

Byron Shire Council

Ocean Shores to Brunswick Valley STP Transfer Feasibility Study

November 2016

Executive summary

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.4 and the assumptions and qualifications contained throughout the Report.

The purpose of this Study was to examine the feasibility of transferring raw wastewater from the Ocean Shores catchment to the Brunswick Valley Sewage Treatment Plant (BVSTP). The ultimate objective of this strategy is to consolidate the treatment of wastewater at BVSTP from the combined catchments of Mullumbimby, Brunswick Heads and Ocean Shores. In this strategy, the existing Ocean Shores STP (OSSTP) will be decommissioned and the upgrade of OSSTP (identified as being required in the near future) will be avoided. This Study examined the feasibility of the proposed transfer, particularly from a process and financial point of view.

The population projections adopted for this Study were based on the latest estimates in the *Byron Shire Strategic Business Plan*¹ (2016).

This Study found that it is technically feasible to transfer the wastewater flows and loads from Ocean Shores directly to BVSTP for treatment. The transfer will require a 3.25 km common rising main to be extended, from immediately upstream of the existing OSSTP inlet, to BVSTP. This extension would make use of an easement that has been provisionally identified by BSC in previous work for the transfer of treated effluent from OSSTP to the Mullumbimby recycled water scheme (Council Resolution 06-759). Only one section of easement remains to be acquired.

Two sewage pump stations (SPS) currently transfer all wastewater from the Ocean Shores catchment to OSSTP. Of these, the larger (SPS 5009) has sufficient capacity to pump via the extended rising main to BVSTP. The smaller pump station (SPS 5004) will require a pump upgrade in order to meet requirements for the transfer to BVSTP. The SPS 5004 wet well will also require upgrading to accommodate the larger pumps. It is noted that an upgrade of SPS 5004 is currently planned by BSC as part of its asset renewal program and to meet operational requirements.

Other transfer options, including potential preliminary treatment (screening and grit removal) and dry weather flow balancing at OSSTP, followed by re-pumping to BVSTP, were considered. On a balance of factors, including anticipated least operational complexity and lower long-term costs, the direct raw wastewater transfer option from Ocean Shores to BVSTP is preferred.

The existing BVSTP does not have sufficient hydraulic capacity to treat current or future peak wet weather flows capable of being delivered to the plant from the combined Ocean Shores and existing connected catchments of Mullumbimby and Brunswick Heads. Consequently, for the Ocean Shores transfer to be feasible, the minimum required capacity upgrade at BVSTP must include additional hydraulic capacity at the inlet structure and inlet works, and a suitably sized lagoon-type wet weather flow storage facility. A constructed wetland is also recommended to provide an environmental 'buffer' for effluent 'polishing'. The wetland system would also treat any surplus wet weather flow discharged from the proposed wet weather storage facility. The proposed wetland will also have aesthetic value (e.g. as a bird habitat). It is recommended that alignment be sought between the licence requirements for BVSTP and those for Byron STP, which already includes a wetland.

In terms of mainstream treatment capacity, average dry weather flow (ADWF) estimates based on population projections indicate that the existing BVSTP design capacity (ADWF 3.8 ML/d)

¹ Prepared by Hydrosphere Consulting (Sept., 2016)

would likely be reached by 2025 on peak days (including adopted allowances for tourists), assuming the Ocean Shores transfer is implemented by that time. However, non-peak day ADWF estimates (nominally excluding tourists) for the combined catchments indicate that the existing BVSTP design capacity would be reached considerably later, indicatively in 2035-36. Peak day ADWF by 2035-36 was projected to be 4.3 ML/d (i.e. 15% over the existing design capacity). Therefore, in terms of dry weather flow treatment capacity, there is an opportunity to defer major capital works for process capacity augmentation at BVSTP by up to twenty years (to no later than 2035-36). However, this opportunity is subject to a number of risks associated with operating the existing plant close to its design capacity in the medium term (<20 years). Further study is recommended to enable BSC to better quantify, understand and evaluate these risks, assuming that deferment of capital expenditure for STP treatment capacity augmentation is a key issue.

Given that capital expenditure is likely to be constrained in the medium term (<20 years), the recommended option with lowest capital and whole-of-life costs (NPV) identified in this Study is Option 4. This option involves the transfer of wastewater from Ocean Shores to BVSTP and provision of an immediate minimum upgrade to deliver hydraulic, inlet works and wet weather flow handling requirements, as well as a tertiary wetland. The capacity augmentation of the major process units at BVSTP (i.e. bioreactor and clarifiers) will be deferred. Based on the current low-growth population projections for all three catchments (Mullumbimby, Brunswick Heads and Ocean Shores), a major capacity augmentation at BVSTP can be deferred until ca. 2035-36 at the latest. By then, the loading on the plant will reach 115% of design loads on peak days (including tourist loads) or close to 100% on non-peak days (excluding tourists). This deferral option carries an increased risk profile, which is expected to be acceptable to BSC, subject to further study for confirmation. It will entail a reduced capital budget of \$10.6 M, within an indicative timeframe of less than four years (i.e. by 2020-21). This estimate includes the cost of the raw wastewater transfer pipeline from Ocean Shores and includes \$3.75 M for project overheads, risk and contingencies. The capital cost (in 2015 dollars) deferred until 2035-36 will be \$22.7 M. The Net Present Value (NPV) of Option 4 is estimated to be \$35.9 M, which represents a significant saving of \$12.6 M in whole-of-life terms, compared with the base case (lowest risk) option.

The base case option identified in this Study (Option 1) is the implementation of the transfer of raw wastewater from Ocean Shores and full capacity augmentation at BVSTP. This option has the lowest risk profile and includes provision of wet weather storage, a tertiary constructed wetland and sufficient hydraulic and process treatment capacity for at least the next 30 years (until beyond 2045), based on current adopted population and flow projections. This option will require an estimated capital budget of \$33.2 M, within a timeframe of less than four years (indicatively by 2020-21). This estimate includes the cost of the raw wastewater transfer from Ocean Shores as well as an allowance of \$11.8 M for project overheads, risk and contingencies. The Net Present Value (NPV) of Option 1 is estimated to be \$48.5 M. Option 1 is not recommended unless the risks associated with other options (involving deferral of a portion of the capital costs for BVSTP capacity augmentation) are found to be unacceptable.

The proposed STP consolidation strategy (Option 4) was compared with the alternative strategy (i.e. retaining both STPs and upgrading Ocean Shores STP with provision for future treated effluent transfer from the latter to Brunswick Valley for water recycling purposes). For all options considered at BVSTP, the proposed strategy had the lowest whole-of life cost (NPV). Depending on the preferred option (i.e. extent to which capital investment for capacity augmentation at BVSTP is deferred) and related assumptions, the proposed strategy has the potential to save between \$5 M and \$18 M in NPV terms, compared with the alternative strategy.

This Study makes a number of additional recommendations, relating to aspects such as: future environmental licence requirements; assumptions regarding future water recycling; and the need to better understand key project risks. These recommendations should be given due consideration prior to (or as part of) the implementation of any project arising from this Study.

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Disclaimer

This report: has been prepared by GHD for Byron Shire Council and may only be used and relied on by Byron Shire Council for the purpose agreed between GHD and the Byron Shire Council as set out Sections 1.3 and 1.4 of this report.

GHD otherwise disclaims responsibility to any person other than Byron Shire Council arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The inclusion of safety in design principles within legislation means that it is no longer sufficient to assume that compliance with a code or standard is enough. Safety in design is only addressed on a high level as part of this planning study.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer to Sections 1.4 and 1.5). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared the preliminary cost estimates set out in Section 11 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD. These assumptions include but are not limited to the use of information from previous project experience, escalation based on information in the public domain and equipment price estimates from suppliers, some of which may be subject to exchange rate fluctuations.

The Cost Estimate has been prepared for the purpose of planning, including budget setting, and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the project can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

1. Introduction

1.1 Background

The existing Ocean Shores STP (OSSTP) was originally built in the 1980s, with the last significant upgrade being in ca. 1995. Since that time the plant has had only minor capital works improvements, including the installation of one steel grit tank. The capacity of the existing IDEA process has been assessed at around 1.1 ML/d average dry weather flow (ADWF), excluding the original Pasveer channel, which is currently not used for mainstream treatment². The current ADWF treated at OSSTP is in the order of 1.3 ML/d, meaning that it is potentially operating slightly over its assessed capacity. The current equivalent population (EP) loading is estimated to be in the range of approximately 5,600 to 6,500 EP (based on ADWF (2012-14) and depending on unit flow assumptions) or around 5,800 EP from the latest population estimates (BSC, 2012). This compares with a nominal original design EP rating for the IDEA process of 6,500 EP. However, there are a number of operational issues at the plant that constrain capacity, including solids removal from the 'Catch Pond' after the Intermittent Aeration Tank (IAT), disinfection of by-pass flows from the tertiary lagoons/wetlands and limiting capacity of the existing sludge lagoons. Further background information is contained in a recent report for the OSSTP (GHD. 2014a).

Byron Shire Council (BSC) commissioned GHD (2014-15) to undertake a planning study to investigate the augmentation requirements for OSSTP. The planning study (GHD, 2014b) found that the plant could be upgraded at a cost in the vicinity of \$30 M, to provide capacity for 10,700 equivalent persons (EP). The proposed upgrade would align OSSTP with Council's STPs at (West) Byron and Brunswick Valley in terms of effluent quality and 'modern' treatment technology standards. The underlying population projections provided by BSC to GHD (2014-15) at the time indicated that a loading of 10,700 EP could be reached, indicatively, by 2040.

1.2 Need for further investigation

Further to the GHD (2014-15) planning study, BSC has indicated the need to investigate other alternatives to the augmentation of capacity at OSSTP. Some of the underlying drivers include:

- A capital cost of around \$30 M for OSSTP capacity augmentation would be significant and will need to be justified against a background of other alternatives having been assessed;
- Population growth in the Ocean Shores catchment has been re-assessed. Compared with those provided to GHD (2014-15) as the basis for the recent planning study, current population projections are similar in the medium term (next ten years), and slightly lower in the longer term (next thirty years). According to the latest information available to BSC, the projected population served by OSSTP might reach approximately 7,800 EP by 2025 and 9,100 by 2045 (compared with approx. 8,000 EP by 2026 and 10,700 EP by 2040 in the earlier projections used by GHD at a compound growth rate around 2% pa).
- The Brunswick Valley STP (BVSTP) is located relatively nearby to the OSSTP (less than approximately 3 km, subject to route) and is the newer of the two plants, having been built in 2009-10. There is sufficient space at the BVSTP site to provide additional treatment capacity by augmentation of the existing process. The questions of timing and ultimate

² The Pasveer channel is currently used to co-treat waste sludge from the Mullumbimby Water Treatment Plant (WTP) and leachate from the Myocum landfill. The use of the Pasveer channel for these purposes is under review by BSC. The channel is structurally in poor condition.

capacity of an augmented plant would need to be re-assessed in terms of actual vs. projected population growth.

- It is anticipated that economies (in both capital and operating costs) can be achieved by consolidating treatment at BVSTP and potentially ceasing (or minimising) operations at OSSTP in the long term. Careful consideration of the feasibility and costs of transferring sewage from Ocean Shores to BVSTP will be required.
- Previous work by BSC identified an easement for a pipeline from OSSTP to BVSTP to transfer treated effluent, for water recycling purposes (Council Resolution 06-759). The potential transfer of raw wastewater from OSSTP to BVSTP would replace the transfer of treated effluent but could utilise the same easement previously identified.

1.3 Purpose of this report

This report documents the outcomes of a feasibility assessment investigating the technical and cost implications of transferring wastewater from the Ocean Shores catchment to BVSTP. The report is intended to be used for planning purposes to assist BSC with strategic decisions around future capital works and management of its sewerage and wastewater treatment operations in the medium to long term.

1.4 Scope and limitations

Included in the scope of work for this Study are the following:

- Considerations around BVSTP treatment capacity augmentation requirements, including those for treating wet weather flows;
- Considerations around effluent (or raw wastewater) storage
- Considerations around tertiary wetlands prior to river discharge
- Definition and assessment of options for OS-BVSTP transfer pipeline aligned with BVSTP upgrade or capacity augmentation requirements (as defined in Sections 8.1 and 8.2 below)
- Capital and operating cost estimates (concept level) at sufficient level of details for comparison of options and preliminary budget-setting purposes
- Comparison of options on a Net Present Value basis
- One report (this document) to summarise the study, with recommendations

This report has been based on the latest population and flow projections provided by BSC in the form of the Byron Shire Developer Contributions Plan³ (2012) and Council's Strategic Business Plan⁴ (2016). The data provided has been interpreted and applied in consultation with BSC officers responsible for Utilities management and Water Infrastructure Services Planning. However, GHD is not able to verify the information provided by BSC and does not warrant that the information is correct.

This report has been based on additional information provided by BSC, including the existing plant data collated and summarised in Sections 2, 4 and 5. Whilst every effort has been made to ensure that the information used is consistent with GHD experience from similar projects, GHD is not able to check the information. GHD does not warrant that the information supplied is correct.

³ Incorporating Section 94 Contribution Plan and Section 94A Plan

⁴ Hydrosphere (2016). *Strategic Business Plan* prepared for Byron Shire Council by Hydrosphere Consulting, Sept. 2016, Table 5, p5.

This Study did not include a condition assessment of the existing BVSTP and related equipment.

This Study did not include a condition assessment or a review of the capacity of the existing BVSTP effluent outfall pipeline and/or related infrastructure.

