Irrigation Management Plan November 2017

BOC Limited Kooragang Island

23 November 2017

working with the environment

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1 Introduction

1.1 BOC Limited Kooragang Island

The following Irrigation Management Plan (IMP) has been prepared by MJM Environmental Pty Ltd for BOC Limited Kooragang Island, herein referred to as BOC. The IMP has been prepared in order to identify and detail all necessary measures required to avoid adverse environmental impacts for operation of the irrigation system utilising cooling tower effluent, and to comply with all relevant legislation.

BOC operates under Department of Planning and Environment (the Department) Development Application (DA) 8354 as Consent Authority. BOC also holds NSW Environmental Protection Authority (EPA) Environmental Protection Licence (EPL) 20165.

The facility supplies and manufactures compressed and bulk gases for industry. BOC Kooragang processes waste carbon dioxide gas to liquefied form, and manufactures liquefied nitrogen gas as a by-product. The facility operates 24 hours a day, 7 days a week. The waste carbon dioxide is provided from Orica's Kooragang facility through a pipeline, liquefied, and stored in aboveground tanks prior to processing. The by-product nitrogen gas is stored, and sold as a product redistributed from BOC Kooragang via a direct pipeline to the nearby Cargill facility. Liquid nitrogen gas, liquid argon gas, and liquid oxygen gas are also stored onsite and redistributed to industry. Cooling towers are utilised as part of the production process.

1.2 DA 8354 Approval conditions

On 7 November 2017 BOC was granted approval from the Department to utilise cooling tower effluent for irrigation in accordance with the Conditions of Approval under DA 8354. Conditions B1 and B2 specify that the following is to be performed prior to commencement of operation:

B1. Prior to the commencement of operation, BOC Kooragang must prepare an Effluent Irrigation Management Plan for the Development to the satisfaction of the Secretary. The Effluent Irrigation Management Plan must:

- *a) be submitted to the Secretary for approval prior to the commencement of operation;*
- *b) be prepared by a suitably qualified and experienced expert;*
- *c) include detailed baseline data;*
- *d) identify the statutory approvals that apply to the Development;*
- *e) include a program to monitor and report on:*
  - *i. soil and groundwater; and*
  - *ii. effluent flows and quality; and*
  - *iii. effluent storage and disposal;*
- *f) set specific performance indicators/criteria in accordance with the Effluent Guidelines and including the ANZECC Guidelines long-term trigger values for irrigation; and*
- *g) include a contingency plan to detail:*
  - *i. the procedures for corrective action where the results from the monitoring program required under (e) do not meet the performance indicators/criteria under (f);*
  - *ii. triggers for ceasing irrigation activities; and*
  - *iii. measures to manage any unpredicted impacts and their consequences.*

B2. BOC Kooragang must:

- *a) not commence operation until the Effluent Irrigation Management Plan required by Condition B1 is approved by the Secretary; and*
- b) *implement the most recent version of the Effluent Irrigation Management Plan approved by the Secretary.*

The following IMP is intended to fulfil Conditions B1 and B2 of DA 8354.

1.3 Background

BOC currently possess two (2) cooling towers onsite and cooling tower blowdown (waste) water is produced at a rate of 18,200 litres per week. The effluent continues to four (4) 10,000 litre capacity storage tanks onsite, totalling a capacity of 40,000 litres of effluent storage onsite. The collected effluent is utilised for irrigation purposes in a selected grassed area on the BOC site.

1.4 Environmental Performance Objectives

An ill-managed irrigation system has the potential to cause adverse impacts upon the environment, which may include but are not excluded to:

- Pooling and waterlogging of effluent on the irrigated area(s)
- Flooding of effluent on the irrigated area(s)
- Ineffective drainage onsite
- Increased (unsustainable) groundwater recharge and rising water table
- Increased incidence of water-borne diseases (e.g. mosquito-borne illnesses) due to stagnant water
- Reduced downstream river or water source quality (destination such as a river or ocean)

BOC therefore commit to following best practice for the operation and maintenance of the cooling tower effluent irrigation system.

The environmental objectives for the irrigation system are the following:

- Compliance with conditions of DA 8354 and EPL 12014
- Compliance with all relevant planning instruments and legislation
- Sustainable resource usage including reuse of effluent through a full reuse scheme
- Protection of surface waters and stormwaters
- Sediment, runoff and erosion control
- Protections of groundwater
- Protection of soil
- Protection of flora and fauna
- Prevention of public health risks
- Management of public amenity
- Waste management
- Ability to implement appropriate contingency plans as necessary

The following IMP is intended to be read in conjunction with the extensive information provided in the approval documentation which is available in the following reports and associated appendices:

- *034-1675 Cooling Tower Effluent for Irrigation – Statement of Environmental Effects (SEE*) finalised 15 March 2017
- *034-1675 BOC Kooragang DA 8354 Response to Request for Response to Submissions finalised* 22 June 2017

2 Statutory Context

2.1 Land zoning

BOC's site is located at Lot 5 DP 1015754 9 Egret Street Kooragang, New South Wales. The location is zoned under the *State Environmental Planning Policy (State Significant Precincts) 2005* (SEPP 2005) as part of the *Three Ports* precinct. The Three Ports precinct includes Newcastle, Port Botany and Port Kembla. The Newcastle port site is zoned *SP1 Special Activities*. The location is within the '*Port of Newcastle Lease Area'* of the *State Environmental Planning Policy (Three Ports) 2013* (SEPP 2013). Therefore the SEPP is the main planning instrument and the Department is the consent authority for the activity.

The objectives of Zone SP1 are shown in Table 2-1 as taken from the SEPP 2013.

Table 2-1: Zone SP1 objectives and evaluation comments

Objective	Evaluation comments
To provide for special land uses that are not provided for in other zones.	The SEPP provides for a broad range of activities on Kooragang Island including BOC's current industrial activities. BOC's site perform the normal operations therefore is in keeping with the objective. Irrigation is performed on an already grassed area of the BOC site, therefore is appropriate.
To provide for sites with special natural characteristics that are not provided for in other zones.	The SEPP provides for a BOC's current industrial activities within the Lease area. BOC's site performs the normal operations therefore is in keeping with the objective. Irrigation is performed on an already grassed area of the BOC site, therefore is appropriate.
To facilitate development that is in keeping with the special characteristics of the site or its existing or intended special use, and that minimises any adverse impacts on surrounding land.	The SEPP provides for a BOC's current industrial activities within the Lease area. BOC's site performs normal operations therefore meets the existing and intended uses of the area. Irrigation is performed on an already grassed area of the BOC site. Impacts on surrounding land are minimised and this will be shown in section 6 of the *Cooling Tower Effluent for Irrigation – SEE*. Other industries exist at the Kooragang area that currently utilise irrigation to grassed areas of site, therefore the project is not foreign to the industrial area.
To maximise the use of waterfront areas to accommodate port facilities and industrial, maritime industrial, freight and bulk storage premises that benefit from being located close to port facilities.	The BOC site does not exist on a waterfront area therefore will not have negative impacts on the waterfront areas.
To enable the efficient movement and operation of commercial shipping and to provide for the efficient handling and distribution of freight from port areas through the provision of transport infrastructure.	The BOC site is an existing facility. Irrigation of the effluent will not adversely impact upon efficient traffic movements or port infrastructure as shown in section 6 of the *Cooling Tower Effluent for Irrigation – SEE*.
To provide for port related facilities and development that support the operations of Port Botany, Port Kembla and the Port of Newcastle.	The irrigation of effluent will support port-related facilities by allowing BOC to continue operating due to decreased operational costs and wastewater sent offsite.
To facilitate development that by its nature or scale requires separation from residential areas and other sensitive land uses.	The Lease Area is separate from residential and sensitive land uses, which is typical and beneficial for industry operations such as BOC.
To encourage employment opportunities.	The irrigation of effluent continued employment for BOC personnel, initial construction and set-up contractors, and ongoing employment for continue operation and maintenance of the system.

2.2 Identification of Current Approvals and Consents

The Department of Planning and Environment is the consent authority for modifications and development approval under a Part 4 development application (DA) under the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The land is owned by Port of Newcastle Lessor Pty Limited c/o Property NSW (PON) and approval was granted from PON during the application process.

Newcastle City Council was contacted during October 2016 as the site was previously zoned under the jurisdiction of Newcastle City Council prior to 2013. During correspondence it was determined that Council was not required grant consent for the activity to occur. The original facility development application was granted over 35 years ago around 1974. The following DAs are applicable from Newcastle City Council:

- DA 2013/904 – Replacement of one tank and additional liquid CO_2 storage tank
- DA 05/2271 for Construction of office, amenities and forklift store buildings, truck wash building, car and truck parking facilities and associated driveway
- DA 99/2795 for Subdivision of land into seven lots
- DA 90/0472 for Carbon dioxide purification and liquefaction plant

BOC operates under SafeWork NSW and possesses an *Acknowledgement for Notification of Hazardous Chemicals on Premises* (dangerous goods) issued by SafeWork NSW.

BOC is licensed with NSW EPA under Section 55 of the *Protection of the Environment Operations Act 1997* (POEO Act), and operates under EPL 20165 with the following activities:

- Scheduled Activities:
  - Chemical Production
  - Chemical Storage
- Fee Based Activities:
  - Dangerous goods production
  - General chemicals storage
  - Chemical storage waste generation

EPA approval was required and obtained for the irrigation activity.

2.3 Applicable Legislation, Guidelines and Standards

The NSW EPA's *Environmental Guidelines – Use of Effluent by Irrigation* (2004) document has been applied for the design, operation and maintenance of the irrigation system.

