Torres Strait Island Regional Council

Saibai Sewage Treatment Plant

Part 1: Condition Assessment

Part 2: Upgrade Options Study Report

Part 3: Environmental Evaluation

Revision B

7 November 2017

Torres Strait Island REGIONAL COUNCIL

GANDEN ENGINEERS AND PROJECT MANAGERS

GANDEN Project No. 0615

Executive Summary

Torres Strait Island Regional Council (TSIRC) have been experiencing operational issues with the Saibai Island Sewage Treatment Plant (STP) resulting in in numerous breaches of the Environmental Licence conditions. The Department of Environment and Heritage Protection (DEHP) issued a "Notice to conduct or commission an environmental evaluation" to TSIRC on the 5th of June 2017 following several environmental non-compliances with the Environmental Authority (EA) EPPR00713013 for ERA 16-A(b)(ii).

The non-compliances noted are summarised as: -

1. Exceedances of effluent water quality parameters (numerous between November 2016 and January 2017);
2. Overflow of effluent from final effluent tank causing release of effluent into the coastal waters; and
3. Release of poorly treated effluent from the Saibai Island STP with the potential to cause environmental harm;

TSIRC has engaged GANDEN Engineers and Project Managers to undertake a condition assessment, environmental evaluation and options analysis for the upgrade of the Saibai Sewage Treatment Plant.

In July 2017, GANDEN attended site with TSIRC representatives Tom Day and Toni Veronese to inspect the existing plant condition and gain insight into the current operation of the plant. A Condition Assessment Report (0615 – Saibai STP Condition Assessment Report) has been produced and has been appended to this report. Outcomes from the condition assessment indicate the overall condition of the sewage treatment plant is poor and the treatment process has failed, resulting in untreated flow being released to the environment. The failure of the treatment process is, largely, due to the failure of major process equipment such as pumps, blowers, instrumentation and electrical faults. This is due to a combination of inappropriate selection and specification of equipment and materials, coupled with the apparent lack of maintenance of the assets.

This report analyses options for the upgrade or replacement of the Saibai Sewage Treatment Plant which, as identified above, is in poor condition and is approaching (prematurely) the end of its service life. Some of the key considerations for the analysis included: -

1. The STP is subject to a highly corrosive environment due to the tropical climate and proximity to the ocean, and as a result all equipment and materials shall be suitably selected to resist corrosion; and
2. Operations and maintenance difficulties are common in remote communities – a low maintenance plant is preferred due to longer lead times on equipment and difficulty accessing specialist labour.

Options Assessment

A two-gated options assessment methodology was used to identify the most suited option for the upgrade of the plant by firstly identifying treatment technologies, followed by a multi-criteria analysis (MCA). Gate 1 identified relevant treatment technologies used throughout Australia, which were then assessed against the following three criteria main criteria: -

1. Will the proposed treatment technology provide sufficient treatment and satisfy the effluent quality parameters outlined in the Environmental Authority?
2. Is the option possible and practical to implement?
3. Is the option easy to operate and maintain?

All these options were considered taking into account the specific challenges and the unique nature of sewage treatment in a remote island community.

The outcomes from the Gate 1 assessment are displayed in the table below.

Table 1: Mandatory Criteria Summary

Option	Effluent Quality	Possible or Practical to Implement	Easy to Operate & Maintain	Outcome (Pass or Fail)
1. Refurbishment of Existing Plant	✓	✗	✗	Fail
2. New MLE, Keep Existing Clarifier	✓	✓	✓	Pass
3. New MLE Plant	✓	✓	✓	Pass
4. New SBR Plant	✓	✓	✓	Pass
5. New MBR Plant	✓	✓	✗	Fail
6. New Oxidation Ditch	✓	✗	✓	Fail
7. New Trickling Filter	✗	✗	✓	Fail
8. New Lagoons	✗	✗	✓	Fail
9. New MBBR	✓	✓	✗	Fail
10. New RBC	✗	✓	✓	Fail

Only three options passed the Gate 1 criteria and were subject the MCA assessment, including -

- Option 2 - New MLE, Keep existing Clarifier
- Option 3 - New MLE Plant
- Option 4 - New SBR plant;

The three options above were assessed against five key assessment criteria, which were: -

1. Whole of life costs – High-level cost estimate to design, construct, operate and maintain the treatment plant;
2. Proven treatment technology – Has the technology been proven in similar installations and operating conditions?
3. Resourcing & Operational support required – What level of resourcing is required to operate and maintain the plant?
4. Fit-for-purpose/fit-for-place – Is the plant durable and able to withstand the corrosive conditions on Saibai island, flooding and salt water inundation
5. Process resilience – How resilient is the process regarding changes in influent flows, influent characteristics, etc.

Outcomes from the MCA assessment are displayed in the table below: -

Table 2 - MCA Scores

Option	MCA Score
2. New MLE, Keep Existing Clarifier	4.825

Option	MCA Score
3. New MLE Plant	4.605
4. New SBR Plant	4.190

Conclusions and Recommendation

Following the outcomes of the MCA criteria, the recommended option is **Option 2 – New MLE, Keep Existing Clarifier**, which is deemed the most suited for the upgrade of the Saibai Sewage Treatment Plant for the following reasons: -

1. Scored the highest in the MCA analysis;
2. Easy to operate and maintain;
3. Does not require full-time monitoring nor does it require highly skilled operators;
4. No instrumentation, except flowmeter, is required;
5. Can be installed within the existing sewage treatment plant boundary;
6. Has excellent process resilience;
7. Fastest to implement; and
8. Process tanks and major equipment items can be manufactured entirely offsite and shipped to the island minimising onsite installation timeframes. In comparison to the precast concrete tank which requires assembly onsite, waterproofing and the application of protective coatings, this option is significantly cheaper.

Preliminary sizing has been carried out to identify approximate plant footprint, major infrastructure requirements and capital expenditure (CAPEX) estimates. The O&M costs (OPEX) for the treatment plant is considered to be less than the existing plants due to less drives (i.e. mixers and blowers not required), instrumentation, pumping requirements and selection of more robust pumps.

Further CAPEX and OPEX savings may be realised with the relaxation of the Environmental Authority regarding disinfection (Currently under negotiation with DEHP). The current configuration of the plant requires the effluent to be pumped to the outfall. If disinfection of the effluent is not required, flows can gravitate directly from the Clarifier to the outfall, providing CAPEX and OPEX savings as a chlorine dosing system, chlorine contact tanks and an effluent pump station is not required.

It was assessed that Option 2 – New MLE, Keep Existing Clarifier would cost approximately $4,784,000.00[1] to build.

[1] This pricing has been obtained by requesting quotations for the works based on the preliminary design drawings however limited responses were received and as such a 30% contingency has been allowed for the works.

Client:
Torres Strait Island Regional Council
PO Box 7532
Cairns, Qld 4870

Prepared by:
GANDEN Pty Ltd ATF Nutt Unit Trust t/a
GANDEN Engineers and Project Managers
ABN 68 309 950 600
PO Box 461
Varsity Lakes Qld 4227
www.GANDEN.com.au

Quality Management System 9001:2008 Cert No: 1018

Environmental Management System 14001:2004 Cert No: 1018 EMS

Occupational Health and Safety 48001:2001 Cert No: 1018 OHS

Revision	Date	Description	Author	Reviewed	Approved
Rev A	23 /10/ 2017	Issued for Client Review	A. Bull	D. Nutt	J. Hennekens
Rev B	07/11/2017	Client Review	A. Bull	J. Hennekens	D. Nutt

Disclaimer:

GANDEN Engineers and Project Managers has prepared this report for the sole use of the Client and for the intended purposes as stated in the agreement between the Client Representative and GANDEN Engineers and Project Managers under which this work was completed. The report may not be relied upon by any other party without the express written agreement of GANDEN Engineers and Project Managers.
GANDEN Engineers and Project Managers has exercised due and customary care in the creation of this report but has not, save as specifically stated, independently verified information provided by others.
No other warranty, express or implied is made in relation to the conduct of the review or the contents of this report. GANDEN Engineers and Project Managers assumes no liability for any loss resulting from errors, omissions or misinterpretations made by others. The use of this report by third parties without written authorisation by GANDEN Engineers and Project Managers shall be at their own risk and GANDEN Engineers and Project Managers accept no duty of care to any such third party.
Any recommendations, opinions or findings stated in this report are based on circumstances and facts as they existed at the time GANDEN Engineers and Project Managers performed the work.
Any changes in such circumstances and facts upon which this report is based may adversely affect any recommendations, opinions and/or findings contained in this report.
No part of this report may be copied or duplicated without the express written permission of the Client and GANDEN Engineers and Project Managers. Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work referred to in the Agreement however may have been revised between the Client Representative and GANDEN Engineers and Project Managers. This work has been undertaken in accordance with the GANDEN Engineers and Project Managers' third-party-certified Integrated Management System.

Torres Strait Island REGIONAL COUNCIL

GANDEN ENGINEERS AND PROJECT MANAGERS

Contents

Table of figures

Table of tables

Glossary of Terms

Abbreviations	
ADWF	Average Dry Weather Flow
BOD	Biological Oxygen Demand
DEHP	Department of Environment and Heritage Protection
CIP	Clean In Place
EA	Environmental Authority
EP	Equivalent Person
EV	Environmental Values
MBR	Membrane Bioreactor
MBBR	Moving Bed Bioreactor
MLE	Modified Ludzack-Ettinger
PIF	Peak Instantaneous Flows
PWWF	Peak Wet Weather Flows
TSIRC	Torres Strait Island Regional Council
SBR	Sequential Batch Reactor
SCADA	Supervisory Control and Data Acquisition
STP	Sewage Treatment Plant
RAS	Return Activated Sludge
RBC	Rotating Biological Contactor
WAS	Waste Activated Sludge
WQO	Water Quality Objectives

1. Background

1.1 Overview

Saibai Island is one of the Northern most islands in the Torres Strait and is situated approximately 3 kilometers from Papua New Guinea. The existing Sewage Treatment Plant (STP) is located on the western edge of the community and discharges effluent via a marine pipeline to the north of the STP, see image below.

Figure 1 - Saibai STP Locality Plan

Torres Strait Island Regional Council (TSIRC) owns and operates the Saibai Island Sewage Treatment Plant (STP) that services the island community. The existing STP is a packaged Modified Ludzack-Ettinger (MLE) plant supplied by Enviroflow which consists of inorganics removal by a static screen, a series of fiberglass tanks for biological nutrient removal followed by secondary clarification and disinfection prior to discharge to the ocean. This plant was upgraded in 2008.

TSIRC have been experiencing operational issues with the STP resulting in in numerous breaches of the Environmental Authority discharge conditions. The primary cause of the deficient performance has been identified as frequent breakdown to pumps, blowers, sodium hypochlorite disinfection systems and power supply to the equipment due to the harsh environment and as a result of maintenance and funding difficulties.

Operational and maintenance difficulties are common in remote communities, such Saibai Island. These difficulties have led to sections of the STPs remaining offline for considerable periods, causing ongoing failure in the treatment process and ultimately, resulting in non-compliant effluent.

The Department of Environment and Heritage Protection (DEHP) issued a "Notice to conduct or commission an environmental evaluation" to TSIRC on the 5th June 2017 following several environmental non-compliances with the Environmental Authority (EA) EPPR00713013 for ERA 16-A(b)(ii).

The non-compliances noted are summarised as: -

1. Exceedances of effluent water quality parameters (numerous between November 2016 and January 2017);
2. Overflow of effluent from final effluent tank causing release of effluent into the coastal waters; and
3. Release of poorly treated effluent from the Saibai Island STP with the potential to cause environmental harm;

1.2 Notice to Commission Environmental Evaluation

Refer to Appendix B - for the DEHP "Notice to conduct or commission an environmental evaluation".

As a result of the non-conformances, DEHP have requested that TSIRC undertake an environmental investigation addressing the following: -

1. Environmental Assessment including: -
    a. Identify the Environmental Values (EVs) and Water Quality Objectives (WQOs) relevant to releases from the Saibai Island STP;
    b. Provide a description of the default EV/WOQs, characteristics and resilience of the receiving environment; and
    c. Determine the quality that must be achieved for effluent release to protect or enhance EVs and achieve the WQOs.
2. Assessment and projection of sewage flow loadings of the project sewage flow loadings into the Saibai STP for a 20-year planning horizon and be developed with the Department of Energy and Water Supply '*Planning Guidelines for Water Supply and Sewerage, April 2010*'.
3. Detail the capacity of existing sewage infrastructure to meet current and future service demands and environmental standards and identify options for achieving release quality that must be achieved to protect or enhance EVs and achieve the WQOs including, but not limited to:
    a. A statement of the current performance of the plant in respect to effluent release;
    b. Details of all options available and a detailed evaluation of potential options to improve and maintain suitable quality of effluent releases;
    c. Details of technology considerations and their suitability for use in relation to the locality and skill level of operators;
    d. Review of similar technology and applications in similar environments; and
    e. Details of cost considerations that include installation/augmentation, commissioning and maintenance.
4. Report on the analysis of options considered, which must: -
    a. Determine an evaluation criterion linked to quantified service objectives, and which must include consideration of service standards, regulatory compliance, operational and performance efficiency as well as social, environmental and financial objectives;
    b. Determine options which include existing, non-asset and new asset options; and
    c. Undertake the options analysis, which must include whether the option is technically feasible; considers the physical and operational capacity of the infrastructure including infrastructure appropriateness, condition and limitations; a financial analysis to determine financial viability including financial constraints of each option over the whole lifecycle of the sewage treatment plant and associated infrastructure; analysis of environmental impacts; and a risk assessment of each chosen option.
5. Outline a proposed implementation strategy based on the option/s identified through Requirement 4, which must:
    a. Determine the preferred project delivery option; and
    b. Develop an implementation program with consideration of funding sources and allocation.

1.3 Condition Assessment

A site inspection and condition assessment of the Saibai Sewage Treatment Plant was undertaken by GANDEN, accompanied by TSIRC representatives on the 1st August 2017.

Outcomes from the report indicate that the overall condition of the sewage treatment plant is poor and the treatment process has failed, resulting in untreated flow released to the environment. The failure of the treatment process is, largely, due to the failure of major equipment items such as pumps, blowers, mixers and instrumentation. This is due to a combination of inappropriate specification of equipment and materials, coupled with the apparent lack of maintenance of the assets. To bring the STP back to design performance, the following rectification/refurbishment works are required, as a minimum: -

- Replace/repair the DN200 MDPE outfall pipeline extending the required 400m out to ensure the effluent release point provides suitable clearance from the foreshore;
- Repair or replace the stainless-steel inlet screen and support structure. Fabricate out of suitable corrosion resistance materials and isolate dissimilar metals;
- Installation of shade/roof over screen to prevent blinding of the screen from dried materials;
- Refurbish the screenings collection trailer and sump;
- De-sludge all tanks to remove solids accumulated to ensure proper flow paths are maintained;
- Inspect fiberglass tanks and undertake integrity tests to determine actual residual life and refurbish if possible. Alternatively, replace all fiberglass tanks if 20-year life cannot be guaranteed;
- Replace aeration blowers;
- Replace WAS/RAS pumps (may be able to seek alternative recycling and wasting via gravity, therefore actuated valves);
- Replace Aerobic Return Pump;
- Replace supernatant pumps;
- Replace Clarifier Lift Pump Station including tank, pumps and instrumentation;
- Refurbish/clean and maintain the Clarifier and address corrosion issues;
- Replace Flowmeters & actuated valves;
- Replace pipework and pipe supports;
- Replace corroded pump skids;
- Replace all mixers;
- Replace mixer support frames;
- Repair/modify to walkways/platforms to conform to Australian Standards and rectify stability issues;
- Replace structural bolts etc. that have perished on the platforms/walkways;
- Replace all site run electrical cabling, cable trays, power outlets etc.;
- Repair the site fence and front gate;
- Replace the Final Effluent Pump Station, pumps and instrumentation;
- Replace the Clarifier Sprinkler Pump and fittings;
- Replace eyewash/safety shower with self-contained unit with tank;
- Install purpose built Sodium Hypochlorite storage shed and dosing system conform the relevant Australian Standards;
- Rectify operational issues with Potable and Service water supply to prevent contamination;
- Replace all ABS and PVC pipework;
- Replacement or refurbishment of the existing switchboard, RTUs etc. to suit modified plant;

- Process design review and modifications ensuring required treatment is achieved. This would include the production of as constructed P&IDs, updated functional description and operating philosophy, O&M manuals etc.
- Installation of SCADA systems;
- Recommissioning of refurbished plant;
- Operator training including daily checklists; and
- Supply of spare pumps, instrumentation and the like;

The works outlined are the minimum work required to get the STP functioning, however, there is no guarantee that the existing tanks etc. will provide a long-term solution. Assets to be reused will need to undergo further condition assessment and possible refurbishment works to prolong their service life.

GANDEN believes refurbishment of the existing treatment is not a viable option.

1.4 Environmental Assessment

Refer to the Environmental Evaluation Report for details in regards to Environmental Values and Water Quality Objectives.

1.5 Current Environmental Authority Negotiations

TSIRC have submitted an application to DEHP requesting the removal of disinfection of the effluent from the Environmental Authority.

2. Design Criteria

The design envelope for this project is defined through estimations of population growth, previous design parameters, typical load characteristics, effluent and influent sampling results and flow calculations provided by TSRIC.

2.1 Historical Flows and Flow Projections

The current STP influent flows into the STP are unknown due to the failure of the existing influent flowmeter. TSIRC have undertaken investigations to determine the actual influent volumes transferred into the treatment based on: -

- Calculations based on pump starts/stops in pump station 1 (immediately upstream of STP) from recent SCADA trends.
- Readings from influent flowmeter – A new flowmeter was installed on the inlet pipeline.

Preliminary calculations indicate Average Dry Weather Flows (ADWF) varying between 140 and 170kL/day. The 2008 Design Report indicates that the existing treatment plant is designed for ADWF of 150 kL/day.

In high-density population areas (i.e. cities) the average wastewater production per person varies between 200 – 220 L/EP/day, however, in small remote communities such as Saibai, water consumption can be up to 2 to 3 times higher than in large population areas resulting in increase in wastewater generation. There is evidence from conductivity results that seawater infiltration at higher tides contributes to additional flow.

Recent water consumption data provided my TSIRC indicates the total water consumption on Saibai Island is roughly 220 kL/day. Based on a population of 465 (2016 Census Results), the community is using roughly 430L/EP/day. The hydraulic design will be based on wastewater generation of 300L/EP/day with an equivalent population of 650EP.

If the inlet screen height is increased, the existing SPS01 pumps will need to be assessed and may require upgrading due to the increase in static head.

Table 3 – Saibai STP Design Envelope

Parameter	Current	Ultimate Design	Units
Equivalent Population (EP)	465 (2016 Census)[2]	650	EP
Wastewater Production (L/EP/d)	-	300	L/EP/day
ADWF (Average Dry Weather Flow)	50 – 170	195	kL/day
PWWF (Peak Wet Weather Flow)	-	975 (5 x ADWF)	kL/day

[2] The results from the 2016 Census may not be accurate

Parameter	Current	Ultimate Design	Units
PIF (Peak Instantaneous Flow)	10 L/s	Maximum pumped flow rate from SPS 1 with 2 pumps operating + 30%[3]	L/s

2.2 Influent Envelope

Limited raw sewage data is available for the Saibai STP. TSIRC have provided influent and effluent sampling results from the plant between September 2016 and May 2017. The four most recent sampling results from February to April 2017 have been used to determine the adopted design criteria. Higher conductivity and lower influent strength indicates that there is seawater infiltration.

These results are expected from a domestic population located close to the sea.

Table 4 - Influent Envelope

Parameter	6th Feb-2017	7th March 2017	9th May 2017	13th April 2017	Average	Adopted Design Envelope
BOD (mg/L)	220	230	290	93	**209**	**180-350**
Total Suspended Solids (mg/L)	320	130	370	110	**230**	**200-380**
Electrical Conductivity (µS/cm)[4]	1800	5700	1100	7900	**4125**	**500-15,000**
Total Phosphorus (mg/L)	5.5	5.4	8.6	2.8	**5.5**	**4-8**
Total Nitrogen (mg/L)	43	44	77	20	**46**	**40-80**
Ammonia (mg/L)	40	40	45	11	**32.25**	**35-65**

2.3 Effluent Quality Requirements

The current effluent quality requirements are summarised in Table 5 - Current Effluent Release Limits (from February 2002). TSIRC is currently negotiating to remove the faecal coliform limit for a new treatment plant with an extended outfall. This would remove the requirement to disinfect without any negative impact on the community. Refer to the environmental evaluation.

[3] Existing pumps will need to be upgraded due to significant increase in static head for upgraded plant. Upgraded plant will be hydraulically designed to cater for maximum flows of new SPS 01 pumps + 30%. Pumps to be selected during detailed design.

[4] The electrical Conductivity is elevated likely as a result of seawater ingress within the system, there is however limited to no impact expected on the treatment process.

Table 5 - Current Effluent Release Limits (from February 2002)

Parameter	Units	Release Limit	Limit Type
5-day Biochemical Oxygen Demand (BOD_5)	mg/L	20	80th percentile Maximum
Suspended Solids (SS)	mg/L	30-90	80th percentile Maximum
pH	-	6.5 – 8.5	Range
Dissolved Oxygen (DO)	mg/L	2	Minimum
Ammonia Nitrogen (NH_3-N)	mg/L	5-8	50th percentile Maximum
Total Nitrogen (TN)	mg/L	20-40	50th percentile Maximum
Total Phosphorus (TP)	mg/L	10-15	50th percentile Maximum
Oil and Grease	mg/L	10	Maximum
Faecal Coliform	Organisms/100mL	150-600	50th percentile Maximum

2.4 O&M Considerations

The assessment was required to consider the ongoing operation and maintenance of the STP following the defects liability period, specifically: -

- Confined Space entry – STP operators do not have confined space entry certification or equipment available. The design shall consider the requirements for confined spaced entry and minimize or eliminate where possible;
- Working at Heights – STP operators do not have working at heights certification or equipment available. The design shall consider the requirements for working at heights and minimize or eliminate where possible;
- Lifting Equipment – There are no cranes or mobile lifting equipment available for use on Saibai Island. If required, a forklift can be borrowed from the barge for short periods of time. The island's backhoe also has fork attachments. Mechanical equipment shall be designed to be easily accessed for maintenance activities and space provided for removal using the backhoe;
- Minimise maintenance requirements – There is trade qualified electricians or plumbers on the island. Access to externally sourced skilled maintenance is limited and the budget for servicing is limited. The design is to minimise maintenance where possible;
- STP Operators – STP operators have limited skills and access to skilled support is limited. The process is to be designed to be easily operated without in-depth knowledge of the treatment process. The number of process tanks, mechanical equipment and instrumentation shall be kept to a minimum;

- All electrical components, mechanical equipment, tanks and walkways shall be selected using suitable materials to withstand the hot, humid and corrosive environment, and shall be designed to maximise the asset life;
- Redundancy of major process equipment – Major process equipment is to be Duty/Standby where possible due to the lack of skilled labor and long lead times to get skilled labor to the island; and
- Consideration into demolition, replacement or refurbishment works of the plant in the future.

3. Options Analysis Methodology

The options investigation was undertaken using a two-gate approach, derived from the following method: -

1. Identifying the objectives for the project,
2. Identify comparison criteria,
3. Identify options,
4. Analysis of options,
5. Recommendations.

3.1 Objective of Options Analysis

The overall objective of this project was to provide a fit-for-purpose and fit-for-place solution for the upgrade of the Saibai STP to rectify operational issues and achieve continual compliance with the Environmental Authority conditions.

3.2 Evaluation Criteria

A two-gated approach was used to compare all options for the upgrade of the Saibai STP. The following gates were used: -

Gate 1 Mandatory Treatment Requirements	Gate 2 Scoring
•Evaluation of sewage treatment technologies. •The treatment technology options must meet the following criteria: 1. Will the desired effluent quaility be acheived? 2. Is the option possible and practical to implement? 3. Is the option easy to operate and maintain? • Only options that can answer "yes" to all 3 progress to Gate 2.	• Multi-Criteria Analysis: - Whole of life costs - Proven technology - Resourcing - Durability of materials and equipment - Process Resilience • The top 3 options to progress to Gate 3

3.2.1 Gate 1 – Mandatory Requirements

Sewage treatment technology options were listed, and the following evaluation criteria was applied to Gate 1: -

1. Will the desired effluent quality be achieved?
    - Will the proposed treatment technology provide sufficient and robust and reliable treatment and satisfy the effluent quality parameters outlined in the Environmental Authority? Refer to Table 5 - Current Effluent Release Limits (from February 2002).
2. Is the option possible and practical to implement?
    - Can the option be accommodated on the existing STP site?
    - Can the components be transported to the island by barge?
    - Can flood mitigation methods me implemented easily by design without significant cost implications (i.e. raised above flood levels etc.)?
3. Is the option easy to operate and maintain?
    - Does this option require full time operational supervision?
    - Does this option require skilled labor to operate?
    - Are there long lead times on replacement items?

All treatment technology options that satisfy the above criteria will progress to Gate 2.

3.2.2 Gate 2 – Multi Criteria Analysis

In Gate 2, options were compared using a multi-criteria analysis. The multi-criteria analysis included: -

1. Whole of life costs – High-level cost estimate to design, construct, operate and maintain the treatment plant;
2. Proven treatment technology – Has the technology been proven in similar installations and operating conditions?
3. Resourcing & Operational support required – What level of resourcing is required to operate and maintain the plant?
4. Fit-for-purpose/fit-for-place – Is the plant durable and able to withstand the corrosive conditions on Saibai island, flooding and salt water inundation
5. Process resilience – How resilient is the process regarding changes in influent flows, influent characteristics, etc.

Each option was assessed and given a score out of 5 (1 being the lowest & 5 the highest). The weighting displayed in the table below were applied to the scores. The scores were then multiplied by the weightings and then all scores added. The option with the highest score was considered the preferred option.

The following weighting has been given to each of the 5 MCA categories.

Criteria	Whole of Life Cost	Proven Technology	Resourcing	Fit-for-purpose/fit-for place	Process Resilience	Score	**Weighting**
Whole of Life Cost		✓	✓	✓✓	✓	5	**22%**
Proven Technology	✓		✓	✓	Equal	3.5	**15%**
Resourcing	✓	✓		✓	✓	4	**17.5%**
Fit-for-purpose/fit-for place	✓✓	✓	✓		✓✓	6	**26%**
Process Resilience	✓	Equal	✓	✓✓		4.5	**19.5%**

4. Review of Treatment Process Technologies

The following options for the rectification of issues at the Saibai Sewage Treatment Plant (STP) were considered: -

1. Refurbishment of Existing Plant
2. New MLE, Keep Existing Clarifier
3. New MLE Plant
4. New SBR Plant
5. New MBR Plant
6. New Oxidation Ditch
7. New Trickling Filter
8. New Lagoons
9. New MBBR
10. RBC

It should be noted that the existing control room building, drying beds and storage shed are all in good serviceable condition and would be retained and reused regardless of the preferred option. The upgrade of the treatment plant would involve the replacement or refurbishment of the primary treatment process.