No geotechnical investigation was undertaken for any of the sites (STP and proposed transfer pipeline route). For this Study it was assumed that expansion of the BVSTP site with additional infrastructure would be feasible for a treatment plant of similar design to that existing at this site. A detailed geotechnical investigation will be required prior to any detailed design or implementation of the project.

No additional site survey investigation was carried out as part of this Study. The site survey information used (STP and existing or proposed pipelines) was sourced from existing drawings provided by BSC.

This Study has focussed on BVSTP process capacity and its ability to absorb additional flows and loads from Ocean Shores. Hydraulics issues were addressed only in relation to the ability of this plant to treat wet weather flow from its existing catchments (i.e. Mullumbimby and Brunswick Heads) plus the proposed transfer from Ocean Shores. A detailed review of BVSTP internal hydraulics was not included in the scope of work for this Study.

No investigation of the urban and site reuse systems for recycled water from the STPs was undertaken as part of this Study

1.5 Assumptions

This Study was based on the following assumptions:

- Population projections as per the latest Strategic Business Plan⁵ (2016), as provided by Byron Shire Council
- Previous population projections obtained from studies in the period ca. 2003-2012, as listed in Section 2.1.1
- Unit flows per population equivalent as explained in Section 2.2.1
- Information from existing STP design reports and as-built drawings (Fulton Hogan/Cardno, 2010)
- Information on easement for previously proposed OSSTP-BVSTP effluent transfer pipeline and associated survey (conducted by B & P Surveys, 2012)
- Data and information collected from previous studies (GHD, 2014& b) for OSSTP
- Additional plant operating data supplied by BSC
- Existing environmental licence requirements (notably for BVSTP effluent quality) will
 remain unchanged in future, and that a renewed licence with the same effluent quality
 requirements will be issued by the NSW Environment Protection Authority (EPA) for a
 plant with expanded treatment capacity at Brunswick Valley.

⁵ Hydrosphere (2016). *Strategic Business Plan* prepared for Byron Shire Council by Hydrosphere Consulting, Sept. 2016, Table 5, p5.

2. Population and flow projections

2.1 **Population**

2.1.1 Approach for population projections

Population projections were adopted from a combination of sources provided by BSC, namely:

- GHD (2003) *Brunswick Area Sewerage Augmentation Concept Design and Detailed Investigations.* This report also formed the wastewater characterisation design basis (GHD, 2007) for the Brunswick Valley STP
- GHD (2008a) Brunswick Area Sewerage Augmentation Scheme Schematic Design Report, May 2008
- Byron Shire Council (2010) Population Projection for Mullumbimby and Brunswick Heads Water & Sewer Model. BSC internal document (June 2010)⁶
- Byron Shire Council (2010) Population Projection for Ocean Shores Sewer & Water Model BSC internal document (July 2010)⁷
- Byron Shire Developer Contribution Plan (2012) Incorporating a Section 94 Contribution Plan and a Section 94A Plan

Byron Shire Council *Strategic Business Plan*⁵ (2016)The GHD (2008a) *Brunswick Area Sewerage Augmentation Scheme Schematic Design Report* made reference to a flow reassessment and adoption of lower unit flow rates (per resident population or population equivalent) than those originally adopted in the GHD (2003) concept design investigations. These lower unit flow rates (290 L/EP/d) from the GHD (2008a) report were adopted here for the Low Growth scenario (see below) and the original (GHD, 2003) unit flow rates for the High Growth scenario (see below) for a more conservative estimate, allowing for high infiltration/ inflow (I/I).

The more recent Developer Contribution Plan (2012) had lower growth rates projected for the Ocean Shores catchment than the previous projections (in 2010) that formed the basis for the Ocean Shores Planning Study (GHD, 2014 a,b). Similarly, the previous population projections (GHD, 2003; 2007) had higher numbers of permanent residents than those from the more recent Developer Contribution Plan (2012). However, the Developer Contribution Plan (2012) did not give specific provision for tourists (overnight guests and day trippers) required to make up the peak season population estimates in the forward projections.

The most recent growth projections are sewerage system equivalent tenements (ET) taken from BSC's Strategic Business Plan (2016). These projections are from 2015 to 2045, being Council's current planning horizon. It was assumed⁸ that the ET projections in the Strategic Business Plan were based on peak populations, including tourists.

Accordingly, for the purposes of this Study, revised projections for the combined catchments were compiled using the following approach:

⁶ BSC Internal Technical Note: Ref. 24.2010.17.1/ENG703300/#977886

⁷ BSC Internal Technical Note 24.2010.17.1/ENG703300/#989427

⁸ The notes provided by Hydrosphere (2016) in the Strategic Business Plan (section 1.2) indicate a peak population of 34,500 people for 2014/15 (referencing DPI-Water, 2016a). The corresponding Sewerage ET adopted for 2015 (Section 1.2.1, Table 5 of the same report) was 15,148 ET (all areas), which gives approximately 2.3 persons/ ET. Since this ratio is a reasonable number, the assumption of peak population being included in the ET growth projections was considered to be reasonable. The permanent population for 2014/15 was stated as 20,500 people (i.e. a significantly lower figure).

• Mullumbimby and Brunswick Heads catchments:

- Peak population projections based on ET projections from the Strategic Business Plan (2016) and an assumption⁹ of 2.46 Equivalent Persons (EP) per ET.
- Tourist population numbers adopted as a median of high and low growth projections from previous estimates (GHD, 2003; BSC, 2010) – see references above. The tourist population numbers were assumed to be included in the population estimates derived from the Business Plan (2016) projections (see above), and only subtracted for the purpose of estimating non-peak day population numbers, excluding tourists (overnight and day trippers).

• Ocean Shores catchment:

- Population projections based on ET projections from the Strategic Business Plan (2016) and an assumption of 2.46 Equivalent Persons (EP) per ET.
- An assumption of negligible tourist (overnight guests or day trippers) contributions to loads for the Ocean Shores catchment¹⁰.
- Combined catchments:
 - By summation of the above for projection purposes when estimating the future STP upgrade requirements for the combined catchments.

2.1.2 Results of population projections for combined catchments

For the purposes of this Study, and in consultation with BSC¹¹, the *peak* population projections derived from the Strategic Business Plan (2016) were adopted (refer to Section 2.1.1). The adopted total population projections for the combined catchments are given in Figure 1. A further breakdown is given in charts and tables in Appendix A. Previous projections from a combination of sources (including the Developer Contribution Plan, 2012; and other earlier studies) are also given for comparative purposes.

2.1.3 Results of population projections for Ocean Shores catchment

If the catchments are not combined (i.e. sewage is not transferred from Ocean Shores to BVSTP, then OSSTP will need to be upgraded. A previous planning study (GHD, 2014a,b), followed by an Addendum report (GHD, 2016) to this Study, examined high and low population projections for the Ocean Shores catchment. The previous planning study (2014b) recommended a plant upgrade to a capacity of 10,700 EP, based on higher growth projections, compared with an upgrade to 7,100 EP based on lower growth projections in the draft Addendum report (GHD, 2016).

⁹ The EP/ET ratio of 2.46 was derived from 240 L/EP/d (design basis for Byron Bay STP) and the current BSC planning guideline of 590 L/ET/d (BSC, D Baulch email communication to GHD, 11 June 2015).

¹⁰ BSC (Dean Baulch) email communication to GHD (D de Haas, 10-11 June, 2015) – refer also to previous Planning Study for Ocean Shores STP, (GHD, 2014a,b). This assumption is not critical in that the exact location of tourist contributions to the three catchments (OS, BH & M) is not important from a planning perspective, following the transfer of combined flows from Ocean Shores to BVSTP, provided that the summed allowance for tourist numbers is appropriate.

¹¹ BSC (D Baulch (meeting with GHD (D de Haas) on 6 October 2016 in BSC offices.

Referring to Figure 2, it can be seen that the most recent population projections for Ocean Shores from the Strategic Business Plan (2016, see above), are higher than the original high growth projections (GHD, 2014a) in the short-medium term (up to ca. 2025) but follow a mid-trajectory in the longer term (2025 to 2045). Some further work might be required to resolve the discrepancies between current OSSTP flows and the previous and most recent population short-term projections. For planning purposes in this Study, the OSSTP upgrade strategy proposed in the GHD (2014b) planning study was considered to be appropriate, being a close match to the adopted population projections (from Strategic Business Plan, 2016).

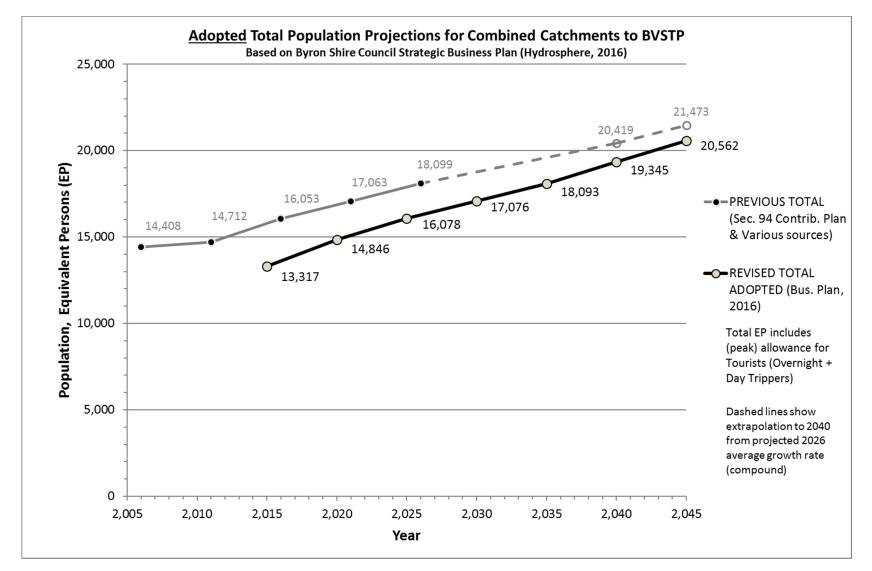


Figure 1 Adopted Total Population Projections - combined catchments of Brunswick Heads, Mullumbimby and Ocean Shores

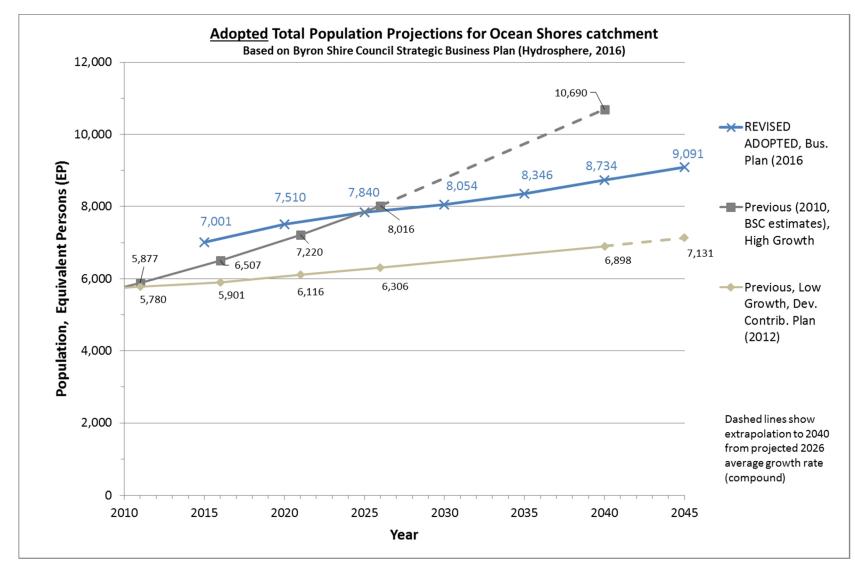


Figure 2 Adopted Population Projections for Ocean Shores catchment

2.2 Dry weather Flow

2.2.1 ADWF from population projections

Average dry weather flow (ADWF) projections were carried out using the adopted unit flow allocations per equivalent population, as given in Table 1.

Table 1	Adopted unit flow	s per equivalent	population of	r tenement

Catchment	Unit Flow per Equivalent Population (L/EP/d)	Approximate Unit Flow per Equivalent Tenement (Note 1) (L/ET/d)	Notes
Ocean Shores	240	590 to 624	Based on Planning Study (GHD, 2014a, b)
Mullumbimby	240 290	590 to 624 713 to 754	Design assumption From GHD (2005) ¹² , allowing for lower I/I
Brunswick Heads	240 326	590 to 624 802 to 848	Design assumption From GHD (2005) ¹² , allowing for slightly lower I/I
Overnight Tourists	200	492 to 520	From GHD (2003)
Day Trippers	30	74 to 78	From GHD (2003)

Note 1: For EP/ET ratio in the range^{13,14} 2.46 to 2.6. The adopted EP/ET ratio was 2.46.

The calculated ADWF based on peak season¹⁵ population projections is given in Figure 3 below. A breakdown of the projected flows is given in Appendix B. The results suggest that:

- Peak season ADWF from the Mullumbimby (M) and Brunswick Heads (BH) catchments currently connected to the BVSTP, which nominally includes Overnight Tourists and Day Trippers allowances, will reach 2.75 ML/d by 2045 (i.e. about 72% of the existing plant design ADWF of 3.8 ML/d), assuming a design unit flow rate of 240 L/EP/d. If additional allowance in the unit flow rate is made for Infiltration/Inflow (I/I in the lower range 290 to 326 L/EP/d for the M and BH catchments, refer to Table 1), then the peak season ADWF is projected to reach 3.51 ML/d by 2045 (i.e. 92% of the existing design ADWF for BVSTP).
- Assuming the transfer of wastewater from Ocean Shores, as proposed in this Study is implemented, peak season ADWF from the combined Mullumbimby, Brunswick Heads and Ocean Shores catchments will reach 4.93 ML/d by 2045 at the adopted deign unit flow rate of 240 L/EP/d, or approximately 5.69 ML/d by the same date if additional I/I flow allowance is included for the M + BH catchments (see above).

