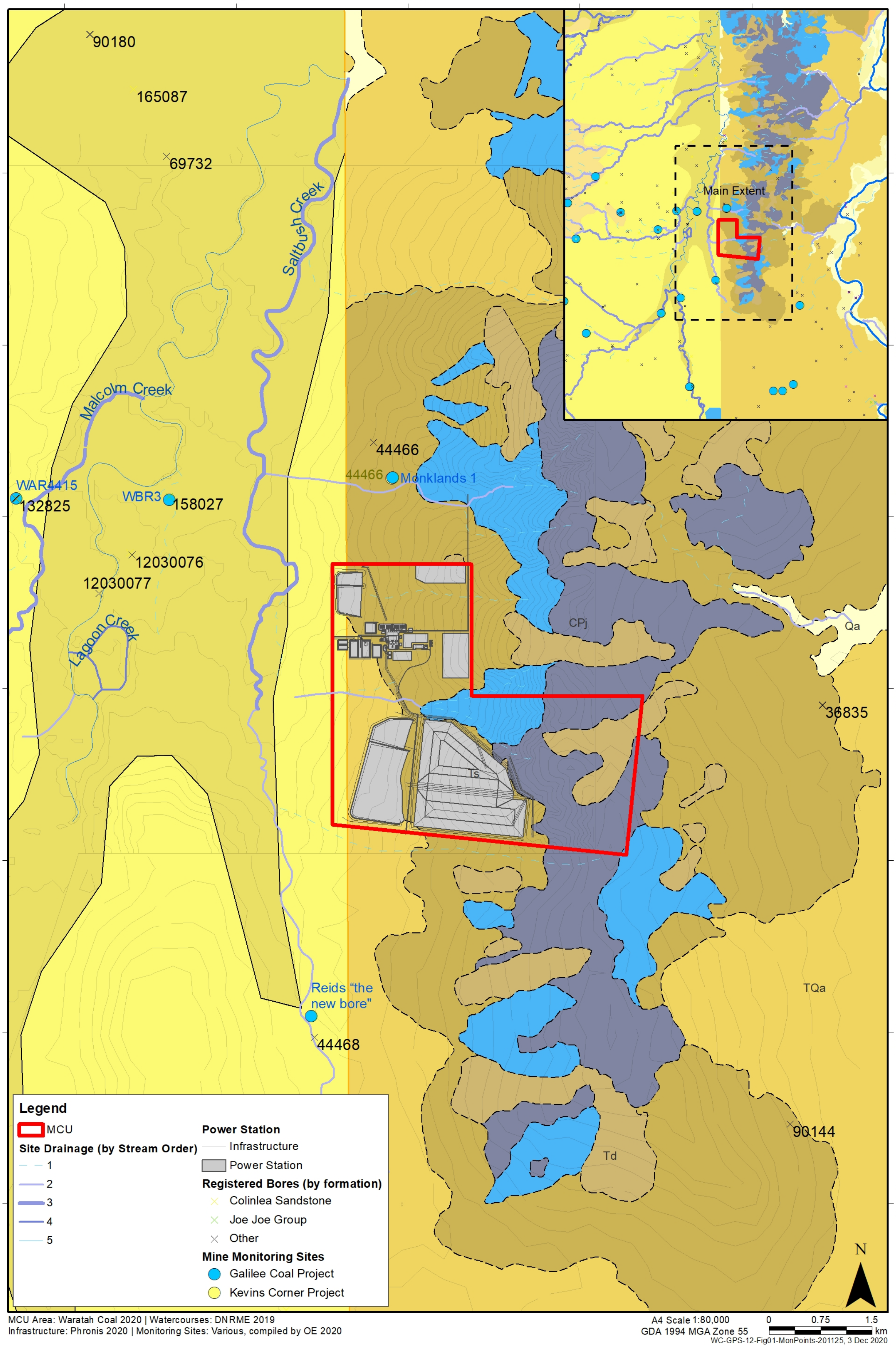


Figure 2-2. Regional geological mapping and water bores

2.3.2 Permian Aquifers

Based on the investigation by Heritage Computing (2013), the piezometric surface within Permian aquifers in the area was found to most probably also reflect topography, with elevated water levels/pressures in areas distant from the major drainages and reduced levels in areas adjacent to the alluvial lands. The Permian aquifer system within the Project area is continuous through the major geological formations.

The various sedimentary rocks have low permeability due to their fine-grained nature, the predominance of cemented lithic sandstones and the common occurrence of a clayey matrix in the sandstones and conglomerates. The permeability of the aquifer system is controlled by joint spacing and aperture width and in some units by primary porosity. Permeability of the rock units generally decreases with depth of burial as the joints tighten and become less frequent, with higher permeabilities expected in the coal seams due to cleating. The coal seams are generally more brittle and therefore more densely fractured than the overburden and interburden strata, with groundwater flow predominantly through cleat fractures. Due to the laminar nature of the coal measures, groundwater flow generally occurs within, or along the boundaries between, stratigraphic layers. The laminated fabric of the interbedded sandstone/siltstone/mudstone strata suggests that vertical hydraulic conductivities are significantly lower than horizontal hydraulic conductivities.

2.3.3 Groundwater Depths and Flow Directions

Shallow groundwater flow is generally to the north along the Lagoon and Sandy Creek drainages, with flow expected to be westwards towards Saltbush and Lagoon Creeks across the project site, following the topography. The depth to the regional (not perched) water table is generally a minimum of about 10 m along the drainages, increasing to the order of 100 m beneath the Clematis Sandstone ridge to the west.

Standing water levels measured in bores running along similar geology 20 km to the north and south indicates a typical depth to peizometric surface (i.e. water table head) in the order of:

- Colinlea Sandstone: 10 – 22 m (min 7 m, max 37 m)
- Joe Joe sediments: 20 – 31 m (min 13 m, max 37 m)
- Regolith and Tertiary sediments; 10 – 28 m (min 5 m, max 45 m)

Seven registered groundwater bores within 5 km of the MCU area within the same alluvial geology with data on standing water level in three (RN36823, RN36835 and RN90144) recording it between 15.2 to 33 mbgl (refer Figure 2-2). Sampling of other bores further to the west also show water levels well below 10m depth. EC is recorded at 1,100 µS/cm at another bore (RN44468), and saltier in other bores in the area, other than Colinlea Sandstone which is relatively fresh.

The Colinlea Sandstone is encountered in the bores to the south-east of the project, at around 70m depth, although as noted above the standing water level rises above this level.

Together, this indicates a depth to groundwater that is greater than 10 m, and likely 20 – 30 m or more for the Colinea Sandstone, with depth decreasing (water table closer to the surface) moving west from the site towards Saltbush Creek, outside of the MCU area.

2.3.4 Groundwater quality

Water quality from registered groundwater bores, the nearby Galilee Coal Project monitoring network, and other nearby coal project bores was collated and summary statistics generated for the key hydrogeological units present on the site. Results for the key parameters for each of the main units is shown in Appendix C.

In general, groundwater in the Tertiary aquifers can be described as saline with a neutral pH, being a bicarbonate-carbonate groundwater, with generally low metals, other than lead, zinc and iron, and elevated nitrogen. The Colinlea Sandstone shows a similar salinity level and water type, but higher range at some bores to quite saline, with a neutral pH, low metals other than aluminium, boron, iron, molybdenum, nickel and zinc. Total nitrogen levels are lower, but phosphorous is higher compared to the tertiary bores.

3 Environmental Values and Water Quality Objectives

Draft Environmental Values (EVs) and 'water quality chemistry ranges' have been developed by the Queensland Government as part of consultation materials, which will form the basis for groundwater EVs, water quality objectives (WQOs), and mapping for inclusion in the *Environmental Protection (Water) Policy 2009* (Qld), presented in the *Regional groundwater chemistry zones: Fitzroy-Capricorn-Curtis Coast and Burdekin-Haughton-Don regions: Summary and results* report (McNeil *et al*, 2018).