All mechanical equipment is required to be placed on plinths or otherwise elevated to at least 300mm from the existing surface level to mitigate against flooding risk. Mechanical equipment will be (were possible) be sized to allow for lifting using lifting devices like engine hoists for removal rather than equipment that is not easily available on the island (such as Franna's or forklifts.

Options provided here were modelled using the Biowin © software and from a process technical perspective will work and provide compliant effluent. Refer to Appendix C - for further details.

4.1 Option 1 - Refurbish the Existing Plant

The existing sewage treatment plant is Modified Lutzack Ettinger (MLE) process with the addition of a pre-anoxic zone. The plant has sufficient bioreactor sizing. The complexity of the existing plant and poor selection of process equipment and materials are the main contributors to the poor effluent quality and ongoing maintenance issues.

Historically, the existing treatment plant has never satisfied the licence conditions since the inception of the plant in 2001. In 2008, modifications were made to the existing plant to achieve EA compliance by the addition of the stainless steel secondary treatment clarifier. Although the clarifier is believed to have improved the effluent quality, the high maintenance requirements, and limited availability if skilled labour on the island has led to the failure of major process equipment (i.e. blowers, pumps, mixers etc.) resulting in further breaches to the effluent release limits. The addition of the clarifier also introduced further complexity to the plant.

Refurbishing the existing plant is, effectively, replacing all equipment. Based on the condition assessment undertaken as part of the review, the following works will be required to refurbish the treatment plant: -

- Replace/repair the DN200 MDPE outfall pipeline extending the required 400m out to ensure the effluent release point provides suitable clearance from the foreshore;
- Repair or replace the stainless-steel inlet screen and support structure. Fabricate out of suitable corrosion resistance materials and isolate dissimilar metals;
- Installation of shade/roof over screen;
- Refurbish the screenings collection trailer and sump;

- De-sludge all tanks to remove solids accumulated to ensure proper flow paths are maintained;
- Inspect fiberglass tanks and undertake integrity tests to determine actual residual life and refurbish if possible. Alternatively, replace all fiberglass tanks if 20-year life cannot be guaranteed;
- Replace aeration blowers;
- Replace WAS/RAS pumps (may be able to seek alternative recycling and wasting via gravity, therefore actuated valves);
- Replace Aerobic Return Pump;
- Replace supernatant pumps;
- Replace Clarifier Lift Pump Station including tank, pumps and instrumentation;
- Refurbish/clean and maintain the Clarifier and address corrosion issues;
- Replace Flowmeters & actuated valves;
- Replace pipework and pipe supports;
- Replace corroded pump skids;
- Replace all mixers;
- Replace mixer support frames;
- Repair/modify to walkways/platforms to conform to Australian Standards and rectify stability issues;
- Replace structural bolts etc. that have perished on the platforms/walkways;
- Replace all site run electrical cabling, cable trays, power outlets etc.;
- Repair the site fence and front gate;
- Replace the Final Effluent Pump Station, pumps and instrumentation;
- Replace the Clarifier Sprinkler Pump and fittings;
- Replace eyewash/safety shower with self-contained unit with tank;
- Install purpose built Sodium Hypochlorite storage shed and dosing system conform the relevant Australian Standards;
- Rectify operational issues with Potable and Service water supply to prevent contamination;
- Replace all ABS and PVC pipework;
- Replacement or refurbishment of the existing switchboard, RTUs etc. to suit modified plant;
- Process design review and modifications ensuring required treatment is achieved. This would include the production of as constructed P&IDs, updated functional description and operating philosophy, O&M manuals etc.
- Installation of SCADA systems;
- Recommissioning of refurbished plant;
- Operator training including daily checklists; and
- Supply of spare pumps, instrumentation and the like.

It is noted that the existing fiberglass tanks, if retained will be difficult to remove if failure occurs due to the complexity of the STP with walkways, pipework and mixer frames blocking crane access.

4.2 Option 2 - New Conventional Plant, Keeping the Existing Clarifier (MLE Process)

This option is to remove all equipment except the stainless-steel clarifier, which can be reused with some pickling and passivation of some areas of surface corrosion. The plant would be set up in a MLE process, with one new anoxic reactor and one aerobic reactor manufactured from stainless steel.

Both concrete and stainless-steel tanks were considered, but stainless tanks have the advantage of being able to be manufactured off-site and rapidly installed. Either grade 316 or SAF 2205 stainless tanks will provide adequate protection. If 316 stainless tanks were used, then it is recommended that this steel be highly polished in the factory and have a routine wash down (either manually once a week or using an automatic spray). All stainless tanks should be pickled and passivated in the factory. The tanks would be best mounted on legs with plinths to prevent corrosion occurring at the base.

Referring to the document Saibai STP Condition Assessment Report, the existing secondary treatment tanks are approaching the end of their service life and shall be replaced as part of the upgrade. To implement this option, the following works would be required: -

- Removal and disposal of all redundant infrastructure (tanks, pumps, mixers, walkways etc.) except for the stainless-steel Clarifier, office and drying beds;
- Installation of two new static inlet screens (duty/duty);
- Installation of two new secondary treatment tanks (anoxic and aerobic bioreactors);
- Installation of externally mounted jet aerators attached to the aerobic tank (duty/standby and hot swappable spare). The suction would be connected to the Anoxic tank which will provide mixing and recycling of wastewater between the aerobic and anoxic zones;
- Installation of Return Activated Sludge (RAS) pumps (duty/standby);
- Installation of Waste Activated Sludge (WAS) pump (if automatic wasting is preferred);
- Installation of Chlorine Contact Tank (if required, pending outcomes from Environmental Authority amendment application);
- Installation of Final Effluent Pumps (if chlorination is used, pending outcomes from Environmental Authority amendment application); and
- Installation of new Chlorine Dosing System (if required, pending outcomes from Environmental Authority amendment application).

If disinfection is omitted from the Environmental Authority, effluent can be released directly from the clarifier under gravity conditions removing the need for the effluent pump station.

A 3D model has been developed for the proposed layout which is available as a Navisworks file. Refer to the Saibai Island STP Condition Assessment for further details.

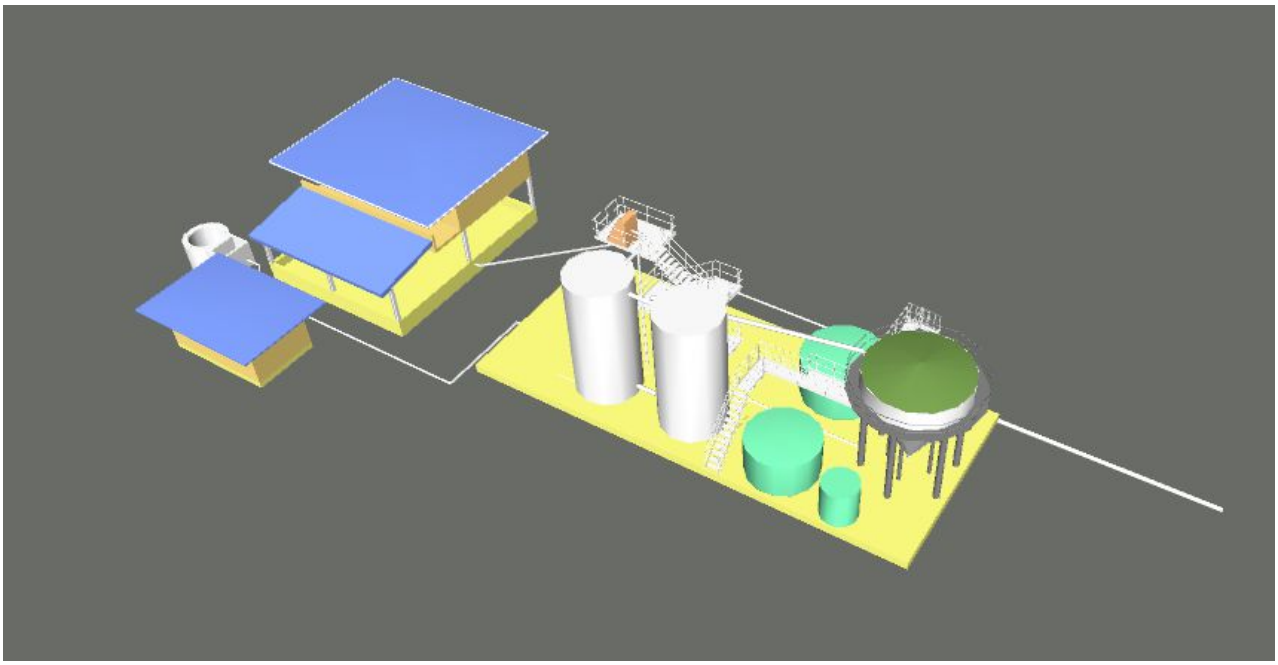


Figure 2 - 3D Model of Options 2 & 3

4.3 Option 3 – New Conventional Plant (MLE)

This process is the same as Option 2 except a new clarifier would be used. The existing clarifier had been deemed suitable and in good condition, therefore the installation of a new clarifier and the demolition of the existing clarifier is not justified. Refer to Appendix A - for details.

Figure 3: Typical Conventional MLE Plant with anoxic tanks, aerobic tanks and clarifiers. Tanks could be made of stainless steel or concrete, but steel would be easier to construct on site.

4.4 Option 4 – New Sequencing Batch Reactor

Sequencing batch reactors (SBR) are a conventional treatment process which operates with a continual fill, react, settle, and decant mode loop. The bioreactor is used for settling, negating the need for a clarifier. A SBR/IDEA treatment process set up in a MLE configuration would provide the require effluent quality, can be accommodated within the existing site boundary and can be designed for minimal operational input. This treatment process is currently being installed on Palm Island and a similar, but smaller, design would be suitable.

The decanter presents a single failure point within the treatment system, however, this can be designed to 'fail' in a high position limiting any solids carryover. The decanter will also be difficult to maintain/replace as it would require a crane to lift it out of the tank.

To implement the SBR/IDEA process, the following works would be required: -

- Removal and disposal of all treatment infrastructure currently located on the existing concrete slab;
- Installation of two new static inlet screens;
- Installation of a new bioreactor (concrete or stainless steel) and chlorine contact tank;
- Installation of chlorine dosing system (if required, pending outcomes from Environmental Authority amendment application);
- Installation of RAS pump (duty/standby)
- Installation of WAS pumps (if automatic wasting is preferred);
- Installation of new Effluent Pumps;
- Installation of decanter (located in Bioreactor); and
- Installation of externally mounted jet aerators (duty/standby) providing process air to the aerobic zone. The suction would be connected to the Anoxic tank which will provide mixing and recycling of wastewater between the aerobic and anoxic zones.

Figure 4: Typical SBR with decanter shown

A 3D model has been developed for the proposed layout which is available as a Navisworks file refer to Figure 5 Option 4 3D model and Appendix A - Concept Design Drawings for details.

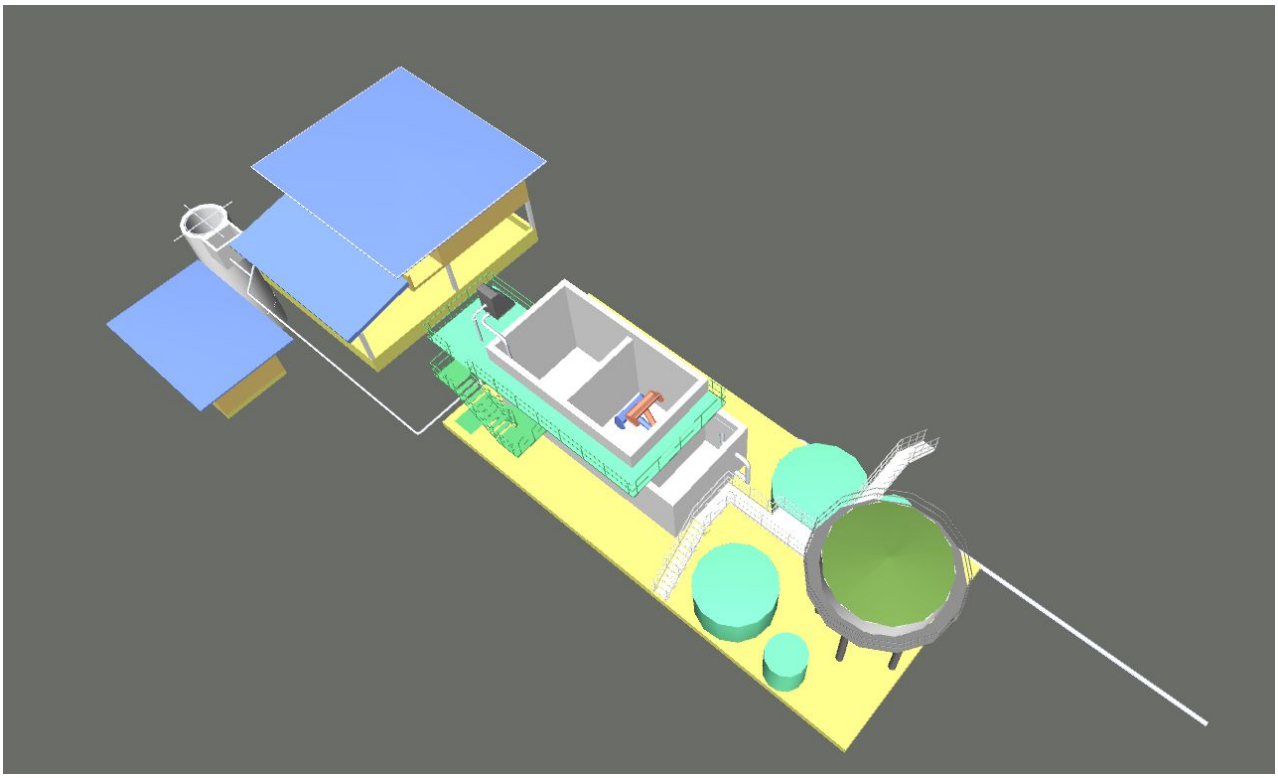


Figure 5 Option 4 3D model

4.5 Option 5 - Membrane Bioreactor (MBR)

Membrane bioreactors can be set up in MLE configuration to achieve the required effluent quality. Flat sheet or hollow fibre membranes are used to filter the biomass so the filtered water, called permeate, can be pumped out as effluent and the biomass remains in the bioreactor. An MBR plant provides exceptional effluent quality and requires a relatively small footprint, however, this process is more difficult to maintain than conventional or SBR plants, and requires significant instrumentation and control. In addition, there is more input required from operators in relation to preventative maintenance such as backwashing and chemical cleans (CIP).

To implement the MBR plant, the following works would be required: -

- Removal and disposal of all primary and secondary treatment infrastructure currently located on the existing concrete slab;
- Installation of a complex inlet works comprising of: -
    - 2mm Automatic Fine Screens,
    - Grit Removal, and
    - Flow Balancing Tank.
- Installation of a new Bioreactor Tank;
- Installation of a Membrane tank and membranes;
- Installation of membrane feed pumps;
- Installation of numerous pressure monitoring instruments;
- Installation of a Clean in Place (CIP) system;
- Installation of a chlorine contact tank (if required, pending outcomes from Environmental Authority amendment application); and
- Installation of chlorine dosing system if required, pending outcomes from Environmental Authority amendment application.

Figure 6: Hollow Fibre Membrane Cassette at Awonga Point MRB, Weipa, Qld

4.6 Option 6 -New Oxidation Ditch

An oxidation ditch is, typically, an oval-shaped tank in the ground that has an aerator (normally a brush type aerator, though diffused aeration is employed on larger plants). The principle of an oxidation ditch is to create a circular motion around the bioreactor where the biomass goes from an aerated aerobic zone to an anoxic zone several times before discharge. The oxidation ditch can have a settle mode, like an SBR or have a clarifier.

An oxidation ditch would provide the required effluent quality and is relatively easily maintained, however, will not be practical to implement on the existing treatment plant site. To install the oxidation ditch, significant earthworks and concreting would be required. Since the existing STP site forms part of the bund around the community this option is not practical and would be susceptible to flooding under storm or king tide events.

Figure 7: Oxidation Ditch with Brush Aerator at Lorim Point STP, Weipa, Qld

4.7 Option 7 – New Trickling Filter

Tricking filters are bioreactors that have rock media that allows biomass to attach to the media. The treatment process would require a primary settling tank prior to the trickling filter. This biomass ammonia and BOD in the influent allowing the biomass to grow. Eventually the biomass clump, called humus, becomes large enough that it detached from the rocks and slumps out of the tricking filter. A clarifier, known as a humus tank, then capture the biomass for wasting.

Trickling filters are common in regional areas, but are generally being replaced with more modern treatment process such as conventional treatment plants, oxidation ditches, MBR or SBR. A trickling filter plant will likely not achieve the required effluent quality, nor will it be accommodated within the existing STP boundary.

Tricking filters are prone to odour and vector issues.

Figure 8: Trickling Filter at Cherbourg STP, Qld

4.8 Option 8 - New Lagoons

Lagoon systems, typically consist of screening, followed by anaerobic, aerobic and/or facultative lagoons. Lagoons are commonly employed in remote communities where sufficient land is available. The benefits of lagoons is the reduced operations and maintenance requirements and low power usage (if not aerated).

Many lagoon systems around Queensland have issues with achieving the required effluent quality. Conventional lagoon treatment requires a large footprint and cannot be accommodated on the existing STP site. Saibai Island is low lying and susceptible to flooding. The high nutrient water and high temperatures also commonly result in algal blooms which introduce further risks to the treatment process.

Figure 9: Lagoons in Nhulunbuy, NT

4.9 Option 9 – New Moving Bed Biofilm Reactor (MBBR)

A Moving Bed Biofilm Reactor (MBBR) will achieve the required effluent quality and can be accommodated within the existing STP footprint. MBBR uses high surface area media in the bioreactors, normally made of plastic, to allow attached growth of some of the mixed liquor in the bioreactor, so that there is less suspended matter that needs to be clarified. This process is normally chosen when, either, a small clarifier is required, a plant has issues with sludge settleability, or the plant is overloaded. In this case, the existing clarifier is of sufficient size, there is no reason to suspect poor settleability and a new plant would be sufficiently sized. There is no benefit that justifies spending the additional money to install this media.

To implement this process, the following works would be required: -

- Removal and disposal of all primary and secondary treatment infrastructure currently located on the existing concrete slab;
- Installation of a inlet works comprising of: -
    - 3mm Fine Screens, and
    - Grit Removal.
- Flow Balancing Tank;
- Installation of anoxic and aerobic bioreactor tanks with media;
- Installation of Chlorine Contact Tank if required, pending outcomes from Environmental Authority amendment application;
- Installation of new Chlorine Dosing System if required, pending outcomes from Environmental Authority amendment application; and
- Installation of Final Effluent Pumps.

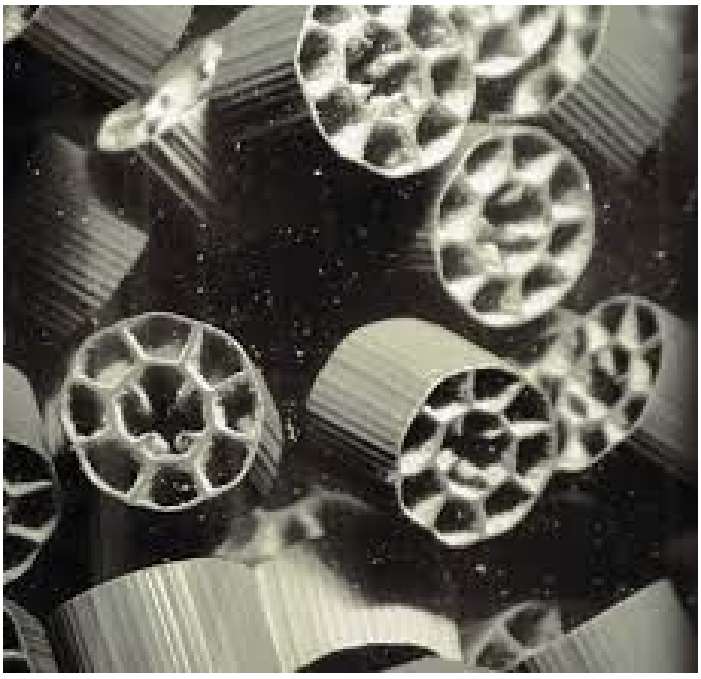


Figure 10: Typical MBBR media

4.10 Option 10 – New Rotating Biological Contactor (RBC)

A Rotating Biological Contactor (RBC) utilises high surface area discs that are continuously rotating at low speed. The rotation allows microorganisms to attach to the discs, and the microorganisms go from submerged in the influent to being in air. This allows aeration to be provided at low energy use.

RBC could be accommodated within the existing STP footprint, however, this process does not produce sufficient quality effluent unless some type of pre-treatment is provided.

RBC's are generally limited to very small installations. Ongoing maintenance issues would need to be considered.

To implement this process, the following works would be required: -

- Removal and disposal of all primary and secondary treatment infrastructure currently located on the existing concrete slab;
- Installation of inlet works comprising of: -
    - 3mm Fine Screens, and
    - Grit Removal.
- Flow Balancing Tank;
- Installation of a bioreactor tanks (anoxic tank to allow denitrification);
- Installation of RBC unit;
- Installation of Chlorine Contact Tank;
- Installation of new Chlorine Dosing System; and
- Installation of Final Effluent Pumps.

Figure 11: Typical Rotating Biological Contactor

5. Options Analysis

5.1 Gate 1 Assessment: - Mandatory Criteria

Each of the treatment technologies described in Section 4 has been assessed using the following mandatory criteria (refer to 3.2.1 Gate 1 – Mandatory Requirements for a description of each of the criteria): -

1. Effluent Quality (Service standards, regulatory compliance),
2. Possible or Practical to implement (operational and performance efficiency), and
3. Easy to Operate & Maintain.

The table below displays a summary of the outcomes for each treatment technology reviewed against the Gate 1 assessment criteria.

Table 6: Mandatory Criteria Summary

Option	Effluent Quality	Possible or Practical to Implement	Easy to Operate & Maintain	Outcome (Pass or Fail)
1. Refurbishment of Existing Plant	✓	✗	✗	Fail
2. New MLE, Keep Existing Clarifier	✓	✓	✓	Pass
3. New MLE Plant	✓	✓	✓	Pass
4. New SBR Plant	✓	✓	✓	Pass
5. New MBR Plant	✓	✓	✗	Fail
6. New Oxidation Ditch	✓	✗	✓	Fail
7. New Trickling Filter	✗	✗	✓	Fail
8. New Lagoons	✗	✗	✓	Fail
9. New MBBR	✓	✓	✗	Fail
10. New RBC	✗	✓	✓	Fail

After applying the screening criteria to each of the options, three treatment process options satisfied the requirements of the three-mandatory criterion and progressed to Gate 2.

5.2 Gate 2 – Multi Criteria Analysis

The following three treatment process options passed the Gate 1 criterion and were assessed using a Multi Criteria Analysis (MCA): -

1. Option 2 - New Conventional Plant, Keeping the Existing Clarifier (MLE Process);
2. Option 3 – New Conventional Plant (MLE); and
3. Option 4 – New Sequencing Batch Reactor.

Conceptual designs were developed for the three passing options. Refer to Figure 2 - 3D Model of Options 2 & 3 and Figure 5 Option 4 3D model.

All options use similar equipment for treatment (i.e. jet aerators for aeration and centrifugal RAS pumps). Although the SBR has a decanter, the differences in maintenance requirements, operator input and power on all three options is marginal. The operational costs are deemed to be the same across all options. Capital Costs have therefore only been used in the assessment.

5.2.1 Option 2 - New Conventional Plant, Keeping the Existing Clarifier (MLE Process) MCA Analysis

Table 7 – Option 2 MCA

Criterion	Description / Comment	Score		
		x/5	Weighting	Weighted Score (%)
Proven Technology	MLE Process is a standard treatment process used throughout the world to achieve low ammonia, BOD, TSS and total nitrogen levels. The existing clarifier has been assessed as having sufficient capacity to meet the required effluent quality.	5	15%	0.75
Fit-for-purpose Fit-for-place	This process is simple, easy to operate and maintain and can be constructed using suitable selected materials to withstand the corrosive environment on Saibai Island. The proposed MLE arrangement includes two elevated tanks (7.0m TWL from slab) allowing the system to operate under gravity flow. This requires no intermediate pumping.	5	26%	1.3
Resourcing	The MLE process, can be designed to be easy to operate and maintain with minimal operator input. Routine maintenance is required on jet aerators and pumps.	4	17.5%	0.7
Process Resilience	The process is simple an effective. The process is constantly running with no complex SCADA control. Sufficient standby equipment will be required. The process is impossible to bypass and operator input is minimal (other than biomass wasting, sampling and housekeeping)	5	19.5%	0.975
Capital Cost	Capital Expenditure - $4,784,000.00	5	22%	1.1
SCORE (x/5)				**4.825**

5.2.2 Option 3 – New Conventional Plant (MLE) MCA Analysis

Table 8 - Option 3 MCA Analysis

Criterion	Description / Comment	Score		
		x/5	Weighting	Weighted Score (%)
Proven Technology	MLE Process is a standard treatment process used throughout the world to achieve low ammonia, BOD, TSS and total nitrogen levels. The existing clarifier has been assessed as having sufficient capacity to meet the required effluent quality.	5	15%	0.75
Fit-for-purpose Fit-for-place	This process is simple, easy to operate and maintain and can be constructed using suitable selected materials to withstand the corrosive environment on Saibai Island. The proposed MLE arrangement includes two elevated tanks (7.0m TWL from slab) allowing the system to operate under gravity flow. This requires no intermediate pumping.	5	26%	1.3
Resourcing	The MLE process, can be designed to be easy to operate and maintain with minimal operator input. Routine maintenance is required on jet aerators and pumps.	4	17.5%	0.7
Process Resilience	The process is simple an effective. The process is constantly running with no complex SCADA control. Sufficient standby equipment will be required. The process is impossible to bypass and no operator input (other than biomass wasting, sampling and housekeeping). This process is capable of treating varying influent envelopes making it suitable for installation in small communities. The plant will run on power outage with loss of treatment for extended outages. There are no points of failure or potential for overflow.	5	19.5%	0.975
Capital Cost	Capital Expenditure - $5,784,000.00	4	22%	1.1
SCORE (x/5)				**4.605**

5.2.3 Option 4 – New Sequencing Batch Reactor MCA Analysis

Table 9 - Option 4 MCA Analysis

Criterion	Description / Comment	Score		
		x/5	Weighting	Weighted Score (%)
Proven Technology	SBR is a standard treatment process used throughout the world to achieve low ammonia, BOD, TSS and total nitrogen levels. This technology can be designed to be easy to construct, operate and maintain with a minimal amount of instrumentation and mechanical equipment.	5	15%	0.75
Fit-for-purpose Fit-for-place	This process is simple, easy to operate and maintain and can be constructed using suitable selected materials to withstand the corrosive environment on Saibai Island.	5	26%	1.3
Resourcing	Resourcing for this treatment option is minimal, it is estimated a part-time operator would be required to monitor the plant daily and take samples as required. This fits within the requirements of the existing resourcing at the STP. Routine maintenance is required on jet aerators, decanter and pumps.	4	17.5%	0.7
Process Resilience	The process is simple an effective. The process is constantly running with no complex SCADA control. Sufficient standby equipment will be required. The process is impossible to bypass and no operator input (other than biomass wasting, sampling and housekeeping). The SBR has no pumping requirements through the biological treatment process operating under gravity (Note: Pumping of effluent required). Under power outage of equipment failure, the plant will continue to run with reduced treatment. The decanter will be used as an overflow, in the event of it failing it will return to its starting level. This process is capable of treating varying influent envelopes making it suitable for installation in small communities. A single mechanical failure point is the decanter, if the decanter fails there will be no 'proper' clarification resulting in solids carryover.	4	19.5%	0.78
Capital Cost	Capital Expenditure - $6,994,000.00	3	22%	0.66
SCORE (x/5)				**4.19**

6. Analysis and Recommendation

6.1 MCA Outcomes

The following summarises the scores of the MCA.