¹² The GHD (2005) reassessed flows using lower I/I values formed the basis of the plant design (GHD, 2007).

¹³ An EP/ET ratio of 2.46 from 240 L/EP/d (design basis for Byron Bay STP) and current BSC planning guideline of 590 L/ET/d.

¹⁴ An EP/ET ratio of 2.6 from previous (BSC, 2010) population projections (see to reference in Section 2.1.1)

¹⁵ Peak season is taken as total adopted population estimates, including the full quota of Overnight Visitors and Day Trippers.

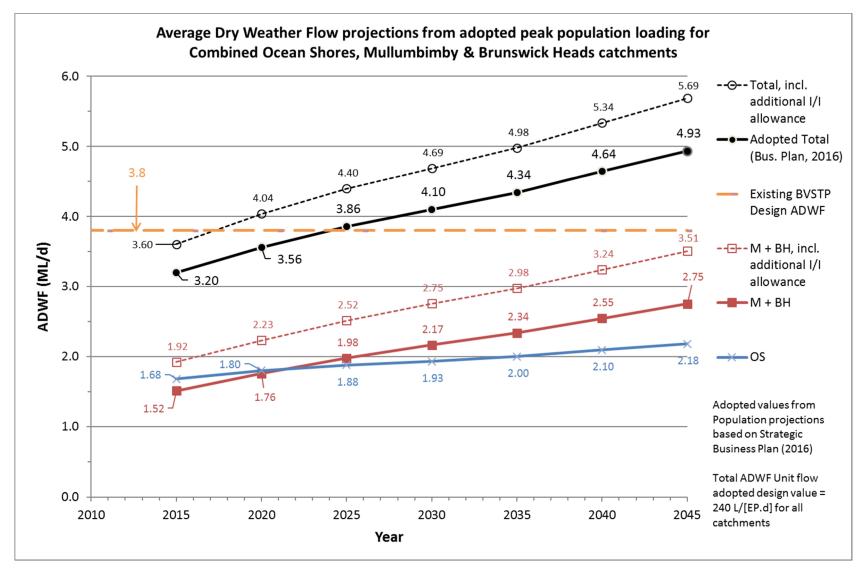


Figure 3 Average dry weather flow projections based on population projections and adopted design unit flow

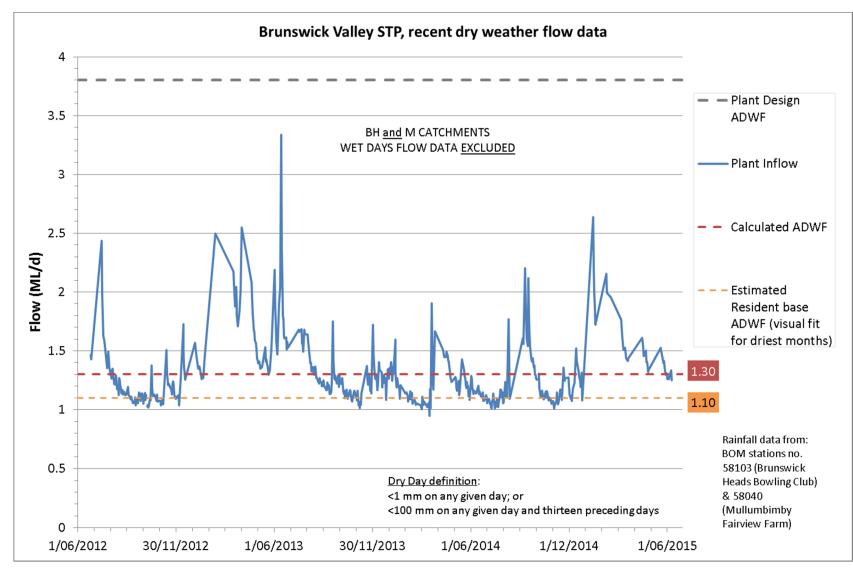


Figure 4 Recent (2012-15) dry weather flows received at BVSTP, based plant and rainfall records

2.2.2 Current plant ADWF

The current ADWF to the Ocean Shores STP (as assessed by GHD, 2014a) is approximately 1.3 ML/d (2014 data).

The current ADWF to the BVSTP was estimated based on recent (June 2012- June 2015) daily total flows recorded at the plant¹⁶ and matching rainfall records¹⁷ for the Mullumbimby and Brunswick Heads. Dry weather flow data was derived by filtering the data set to exclude wet days¹⁸. The results are shown in Figure 4 above. The data suggests that:

- ADWF on peak days during tourist season periods (typically mid-summer months, indicatively December-February) currently typically range¹⁹ approximately 1.5 to 2.0 ML/d. This agrees reasonably well with the estimates from population projections for the corresponding period, depending on the assumptions for I/I allowance (e.g. approximately 1.5 to 1.92 ML/d for 2015 refer to Figure 3 above).
- Outside of peak season (see above), ADWF typically ranges approximately 1 to 1.5 ML/d, and on the lower end of that range (1.0 to 1.3 ML/d) during the driest months refer to Figure 4). This matches reasonably well with the flow estimates for resident population only of the two catchments (M + BH, data not plotted in Figure 3 refer to Appendix B), excluding tourists and without additional I/I allowance (i.e. subtracting flow allowances of 0.43 ML/d and 0.07 ML/d respectively for Overnight Tourists and Day Trippers respectively from the projected ADWF of 1.51 ML/d derived from peak population projections and the adopted design unit flow rate of 240 L/EP/d). Therefore, it can be concluded that the projected ADWF based on adopted population and unit flow estimates are reasonable and reflective of typical conditions in the catchment in terms of average I/I allowance. Lower base dry weather flows would likely occur during the driest months, which are typically in the winter-spring period (Jul-Nov) when peak day contributions from tourists are also lowest.
- The coupling of flow projected from higher population projections and higher I/I allowance seems unlikely, based on the comparison between the projections for Mullumbimby and Brunswick Heads population numbers (refer to Appendix B), and current dry weather flows (Figure 4). However, the available data²⁰ suggest that peak single-day flows (nominally in dry weather) currently range from approximately 2.0 to 3.3 ML/d (i.e. approximately 1.3 to 2.2 times ADWF from population projections for 2015). Elevated plant daily flow totals in this range are likely due to lingering I/I effects from wet weather that were not effectively 'filtered out' of the dataset using the adopted definition of dry weather (refer to footnote¹⁴). The M and BH catchments are known to have significant ongoing I/I issues. It would therefore be prudent for the design of BVSTP (upgrade including OS transfer under review in this Study) to make a conservative allowance for clarifier capacity to handle peak wet weather flows (refer to Section 2.3), as well as lingering I/I effects on daily peak flows on dry days following wet weather.

¹⁶ Data supplied by BSC for the two plant inflow flow meters (i.e. one each on the two rising mains into the plant)

¹⁷ Bureau of Meteorology daily rainfall data for stations located at Fairview Farm (Mullumbimby) and Brunswick Heads Bowling Club respectively for the two catchments.

¹⁸ A wet day was defined as any day on which >1 mm was recorded in either of the two catchments, or any day on which the cumulative rainfall on that day plus the thirteen preceding days was >100 mm. The relatively long preceding period (thirteen days) applied was selected because of known Infiltration/ Ingress issues in the catchments (particularly Mullumbimby) and the associated 'tapering off' of flows to the sewers following significant rainfall events.

¹⁹ Ignoring peak day flows >2.5 ML/d that are probably due to lingering wet weather effects.

²⁰ Excluding one peak day flow (3.3 ML/d) that occurred in the dataset during Jun-2013 and appeared to be an outlier.

2.3 Wet Weather Flow

2.3.1 Design Peak Wet Weather Flows

Mullumbimby and Brunswick Heads

According to GHD (2008a), there are two existing main pump stations²¹ that deliver flow to the BVSTP in its current form, namely:

- PS 4000 serving the Mullumbimby sewerage scheme; and
- PS 2000 serving the Mullumbimby sewerage scheme

The design assumptions for these pump stations are summarised in Table 2.

Catchment served	Pump Station number	Design maximum flow rate, L/s (instantaneous or peak wet weather)	Wet well volume (kL) From Pump Stop Level to:	Notes
Mullumbimby	SPS 4000	156 L/s	Start (min.): 7 Start (max.): 14 Standby: 15.5 Alarm: 17 TWL: 23.2	Based on projected 2025 PWWF (130 L/s or 7ADWF) pumped over 20 hours in a 24- h period
Brunswick Heads	SPS 2000	158 L/s	Start (min.): 7 Start (max.): 14 Standby: 15.5 Alarm: 17 TWL: 27.6	Based on projected 2025 PWWF (132 L/s) pumped over 20 hours in a 24-h period
Total	(to BVSTP)	314 L/s 27.13 ML/d	-	-

Table 2 Design Information for Sewage Pump Stations delivering to BVSTP

Source: GHD (2008a)

The design flows in Table 2 match the instantaneous peak flow rates given in the design report for the BVSTP (Fulton Hogan, 2010), namely:

- Rising Main 1 ("Brunswick Raw Sewage"): 158 L/s
- Rising Main 2 ("Mullumbimby Raw Sewage"): 156 L/s
- Sub-total Raw Sewage: 314 L/s (or 7.1 times ADWF where ADWF = 3.8 ML/d)
- Return Activated Sludge (RAS included in flow via Inlet Works): 150 L/s
- Inlet Works (Total peak flow including peak RAS): 314 + 150 = 464 L/s

²¹ Both PS 4000 and PS 2000 were new pump stations, proposed and built at the same time as the new BVSTP (GHD, 2008)

The existing BVSTP is designed for (full) biological treatment at a sustained peak raw wastewater inflow rate of 5.8 times ADWF (255 L/s or 22 ML/d), subject to assumptions relating to the clarifier design (refer to discussion in Section 6.4.2 below). The (instantaneous) peak hydraulic raw wastewater capacity of the plant is 314 L/s.

Ocean Shores

According to the recent GHD (2014a,b) planning reports, the existing sewerage scheme for Ocean Shores has two pump stations that deliver wastewater to the Ocean Shores STP (OSSTP). These are listed in Table 3, along with the current rated capacity of these pump stations.

Catchment served	Pump Station number	Design maximum flow rate, L/s (instantaneous or peak wet weather)	Wet well volume (kL) From Pump Stop Level to:	Notes
Ocean Shores (northern, Kiah Close)	SPS 5009	252 (original pumps) 136 L/s for current pump installed (single pump) (Up to approx. 165 L/s for dual pump operation)	Start (speed 1): 12.9 Start (speed 2): 16.1 Start (speed 3): 19.3 Standby: 22.5 Alarm: 29.0 TWL: 64.4	Variable speed, Duty BEP from pump curve
Ocean Shores (southern, Rajah Rd)	SPS 5004	48 (single pump) (Approx. 62 L/s for dual pump operation)	Start: 2.8 Standby: 3.9 Alarm: 5 TWL: 11.2	Fixed speed, single Duty pump BEP from pump curve. Duty- assist operation is possible
Total	(to OSSTP)	300 (original pumps) Up to approx. 227 L/s for current pumps installed, with dual pump operation		Sum of design Duty BEPs from pump curves

Table 3 Design Information for Sewage Pump Stations delivering to OSSTP

Source: Flygt pump curves (Best Efficiency Point, BEP)

The nominal peak hydraulic capacity of OSSTP inlet works (as assessed by GHD, 2014a,b) is at least 270 L/s. However, this assessment noted that:

- The estimated peak capacity of 270 L/s is conservative, assuming that all the flow travels via by-pass weir and manual screen and allows for 232 L/s peak raw inflow²² plus 38 L/s of in-plant recycles. In practice, a higher capacity may be possible with some portion of the combined flow passing through the mechanical screen (partially blinded as a worst case scenario).
- The original inlet works (as built in 1996) was subsequently modified by installation of one vortex grit tank. The original inlet works (without grit removal) was rated for an instantaneous PWWF of 156 L/s (for a design ADWF of 1.92 ML/d or 8,000 EP), with the potential to ultimately double the treatment plant capacity to 16,000 EP. The ultimate design peak hydraulic capacity of the plant was not clearly defined in the original plant documentation, but presumably would be close to 312 L/s.

The limited dataset²³ used in the GHD (2014a,b) assessment of wet weather flows suggested that the cumulative maximum flow received over a defined period at the STP (i.e. sum of SPS 5009 and 5004 combined) was as follows:

- Cumulative maximum flow averaged over 24 h: 55.8 L/s
- Cumulative maximum flow averaged over 3 h: 106.0 L/s
- Cumulative maximum flow averaged over 2 h: 121.1 L/s
- Cumulative maximum flow averaged over 1 h: 135.6 L/s

2.3.2 Current Peak Weather Flow

Brunswick Valley STP

Figure 5 shows recent totalised daily flow data for BVSTP, including wet weather, with rainfall plotted on the same chart. It can be seen from this chart that:

- The plant is quite susceptible to high wet weather flows. This is a known issue²⁴ due to relatively high I/I, particularly in the older parts of the Mullumbimby and Brunswick Heads catchments.
- Sustained (i.e. daily total) flows have exceeded the plant design PWWF (sustained) for full biological treatment (22 ML/d), once during the three-year period observed here (i.e. 23.4 ML/d on 5/4/2013).
- Daily total flows during wet weather have exceeded approximately 4 times ADWF (15.2 ML/d) on at four days during the three-year period observed here (refer to Figure 5).
- Daily total flows have not exceeded the instantaneous peak design flow rate of the plant (27.1 ML/d) during the three-year period observed here.