The report identified the management intent for groundwaters as to *'maintain current water quality (where water quality is in natural condition). Where there is evidence of anthropogenic disturbance in groundwater quality, a long term goal to improve water quality may be established and reflected by the adoption of water quality objectives for affected indicators.'*

The report identifies seven major aquifer classes, of which only two intersect with the Project and its surrounds as follows:

- Alluvium – the project is within the Suttor alluvial aquifer zone, with near stream alluvium mapped near Saltbush and Lagoon Creeks.
- Fractured Rock – the project site sits on the western extent of the Drummond Basin Sediments mapped area. However, based on stratigraphy, the Drummond Group does not occur under the project, and instead flanks the Joe Joe Group (located east of this Group), which is the lowest stratigraphic unit considered.
- Basins Partially Underlying the GAB Zones – the Central Galilee Coal Measures covers the site.
- Cainozoic deposits overlying the GAB zones – the project sits over Saline Tertiary Sediments.

The environmental values for each zone are shown in Table 3-1, with water quality percentiles by chemistry zone for the different indicators from McNeil *et al* (2018) provided in Appendix B.

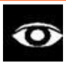
3.1 Water Users

A search of the Queensland Government Water Entitlement Viewer found one water entitlement (number 603589) immediately north of the project area, from the Betts Creek beds for the purpose of dewatering. However, operations on the site are unlikely to affect or be affected by this water licence area.

A number of licences are also located to the west, associated with the GAB, but again are outside of the influence of the project.

The Queensland registered bore network includes a number of bores within 5 km of the project, located primarily within the Colinlea Sandstone or the alluvial aquifers associated with Saltbush and Lagoon Creeks to the west.

Table 3-1. Draft Groundwater Environmental Values

Symbol	Environmental Value	Alluvium	Basins Partially Underlying the GAB Zones		Cainozoic deposits overlying the GAB zones	
			Central Galilee Coal Measures	Western Galilee Clematis	Saline Tertiary Sediments	Central Moderately Saline Weathered Remnants
	Aquatic ecosystems (SMD)	✓	✓	✓	✓	✓
	Irrigation	✓		✓	✓	✓
	Farm supply					
	Stock water	✓	✓	✓	✓	✓
	Aquaculture					
	Human consumer					
	Primary recreation					
	Secondary recreation					
	Visual recreation					
	Drinking water			✓	✓	✓
	Industrial use				✓	✓
	Cultural and spiritual values	✓	✓	✓	✓	✓

4 Monitoring Program

4.1 Overview

The monitoring program is required to detect impacts from the project on groundwater - namely the water table within the surficial Tertiary and Alluvial aquifers, and within the deeper Permian aquifers particularly within the Colinlea Sandstone given its use in water supply in the area.

The key Potential Contaminants of Concern (PCoC) associated with the project – primarily ash storage on the site – has been described in OE (2020b), with the following considered PCoC for groundwater:

- Physico-chemical:
  - pH, salinity (as EC)
  - Sodium, sulfate, fluoride
- Nutrients (likely minor):
  - Total nitrogen and phosphorous
- Metals and metalloids:
  - Ash related – aluminium, arsenic, boron, cadmium, selenium
  - Others which should be considered – chromium, copper, lead, manganese, mercury, molybdenum, nickel, zinc
- Hydrocarbons (likely minor):
  - Total Recoverable Hydrocarbons

Table 4-1 shows the anticipated concentrations in the ARWD compared to background concentrations from the available data. As can be seen, there is potential should the dams leak for elevated concentrations of some constituents to affect groundwater – namely the metals and metalloids. Given the pH and EC levels in the groundwater, these may not be strongly affected, depending on local conditions, however the ionic signature of waters would be expected to differ between the dams and groundwaters and be another useful indicator.

Table 4-1. Comparison of background levels and anticipated dam quality

Analyte	Units	Typical maximum concentration in ARWD	Typical background concentration		
			Surficial Sediments	Colinlea Sandstone	Joe Joe Group
pH		7.5 – 9.0	6.9 – 7.4	6.9 – 7.7	5.9 – 7.4
EC	uS/cm	Elevated	206 – 6,450	1,530 – 22,300	1,020 – 2,190
Aluminium	mg/L	3	-	0.05	1.95
Arsenic	mg/L	1	<0.0001	0.002	0.003
Boron	mg/L	4	-	0.52	0.28
Cadmium	mg/L	0.010	<0.001	0.001	-
Mercury	mg/L	0.0002	-	<0.0001	-
Lead	mg/L	0.010	0.09 – 2.55[1]	<0.001	<0.001
Selenium	mg/L	0.400	-	<0.01	<0.01
Zinc	mg/L	0.300	0.114	0.055	0.006

Table notes:
1 Since the median was so high, the 20th to 80th percentile has been provided for context

4.2 Seepage Monitoring

4.2.1 Location of Bores

A network of groundwater monitoring bores will be situated around the ash cells and ARWD, to measure the depth to water and key water quality parameters relevant to providing both ongoing baseline conditions and early warning of leaks. This is shown in Figure 4-1. Wells will include:

- Bores screened in the water table, being the upper aquifer encountered (surficial Tertiary and Cainozoic sediments, and Permian sandstones and sediments where they outcrop / subcrop
- Deeper bores nested with the above bores to track water in the underlying aquifers, as well as groundwater pressure head differences between the nested screens.

An indicative selection of water table and nested bore sites is shown in Figure 4-1. The bores include those around the ash cells and ARWD, plus locations at the western boundary to provide longitudinal changes.

4.2.2 Monitoring Parameters and Frequency

Monitoring will be conducted over those bores that are able to be installed prior to construction for as long as possible, but at least for one year, undertaking quarterly monitoring to set a baseline. As a minimum, the background bores and two bores in each of the key groundwater systems (surficial aquifers and Colinlea Sandstone) in proximity to the ash cells and ARWD will be installed to allow for this baseline data collection, prior to operations commencing.

During construction, monitoring will be undertaken on a quarterly basis as a minimum. During the first 2 years of operations, monitoring will be conducted as follows:

- First 6 months of operations – monitor for field parameters on a weekly basis (pH, EC, Standing Water Level (SWL)), and laboratory parameters on a monthly basis (remainder of parameters).
- Following 18 months:
  - if no impacts are identified, reduce field monitoring to monthly, and laboratory testing to quarterly.
  - If impacts (or potential impacts) are identified, continue to monitor at the existing (first 6 months) rates.

Following this first two year period, a review of the data will be conducted, and the frequency may be reduced if warranted – this would be anticipated to include monitoring of fewer bores in each quarterly round, focused on simple identified indicators (in-situ where possible), with a full round conducted each 6-months.

Parameters to be monitored will include the PCoC's identified in Section 4.1, and other relevant indicators, namely:

- Physico-chemical:
  - pH, salinity (as EC),
  - Sodium, magnesium, potassium, calcium
  - Sulfate, fluoride
- Nutrients:
  - Total nitrogen and phosphorous