Table 10 - MCA Scores

Option	MCA Score
2. New MLE, Keep Existing Clarifier	4.825
3. New MLE Plant	4.605
4. New SBR Plant	4.190

Based on this analysis Option 2 – New MLE, Keep Existing Clarifier is deemed the most suited for the upgrade of the plant and is the recommended option for the following reasons: -

- Scored the highest in the MCA analysis;
- Easy to operate and maintain;
- Does not require full-time monitoring nor does it require highly skilled operators;
- No instrumentation, except flowmeter, is required;
- Can be installed in the existing sewage treatment plant site;
- Has excellent process resilience;
- Fastest to implement; and
- Can be manufactured entirely offsite and shipped to the island.

6.2 Social, Environmental and financial Objectives

The above MCA and analysis has focused on finding an appropriate treatment technology and technical aspects of the wastewater treatment facility. This section explores any Social, Environmental and financial objectives in regard to the treatment facility.

6.2.1 Social Objectives

The design of the WWTP is primarily focused on a robust and simple treatment process. Social objectives that have been taken into consideration are to use local labour where possible for the construction phase of the plant and to provide simple operation and maintenance tasks that can be undertaken by local operators (with training and support).

The broader social impacts of the treatment plant are considered minor as the treatment plant will be constructed within the current footprint of the plant and overall will lead to an improvement in effluent quality. During the construction phase of the project there will be a social impact due to the presence workers required to provide specialist skills during construction.

Where possible, local workforce will be used and if required, additional training will be provided.

6.2.2 Environmental Objectives

Process resilience of the treatment process has been used as a criterion within the MCA. Process resilience means that the treatment plant will be able to achieve (or improve upon) the effluent quality criteria under a whole range of operating conditions and with redundancy and safeguards in place to allow for compliant effluent at all times.

The design choices have a holistic approach and, where possible, reuse existing components of the plant to reduce costs, materials and labour requirements. In addition, careful consideration has been made to the environmental costs of importing materials and labour to an island community like Saibai (this forms the driver for removing the sodium hypochlorite dosing system from the design). All the design options that passed through the first gate of the assessment process are in principle compliant with the environmental objectives as it was part of the assessment process.

6.2.3 Financial Objectives

Financial objectives are considered in detail through obtaining pricing from leading plant and equipment constructors. During the option assessment and preliminary design stages, different options were assessed using GANDEN's knowledge of asset costs and a basic assessment of the cost associated with transport and labour of the different options. The three options that came out of the options assessment are considered similar in most aspects of construction, the key differences being reuse of the existing clarifier, versus fabrication of a new clarifier, and the use of stainless steel tanks versus pre-cast concrete tanks.

6.3 Risk Assessment

A holistic risk assessment was undertaken for the three options that were further assessed for gate 2. The risks associated with each of these options are considered to be similar, and risks are able to be mitigated to an acceptable level through the detailed design stage. Refer to Appendix E - for the details of the risk assessment.

7. Concept Design

7.1 Process Overview

The MLE process has been sized to treat up to 5 x ADWF. The plant can be constructed within the existing footprint and provides a simple but robust treatment process which is simple to operate and resilient to varying influent flows. Where possible, equipment and instrumentation has been removed to simplify the process and reduce complexity. The MLE plant will provide inorganics, biological and solids removal through a three-stage treatment process which includes: -

1. Inlet works (screenings removal);
2. Anoxic Tank;
3. Aerobic Tank with jet aeration;
4. Clarification using existing clarifier and new RAS pumps;
5. Disinfection (if required);

7.1.1 Process Modelling

GANDEN has used the Biowin © modelling software to ensure that the options presented here will be able to achieve the effluent quality criteria and provde robust and stable treatment with minimal complexity and operator interference. The results for the Biowin © modelling are available in Appendix C -

7.1.2 Pre-treatment / Inlet Works

The preliminary treatment, or inlet works, is the physical removal process that removes gross and fine solids from the wastewater for protection of blockages downstream. The proposed inlet works will consist of duty/duty static rundown screens that will be installed prior to the bioreactor tanks. Two screens are recommended (duty/duty) so that one may be taken offline for maintenance, i.e. single point of failure is eliminated.

A plant bypass will be installed with a manual gate valve, the valve will be locked to prevent misuse. The plant will be designed such that the bypass will only need to be used during major maintenance activities that involve the isolation of both screens, the primary treatment tanks or the clarifier.

The screens would be elevated above the level of the bioreactor to allow gravity flow into the bioreactor. This type of screen is currently installed at several TSIRC STP's including the Saibai STP. The existing screen has experienced some corrosion around welds and connections. It is recommended the new static screen is made from a higher grade of stainless steel (SAF 2205) to provide enhanced corrosion resistance. To prevent corrosion issues in the future, a regime of wash downs of all stainless-steel equipment is proposed, along with yearly inspections. Pickling and passivating of the stainless-steel can be undertaken during construction to minimise corrosion.

Automatic cleaning screens (i.e. screw screens, band screens etc.) are deemed to be inappropriate for this site due to issues with mechanical maintenance.

An electromagnetic flowmeter will be installed upstream of the static screen to monitor influent flows. This flowmeter has no moving parts and should provide a long, problem free service life.

The static screen has no moving parts and is easy to operate. The screen is designed to be self-cleaning, with spray bars fitted, however, operators will be required to inspect and hose down the screen daily to ensure screenings to not dry out on the screen.

The screen can be provided with a drop-down chute directing screenings into a collection trailer or bin, similar to the installation of the existing screen. The collection trailer or bin will be located directly beneath the screen and will sit atop a concrete bund. The concrete bund will have a sump to catch all spillages. A small sump pump will be provided to transfer flows from the inlet sump back into the screen.

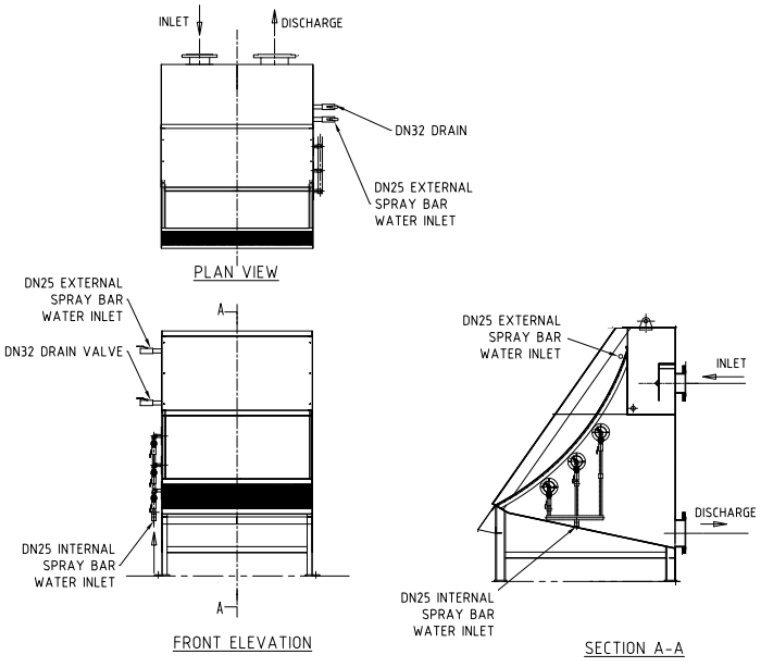


Figure 12 - Static Screen (typical)

Figure 13 – New Static Rundown Screens at Palm Island. Two screens facing each other is proposed.

7.1.3 Biological Treatment

A single train Modified Ludzack-Ettinger (MLE) treatment process consists of two bioreactor tanks for biological treatment. Two grade 316 or SAF 2205 Stainless Steel tanks (Anoxic and Aerobic), will be installed adjacent to the clarifier to provide biological treatment. Refer to Appendix D - for information on Stainless Steel Construction in coastal areas, from the Australian Stainless Reference Manual.

The tanks will be hydraulically linked via low level and high-level connections.

7.1.3.1 Anoxic Tank

The anoxic tanks provide denitrification to reduce the nitrate and thus total nitrogen levels. Influent is fed from the inlet works screen, via gravity, into the Anoxic Tank. The anoxic tank is hydraulically linked to the aerobic tank via low-level and high-level connections.

Mixing of the Anoxic Tank will be achieved by connecting the Jet Aeration suction pipework to the Anoxic tank.

The tank will remain full at all times so no level instruments are required.

7.1.3.2 Aerobic Tank

The Aerobic Tank provides BOD removal and nitrification of Ammonia (i.e. conversion of ammonia to nitrate). Two (2) Jet Aerators (duty/standby + hot swappable spare) will be installed outside the Aerobic Tank to provide process air to the treatment process. The suction of the jet aerators will be connected to the Anoxic Tank and discharge into the Aerobic Tank. At least one spare jet aerator pump is recommended. All pumps should be connected to a GPO with a phase changeover switch so that they can be rapidly swapped out without an electrician.

An A-recycle, or aerobic return is required to recirculate flows between the aerobic and anoxic tanks. As the aerobic tank provides nitrification of ammonia, the flows transferred back into the anoxic zone will provide further removal of nitrogen. By configuring the jet aerators in a way that the suction is via the anoxic tank, a flow path will be created between the Aerobic and Anoxic tanks removing the need for an A-recycle pump.

The Jet Aerators consist of a pump (to be located outside of the tank to allow ease of access for maintenance and replacement), air inlet and jet nozzle (located inside the tank). Liquid is pumped through the jet nozzle ejector and past the air inlet branch. The venturi nozzle is designed to entrain air in the discharge of the pump, therefore aerating the water within the tank.

An isolation valve and non-return valve will be provided on the intake and discharge of each pump to allow isolation for removal.

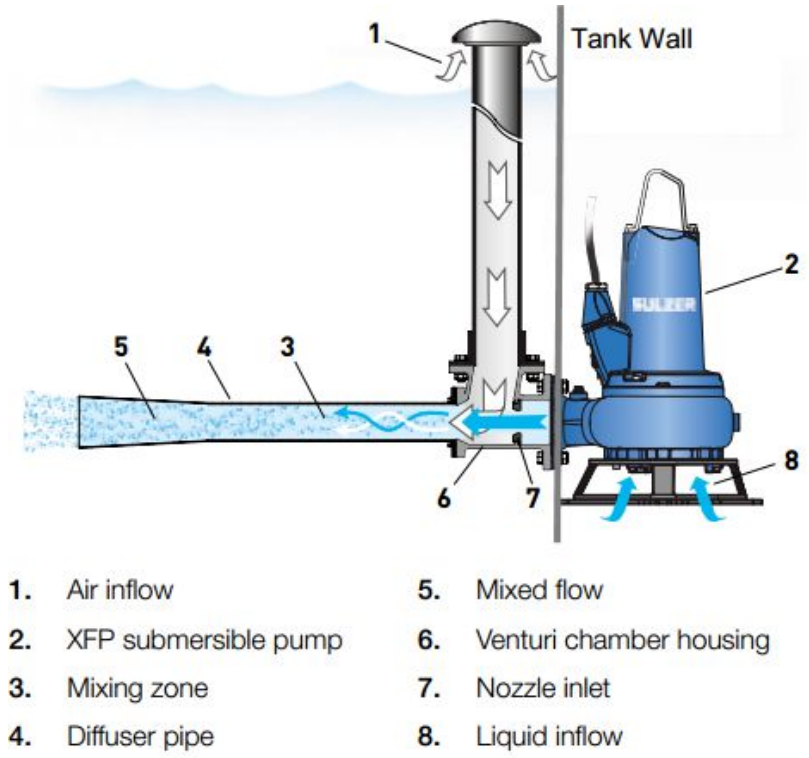


Figure 14 - Jet Aerator (currently being installed at various TSIRC STPs)

7.1.3.3 Waste Activated Sludge

Wasting is required to remove old biomass. The wasting is required to maintain an optimal biomass concentration MLSS of 3,000 - 4000mg/L within the bioreactor. The amount of sludge to be wasted will around 3,000 L/day, but this can be done once a week or fortnight.

Due to the configuration of the high tanks, a WAS pump will not be required as wasting can be achieved by draining directly to the drying beds. A manual valve can be provided to transfer flows from the Anoxic tank to the existing drying beds.

Alternatively, if automatic wasting is preferred, an actuated valve or pump can be provided, however this is not recommended.

7.1.4 Clarification

The existing clarifier will be retained for solids separation downstream of the anoxic tank. Flows from the Anoxic tank will gravitate into the stilling well (located in center of clarifier). Mixed liquor biomass within the wastewater will fall to the bottom of the tank and the top layer of clearwater overflows over the launders on the outside of the tank. The effluent from the Clarifier can discharge, via gravity to the ocean via the outfall pipeline.

If disinfection is required, effluent from Clarifier will need to flow into chorine contact tanks for disinfection prior to being pumped out via the effluent outfall.

The existing clarifier has been designed for a small footprint with steep 60° walls providing efficient solids removal without the need for a mechanical rake.

Settled activated sludge in the clarifier is returned to the anoxic tank using the return activated sludge (RAS) pump. The RAS pump rate is typically around 2 times the influent flow. It is recommended that the RAS pump be VSD controlled.

Duty, standby and spare RAS pumps are recommended.

7.1.5 Disinfection (if required)

TSIRC are currently seeking a dispensation for the faecal coliform (FC) limit in the Environmental Authority. If the FC limits are removed, then disinfection will not be required.

For disinfection, a 12.5% Sodium Hypochlorite dosing system and a HDPE chlorine contact tank with internal baffles would be installed downstream of the Clarifier. Effluent form the Clarifier will flow into the Chlorine Contact tank (CCT), Sodium Hypochlorite will be dosed into the inlet pipework. The tank will be designed to provide a minimum of 30 minutes contact time (CC) based on influent flows.

If disinfection is required, an effluent pump station will need to be installed as there will not be sufficient driving head from the CCT.

Sodium hypochlorite would be delivered to site in 200L drums.

7.1.6 Effluent Pump Station (if required)

An Effluent Pump Station consisting of a small poly rainwater tank and a duty/standby effluent pump set would be provided if required. Currently, there are two small polymer tanks onsite, one used as a clarifier lift tank and one effluent storage. Either of these tanks could be retained and reused for the Effluent Pump Station.

The Duty/Standby effluent pumps will be controlled by a hydrostatic level instrument installed in the tanks. A hot swappable spare pump will be provided to allow operators to easily replace pumps.

7.1.7 Effluent Flow Meter

An electromagnetic flowmeter will be installed downstream of the Clarifier to monitor effluent flows. This flowmeter has no moving parts and should provide a long, problem free service life.

7.1.8 Sludge Drying Beds

WAS from the Anoxic tank would be transferred to the drying beds where the sludge will dry over time. The existing drying beds were refurbished in 2012 and are in good, serviceable condition.

Once sludge is dried, it can be removed and disposed in the landfill.

The water from the sludge will evaporate and filter through the sand in the drying beds. The filtrate is known as supernatant. The supernatant from the drying beds drains into a pump well adjacent to the drying beds.

7.1.9 Supernatant Pump Station

The Supernatant Pump Station receives filtrate from the drying beds and will pump into the inlet screen. The existing pump station structure is in good serviceable condition and can be reused within minimal repair works. A new pump and level instrumentation will be installed as part of the upgrade. A hot swappable spare pump will be provided to allow operators to easily replace pumps.

7.1.10 Service Water System

The existing service water system is complex due to the installation of the service water system at SPS 1. It is recommended that a bigger booster pump is installed at the SPS 1 location to provide service water for the site.

7.1.11 Admin Building

The existing control room building is in good condition. It is recommended that some minor replacements and refurbishment works are undertaken to prolong the life of the building. Minor repair works include the replacement of air conditioning units that have corroded and removal or algal growth form the ceiling, may require replacement of some of the ceiling depending on the severity of damage.

7.1.12 Switchboard

The existing switchboard was installed in 2012 and is in good condition, however, the new plant would require a new purpose-built switchboard to be constructed.

7.2 Marine Outfall

The existing DN200 MDPE outfall pipeline was constructed in 2001 is designed to discharges into the ocean approximately 400m North of the STP. During the site visit, TSIRC advised the pipeline was cut several years ago due to a blockage in the pipeline, but are unsure of the exact location due to conflicting information between previous reports. The actual cause of the blockage is unknown; however, it is thought to be from one of the following: -

- Crustacean buildup within the pipeline;
- Buildup of silt in the pipeline;
- Damage caused by recreational use in the area i.e. boats, anchors etc; and
- Poor design or execution of the pipeline.

From investigations and the As-Constructed drawing of the pipeline (dated 2001), the outfall pipeline has been trenched from chainage 0 to chainage 260 where it breaches (Note: this is from 2001, as this is located around the low tide level, it is likely the surface has changed). Ganden assumes that the pipeline was blocked and has been cutoff between chainage 250 and 400.

As the pipeline has been cut, it has been flagged as a breach in the STP environmental license. TSIRC are required to replace the cut section or replace the entire outfall pipeline.

The condition of the existing pipeline is unknown therefore it is recommended that the entire outfall pipeline is replaced to match the initial design.

Any new design should consider marine growth around the outfall. Duckbill valves can provide protection from marine growth.

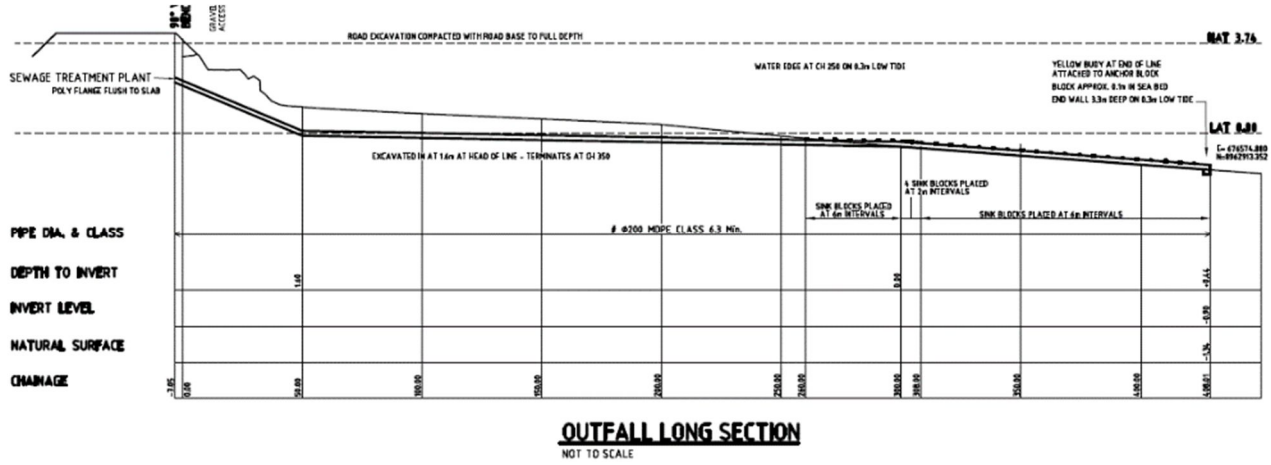


Figure 15 - Outfall Pipeline Long Section (From drawing 90014-15 dated 16/08/2001)

7.3 Temporary Treatment During Construction

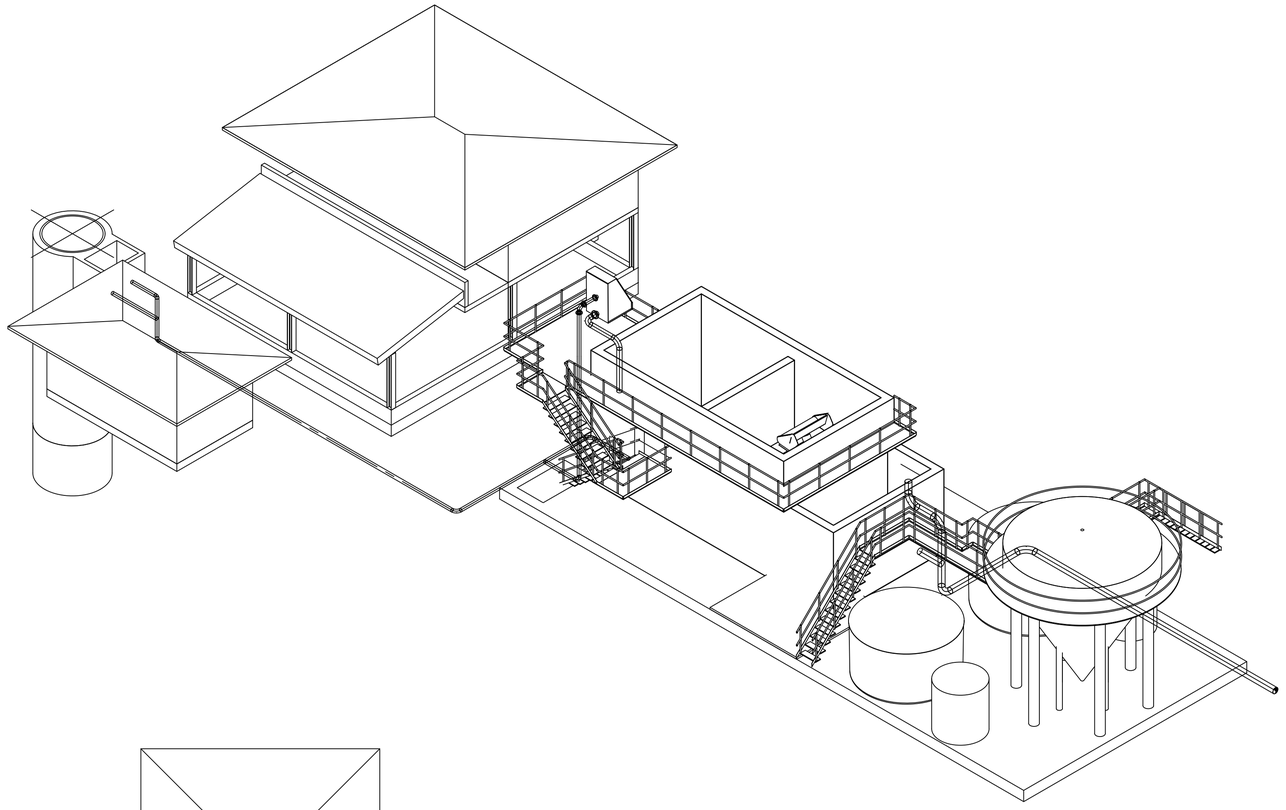
During the construction of the upgraded treatment plant, a temporary treatment plant will be setup to allow minimal treatment of the sewage during the construction of the plant. As there is limited space on the existing site, the proposed temporary treatment plant will utilise existing tanks and equipment.