Instantaneous flow data (from SCADA) during the period 22/6/2015 to 30/6/2015 (a minor wet weather event) did not exceed 180 L/s (15.55 ML/d). Refer to Appendix D.

Ocean Shores STP

Plant flow and rainfall data recorded at OSSTP in the period 2010-2014 is shown plotted in Figure 6. This figure shows that sustained (i.e. daily total) flows at OSSTP in this period during

²² Based limited flow meter data (GHD, 2014a) for the rising mains at the STP (SCADA data from 25/08/2014 to 28/08/2014), the maximum pump rates were found to be 62 L/s and 170 L/s for SPS5004 and SPS5009, respectively.

²³ Based limited flow meter data (GHD, 2014a) for the rising mains at the STP (SCADA data from 25/08/2014 to 28/08/2014), the maximum pump rates were found to be 62 L/s and 170 L/s for SPS5004 and SPS5009, respectively.

²⁴ Discussions with BSC Water & Sewerage technical staff (May 2015) indicate that the I/I issues in the older parts of the catchments are unlikely to improve significantly in the near future but new developments are less likely to suffer from the same degree of I/I.

wet weather did not exceed 13.5 ML/d (156 L/s). Average dry weather flow was assessed²⁵ in the range 1.3 to 1.4 ML/d for the 2010-14 period (GHD, 2014a).

Recent (2014) limited SCADA data showing instantaneous flow rates for SPS 5009 and 5004 are shown in Figure 7 and Figure 8 respectively (taken from GHD, 2014a). The data suggests that SPS 5009 achieved its full design capacity at maximum speed (on VSDs) during this period for the currently installed pumps, peaking at 170 L/s (compared with up to 165 L/s rated maximum capacity from the existing pumps, with dual pump operation, and theoretical system curves). SPS 5004 briefly recorded a peak of 61 L/s, which compares well with the rated maximum capacity of 62 L/s for dual pump operation.

²⁵ Dry weather definition: any day on which the cumulative total rainfall for that day and six preceding days (i.e. 7-day cumulative) was <2 mm.</p>

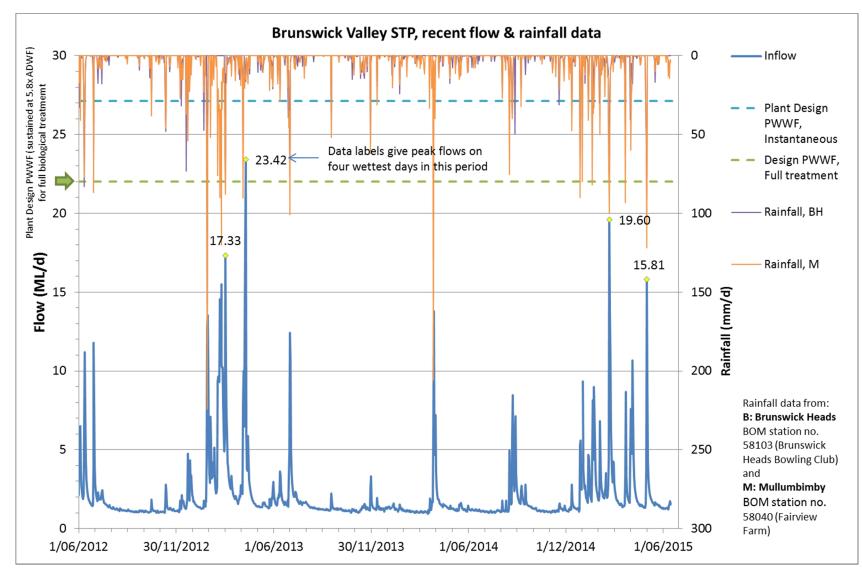


Figure 5 Recent (June 2012 to June 2015) daily total flow and rainfall data for BVSTP

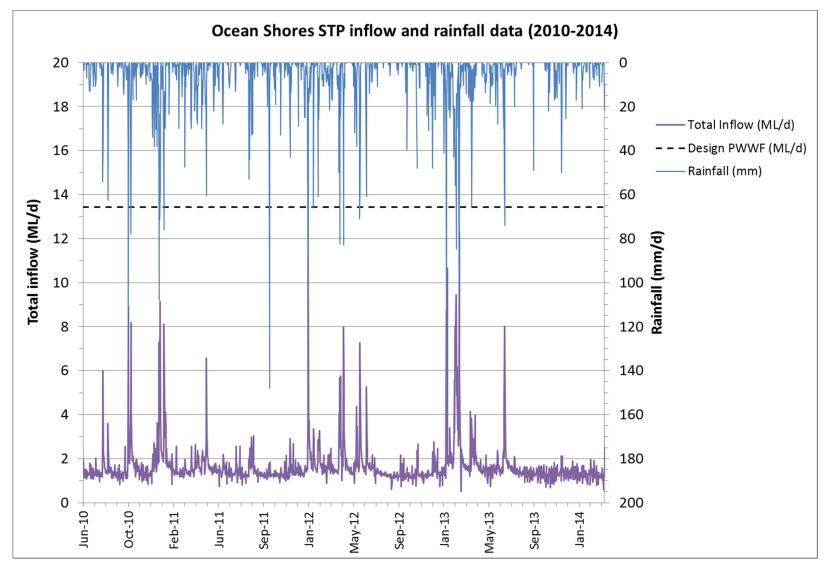


Figure 6 Daily total flow and rainfall data (June 2010 to Mar 2013) for OSSTP

Source: GHD (2014a)

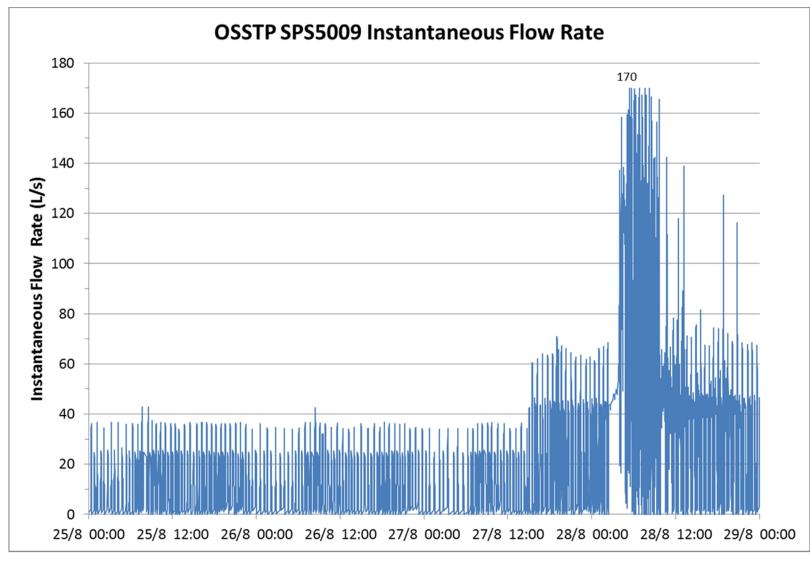


Figure 7 Instantaneous flow data (limited period 25-28 Aug. 2014) for Ocean Shores Sewage Pump Station 5009

Note: Design flow rate for this pump station (from pump curves) is 252 L/s (pumps equipped with variable speed drives)

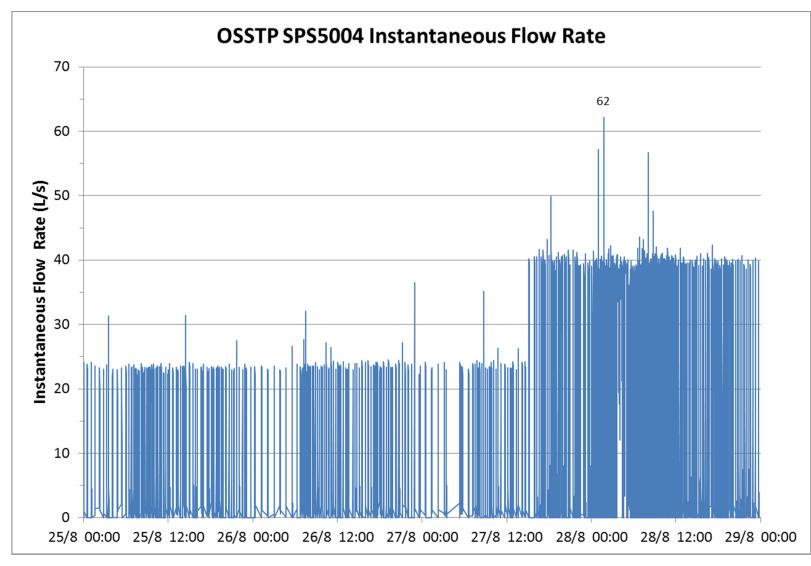


Figure 8 Instantaneous flow data (limited period 25-28 Aug. 2014) for Ocean Shores Sewage Pump Station 5004

Note: Design flow rate for this pump station (from pump curves) is 48 L/s for single pump operation (2 no. fixed speed pumps, duty-assist)

2.4 Average annual flow

Average annual flows²⁶ recorded at BVSTP during the period 1 June 2012 - 16 June 2015 are given in Table 4.

Table 4	Average BVSTP annual flows (1 June 2012 – 16 June 2015)
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Parameter	Value	Unit
Total flow	2 305.3	ML
No. of days in recording period	1 107	Days
Average annual flow (AAF)	761	ML/year
Average annual flow (daily basis)	2.08	ML/d
Total dry weather27 flow	765.2	ML
No. of dry days in recording period	590	Days
Average dry weather flow (ADWF, daily basis, from above)	1.30	ML/d
Ratio AAF/ADWF	1.60	-

²⁶ Based on BVSTP raw inflow meters on rising mains from PS1 (SPS2000) and PS2 (SPS4000) serving the plant

²⁷ Refer to definition in Section 2.2.2

3. Licence requirements

A copy of the NSW Environmental Protection Authority Environment Protection Licence (Version date 11 February 2013; or 'Licence') for the Brunswick Valley STP is provided in Appendix C. Key points are summarised below.

3.1 Flow limits

The licence is limited to a maximum flow of 22.04 ML/d to be discharged to water (or solids or liquids applied to the area). This equates to 5.8 times current design ADWF capacity (3.8 ML/d) refer to Section 4. Peak pumping capacity into the plant (refer to Section 2.3.1) is higher than this, equating to 7.1 times design ADWF. If the peak pumping capacity is sustained over one or more days, then the licence flow limit will be exceeded. To date, such a high flow event is not known to have occurred²⁸.

If Ocean Shores wastewater flows are transferred to BVSTP, the maximum daily (total) flow is likely to increase by at least 12 ML/d for the existing catchments (refer to 2.3.2). A new Licence will need to be negotiated for the BVSTP.

For this report, it was assumed that BSC will negotiate a new future licence for the plant, if and when required. For the purposes of this Study, it was assumed that the plant will be upgraded in a manner that is similar to the current design philosophy for BVSTP as a conservative starting position. The maximum daily flow limit for the new licence would need to be revised to at least 5.8 x 5.7 ML/d (33 ML/d) to consistent with the existing plant design philosophy.

For this Study, it was assumed that in future, a peak (instantaneous) hydraulic capacity (or flow limit) will be designed to accommodate the revised peak raw wastewater pumping capacity, including Ocean Shores. The combined peak pumping capacity of the four raw wastewater pump stations feeding the consolidated upgraded BVSTP (i.e. serving Ocean Shores, Mullumbimby and Brunswick Heads catchments - refer to Section 2.3.1) may be up to 614 L/s (refer to Sections 2.3.2 and 8.1.1). This amounts to seven times design ADWF if BVSTP dry weather capacity is nominally doubled to 7.6 ML/d. A lower design ADWF capacity (e.g. 5.7 ML/d) is likely to be sufficient at current population growth rates. This means that the apparent ratio of peak wet weather flow to design ADWF is likely to be higher (around 9 times ADWF). The plant upgrade strategy and peak wet weather flow management is discussed in Section 7.

3.2 Load limits

The annual mass load limits shown in Table 5 apply to the BVSTP effluent.

²⁸ The highest flow event (daily total flow) in the most recent period for which data was examined in this Study (refer to Section 2.3.2) was 23.42 ML/d on 5/4/2013. Prior to that, during the two-year Process Proving Period (26 Feb. 2011 to 11 Jan 2013) following plant commissioning, the maximum daily flow recorded was 13.8 ML/d.

Assessable Pollutant	Annual Load Limit (kg)	Equivalent Average Concentration (mg/L) at:			
		ADWF = 3.8 ML/d	AAF = 6.08 ML/d (Note 1)	ADWF = 5.7 ML/d	AAF = 9.12 ML/d (Note 1)
BOD	15,818	11.4	7.1	7.6	4.8
Total N	15,818	11.4	7.1	7.6	4.8
Total P	475	0.34	0.21	0.23	0.14
Total Suspended Solids	23,726	17	11	11	7
Oil & Grease	3,163	2.3	1.4	1.5	<1

Table 5 Brunswick Valley STP existing licence mass load limits

Note 1: Values for estimated Annual Average Flow (AAF) assuming AAF = 1.6 * ADWF (based on 2012-14 data), refer to Section 2.4.