The following legislation, documents, guidelines and standards are also considered applicable to the BOC project:

- State Environmental Planning Policy (Three Ports) 2013
- Environmental Planning and Assessment Regulation 2000
- Environmental Planning and Assessment Act 1979 (EPA&A Act)
- Environment Protection and Biodiversity Conservation Act 1999
- Environmentally Hazardous Chemicals Act 1985
- Protection of the Environment Operations Act 1997
- Protection of the Environment Operations Amendment Act 2011
- EPA's Environmental Guidelines – Use of Effluent by Irrigation (2004)
- Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)
- Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines (ANZECC guidelines)
- NSW Department of Primary Industries Office of Water Recycled Water Guidance Document: Recycled Water Management Systems (2015)
- SafeWork NSW Dangerous Goods Legislation
- AS1940 1993: The storage and handling of flammable and combustible liquids
- AS4452 1997: The storage and handling of toxic substances
- Work Health and Safety Act 2011
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- Contaminated Land Management Act 1997
- Environmentally Hazardous Chemicals Act 1985
- Water Act 1912
- Water Management Act 2000
- Waste Classification Guidelines 2009
- NSW Acid Sulphate Soil Manual 1998

- NSW EPA Soil Sampling Guidelines
- AS4482.1-2005 - Guide to the investigation and sampling of sites with potentially contaminated soil
- NSW EPA Noise Policy for Industry (2017)
- NSW EPA Assessing Vibration: A Technical Guide 2006

2.4 Evaluation to Environmental Planning and Assessment Regulation 2000

The *Environmental Planning and Assessment Regulation 2000* (the Regulation) is used to determine whether a proposed development is Designated Development for the purposes of the DA. A Designated Development requires specific documentation and approval processes, including an Environmental Impact Statement (EIS).

The Regulation was consulted in terms of the proposed scope of BOC's irrigation project. Clause 32, Schedule 3 of the Regulation states the following development is considered designated:

> *32(1)(a)(iii) Waste management facilities or works that store, treat, purify or dispose of waste or sort, process, recycle, recover, use or reuse material from waste and that dispose (by landfilling, incinerating, storing, placing or other means) of solid or liquid waste that comprises more than 1,000 tonnes per year of sludge or effluent.*

BOC intends to reuse cooling tower blowdown water (effluent) for irrigation purposes as an alternative to disposal offsite, therefore is required to consider Clause 32.

BOC produces effluent from the cooling tower operation at a maximum rate of 18,200 litres per week. The maximum volume produced over one (1) year equates to 946,400 litres which is equivalent to 946 tonnes. The volume of effluent produced will not be increased under any circumstance above 946 tonnes per year.

2.5 Evaluation to SEPP (Three Ports) 2013

Part 2 of the SEPP (Three Ports) 2013 covers *Permitted or Prohibited Development*. Zone objectives and land usage was discussed previously in *Section 2.1 Land zoning*.

Part 3 of the SEPP (Three Ports) 2013 covers *Exempt or Complying Development*. The proposed modifications are not considered exempt or complying development.

Part 4 of the SEPP (Three Ports) 2013 covers *State Significant Development and Infrastructure*. The proposed modifications are not considered state significant development or infrastructure.

Part 5 of the SEPP (Three Ports) 2013 covers *Miscellaneous* which are:

- Preservation of trees or vegetation:
    - No vegetation is required to be removed for the project.
    - As the project is irrigation to grassed areas, the potential impacts to vegetation are a major aspect of the project. Potential impacts and mitigation methods for the proposed project were therefore presented in the body of the original SEE.
- Heritage conservation:
    - The site is not identified as a heritage conservation area.
    - The site is not identified as an Aboriginal place of heritage significance.

3 Irrigation System overview

3.1 Purpose of Irrigation

Historically BOC disposed of the cooling tower effluent off-site using a waste contractor. The amount of cooling tower blowdown water produced and disposed was a significant cost to BOC's operations.

Therefore, BOC Kooragang performed investigations to determine that the cooling tower blowdown stream was suitable to be used to irrigate a selected area of land at the site, shown in Figure 3.1, as a full reuse scheme. The investigations consisted of the following stages:

- Planning:
  - Consultation with relevant authorities.
- Site selection:
  - Identification of suitable site and assessment conducted.
  - Detailed effluent quality investigations.
  - Baseline soil and groundwater investigations.
- Design:
  - Establish minimum area of irrigation land required based on limiting loading rates.
  - Calculation of minimum irrigation land area and wet weather storage required (including water balance).
  - Define operational processes to be used in effluent irrigation and management.
- Statutory requirements:
  - Comply with EPA and other relevant authorities in the planning and design stages.
  - Apply for necessary approvals.
- Installation:
  - Install system in accordance with conditions of relevant authorities.
  - Develop a monitoring and reporting program.
- Operation and maintenance:
  - Operate and maintain system in accordance with best management practices and any applicable approvals.

Figure 3.1: Grassed area for irrigation of cooling tower effluent

3.2 Cooling tower effluent production

BOC Kooragang's cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. The cooling tower uses the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature.

The BOC Kooragang cooling tower classification is based on the type of air induction into the tower, in this case a mechanical induced draft cooling tower, which uses power-driven fan motors to force or draw air through the tower. Quantitatively, the material balance around a wet, evaporative cooling tower system is governed by the operational variables of make-up flow rate, evaporation and windage losses, draw-off rate, and the concentration cycles.

Water pumped from the tower basin is the cooling water routed through the process coolers and condensers in an industrial facility. The cool water absorbs heat from the hot process streams which need to be cooled or condensed, and the absorbed heat warms the circulating water. The warm water returns to the top of the cooling tower and trickles downward over the fill material inside the tower. As it trickles down, it contacts ambient air rising up through the tower either by natural draft or by forced draft using large fans in the tower. That contact causes a small amount of the water to be lost as windage/drift and some of the water to evaporate. The heat required to evaporate the water is derived from the water itself, which cools the water back to the original basin water temperature and the water is then ready to recirculate. The evaporated water leaves its dissolved salts behind in the bulk of the water which has not been evaporated, thus raising the salt concentration in the circulating cooling water. To prevent the salt concentration of the water from becoming too high, a portion of the water is drawn off/blown down for disposal. Fresh water make-up is supplied to the tower basin to compensate for the loss of evaporated water, the windage loss water and the draw-off water. The blowdown water is the wastewater produced from the cooling towers. Figure 3.2 and Figure 3.3 show the location of the cooling towers and the wastewater storage tanks.

Figure 3.2: Location of BOC Kooragang's cooling towers and wastewater tanks

Figure 3.3: Cooling tower blowdown wastewater storage tanks and cooling towers

3.3 Water balance

BOC is utilising a full-reuse scheme; that is, to fully utilise the effluent from the cooling towers where possible during normal operations and conditions. A water balance is required to calculate the amount of water and nutrients that can be applied to meet crop requirements, while avoiding runoff and percolation. A water balance was performed for the project approval to calculate the amount of water and nutrients that can be applied to meet crop requirements, while avoiding runoff and percolation. As per the Effluent Guidelines, the water balance is comprised of:

Precipitation + effluent applied = evapotranspiration + percolation + runoff

The inputs to the water balance is shown in Table 3-1, and the full calculations can be found in *034-1675 Response DA 8354 (2017-06-22)*.

Table 3-1: BOC effluent flows

Item	Units	Value	Note / Description
Maximum amount of water generated by cooling tower	L/week	18,200	Cooling tower operation is constant and is not seasonal, therefore the maximum amount generated per week can be assumed to be constant for the full year.
	L/day	2,600	
Irrigation area	m^2	1,544	Figure 3.1

The water balance calculations use the following data as input:

- Irrigation area.
- Rainfall data. The availability of effluent to be used as irrigation varies with rainfall events.
- Expected effluent flow per day.
- Expected runoff volumes (0 for a full reuse scheme).
- Evaporation data. The availability of effluent to be used as irrigation water varies with amount of water evaporated to atmosphere.
- Evapotranspiration. Evaporation data is used as input to estimate evapotranspiration, and applies a crop factor based upon plant productivity. Evapotranspiration is a more accurate estimation of evaporation from land surface where vegetation is present.

The above data sources are used to estimate the *percolation* at BOC in the water balance. Percolation is the '*movement of water down through the soil profile*' as per the Effluent Guidelines, and occurs naturally through rainfall. Percolation also occurs from irrigation in addition to rainfall. The percolation rate is based upon utilising the irrigation system for a conservative estimate of two (2) hours per day over which time the system will discharge the daily rate of effluent to the irrigation area. Therefore, the system will not be operating over 24 hours. The estimated rate of percolation is then compared to the soil type's permeability rates based on literature data.

The water balance showed that the estimated percolation rate of the effluent irrigated at BOC for each month is well below the typical range of percolation rates for the soil type at the facility. The soil type is therefore able to handle the capacity of the effluent applied based upon percolation rates. Therefore, the water balance showed that the addition of effluent is unlikely to cause ponding or waterlogging of the irrigation area at the rate of application, and the effluent is expected to percolate freely through the soil type.

3.4 Existing effluent systems onsite

BOC currently have Council Approval for two (2) existing effluent systems, which are referred to as:

- Septic Tank and Collection Well Pump Out (herein referred to as the *septic system*); and the
- Septic tank and Absorption Trench/Evapotranspiration Area (herein referred to as the *absorption trench*)

The locations of the existing effluent systems are shown in Figure 3.4.

The BOC office and plant has, on average, three (3) staff members onsite during normal operating hours. The office and plant contain one kitchen, and toilets. BOC does not have access to Hunter Water's sewer system. Onsite treatment of amenity wastewater (toilets and sinks) is performed by an onsite septic wastewater treatment system, which is managed using an approved contractor. The wastewater from the amenities at BOC Kooragang will remain in place and serviced by an approved contractor. No wastewater from amenities is to be utilised for irrigation.