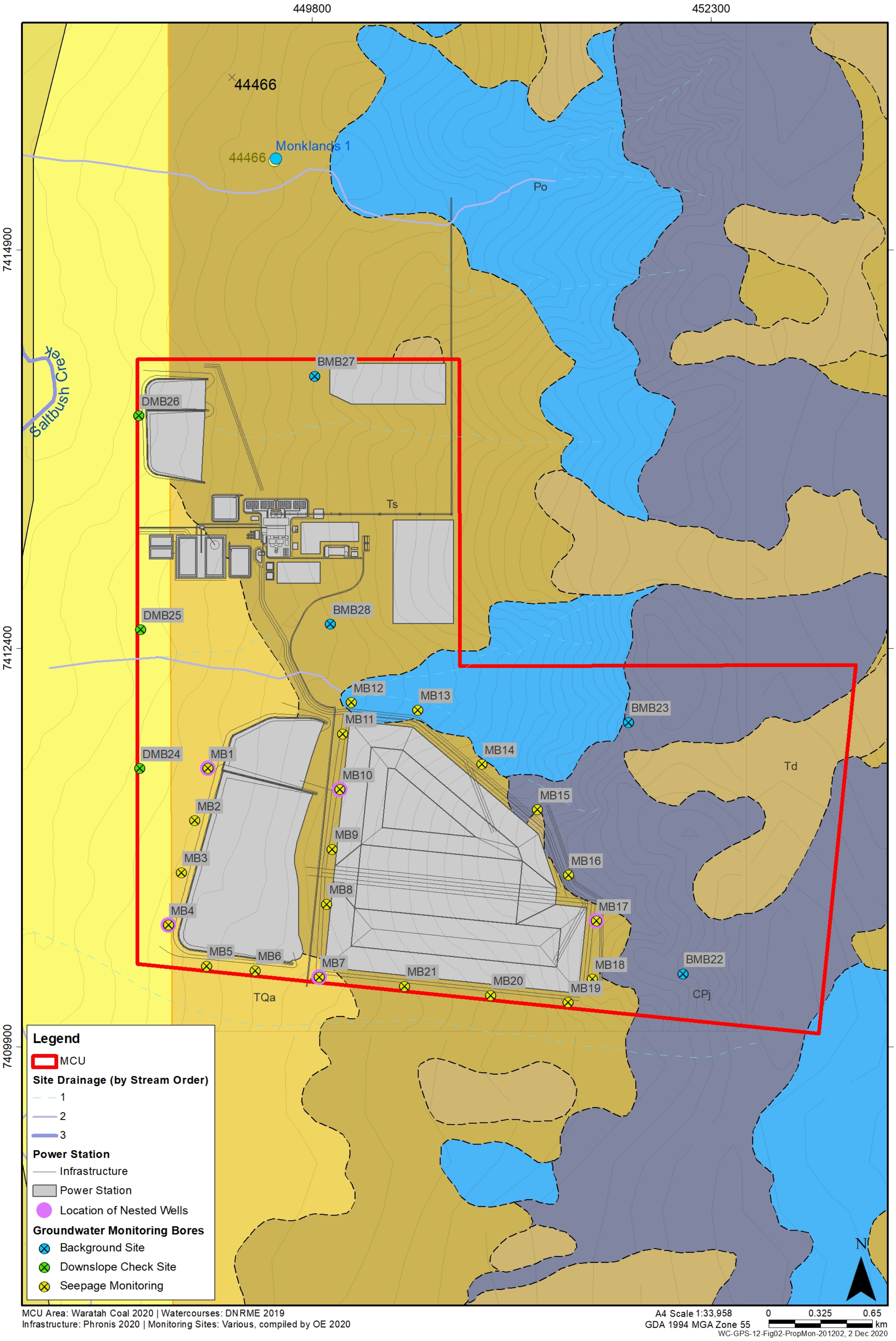


Figure 4-1. Proposed groundwater monitoring network

- Metals and metalloids:
  - Aluminium, arsenic, boron, cadmium, selenium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, zinc.

Hydrocarbons (as total recoverable hydrocarbons) will be monitored during the baseline program to set the baseline conditions, as hydrocarbons may be present due to the coal seams. However, once sufficient baseline data is obtained, ongoing operational monitoring of hydrocarbons will not be required, unless in response to a spill.

4.3 Background Monitoring

Background monitoring bores have been identified within the site, comprising bores located upslope (up-gradient) of the ash cells, and further to the north, but within the same geological measures, to provide un-impacted sites for comparison.

Actual locations will be refined during detailed design as geotechnical testwork provides soil and geological data, and as the bores are installed and developed.

The location of background bores is shown in Figure 4-1.

The background bores will be monitored alongside the impact bores, at the same frequency and for the same parameters.

4.4 General Methodology

Groundwater monitoring must be conducted using appropriate methodology suitable to the sites and analytes being measured. Sampling should be conducted in accordance with the following:

- DES (2018). Monitoring and Sampling Manual: Environmental Protection (Water) Policy. Department of Environment and Science, Brisbane.
- AS/NZS 5667.1 - Water quality - Sampling Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples
- AS/NZS 5667.11 - Water quality - Sampling Guidance on sampling of groundwaters, and
- This Groundwater Monitoring Program.

Generally, groundwater sampling should involve measurement of groundwater level, followed by purging of the bore (nominally 3 – 6 x bore volume of water), and collection of a sample after the bore has been allowed to recharge, to ensure collection of interstitial groundwater rather than water sitting within the bore itself.

Samples are collected by hand bailer (preferably clean disposable bailer) or pump (decontaminated between sites, or peristaltic pump with clean or fresh tubing) and decanted or filled into pre-labelled and appropriately preserved laboratory supplied bottles. Samples for dissolved metals analysis are to be field filtered through a 0.45um filter using a disposable syringe directly into the supplied bottles, with a fresh filter and syringe used at each site. All non-disposable equipment must be decontaminated between each sampling event or site.

Samples are to be placed immediately on ice in an esky before being transported to a NATA accredited laboratory with completed Chain of Custody Documentation.

In-situ (field) testing is to be undertaken on remaining water after filling the laboratory bottles, using a pre-calibrated field test kit. Sensors are placed in the container and readings allowed to stabilise before the results are recorded.

4.5 Trigger Values and Assessment

Interim baseline groundwater quality and levels have been provided in Appendix C, however site-specific baseline data is not considered sufficient to develop determination of specific trigger values at this stage. Instead, it is proposed that any change be conditioned on the difference between baseline / background conditions and operational conditions, with a requirement to implement a groundwater monitoring program and seepage response plan.

Baseline monitoring will be conducted to develop the baseline conditions prior to the project commencing at each of the bores identified in Figure 4-1, and background bores will be monitored alongside the impact bores during operations.

This provides for a before-after-control-impact type monitoring program, where results are compared to long term (baseline) ranges, being the 20^{th} to 80^{th} percentiles and median, and to the current results and trends from background sites.

Early warning triggers will include the following key measures, with initial trigger values finalised during the baseline monitoring program, and rolling statistics generated for comparison during operations:

- Field parameters – pH, EC, SWL
- Physico-chemical - Sodium, magnesium, potassium, calcium, sulfate, chloride
- Metals and metalloids - Aluminium, arsenic, boron, cadmium, selenium, lead, zinc.

The other parameters listed in Section 4.2.2 will also be monitored, and added to the triggers listed above, should background and dam levels warrant their inclusion (these have been chosen as the key indicators for potential seepage occurring).

4.6 Reporting

Each monitoring round will include a factual report outlining the results, control charts of historical and current water quality against trigger values, and recommendations for further action or changes to monitoring.

An annual monitoring report will be prepared summarising the year’s monitoring and performing a more detailed analysis of groundwater and seepage interactions on the site.

5 Contingency Measures

The groundwater program is concerned with detecting and responding to seepage from the dams, particularly the ash cells and ARWD. A seepage response plan (part of the ash management system or a separate plan) will be developed, to include relevant contingency plans In the event that trigger values are exceeded.

Draft contingency responses are provided below.

Trigger Level 1: SWL and groundwater chemistry within historical 20th to 80th percentile ranges, and similar to background bore levels.

Actions:

- Continue monitoring.
- No further response required.

Trigger Level 2: Water level and/or chemistry exceeds 20th to 80th percentile ranges but is within 10% of the maximum range.

Actions:

- Check background bores to determine whether this is a natural change in the area.
- If the change is not seen in the background bores, increase monitoring frequency to weekly.
- Determine extent of change by analysis of data from all potential impact bores.
- If leak identified, initiate rectification works.

Trigger Level 3: Water level and/or chemistry exceeds the maximum ranges, and no similar change is occurring in background bores.