Except for Oil & Grease (O&G), the concentrations of pollutants back-calculated from the load limits are within the envelope of licence/design concentrations and/or current plant performance (refer to Sections 3.3 and 4 below). In the case of O&G, the back-calculated concentration limits are lower than the tabulated concentration licence and design limits (refer to Table 6 and Section 4). This appears to be an anomaly. The back-calculated concentration limits (Table 5) imply that final effluent O&G will need to be at or near typical detection limits for this parameter.

It is noted from Table 5 that to meet current licence load limits, the required concentrations decrease in future as plant population loads and flows increase. Alternatively, a new licence with increased load limits will need to be negotiated.

3.3 **Concentration limits**

The concentration limits tabulated in Table 6 apply to the BVSTP effluent.

Pollutant	Units	90 th percentile concentration limit	100 th percentile (Maximum) concentration limit
BOD	mg/L	10	15
Faecal coliforms	cfu/100 mL	200	600
Ammonia	mg/L as N	2	4
Total N	mg/L as N	10	15
Oil & Grease	mg/L	5	10
рН	pH units	-	6.5 (Min.) to 8.5
Total P	mg/L as P	0.3	1
Total Suspended Solids	mg/L	15	30

Table 6 Brunswick Valley STP existing licence concentration limits

Note: Tabulated values from the licence apply to the effluent discharge to receiving waters i.e. discharge pipe on eastern arm of western billabong of Brunswick River (Licence 'Point 1').

3.3.1 Note on disinfection requirements

A constructed wetland (downstream of secondary effluent UV disinfection) has been included in the proposed concept for BVSTP upgrade associated with the transfer of flow from Ocean Shores in this Study (refer to Section 8.2.14). The requirement for additional (tertiary) disinfection downstream of the proposed wetland is uncertain and subject to NSW EPA requirements for licensing of the upgraded plant, including the proposed transfer.

Depending on the outcome of future EPA licence requirements, it might be necessary provide tertiary disinfection downstream of the proposed wetland. However, for the purposes of this Study, it was assumed that this will not be necessary and no inclusion for this has been made in the costs estimates (Section 11). It was assumed that the future (new) Environmental Protection Licence (EPL) requirement for the BVSTP plant will be similar to the existing EPL for the Byron STP, where the point of compliance for effluent quality (including bacteriological quality i.e. faecal coliforms) is at the discharge to the wetland (i.e. downstream of secondary treatment effluent UV disinfection but upstream of the wetland).

3.4 Biosolids limits

The licence requires that biosolids at the premises must be stored, treated, processed, classified, transported and disposed in accordance with the (NSW) 'Biosolids Guidelines' (Use and Disposal of Biosolids Products), or as otherwise approved in writing by the EPA.

3.5 Odour

The licence does not identify a 'potentially offensive odour' (or odour source) at the STP. However, the licence notes that Section 129 of the NSW Environment Operations Act (1997) provides that BSC ('the licensee') must not cause or permit the emission of any offensive odour from the premises. Provisions are also made for cases where an odour is identified as being 'potentially offensive' and the odour was 'emitted in accordance with the conditions of a licence directed at minimising odour'. An example would be failure of odour mitigation or odour control systems at the plant, in which case BSC would be required to make a defence to the EPA.

4. Existing plant capacity

4.1 Design loads

The BVSTP is designed for loadings as summarised in Table 7.

Fulton Hogan (2010) noted the following for the adopted design loadings

- Nutrient ratios (i.e. TKN/COD or TP/COD) are typical or 'average' for (domestic) sewage
- The sewage is 'well fermented' in the sewers with a (relatively) high biodegradable COD content that is favourable for biological nutrient removal
- Estimated sulphide concentrations are (relatively) high, presenting both odour and corrosion risks that need to be controlled.

Parameter		Value	
50%ile Loads:	Loa		Concentration
Flow (ADWF)	3.8 N		
COD	2050	540 mg/L	
TKN	205	kg/d	54 mg/L
TP	38 k	g/d	10 mg/L
TA		-	230 mgCaCO ₃ /L
SO ₄		-	37 mg/L
Sulfide (estimated generation in sewage		-	2-5-9 mgS/L
rising mains at 19-24-29 degC)			
Peaking Factors (x 50%ile):	90%ile	Peak Rate	Diurnal Peak
Flow:			
Hydraulics			
Sustained		5.8	
Instantaneous		7.1	
Process	1.3	7.1	2
COD mass load	1.3		2.5
Peak flow rate:			l
Sustained	255 l	/s; 920 m3/h	; 22 ML/d
Instantaneous	314 L	/s; 1120 m3/l	h; 27 ML/d
50%ile Sewage Characteristics:			
COD/BOD		2.4	
Unbiodeg soluble COD / total COD, fus		0.05	
Unbiodeg particulate COD / total COD, fup		0.20	
RBCOD / CODtotal, fbs		0.15	
TKN/CODtotal		0.100	
TP/CODtotal		0.019	
Unbiodegradable soluble N fraction, fnus	0.035 (raw	, decreased b	y alum dosing)
ML Temperature (min-ave-max)		19-24-29 de	
, , , ,			-

Table 7 Design loadings for existing BVSTP

Source: Fulton Hogan (2010) Design Report

4.2 Hydraulic capacity

The STP is capable of simultaneously receiving the maximum instantaneous pump flow rates from both the Mullumbimby and the Brunswick Heads sewage systems as follows (refer to Table 2 and Section 2.3.1):

- Mullumbimby: 156 L/s
- Brunswick Heads: 158 L/s
- TOTAL: 314 L/s

The hydraulic capacity of Brunswick Valley STP augmentation is based on the following criteria:

The inlet works is designed to accept a flow of 7.1 x ADWF and provides mechanical screening and degritting of this flow. A full flow bypass channel around the mechanical screens, with manually raked screen, is provided.

The biological treatment stage (oxidation ditch and clarifiers) is designed for 7.1 x ADWF hydraulic instantaneous peak flow, or 5.8 x ADWF sustained peak flow, is designed for reduction of nitrogen and phosphorus.

The UV disinfection stage is designed to provide effective reduction of effluent coliforms at a flow of 3 x AWDF, and the hydraulic capacity of the UV disinfection stage is 7 x ADWF.

The plant hydraulic profile shows that:

- Return Activated Sludge (RAS) is recycled to the upstream end of the inlet works, presumably to provide for screening of the RAS. This is somewhat unusual; no additional RAS screen is provided and the hydraulic gradeline through inlet works includes the peak RAS flow allowance of 150 L/s.
- There is no by-pass facility around the bioreactor to the clarifiers²⁹ (i.e. if peak flows into the plant exceed 5.8 x ADWF on a sustained basis, these flows will continue to flow via the bioreactor to the clarifiers and will potentially cause solids loading 'stress' on the clarifiers (beyond their design sustained solids loading rate). Similarly, short-term instantaneous peak flows (>5.8 x ADWF) will increase short-term solids loading rates on the clarifiers beyond the design sustained solids loading rate.
- The differential top water level between the feed channel downstream of inlet works and the bioreactor (oxidation ditch) outlet channel is 0.16 m (i.e. <0.2 m). This is very limited with little or no opportunity for the potential retrofit of a bioreactor by-pass channel as described above. Furthermore, in the current arrangement, any by-pass from the downstream end of inlet works will include RAS, thereby defeating the purpose of the by-pass. A raw wastewater reactor by-pass (without RAS) would be required to reduce solids loading rate on the clarifiers. This would require modification of the hydraulic profile with a new splitter structure upstream of the existing inlet works with additional considerations around the question of screening by-pass flows.
- Flow gravitates out of the plant from the clarifier launders, via the UV disinfection system, then to the plant outlet manhole and effluent discharge pipeline. It is ultimately discharged to the 'oxbow lake' in the Brunswick River. Total head loss from the clarifier launder to the UV outlet overflow channel is approximately 1.16 m, and from the UV outlet overflow channel to the effluent outfall pipeline to river (at average high tide) is approximately 2.62 m. The UV and outfall systems have been designed to take into account prevailing flood levels on the site (refer to Section 4.3). For example, the UV reactor top-of-concrete level

²⁹ The (West) Byron STP (BSTP) plant, by comparison, has a by-pass facility from inlet works directly to the clarifier feed for flows >3 ADWF (adjustable weir), which reduces clarifier feed solids concentration and loading rates during PWWF events. In other respects the BVSTP and BSTP designs are similar.

is at Reduced Level (RL) 6.100 m Australian Height Datum (AHD), which allows for a freeboard of +2.8 m above the 100-year Average Recurrence Interval (ARI) flood level. However, the effluent outlet manhole and discharge pipeline are below this flood level and expected to be inundated in such a flood condition.

4.3 Flood levels

According to the Fulton Hogan (2010) design report, all buildings, critical facilities and tankage are designed to be protected from a 100 year ARI flood level of RL 3.30 m AHD and with a freeboard of not less than +1.0 m generally and +1.2 m for electrical equipment.

The design report further stated that the specification for the plant required the cross sectional area of the new STP to be limited to 50% of the area above existing ground level and ARI 100 flood level of 3.3 m. The plant layout exceeded 50% of the cross sectional area. Byron Shire Council arranged for a new flood model to be prepared to determine the effect of the plant layout on the flood level at Mullumbimby. The model determined that the plant layout had no measurable effect on the flood level.

4.4 **Process units**

Process unit details for BVSTP are contained in the Fulton Hogan (2010) design report and have not been repeated here. In summary, the treatment process consists of the following units:

- Mechanical step screen (1 no. 3 mm nominal aperture), with manual by-pass screen (1 no., 25 mm aperture)
- Vortex tank for grit removal (1 no., 3.35 m top diameter air-lift grit pump to 1 no. mechanical classifier)
- Ferric sulphate dosing facilities at inlet works for sulphide (odour and corrosion) control
- Four air extraction and treatment from inlet works (nominal 15 air changes per hour) for odour control via a biofilter (gravel/compost media bed)
- Anaerobic reactor (3 no. compartments in series, 10% overall biological mass fraction)
- Oxidation Ditch (6 m wide, 4 m deep, 139 m circuit length), 21 h nominal HRT, 20 day SRT, with submersible banana-blade mixers for mixed liquor circulation
- Diffused aeration (2 no. duty/1 no. standby positive displacement blowers, each 30 kW and 1005 Nm³/h nominal maximum airflow rate each; maximum SOTR 175 kg/h; turndown 5:1)
- Clarifiers (2 no. 23 m diameter secondary clarifiers, 3 m side water depth)
- RAS system (2 no. pumps per clarifier, max. total RAS rate 3.5 times design ADWF)
- Waste activated sludge (WAS) to aerobic digester
- Scum pumps from clarifiers to Oxidation Ditch
- UV disinfection
- Effluent systems
 - Site Service Water
 - Off-site reuse (1.9 ML storage tank on site for optional transfer to Mullumbimby see below)
 - Transfer Pump Station (2 no. pumps, 22 L/s each or 0.5 times design ADWF) to Mullumbimby effluent storage facility (dam)
 - Effluent discharge to Brunswick River

- Biosolids treatment
 - Aerobic Digester (292 kL; 20 day solids retention time)
 - Sludge dewatering via one gravity drainage deck/belt filter press (1.2 m effective belt width; 35 h/week operation at design loading)
 - Filtrate return pump station
 - Ancillary equipment
 - Polymer dosing system
 - Compressor
 - Conveyors
 - Sludge storage (covered area, six bays for up to one month dewatered biosolids storage at design load)
- Chemical dosing equipment
- Site Drainage Pump Station (2 no. pumps, 10 L/s each)

4.5 Clarifier capacity

The existing circular clarifiers (2 no. 23 m diameter) were designed more 'aggressively' than the (West) Byron STP, which has largely the same process configuration as the BVSTP. The main difference lies in the design sludge settleability assumptions – refer to the discussion in Section 5.1.3 below. A summary comparison of the clarifier capacities of the two plants, on a relative basis, is given in Table 8.

Although not outside the design range encountered for secondary clarifiers in general, the BVSTP clarifiers are at the higher end of the range for design peak overflow and/or solids loading rate typically used for biological nutrient removal (BNR) plants. BNR plants tend to have less favourable sludge settleability than some other types of activated sludge systems that tend to have higher organic loading rates and less apparent negative impact from nitrogen removal biological processes on sludge settleability. The sludge settleability at BVSTP is discussed in Section 5.1.3 below and has been found to be worse than expected. It was postulated by Hartley (2013b), that, during the plant process proving period, settleability will improve as the plant approaches design loading. However, this was speculative on the basis that the prevailing dissolved oxygen concentration (evidenced by the ammonia/nitrate ratio as a surrogate measure of anoxic fraction in the oxidation ditch) is the main underlying cause of relative poor settleability. On-going septicity (high dissolved sulphide) of the raw influent at BVSTP is a factor that could be contributing to the poor settleability. This is not likely to change with plant loading, and could, in fact, deteriorate with the transfer of raw wastewater from Ocean Shores (longer rising mains).

For low effluent (total) suspended solids concentrations (<10 mg/L), clarifier design procedures that adopt relatively poor sludge settleability as a design basis, typically suggest peak overflow rates of <1 m/h and <7.5 kg/(m².h) including RAS. These values compare with 1.1 to 1.4 m/h and 7.9 to 10 kg/(m².h) respectively for BVSTP (refer to Table 8). The more aggressive design for the BVSTP clarifiers is likely to be the reason behind anecdotal operator reports that the plant experiences difficulty with solids loss under peak flow conditions – refer to Section 5.1.3 below.

Therefore, a more conservative approach for the future augmentation of clarifier capacity at BVSTP is recommended.