Figure 3.4: Septic system and absorption trench locations

3.5 Description and operation of Irrigation System

3.5.1 Pre-Treatment Filtration

Preliminary effluent quality investigations showed that the levels of Fluoride in the cooling tower effluent were above the applied ANZECC irrigation guidelines. The fluoride levels originate from Hunter Water's town-supplied potable water source which is dosed with fluoride as part of the drinking water treatment system, which is then concentrated through recycling and evaporation in the cooling towers.

Investigations were commenced to provide a treatment option for removal of fluoride from the cooling tower wastewater. Investigations showed that fluoride was successfully removed using a filter containing activated alumina.

The irrigation system at BOC includes a pre-treatment filtration step for removal of fluoride prior to irrigation. The original design can be found in report *034 1612 - BOC Treatment Design Report (2016-11-16)*. The process configuration consists of the following:

- Existing 2 X 10 kL cooling tower blowdown storage tanks (totalling 20 kL storage capacity)
- 2 X 10 kL additional water storage tanks
- Use of existing cooling tower blowdown pump facility
- 1 X flow meter
- Activated alumina filtration through 4 X gravity filters
- 1 X treated water storage tank submersible pump
- Irrigation pipework

A schematic and photograph of the pre-treatment system is shown in Figure 3-5 and Figure 3-6.

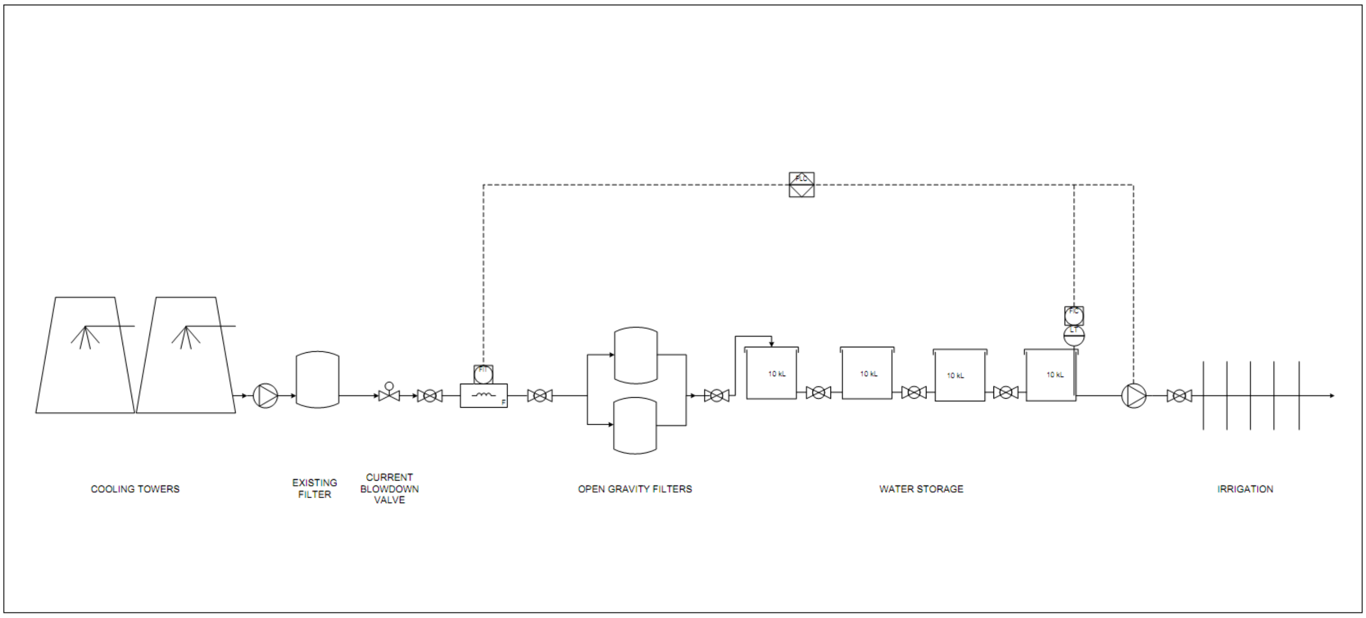


Figure 3-5: Treatment system schematic (not to scale)

Figure 3-6: Installed pre-treatment system and storage

3.5.2 Irrigation System and Pipework

Appendix A contains *Site Plan 9 Egret Street Kooragang 034-1637 220517* which shows the irrigation system and site plan. Figure 3-7 shows the irrigation pipework system schematic from the pre-treatment system to the grassed irrigation area.

The irrigation system includes the following controls as a summary:

- Supervisory Control and Data Acquisition (SCADA) control system in place on irrigation system with appropriate feedback systems.
- Operational modes that include automated operation using a timer for operation during permitted times of the day. The system has been designed for 2 hours of irrigation per day.
- High and low-level alarms and appropriate valves and pipework for all tanks, including existing cooling tower storage tanks.
- Installation of a flow meter.

BOC's irrigation system utilises drip irrigation, which prevents aerosol drift offsite. No additional surface water sources are planned for BOC Kooragang and all effluent storage is located in nominated tanks.

BOC have implemented the internal document *Kooragang Irrigation Procedure* which is provided in Appendix B. For a detailed description and operation of the irrigation system including automation, please refer to the procedure which includes the following information:

- Start and stop procedures for system
- SCADA control system details and screenshots for use
- Level and flow monitoring performed by the system
- Operational parameters and operating modes (auto, manual, idle and off)
- Alarms, instrumentation and notifications

Figure 3-7: Irrigation pipework system diagram (not to scale)

3.5.3 Wet weather storage

Section 7.4 of the *Cooling Tower Effluent for Irrigation - Statement of Environmental Effects February* (2017) showed that the total effluent applied to the land during irrigation is of a volume approximately 1 to 2% of the calculated historical maximum rainfall event. Therefore, the volume of effluent is insignificant in comparison to the potential rainfall event.

However wet weather storage has been considered to meet best practice requirements.

BOC utilise two (2) additional water storage tanks of total capacity 20,000 litres for additional storage capacity allows for an approximate additional week of storage should the need occur.

4 Monitoring Programs

4.1 EPL Monitoring Programs

Monitoring points have been included in EPL 20165 for the operation of the irrigation system. The following sections outline the proposed monitoring points and programs for:

- Cooling tower wastewater (effluent)
- Groundwater
- Soil

BOC uses the site's existing CMMS for scheduling and reminders of monitoring programs. The monitoring is performed by suitably qualified subcontractors and analysis is performed at a NATA-accredited laboratory.

The monitoring data is communicated to EPA in accordance with the *POEO Amendment 2011*, which also means BOC Limited Kooragang Island are required to publish the results of EPL monitoring on the company website. The data is required to be publicly available within two (2) weeks of receiving the results. Monitoring data will also be communicated to the Department.

4.1.1 EPL Effluent Monitoring Program

The outlet of the irrigation system balance/ buffer tank is utilised as a discharge point for effluent monitoring as shown in Figure 4-1. The cooling tower blowdown water used for irrigation is monitored for the analytes outlined in Table 4-1. The wastewater will be monitored quarterly for the first year of operation.

Figure 4-1: Effluent monitoring sample collection point

After the first year of operation, the monitoring program may be reviewed to ensure suitability for subsequent years. Measurement of volume of flows proceeding to the irrigation area is performed by reading the installed flow meter.

Table 4-1: Cooling tower effluent monitoring analytes

Analyte	Unit	Frequency
pH	-	Quarterly
Electrical conductivity	µS/cm	Quarterly
Sodium Absorption Ratio	-	Quarterly
Alkalinity as calcium carbonate (hardness)	mg/L	Quarterly

Analyte	Unit	Frequency
Chloride	mg/L	Quarterly
Sodium	mg/L	Quarterly
Fluoride	mg/L	Quarterly
Nitrogen (total)	mg/L	Quarterly
Total Kjeldahl Nitrogen	mg/L	Quarterly
Sulphate	mg/L	Quarterly
Total dissolved solids	mg/L	Quarterly
Phosphorus	mg/L	Quarterly
Metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)	mg/L	Quarterly
Biological oxygen demand (BOD)	mg/L	Quarterly
Volume	kL/year	Quarterly
Biocides*	mg/L	Commissioning and annually*
Benzotriazole*	mg/L	Commissioning and annually*

*Please refer to Section 4.1.1.1

4.1.1.1 Cooling tower dosing chemicals

Biocides are chemicals added to evaporative applications such as cooling towers to target organisms in the make-up water and reduce bacterial growth that can harm humans. Legionnaires disease is an example of an illness that can be prevented using biocides. Cooling towers can also be dosed with chemical treatments that prevent corrosion, scaling and fouling to extend asset life. The cooling towers are dosed with the following substances comprised of the listed components.

Table 4-2: Cooling tower dosing chemicals used at BOC

Substance name	Composition	Purpose
Nalco 7330 (manufactured by Nalco)	A mixture of: 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl- 2H-isothiazol-3-one (3:1) 1-5 %	Biocide
3D Trasar 3DT188 (manufactured by Nalco)	Phosphoric Acid 5-10% Sulfuric Acid 1-5% Benzotriazole 1-5%	Corrosion protection and pH control in cooling tower

As per the report *034-1675 BOC Kooragang DA 8354 Response to Request for Response to Submissions* (22 June 2017) at the time of writing there does not appear to be a viable method for biocide analysis in Australia by an independent laboratory. Should a method become available BOC will look into implementation of the method as part of the monitoring regime.