Actions:

- Continuation of actions as per Trigger Level 2 – monitoring, analysis of bore data.
- Undertake detailed investigation of dams in proximity to identified extent of change in groundwater for dam integrity.
- If leak identified, initiate rectification works.

6 Conclusions

This report has been prepared to support an application for development approval and Environmental Authority for the proposed Galilee Power Station on Lot 2 on SP136836, Monkland Road, Hobartville. The assessment described in this report included an assessment of the existing environment; groundwater level and quality; and a proposed monitoring program to detect change within groundwaters underlying the project.

The monitoring program is sufficient to detect change, and the assessment will rely on comparison with baseline conditions and background bores in a before-after-control-impact style monitoring program. Potential Contaminants of Concern have been identified and trigger values will be determined through the baseline program.

Overall, the proposed monitoring will ensure that groundwater is well understood on the site prior to operations commencing, and seepage is detected early so as that rectification works can proceed before significant environmental harm occurs.

7 References

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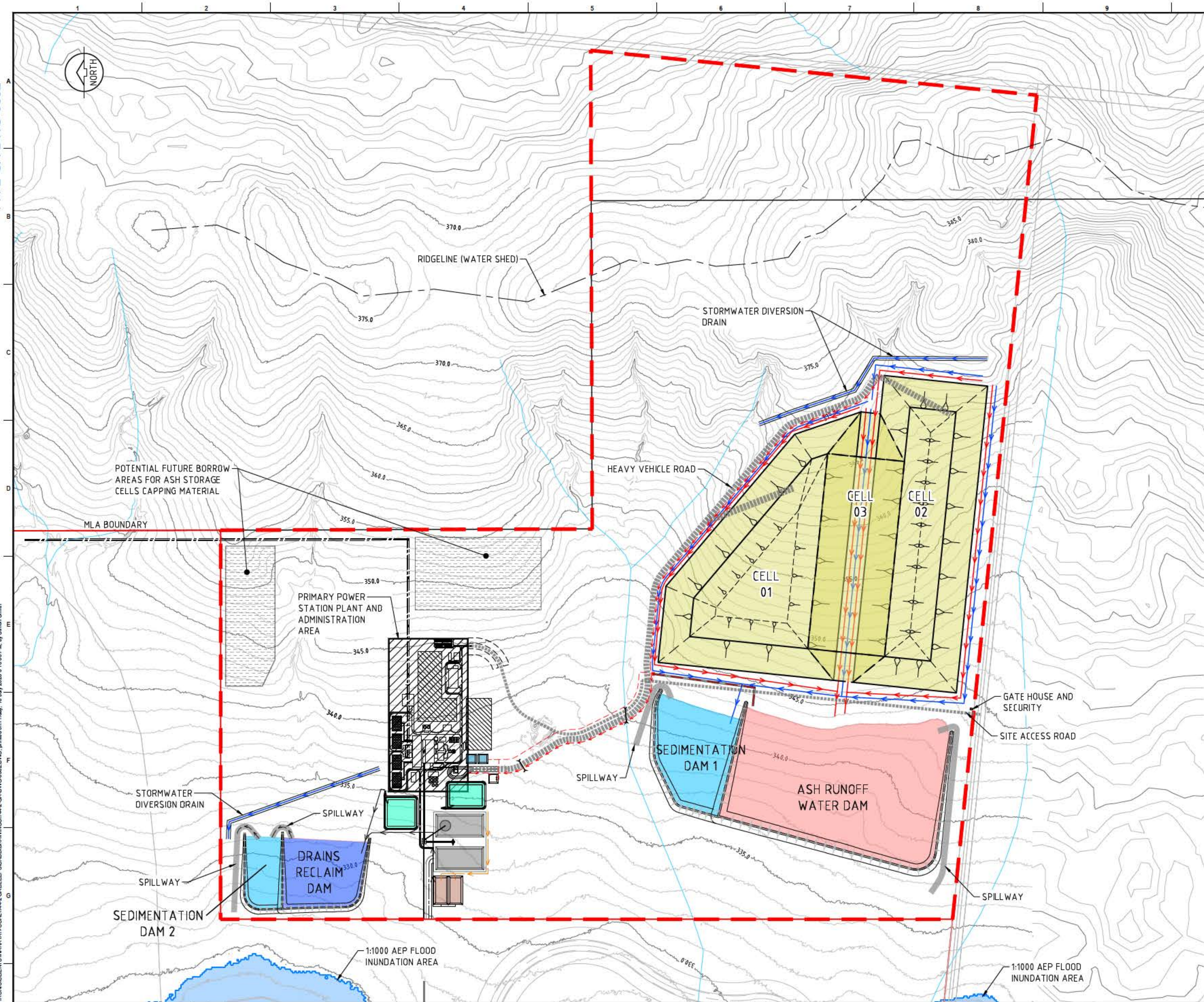
McNeil, V.H., Thames, D., Vaca, F., Bennett, L. & McGregor, G.B. (2018). Regional groundwater chemistry zones: Fitzroy-Capricorn-Curtis Coast and Burdekin-Haughton-Don regions: Summary and results. Draft for consultation. Water Planning Ecology: Department of Environment and Science, Queensland Government.

Appendix A

Figures



LEGEND

- 370.0 EXISTING CONTOURS (1.0m)
- SITE BOUNDARY
- STORMWATER DIVERSION DRAIN
- *CLEAN WATER DRAIN
- STORMWATER PIPELINE
- STORMWATER RISING MAIN
- *ASH RUNOFF WATER DRAIN
- DRAINS TO DRAINS RECLAIM DAM
- H.V. ROAD TABLE DRAIN/SW PIPELINE
- SITE ACCESS ROAD
- H.V. ROAD
- ASH STORAGE AREA

*REFER NOTE 1 ON DRG GA-DWG-0005

REV	DATE	BY	DESCRIPTION	CHK	APPD
F	10.07.20	SAS	MINOR AMENDMENTS	LC	SWN
E	15.06.20	GS	LEGEND REVISED	LC	SWN
D	27.05.20	GS	PRELIMINARY ISSUE	LC	SWN
C	18.12.19	CAG	PRELIMINARY ISSUE	LC	SWN
B	09.10.19	CAG	PRELIMINARY ISSUE	PB	SWN
A	04.10.19	SAS	PRELIMINARY ISSUE	PB	SWN

REFERENCE COORDINATION DRAWINGS

DESCRIPTION	DRAWING NO.	REV	CHK

SURVEY DATUM

HORIZONTAL DATUM | VERT CAL DATUM

SCALES

0 100 200 400 600

Full Size 1:10000 ; Half Reduction 1:20000
SCALE (m)

A1 ORIGINAL
DO NOT SCALE THIS DRAWING

APPROVED

SIGNED

DATE | RPEQ

PHRONIS CONSULTING
Lvl 5 Bldg 2 50 McDougall St, Milton, Qld 4064
T (07) 3506 1100 Fax (07) 3229 8177
Website: www.phronis.com.au