Design parameter	Units	BVSTP	(W)BSTP	Notes
Number of clarifiers	No.	2	2	
Diameter, each	m	23	33	
Area, each	m2	415	855	
Area, total	m2	831	1711	
Design Stirred SVI, 90%ile	mL/g	59	90	
Design MLSS, Peak (90%ile)	mg/L	4,900	3,900	
Design ADWF	ML/d	3.8	6.95	
Maximum design hydraulic flow (instantaneous)	(xADWF)	7.1	7	
Peak design process flow for full treatment	(xADWF)	5	3	
Mixed liquor by-pass	-	No	Yes	
Max. RAS ratio at peak flow	(xADWF)	3.5	2	
Peak surface solids loading rate at maximum hydraulic loading rate incl. RAS	kg/(m².h)	9.9	5.9	Without reactor mixed liquor by-pass operating
	kg/(m².h)	N/A	2.5	With reactor mixed liquor by-pass operating (>3 ADWF)
Peak surface solids loading rate for full treatment incl. RAS	kg/(m².h)	7.9	3.3	
Peak overflow rate	m/h	1.35	1.19	At max. hydraulic flow rate
	m/h	0.95	0.51	At peak process design flow rate (full treatment)

Table 8Comparison of design basis for existing Brunswick Valley and
(West) Byron STP clarifiers

BVSTP: Brunswick Valley STP

(W)BSTP: (West) Byron STP

5. Existing plant performance

5.1 **Previous reports**

5.1.1 Overall performance

The performance of BVSTP after commissioning was extensively documented during the process proving/ defects liability period over two years from ca. Feb. 2011 to Feb. 2013. This information has been reported³⁰ to and saved by BSC.

In summary, these reports showed that the plant achieved very good performance with compliance in most respects relative to contractual (i.e. 'specified') design targets, which were based partly on the Licence requirements at the time. A summary of the results is given in Table 9 and Table 10 below.

It is worth noting that effluent concentration limits for Faecal Coliforms are only listed in the current EPA Licence (refer to Section 3.3) for river discharge, and correspond with those listed in Table 9. The more stringent Faecal Coliform limits listed for "UV effluent" in Table 9 are driven by BSC internal specifications for water recycling (i.e. not listed in the EPA licence).

The results in Table 9 show that actual plant loading during the two-year process proving period was generally within the design specifications. The maximum daily total flow (in wet weather) was 13.8 ML/d (compared with design 22 ML/d) and average flow <2 ML/d (compared with design ADWF 3.8 ML/d). In terms of flow, the plant was therefore only loaded to <52% of its design capacity during this time. The raw wastewater concentrations were close to the adopted design values, with the nutrient ratios (COD/BOD; TKN/COD; and TP/COD) on average being slightly more favourable for nutrient removal than the adopted design values. In COD mass load terms, the plant was operating at only about 42% of its design capacity on average, although the constraints around the accuracy of raw wastewater sampling (for concentrations) makes this estimate less certain.

The results in Table 10 show that the plant was generally compliant with the specified effluent quality design targets. The following effluent quality exceedance issues were noted (figures in red in Table 10):

- Maximum ammonia and Total P limits (for river discharge)
- Maximum Faecal Coliforms limit for river discharge
- Maximum Faecal Coliforms limit for UV effluent
- 90%ile Faecal Coliforms limit for service water

5.1.2 Wet weather event

The reports during the process proving period made reference to one wet weather incident in late January 2013 (when the maximum daily flow of 13.8 ML/d was recorded). During this incident, the plant suffered gross loss of biomass from the clarifiers due to an operational control error (under diurnal control) in which the RAS ratio³¹ fell to 0.2. This incident occurred during a non-sampling period and therefore the expected high suspended solids concentration in the effluent was not measured. However, the bioreactor MLSS concentration dropped significantly

³⁰ Process Report Nos. 1 to 17 and *Process Tuning Guidelines* prepared by Ken Hartley for Byron Shire Council (dated March 2011 to February 2013).

³¹ Note: Design RAS ratio (s) as follows: s= 0.6 at sustained PWWF = 5.8 x ADWF; or minimum s=0.49 at instantaneous PWWF = 7.1 x ADWF.

from 3,100 to 2,100 mg/L. To recover, sludge wasting from the bioreactor was suspended for eleven days.

5.1.3 Sludge settleability

The plant clarifiers were designed with the following assumptions:

- 50th percentile (50%ile) Stirred Sludge Volume Index: 55 mL/g with alum dosing
- 90th percentile (90%ile) Stirred Sludge Volume Index: 59 mL/g with alum dosing (equivalent³² to 103 mL/g unstirred SVI)
- 50th percentile MLSS: 3,800 mg/L (90th percentile MLSS: 4,900 mg/L)
- Clarifier peak overflow (surface loading) rate 1.1 m/h

The failure analysis using flux theory given in the BVSTP design report³² shows that, at design values of 50% MLSS, 90% SSVI and max. RAS rate of 154 L/s, the clarifiers (2 no. online) were expected to 'fail' (in terms of clarification performance) at a peak flow of 323 L/s (1163 m³/h). This peak flow is only slightly over the design instantaneous peak inflow rate for the plant (314 L/s) – refer to Table 2. The inference is that at a prevailing settleability close to SSVI 90 mL/g (design 90% ile), there is little or no factor of safety in the design for the clarifiers to handle the instantaneous peak flow (314 L/s or 7.1 x ADWF). The clarifiers are only rated for a sustained maximum flow rate of 255 L/s (5.8 x ADWF) for full clarification (biological treatment).

The Design Report (Fulton Hogan, 2010) noted that the adopted sludge settleability for BVSTP was based on data from (West) Byron STP (BSTP). This data showed better settleability at BSTP than the original design, namely:

- BSTP actual 50th percentile SSVI = 53 mL/g with alum (c.f. BSTP 50%ile design³³ value 90 mL/g,)
- BSTP actual 90th percentile SSVI = 59 mL/g with alum (c.f. BSTP 90%ile design value not stated)
- BSTP design median (or 50%ile) MLSS = 3,000 mg/L
- BSTP clarifier peak overflow (surface loading) rate³⁴ = 0.51 m/h at 3 x ADWF

Notes in the Design Report³² indicate that the BVSTP clarifier design is "*basically a scaled down West Byron (design) with increased SRT and higher MLSS to compensate. The clarifiers can handle the full flow from the reactor because of the improved SSVI (60 c.f. 90 mL/g)*".

During the process proving period (2011-2013), it was shown that settleability at BVSTP was <u>not</u> as good as at the Byron plant. Refer to Figure 9. The long-term SSVI ranged typically 75 to 90 mL/g (i.e. the observed median or 50%ile exceeded the design 90%ile assumption of 59 mL/g). Similarly, the (unstirred) SVI typically ranged typically approximately 150 to 225 mL/g (i.e. significantly higher than the design 50%ile assumption, see above). Therefore, it can be expected that subject to actual sludge settleability and bioreactor MLSS, the BVSTP clarification capacity could be compromised under peak flow conditions. This aspect was discussed in Section 4.5 above.

The final process proving report (Hartley, 2013b) concluded that:

 Sludge settleability was worsened by low plant loading, leading to a low dissolved oxygen (DO) setpoint for operating the oxidation ditch (i.e. a relatively high anoxic fraction or

³² Fulton Hogan (2010) Design Report for BVSTP (Appendix B).

³³ Refer to John Holland/ Cardno (2005) Design Report for (West) Byron STP.

³⁴ The BSTP Design Report (see above) notes that the clarifiers at the Byron plant were conservatively designed in terms of area and surface loading rate for a low effluent suspended solids.

ammonia/nitrate ratio, which was theorised to stimulate growth of filamentous bacteria and 'sludge bulking')

- Under the prevailing load, a minimum SVI of about 170 mL/g (SSVI about 80 mL/g) is achieved at a DO setpoint of 0.3 mg/L
- Sludge settleability would improve as plant loading approaches design load (speculative, based on theory and data presented).

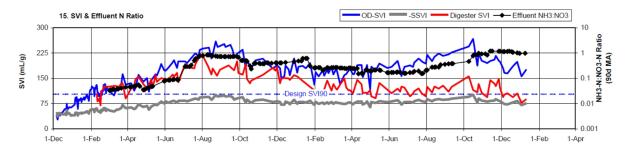


Figure 9 Long-term (2011-2013) settleability data for BVSTP

Source: Hartley (2013b). Note "Design SVI90" (90th percentile SVI) horizontal line plotted at 103 mL/g.

Paramete	er	Design	Average Lo	ad to Date ¹
			17-Nov-12 to 11-Jan-13	26-Feb-11 to 11-Jan-13
Mass Load				
Rainfall	total mm		237	3170
Raindays / total days Flow:			21 / 56	247 / 686
Mullumbimby	ML/d		1.18	1.48
Brunswick Heads	ML/d		0.65	0.55
Total ²	ML/d	ADWF 3.8	1.71	1.99
Maximum day	ML/d	22	4.76	13.8
COD load	kg/d	2050	861	850
Sewage Quality				
COD	mg/L	540	576	495
COD:BOD		2.4	2.04	2.20
TKN:COD		0.10	0.095	0.090
TP:COD		0.018	0.015	0.016
Total alkalinity m Sulfide soluble:	ngCaCO3/L	230	263	202
Raw sewage	mg/L	2-9 (19-29 degC)	ND	0.5
After Fe dosing	mg/L	3		
VFA mg	/L as acetic	~50	61	45
-		(total RBCOD 80)		

Table 9 Plant loading summary during process proving period (2011-13)

1. Defects liability period start 26-Feb-11. ND = no data

2. Total may not equal sum of inputs due to flow meter differences

Table 10 Effluent summary during process proving period (2011-13)

Parameter	Targe	t/Desig	n Limits³	Performance to Date					
				17-Nov	-12 to 11	-Jan-13	26-Fe	b-ll to l	I-Jan-I3
	50%	90%	Max	50%4	90%	Max	50%4	90%	Max
Inflow ML/d	3.8		22.0	1.71		4.76	1.99		13.8
Outflow ML/d									
River	3.8		22.0	1.63			1.98		
Reuse	3.8		5.7	0.12			0.17		
Total	3.8		22.0	1.76			2.12		
Effluent Quality (mg/L UN	10)							
BOD		10	20	1	2	2		2	4
SS	5	15	30	3	3	4	2	4	13
Total N									
Specified	4	10	20	1.0	1.7	2.0	1.6	4.0	7.2
EPA		10	15						
NH3-N	0.5	2	4	0.10	0.18	0.22	0.08	0.73	4.2
Total P									
Specified	0.3	0.5	I	0.21	0.25	0.25	0.10	0.23	1.4
EPA		0.3	1						
O&G		5	10	06	0	0	1.0	2.0	5.0
pH (range, units) F. coliforms:			6.5-8.5			7.6-7.8			7.0-8.0
(cfu/100mL) UV effluent	2	14	28	ND	ND	ND	3	12	93
		200	600		13	14	10	65	21000
River discharge Site service ⁵		10		ND	ND	ND	3	25	92

I. ND = no data

2. Any red data are exceedances of 90%ile or maximum limits

3. 90% iles apply to 26 fortnightly samples over each year ending 27-Sep; 50% iles are design values adopted to meet 90% ile and maximum limits

4. Flows are averages; totals may not equal sum of inputs due to flow meter differences

5. Limit shown is Qld Class A (95%ile) for open industrial use & irrigation with unrestricted access

6. 2 no. oil & grease samples

Source for Table 9 & Table 10: Hartley (2013a)

5.2 Recent data

5.2.1 Effluent quality

The recent effluent quality data (since Feb 2013, i.e. post-process proving period) is summarised in Table 11. The results show that the effluent quality is generally compliant with the EPA Licence requirements, except for:

- Ammonia at maximum (presumably due to infrequent under-aeration issues)
- Total P at maximum (presumably due to infrequent alum under-dosing issues)
- Faecal coliforms (presumably due to infrequent issues with the UV disinfection equipment, or possibly infrequently high suspended solids carryover from the clarifiers that might be only partially reflected in the sample results for TSS recorded).

Table 11 Recent BVSTP effluent quality data (for EPA Licence compliance monitoring)

Parameter	Licence			Recent performance (13/2/13 to 27/5/15)				
Limit	50%ile	90%ile	Max.	50%ile	90%ile	Max.		
BOD, mg/L	-	10	15	1	3	7		
SS, mg/L (TSS)	-	15	30	2	5	12		
Total N, mgN/L	-	10	15	1.3	2.6	10.2		
Ammonia N, mgN/L	-	2	4	0.2	1.4	9.4**		
Total P, mgP/L	-	0.3	1.0	0.11	0.42	2.24**		
Oil & Grease, mg/L	-	5	10	0 (ND)	2	3		
рН	6.5 to 8.5 (N	/lin. – Max.)		6.9 (Min.)		7.8		
Faecal coliforms, cfu/ 100 mL	-	200	600	7	190	5800**		

** Denotes licence limit exceedance;

ND: not detected (or below detection limit)

5.2.2 Other operational monitoring parameters

Sludge settleability has not been monitored recently for the plant. The last five values for unstirred Sludge Volume Index (SVI) were recorded in Feb-Mar. 2013, at the end of the process proving period, and ranged from 163 to 194 mL/g (average 177), which is close to the typical range noted by Hartley (2013b) for the current operation (refer to Section 5.1.3 above).

Anecdotal information from the BVSTP operators and BSC managers is that the plant has difficulty retaining MLSS (biomass) under peak wet weather flow conditions (or, as a rough indication, at flows greater than approximately 15 ML/d or 4 times design ADWF).