The supplier Nalco was contacted for further information about the biocide, Nalco 7330. The substance contains an active biocidal component *5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one.* The substance is an organic compound containing a heterocyclic (ring) structure. The substance is dosed at an initial concentration of 100 ppm to the cooling tower, which therefore means an initial concentration of the active substance of approximately 1.5 ppm. The cooling tower is then not permitted to blow down for two (2) hours following dosing. During the two-hour period the active biocide degrades. Therefore, the active biocidal component is expected to be present in the blowdown water at a maximum concentration of 1.5 ppm at the start of dosing, and degrades further until it is non-detectable by Nalco equipment before blowdown.

Benzotriazole acts as the corrosion inhibitor, which is also a heterocyclic compound and soluble in water. Benzotriazole operates by forming an inert layer (film) as a barrier on the surfaces of metals in such units as cooling towers. Dosing at 100 ppm means that the initial concentration of benzotriazole in the cooling tower water would be between 1 and 5 ppm (approximately up to 4.9 mg/L). Benzotriazole is also used in photographic processes, art preservation, aircraft de-icers and as an ingredient in dishwashing detergents. Therefore, release to the environment can occur through a number of sources and is only partly removed in wastewater treatment plants. The substance is persistent and does not appear to readily biodegrade, although some studies have shown that UV light can assist in partial degradation. Reverse osmosis and ozonation methods appear to successfully remove benzotriazole, along with filtration through magnetic graphene. Successful removal has also been shown with a binary zinc-aluminium oxide filter media (Xu et al, 2010) a media which holds similarities to the proposed activated alumina filter (aluminium oxide). It is therefore proposed that as the benzotriazole is below the toxic threshold for plants, and the use of the metal oxide (alumina) filter, that the proposed use for irrigation may be suitable.

The supplier Nalco (through Ecotech) has advised that a test can be performed for the active component in the biocide and the corrosion protection substance through their internal laboratory.

In order to perform due diligence BOC will perform the test for the biocide and benzotriazole during initial commissioning and annually at the outlet of the treatment system. It is expected that the biocide will be at, or below detection levels due to the described degradation process. The value will be compared to the threshold in the ANZECC Irrigation Guidelines as a conservative assumption.

BOC will continue to monitor the proposed irrigation area visually, and through the monitoring programs. Should the irrigation area appear to be affected by the benzotriazole, BOC will perform investigations into treatment of the substance, or through another alternative dosing substance.

4.1.2 EPL Groundwater Monitoring Program

The bores installed are included in the EPL as monitoring points for groundwater monitoring which are shown in Figure 4-2.

Figure 4-2: Location of groundwater monitoring bores BH1 to BH6

The analytes outlined in Table 4-3 will be monitored via the installed bores for the stated frequencies on the first year and subsequent years of operation. After the first year of operation, BOC proposes the monitoring program can be reviewed to ensure suitability for subsequent years.

Table 4-3: BOC groundwater monitoring program

Analytes	Unit	Frequency 1st year	Frequency subsequent years
Fluoride	mg/L	Quarterly	6-monthly
pH	-	Quarterly	6-monthly
Standing water level	m	Quarterly	6-monthly
Electrical conductivity	µS/cm	Quarterly	6-monthly

Analytes	Unit	Frequency 1st year	Frequency subsequent years
Sodium Absorption Ratio	-	Quarterly	6-monthly
Alkalinity as calcium carbonate (hardness)	mg/L	Quarterly	6-monthly
Chloride	mg/L	Quarterly	6-monthly
Sodium	mg/L	Quarterly	6-monthly
Nitrogen (total)	mg/L	Quarterly	6-monthly
Nitrate	mg/L	Quarterly	6-monthly
Total Kjeldahl Nitrogen	mg/L	Quarterly	6-monthly
Sulphate	mg/L	Quarterly	6-monthly
Phosphorus	mg/L	Quarterly	6-monthly
Available phosphorus (reactive phosphorus)	mg/L	Quarterly	6-monthly
Total dissolved solids	mg/L	Quarterly	6-monthly
Dissolved metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg)	mg/L	Quarterly	Annually

4.1.3 EPL Soil Monitoring Program

The irrigation area is included as a monitoring point for soil monitoring. Soil sampling is performed at the following locations as shown in in Figure 4-3:

- Sampling grid in the irrigation area.
- Three (3) background samples in the immediate surroundings of non-irrigated areas.

For the irrigation area sampling grid, composite samples will be taken for:

- Top soils; and
- Sub-surface soils.

Figure 4-3: Location of soil sampling locations

The analytes outlined in Table 4-4 will be monitored for the stated frequencies on the first year and subsequent years of operation. After the first year of operation, BOC proposes the monitoring program can be reviewed to ensure suitability for subsequent years.

Table 4-4: BOC soil monitoring program

Pollutant	Units	Frequency
Fluoride	mg/kg	Annually
Bray Phosphorus (as Fluoride Extractable Phosphorus, Available phosphorus)	mg/kg	Annually
Collwell Phosphorus (as Bicarbonate Extractable Phosphorus)	mg/kg	Annually
Cation Exchange Capacity	meq/100g	Annually
Chloride	mg/kg	Annually
Conductivity	dS/m	Annually
Exchangeable Calcium	meq/100g	Annually
Exchangeable Magnesium	meq/100g	Annually
Exchangeable Potassium	meq/100g	Annually
Exchangeable Sodium	meq/100g	Annually
pH	-	Annually
Moisture	%	Annually
Nitrate	mg/kg	Every 3 years
Nitrogen (total)	mg/kg	Every 3 years
Nitrogen Oxides	mg/kg	Every 3 years
Phosphorus (total)	mg/kg	Every 3 years
Phosphorus Sorption Capacity	mg/kg	Every 3 years
Total Kjeldahl Nitrogen (TKN)	mg/kg	Every 3 years
Cumulative contaminant loading	-	After first two data sets are available

4.2 Internal monitoring

4.2.1 Acceptance Criteria and Performance Indicators for Effluent Quality

Acceptance criteria and performance indicators for effluent water quality will be applied in order of the following hierarchy as presented in Table 4-5:

1. The *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use* long-term trigger values.
2. Trends obtained from baseline effluent quality and ongoing quarterly monitoring.

The ANZECC guidelines will take precedence over the expected effluent quality trends based upon end-use of the effluent for irrigation.

The baseline and trends in water quality will be utilised for internal performance monitoring.

Table 4-5: BOC internal acceptance criteria and effluent quality performance indicators

Analyte	Units	ANZECC Recommended Irrigation Thresholds [1]
pH	pH Unit	**6 – 9**
Electrical conductivity	µS/cm	-
Sodium Absorption Ratio (SAR)	-	-
Alkalinity as calcium carbonate (hardness)	mg/L	-
Chloride	mg/L	-
Sodium	mg/L	-
Fluoride	mg/L	**1.0[2] 2.0[3]**
Nitrogen (total)	mg/L	**25 - 125[2] 5[3]**
Phosphorus	mg/L	**0.8 - 12[2] 0.05[3]**
COD	mg/L	-
TSS	mg/L	-
Enterococci	CFU/100mL	-
Faecal (thermo tolerant) Coliforms	CFU/100mL	**<10,000**
Cadmium	mg/L	**0.01[2] 0.05[3]**
Zinc	mg/L	**2.0[2] 5.0[3]**
Aluminium	mg/L	**5.0[2] 20[3]**
Arsenic	mg/L	**0.1[2] 2.0[3]**
Beryllium	mg/L	**0.1[2] 0.5[3]**
Boron	mg/L	**0.5[2] 2 – 4[5]**
Chromium VI	mg/L	**0.1[2] 1.0[3]**
Cobalt	mg/L	**0.05[2] 0.1[3]**
Copper	mg/L	**0.2[2] 5.0[3]**
Iron	mg/L	**0.2[2] 10[3]**
Lead	mg/L	**2.0[2] 5.0[3]**
Lithium	mg/L	**2.5[2]**

Analyte	Units	ANZECC Recommended Irrigation Thresholds [1]
		2.5[3]
Manganese	mg/L	**0.2[2]** **10[3]**
Mercury	mg/L	**0.002[2]** **0.002[3]**
Molybdenum	mg/L	**0.01[2]** **0.05[3]**
Nickel	mg/L	**0.2[2]** **2.0[3]**
Selenium	mg/L	**0.02[2]** **0.05[3]**
Uranium	mg/L	**0.01[2]** **0.1[3]**
Vanadium	mg/L	**0.1[2]** **0.5[3]**
Herbicides	µg/L	**1,000[6]**
Pesticides	µg/L	**1,000[6]**

[1] Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.
[2] Short-term trigger value (STV) – The STV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years).
[3] Long-term trigger value (LTV) – The LTV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation.
[4] Trigger value chosen for areas with restricted public access.
[5] Trigger value chosen for moderately tolerant crops.
[6] General limit set for herbicides for NSW.

4.2.2 Site Inspections and Management Practices

BOC aim to meet all environmental objectives of the irrigation system. The following measures are in place, and are focused on in relation to the irrigation system to ensure ongoing monitoring and mitigation of potential risks. Inspections are recorded in BOC's internal procedures and environmental management system (EMS).