CLIENT

Waratah Coal
THE NEW ENERGY IN COAL

PROJECT
GALILEE POWER STATION PROJECT
CONCEPT DESIGN

TITLE
GALILEE POWER STATION
CONCEPT DESIGN
SITE
LAYOUT PLAN

DRAWING STATUS
PRELIMINARY
NOT FOR CONSTRUCTION

DESIGNED	CHECKED	APPROVED
LC	PB	SWN

PROJECT No	DRAWN	DATE
144-2	CG	26.09.19

DRAWING No: 144-2 - GA- DWG-0002 | REV: F

Appendix B

Water Quality Trigger Values

Table B1. Groundwater Water Quality Objectives

Class	Chemistry zone	%ile	Na mg/L	Ca mg/L	Mg mg/L	HCO_3 mg/L	Cl mg/L	SO_4 mg/L	NO_3 mg/L	EC µS/cm	Hard mg/L	pH	Alk mg/L	SiO_2 mg/L	F mg/L	Fe mg/L	Mn mg/L	Zn mg/L	Cu mg/L	SAR	TN mg/L	TP mg/L
Alluvium	Suttor	20	142	11	6	49	94	23.2	0	821	45	7.1	40	19.2	0.14	0	0.01	0.01	0	8.39	0	id
		50	838	48	71	142	1180	99.1	0.5	6500	462	7.6	129	32	0.38	0.02	0.07	0.06	0.033	15.1	0.109	id
		80	3170	443	410	399	6354	629.3	1.77	21380	2646	8.1	352.6	49.8	0.8	0.803	0.585	0.433	0.324	29.68	0.385	id
Cainozoic deposits overlying the GAB zones	Saline Tertiary Sediments	20	257	10	11	132	326	7.1	0	1019	81	7.1	58.4	15	0.1	0	0.01	0	0	7.89	0	0.021
		50	690	54	70	290	1000	51	0.5	3760	458	7.8	224.5	25.5	0.3	0.02	0.02	0.01	0.001	15.69	0.109	0.082
		80	1800	202	220	508	3596	192.3	2.47	12306	1458	8.2	406.8	56	0.6	0.19	0.1	0.05	0.022	28.27	0.537	0.082
	Central Moderately Saline Weathered Remnants	20	96	23	17	170	75	12	0.83	880	135	7.1	140	25.5	0.2	0.01	0.005	0.01	0	2.47	0.18	id
		50	215	37	35	256	303	32	7	1410	241	7.7	218	60	0.3	0.025	0.01	0.025	0.005	6.04	1.522	id
		80	286	59	64	511	430	52	46	1953	411	8.1	425.6	78	0.4	0.09	0.04	0.117	0.03	7.97	10	id
Basins Partially Underlying the GAB Zones	Central Galilee Coal Measures	20	121	8	4	83	120	5.4	0	780	47	7.2	76.4	13	0.2	0	0	0.001	id	5.13	0	id
		50	293	32	22	191	370	73	0	1555	174	7.7	174.5	17	0.4	0.045	0.04	0.02	id	11.83	0	id
		80	1032	122	105	406	1666	248.8	3	4600	753	8	333.6	25.7	1.2	0.31	0.193	0.11	id	21.89	0.652	id
	Western Galilee Clematis	20	40	1	2	22	55	2.3	0.2	210	11	6.9	26.4	10	0.1	0.03	0.01	id	id	4.24	0.043	id
		50	122	3	6	51	115	5.3	0.5	470	34	7.4	66	14	0.2	0.08	0.02	id	id	10.81	0.109	id
		80	630	68	51	150	1085	60.8	1.16	3375	400	7.8	125.8	23.2	0.5	0.477	0.237	id	id	17.17	0.252	id

Table notes:

Na: Sodium, Ca: Calcium, Mg: Magnesium, HCO_3: Bicarbonate, Cl: Chloride, SO_4: Sulfate, NO_3: Nitrate, EC: Electrical conductivity, Hard: hardness, Alk: alkalinity, SiO_2: Silica, F: Fluoride, Fe: Iron, Mn: Manganese, Zn: Zinc, Cu: Copper, SAR: Sodium adsorption ratio, TN: total nitrogen, TP: total phosphorus, mg/L: milligrams per Litre, µS/cm: microsiemens/centimetre

Table B2. Water quality trigger values for toxicants

Parameter	Newham et al (2017)[1]	Draft Trigger Values – Saltbush Creek[2]
Sandy Creek (Belyando River sub-basin fresh waters, Toxicants)		
Dissolved metals and metalloids		
Aluminium (µg/L)	55 (pH > 6.5) 0.8 (pH < 6.5)[LR]	800[#] (n = 6)
Arsenic (µg/L)	13 (As V) 24 (As III)	13 (As V) 24 (As III)
Boron (µg/L)	370	370
Cadmium (µg/L)	0.2	0.2
Chromium (µg/L)	1 (Cr VI) 3.3 (Cr III)[LR]	1 (Cr VI) 3.3 (Cr III)[LR]
Cobalt (µg/L)	1.4[LR]	1.4[LR]
Copper (µg/L)	1.4	2.0[#] (n = 6)
Iron (µg/L)	300[LR]	1,760
Lead (µg/L)	3.4	3.4
Manganese (µg/L)	1900	1900
Mercury (µg/L)	0.06 (inorganic)[99]	0.06 (inorganic)[99]
Molybdenum (µg/L)	34[LR]	34[LR]
Nickel (µg/L)	11	11
Selenium (µg/L)	5 (total)[99] 11 (Se IV)[LR]	5 (total)[99] 11 (Se IV)[LR]
Silver (µg/L)	0.05	0.05
Uranium (µg/L)	0.5[LR]	0.5[LR]
Vanadium (µg/L)	6[LR]	6[LR]
Zinc (µg/L)	8	8
Total Recoverable Hydrocarbons		
C6-C9	<20	<20[#]
C10-C36	<100	460[#]

Table notes:

1 from ANZG (2018) for slightly to moderately disturbed waters (95% protection, 99% for some elements as recommended by ANZG 2018 (and Newham et al 2017)), other than hydrocarbons, from DES (2017)

2 Adopting trigger values from the guideline values presented by Newham et al (2017), unless denoted with a # (site specific values used), in which case the 80th percentile is used

as noted in '2' above, denotes site specific trigger value

LR Low reliability value from ANZG (2018)

99 Refers to the use of the 99% protection level as recommended by ANZG (2018) for slightly-moderately disturbed waters for this analyte

Appendix C

Water Quality Data

Table C1. Regional groundwater quality – phys-chem, cations and anions, alkalinity*

Ground water System	Parameter	Phys-chem		Cations & Anions										Alkalinity				
		EC	pH	Ca	Mg	K	Na	Cl	F	SiO_2	SO_4	Total Anions	Total Cations	HCO_3	CO_3	OH	Total	Hardness
Regolith (sands, conglomerate, laterite)	All data 20%ile	7520	5.4															
	Sites Median	25652	6.0															
	All data 80%ile	49200 36	6.1 7															
Tertiary	All data 20%ile	206	6.9	4.0	2.9	1.0	30.8	34.0			6.7	21.8	15.6	38.0	0.3		21.6	22.2
	Sites Median	8789	7.1	32	37	10	367	617	0.1 1	64 1	63	29	24	164	154	<1 3	28	23
	All data 80%ile	6450 10	7.4 5	35 7	45 7	9 7	487 7	819 7			58 7	37 3	35 3	150 7	150 7		36 5	23 2
Colinlea Sandstone	All data 20%ile	1530	6.9	16.0	6.0	6.0	322.0	470.0	0.4	15	1.0	89.6	88.0	120.0	0.8 - 1		49.2	48.4
	Sites Median	9617	7.2	91	131	21	1944	3202	1.0	17 4	266	124 4	125 4	178	60	<1 4	115	507
	All data 80%ile	22300 55	7.7 51	153 16	295 16	30 16	4830 16	7300 16	1.0 8	18 7	920 16	152 4	154 4	341 16	33 15		282 13	1560 9
Joe Joe Group	All data 20%ile	1020	5.9	40.6	1.2	9.2	423.0	593.0			60.0	23.6	23.2	1.8	<1	<1	177.0	
	Sites Median	2872	8.2	51	14	19	779	902			91	38	38	142	67	320	530	
	All data 80%ile	2190 24	7.4 21	63 4	24 4	28 4	1100 4	1230 4			116 4	51 4	52 4	282 4	110 4	1280 4	784 4	

Table notes:

* Medians are the average of medians at each site used. However, 20th and 80th percentiles use all data to derive, rather than deriving for each site and averaging (as this tends to average down to close to the median)

* Small number to right indicates total number of data points (across all sites in the groundwater system)