MLSS is occasionally³⁵ measured by the operators. The results are shown plotted in Figure 10 along with the four highest wet weather flow events (>4.5 times design ADWF) during the corresponding period (refer also to Section 2.3.2 above). The results in Figure 10 do not show a clear relationship between MLSS and occurrence of high flow events. If significant biomass washout occurred during such events, then a sudden drop in MLSS concentration would have been observed, followed by a slow recovery. However, the low frequency of MLSS sampling by operators might not fully reflect the actual plant behaviour.

An attempt was made to use on-line MLSS instrument³⁶ data to illustrate the problem. Some examples are shown in Appendix D:

- 1. For the period spanning the peak flow event on 10/04/2013. However, during this period the instrument produced too much scatter in the data (high-end interference, probably due to probe fouling) to be useful.
- 2. For the period spanning a recent smaller peak flow event of 26-28/06/2015. During this period, the on-line MLSS instrument operated reliably and showed a transient decrease in oxidation ditch MLSS concentration during the peak flow event. However, the MLSS concentrations recovered quickly (within a few hours). This suggests normal clarifier operation as a portion of the oxidation ditch MLSS inventory was displaced to the clarifier blankets but then recirculated via the RAS. The RAS ratio (relative to inflow) was operated in the range of approximately 1 to 3.5 (:1) i.e. a 'safe' operating condition being higher than the design values (normal 1:1; minimum 0.49:1 relative to peak flow of 3.5 times ADWF).

³⁵ The MLSS sampling frequency in the dataset by BSC considered here (post-process proving period to date i.e. Jan 2013 to Jun 2015) averaged 23 days but ranged widely from 3 days to 263 days.

³⁶ Online MLSS instrument fitted to the oxidation ditch after the plant was commissioned (not part of the original design).

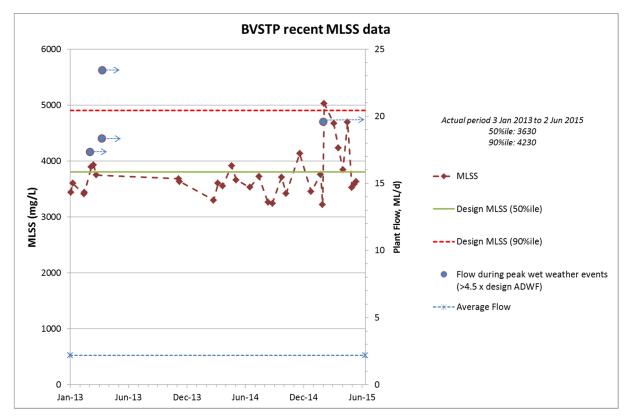


Figure 10 Recent MLSS data for BVSTP in relation to high flow events in wet weather

6. Process modelling

6.1 Model process flow diagram

The process flow diagram for the existing plant was used as the basis for modelling. Refer to Appendix E.

The proposed modified process flow diagram for the plant augmentation (to include Ocean Shores loads) is given in Appendix F.

6.2 Models applied

6.2.1 Activated sludge model

An in-house spreadsheet-based activated sludge model was applied. The basis of this model is similar to that used for the plant design, as documented in Appendix B of the Design Report by Fulton Hogan/Cardno (2010).

6.2.2 Clarifier model

An in-house clarifier model based on modified flux theory (Ekama et al., 1997) was applied. The basis of this model is similar to that used for the plant design, as documented in Appendix B of the Design Report by Fulton Hogan/Cardno (2010).

6.3 Key model inputs

6.3.1 Wastewater characteristics

The design wastewater characteristics for BVSTP and those adopted for planning purposes for OSSTP are given in Table 12 below, along with the combined characteristics. The combined characteristics assume that the plant augmentation makes provision for 1.9 ML/d ADWF from Ocean Shores (compared with predictions in the range 1.7 to 2.2 ML/d from population projections, depending on the growth scenario). Provision is made for 3.8 ML/d ADWF (the existing plant design capacity) from the Mullumbimby and Brunswick Heads catchments combined. Refer to population and flow projections in Section 2.

The OSSTP wastewater composition assumptions made here (from GHD, 2014a) are slightly more conservative than the design values for BVSTP (refer to Table 12). No detailed wastewater characterisation data for OSSTP was available for this Study to confirm these assumptions. It is recommended that a detailed wastewater characterisation program be carried out prior to detailed design to confirm the assumptions made in this section.

6.3.2 Other model parameters

Assumptions for other key model parameters are stated in Table 12. As far as possible, these are consistent with the design assumptions for the existing BVSTP.

Parameter	Load (kg	otherwise stated)	Load per EP (g/EP/d)			Concentration (mg/L)			
Value for:	BVSTP	OS	OS + BVSTP	BVSTP	OS	OS + BVSTP	BVSTP	OS	OS + BVSTP
Peak Flow									
Sustained (L/s)	255	140	395						
(ML/d)	22.0	12.1	34.1						
times ADWF	5.8	6.4	6.0						
Instantaneous (L/s)	314	300	614						
(ML/d)	27.1	25.9	53.0						
times ADWF	7.1	6.8	9.3						
50%ile Loads									
Nominal Equivalent Persons (EP) @ 240 L/EP/d	15,833	7,917	23,750						
Flow, ADWF (ML/d)	3.8	1.9	5.7						
COD	2,052	1,140	3,192	129.6	144.0	134.4	540	600	560
TKN	205.2	122.6	327.8	13.0	15.5	13.8	54	64.5	58
TP	38	18.2	56.2	2.4	2.3	2.4	10	9.6	10
Total Alkalinity (as CaCO3)	874	551	1425				230	290	250
Sulfate (SO42-)							37	no data	37
Sulfide (as S) at 19-24-29 degC							2-5-9	no data	2-5-9

Table 12 Adopted raw wastewater characteristics and related parameters for modelling

Table 12 continued

Factors	BVSTP	BVSTP					OS + BVSTP		
Peaking factors (x 50%ile)	90%ile	Peak	Diurnal Peak	90%ile	Peak	Diurnal Peak	90%ile	Peak	Diurnal Peak
Flow									
Sustained Flow /Process	-	5.8	2	-	6.4	2	-	6.0	2
Instantaneous Flow /Hydraulics	-	7.1	-	-	6.8	-	-	9.3	-
Load									
COD Mass Load	1.3	-	2.5	1.3	-	2.6	1.3	-	2.53
TKN Mass load	-	-	not stated	-	-	3.2	-	-	3.0
TOD Mass load			not stated						2.65
Raw Wastewater Characteristics	50%ile						50%ile		
COD/ BOD	2.4						2.4		
USCOD/ TCOD, fus	0.05						0.05		
UPCOD/ TCOD, fup	0.20						0.20		
RBCOD/ TCOD, fbs	0.15						0.15		
USTKN/ TKN, fnus	0.035						0.027		
TKN/TCOD	0.1						0.1		
TP/TCOD	0.019						0.019		

Table 12 continued

Other key model parameters	BVSTP			OS			OS + BVSTP		
Mixed liquor temperature (°C)	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.
	19	24	29	no data			19	24	29
Nitrifier kinetics (at 20°C) Note 2									
Max. Specific Growth rate (d ⁻¹)		1.0						1.0	
Specific Decay rate (d ⁻¹)		0.04						0.04	
Ammonia half-saturation coefficient (mgN/L)		1.0						1.0	
Notes									
Note 1: Ocean Shores values based on a combina	tion of GHD (20	14b) adopted	concentrations for OSS	STP Planning	and popu	lation projections fro	m this Study (refer t	o Section 2.1)
Note 2: Nitrifier kinetic parameters quoted here are (as applied by GHD 2014b) for OSSTP planning w				nsistent with t	hat used a	as the design basis fo	or the existing BVST	P. Biowin™ ı	model parameter
RBCOD: Readily biodegradable COD									
USCOD: unbiodegradable COD									
UPCOD: unbiodegradable COD									
TCOD: Total COD									
USTKN: Unbiodegradable soluble TKN (at zero Alu	um dose; USTK	N decreases v	vith Alum dose, based	on West Byro	on STP da	ta)			

6.4 Model results

6.4.1 Activated sludge model

The model results are given in Appendix G.

These may be compared to those given in Appendix B of the Design Report for the existing plant (Fulton Hogan/Cardno, 2010). The results are similar.

6.4.2 Clarifier model

The key model outputs from the flux theory model analysis are given in Table 13.

	CLARIFIER FLUX	K CALCU	LATIONS	S - KEY OL	JTPUTS								
			Assumin	ıg: Peak m	onth ML	SS = <mark>4900</mark> n	ng/L; SSVI	= <mark>59</mark> mL/g ((BVSTP <mark>de</mark>	sign 90%il	e)		
Model Case No.	<u>Scenario</u>	Mixed liquor bypass	ADWF (ML/d)	PWWF/ ADWF ratio to clarifiers	PWWF (L/s)	Max. RAS (L/s) per clarifier	No. of Clarifiers	Clarifier Total	Total Area	Required	Clarifier diameter	Approx. spare clarifier capacity (% of total area provided)	
Case 1.1	Current Design at 5.8 ADWF	No	3.8	5.8	255	77	2	622	831	19.9	23.0	25%	Existing clarifiers do not have reactor flow-bypass facilities; RAS is recycled via inlet works for screening
Case 1.2	Current Design at 7.1 ADWF	No	3.8	7.1	312	77	2	834	831	23.0	23.0	0%	Ditto
			Assumin	ıg: Peak m	onth ML	SS = 4900 n	ng/L; SSVI	= <mark>90</mark> mL/g (approx. B	SVSTP actua	al 90%ile; Byr	ron STP design 5	0%ile)
Case 2.1	Current Design at 5.8 ADWF	No	3.8	5.8	255	77	2	1283	831	28.6	23.0	-54%	Existing clarifiers do not have reactor flow-bypass facilities; RAS is recycled via inlet works for screening
Case 2.2	Current Design at 7.1 ADWF	No	3.8	7.1	312	77	2	2091	831	36.5	23.0	-152%	Ditto
Case 3.1	Proposed Future Design at 6 ADWF	No	5.7	6.0	396	77	4	1660	1662	23.0	23.0	0%	Proposed 50% ADWF and bioreactor capacity plant augmentation. For consistency with current design, asssume new reactor and clarifiers will also not be equipped with reactor flow by-pass
Case 3.2	Proposed Future Design at 7.1 ADWF	No	5.7	7.1	468	77	4	2170	1662	26.3	23.0	-31%	Ditto

Table 13 Key outputs from clarifier modelling

6.5 Summary of modelling

6.5.1 Activated sludge model

A summary of the model results is given in Table 14.

Table 14 Summary results from activated sludge modelling

Process Train	OS+B\ train)	/STP (Ex		OS+BVSTP (New train)			
Parameter	Tave	Tmin	Tmax	Tave	Tmin	Tmax	
Mixed liquor temperature (°C):	20	19	29	20	19	29	
Parameter, units	Value						
ADWF, ML/d	3.8			1.9			
Sludge age, d	19.5			19.5			
Process Volume (bioreactors total), ML Oxidation ditch channel dimensions, m • Depth (water) • Width • Length (mid-point circuit, 2-pass) • Straight length	 3.7 4.0 6.0 13 60) 9					
Average MLSS concentration, mg/L	3786			3785			
Peak month MLSS concentration, mg/L	4922			4921			
Average Actual Total Oxygen demand, kg/d	1445			722			
Average SOTR, kg/h (diffused air)	124	125	122	62	62	60	
Maximum SOTR, kg/h (diffused air)	176	176	175	87	87	86	
SOTR turndown required (Max./Min.) for airflow	5.8			5.7			
Alum dose, mg/L as dry alum	<= 10			<= 10			
Alkalinity depletion due to alum dosed, mg/L CaCO ₃	<=4			<=4			
Effluent Ammonia, mgN/L	0.7	0.7	0.6	0.7	0.8	0.6	
Effluent Nitrate, mgN/L	0.3	0.3	0.3	0.3	0.3	0.3	
Effluent Total N, mgN/L	3.4	3.5	3.2	3.4	3.5	3.2	
Effluent soluble P, mgP/L	0.01			0.01			
Effluent Total P, mgP/L	0.21			0.21			
Effluent TSS, mg/L (assumed)	4			4			

The results show that the BVSTP can be feasibly upgraded by adding 50% to the existing bioreactor process capacity. The new (smaller) oxidation ditch bioreactor will be narrower and slightly shallower than the existing oxidation ditch, but a similar length, in order to keep the aeration system design as consistent as possible.

Subject to the confirmation of design wastewater characteristics (refer to Section 6.3.1, particularly for Ocean Shores), the design sludge age for the plant (both existing and new process trains), when subjected to the combined loads of the Mullumbimby, Brunswick Heads and Ocean Shores catchments, can be similar to that for the existing plant (i.e. 19.5 days compared to 20 days for the existing plant). This is expected to produce an operating MLSS (average and peak) that matches the design assumptions for the clarifiers, as discussed in Section 6.5.2).

In terms of aeration, the estimated oxygen requirement (Standard Oxygen Transfer Rate or SOTR – refer to Table 14) for the existing process train (oxidation ditch bioreactor) is projected to be largely within the range of the existing blower and diffused aeration equipment (refer to Section 4.4). However, subject to design wastewater characteristics being confirmed, the maximum SOTR is expected to marginally exceed the design maximum capacity of the existing system (by a negligible margin of about 1 kg O₂/h).

The new process train will also be aerated by means of diffuser air with a similar design to that of the existing plant. Subject to equipment selection, including the diffuser type and number, the efficiency of aeration of the new train will be marginally lower (indicatively 10%) than that of the existing system. This is due to the altered tank geometry (reduced tank depth), to maintain the DO profile required for good biological nitrogen removal performance along the channel length. Such details can be confirmed during detailed design and will make an insignificant difference to cost considerations that form part of this feasibility study.