Table 4-6: Site inspection and management practices implemented at BOC

Item	Site Management Practice
Daily site inspections	Daily site inspections of the following areas and processes: - Perimeter of the irrigation area to ensure pooling, runoff or waterlogging is not occurring - Drip irrigation system and pipework in proper operation - Cleaning and replacement of lines as necessary following inspections - Irrigation system, when in operation - Effluent treatment system skid including instrumentation and valves - Effluent storages
Weekly site inspections	Daily site inspections of the following areas and processes: - Perimeter of the irrigation area to ensure pooling, runoff or waterlogging is not occurring - Drip irrigation system and pipework in proper operation - Irrigation system, when in operation - Effluent treatment system skid including instrumentation and valves - Effluent storages - Soil surrounding the site's structures. - Stormwater drains and trenches - Site boundaries and adjoining public areas - Remaining areas nominated and described in BOC's *Mosquito Management Plan*

Item	Site Management Practice
Following rainfall event(s)	The weekly inspection list and the areas covered in BOC's *Mosquito Management Plan* are performed following a rainfall event.
General	- Spill procedures and pollution incident management plans maintained as per current procedures. - Review and upkeep of emergency and incident response procedures. - Spill response and incident response equipment stored onsite - Review and upkeep of current operational waste management programs to contain all waste onsite and dispose of appropriately. - Permanent fencing where necessary to mark 'no-go' zones to prevent soil erosion. - Keep current entry, access and exit for vehicles clearly marked and all roads sealed to minimise soil movement and loss. Regular inspections of access areas and repairs as necessary. - Regular maintenance of vehicles to avoid oil or fuel spills. - Spill kits present onsite and maintained. - All servicing of vehicles to be performed offsite. - Sediment control devices put in place if determined necessary, and routinely checked.
Vegetation	- Upkeep of site vegetation is performed including regular mowing of lawns and irrigation area. - No removal of site vegetation. - Inspection performed for potential weed infestation. Weeds are treated at earliest stage. - If threatened or endangered flora and/or fauna species are identified during operation, an ecologist or similar specialist is to be contacted. - If planting of additional vegetation is planned, the flora must be native to the area

4.2.3 Mosquito Management

A site-specific mosquito management plan has been implemented at BOC as *034-1675 Mosquito Management Plan (2017-06-19)*. The objectives of the mosquito management plan are:

- Utilise a balanced approach to consider health and environmental considerations for the control of mosquitoes onsite.
- Provide management for disease control in the first instance, while also reducing nuisance mosquitoes.
- Identify potential breeding areas and conditions.
- Encourage awareness and management for employees, contractors and visitors to BOC.
- Assist to prevent both nuisance biting mosquitoes and disease transmitting mosquitoes affecting employees, visitors and the local population.
- Aim to limit mosquito populations onsite at BOC through best practice methods and techniques.
- To ensure the operations and activities performed onsite at BOC, including irrigation, do not increase adverse impacts upon health and environment due to mosquitoes.

4.2.4 Filter Media Waste Management

The effluent treatment process includes use of activated alumina as a filter media. Once spent, the filter media requires disposal as a waste in accordance with the NSW EPA's *Waste Classification Guidelines* (2014). No additional waste streams are produced from the irrigation process.

The filter is designed for a media life of 12 months, and therefore the media is replaced on a 12-month basis. The spent filter media used in the proposed filters require sampling and analysis to determine the waste classification and disposal options according to the Waste Classification Guidelines. Prior to disposal BOC performs appropriate waste classification utilising an independent third-party consultant and NATA-accredited laboratory. Once the media is analysed and classified, the waste is disposed offsite to an appropriate destination using an appropriately licensed waste contractor as required, including the use of waste data forms as necessary.

4.3 Baseline Monitoring Data

The use of effluent for irrigation at BOC Kooragang have been considered for potential risks to the soil and groundwater at the site. A monitoring program was performed to obtain baseline data, site characterisation, determining the current quality of soil and groundwater at the site and therefore suitability for irrigation. BOC Kooragang will utilise the baseline monitoring program and the ongoing monitoring programs during operation to assess quality and suitability of effluent, soil and groundwater quality.

4.3.1 Effluent

Effluent quality has been measured as part of baseline monitoring and the expected effluent quality has been compared to the Effluent Guidelines' *Table 3.1 Classification of effluent for environmental management*. The effluent is considered to be a Low Strength Effluent.

Table 4-7: Classification of effluent strength for environmental management according to the *Effluent Guidelines'* Table 3.1

Analyte	Units	Expected quality	Classification
Total Nitrogen	mg/L	~3	< 50; therefore Low
Total Phosphorus	mg/L	<1	< 10; therefore Low
BOD	mg/L	<40	<40; therefore Low
Total dissolved solids (TDS)	mg/L	<600	<600; therefore Low
Metals	mg/L	Meets ANZECC guidelines	Criteria is that *High strength* effluent is of quality more than 5 times the ANZECC guidelines. All metals are below the threshold limits applied; therefore Low
Oil and Grease	mg/L	Negligible	< 1,500; therefore Low

Baseline cooling tower effluent sampling was performed at BOC Kooragang on 18 May 2017, as shown in Table 4-8 and taken from report *034 1714 - BOC Kooragang Cooling Tower Effluent Report (2017-05-22)*.

Table 4-8: BOC Kooragang cooling tower effluent sampling results 18 May 2017

Analyte	Units	Result	Recommended Irrigation Thresholds [1]
pH	pH Unit	8.72	6 – 9
Electrical conductivity	µS/cm	1,350	-
Sodium Absorption Ratio	-	61.4	-
Alkalinity as calcium carbonate (hardness)	mg/L	39	-
Chloride	mg/L	294	-
Sodium	mg/L	223	-
Biochemical Oxygen Demand (BOD)	mg/L	4	-
Fluoride	mg/L	0.7	1.0[2] 2.0[3]
Nitrogen (total)	mg/L	5.0	25 - 125[2] 5[3]
Total Kjeldahl Nitrogen	mg/L	1.3	25 - 125[2] 5[3]

Sulfate	mg/L	105	400
Total dissolved solids	mg/L	690	1000
Phosphorus	mg/L	0.08	0.8 - 12[2] 0.05[3]
Cadmium	mg/L	<0.0001	0.01[2] 0.05[3]
Zinc	mg/L	<0.005	2.0[2] 5.0[3]
Arsenic	mg/L	<0.001	0.1[2] 2.0[3]
Chromium	mg/L	0.002	0.1[2] 1.0[3]
Copper	mg/L	0.013	0.2[2] 5.0[3]
Lead	mg/L	<0.001	2.0[2] 5.0[3]
Mercury	mg/L	<0.0001	0.002[2] 0.002[3]
Nickel	mg/L	<0.001	0.2[2] 2.0[3]

[1]Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - *Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use*.

[2] Short-term trigger value (STV) – The STV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated for a shorter period of time (20 years).

[3] Long-term trigger value (LTV) – The LTV is the maximum concentration (mg/L) of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation.

The result for Total Nitrogen met the LTV limit with a concentration of 5.0 mg/L. The Phosphorus exceeded the LTV limit with a concentration of 0.08 mg/L. However, it is noted that the guidelines state the LTV for phosphorus is set '*to minimise bioclogging of irrigation equipment only*' which can be alleviated through maintenance. The remaining analytes were compliant with the recommended threshold levels.

4.3.2 Groundwater

Baseline groundwater sampling was performed at BOC Kooragang on 16 and 18 May 2017, as shown in Table 4-9 and taken from report *034 1714 - BOC Kooragang Groundwater (2017-06-08)*. Groundwater investigation levels (GILs) are shown as comparable guidelines.

Table 4-9: BOC Kooragang Groundwater Results – May 2017

Analyte	Units	BH1	BH2	BH3	BH4	BH5	BH6	GILs
pH	pH	7.78	7.43	7.69	7.57	7.84	8.04	-
Conductivity	µS/cm	713	673	492	694	670	722	-
Sodium Absorption Ratio	-	0.53	0.37	0.26	0.48	1.70	1.10	-
Total Alkalinity as calcium carbonate	mg/L	228	244	181	248	233	269	-
Chloride	mg/L	22	20	11	19	41	34	-
Sodium	mg/L	20	14	8	18	50	39	-
Nitrogen (total)	mg/L	52.0	33.4	9.1	60.8	2.8	4.0	-
Total Kjeldahl Nitrogen	mg/L	52.0	33.4	8.9	60.8	2.5	3.8	-
Nitrate	mg/L	0.01	0.05	0.20	0.03	0.32	0.15	50
Sulfate	mg/L	88	48	42	50	<50	10	500
Phosphorus	mg/L	29.8	24.2	14.0	51.2	1.93	2.60	-

Reactive Phosphorus	mg/L	0.02	<0.01	0.14	0.06	0.30	0.57	-
Total dissolved solids	mg/L	840	795	432	815	372	429	-
Fluoride	mg/L	0.5	0.8	0.6	0.9	0.8	0.9	-
Standing Water Level	m	2	2	1.5	2.5	2	2	-
Metals (dissolved)								
Arsenic	mg/L	<0.001	<0.001	0.002	<0.001	0.001	0.002	0.024 as As(III) 0.013 as As(V)
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001 as Cr(VI)
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.0014
Nickel	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.011
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0034
Zinc	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006

[1] Levels considered appropriate for comparison here, taken from *National Environmental Protection (assessment of site contamination) Amendment Measure 2013; Schedule B1 'Guideline on Investigation Levels for Soil and Groundwater'; (Vol 2) Table 1C for fresh water aquatic ecosystems*

It can be seen that the results of the baseline groundwater sampling do not exceed any of the applied GILs.

4.3.3 Soil

Baseline soil sampling was performed at BOC Kooragang on 18 May 2017 and data summary as shown in Table 4-10 and taken from the report *036-1714 - BOC Soil Sampling 2017 (2017-06-05)*. Sampling was performed in accordance with the sampling grid advised by NSW EPA's Soil Sampling guidelines and *AS4482.1-2005 – Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil*. Analytes below the limit of detection, such as additional VOCs and PAHs, are not included in the table.