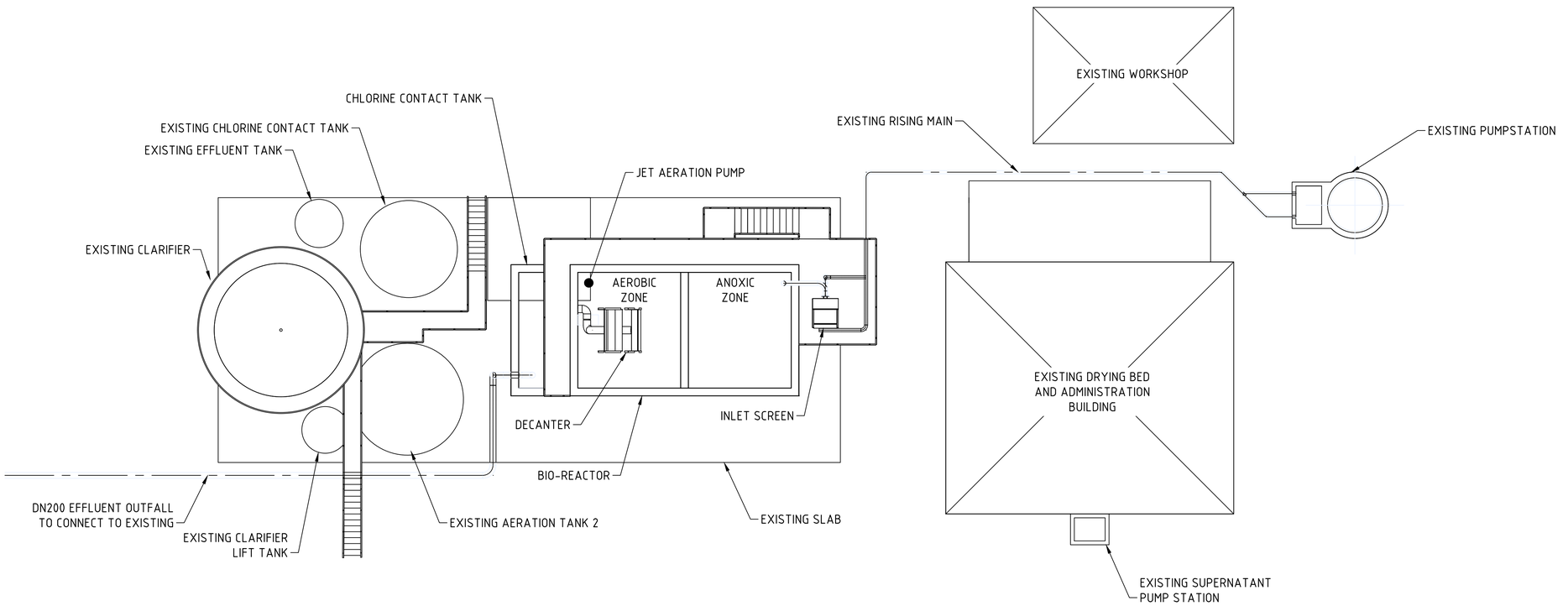
It is proposed the temporary treatment is made up of: -

- Two of the existing fiberglass tanks will be used to create an anoxic and aerobic zone;
    - A mixer will be installed in the Anoxic tank;
    - Jet Aerator will be installed in the Aerobic tank;

- Clarifier Lift Tank – The pumps and instrumentation within the tank will need to be replaced to be used as temporary treatment. This tank will be removed following commissioning of the new plant.
- Clarification – the existing clarifier will be retained and reused;
- RAS and WAS pipework will need to be reconfigured;

Appendix A - Concept Design Drawings





GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	15.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

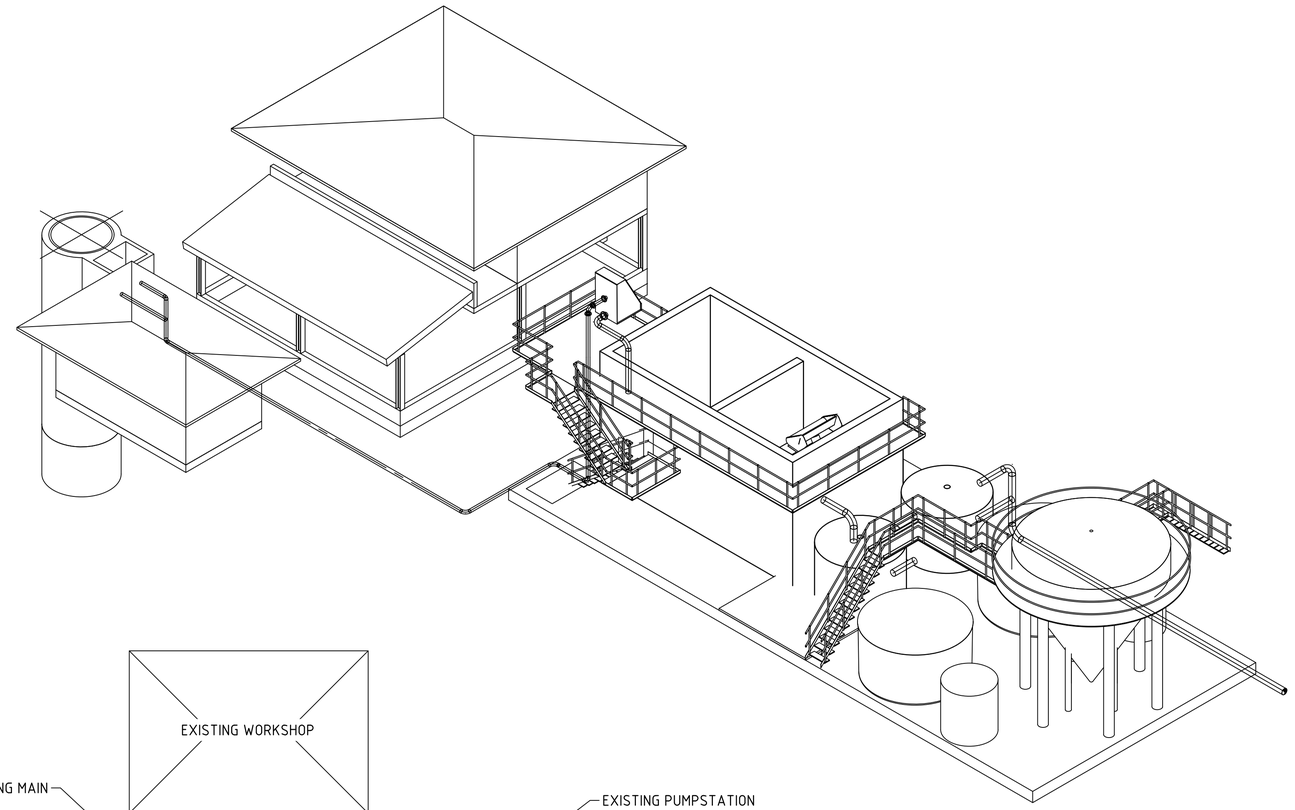
DRAWING STATUS INFORMATION

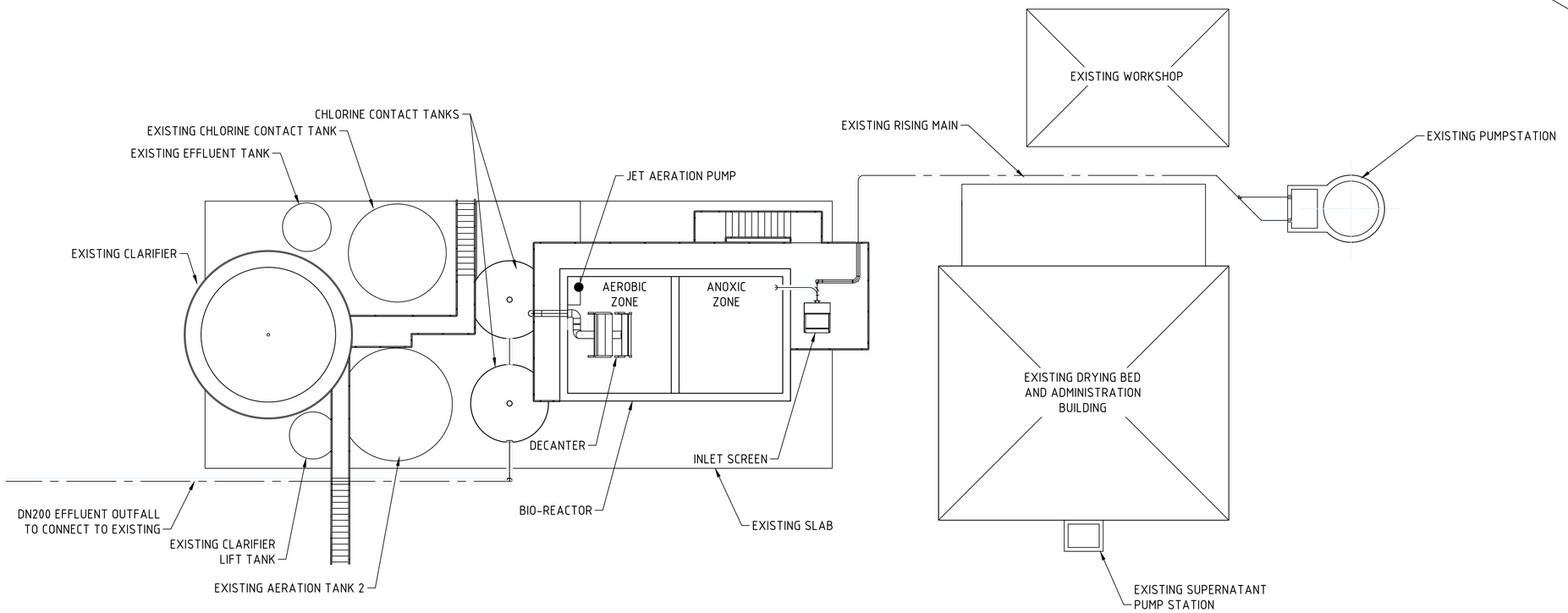
TITLE
SAIBAI STP
OPTIONS ANALYSIS
OPTION 1 - SBR
GENERAL ARRANGEMENT

DRAWING NUMBER 0615-SAI-GA-002

REVISION A

File Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBS\TPORTHOS\DWGS\0615-SAI-GA-002.DWG Plot: 8/1/2017 2:45 PM





GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	15.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

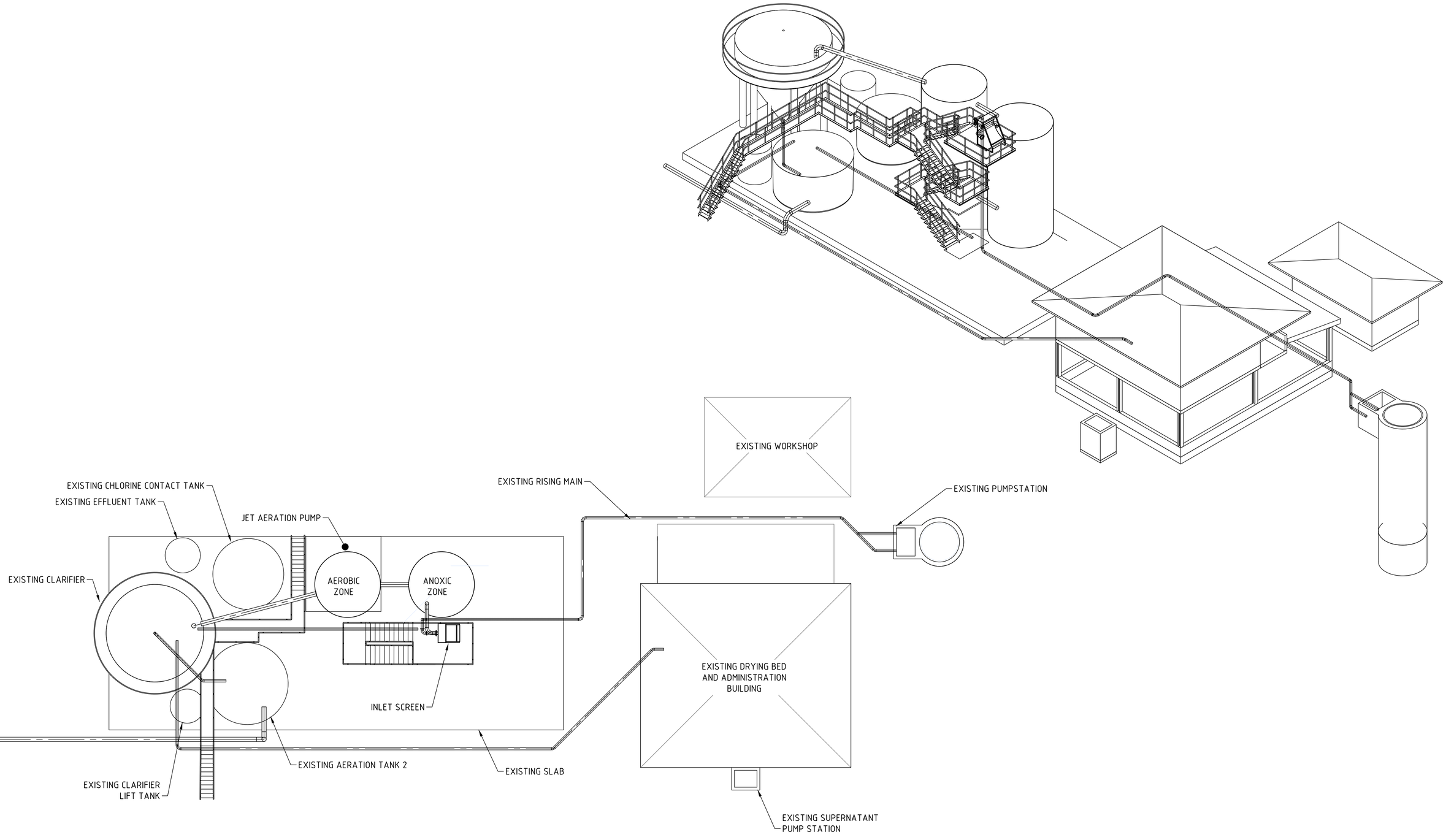
DRAWING STATUS INFORMATION

TITLE
SAIBAI STP
OPTIONS ANALYSIS
OPTION 2 - SBR
GENERAL ARRANGEMENT

DRAWING NUMBER 0615-SAI-GA-004

REVISION A

File: Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\0615STP-NORTHQS\DWGS\0615-SAI-GA-004.DWG Plot: 8/15/2017 2:45 PM



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	15.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP
OPTIONS ANALYSIS
OPTION 3 - MLE
GENERAL ARRANGEMENT

DRAWING NUMBER 0615-SAI-GA-006

REVISION A

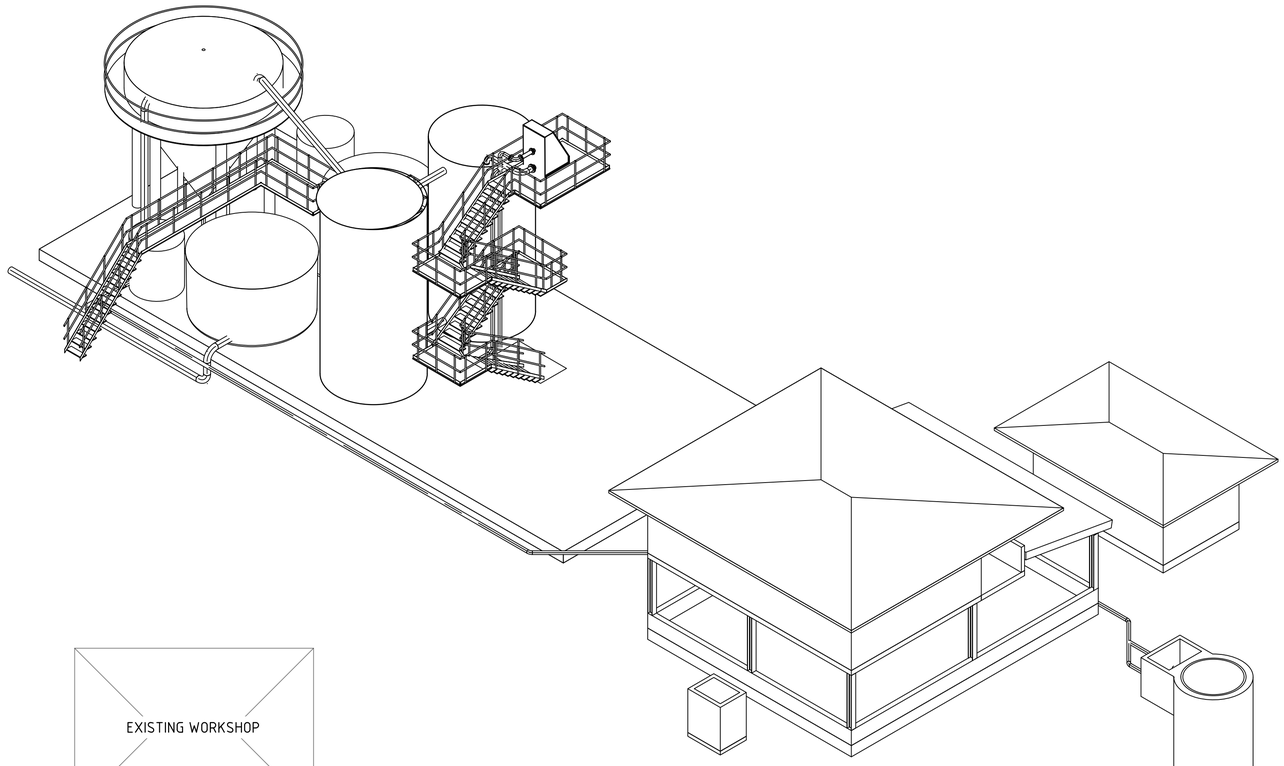
File Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBSTPORTHOS\DWGS\0615-SAI-GA-006.DWG Plot: 9/15/2017 2:35 PM

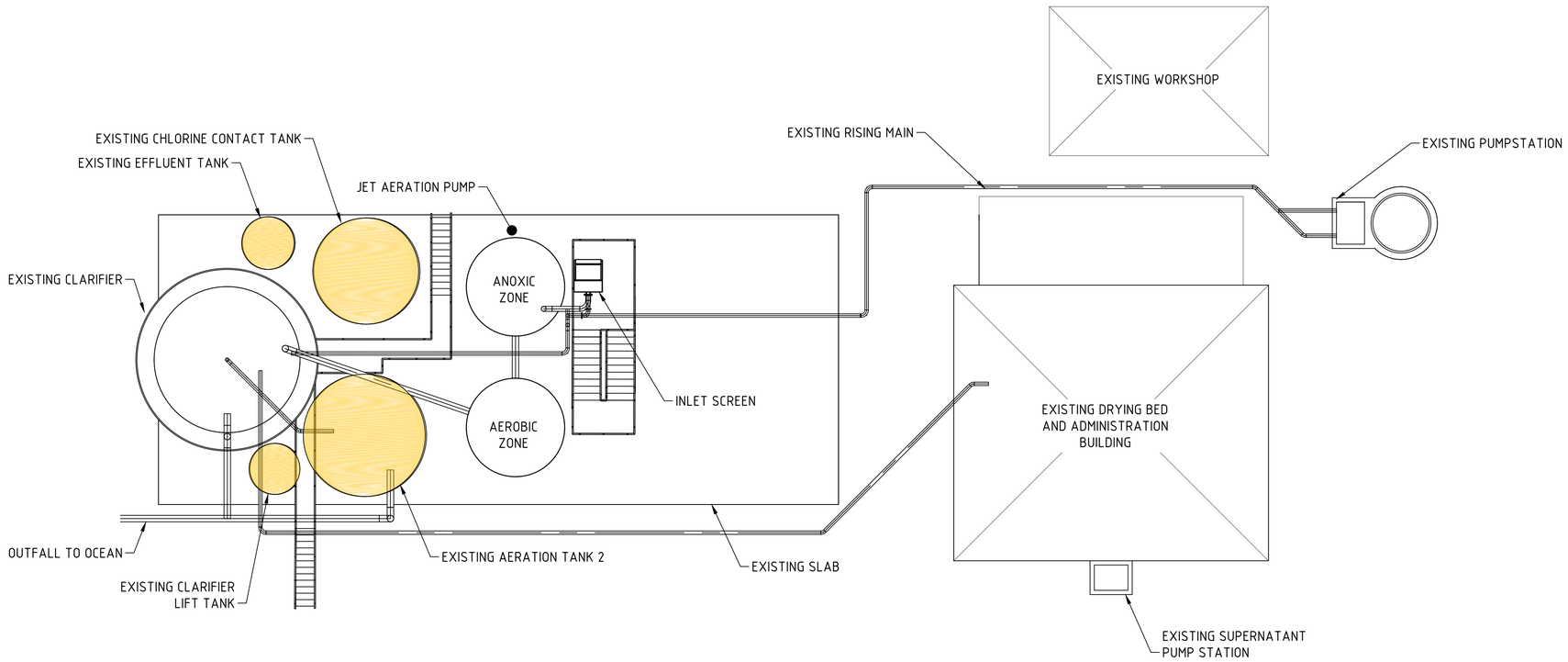
LEGEND

TEMPORARY TREATMENT DURING CONSTRUCTION. STRUCTURES TO BE DEMOLISHED AFTER CONSTRUCTION.

NOTE

1. REQUIREMENT FOR CHLORINE CONTACT TANK & FINAL EFFLUENT PUMP STATION TO BE CONFIRMED PENDING OUTCOMES FROM THE LICENCE AMENDMENT APPLICATION FOR THE REMOVAL OF DISINFECTION.
2. ALL EQUIPMENT, TANK, PUMPS AND PIPEWORK LOCATIONS AND SIZES TO BE CONFIRMED DURING DETAILED DESIGN.





GANDEN
ENGINEERS AND PROJECT MANAGERS

HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	15.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
GENERAL ARRANGEMENT

DRAWING NUMBER 0615-SAI-GA-002

REVISION B

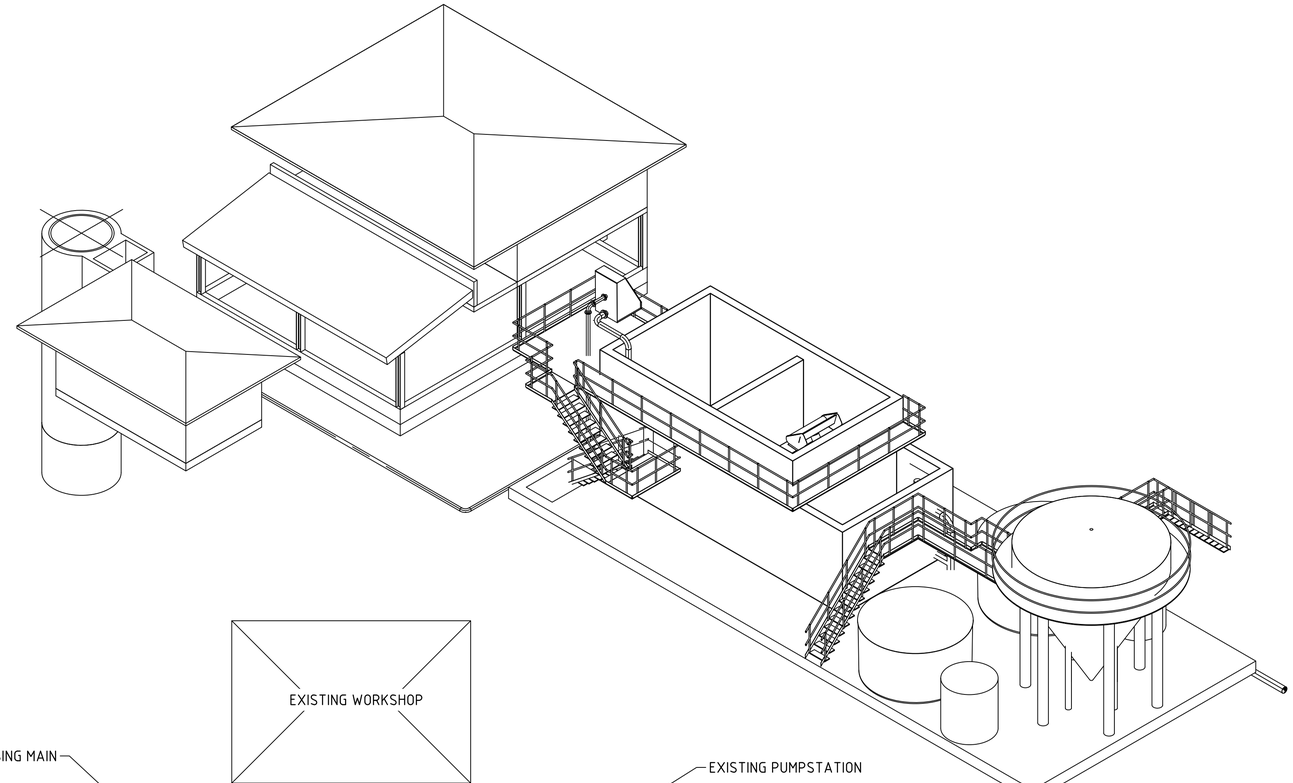
File: Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBSTPORTHOS\DWGS\0615-SAI-GA-002.DWG Plot: 11/8/2017 9:27 AM

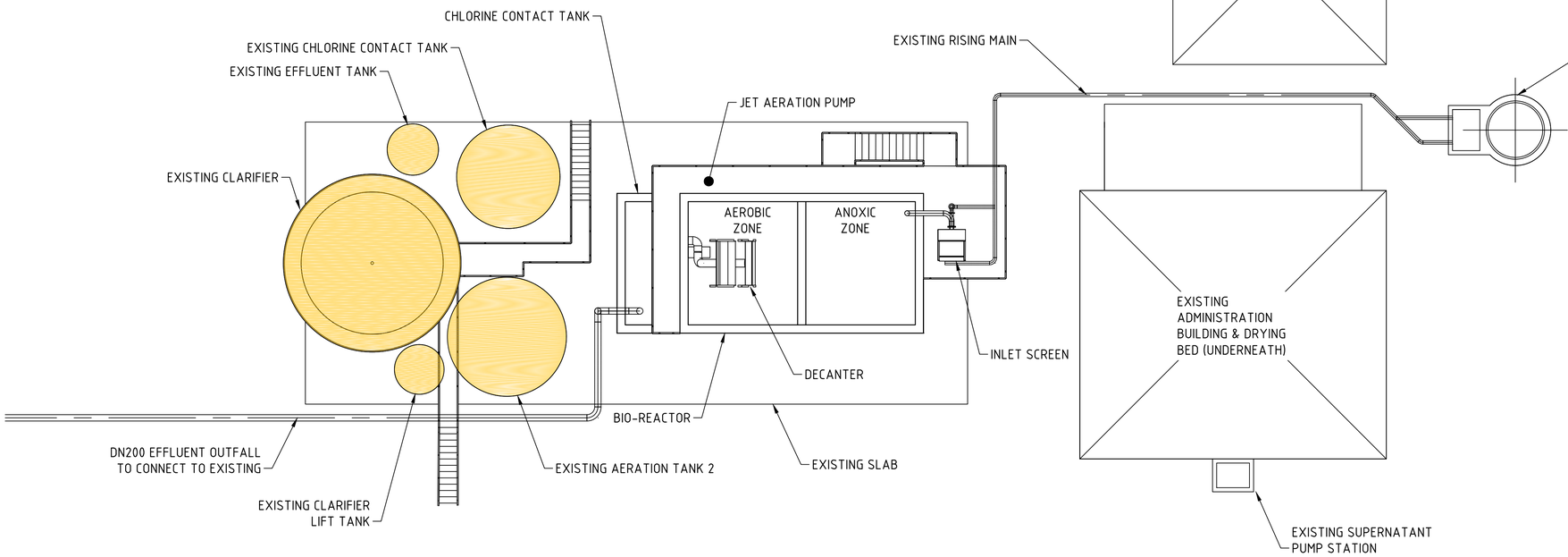
LEGEND

TEMPORARY TREATMENT DURING CONSTRUCTION. STRUCTURES TO BE DEMOLISHED AFTER CONSTRUCTION.

NOTE

1. REQUIREMENT FOR CHLORINE CONTACT TANK & FINAL EFFLUENT PUMP STATION TO BE CONFIRMED PENDING OUTCOMES FROM THE LICENCE AMENDMENT APPLICATION FOR THE REMOVAL OF DISINFECTION.
2. ALL EQUIPMENT, TANK, PUMPS AND PIPEWORK LOCATIONS AND SIZES TO BE CONFIRMED DURING DETAILED DESIGN.





GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	06.11.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

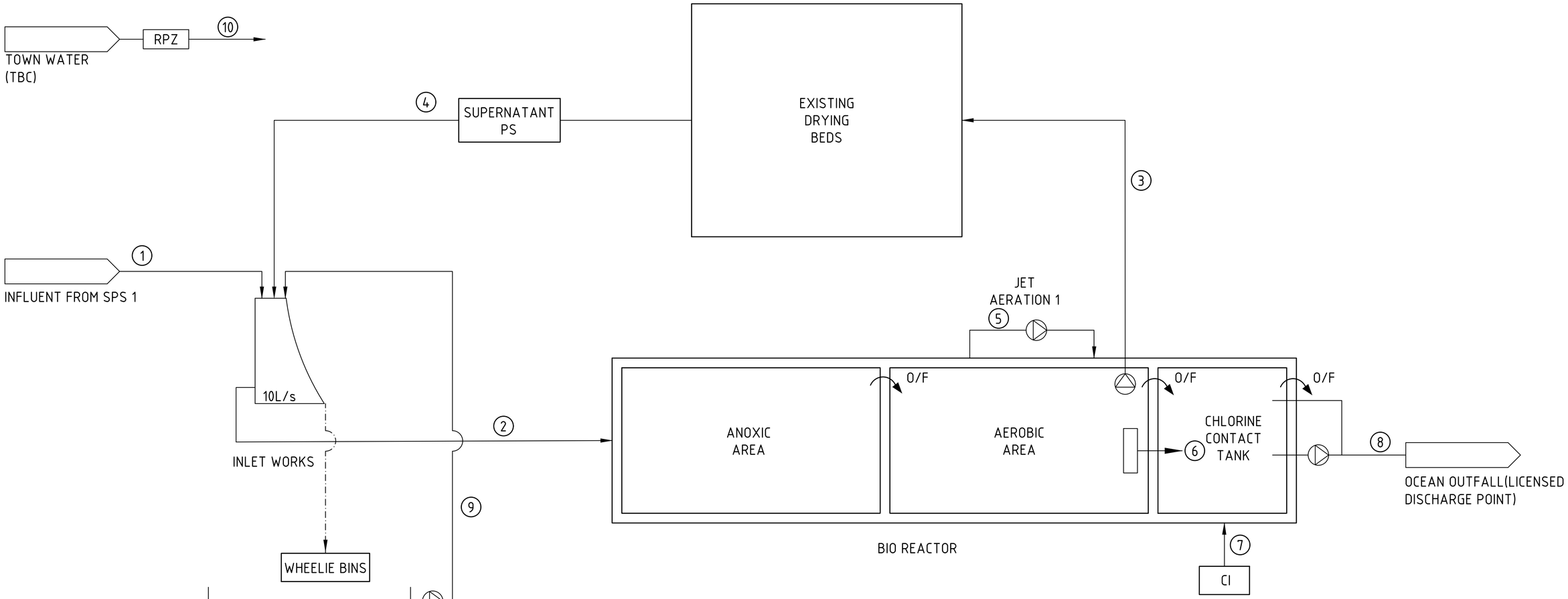
DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 4 - SBR
GENERAL ARRANGEMENT

DRAWING NUMBER 0615-SAI-GA-003

REVISION A

File Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBS\STPOPTIONS\DWGS\0615-SAI-GA-003.DWG Plot: 11/6/2017 9:29 AM



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	18.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island
REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP
OPTIONS ANALYSIS
OPTION 1 - SBR
PROCESS FLOW DIAGRAM

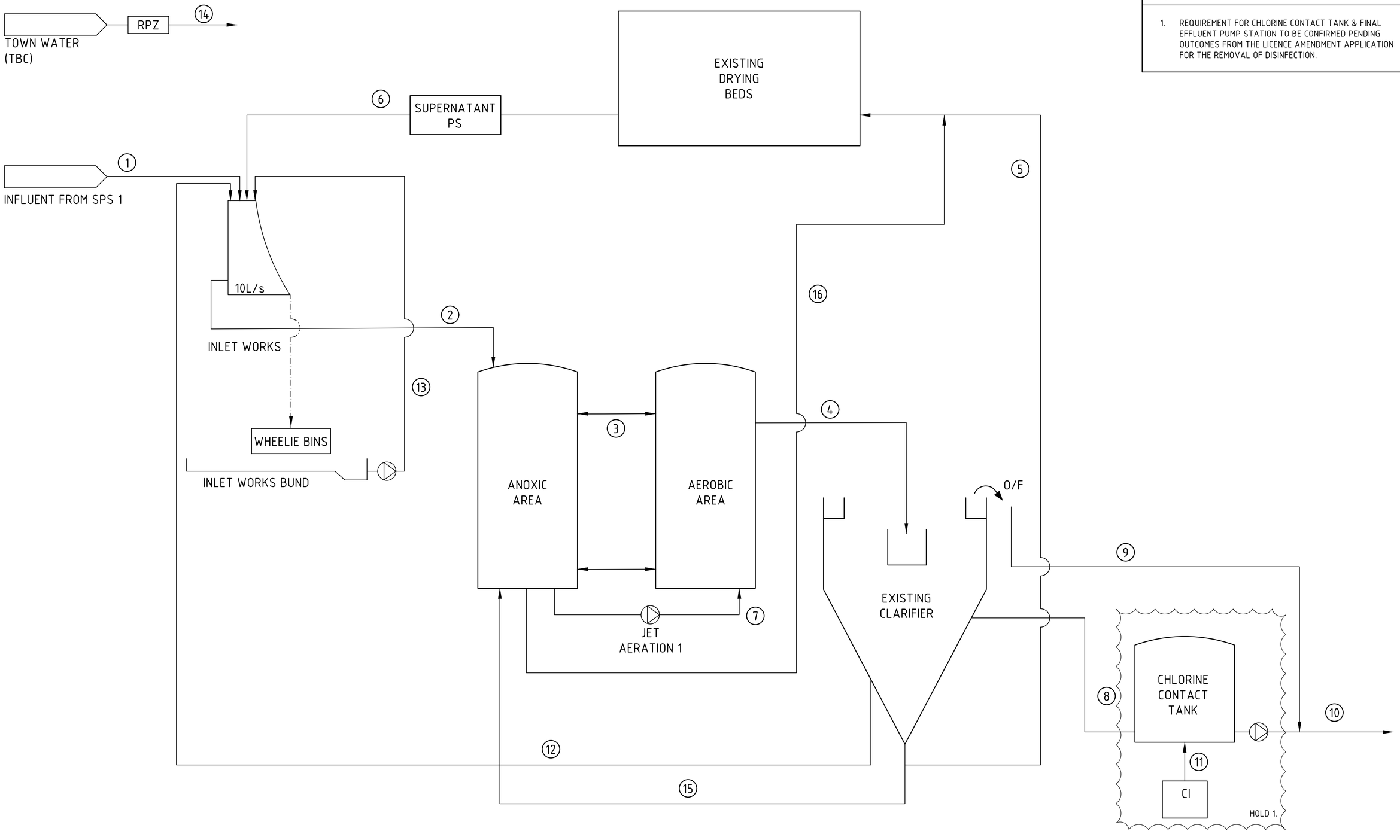
DRAWING NUMBER 0615-SAI-PF-001

REVISION A

File Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBS\TP\ORTHOS\DWGS\0615-SAI-PF-001.DWG Plot: 8/18/2017 8:59 AM

HOLD

1. REQUIREMENT FOR CHLORINE CONTACT TANK & FINAL EFFLUENT PUMP STATION TO BE CONFIRMED PENDING OUTCOMES FROM THE LICENCE AMENDMENT APPLICATION FOR THE REMOVAL OF DISINFECTION.



GANDEN
ENGINEERS AND PROJECT MANAGERS

HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	18.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island
REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
PROCESS FLOW DIAGRAM

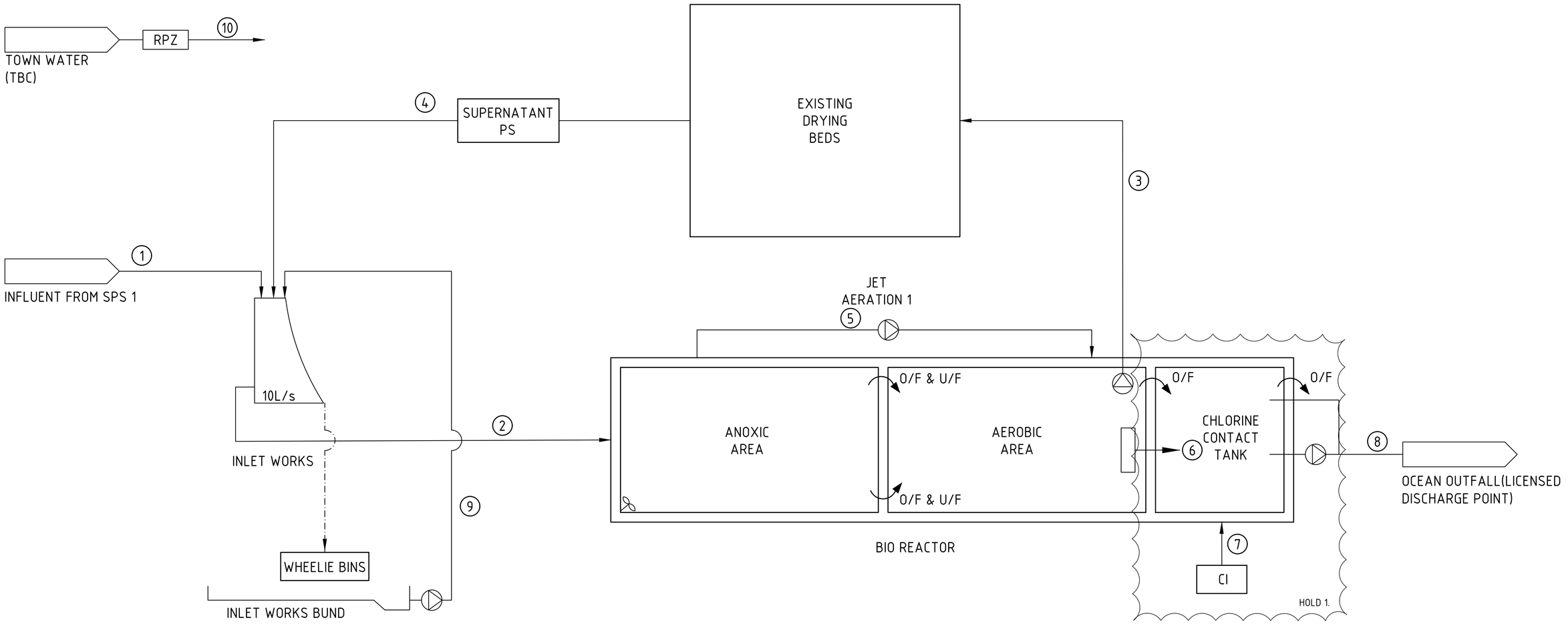
DRAWING NUMBER 0615-SAI-PF-001

REVISION B

File Location:N:\CQ...\PROJECTS\0615...SAIBAI STP ENVIRONMENTAL REPORT\07...DRAWINGS\01...CAD\SBISTPORTHOS\DWGS\0615-SAI-PF-001.DWG Plot: 11/6/2017 9:29 AM

HOLD

1. REQUIREMENT FOR CHLORINE CONTACT TANK & FINAL EFFLUENT PUMP STATION TO BE CONFIRMED PENDING OUTCOMES FROM THE LICENCE AMENDMENT APPLICATION FOR THE REMOVAL OF DISINFECTION.



GANDEN
ENGINEERS AND PROJECT MANAGERS

HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV.	DESCRIPTION	DATE	DWN	APP
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	15.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	**REV.**
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

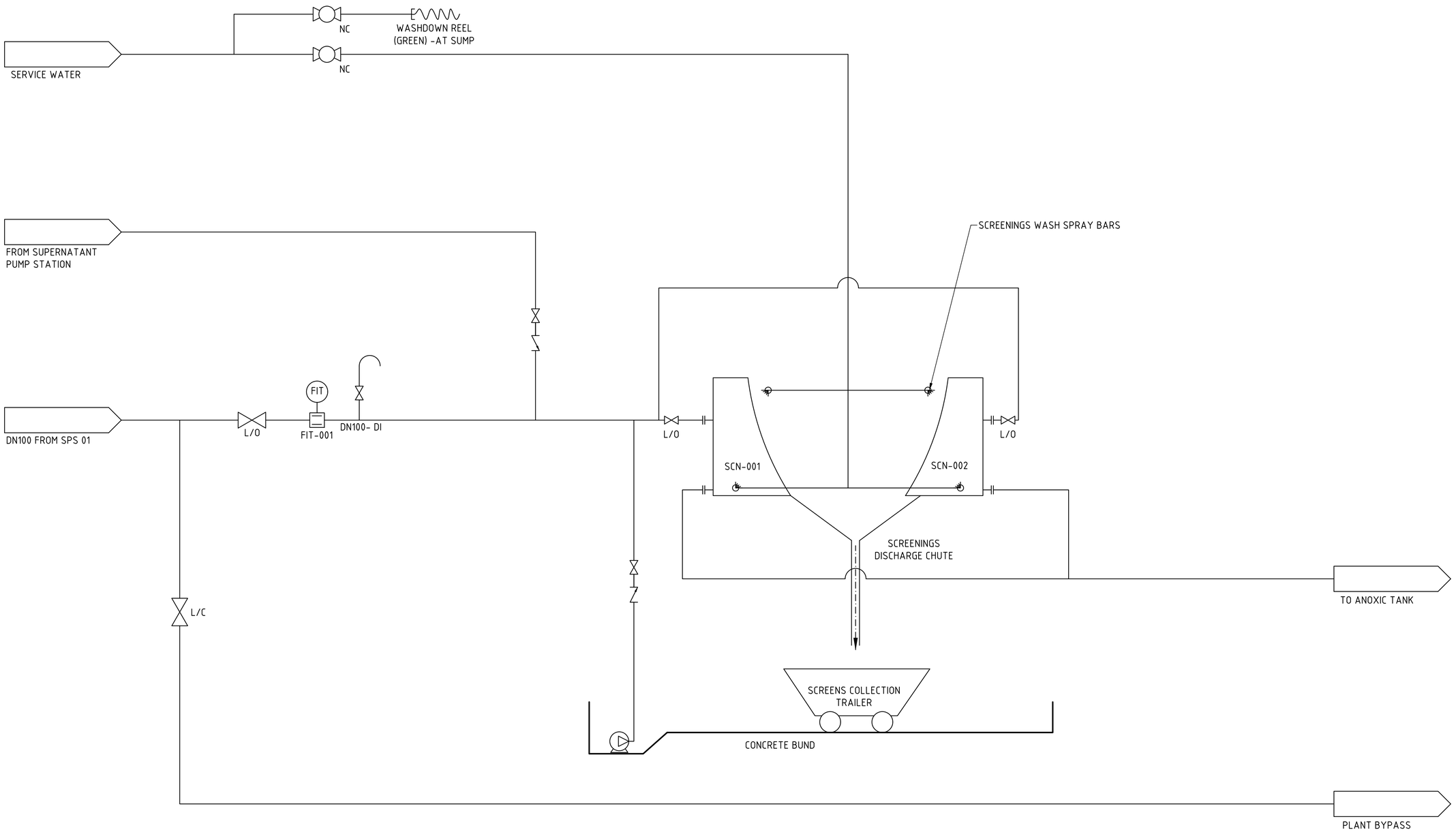
Torres Strait Island REGIONAL COUNCIL

DRAWING STATUS **INFORMATION**

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 4 - SBR
PROCESS FLOW DIAGRAM

DRAWING NUMBER 0615-SAI-PF-002

REVISION B



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
	REVISIONS			
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	23.10.17	AB	DN

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island
REGIONAL COUNCIL

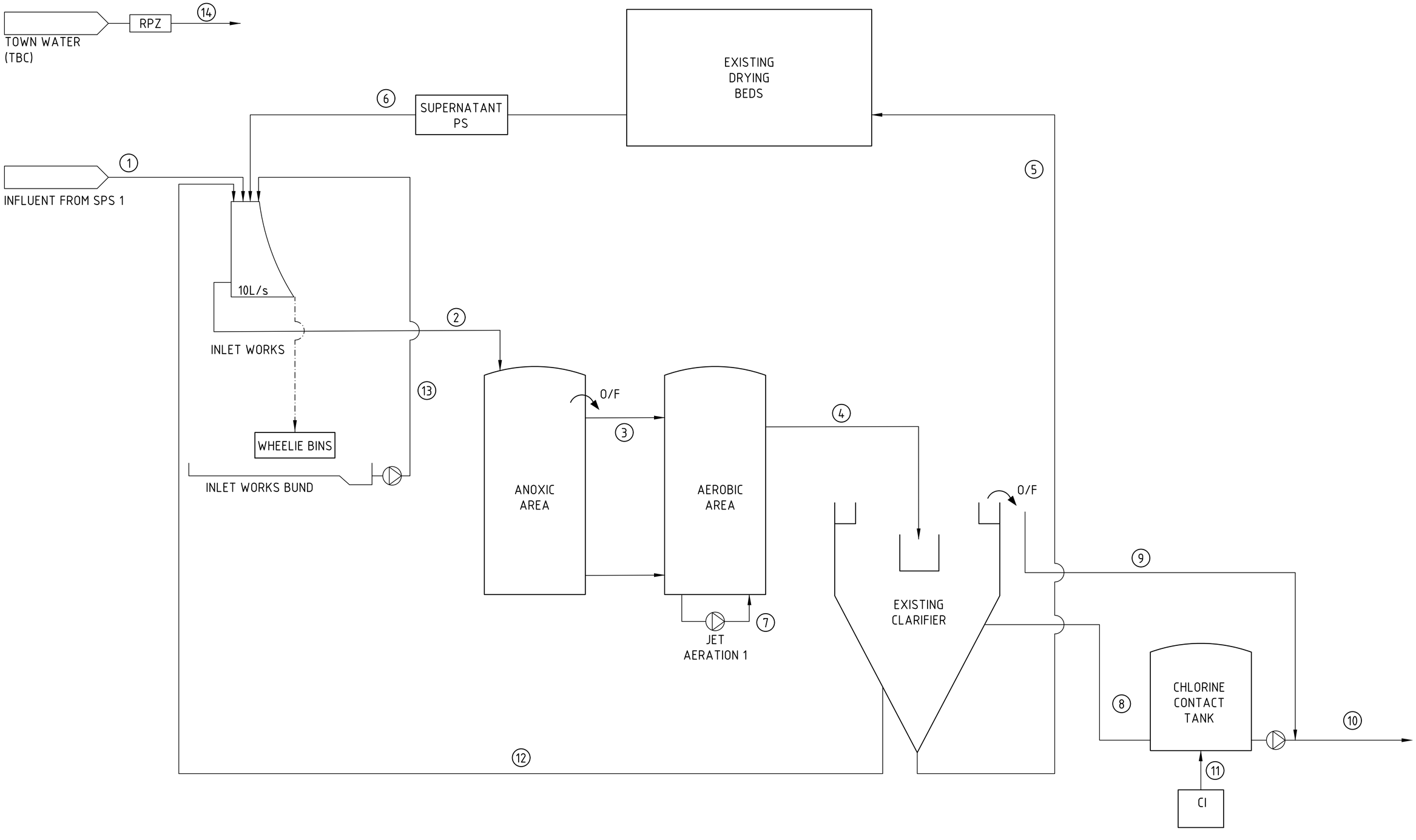
DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
PIPING & INSTRUMENTATION DIAGRAM
INLET WORKS

DRAWING NUMBER 0615-SAI-PID-001

REVISION B

File: Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SBSTPORTHOS\DWGS\0615-SAI-PID-001.DWG Plot: 11/6/2017 9:39 AM



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	18.09.17	PM	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island
REGIONAL COUNCIL

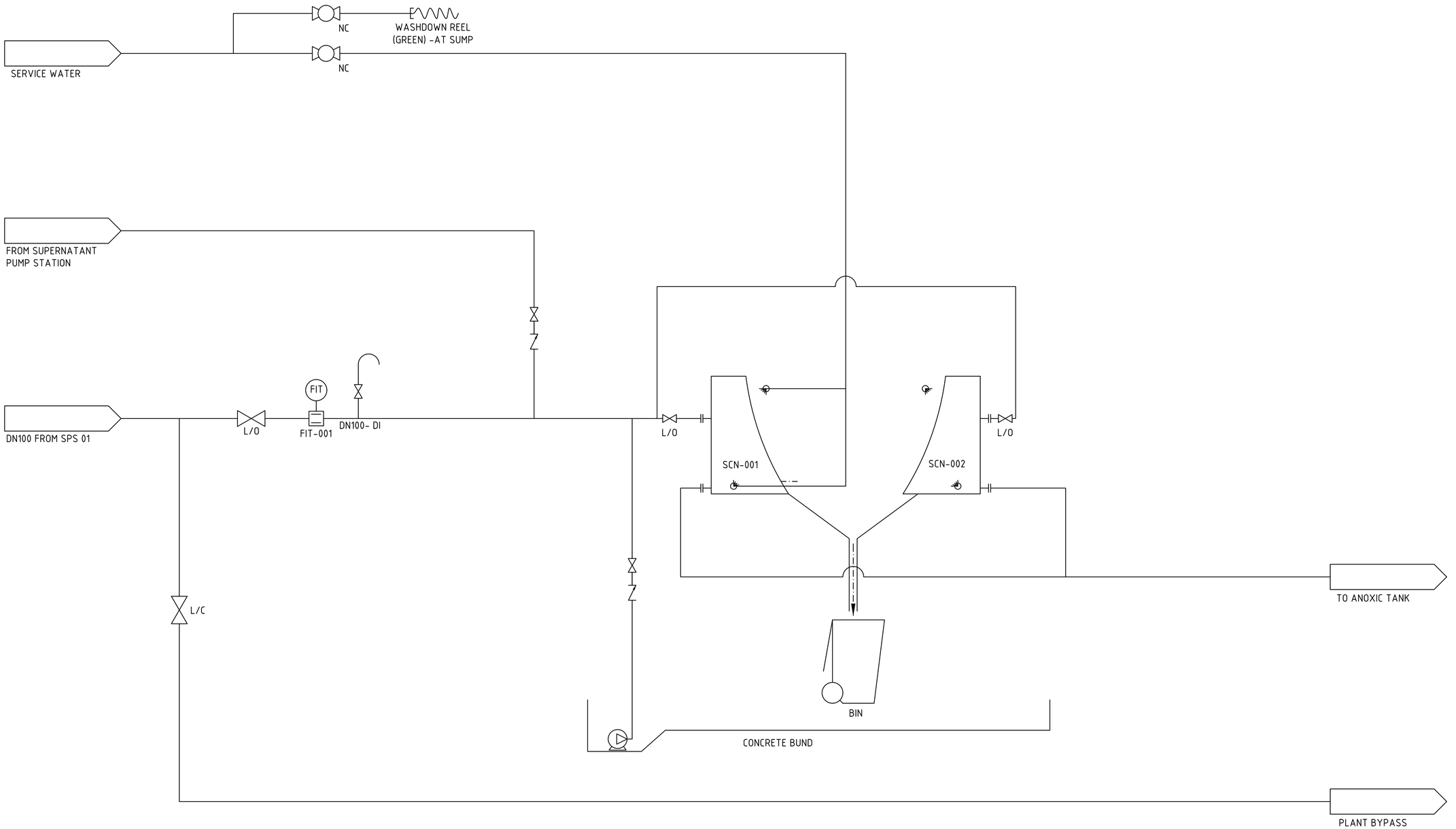
DRAWING STATUS INFORMATION

TITLE
SAIBAI STP
OPTIONS ANALYSIS
OPTION 3 - MLE
PROCESS FLOW DIAGRAM

DRAWING NUMBER 0615-SAI-PF-003

REVISION A

File Location:N:\CQ...\PROJECTS\0615...SAIBAI STP ENVIRONMENTAL REPORT\07...DRAWINGS\01...CAD\SIBS\STPCKRTHDS\DWGS\0615-SAI-PF-003.DWG Plot: 9/18/2017 9:04 AM



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES — 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
A	INFORMATION	23.10-17	AB	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

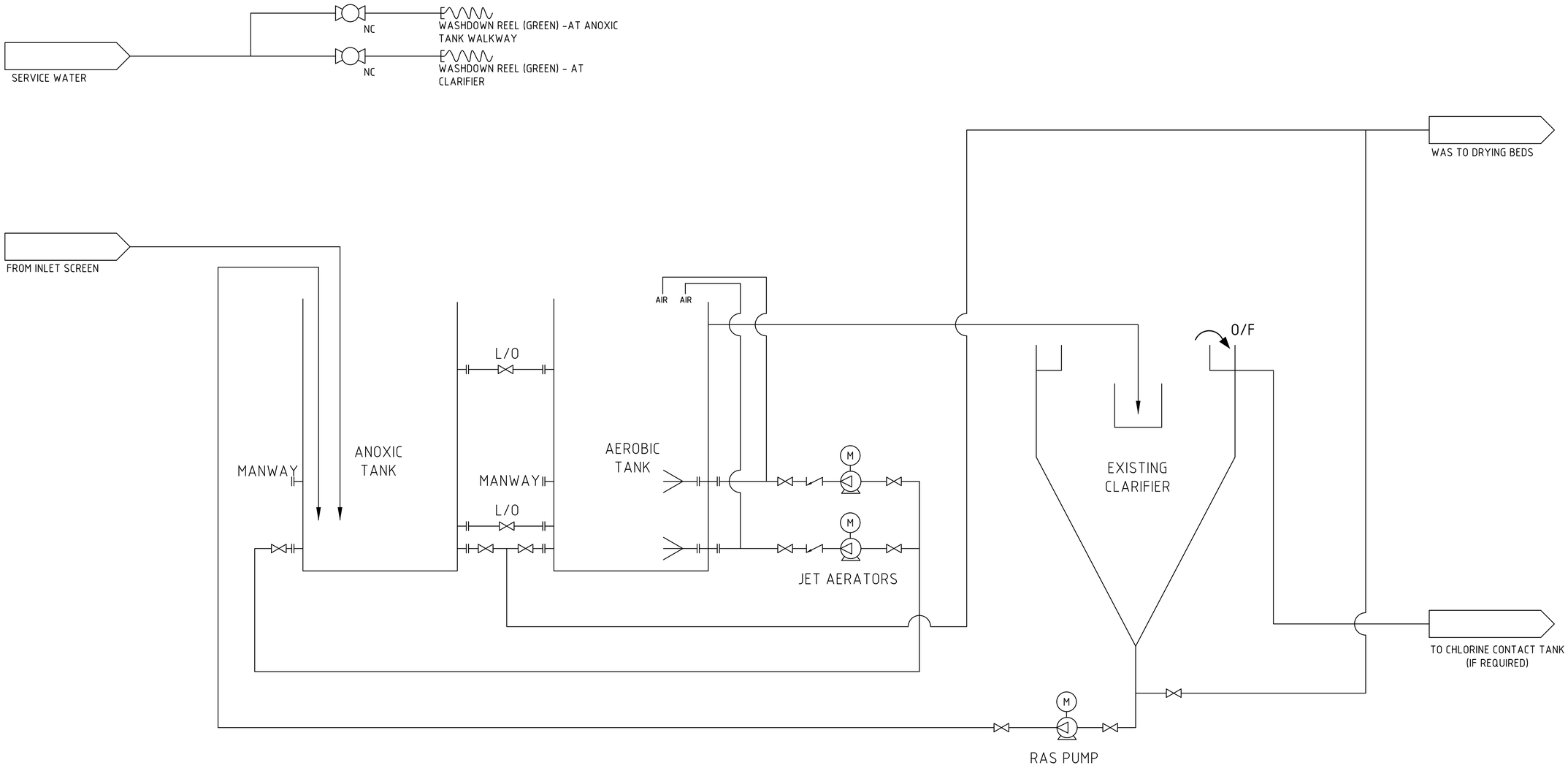
Torres Strait Island REGIONAL COUNCIL

DRAWING STATUS: INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 3 - MLE
PIPING & INSTRUMENTATION DIAGRAM
INLET WORKS

DRAWING NUMBER: 0615-SAI-PID-001

REVISION: A



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
	REVISIONS			
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	23.10.17	AB	DN