Table C2. Regional groundwater quality – nutrients*

Ground water System	Parameter	NH_3	NO_3	NO_x	NO_2	TKN	TN	TP
Regolith (sands, conglomerate, laterite)	All data 20%ile	No data						
	Sites Median							
	All data 80%ile							
Tertiary	All data 20%ile	0.066	0.300	1.01	1.01	0.12 - 0.18	1.4	<0.01
	Sites Median	0.110	0.750	7.14	7.10	0.28	7.4	0.010
	All data 80%ile	0.150 3	1.200 2	12.3 3	12.3 3	0.42 3	12.5 3	0.012 - 0.016 3
Colinlea Sandstone	All data 20%ile	0.278	0.700	<0.01		0.48	0.48	0.014
	Sites Median	0.413	0.875	0.010	<0.01 3	0.67	0.67	0.048
	All data 80%ile	0.554 3	1.000 8	0.012 - 0.016 3		0.84 3	0.84 3	0.078 3
Joe Joe Group	All data 20%ile	No data						
	Sites Median							
	All data 80%ile							

Table notes:

* Medians are the average of medians at each site used. However, 20^{th} and 80^{th} percentiles use all data to derive, rather than deriving for each site and averaging (as this tends to average down to close to the median)
* Small number to right indicates total number of data points (across all sites in the groundwater system)
* Ranges provide best estimate of the statistic based on the data, made ambiguous by the amount of censored data

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Table C3. Regional groundwater quality – dissolved metals*

Ground water System	Parameter	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn
Regolith (sands, conglomerate, laterite)	All data 20%ile	No data										
	Sites Median											
	All data 80%ile											
Tertiary	All data 20%ile				0.003	0.001		0.09	0.09			0.027
	Sites Median		<0.0001 3	<0.001 3	0.005	<0.001	<0.0001 3	1.46	3.46		<0.001 3	0.114
	All data 80%ile				0.008 3	0.001 3		2.55 3	6.17 3			0.186 3
Colinlea Sandstone	All data 20%ile		<0.001	<0.0001	0.001	<0.001	0.24 - 0.26	<0.001	0.28		<0.001	<0.005
	Sites Median	<0.01 1	0.002	0.001	<0.001	0.005	0.48	<0.001	0.86	<0.0001 3	0.010	0.055
	All data 80%ile		0.002 - 0.003 4	0.0014 - 0.0015 3	0.001 4	0.008 4	0.72 4	<0.001 4	1.43 4		0.016 4	0.086 4
Joe Joe Group	All data 20%ile	<0.01	0.001		<0.001	<0.001			<0.001			<0.005
	Sites Median	1.6	0.003		0.012	0.002	<0.05	<0.001	0.03		<0.001	0.006
	All data 80%ile	2.5 4	0.004 4		0.019 - 0.020 4	0.002 - 0.003 4			0.06 4			0.008 4

Table notes:

* Medians are the average of medians at each site used. However, 20th and 80th percentiles use all data to derive, rather than deriving for each site and averaging (as this tends to average down to close to the median)

* Small number to right indicates total number of data points (across all sites in the groundwater system)

* Ranges provide best estimate of the statistic based on the data, made ambiguous by the amount of censored data

Table C4. Regional groundwater quality – total metals*

Ground water System	Parameter	Al	As	B	Cr	Cu	Fe	Pb	Mn	Mb	Ni	Se	Ag	Zn
Regolith (sands, conglomerate, laterite)	All data 20%ile	No data												
	Sites Median													
	All data 80%ile													
Tertiary	All data 20%ile													
	Sites Median						6.10 1		0.010 1					
	All data 80%ile													
Colinlea Sandstone	All data 20%ile						0.08		0.040					<0.005 - 0.006
	Sites Median	0.05 1	<0.001 1	0.52 1	<0.001 1	<0.001 1	0.62	<0.001 1	0.312	0.004 1	0.002 1	<0.01 1	<0.001 1	0.006
	All data 80%ile						0.61 8		0.178 8					0.008 - 0.009 2
Joe Joe Group	All data 20%ile	0.20	0.002	0.21	<0.001	<0.001	0.16		0.019	0.041	<0.001			0.010
	Sites Median	1.95	0.003	0.28	0.013	0.002	0.36	<0.001 4	0.046	0.130	0.001	<0.01 4	<0.001 4	0.022
	All data 80%ile	3.07 4	0.004 4	0.35 4	0.021 4	0.004 4	0.55 4		0.067 4	0.203 4	0.002 4			0.032 4

Table notes:

* Medians are the average of medians at each site used. However, 20th and 80th percentiles use all data to derive, rather than deriving for each site and averaging (as this tends to average down to close to the median)

* Small number to right indicates total number of data points (across all sites in the groundwater system)

* Ranges provide best estimate of the statistic based on the data, made ambiguous by the amount of censored data

Table C5. Bore details[1]

Name	RN	Formation	Aquifer Depth (m)	SWL (m)	Total Depth (m)	Source
	8090	Tertiary	59.44	45.11	60.4	Registered Bore Network
Monklands 1	44466	Tertiary				Heritage Computing (2013)
	69730	Colinea Sandstone	51	7	57	Registered Bore Network
	69731	Colinea Sandstone	45	11.4	59	Registered Bore Network
	69732	Colinea Sandstone	19	8.78	20	Registered Bore Network
	89327	Colinea Sandstone	89	27	59	Registered Bore Network
	90144	Colinea Sandstone	71	33	77	Registered Bore Network
	90490	Colinea Sandstone	70.1		70.1	Registered Bore Network
	103120	Colinea Sandstone	45.7	36.58	54.9	Registered Bore Network
	132697	Colinea Sandstone	96		99	Registered Bore Network
WAR44-15(NEW)	132791	Colinea Sandstone	56		62	E3 (2010), Heritage Computing (2013)
	132793	Colinea Sandstone	62.6		76.9	Registered Bore Network
	132798	Colinea Sandstone	40			Registered Bore Network
	132800	Colinea Sandstone	47.2			Registered Bore Network
	132801	Colinea Sandstone	20			Registered Bore Network
	132802	Colinea Sandstone	57.5			Registered Bore Network
	132803	Colinea Sandstone	54.4			Registered Bore Network
	132804	Colinea Sandstone	56.5		61	Registered Bore Network
	132813	Colinea Sandstone	64.8		72.9	Registered Bore Network
	132814	Colinea Sandstone	83			Registered Bore Network
WAR44-15(RETRO)	132822	Colinea Sandstone				E3 (2010), Heritage Computing (2013)
WAR44-15(MONITOR)	132825	Colinea Sandstone				E3 (2010), Heritage Computing (2013)
	132891	Colinea Sandstone	51		89	Registered Bore Network
	132892	Colinea Sandstone	30	10.28	30	Registered Bore Network
	132893	Colinea Sandstone	32	11.28	34.9	Registered Bore Network
	132894	Colinea Sandstone	28	16.56	34	Registered Bore Network
	132895	Joe Joe Group	24		44	Registered Bore Network
	132896	Colinea Sandstone	13		15	Registered Bore Network
	132897	Joe Joe Group	50		67	Registered Bore Network
	132898	Joe Joe Group	28	30.22	36	Registered Bore Network
	132899	Colinea Sandstone	10	16.36	18	Registered Bore Network
	132900	Joe Joe Group	66		72	Registered Bore Network
	132901	Joe Joe Group	52		60	Registered Bore Network
	132902	Tertiary	24	13.77	30	Registered Bore Network
	132903	Tertiary	6	10.29	12	Registered Bore Network
	132904	Joe Joe Group	64		76	Registered Bore Network
	132905	Joe Joe Group	30	25.81	36	Registered Bore Network
	132906	Tertiary	6	10.84	10	Registered Bore Network