Table 4-10: Baseline soil results - average results for irrigation area and background points

Analyte	Unit	Average Irrigation Area result		Average Background Result		Health Investigation Levels
		Surface	Sub surface	Sub surface	Sub surface	
pH	pH Unit	8.1	8.7	8.3	8.7	-
Fluoride	mg/kg	56	30	60	67	-
Chloride	mg/kg	7	<10	<10	<10	-
Conductivity	µS/cm	74	50	68	61	-
Cation Exchange Capacity	meq/100g	1.9	1.1	2.2	2.0	-
Exchangeable Calcium	meq/100g	1.9	1.1	2.2	1.9	-
Exchangeable Magnesium	meq/100g	<0.2	<0.2	<0.2	<0.2	-
Exchangeable Potassium	meq/100g	<0.2	<0.2	<0.2	<0.2	-
Exchangeable Sodium	meq/100g	<0.2	<0.2	<0.2	<0.2	-
Moisture	%	3	2	2.5	2.5	-
Nitrate	mg/kg	1	0	1.9	1.0	-
Nitrogen (total; TKN + NOX)	mg/kg	704	227	640	343	-
Total Kjeldahl Nitrogen (TKN)	mg/kg	704	227	640	343	-
Phosphorus (total)	mg/kg	141	69	188	190	-
Phosphorus Sorption Capacity	mg P sorbed/kg	311	146	478	470	-
Bray Phosphorus *	mg/kg	10	2	20.5	12.5	-
Collwell Phosphorus **	mg/kg	16	10	28	20	-
Arsenic	mg/kg	<5	<5	<5	<5	3,000
Cadmium	mg/kg	<1	<1	<1	<1	800
Chromium	mg/kg	4.7	2.7	5	5	3,000 (as CrVI)
Copper	mg/kg	7.6	<5	5.5	5.5	25,000
Lead	mg/kg	27	8	15	9	1,500
Nickel	mg/kg	3	2	3	4	4,000
Zinc	mg/kg	106	39	76	61	400,000
Mercury	mg/kg	<0.1	<0.1	<0.1	<0.1	4,000 (inorganic)
Suspension Peroxide Oxidation – Combined Acidity and Sulfate (SPOCAS)						
pHKCl	pH Unit	9.3	9.6	9.4	9.5	-

Analyte	Unit	Average Irrigation Area result		Average Background Result		Health Investigation Levels
		Surface	Sub surface	Sub surface	Sub surface	
pH OX	pH Unit	7.5	8.2	7.8	8.0	-
KCl Extractable Sulphur	% S	<0.02	<0.02	<0.020	<0.020	-
Titratable Actual Acidity	mole H+ / t	<2	<2	<2	<2	-
Titratable Peroxide Sulphur	% pyrite S	<0.02	<0.02	<0.020	<0.020	-
Acidity - Peroxide Oxidisable Sulphur	mole H+ / t	12.3	<10	11	9	-
Net acidity excluding ANC† (sulfur units)	%S	0.02	<0.02	0.02	0.01	-
Net acidity excluding ANC† (acidity units)	mole H+ / t	12	<10	11	9	-
Liming rate excluding ANC†	kg/$CaCO_3$/t	0.9	<1	0.7	0.7	-
Volatile Organic Compounds (VOCs)						
Dichlorodifluoromethane	mg/kg	<5	<5	<5	<5	-
Chloromethane	mg/kg	<5	<5	<5	<5	-
Vinyl chloride	mg/kg	<5	<5	<5	<5	2
Bromomethane	mg/kg	<5	<5	<5	<5	-
Chloroethane	mg/kg	<5	<5	<5	<5	-
1,2-dichloroethane	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Tetrachloroethene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Trichloroethene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
1,1,1-trichloroethane	mg/kg	<0.5	<0.5	<0.5	<0.5	-
cis-1.2-Dichloroethene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Carbon Tetrachloride	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Naphthalene	mg/kg	<1	<1	<1	<1	11,000[2]
Polycyclic Aromatic Hydrocarbons (PAHs)						
Sum PAHs	mg/kg	<0.5	<0.5	0.4	0.7	4,000
Naphthalene	mg/kg	<0.5	<0.5	0.4	0.4	-
Acenaphthylene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Fluorene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Phenanthrene	mg/kg	<0.5	<0.5	<0.5	<0.5	-

Analyte	Unit	Average Irrigation Area result		Average Background Result		Health Investigation Levels
		Surface	Sub surface	Sub surface	Sub surface	
Anthracene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Pyrene	mg/kg	<0.5	<0.5	0.3	0.3	-
Benzo(a)anthracene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Benzo(a)pyrene	mg/kg	<0.5	<0.5	<0.5	<0.5	40
Benzo(b+j)fluoranthene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Benzo(g,h,I)perylene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Benzo(k)fluoranthene	mg/kg	<0.5	<0.5	<0.5	<0.5	-
Chrysene	mg/kg	<0.5	<0.5	<0.5	<0.5	-

*As Fluoride Extractable P
**As Bicarbonate Extractable P
***Peroxide Oxidation Combined Acidity and Sulphate for Acid Sulphate Soil
† Acid neutralising capacity
[1] Levels considered appropriate for comparison here, taken from *National Environmental Protection (assessment of site contamination) Amendment Measure 2013; Schedule B1 'Guideline on Investigation Levels for Soil and Groundwater'; (Vol 2) Table 1A(1) Health Investigation Levels for soil contaminants for land use Commercial Industrial (D)*
[2] *National Environmental Protection (assessment of site contamination) Amendment Measure 2013; Schedule B1 'Guideline on Investigation Levels for Soil and Groundwater'; Table 1A(6) Health Screening Levels Soil* for direct soil contact for industrial area.

The soil pH ranged from 7.8 to 8.9, and the background points showed a consistent pH range similar to the proposed irrigation area. Grassed areas are currently in existence. Optimum plant growth is between 6 and 7.5. The effluent pH has shown historically it will meet the irrigation threshold levels therefore it is not expected to have adverse effects on the baseline soil pH.

Fluoride was detected for most samples from 40 mg/kg to 90 mg/kg at the proposed irrigation area and background area. The rest of the samples were below the detection limit of 40 mg/kg. Fluoride is covered in the effluent guidelines as it concerns risks to grazing animals.

The majority of results for Chloride at the proposed irrigation area and background did not reach the limit of reporting.

The Conductivity results show a consistent range in both the proposed irrigation area and background soils, ranging from 42 µS/cm to 95 µS/cm (which converts to 0.042 to 0.095 dS/m). An indicator of salt (salinity) concentration is electrical conductivity of a soil sample. The Effluent Guidelines state that where the conductivity is less than 2 dS/m, effects on plants are mostly negligible, therefore the soil is suitable for this parameter.

The Exchangeable Cations Magnesium, Potassium and Sodium in the irrigation and background soil were below the limit of reporting. The Exchangeable Calcium and Cation Exchange Capacity ranged from 0.7 to 4.0 meq/100g which appears to be due to the Exchangeable Calcium. The surface soil had a higher range of 1.0 to 4.0 meq/100g, while the sub-surface soil range was 0.7 to 1.9 meq/100g. The cation exchange capacity (CEC) of a soil looks at the cations of calcium, magnesium, potassium, sodium and aluminium, and relates to soil structure. Higher CECs result in a good soil structure and nutrient availability. Sandy soils by nature have a low CEC. The soils at Kooragang possess a sandy topsoil with clay present from 3 metres deep. The grassed areas of site show that the soil is capable of providing structure and stability for the existing grasses. Organic matter can be added to soils with a low CEC if required.

Phosphorus is required for plant growth and Australian soils are able to immobilise phosphorus in soils, therefore many plants require the addition of phosphorus to enable plant growth. Alluvial soils and sandy soils have a relatively low phosphorus sorption capacity, which can result in leaching of phosphorus applied to land to sources such as groundwater.

Total Phosphorus in the surface soil of the proposed irrigation area range from 67 to 182 mg/kg, which appeared to show a slightly higher trend than the sub-surface samples ranging from 55 to 85 mg/kg. The surface soil in the background samples range from 59 to 356 mg/kg. The nitrogen appears to be comprised of mostly Total Kjeldahl Nitrogen (TKN) and the background samples appear comparable to the proposed irrigation area results.

Bray and Colwell Phosphorus are measures of the available phosphorus for plant uptake in the soil. The Bray Phosphorus (as Fluoride Extractable P) at the proposed irrigation area ranged from 1.3 to 21 mg/kg, which was comparable to the background results range of 1.3 to 34.2 mg/kg. The Colwell Phosphorus (as Bicarbonate Extractable P) at the proposed irrigation area ranged from 7 to 22 mg/kg, which was reasonably comparable to the background results range of 8 to 41 mg/kg. Therefore, it can be seen the current phosphorus available for plants in the soil is a low percentage compared to the total phosphorus measured.

Phosphorous sorption capacity ranged <250 to 404 mg of phosphorus absorbed per kilogram of soil (mg P sorbed/kg) at the proposed irrigation area, which was slightly lower than the background samples ranging from <250 to 910 mg P sorbed/kg. The effluent phosphorus concentration is expected to be approximately 0.02 to 1 mg/L. Therefore, as the current sorption capacity is non-detectable to low, the addition of low levels of phosphorus through irrigation with the effluent may be advantageous, as it may be taken up by the existing grass and used as a nutrient, and there is unlikely to be excess phosphorus available. Therefore, the phosphorus concentrations are not expected to cause adverse effects on the groundwater at Kooragang.

Total Nitrogen in the surface soil of the proposed irrigation area ranges from 230 to 1,250 mg/kg, while the surface soil in the background samples range from 140 to 940 mg/kg. The nitrogen appears to be comprised of mostly Total Kjeldahl Nitrogen (TKN), which reflects the organically bound nitrogen in ammonia and ammonium. The nitrogen present in the effluent is expected to be up to 5 mg/L therefore a low strength effluent (<50 mg/L).