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

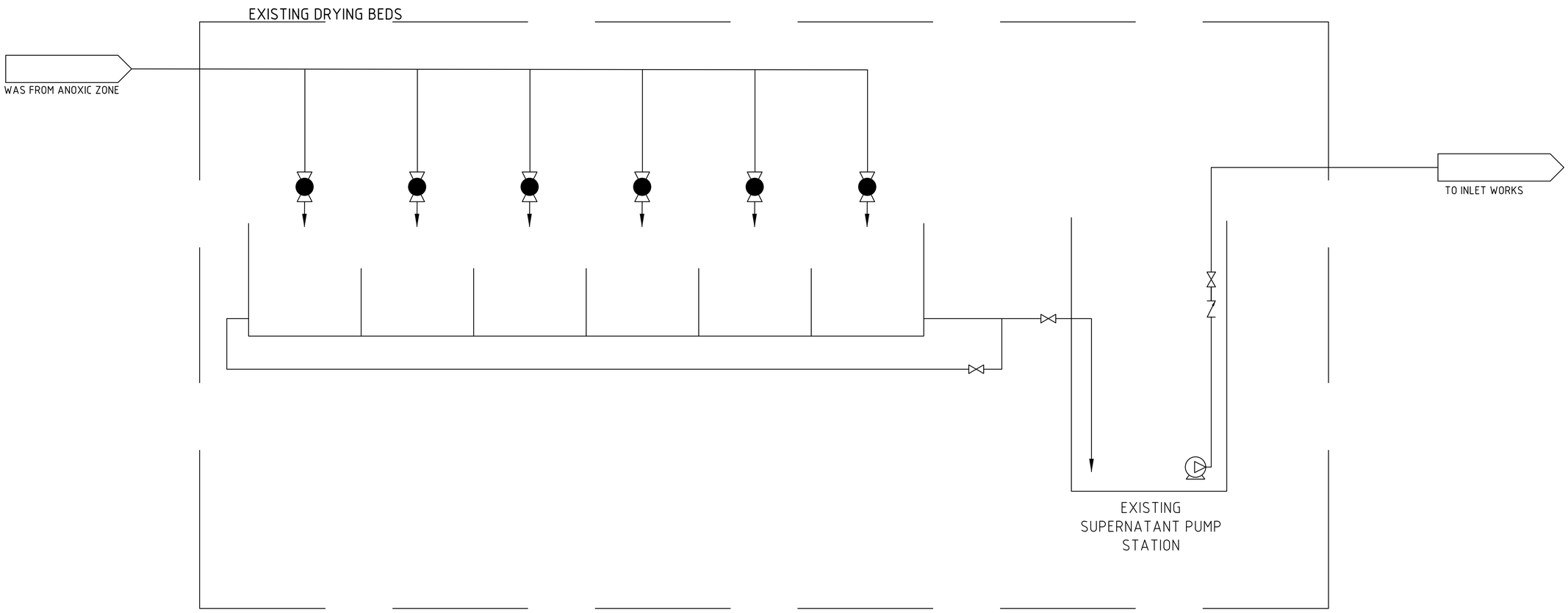
DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
PIPING & INSTRUMENTATION DIAGRAM
BIOREACTOR & CLARIFICATION

DRAWING NUMBER 0615-SAI-PID-002

REVISION B

File: I:\admin\X-02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\0615STPORTHOSNVISS\0615-SAI-PID-002.DWG Plot: 11/6/2017 9:30 AM



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
	REVISIONS			
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	23.10.17	AB	DN

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island
REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
PIPING & INSTRUMENTATION DIAGRAM
DRYING BEDS

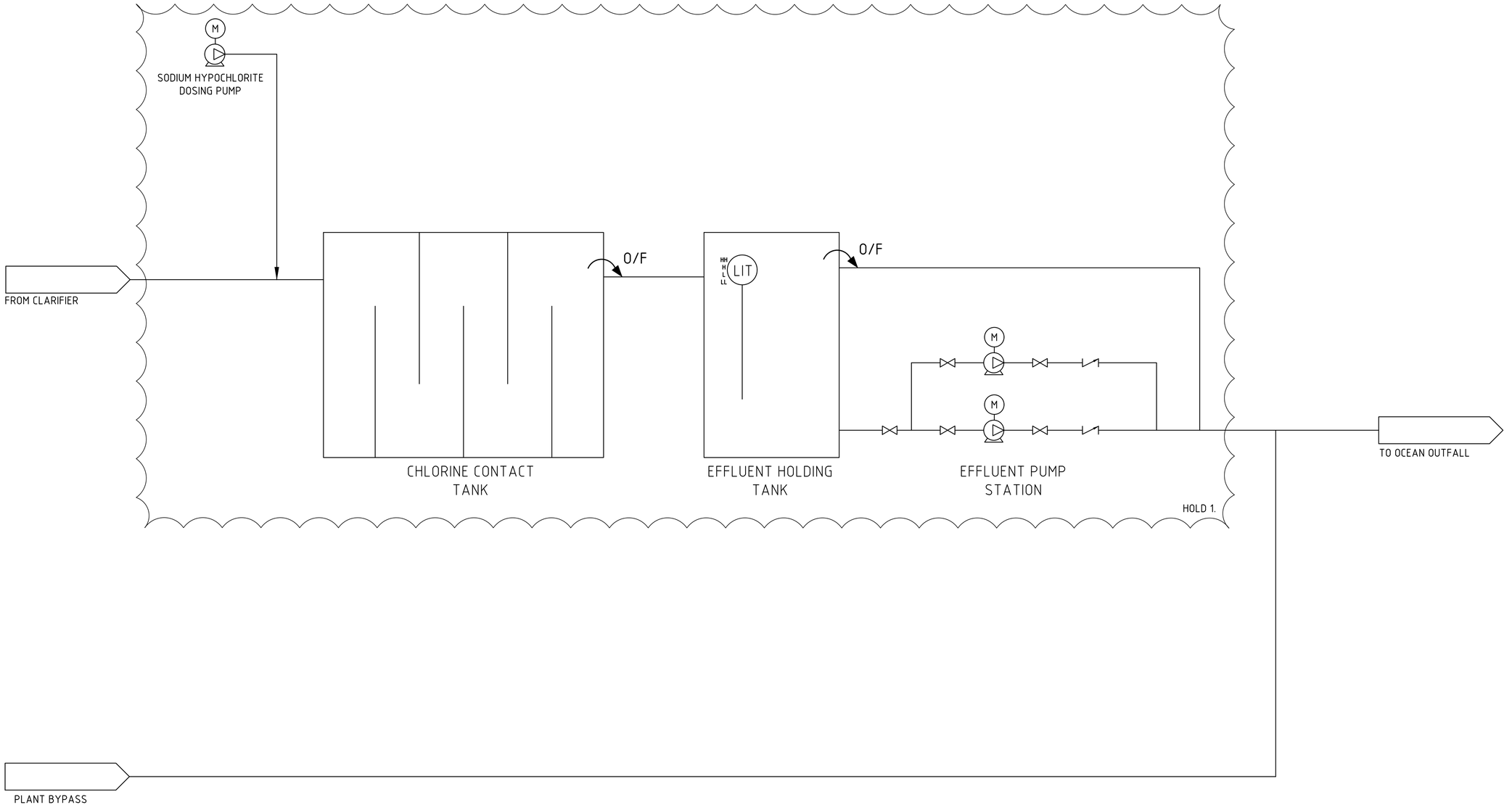
DRAWING NUMBER 0615-SAI-PID-003

REVISION B

File: Location:N:\02 - PROJECTS\0615 - SAIBAI STP ENVIRONMENTAL REPORT\07 - DRAWINGS\01 - CAD\SUBSTPORTHOS\DWGS\0615-SAI-PID-003.DWG Plot: 11/6/2017 9:31 AM

HOLD

1. REQUIREMENT FOR CHLORINE CONTACT TANK & FINAL EFFLUENT PUMP STATION TO BE CONFIRMED PENDING OUTCOMES FROM THE LICENCE AMENDMENT APPLICATION FOR THE REMOVAL OF DISINFECTION.



GANDEN
ENGINEERS AND PROJECT MANAGERS
HEAD OFFICE - GOLD COAST
4/5 No: 9 CENTRAL DRIVE,
BURLEIGH HEADS, QLD 4220
T 07 5593 5731
E enquiries@ganden.com.au

SCALES 100mm ON ORIGINAL DRAWING

ORIG. SIZE A1

REV	DESCRIPTION	DATE	DWN	APP
B	INFORMATION	06.11.17	PM	DN
A	INFORMATION	23.10.17	AB	DN

REVISIONS

AS CONSTRUCTED	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	
FOR CONSTRUCTION	REV.
NAME:	
DATE:	
SIGNATURE:	
RPEQ No.	

Torres Strait Island REGIONAL COUNCIL

DRAWING STATUS INFORMATION

TITLE
SAIBAI STP OPTIONS ANALYSIS
OPTION 2 AND 3 - MLE
PIPING & INSTRUMENTATION DIAGRAM
DISINFECTION & EFFLUENT PUMP STATION

DRAWING NUMBER 0615-SAI-PID-004

REVISION B

File Location:N:\02_PROJECTS\0615_SAIBAI STP ENVIRONMENTAL REPORT\07_DRAWINGS\01_CAD\SBSTPORTHOS\DWGS\0615-SAI-PID-004.DWG Plot: 11/6/2017 9:31 AM

Appendix B - Notice to conduct or commission an environmental evaluation

Notice

Environmental Protection Act 1994

Environmental Evaluation

Notice to conduct or commission an environmental evaluation

This notice to conduct or commission an environmental evaluation is issued by the administering authority pursuant to 326B of the Environmental Protection Act 1994

Chief Executive Officer
Torres Strait Island Regional Council
PO Box 7336
CAIRNS QLD 4870

Your reference: EPPR00713013
Our reference: STAT1145 / 101/0009197

5 June 2017

Take notice: that under the *Environmental Protection Act 1994* (the Act) a notice to conduct or commission an environmental investigation is issued to Torres Strait Island Regional Council (you) by the administering authority. The administering authority is the Chief Executive of the Department of Environment and Heritage Protection (the department).

The notice to conduct or commission an environmental investigation is issued in respect of the activities of Torres Strait Island Regional Council at the Saibai Island Sewage Treatment Plant on land described at Lot 3 on TS157 situated at Saibai Island (the premise).

A. Grounds

The notice to commission an environmental investigation is issued on the following grounds:

- An activity or proposed activity is causing or is likely to cause environmental harm.

The facts and circumstances forming the basis for these grounds are:

Offence against section 430(3) of the *Environmental Protection Act 1994* (condition C4)

1. The Torres Strait Island Regional Council (TSIRC) is the holder of Environmental Authority (EA) EPPR00713013, which authorises TSIRC to carry out Environmentally Relevant Activity (ERA) 16-1(b)(ii) Sewage treatment: >100-1,500EP with treated effluent discharged other than as in 1(b)(i).
2. TSIRC undertakes sewage treatment activities on land described as Lot 3 on TS157, Saibai Island.
3. On 31 January 2017, the Department of Environment and Heritage Protection (the department) was provided water quality monitoring results by TSIRC of treated sewage effluent from the Saibai Island STP, which is discharged via ocean outfall to adjacent waters.
4. The water quality monitoring was undertaken on 8 November 2016 and 11 January 2017, and the results identify the following exceedences with the EA:

Date	Water Quality Parameter	Water Quality Limit	Limit Type	Result
8 November 2016	Faecal Coliforms (Organisms/100 ml)	150 600 (organisms)	50th percentile Maximum	- >100,000
8 November 2016	5-Day Bio-chemical Oxygen Demand (mg/L)	60mg/L	80th percentile Maximum	- 88
8 November 2016	Total Nitrogen (mg/L)	40mg/L	50th percentile Maximum	- 47
8 November 2016	Ammonia Nitrogen (mg/L)	8mg/L	50th percentile Maximum	- 34
11 January 2017	5-Day Bio-chemical Oxygen Demand (mg/L)	20 60	80th percentile Maximum	- 120
11 January 2017	Ammonia Nitrogen (mg/L)	5 8	50th percentile Maximum	- 25

Table 1: Water quality limit exceedances 8 November 2016 and 11 January 2017

Offence against section 430(3) of the *Environmental Protection Act 1994* (condition C1)

5. On 27 January 2017, TSIRC notified the department of an overflow of effluent from the final effluent tank at the Saibai Island STP.
6. The overflow event was first identified by TSIRC on 23 January 2017 and continued until 27 January 2017.
7. Effluent was released to coastal waters immediately adjacent to the activity.

Section 326B of the *Environmental Protection Act 1994*

8. The release of poorly treated effluent from the Saibai Island STP has the potential to cause environmental harm to the environmental values of surface water and aquatic ecosystems.

B. Requirements

The report on the environmental investigation must address the following relevant matters:

1. An **appropriately qualified person**, as defined in this Notice must:
    a) Identify the environmental values (EVs) and water quality objectives (WQOs) relevant to releases from the Sabai Island STP;
    b) Provide a description of the default EVs/WQOs, characteristics and resilience of the receiving environment;
    c) With reference to items (a) and (b), determine the quality that must be achieved for effluent release to protect or enhance EVs and achieve the WQOs.

    Environmental value is—

    a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or

b) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

Note: This may involve a nominal assessment of EVs and WQOs including a desktop assessment.

2. An **appropriately qualified person**, as defined in this Notice, must conduct an assessment of the projected sewage flow loadings into the Sabai Island STP for a 20 year planning horizon and be developed with the Department of Energy and Water Supply *'Planning Guidelines for Water Supply and Sewerage, April 2010' (including Chapter 6 amendments made March 2016).*

3. Detail the capacity of existing sewage infrastructure to meet current and future service demands and environmental standards and identify options for achieving release quality that must be achieved to protect or enhance EVs and achieve the WQOs. The details should include, but not be limited to:

    a) A statement of the current performance of the plant in respect to effluent release;

    b) Details of all options available and a detailed evaluation of potential options to improve and maintain suitable quality of effluent releases;

    c) Details of technology considerations and their suitability for use in relation to the locality and skill level of operators;

    d) Review of similar technology and applications in similar environments; and

    e) Details of cost considerations that include installation/augmentation, commissioning and maintenance.

4. Report on the analysis of options considered, which must:

    a) Determine an evaluation criteria linked to quantified service objectives, and which must include consideration of service standards, regulatory compliance, operational and performance efficiency as well as social, environmental and financial objectives;

    b) Determine options which include existing, non-asset and new asset options; and

    c) Undertake the options analysis, which must include whether the option is technically feasible; considers the physical and operational capacity of the infrastructure including infrastructure appropriateness, condition and limitations; a financial analysis to determine financial viability including financial constraints of each option over the whole lifecycle of the sewage treatment plant and associated infrastructure; analysis of environmental impacts; and a risk assessment of each chosen option.

5. Outline a proposed implementation strategy based on the option/s identified through Requirement 4, which must:

    a) Determine the preferred project delivery option; and

    b) Develop an implementation program with consideration of funding sources and allocation.

Appropriately qualified person(s) means a person or person who has professional qualifications, training skills and or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis to performance relative to the subject matter using the relevant protocols, standards, method or literature.

The environmental report must be submitted to the department on or before:

- **5:00pm, Tuesday 7 November 2017.**

As the recipient of this notice, you are also required to provide a statutory declaration in the form attached, to accompany the environmental report submitted to the department. The suitably qualified person who prepares the environmental report must also provide a statutory declaration in the form attached to accompany the environmental report submitted to the department.

You can view an electronic version of the statutory declaration for a recipient using the following search term (ESR/2016/1997).[1]

An electronic version of the statutory declaration for a suitably qualified person form is available using the search term (ESR/2016/2266).

Take notice:

- the requirements of the notice to conduct or commission an environmental investigation take effect immediately upon service of this notice;
- this notice remains in force until further notice from the department; and
- you are responsible for meeting the costs of conducting or commissioning the environmental evaluation, preparing the environmental report and providing any further information as requested by the department.

C. Reviews and appeals

The provisions regarding reviews of decisions and appeals are found in sections 519 to 539 of the Act.

A person who is dissatisfied with certain decisions of the department, may be able to apply to have the department review that original decision.

Generally, a request to have a decision reviewed must be made:

- within 10 business days of the decision being notified to the person;
- be supported by enough information to enable the department to decide the application for review; and
- be made using the application for review of an original decision form (ESR/2015/1573).

Where an application has been made for a decision to be reviewed, the applicant may also apply to the relevant court for a stay of the decision to secure the effectiveness of the review.

Once the original decision has been reviewed, a person who is dissatisfied with the review decision may be able to appeal against that decision to the relevant court within 22 business days after receiving notice of the review decision.

A person whose interests are or would be adversely affected by a decision of the department may also be able to request a statement of reasons for a decision or a statutory order review under the *Judicial Review Act 1991*.

For further information about reviews and appeals see the:

- Information sheet - internal review and appeal to the Planning and Environment Court (ESR/2015/1572).

[1] This is the publication number. The publication number can be used as a search term to find the latest version of a publication at <www.ehp.qld.gov.au>.

- Information sheet - internal review and appeal to the Land Court (ESR/2015/1742).

You may have other legal rights or obligations and should seek your own legal advice.

D. Penalty

Failure to comply with a notice to conduct or commission an environmental evaluation is an offence.

1. The maximum penalty for an individual is 300 penalty units, totalling $36,570.00.

2. The maximum penalty for a corporation is 1500 penalty units, totalling $182,850.00.

Should you have any queries in relation to this notice, please contact Calvin Quick of the department on telephone number (07) 4222 5161.

Signature

5 June 2017

Date

Tony Baker
Manager (Compliance)
Delegate of the Chief Executive
Department of Environment and Heritage Protection
Environmental Protection Act 1994

Enquiries:
Calvin Quick
Senior Environmental Officer
Department of Environment and Heritage Protection
Level 3, 5B Sheridan Street
CAIRNS QLD 4870
Ph: (07) 4222 5161
Email: calvin.quick@ehp.qld.gov.au

Appendix C - Biowin Modelling Results

BioWin user and configuration data

Project details

Project name: Saibai STP **Project ref.: 0615 MLE Rev C**

Plant name: Saibai **User name: Chris Coxon**

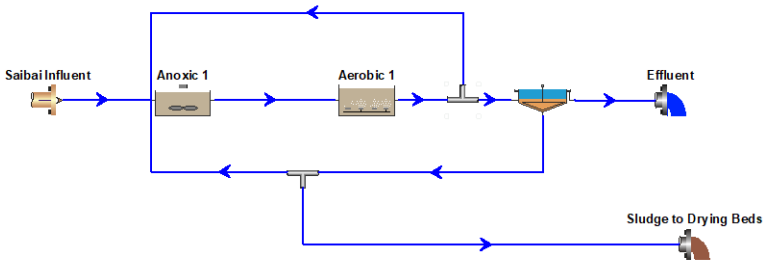
Created: 11/10/2017 **Saved: 7/11/2017**

Steady state solution

SRT: ----- days

Temperature: 20.0°C

Flowsheet



Configuration information for all Bioreactor units

Physical data

Element name	Volume [m3]	Area [m2]	Depth [m]	# of diffusers
Anoxic 1	53.0000	9.6364	5.500	Un-aerated
Aerobic 1	53.0000	9.6364	5.500	24

Operating data Average (flow/time weighted as required)

Element name	Average DO Setpoint [mg/L]
Anoxic 1	0
Aerobic 1	2.0

Element name	Average Temperature [deg. C]
Anoxic 1	20.0

Aeration equipment parameters

Element name	k1 in C = k1(PC)^ 0.25 + k2	k2 in C = k1(PC)^ 0.25 + k2	Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	Area of one diffuser	Diffuser mounting height	Min. air flow rate per diffuser	Max. air flow rate per diffuser	'A' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'B' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2	'C' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2
Anoxic 1	1.2400	0.8960	0.8880	0.0410	0.2500	12.0000	240.0000	3.0000	0	0
Aerobic 1	1.2400	0.8960	0.8880	0.0410	0.2500	12.0000	240.0000	3.0000	0	0

Configuration information for all BOD Influent units

Operating data Average (flow/time weighted as required)

Element name	Saibai Influent
Flow	200
Total Carbonaceous BOD mgBOD/L	250.00
Volatile suspended solids mg/L	200.00

Total suspended solids mg/L	250.00
Total Kjeldahl Nitrogen mgN/L	50.00
Total P mgP/L	6.00
Nitrate N mgN/L	0
pH	7.50
Alkalinity mmol/L	6.00
Calcium mg/L	80.00
Magnesium mg/L	15.00
Dissolved O2 mg/L	0

Element name	Saibai Influent
Fbs - Readily biodegradable (including Acetate) [gCOD/g of total COD]	0.1600
Fac - Acetate [gCOD/g of readily biodegradable COD]	0.1500
Fxsp - Non-colloidal slowly biodegradable [gCOD/g of slowly degradable COD]	0.6463
Fus - Unbiodegradable soluble [gCOD/g of total COD]	0.0500
Fup - Unbiodegradable particulate [gCOD/g of total COD]	0.2000
Fna - Ammonia [gNH3-N/gTKN]	0.6600
Fnox - Particulate organic nitrogen [gN/g Organic N]	0.5000
Fnus - Soluble unbiodegradable TKN [gN/gTKN]	0.0200
FupN - N:COD ratio for unbiodegradable part. COD [gN/gCOD]	0.0350
Fpo4 - Phosphate [gPO4-P/gTP]	0.5000
FupP - P:COD ratio for unbiodegradable part. COD [gP/gCOD]	0.0110
FZbh - OHO COD fraction [gCOD/g of total COD]	0.0200
FZbm - Methylotroph COD fraction [gCOD/g of total COD]	1.000E-4
FZaob - AOB COD fraction [gCOD/g of total COD]	1.000E-4
FZnob - NOB COD fraction [gCOD/g of total COD]	1.000E-4
FZaao - AAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbp - PAO COD fraction [gCOD/g of total COD]	1.000E-4
FZbpa - Propionic acetogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbam - Acetoclastic methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZbhm - H2-utilizing methanogens COD fraction [gCOD/g of total COD]	1.000E-4
FZe - Endogenous products COD fraction [gCOD/g of total COD]	0

Configuration information for all Effluent units

Configuration information for all Ideal clarifier units

Physical data

Element name	Volume[m3]	Area[m2]	Depth[m]
Exist Clarifier	93.1480	21.1700	4.400

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Exist Clarifier	Flow paced	200.00 %

Element name	Average Temperature	Reactive	Percent removal	Blanket fraction
Exist Clarifier	Uses global setting	No	99.80	0.05

Configuration information for all Sludge units

Configuration information for all Splitter units

Physical data

Element name	Volume[m3]	Area[m2]	Depth[m]
Splitter10	0	N/A	N/A
Splitter8	0	N/A	N/A

Operating data Average (flow/time weighted as required)

Element name	Split method	Average Split specification
Splitter10	Flowrate [Side]	6
Splitter8	Flow paced	400.00 %

BioWin Album

Album page - Page 1

Album page - Page 2

Album page - Page 3

Global Parameters

Common

Name	Default	Value	
Hydrolysis rate [1/d]	2.1000	2.1000	1.0290
Hydrolysis half sat. [-]	0.0600	0.0600	1.0000
Anoxic hydrolysis factor [-]	0.2800	0.2800	1.0000
Anaerobic hydrolysis factor (AS) [-]	0.0400	0.0400	1.0000
Anaerobic hydrolysis factor (AD) [-]	0.5000	0.5000	1.0000
Adsorption rate of colloids [L/(mgCOD d)]	0.1500	0.1500	1.0290
Ammonification rate [L/(mgCOD d)]	0.0800	0.0800	1.0290
Assimilative nitrate/nitrite reduction rate [1/d]	0.5000	0.5000	1.0000
Endogenous products decay rate [1/d]	0	0	1.0000

AOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9000	0.9000	1.0720

Substrate (NH4) half sat. [mgN/L]	0.7000	0.7000	1.0000
Byproduct NH4 logistic slope [-]	50.0000	50.0000	1.0000
Byproduct NH4 inflection point [mgN/L]	1.4000	1.4000	1.0000
AOB denite DO half sat. [mg/L]	0.1000	0.1000	1.0000
AOB denite HNO2 half sat. [mgN/L]	5.000E-6	5.000E-6	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiHNO2 [mmol/L]	0.0050	0.0050	1.0000

NOB

Name	Default	Value	
Max. spec. growth rate [1/d]	0.7000	0.7000	1.0600
Substrate (NO2) half sat. [mgN/L]	0.1000	0.1000	1.0000
Aerobic decay rate [1/d]	0.1700	0.1700	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0800	0.0800	1.0290
KiNH3 [mmol/L]	0.0750	0.0750	1.0000

AAO

Name	Default	Value	
Max. spec. growth rate [1/d]	0.2000	0.2000	1.1000
Substrate (NH4) half sat. [mgN/L]	2.0000	2.0000	1.0000
Substrate (NO2) half sat. [mgN/L]	1.0000	1.0000	1.0000
Aerobic decay rate [1/d]	0.0190	0.0190	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0095	0.0095	1.0290
Ki Nitrite [mgN/L]	1000.0000	1000.0000	1.0000
Nitrite sensitivity constant [L / (d mgN)]	0.0160	0.0160	1.0000

OHO

Name	Default	Value	

Max. spec. growth rate [1/d]	3.2000	3.2000	1.0290
Substrate half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Anoxic growth factor [-]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.6200	0.6200	1.0290
Anoxic decay rate [1/d]	0.2330	0.2330	1.0290
Anaerobic decay rate [1/d]	0.1310	0.1310	1.0290
Fermentation rate [1/d]	1.6000	1.6000	1.0290
Fermentation half sat. [mgCOD/L]	5.0000	5.0000	1.0000
Fermentation growth factor (AS) [-]	0.2500	0.2500	1.0000
Free nitrous acid inhibition [mol/L]	1.000E-7	1.000E-7	1.0000

Methylotrophs

Name	Default	Value	
Max. spec. growth rate [1/d]	1.3000	1.3000	1.0720
Methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Denite N2 producers (NO3 or NO2) [-]	0.5000	0.5000	1.0000
Aerobic decay rate [1/d]	0.0400	0.0400	1.0290
Anoxic/anaerobic decay rate [1/d]	0.0300	0.0300	1.0290
Free nitrous acid inhibition [mmol/L]	1.000E-7	1.000E-7	1.0000

PAO

Name	Default	Value	
Max. spec. growth rate [1/d]	0.9500	0.9500	1.0000
Max. spec. growth rate, P-limited [1/d]	0.4200	0.4200	1.0000
Substrate half sat. [mgCOD(PHB)/mgCOD(Zbp)]	0.1000	0.1000	1.0000
Substrate half sat., P-limited [mgCOD(PHB)/mgCOD(Zbp)]	0.0500	0.0500	1.0000
Magnesium half sat. [mgMg/L]	0.1000	0.1000	1.0000
Cation half sat. [mmol/L]	0.1000	0.1000	1.0000
Calcium half sat. [mgCa/L]	0.1000	0.1000	1.0000
Aerobic/anoxic decay rate [1/d]	0.1000	0.1000	1.0000
Aerobic/anoxic maintenance rate [1/d]	0	0	1.0000

Anaerobic decay rate [1/d]	0.0400	0.0400	1.0000
Anaerobic maintenance rate [1/d]	0	0	1.0000
Sequestration rate [1/d]	4.5000	4.5000	1.0000
Anoxic growth factor [-]	0.3300	0.3300	1.0000