Name	RN	Formation	Aquifer Depth (m)	SWL (m)	Total Depth (m)	Source
	132907	Tertiary	22	26.31	36	Registered Bore Network
	132908	Tertiary	2		18	Registered Bore Network
	132911	Colinea Sandstone	35	10.27	44	Registered Bore Network
	132912	Colinea Sandstone	10	8.23	18	Registered Bore Network
	158698	Colinea Sandstone	64		72.85	Registered Bore Network
	158699	Colinea Sandstone	74		95	Registered Bore Network
	165086	Joe Joe Group	54	20	90	Registered Bore Network
	165087	Colinea Sandstone	120	25	132	Registered Bore Network
	165384	Colinea Sandstone	55	21.1	84	Registered Bore Network
	12030076	Colinea Sandstone	22.9	9.3	28.3	Registered Bore Network
	12030077	Tertiary	4	1.86	8.2	Registered Bore Network
	12030184	Tertiary	29.5		61	Registered Bore Network
Reids “the new bore"		Tertiary				Heritage Computing (2013)
Reids the old bore		Tertiary				Heritage Computing (2013)
AVP-03		Colinea Sandstone				URS (2012)
AVP-05		Colinea Sandstone				URS (2012)
AVP-06		Colinea Sandstone				URS (2012)
AVP-07		Colinea Sandstone				URS (2012)
AVP-09		Colinea Sandstone				URS (2012)
AVP-10		Colinea Sandstone				URS (2012)
AMB-01		Colinea Sandstone				URS (2012)
AMB-02		Colinea Sandstone				URS (2012)
AMB-04		Colinea Sandstone				URS (2012)
ATSF-01B		Laterite				URS (2012)
ATSF-02		Conglomerate within Laterite				URS (2012)
ATSF-03		Conglomerate within Laterite				URS (2012)
ATSF-05b		Joe Joe Group				URS (2012)
ATSF-05c		Laterite				URS (2012)
ATSF-06b		Colinea Sandstone				URS (2012)
ATSF-06c		Surface Sands				URS (2012)
ATSF-07b		Base laterite				URS (2012)
ATSF-07c		Base surface sands				URS (2012)
ATSF-08b		Joe Joe Group				URS (2012)
ATSF-08c		Surface Sands / top laterite				URS (2012)
ATSF-09a		Joe Joe Group				URS (2012)
P4A		Colinea Sandstone				Waratah Coal monitoring program
P4B		Joe Joe Group				Waratah Coal monitoring program
P4C		Joe Joe Group				Waratah Coal monitoring program

Name	RN	Formation	Aquifer Depth (m)	SWL (m)	Total Depth (m)	Source
P4D		Joe Joe Group				Waratah Coal monitoring program
P5A		Joe Joe Group				Waratah Coal monitoring program
P5D		Joe Joe Group				Waratah Coal monitoring program

Table notes:

1 RN – Bore Registration Number, SWL – Standing Water Level (as m below ground level).

Attachment D

Waste Stream Characterisation

Attachment D

Waste Stream Characterisation

Waste	Form	Definition	Classification[3]	Quantity[4]	Destination (this column needs to address the Waste hierarchy)[1]
Fly Ash	Solid	Fine powder that is a by-product of coal combustion in coal fired power plants and is removed from flue gas by equipment such as bag filters or electrostatic precipitators.	Regulated waste (24, category 1) If used under the End of Waste (EOW) Code 'Coal Combustion Products' (ENEW07359717), then it is considered a resource and not a waste	Up to 620,000 t/y	Fly ash production will be minimised where possible through efficient operation (2), with opportunities for reuse (3) in accordance with the EOW Code sought during operations – including for cement products, road pavement binders, paints and adhesive additives, bedding material, soil ameliorant and land application. Reuse on-site will be encouraged where practicable – for example by being incorporated into civil works. The remaining material will be stored on site within the ash storage cells in the waste containment facility on site (7).
Economiser Ash	Solid	Larger ash particles that settle out of the flue gas in the economiser section of the boiler.			
Boiler Bottom Ash	Solid	Larger ash particles, potentially including fused agglomerations of ash depending on the coal composition and boiler conditions, that drop out of the combustion zone in the boilers and are removed from the bottom of the boiler.			
Coal Rejects	Solid	Coal lost from the handling system as a result of spillages, equipment breakdown etc., and any foreign material rejected from the coal grinding circuit (typically rock fragments and similar inert materials).	Not regulated. Not listed in Part 1 of Schedule 9. Does not exceed any of the categorisation thresholds for solid tested waste.	Up to 1,500 t/y	Coal that is uncontaminated may be returned to the stockpiles and subsequently used in the boilers (3). Coal that has been contaminated by foreign material during handling and is not suitable for use in the power station, and any other reject material will be combined with the fly ash and sent to the ash storage cells (7).
Limestone/Desulphurisation Waste	Solid	Gypsum produced from the desulphurisation process.	Potentially Regulated waste (item 21, category 1), but testing is expected to demonstrate that it is not regulated (no expectation that any categorisation thresholds will be exceeded).	Up to 240,000 t/y	A market will be sought to take some or all of the gypsum produced in the desulfurisation process to use in building products, soil conditioner, etc. (3). The viability of such use will be dictated by the market conditions at the time and transport costs involved. The remaining material will be mixed with the ash and stored on site in the ash storage cells (7).
Reverse Osmosis Brine Rejects	Liquid	Brackish/salty water containing approximately 2000-3000 ppm of salt removed from raw water during production of demineralised water. (The salt concentration of this water means that it could potentially be used for stock watering, provided there were no species present that might be toxic to animals).	Regulated waste (40, category 2), but testing is expected to demonstrate that it is not regulated (no expectation that any categorisation thresholds will be exceeded).	254 ML/y	This will be reused in conditioning the ash (3) to reduce the requirement for additional raw water, prior to placement in the ash storage cells (7).
Sewage Treatment Plant Effluent	Liquid	Sewage produced on the site will be typical domestic type sewage waste, from site workers, offices, workshops and amenities. This will be treated in an on-site sewage treatment plant, producing recycled water to a specified standard (Class B). Fuels, oils and chemicals will be excluded from the sewer system.	Sewage waste (recycled water)	~5 kL/d or 1,800 kL/y	Recycled water will be irrigated to a specified Land Application Area on site (6, 7) for treatment in the soil / vegetation system and disposal. Where overflow may occur, any overflows will instead be directed to the wastewater pond and can be incorporated into the ash storage system (7). Overflows have not been predicted with the system proposed for the project.
Sewage Treatment Plant Sludges	Liquid	Sludges produced from pumping out sewage treatment plant tanks, to remove built up solids and ensure effective ongoing operation.	Regulated waste (56, category 2)	2.4 kL/y[2]	Sewage sludges will be pumped out and removed by a licenced transporter to a facility licensed to accept this waste for treatment (6) and disposal (7).
Water Treatment Plant Sludges	Liquid	Sludges produced in the water treatment plant as material is filtered and/or settled out in the treatment process, including solids, flocculated materials and flocculants. The Water Treatment Plant will source water from mine dewatering water, or drains reclaim dam. Possibly from Ash Runoff Water Dam if required.	Potentially Regulated waste (item 21, category 1), but testing is expected to demonstrate that it is not regulated (no expectation that any categorisation thresholds will be exceeded).	200 t/y	Water treatment plant sludges will be incorporated into the ash in the ash storage cells within the waste containment facility on site (7).