Nitrate is the form of soil nitrogen most readily available for plant uptake, which ranged from 0.2 to 1.3 mg/kg in the irrigation area which is low in comparison to the total nitrogen.

The irrigation area and background points appeared to contain trace amounts of chromium, copper, lead, nickel and zinc in ranges consistent with those found in the background samples. One sample in the proposed irrigation area showed a trace detection of Mercury.

Arsenic and Cadmium were not detected in the proposed irrigation area samples or the background samples.

Polycyclic Aromatic Hydrocarbons (PAHs) were non-detectable with the exception of a low detection at background locations BG2A and BG2B. Volatile Organic Compounds (VOCs) were non-detectable.

The Suspension Peroxide Oxidation – Combined Acidity and Sulfate (SPOCAS) suite measures an 'acid trail' (determination of acidity produced by oxidation) and a 'sulfur trail' (determination of sulfur to predict potential acidity). The tests use an acid-base accounting method to calculate net acidity of a sample and estimate the quantity of materials required to neutralise the acid. The results for the SPOCAS suite appear to have low traces of acid forming sulphur and pyrite. The Acidity Trail results, including the Titratable Actual Acidity (TAA) and Titratable Peroxide Acidity results were below detection for all samples.

The Titratable Actual Acidity (TAA) results show a current pH (pHKCl) range of 8.9 to 9.6 in the irrigation area and background points. By oxidising the TAA, the results show a minor pH change in the irrigation and background soil, with a pH range between 7.4 to 8.2 as pH OX.

It can be seen that the samples taken at the proposed irrigation area had net acidity results below or close to the limits of detection. The calculated liming rates for potential treatment of the acid is also shown as less than the limit of reporting for most of the samples. Therefore, acid sulphate soils in the site's current state based upon the sampling performed is considered a low risk and the project did not perform excavation to disturb potential acid sulphate soils.

5 Contingency plans

5.1 Preventative measures

The following preventative measures are performed during operation of the system:

- Daily and weekly site inspections during irrigation operations as described in Section 4.2.2.
- Irrigation operations are ceased during wet weather, rainfall events and other adverse conditions.
- Ability to resume disposal of cooling tower effluent offsite with waste contractor if adverse conditions or long term wet weather occurrences do not allow irrigation to land to be performed.

5.1.1 Volumes Disposed Offsite

In the event of disposal of effluent offsite with a waste contractor, the volume of effluent disposed offsite is measured by the licensed waste company in line with waste legislation. The volume disposed is recorded on the Waste Data Form or similar documentation which are then used for tracking purposes. The waste data forms are required to be stored onsite as already required by waste legislation. The forms will continue to be stored and effluent amounts disposed of are recorded at BOC Kooragang.

5.2 Flooding

A contingency plan for if pooling or flooding is noticed despite the preventative measures performed includes the following practices:

- Irrigation will immediately be ceased.
- If pooling appears to be draining offsite or presents a risk of runoff, appropriate bunding will immediately be installed to prevent runoff occurring.
- Disposal of effluent stored onsite will resume with an appropriately licensed waste contractor as necessary to continue operation of cooling towers.
- Irrigation will only be recommenced once pooling has evaporated and drained.
- If pooling or flooding is extreme, pumpout and disposal of the pooled effluent will occur with an appropriate contractor.
- Consideration of permanent options to decrease risk of offsite draining during adverse conditions, such as installation of an earthen bund surrounding the irrigation area.

5.3 Effluent quality outside acceptance criteria

As per Section 4.2.1 the acceptance criteria and performance indicators for effluent water quality will be applied in order of the following hierarchy as presented in Table 4-5:

1. The *Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines - Section 4: Primary Industries - 4.2 Water Quality for irrigation and general water use* long-term trigger values.
2. Trends obtained from baseline effluent quality and ongoing quarterly monitoring.

In the event that monitoring shows the effluent quality does not meet the ANZECC guidelines the following is performed:

- Irrigation is immediately ceased.

- Cooling tower effluent is pumped out and disposed by an appropriate licenced contractor.
- Internal investigations will be performed as to the possible cause of the non-compliance. This may include:
  - Water quality monitoring at identified points of the irrigation process
  - Investigation into operation of treatment process
  - Appropriate repairs and upgrades
  - Verification water quality monitoring
- Irrigation will only be recommenced once levels have returned to the recommended ANZECC levels.

In the event that monitoring shows the effluent quality differs from the baseline data and trendlines gained, but remains compliant with the ANZECC guidelines, the following is performed:

- Internal investigations will be performed as to the possible cause of the non-compliance. This may include:
  - Water quality monitoring at identified points of the irrigation process
  - Investigation into possible process changes
  - Investigation into operation of treatment process
  - Appropriate repairs and upgrades

Changes in water quality may occur as a result of deliberate site practices such as process optimisation, cooling tower filter upgrades, reduction in effluent volume produced and similar changes. If such changes occur the effluent quality will be sampled and analysed for the analytes of interest, and if necessary the site water balance will be repeated to ensure quality remains suitable for irrigation purposes.

6 Document updates

The IMP will be reviewed at the following frequencies:

- At minimum annually
- Upon changes to DA 8354
- Upon changes to EPL 20165
- Upon changes to relevant legislation as necessary
- Upon changes to any of the processes required for irrigation

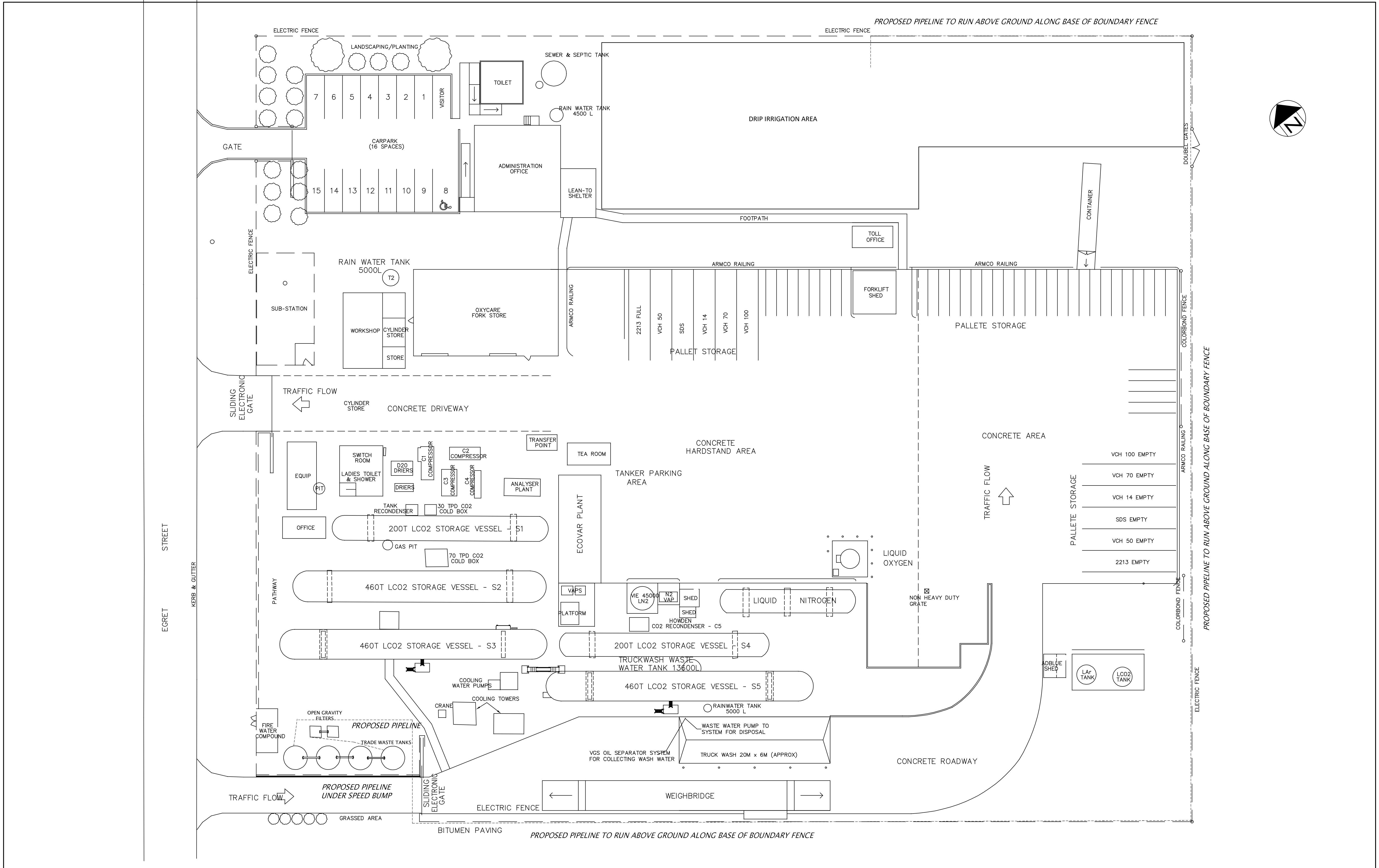
7 References

Cooling Tower Effluent for Irrigation - Statement of Environmental Effects February (2017)

Kooragang Irrigation Procedure (2017)

BOC Kooragang DA 8354 Response to Request for Response to Submissions June (2017)

Appendix A – Site Plan



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TITLE	SITE PLAN 9 EGRET STREET KOORAGANG

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Appendix B – Kooragang Irrigation Procedure

BOC Kooragang Island CO2 Plant Treated Water Irrigation System

Purpose

Purpose

The purpose of the BOC Kooragang Island CO2 Plant Treated Water Irrigation system document is to:

- Provide the general operating procedures for safe and efficient operation of the system.
- Provide alarm management information for the safe and efficient operation of the system.