Acetogens

Name	Default	Value	
Max. spec. growth rate [1/d]	0.2500	0.2500	1.0290
Substrate half sat. [mgCOD/L]	10.0000	10.0000	1.0000
Acetate inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Anaerobic decay rate [1/d]	0.0500	0.0500	1.0290
Aerobic/anoxic decay rate [1/d]	0.5200	0.5200	1.0290

Methanogens

Name	Default	Value	
Acetoclastic max. spec. growth rate [1/d]	0.3000	0.3000	1.0290
H2-utilizing max. spec. growth rate [1/d]	1.4000	1.4000	1.0290
Acetoclastic substrate half sat. [mgCOD/L]	100.0000	100.0000	1.0000
Acetoclastic methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
H2-utilizing CO2 half sat. [mmol/L]	0.1000	0.1000	1.0000
H2-utilizing substrate half sat. [mgCOD/L]	1.0000	1.0000	1.0000
H2-utilizing methanol half sat. [mgCOD/L]	0.5000	0.5000	1.0000
Acetoclastic propionic inhibition [mgCOD/L]	10000.0000	10000.0000	1.0000
Acetoclastic anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
Acetoclastic aerobic/anoxic decay rate [1/d]	0.6000	0.6000	1.0290
H2-utilizing anaerobic decay rate [1/d]	0.1300	0.1300	1.0290
H2-utilizing aerobic/anoxic decay rate [1/d]	2.8000	2.8000	1.0290

pH

Name	Default	Value
OHO low pH limit [-]	4.0000	4.0000
OHO high pH limit [-]	10.0000	10.0000
Methylotrophs low pH limit [-]	4.0000	4.0000
Methylotrophs high pH limit [-]	10.0000	10.0000
Autotrophs low pH limit [-]	5.5000	5.5000
Autotrophs high pH limit [-]	9.5000	9.5000
PAO low pH limit [-]	4.0000	4.0000
PAO high pH limit [-]	10.0000	10.0000
OHO low pH limit (anaerobic) [-]	5.5000	5.5000
OHO high pH limit (anaerobic) [-]	8.5000	8.5000
Propionic acetogens low pH limit [-]	4.0000	4.0000
Propionic acetogens high pH limit [-]	10.0000	10.0000
Acetoclastic methanogens low pH limit [-]	5.0000	5.0000
Acetoclastic methanogens high pH limit [-]	9.0000	9.0000
H2-utilizing methanogens low pH limit [-]	5.0000	5.0000
H2-utilizing methanogens high pH limit [-]	9.0000	9.0000

Switches

Name	Default	Value
OHO DO half sat. [mgO2/L]	0.0500	0.0500
PAO DO half sat. [mgO2/L]	0.0500	0.0500
Anoxic/anaerobic NOx half sat. [mgN/L]	0.1500	0.1500
AOB DO half sat. [mgO2/L]	0.2500	0.2500
NOB DO half sat. [mgO2/L]	0.5000	0.5000
AAO DO half sat. [mgO2/L]	0.0100	0.0100
Anoxic NO3(->NO2) half sat. [mgN/L]	0.1000	0.1000
Anoxic NO3(->N2) half sat. [mgN/L]	0.0500	0.0500
Anoxic NO2(->N2) half sat. (mgN/L)	0.0100	0.0100
NH3 nutrient half sat. [mgN/L]	0.0050	0.0050
PolyP half sat. [mgP/mgCOD]	0.0100	0.0100
VFA sequestration half sat. [mgCOD/L]	5.0000	5.0000
P uptake half sat. [mgP/L]	0.1500	0.1500
P nutrient half sat. [mgP/L]	0.0010	0.0010
Autotroph CO2 half sat. [mmol/L]	0.1000	0.1000

H2 low/high half sat. [mgCOD/L]	1.0000	1.0000
Propionic acetogens H2 inhibition [mgCOD/L]	5.0000	5.0000
Synthesis anion/cation half sat. [meq/L]	0.0100	0.0100

Common

Name	Default	Value
Biomass volatile fraction (VSS/TSS)	0.9200	0.9200
Endogenous residue volatile fraction (VSS/TSS)	0.9200	0.9200
N in endogenous residue [mgN/mgCOD]	0.0700	0.0700
P in endogenous residue [mgP/mgCOD]	0.0220	0.0220
Endogenous residue COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Particulate substrate COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.6000
Particulate inert COD:VSS ratio [mgCOD/mgVSS]	1.6000	1.6000
Molecular weight of other anions [mg/mmol]	35.5000	35.5000
Molecular weight of other cations [mg/mmol]	39.1000	39.1000

AOB

Name	Default	Value
Yield [mgCOD/mgN]	0.1500	0.1500
AOB denite NO2 fraction as TEA [-]	0.5000	0.5000
Byproduct NH4 fraction to N2O [-]	0.0025	0.0025
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

NOB

Name	Default	Value
Yield [mgCOD/mgN]	0.0900	0.0900

N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

AAO

Name	Default	Value
Yield [mgCOD/mgN]	0.1140	0.1140
Nitrate production [mgN/mgBiomassCOD]	2.2800	2.2800
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

OHO

Name	Default	Value
Yield (aerobic) [-]	0.6660	0.6660
Yield (fermentation, low H2) [-]	0.1000	0.1000
Yield (fermentation, high H2) [-]	0.1000	0.1000
H2 yield (fermentation low H2) [-]	0.3500	0.3500
H2 yield (fermentation high H2) [-]	0	0
Propionate yield (fermentation, low H2) [-]	0	0
Propionate yield (fermentation, high H2) [-]	0.7000	0.7000
CO2 yield (fermentation, low H2) [-]	0.7000	0.7000
CO2 yield (fermentation, high H2) [-]	0	0
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Endogenous fraction - aerobic [-]	0.0800	0.0800
Endogenous fraction - anoxic [-]	0.1030	0.1030
Endogenous fraction - anaerobic [-]	0.1840	0.1840
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield (anoxic) [-]	0.5400	0.5400

Yield propionic (aerobic) [-]	0.6400	0.6400
Yield propionic (anoxic) [-]	0.4600	0.4600
Yield acetic (aerobic) [-]	0.6000	0.6000
Yield acetic (anoxic) [-]	0.4300	0.4300
Yield methanol (aerobic) [-]	0.5000	0.5000
Adsorp. max. [-]	1.0000	1.0000
Max fraction to N2O at high FNA over nitrate [-]	0.0500	0.0500
Max fraction to N2O at high FNA over nitrite [-]	0.1000	0.1000

Methylotrophs

Name	Default	Value
Yield (anoxic) [-]	0.4000	0.4000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Max fraction to N2O at high FNA over nitrate [-]	0.1000	0.1000
Max fraction to N2O at high FNA over nitrite [-]	0.1500	0.1500

PAO

Name	Default	Value
Yield (aerobic) [-]	0.6390	0.6390
Yield (anoxic) [-]	0.5200	0.5200
Aerobic P/PHA uptake [mgP/mgCOD]	0.9300	0.9300
Anoxic P/PHA uptake [mgP/mgCOD]	0.3500	0.3500
Yield of PHA on sequestration [-]	0.8890	0.8890
N in biomass [mgN/mgCOD]	0.0700	0.0700
N in sol. inert [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous part. [-]	0.2500	0.2500
Inert fraction of endogenous sol. [-]	0.2000	0.2000
P/Ac release ratio [mgP/mgCOD]	0.5100	0.5100

COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
Yield of low PP [-]	0.9400	0.9400
Mg to P mole ratio in polyphosphate [mmolMg/mmolP]	0.3000	0.3000
Cation to P mole ratio in polyphosphate [meq/mmolP]	0.1500	0.1500
Ca to P mole ratio in polyphosphate [mmolCa/mmolP]	0.0500	0.0500
Cation to P mole ratio in organic phosphate [meq/mmolP]	0.0100	0.0100

Acetogens

Name	Default	Value
Yield [-]	0.1000	0.1000
H2 yield [-]	0.4000	0.4000
CO2 yield [-]	1.0000	1.0000
N in biomass [mgN/mgCOD]	0.0700	0.0700
P in biomass [mgP/mgCOD]	0.0220	0.0220
Fraction to endogenous residue [-]	0.0800	0.0800
COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

Methanogens

Name	Default	Value
Acetoclastic yield [-]	0.1000	0.1000
Methanol acetoclastic yield [-]	0.1000	0.1000
H2-utilizing yield [-]	0.1000	0.1000
Methanol H2-utilizing yield [-]	0.1000	0.1000
N in acetoclastic biomass [mgN/mgCOD]	0.0700	0.0700
N in H2-utilizing biomass [mgN/mgCOD]	0.0700	0.0700
P in acetoclastic biomass [mgP/mgCOD]	0.0220	0.0220
P in H2-utilizing biomass [mgP/mgCOD]	0.0220	0.0220
Acetoclastic fraction to endog. residue [-]	0.0800	0.0800
H2-utilizing fraction to endog. residue [-]	0.0800	0.0800
Acetoclastic COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200
H2-utilizing COD:VSS ratio [mgCOD/mgVSS]	1.4200	1.4200

General

Name	Default	Value
Tank head loss per metre of length (from flow) [m/m]	0.0025	0.0025

Heating fuel/Chemical Costs

Name	Default	Value
Methanol [$/L]	0.5264	0.5264
Ferric [$/L]	0.1196	0.1196
Aluminium [$/L]	0.0957	0.0957
Natural gas [$/GJ]	3.5889	3.5889
Heating oil [$/L]	0.5982	0.5982
Diesel [$/L]	0.8374	0.8374
Custom fuel [$/L]	1.1963	1.1963
Biogas sale price [$/GJ]	2.3926	2.3926

Anaerobic digester

Name	Default	Value
Bubble rise velocity (anaerobic digester) [cm/s]	23.9000	23.9000
Bubble Sauter mean diameter (anaerobic digester) [cm]	0.3500	0.3500
Anaerobic digester gas hold-up factor []	1.0000	1.0000

Combined Heat and Power (CHP) engine

Name	Default	Value
Methane heat of combustion [kJ/mole]	800.0000	800.0000
Hydrogen heat of combustion [kJ/mole]	240.0000	240.0000
CHP engine heat price [$/kWh]	0	0

CHP engine power price [$/kWh]	0.1794	0.1794

Calorific values of heating fuels

Name	Default	Value
Calorific value of natural gas [kJ/kg]	48000	48000
Calorific value of heating fuel oil [kJ/kg]	42000	42000
Calorific value of diesel [kJ/kg]	46000	46000
Calorific value of custom fuel [kJ/kg]	32000	32000

Density of liquid heating fuels

Name	Default	Value
Density of heating fuel oil [kg/m3]	900	900
Density of diesel [kg/m3]	875	875
Density of custom fuel [kg/m3]	790	790

Mass transfer

Name	Default	Value	
Kl for H2 [m/d]	17.0000	17.0000	1.0240
Kl for CO2 [m/d]	10.0000	10.0000	1.0240
Kl for NH3 [m/d]	1.0000	1.0000	1.0240
Kl for CH4 [m/d]	8.0000	8.0000	1.0240
Kl for N2 [m/d]	15.0000	15.0000	1.0240
Kl for N2O [m/d]	8.0000	8.0000	1.0240
Kl for O2 [m/d]	13.0000	13.0000	1.0240

Henry's law constants

Name	Default	Value	
CO2 [M/atm]	3.4000E-2	3.4000E-2	2400.0000
O2 [M/atm]	1.3000E-3	1.3000E-3	1500.0000
N2 [M/atm]	6.5000E-4	6.5000E-4	1300.0000
N2O [M/atm]	2.5000E-2	2.5000E-2	2600.0000
NH3 [M/atm]	5.8000E+1	5.8000E+1	4100.0000
CH4 [M/atm]	1.4000E-3	1.4000E-3	1600.0000
H2 [M/atm]	7.8000E-4	7.8000E-4	500.0000

Properties constants

Name	Default	Value
K in Viscosity = K e ^(Ea/RT) [Pa s]	6.849E-7	6.849E-7
Ea in Viscosity = K e ^(Ea/RT) [j/mol]	1.780E+4	1.780E+4
Y in ML Viscosity = H2O viscosity * (1+A*MLSS^Y) [-]	1.0000	1.0000
A in ML Viscosity = H2O viscosity * (1+A*MLSS^Y) [m3/g]	1.000E-7	1.000E-7
A in ML Density = H2O density + A*MLSS [(kg/m3)/(g/m3)]	3.248E-4	3.248E-4
A in Antoine equn. [T in K, P in Bar {NIST}]	5.2039	5.2039
B in Antoine equn. [T in K, P in Bar {NIST}]	1733.9260	1733.9260
C in Antoine equn. [T in K, P in Bar {NIST}]	-39.5	-39.5

Chemical precipitation rates

Name	Default	Value	
Struvite precipitation rate [1/d]	3.000E+10	3.000E+10	1.0240
Struvite redissolution rate [1/d]	3.000E+11	3.000E+11	1.0240
Struvite half sat. [mgTSS/L]	1.0000	1.0000	1.0000
HDP precipitation rate [L/(molP d)]	1.000E+8	1.000E+8	1.0000
HDP redissolution rate [L/(mol P d)]	1.000E+8	1.000E+8	1.0000
HAP precipitation rate [molHDP/(L d)]	5.000E-4	5.000E-4	1.0000

Chemical precipitation constants

Name	Default	Value
Struvite solubility constant [mol/L]	6.918E-14	6.918E-14
HDP solubility product [mol/L]	2.750E-22	2.750E-22
HDP half sat. [mgTSS/L]	1.0000	1.0000
Equilibrium soluble PO4 with Al dosing at pH 7 [mgP/L]	0.0100	0.0100
Al to P ratio [molAl/molP]	0.8000	0.8000
Al(OH)3 solubility product [mol/L]	1.259E+9	1.259E+9
AlHPO4+ dissociation constant [mol/L]	7.943E-13	7.943E-13
Equilibrium soluble PO4 with Fe dosing at pH 7 [mgP/L]	0.0100	0.0100
Fe to P ratio [molFe/molP]	1.6000	1.6000
Fe(OH)3 solubility product [mol/L]	0.0500	0.0500
FeH2PO4++ dissociation constant [mol/L]	5.012E-22	5.012E-22

Pipe and pump parameters

Name	Default	Value
Static head [m]	0.2500	0.2500
Pipe length (headloss calc.s) [m]	50.0000	50.0000
Pipe inside diameter [mm]	500.000	500.000
K(fittings) - Total minor losses K	5.0000	5.0000
Pipe roughness [mm]	0.200	0.200
'A' in overall pump efficiency = A + B*Q + C*(Q^2)[-]	0.8500	0.8500
'B' in overall pump efficiency = A + B*Q + C*(Q^2)[-]/(m3/d)]	0	0
'C' in overall pump efficiency = A + B*Q + C*(Q^2)[-]/(m3/d)^2]	0	0

Fittings and loss coefficients ('K' values)

Name	Default	Value
Pipe entrance (bellmouth)	0.0500	1.0000
90° bend	0.7500	5.0000
45° bend	0.3000	2.0000
Butterfly value (open)	0.3000	1.0000

Non-return value	1.0000	0
Outlet (bellmouth)	0.2000	1.0000

Aeration

Name	Default	Value
Surface pressure [kPa]	101.3250	101.3250
Fractional effective saturation depth (Fed) [-]	0.3250	0.3250
Supply gas CO2 content [vol. %]	0.0350	0.0350
Supply gas O2 [vol. %]	20.9500	20.9500
Off-gas CO2 [vol. %]	2.0000	2.0000
Off-gas O2 [vol. %]	18.8000	18.8000
Off-gas H2 [vol. %]	0	0
Off-gas NH3 [vol. %]	0	0
Off-gas CH4 [vol. %]	0	0
Off-gas N2O [vol. %]	0	0
Surface turbulence factor [-]	2.0000	2.0000
Set point controller gain []	1.0000	1.0000

Blower

Name	Default	Value
Intake filter pressure drop [kPa]	3.5000	3.5000
Pressure drop through distribution system (piping/valves) [kPa]	3.0000	3.0000
Adiabatic/polytropic compression exponent (1.4 for adiabatic)	1.4000	1.4000
'A' in blower efficiency = A + B*Qa + C*(Qa^2)[-]	0.7500	0.7500
'B' in blower efficiency = A + B*Qa + C*(Qa^2)[[-]/(m3/hr (20C, 101.325 kPa))]	0	0
'C' in blower efficiency = A + B*Qa + C*(Qa^2)[[-]/(m3/hr (20C, 101.325 kPa))^2]	0	0

Diffuser

Name	Default	Value

k1 in C = k1(PC)^0.25 + k2	1.2400	1.2400
k2 in C = k1(PC)^0.25 + k2	0.8960	0.8960
Y in Kla = C Usg ^ Y - Usg in [m3/(m2 d)]	0.8880	0.8880
Area of one diffuser [m2]	0.0410	0.0410
Diffuser mounting height [m]	0.2500	0.2500
Min. air flow rate per diffuser m3/hr (20C, 101.325 kPa)	0.5000	0.5000
Max. air flow rate per diffuser m3/hr (20C, 101.325 kPa)	10.0000	10.0000
'A' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2 [kPa]	3.0000	3.0000
'B' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2[kPa/(m3/hr (20C, 101.325 kPa))]	0	0
'C' in diffuser pressure drop = A + B*(Qa/Diff) + C*(Qa/Diff)^2[kPa/(m3/hr (20C, 101.325 kPa))^2]	0	0

Surface aerators

Name	Default	Value
Surface aerator Std. oxygen transfer rate [kg O /(kW hr)]	1.50000	1.50000
Maximum power per rotor [kW]	20.00000	20.00000

Modified Vesilind

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [m/d]	170.000	170.000
Vesilind hindered zone settling parameter (K) [L/g]	0.370	0.370
Clarification switching function [mg/L]	100.000	100.000
Specified TSS conc.for height calc. [mg/L]	2500.000	2500.000
Maximum compactability constant [mg/L]	15000.000	15000.000

Double exponential

Name	Default	Value
Maximum Vesilind settling velocity (Vo) [m/d]	410.000	410.000
Maximum (practical) settling velocity (Vo') [m/d]	270.000	270.000
Hindered zone settling parameter (Kh) [L/g]	0.400	0.400

Flocculent zone settling parameter (Kf) [L/g]	2.500	2.500
Maximum non-settleable TSS [mg/L]	20.0000	20.0000
Non-settleable fraction [-]	0.0010	0.0010
Specified TSS conc. for height calc. [mg/L]	2500.0000	2500.0000

Emission factors

Name	Default	Value
Carbon dioxide equivalence of nitrous oxide	296.0000	296.0000
Carbon dioxide equivalence of methane	23.0000	23.0000

Biofilm general

Name	Default	Value	
Attachment rate [g / (m2 d)]	80.0000	80.0000	1.0000
Attachment TSS half sat. [mg/L]	100.0000	100.0000	1.0000
Detachment rate [g/(m3 d)]	8.000E+4	8.000E+4	1.0000
Solids movement factor []	10.0000	10.0000	1.0000
Diffusion neta []	0.8000	0.8000	1.0000
Thin film limit [mm]	0.5000	0.5000	1.0000
Thick film limit [mm]	3.0000	3.0000	1.0000
Assumed Film thickness for tank volume correction (temp independent) [mm]	0.7500	0.7500	1.0000
Film surface area to media area ratio - Max.[ ]	1.0000	1.0000	1.0000
Minimum biofilm conc. for streamer formation [gTSS/m2]	4.0000	4.0000	1.0000

Maximum biofilm concentrations [mg/L]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E+4	5.000E+4	1.0000
Methylotrophs	5.000E+4	5.000E+4	1.0000
Ammonia oxidizing biomass (AOB)	1.000E+5	1.000E+5	1.0000
Nitrite oxidizing biomass (NOB)	1.000E+5	1.000E+5	1.0000

Anaerobic ammonia oxidizers (AAO)	5.000E+4	5.000E+4	1.0000
Polyphosphate accumulating organisms (PAO)	5.000E+4	5.000E+4	1.0000
Propionic acetogens	5.000E+4	5.000E+4	1.0000
Methanogens - acetoclastic	5.000E+4	5.000E+4	1.0000
Methanogens - hydrogenotrophic	5.000E+4	5.000E+4	1.0000
Endogenous products	3.000E+4	3.000E+4	1.0000
Slowly bio. COD (part.)	5000.0000	5000.0000	1.0000
Slowly bio. COD (colloid.)	4000.0000	4000.0000	1.0000
Part. inert. COD	5000.0000	5000.0000	1.0000
Part. bio. org. N	0	0	1.0000
Part. bio. org. P	0	0	1.0000
Part. inert N	0	0	1.0000
Part. inert P	0	0	1.0000
Stored PHA	5000.0000	5000.0000	1.0000
Releasable stored polyP	1.150E+6	1.150E+6	1.0000
Fixed stored polyP	1.150E+6	1.150E+6	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved CH4	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved N2	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.000E+10	1.000E+10	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	1.300E+6	1.300E+6	1.0000
Struvite	8.500E+5	8.500E+5	1.0000
Hydroxy-dicalcium-phosphate	1.150E+6	1.150E+6	1.0000
Hydroxy-apatite	1.600E+6	1.600E+6	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.000E+10	1.000E+10	1.0000

Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000
Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	5.000E+4	5.000E+4	1.0000
User defined 4	5.000E+4	5.000E+4	1.0000
Dissolved O2	0	0	1.0000

Effective diffusivities [m2/s]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	5.000E-14	5.000E-14	1.0290
Methylotrophs	5.000E-14	5.000E-14	1.0290
Ammonia oxidizing biomass (AOB)	5.000E-14	5.000E-14	1.0290
Nitrite oxidizing biomass (NOB)	5.000E-14	5.000E-14	1.0290
Anaerobic ammonia oxidizers (AAO)	5.000E-14	5.000E-14	1.0290
Polyphosphate accumulating organisms (PAO)	5.000E-14	5.000E-14	1.0290
Propionic acetogens	5.000E-14	5.000E-14	1.0290
Methanogens - acetoclastic	5.000E-14	5.000E-14	1.0290
Methanogens - hydrogenotrophic	5.000E-14	5.000E-14	1.0290
Endogenous products	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (part.)	5.000E-14	5.000E-14	1.0290
Slowly bio. COD (colloid.)	5.000E-10	5.000E-10	1.0290
Part. inert. COD	5.000E-14	5.000E-14	1.0290
Part. bio. org. N	5.000E-14	5.000E-14	1.0290
Part. bio. org. P	5.000E-14	5.000E-14	1.0290
Part. inert N	5.000E-14	5.000E-14	1.0290
Part. inert P	5.000E-14	5.000E-14	1.0290
Stored PHA	5.000E-14	5.000E-14	1.0290
Releasable stored polyP	5.000E-14	5.000E-14	1.0290
Fixed stored polyP	5.000E-14	5.000E-14	1.0290
Readily bio. COD (complex)	6.900E-10	6.900E-10	1.0290
Acetate	1.240E-9	1.240E-9	1.0290
Propionate	8.300E-10	8.300E-10	1.0290
Methanol	1.600E-9	1.600E-9	1.0290

Dissolved H2	5.850E-9	5.850E-9	1.0290
Dissolved CH4	1.963E-9	1.963E-9	1.0290
Ammonia N	2.000E-9	2.000E-9	1.0290
Sol. bio. org. N	1.370E-9	1.370E-9	1.0290
Nitrous Oxide N	1.607E-9	1.607E-9	1.0290
Nitrite N	2.980E-9	2.980E-9	1.0290
Nitrate N	2.980E-9	2.980E-9	1.0290
Dissolved N2	1.900E-9	1.900E-9	1.0290
PO4-P (Sol. & Me Complexed)	2.000E-9	2.000E-9	1.0290
Sol. inert COD	6.900E-10	6.900E-10	1.0290
Sol. inert TKN	6.850E-10	6.850E-10	1.0290
ISS Influent	5.000E-14	5.000E-14	1.0290
Struvite	5.000E-14	5.000E-14	1.0290
Hydroxy-dicalcium-phosphate	5.000E-14	5.000E-14	1.0290
Hydroxy-apatite	5.000E-14	5.000E-14	1.0290
Magnesium	7.200E-10	7.200E-10	1.0290
Calcium	7.200E-10	7.200E-10	1.0290
Metal	4.800E-10	4.800E-10	1.0290
Other Cations (strong bases)	1.440E-9	1.440E-9	1.0290
Other Anions (strong acids)	1.440E-9	1.440E-9	1.0290
Total CO2	1.960E-9	1.960E-9	1.0290
User defined 1	6.900E-10	6.900E-10	1.0290
User defined 2	6.900E-10	6.900E-10	1.0290
User defined 3	5.000E-14	5.000E-14	1.0290
User defined 4	5.000E-14	5.000E-14	1.0290
Dissolved O2	2.500E-9	2.500E-9	1.0290

EPS Strength coefficients [ ]

Name	Default	Value	
Ordinary heterotrophic organisms (OHO)	1.0000	1.0000	1.0000
Methylotrophs	1.0000	1.0000	1.0000
Ammonia oxidizing biomass (AOB)	5.0000	5.0000	1.0000
Nitrite oxidizing biomass (NOB)	25.0000	25.0000	1.0000
Anaerobic ammonia oxidizers (AAO)	10.0000	10.0000	1.0000
Polyphosphate accumulating organisms (PAO)	1.0000	1.0000	1.0000

Propionic acetogens	1.0000	1.0000	1.0000
Methanogens - acetoclastic	1.0000	1.0000	1.0000
Methanogens - hydrogenotrophic	1.0000	1.0000	1.0000
Endogenous products	1.0000	1.0000	1.0000
Slowly bio. COD (part.)	1.0000	1.0000	1.0000
Slowly bio. COD (colloid.)	1.0000	1.0000	1.0000
Part. inert. COD	1.0000	1.0000	1.0000
Part. bio. org. N	1.0000	1.0000	1.0000
Part. bio. org. P	1.0000	1.0000	1.0000
Part. inert N	1.0000	1.0000	1.0000
Part. inert P	1.0000	1.0000	1.0000
Stored PHA	1.0000	1.0000	1.0000
Releasable stored polyP	1.0000	1.0000	1.0000
Fixed stored polyP	1.0000	1.0000	1.0000
Readily bio. COD (complex)	0	0	1.0000
Acetate	0	0	1.0000
Propionate	0	0	1.0000
Methanol	0	0	1.0000
Dissolved H2	0	0	1.0000
Dissolved CH4	0	0	1.0000
Ammonia N	0	0	1.0000
Sol. bio. org. N	0	0	1.0000
Nitrous Oxide N	0	0	1.0000
Nitrite N	0	0	1.0000
Nitrate N	0	0	1.0000
Dissolved N2	0	0	1.0000
PO4-P (Sol. & Me Complexed)	1.0000	1.0000	1.0000
Sol. inert COD	0	0	1.0000
Sol. inert TKN	0	0	1.0000
ISS Influent	0.3300	0.3300	1.0000
Struvite	1.0000	1.0000	1.0000
Hydroxy-dicalcium-phosphate	1.0000	1.0000	1.0000
Hydroxy-apatite	1.0000	1.0000	1.0000
Magnesium	0	0	1.0000
Calcium	0	0	1.0000
Metal	1.0000	1.0000	1.0000
Other Cations (strong bases)	0	0	1.0000
Other Anions (strong acids)	0	0	1.0000

Total CO2	0	0	1.0000
User defined 1	0	0	1.0000
User defined 2	0	0	1.0000
User defined 3	1.0000	1.0000	1.0000
User defined 4	1.0000	1.0000	1.0000
Dissolved O2	0	0	1.0000

Appendix D - Australian Stainless Reference Manual

chemicals (such a phosphoric, oxalic or sulphamic acids) and must be handled with care according to the manufacturer's directions. After cleaning, it is important to neutralise the acid with a 1% ammonia solution or a solution of baking powder and water, then rinse with clean water and wipe dry.