Waste	Form	Definition	Classification[3]	Quantity[4]	Destination (this column needs to address the Waste hierarchy)[1]
Ash Fabric Filter Bags	Solid	Filter bags, typically constructed of glass fiber or similar heat- and abrasion-resistant material used to remove fly ash from the boiler flue gas. Filter bags are subject to hot abrasive material and physical stresses, and will eventually fail and need to be replaced to maintain the efficiency of the flue gas cleaning process and prevent emissions.	General waste, except where contaminated by fly ash, in which case potentially regulated waste (24, category 1).	200 t/y	Bags will be contaminated with small quantities of fly ash and will have undergone significant wear and tear, so as not to be suitable for recycling or refurbishment. They will be disposed of together with the fly ash in the ash containment facility (7).
Waste Ion Exchange Resins	Liquid	Ion exchange resins are porous, polymeric materials used in water treatment processes to remove soluble ionic species from water, particularly for the production of de-ionised boiler feed water within the power station. Ion exchange resins are regenerated when they become saturated with the ions that they are designed to remove, but after many cycles they begin to break down and must be replaced with new resins to maintain the efficiency of the process. The resin is an inert substrate for the active material that absorbs the ions of interest. Waste resin is likely to contain an elevated level of species present in the raw water.	Water treatment processes operating on raw water – general waste.	Minimal	Spent ion exchange resins will be incorporated into the ash in the ash storage cells within the waste containment facility on site (7).
Coal and Water Laboratory Waste	Liquid	Laboratory operations will generate liquid waste as part of their operations, as part of cleaning, washing and disposing of test solutions and chemicals. Chemicals would typically comprise acids, bases, indicator dyes and the like. As a bulk product it would be expected to be benign. Any wastes containing particular toxic contaminants would be identified as part of operating procedures and collected separately.	General laboratory waste-water does not fall under any listed class of waste but may contain listed items and exceed liquid waste categorisation threshold for one or more substances. Regulated waste (potentially 1, 7 – to be determined based on materials deposited and/or testing). May exceed the liquid waste categorisation threshold for one or more substances.	Minimal	This water will be directed to the waste water pond for incorporation into the ash for storage on site (7). The very minimal amount of this waste means that it will be undetectable in the waste water pond and ash storage areas. Any laboratory wastes identified as containing particular toxic species will be collected separately and sent to a suitable treatment facility for proper treatment and disposal (6, 7).
	Solid	Solid waste will include small amounts of coal and ash from coal combustion testing, as well as general waste (bags, tools, cartons, etc.)	Ash: Regulated Waste (24) Other: General Waste and some recyclables	Minimal	Ash will be disposed of to the ash system for reuse (3) or disposal (7) as described for fly ash above. General waste will be temporarily stored on-site in waste receptacles (skip bins or similar) before removal off-site for recycling (4) – cardboard, metal, etc. – or disposal (7).
Sediment Dam Waste	Solid	Sediments that settle at the bottom of the sediment dams will periodically be dug out and allowed to dry. On drying it is expected to form a fine-grained sandy to silty material.	Inert waste	Intermittent, minimal	This material will be reused on the site for landscaping works or similar (3), or utilised in the ash capping process, either combined in the ash, or as part of the vegetated capping surface, combined with topsoils (3).
Drain Sediments	Solid	Sediments that settle at the bottom of drains on the site will periodically be dug out during dry periods. They are expected to form a fine-grained sandy to silty material.	Inert waste	Intermittent, minimal	
Auxiliary Cooling Tower Sludges	Liquid	Material removed from the cooling tower during cleaning operations, comprising settled solids (sludges, scale, coarser sediments and biofilms).	Inert waste	Intermittent, minimal	This material will be incorporated into the ash to be stored in the ash containment cells (7).
Effluent from Chemical Cleans	Liquid	Solutions of antiscalant and disinfectant chemicals in water, together with dissolved scale and the remains of any biofilms removed from boiler cleans and RO Plant membrane cleans. The pH of waste streams will be adjusted before disposal.	Not a regulated waste: no relevant item and unlikely to exceed any categorisation threshold.	Intermittent. Minimal	Effluent will be pH adjusted (6) and sent to the wastewater ponds for use in conditioning ash (4).
Boiler Blowdown	Liquid	Boiler blowdown is water that is discharged from the boiler either continuously or periodically to prevent the slow accumulation of trace corrosion products and boiler feed water impurities.	Not a regulated waste: no relevant item and unlikely to exceed any categorisation threshold.	Minimal	Blowdown is relatively pure water. It will be sent to the wastewater ponds for use in conditioning ash (4).
Trace Quantities of Oils and Hydrocarbons	Liquid	All waste oils, fuels, chemicals and containers containing such, as well as oily rags, oil filters and the like, will be stored on-site in bunded areas, before being removed off-site by licenced transporters to a licensed site. However, as part of maintenance	Regulated waste (41, category 2), although in very small amounts.	Trace	Any trace contaminants will be incorporated into the ash in the ash storage cells within the waste containment facility on site (7).

Waste	Form	Definition	Classification[3]	Quantity[4]	Destination (this column needs to address the Waste hierarchy)[1]
		operations (and potential faults), the ash storage system may contain at times trace amounts of oil and hydrocarbons. Any rainfall falling on bunded areas will be passed through a hydrocarbon separator before draining to the wastewater pond. As such, trace amounts of hydrocarbons may also be present from this route as it is used to condition ash.			

Table notes:

1 Numbers refer to levels in the waste hierarchy from the *Waste Reduction and Recycling Act 2011* (Qld), namely (in order of preference) Avoid (1), reduce (2), reuse (3), recycle (4), recover (5), treat (6) and dispose (7).

2 Based on 80L/person/year from AS/NZS1547:2012.

3 Numbers refer to the type of regulated waste in Schedule 9, Part 1 to the *Environmental Protection Regulation 2019* (Qld) (EP Reg). The category according to the EP Reg (Schedule 9, or section 42) is also provided.

4 Quantities estimated – subject to detailed design.

Attachment E

Proposed Draft EA Rehabilitation Conditions

Proposed Environmental Authority Conditions – Rehabilitation

1. The holder of the environmental authority must rehabilitate disturbed areas to be safe, stable and non-polluting landform similar to that of surrounding undisturbed areas.
2. The authorised place must be rehabilitated such that:
   a. Suitable native species of vegetation are planted and established;
   b. Potential for erosion of the site is minimised;
   c. The quality of stormwater, water and seepage released from the site is such that releases of contaminants such as suspended solids, turbidity, total dissolved salts, pH, total iron, total aluminium, and total manganese are not likely to cause environmental harm;
   d. The likelihood of environmental nuisance being caused by release of dust is minimised;
   e. The water quality of any residual water bodies meets criteria for subsequent uses and does not have potential to cause environmental harm;
   f. The final landform is stable and not subject to slumping; and
   g. Any actual and potential acid sulfate soils or acidic or excessively alkaline materials in or on the site are either not disturbed; or, submerged, or treated so as to not be likely to cause environmental harm.
3. The holder of this environmental authority must, in consultation with the administering authority, develop and implement a Progressive Rehabilitation Management Plan (PRMP). The PRMP must address progressive rehabilitation of the waste containment facility and include, but not be limited to, the following:
   a. Disturbance type
   b. Disturbance area
   c. The proposed suitability of land for a particular use
   d. Proposed final surface level and contours, final drainage system and species of vegetation to be planted for the rehabilitation program
   e. A description of rehabilitation management techniques incorporating works and monitoring programs and timetables
   f. Acceptance criteria, and
   g. Keeping of appropriate records of rehabilitation measures implemented including taking of photographs demonstrative of rehabilitation achieved and the preparation of annual rehabilitation progress reports.
4. Rehabilitation of ash storage areas required under condition 2 must take place progressively as soon as practical and at least within six months of attainment of final landforms in those areas.
5. The holder of this environmental authority must update and submit a Final PRMP to the administering authority at least 2 years prior to decommissioning the project. The Final PRMP must contain:
   a. All of the elements described in Condition 3, and
   b. Rehabilitation, closure and handover strategy for all disturbed areas of the authorised place.
6. Any amendments to the Final PRMP are to be submitted to the administering authority.

7. A summary of the annual rehabilitation progress report must be submitted to the administering authority with each annual return, from when the PRMP is implemented, until the environmental authority issued under the Environmental Protection Act 1994 is surrendered or the administering authority advises that this reporting is no longer required (whichever is the earlier).
8. For any infrastructure to remain after all activities have ceased, the holder of the environmental authority must obtain the written agreement of the land owner stating they will take over responsibility for that infrastructure.
9. The holder of the environmental authority must complete rehabilitation of disturbed areas to the satisfaction of the administrating authority.