Scope

Scope

This standard applies to the treated water irrigation system at the BOC Kooragang Island CO2 Plant.

Target Audience

This standard applies to all Linde employees who operate the treated water irrigation system at the Kooragang Island site.

Terms and Definitions

Term	Description	Definition
ROC	Remote Operations Centre	The remote operating team.
IMP	Irrigation Management Plan	Defines the operating guidelines for the safe and efficient operation of the treated water irrigation system

Responsibilities

Regional Operations Manager (ROM) – The ROM is responsible for ensuring that all regulatory requirements are complied with for the operation of the treated water irrigation system.

Local operator – The local operator is responsible for the safe and efficient operation of the treated water irrigation system in accordance with the system operating procedures and IMP.

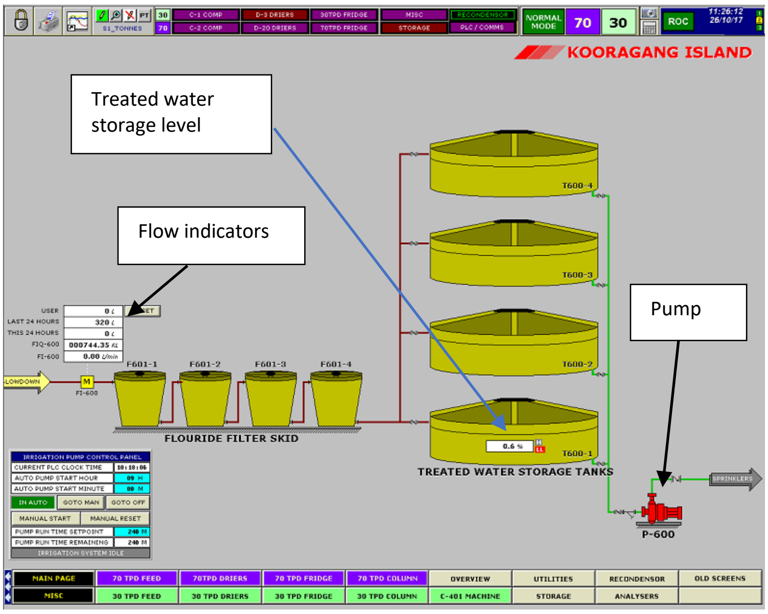
ROC – The ROC is responsible for monitoring and operating the BOC Kooragang Island CO2 Plant

Operating Procedures

System Overview

The BOC Kooragang Island irrigation system is part of the BOC Kooragang Island CO2 Plant. This CO2 plant is operated and monitored on a 24/7 basis. The irrigation system will only operate as and when is required.
The BOC Kooragang Island CO2 Plant is manned (at least one person) Monday to Friday during normal business hours and covered by an afterhours on-call person outside of these times.
The BOC Kooragang Island CO2 Plant is monitored (and operated as required) by the BOC Remote Operations Centre (ROC). This centre is manned on a 24/7 basis and monitors and operates all the process facilities for BOC throughout the region. The ROC does this by utilising the plant SCADA (Supervisory control and data acquisition) system remotely via a separate and secure network.
The ROC and site based personnel are in routine contact and will advise the afterhours contact person if any site based activities are required outside of normal working hours.
The irrigation system will be operated under the same conditions. The system is operated directly (and only) via the SCADA (Supervisory control and data acquisition) system. The monitoring and operation of the irrigation system can thus be done remotely from anywhere. Below is a screen shot of the SCADA irrigation system operating page. This page allows the operator to (remotely or locally) monitor and operate the irrigation system. This system allows the operator to monitor or do the following things…..

- Start and stop the system (using the different operating modes listed further in this document)
- Monitor actual treated water storage level
- Alarm when storage level is high
- Monitor system water flows (instantaneous, daily, annualised, total life cycle and a period of time the operator chooses)
- Visually know when the system (and pump) are operational. The pump will change from red to green when the system is in operation.



Operating Procedures

There are 4 operating modes for the irrigation system. These modes are….

1. Auto
2. Manual
3. Idle
4. Off

<u>Auto Mode</u>

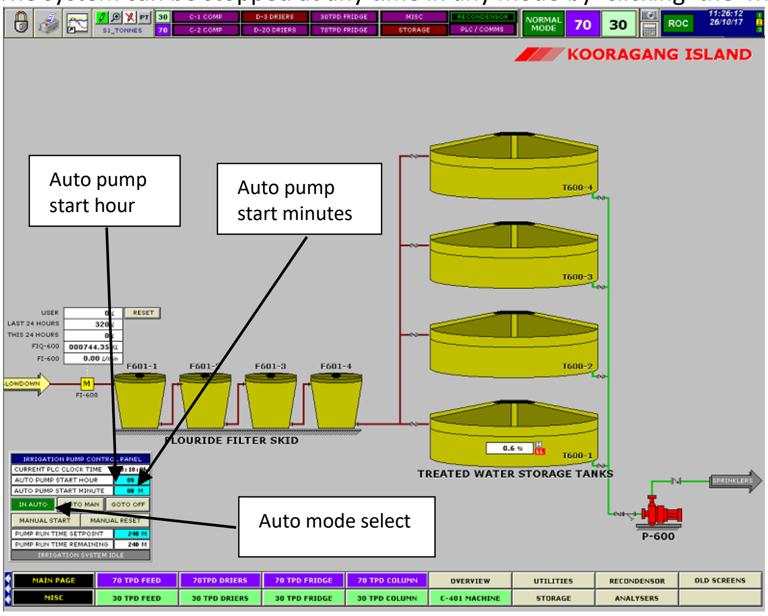
When the system is in auto mode the operator can select a start time “AUTO PUMP START HOUR”) and duration (“AUTO PUMP START MINUTES”) for irrigation using the system control panel.

When the time selected (“AUTO PUMP START HOUR”) for start is reached the pump will start and the irrigation system will then commence operation.

When the duration timer (“AUTO PUMP START HOUR”) reaches the selected period (minutes online) the pump will stop and the irrigation system will revert back to idle mode until the time selected (“AUTO PUMP START HOUR”) for start is reached again for a new cycle.

To commence operation in Auto mode the operator will ‘click’ on the ‘IN AUTO’ button a shown below.

The system can be stopped at any time in any mode by ‘clicking’ the ‘MANUAL RESET’ button



<u>Manual Mode</u>

The system can be switched to manual at any time. This allows the operator to operate the system manually. This would predominantly be for maintenance purposes where frequent starting and stopping of equipment may be required.

To place the system in manual the operator is required to ‘click’ the ‘GOTO MAN’ button. The operator can then start the pump by ‘clicking’ the ‘MANUAL START’ button. Again, the system can be stopped at any time in any mode by ‘clicking’ the ‘MANUAL RESET’ button.

<u>Idle Mode</u>

When the system is in auto mode, but not running it will revert to ‘idle’ mode. This has the system ready to restart when the “AUTO PUMP START HOUR” for start is reached.

<u>Off Mode</u>

The system can be turned off completely at any time by ‘clicking’ the “GOTO OFF” button. The system will not start automatically or when the ‘MANUAL START’ button is pressed.

<u>Operation during adverse weather</u>

During periods of extended rain (>2 hours) the system is to be switched to ‘Off Mode’. The system can then be returned to normal operation once the period of rain has subsided and the irrigation area inspected for no excessive pooling of rainwater.

Alarms

There are several alarms and trips associated with the BOC Kooragang Island irrigation system. The alarms are in place to notify the operator (in the ROC) that the system requires an activity or action to take place. These alarms are…

1. Treated water high storage level – in the event this alarm is activated the system will be turned off and the local operator will engage an external (ie" Pacific Waste) contractor to 'pump out' the storage until such time irrigation can recommence.
2. Treated water storage level low low – this will notify the operator that the storage is now empty and the lower limit (for pump protection) has been reached. There is no action required in this instance.
3. Daily flow high – this will notify the operator that the irrigation system flow for the previous 24 hours was higher than design. The operator will check the system to ensure that system is operating correctly and rectify as required.

System Limits

Routine system and system output monitoring shall be done in accordance with the BOC Kooragang Island Irrigation Management Plan (IMP). This IMP defines the operating limits and requirements of the system to ensure safe, efficient, environmentally friendly and regulatory compliant system. These limits and requirements include (but is not limited to)…..

1. Routine inspection and maintenance of the system
2. Treated water monitoring
3. Soil Monitoring
4. Groundwater Monitoring

It is the responsibility of the Regional Operations Manager (ROM) to ensure the requirements of the IMP are met during the operation of the system.

Specific System Limitations

There will be certain system limitations that may be reached from time to time. These situations may include (but not limited to)….

1. Extended periods of rainfall
2. System maintenance
3. Contamination level/s breach threshold limits on routine testing

In the event these events occur the system is to be turned off until normal conditions return. In the event that this period of system limitation exceeds the treated water storage capacity the site operator shall arrange for offsite disposal of the treated water (ie: pumped out and transported to local water treatment facility)

Verification

Audit Program

The BOC Kooragang Island CO2 Plant Treated Water Irrigation System will be monitored by existing internal auditing systems, where possible, such as operation and engineering audits, management system audits, ISO 9001 : 2008, FSSC : 2010, beverage, and technical audits.

The system will also be monitored by the EPA annual return for the BOC Kooragang Island site.

For more detailed information, see ***IMS-17-01 : About Auditing***.

Document Information

About this Document

Version	Date	Author	Quality Reviewer	Approver
1.0	Nov 2017	Peter McManus		

Change History

Version	Description of Change
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