If the rust has pitted the surface, don't despair! Bad rusting can be repaired with professional polishing but you will need to get expert advice.

REMEDIAL WORK: CLEANING RUST-STAINED FLAT SURFACES

Early action after the onset of tea staining is desirable, before the appearance of the underlying surface is changed. If the surface is pitted, then it is probable that it will require mechanical repolishing.

After mechanically cleaning off tea staining, it is preferable to passivate the surface by using a nitric acid gel or, if the item is portable, by immersion in a nitric acid bath.

For marine exposures, passivation is very strongly recommended. In contrast to other acids, nitric acid is a strong, oxidising acid cleaner and has the added advantage that it is a passivating agent. The Nickel Institute has suggested that rust may be removed by the use of a 10% phosphoric or oxalic acid followed by a 1% ammonia solution neutralisation and then a water rinse.

Alternatively, a mild acid based cleaner such as sulphamic acid (used in some saucepan cleaners) can be used with some care to avoid local changes in appearance.

Never, ever use hydrochloric or sulphuric acids. There are also proprietary chemical cleaning treatments often based on citric acid or other chelating compounds. Although these agents passivate in the sense of removing free iron and other foreign matter, they do not augment the surface oxide film. Use of liquid acids on site is generally unsatisfactory as contact time is short and the acid may run off and damage adjacent components. Unlike the hydrofluoric acid pickling process used after welding, a nitric acid passivation process does not normally change the surface appearance of stainless steel, although it may cloud a mirror polished surface. Careful trials on inconspicuous areas are recommended prior to full scale cleaning. Electropolishing is also used by some contractors to smooth rough edges and both clean and passivate the surface.

It can be carried out on site or, more usually, in purpose-built tanks.

AFTERWARDS: PREVENTION OF RECURRENCE

If tea staining has occurred, 1 or more of the 5 factors outlined in the introduction has not been considered carefully enough when the structure was designed and/or built. To improve the structure, the following steps may be taken to prevent recurrence:

- Increase the frequency of maintenance
- Improve the surface finish by mechanical polishing and/or chemical treatment onsite
- Redesign of the structure and replace the affected part
- Replace the affected part of the structure with a more suitable grade of stainless steel.

If consideration of these steps indicates an uneconomic result, the stainless steel can be painted. Paint systems using lacquers and polyurethane top coats are available and have been used successfully, but care and understanding are required. Painting the stainless steel is a step that should only be used as a last option as it is irreversible.

SECTION 6.5
SPECIFIC APPLICATIONS

This section focusses on the design of stainless steel structures in specific applications, including marine, swimming pools and pressure vessels.

SECTION 6.5.1
DESIGNING STAINLESS STEEL STRUCTURES ON THE COAST

The application "what is tea staining?" on page 96 depicts the successful use of stainless steel in a coastal environment. After a decade of service in a severe environment, it shows little sign of deterioration. The other applications shown (and "what is tea staining?" on page 96) however, show significant staining after only a very brief period in service. This brown 'tea staining' on the stainless steel is avoidable.

MINIMISING THE RISK THROUGH CORRECT SPECIFICATION

This section provides information on tea staining and what fabricators, specifiers and end users should do to help avoid it and enjoy the long life and clean appearance of stainless steel. Specific considerations for fabricators can be found in *Section 7.*

Stainless steel enjoys a strong and enduring reputation for long term appearance and structural integrity.

But, like all materials, stainless steel may become stained or discoloured over time, impairing the overall look. This brown discolouration - tea staining - has been identified in coastal applications in Australia and overseas.

ASSDA has researched factors surrounding tea staining and the information gathered has been supported by experiences from around the world.

IMPORTANT QUALIFICATION

The information in this section has been prepared from research undertaken by or made available to ASSDA at the

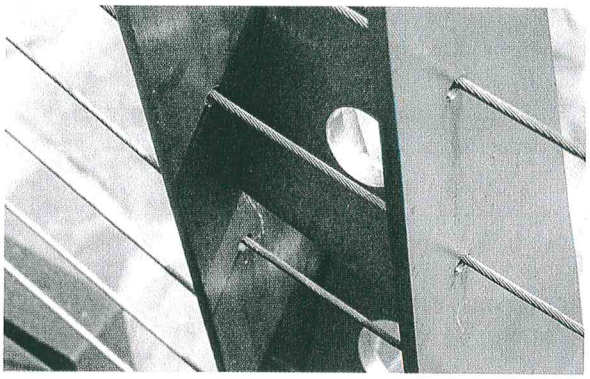
6.5.1

date of publication. Adherence to the recommendations in this section may improve the cosmetic appearance of affected surfaces and minimise risk in new applications.

However, research into the causes of, and treatment for, tea staining have not, to date, resulted in definitive processes or recommendations for cure and prevention.

ASSDA accepts no responsibilty for any opinion or recommendation expressed, for any error or omission occurring herein or for the failure of any recommendation contained in this section to achieve a satisfactory result in any particular application.

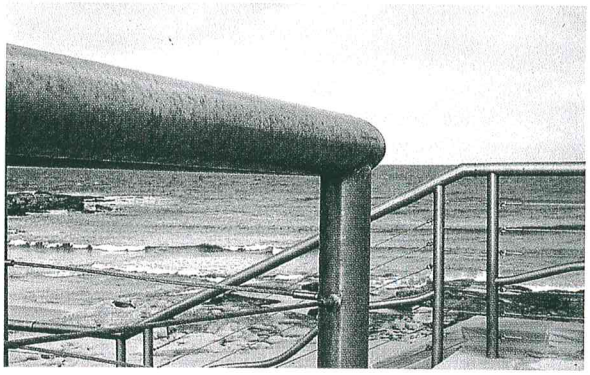
Before acting on any particular application, qualified advice particular to such application should be obtained.



WHAT IS TEA STAINING?

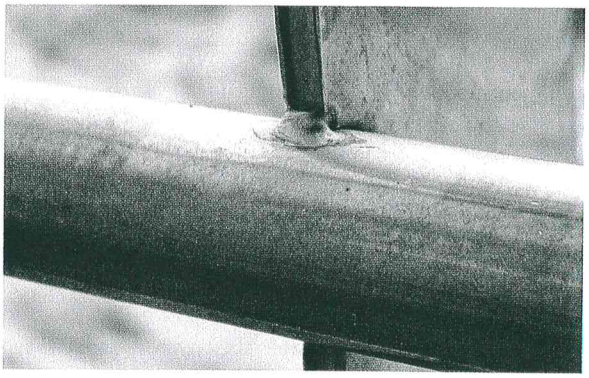
Tea staining can be defined as discolouration of the surface of stainless steel by corrosion. It is a cosmetic issue that does not affect the structural integrity or lifetime of the material.

The relationships between the contributing factors are complex, but generally become increasingly critical closer to salty water.

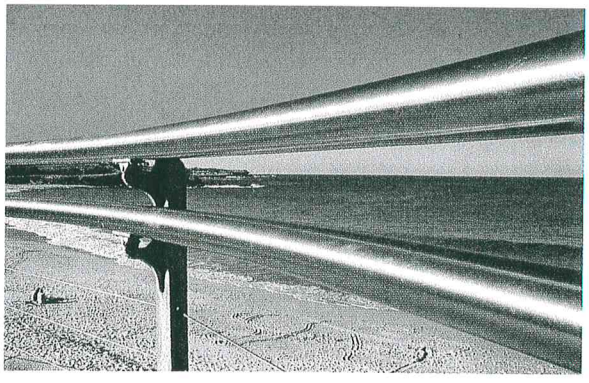


ENVIRONMENTAL FACTORS

Tea staining occurs most commonly within about 5 kilometres of the surf and becomes progressively worse closer to the marine source. However, wind exposure, pollution levels and higher temperatures can create environments where tea staining might occur 20 kilometres or more from sea water. The effect is much less around sheltered bays. These same factors also increase corrosion rates of alternative materials.



Electropolished stainless steel grade 316 in perfect condition after 7 years of exposure in a marine environment.



SURFACE FINISH

Rough surface finishes promote tea staining: the smoother the surface, the better. Smoother surface finishes stay cleaner between washes and don't have deep surface grooves where chlorides and other contaminants can collect and concentrate to cause problems.

WASH REGULARLY

Even smooth stainless steel finishes in coastal environments may show tea staining if not washed regularly.

DESIGN, FABRICATION AND HANDLING

Poor design and fabrication can lead to tea staining or more serious corrosion of stainless steels.

For instance, good designers will avoid crevices such as intermittent welds and areas where water can collect.

Competent stainless steel fabricators will avoid carbon steel contamination, so choose designers and fabricators that are experienced with stainless steel to achieve the best outcome.

APPROPRIATE GRADE SELECTION

Each stainless steel grade has a limit to the concentration of salts that it can comfortably resist, the higher the alloying content (Cr, Mo and N), the higher the resistance to corrosion. Exposure of a particular grade of stainless steel to a more aggressive environment that it can resist will cause tea staining.

Grade 316, or a grade with equivalent corrosion resistance, should be selected as a minimum within 5 kilometres of the surf. For critical applications (eg. splash zones, unwashed areas or rough surfaces), higher grades of stainless steel such as duplex alloys or 'super' grades may be required.

The lower alloyed and less expensive grades (such as 304 or 430) will probably become tea stained or even suffer more severe corrosion in a marine environment.

TREATMENT OF WELDS

Pickling treatments after welding is one method of promoting good performance of stainless steel near the coast. This chemical treatment removes the welding oxide and rapidly restores the passive layer, which gives stainless steel its corrosion resistance. An alternative is to mechanically remove the scale and underlying chromium depleted layer, followed by a chemical passivation treatment.

INSTALLATION AND INSPECTION

After installation, the completed structure should be inspected for surface imperfections or contaminants.

If discovered, imperfections should be removed and the corrosion resistance chemically restored by pickling and passivation treatments or by electropolishing. Hydrochloric acid, sometimes used to clean cement or mortar residues, should not be used on stainless steel - it will stain the surface and may start more serious corrosion.

PLAN TO GET THE DESIRED RESULT

Marine environments are the most aggressive for all building materials.

Stainless steel's corrosion resistance in marine environments means that installations are likely to remain structurally sound for decades[1].

It must be recognised, however, that keeping a pristine surface finish requires understanding and, usually, additional cost. Determine your expectation of the structure and plan ahead to achieve and maintain the intended result. This normally includes a maintenance program.

[1] Perforation of roofs and gutters is possible depending on the application - seek advice if this is a failure criterion.

KEY RECOMMENDATIONS FOR MINIMISING TEA STAINING

The following factors are all important for avoiding tea staining.

ENVIRONMENT

One of the main causes of tea staining is salt deposited on the surface. Tea staining is most likely to occur up to 5 kilometres from a surf beach and 1 kilometre from still marine waters.

There is no hard and fast rule: wind and weather conditions play a big part and the severity of the conditions increases sharply as you approach the surf.

AS 2312 suggests that in some special circumstances, 20 kilometres from the coast can still constitute a marine environment. The closer to the source of salt, the more critical it is to follow the recommendations in this section.

Areas that are sheltered or not rainwashed are particularly susceptible. Examples include downpipes under eaves or the underside of a sloping shelter.

SPECIFY AND INSIST ON A SMOOTH SURFACE FINISH

To minimise the risk of tea staining and maximise corrosion resistance, the smoother the surface finish the better.

A surface roughness (R_a) of less than 0.5 micrometres is strongly recommended.

A No. 4 finish just means an abraded (linished) finish. Specifying a No. 4 finish is inadequate.

Typically, refinishing operations using 320 grit abrasives will achieve a finish better than 0.5 micrometres R_a.

Components used near the sea can be made more resistant to tea staining by pickling to remove surface contaminants. Electropolishing has also been found to be extremely effective.

However, it must be recognised that both processes can change the surface appearance - pickling tends to dull polished surfaces while electropolishing will brighten surfaces.

Smoother mill finishes such as 2B (flat products), Bright Annealed (BA) or mirror polished (No. 8) are available in some products and these offer better resistance to collection of salt deposits and hence to tea staining.

Rolled embossed finishes may be suitable for some applications. These have very smooth surfaces but with a pattern that lowers reflectivity.

Think carefully about the pattern and how it will be oriented - avoid pools of water sitting on the surface.

SPECIFY AND INSIST ON THE RIGHT GRADE

Smooth surface finish and maintenance are important factors for all stainless steel grades in coastal environments.

Use grade 316 unless the job is aesthetically critical and frequent maintenance is unlikely.[2]

Where there are high aesthetic expectations a number of more corrosion resistant stainless steel grades can be considered. The first step up from 316 is 2205 and then the super duplex grades, although the high molybdenum austenitics and high molybdenum ferritics may also be useful.

Smooth surface finish and maintenance are still important with these grades.

[2] Grade 304 has occassionally been successfully used in these environments, but it is not recommended.

CHEMICALLY TREAT THE WELDS

For general architectural applications, welds should comply with AS 1554.6 Level 2, Class B (details of other weld finish classifications are given in *Section 7*). However, this specification does not guarantee the absence of structurally minor surface defects which can acts as traps and corrosion initiating sites. The protruding weld can be ground flush, and good resistance to tea staining achieved (a Grade I finish) when polished to 320 grit or finer finish. The smoother the surface, the better the tea staining resistance. Passivation will occur in chloride free, moist air within a day. Treatment with nitric acid may be applied to:

› Substantially reduce the time required for passivation.

› Provide a more corrosion resistant passive film.

› Remove possible iron contamination.

› Dissolve exposed manganese sulphides.

Post abrasion chemical passivation must be applied if the environment is particularly aggressive.

An alternative cleaning treatment is a Grade II blast cleaned finish. This will require a post blasting passivation treatment. The blasting should remove heat tint and the chromium depleted layer but not make the surface roughness worse than 0.5 µm R_a, must not leave folds or crevices and should not embed corrodents. The Grade II stainless steel wire brushing treatment is not adequate to control tea staining.

Where a polished (or linished or ground) finish is desired, 320 grit (or finer) silicon carbide abrasives should be used with lubrication if possible. In selecting abrasives, consideration should be given to matching the surrounding finish.

A Grade II pickled finish will provide good tea staining resistance without grinding the weld flush, provided there are no significant surface crevices/defects. Where linishing or blasting is not performed, pickling of site welds (using mixed acids - hydrofluoric plus nitric) should take place as a final step in the weld procedure. Pickling will remove any fabrication contaminants and restore the passive chromium oxide layer, resulting in a corrosion resistant surface. Electrocleaning has been used instead of pickling to remove weld scale and heat tint especially when HF use is restricted. While passivation treatments do not normally affect appearance, pickling treatments are likely to alter bright surface finishes. Electropolishing is also a very effective method of passivation.

PERFORM REGULAR MAINTENANCE

Washing removes contaminants (such as salt) that can cause corrosion and is necessary to avoid tea staining.

Rain washing the surface is helpful in reducing tea staining, so design the job to take advantage of the rain, but ensure good and even drainage.

TABLE 52 CRITERIA FOR CLEANING FREQUENCY

ENVIRONMENT	RURAL (INCLUDING SUBURBAN AND RESIDENTIAL AREAS)				SEASIDE (INCLUDING INDUSTRIAL AND SEVERE URBAN AREAS)			
BUILDING ELEMENT	Roof and wall washed by rain water		Eave soffit and undereave wall unwashed by rain water		Roof and wall washed by rain water		Eave soffit and undereave wall unwashed by rain water	
STRUCTURE	DU	DA	DU	DA	DU	DA	DU	DA
CLEANING CRITERION (FOR S30400)[1]	1 time/year	1 time/year	1-2 times/year	2-12 times/ year	1 time/year	1 time/year	3-4 times/ year	4-12 times/year

DU = Deposits Unaccumulated DA = Deposits Accumulated

[1] Cleaning frequency may be less for other other grades but is dependent on surface finish and precise details of design of the stucture, environment, cleaning methods and expectations of performance.

NOTE: Cleaning involves washing with potable, low-chloride water or washing with a neutral detergent followed by rinsing with potable water.

Source: JSSA/NiDI 12 013.

Stipulate that the stainless steel also be washed when cleaning of the surrounding area takes place. As a first approximation, stainless steel should be washed if a window requires washing.

For best results wash with soap or mild detergent and warm water followed by rinsing with clean cold water. The appearance of the surface can be improved further if the washed surface is wiped dry.

If routine cleaning of the surrounding area does not take place, washing frequency for the stainless steel is recommended as *Table 52* shows.

FURTHER READING

Australian Standard, AS/NZS 1554.6 Structural steel welding - Welding stainless steels for structural purposes.

Nickel Institute and Japan Stainless Steel Association, Successful Use of Stainless Steel Building Materials (No. 12 013).

Nickel Institute, Guidelines for the Welded Fabrication of Nickel Stainless Steels for Corrosion Resistant Services (No. 11 007).

SELECTING A SURFACE

Aesthetics dictate the stainless steel surface chosen, but surface finish also dominates the cost and service performance. Surfaces range from bright and shiny (No 8 polished) through linished or ground (No 4 polished), dull (dull rolled) to matt (pickled or surface blasted).

Smoother surfaces have a brighter appearance, with higher corrosion resistance but unfortunately also higher fabrication costs.

Ground (No 4) and blasted surfaces have lower gloss levels, but also lower corrosion resistance. Chemical treatment of these surfaces can restore the corrosion resistance to match or exceed that of the same grade with a smooth surface. Service performance may still be a little inferior as a rougher surface will retain more dirt and deposits, but this can be overcome with more frequent washing.

CLEANING STAINLESS STEEL

Surface contamination by glues, grease and other organic matter should be wiped off with a hydrocarbon solvent, followed by a clean water rinse before it dries.

Plastic surface protection films may leave a glue residue when stripped, especially after being left in the sun for too long. Films with black layers, which are stabilised against UV by carbon black, give the longest period before this problem is encountered. Films stripped when warm from sun exposure are most likely to leave a glue deposit.

These glue deposits can usually be removed with a biodegradeable citrus solvent (look for limonene on the Material Safety Data Sheet) or eucalyptus oil, but it is not possible to be categorical about a suitable solvent as glue chemistry and breakdown is complex. Experimentation may be required.

The solvent must be rinsed from the surface with potable water before it dries. A hose or high pressure water blaster can be used for water economy - exercise care when the stainless membrane is thin.

Drying marks can be avoided by rinsing with alcohol before the rinse water dries.

APPLIED COATINGS

There are many proprietary coatings which are claimed to increase the corrosion resistance of stainless steel. These act by excluding moisture from the surface, preventing corrosion.

They may be polymers or waxes, which degrade in sunlight. They may not be recommended for use in sunlight, or may require frequent renewal as they accelerate staining when they break down. Corrosion beneath partially removed coating residues is also possible.

Ask the supplier for advice on suitability and renewal frequency for your application.

SPECIFYING LIGHT ARCHITECTURAL FABRICATIONS INCLUDING HANDRAIL SYSTEMS TO AVOID TEA STAINING

There are a number of steps in specifying a light architectural system, such as handrail, many of which have substantial costs. Choosing the right combination of grade, surface finish and finish, and maintenance regime for the service conditions can be challenging because there are a number of factors to consider. This guide is intended to assist the dialogue between specifiers and fabricators in arriving at the optimum economic solution.

Most fabricators use grade 316 near the coast and salt water, and grade 304 beyond about 10 kilometres from surf or 1 kilometre from sheltered salt water. Grade 304 can be used indoors. Tubes and fittings with a linished or ground (No 4) or smoother finish are used.

Figure 23 shows a decision tree for achievement of best practice.

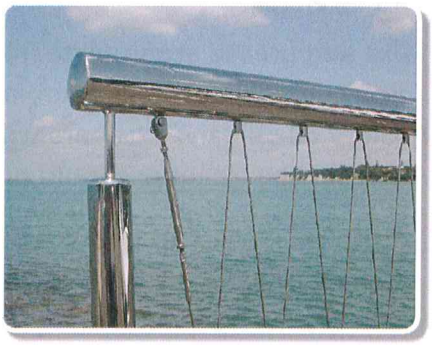
DETECTING CARBON STEEL CONTAMINATION

ASTM A380, 'Standard Practice for cleaning, descaling and passivation of stainless steel parts, equipment and systems' gives a number of methods for detecting carbon steel contamination.

1. The simplest, water wetting and drying accelerates rust staining by periodically wetting the surface with preferably distilled or deionised water, or clean fresh tap water. The sample should be allowed to dry for about an hour, then re-wetted. It should be dry for at least a total of 8 hours in a 24 hour test period.

CLEANING & MAINTENANCE GUIDE TO STAINLESS STEEL

INTRODUCTION



For the preservation of stainless steel Anzor strongly recommends regular maintenance. The following provides a guide to preserving stainless.

Please be aware of this yourself and also pass it on to your clients. If you have any questions or would like further information, please contact your local branch.

For more information on stainless steel, please refer to our **guide**.

EXTERIOR

Like all surfaces, **stainless steel requires cleaning to remove dirt and grime to keep it in pristine condition**. The level of cleaning and maintenance required depends primarily on the environment. In some exterior instances normal rain washing is sufficient, e.g. roofing, but more polluted or corrosive environments, e.g. coastal situations, the surfaces require regular washing to retain their good looks.

The type of finish will also influence the cleaning required, and it is recommended that the rougher the surface the more regularly cleaning is required. For example, Stainless Steel Wire has a rough surface with crevices that harbour corrosive agents which cause discolouration relatively quickly. **Regular cleaning is required** to remove this. A corrosion inhibitor such as "Lanotec" liquid or aerosol applied with a soft cloth will aid in corrosion prevention (stocked by Anzor). Grunt Emergel is ideal for removing any tea-staining or rust on stainless surfaces.

COASTAL SITUATIONS – discolouration or tea staining most commonly occurs within 5 kilometres of the coast and becomes progressively worse closer to the water. Note that in situations right on the seafront, it is recommended that cleaning is performed once a month.

Lanotec™

Lanotec Range of Corrosion Inhibitor Products
www.anzor.com.au/lanotec

Benefits of Lanotec

- Non-toxic and non-carcinogenic.
- Inhibits oxidation and galvanic corrosion.
- Forms a barrier on treated surfaces, preventing corrosive agents from penetrating the surface.
- Non perishing to rubber "O" rings and seals.
- All blends of Lanotec products are user friendly and safe to apply.

Disclaimer: this is meant only as guide, and Anzor does not accept liability for the application of this information – please consult the Australian Stainless Steel Development Association for specific advice.

Appendix E - Risk Assessment

Risk	Risk Rating			Mitigation Measures / Recommendations	Inherent Risk Rating		
	Likelihood	Consequence	Risk Score		Likelihood	Consequence	Risk Score
Influent Envelope - Limited influent samples were available for use and were taken monthly.	D	4	High	Undertake a raw sewage sampling program during the detailed design phase to provide a better understanding of the raw sewage loads. It is evident there is saltwater infiltration present within the network occurring during high tides based on high conductivity values provided in the samples.	D	2	Medium
Influent Flows – Limited data was available in regards to influent flows on the plant. Flows were estimated based on pump run times in SPS 01, water consumption data from the WTP and the influent flowmeter	C	4	High	Install portable flow meter on the influent main into the plant to monitor influent flows more accurately. The concept design of the plant has considered relatively high flows.	C	2	Medium
Influent flows – No data was provided for the Peak Instantaneous Flows into the plant	C	4	High	Undertake investigations into the capacity of the pumps installed in SPS01. Plant to be designed to for the current peak flows from SPS01 + 30% to allow for future expansion in the network. Pumps may need to be upgraded, to be considered during detailed design.	C	2	Medium

SPS01 Pumps not capable of pumping to elevated tanks	C	4	High	Investigation into the sizing of the SPS 01 pumps shall be undertaken during detailed design. Pumps may need to be upgraded due to an increase of approximately 4m of static head.	C	3	Medium
Ground Conditions – Poor ground conditions at the STP site	C	4	High	Limited data is available regarding the existing ground conditions at the STP. It is recommended that during the detailed design phase, a Geotechnical Investigation is carried out to determine the ground conditions.	C	3	Medium
Capacity of existing slab is unknown	C	4	High	The capacity of the existing slab is unknown; however, it is proposed that a Structural assessment of the slab is undertaken during the detailed design phase to determine upgrade requirements	C	2	Medium
New plant is not capable of treating sewage to the standard specified EA conditions	D	4	High	Process modelling has been undertaken during the options analysis. Further process modelling will be undertaken during the detailed design phase of the project.	D	2	Medium
Major equipment failure resulting untreated effluent	D	4	High	Redundancy will be required for all major process equipment will be provided in a Duty/Standby configuration. The plant has been designed to limit failure points that may affect the effluent quality. The two biological treatment tanks and the clarifier are hydraulically linked; therefore, all influent flows will be screened and have some treatment if failure of mechanical equipment occurs.	D	2	Medium
Intentional plant bypass	D	4	High	The preferred method is to LOCK all valves (excluding actuated valves if installed) to prevent misuse and intentional bypass of the plant. There should be no requirement to bypass the plant unless either of the process tanks, or clarifier were required to be taken offline.	D	1	Medium

The plant is too complex and requires specialist operator training	C	3	Medium	The plant is designed to minimise Operation and Maintenance requirements by minimising the number of pumps and instrumentation. Operational requirements for the upgraded plant will include hosing down of screens and tanks, removal and disposal of screenings and wasting of sludge on a weekly basis.	C	1	Low
Confined space entry required for routine maintenance. TSIRC notified operators do not have confined space entry training.	C	4	High	All major process equipment is designed to sit outside of the tank allowing maintenance activities to be carried out without the requirement for confined space entry. There should be no requirement for confined space entry to tanks.	C	1	Low
Working at heights required for routine maintenance. TSIRC notified operators do not have working at heights training.	C	4	High	Walkways designed to AS1657 will be provided for access to the screens and the clarifier. There will be no requirement for working at heights.	C	1	Low
Corrosion of stainless steel tanks resulting in failure	D	4	High	Investigations into the selection of materials has been undertaken during the options analysis. Tanks shall be washed down routinely (weekly) to remove salts and it is proposed an annual inspection is undertaken to monitor and provide preventative maintenance such as passivating or pickling of the stainless steel.	D	2	Medium
Effluent discharges in close proximity to recreational areas	D	4	High	The existing discharge point is unknown. Investigations into the outfall location shall be undertake to determine the discharge location. Outfall to be replaced if required.	D	2	Medium