The effluent quality from the new and existing process trains, after transfer of the Ocean Shores loads to the augmented plant, is expected to be essentially the same as that of the existing process and should meet EPA licence requirements (refer to Table 14 and Sections 3.3 and 5.1.1 above).

6.5.2 Clarifier model

The clarifier model results illustrate the issues discussed in Sections 4.5 and 5.1.3 above. In summary, the following points can be noted:

- The existing clarifiers (2 no. 23 m diameter) have a relatively 'aggressive' design, being for a design settleability of SSVI = 59 mL/g (90%ile). That is, the design assumed significantly better settleability than more conservative designs (e.g. previously at (West) Byron STP, which had a design SSVI = 90 mL/g on a 50%ile basis). This is illustrated in Table 13 (see above). Table 13 shows that the existing clarifiers have a margin of safety (25% spare capacity) at sustained process peak flows of 5.8 times ADWF (255 L/s), and zero margin of safety (0% spare capacity) at a peak flow of 7.1 times ADWF (312 L/s), where ADWF is 3.8 ML/d (44 L/s) for the existing plant.
- Given that the actual settleability at BVSTP to date has typically been worse than the design settleability (SSVI range ~60 to 90 mL/g refer to Figure 9 on page 33), it is not surprising that the operators anecdotally report problems with biomass retention under sustained peak flow conditions. Table 13 shows that theoretically the clarifiers have a deficit in capacity (i.e. a tabulated negative value for spare capacity) for the combination of peak month design MLSS (4900 mg/L) and an SSVI of 90 mL/g.
- Based on a more conservative assessment, including allowance for sustained future peak flows from the combined Mullumbimby, Brunswick Heads and Ocean Shores catchments (refer to Figure 19 on p109), it is recommended that provision be made in the plant augmentation for a minimum clarifier process capacity of sustained operation at 6 times ADWF or 396 L/s (where the augmented plant ADWF is 5.7 ML/d or 66 L/s).
- Using a more conservative sludge settleability (SSVI 90 mL/g being close to the current 90%ile or the Byron STP design 50%ile value), provision for two new clarifiers (23 m diameter each to match the two existing clarifiers) for the plant augmentation is recommended.
- With a total of 4 no. 23 m diameter clarifiers (100% augmentation) provided in future, compared with only 50% bioreactor process capacity augmentation), a change in plant flow splitting and operating philosophy will be required. These changes are described in more detail in Section 7, but in summary will entail the following:

- The new process train (one third of total bioreactor capacity after plant augmentation) will be hydraulically coupled to the two new clarifiers (representing one half of the total clarifier capacity after augmentation).
- Providing a new raw influent flow splitter upstream of inlet works to split the flow in a ratio as follows:
 - 33% to the new process train (with new clarifiers) and 67% to the existing process train (with existing clarifiers) under <u>dry</u> weather conditions (i.e. timeaveraged influent flow rates nominally less than 2 times design ADWF)
 - 50% to the new process train (with new clarifiers) and 50% to the existing process train (with existing clarifiers) under <u>wet</u> weather conditions (i.e. timeaveraged influent flow rates nominally greater than 2 times design ADWF)
 - Surplus wet weather flows (time-averaged influent flow rates nominally greater than 6 times design ADWF) will be diverted to a new wet weather storage facility. Provision to divert more flow to the storage facility will be made, which will be an 'emergency' operational strategy invoked by the plant operators, if required (e.g. if one or more clarifiers is out of service).
- Providing a new RAS flow splitter downstream of the inlet works and upstream of the bioreactors. The purpose of the RAS flow splitter will be to combine the RAS from all four clarifiers (new and existing) and then re-dividing the RAS in proportion to the process requirements. This approach also has the advantage of providing a common total biomass inventory for the two trains, such that their MLSS concentrations and biological behaviour remain largely consistent over the life of the plant, thereby simplifying plant control. For the same reason, it will be possible to use the clarification capacity of all four clarifiers even if one of the two bioreactors in either of the two process trains needs to be taken off line (e.g. this will be useful in future when aeration diffusers or aeration pipework require maintenance).
- The RAS flow split ratio will be consistent with raw influent flow splits (see above), namely:
 - 33% to the new process train and 67% to the existing process train under <u>dry</u> weather conditions
 - 50% to the new process train and 50% to the existing process train under <u>wet</u> weather conditions
- Existing RAS line connection to the inlet works will be closed, and RAS diverted to the new RAS flow splitter.
- RAS screening at the new RAS flow splitter will be provided.
- Providing a new mixed liquor flow splitter downstream of the bioreactors for combining mixed liquor flows (influent and RAS) from the two process trains and re-dividing the combined flow in proportion to the number of clarifiers that are on line, for example:
 - 25% to each clarifier with 4 no. clarifiers on line
 - 33% to each operating clarifier with 3 no. clarifiers on line (1 no. off line)
 - Note: Mixed liquor flow splits will not be directly related to dry vs. wet weather flow considerations.

Refer to the revised Process Flow Diagram for the Augmented Plant (Appendix F) for more information on the flow splitting arrangements proposed.

7.1 Sewerage transfer system

Broadly, there are two options for transfer of wastewater via modifications to the sewerage system serving OSSTP and BVSTP. These are as follows:

- **Option A:** Build a new rising main pipeline from OSSTP to BVSTP. The existing rising mains from SPS 5009 and SPS 5004 that currently discharges to OSSTP inlet works will be connected to the new (common) rising main for transfers of the wastewater to BVSTP. Capacity and/or upgrade requirements of SPS 5009 and SPS 5004 will be checked at the detailed design stage to ensure adequate capacity for pumping via the new rising main extended to BVSTP.
- **Option B:** Continue to discharge wastewater from the Ocean Shores catchment via the existing inlet works, which will require provision of a second vortex grit tank to cater for future growth and hydraulic requirements, as detailed in the OSSTP Planning Study (refer to GHD, 2014b). Convert the first activated sludge bioreactor (Demand Aeration Tank or DAT) at OSSTP into a dry weather holding tank for raw wastewater. The second bioreactor (Intermittent Aeration Tank or IAT) could also be converted (as an option) to provide additional holding capacity for minor wet weather events. Neither of these tanks will continue to serve a treatment function. They would only provide a holding/balancing tank function in order to attenuate diurnal flow rate variations, mainly under dry (or minor wet) weather conditions. A new pump station will be built at OSSTP, connected to the holding tank(s), for transfer of wastewater to BVSTP for treatment. The option can be investigated if allowing surplus wet weather flows (that exceed a nominated peak treatment capacity for sustained wet weather flow at BVSTP) to be directed to the existing lagoons/wetland system at OSSTP, thereby receiving partial (natural) treatment without disinfection³⁷.

The relative advantages and disadvantages of these two options are summarised in Table 15. Based on this comparison, it is clear that Option B has more disadvantages and only one apparent advantage. Since the existing BVSTP operates satisfactorily and gives good performance with respect to its licence requirements without flow balancing, the single advantage for Option B (i.e. flow balancing) can be considered to relatively insignificant. Conversely, the disadvantages of Option B (e.g. potentially higher capital and operating/maintenance costs) are expected to be more significant.

Therefore, Option A was selected as the preferred strategy for the purposes of this Study.

7.2 Treatment plants

7.2.1 Consolidation at BVSTP - Option A

The strategy for Option A is to augment the BVSTP using the same process design concept as the existing plant. The augmented BVSTP plant will treat the combined wastewater loads from the Mullumbimby, Brunswick Heads and Ocean Shores catchments.

Additional biological treatment capacity will be required (refer to Section 8.2). That capacity will be provided by way of a second process train to operate in parallel with and to be integrated, as far as possible, with the existing oxidation ditch-clarifier extended aeration process. In order to facilitate plant operation, and to integrate the two treatment trains as far as possible, careful attention should be given to flow splitting. Provisions to enable the two treatment trains to

³⁷ Subject to future Licence requirements (refer to Section 3.3.1).

operate with a 'common biomass' (mixed liquor suspended solids) should also be made. To this end, the existing RAS line will be redirected from the existing inlet works (where it receives screening) to a new RAS flow splitter equipped with a (new) RAS screen, to serve both the existing and new RAS systems (i.e. from existing and new clarifiers).

To allow management of wet weather flows, a wet weather storage facility will be provided for the plant. This will limit (or even eliminate) the extent and/or frequency with which the clarifiers operate at peak hydraulic flow rates that exceed their design (i.e. process clarification) capacity for sustained flow. Together with the provision of additional clarifier capacity, this should largely eliminate problems that sometimes occur with the existing clarifiers suffering gross solids loss under peak wet weather conditions, threatening process stability.

To provide a 'buffer' for natural tertiary treatment of effluent, a constructed wetland is proposed as an option. The wetland will receive flow in two forms:

- 1. Typical conditions: UV-disinfected secondary effluent
- 2. Extreme wet conditions: combination of UV-disinfected secondary effluent and surplus wet weather flow spilling from a completely full wet weather storage facility

The wetland will provide a 'buffer' between the treatment plant and the receiving water (Brunswick River) to help reduce the potential for carryover of organic matter (primarily suspended solids) from the secondary clarifiers (and wet weather storage if spilling). The wetland will also have a limited capacity to 'polish' the effluent by way of some additional removal of nitrogen compounds (ammonia and/or oxidised N) if present. The wetland may offer aesthetic and community benefits (e.g. as a haven for birdlife). Apart from additional maintenance requirements (e.g. annual harvesting of reeds; prevention of clogging, channelling etc.), the main disadvantage of wetlands is that re-contamination of the effluent with pathogens from wildlife (e.g. birds) can occur. Therefore, the licence compliance point for disinfection (bacterial indicator organisms) should to be upstream of the wetland (refer to Section 3.3, particularly Section 3.3.1, and Appendix C).

7.2.2 Alternative strategy to retain both STPs – Option B

In the alternative strategy, the current operational strategies for OSSTP and BVSTP, and the associated sewerage networks, will be continued. OSSTP will be retained (upgrade required) and will continue to be used to treat the wastewater loads from the Ocean Shores catchment. BVSTP will be retained as existing, to treat the wastewater loads from the Mullumbimby and Brunswick Heads Shores catchment.

Without the transfer of loads from the Ocean Shores catchment, the existing design capacity at BVSTP (ADWF 3.8 ML/d) is projected to be sufficient beyond 2045 (the planning horizon of this Study) (refer to Section 2.2.1 and Figure 3).

If the strategy is to be retained, the capacity augmentation requirements for OSSTP have been considered in reports from a previous planning study (GHD, 2014 a,b). Based on the latest population projections, as discussed in Section 2.1.3, the capacity upgrade (to 10,700 EP) proposed in the planning study report (GHD, 2014a) would be appropriate. It would cater for requirements to beyond 2045, which would be similar to that for BVSTP without the transfer from Ocean Shores. The process option recommended for OSSTP in the planning study (GHD, 2014b) would be "Option 2" (Oxidation Ditch), which would provide close similarity to the process format at BVSTP for conformity between the two plants and ease of operation.

Option	Advantages	Disadvantages
Option A: Pump directly from Ocean Shores catchments to BVSTP	Minimises septicity of wastewater (avoids increased retention time in transfer system due to holding tanks at OSSTP)	SPS 5004 required to be upgraded to pump to BVSTP (adds capital cost)
	No need to partially upgrade OSSTP (e.g. inlet works second grit tank)	No flow balancing in system
	No ongoing operation or maintenance at OSSTP (saves operating and maintenance costs)	Does not make use of existing treatment infrastructure at OSSTP
Option B: Collect and balance flows from Ocean Shores catchments in holding tank(s) at OSSTP. Build new pump station to transfer to BVSTP.	Dry weather (or minor wet weather) flow balancing at OSSTP; facilitates BVSTP operation (attenuates loads with less variation e.g. in aeration control and effluent nutrients)	At some point in the future, OSSTP inlet works will require partial upgrade including second grit tank provision (adds capital cost).
		OSSTP requires some modification for converting existing bioreactors to holding tanks (adds capital cost), and remains partially operational (adds operating and maintenance costs).
		Holding/ balancing wastewater at OSSTP increases septicity thereby increasing odour and corrosion potential; and decreasing treatability for nutrient removal (potentially adds operating and maintenance costs (e.g. greater use of chemicals for odour control and P removal)

Table 15Comparison of options for sewerage transfer system from Ocean Shores
to Brunswick Valley STP

8. Augmentation requirements

8.1 Sewerage transfer system requirements

8.1.1 Hydraulic Analysis

The Ocean Shores STP currently receives flows from pump stations SPS 5004 and SPS 5009. Key operating parameters are summarised in Table 16. The hydraulic analysis considered a range of operating conditions (low or high pipeline friction; wet well at low level or overflow level).

Table 16 Pump station details

Parameter	SPS 5009 Kiah Close	SPS 5004 Rajah Road
Wet well diameter (m)	3.2	1.8
Wet well depth (m)	8	5
Flow at pump best efficiency point (L/s)	136 (installed pumps) 252 (older pumps)	48
Possible pump operation range (L/s)	95 – 355	15 – 70
Typical pump operating range, one pump (L/s)	110 - 140	Approx. 25
Typical pump operating range, two pumps (L/s)	135 - 175	Approx. 40

SPS 5009

Figure 11 shows the system curves for the SPS 5009 system. The estimated operating range for a single pump at 50 Hz is between 110 L/s and 140 L/s. The estimated operating range for parallel pumps at 50 Hz is between 135 L/s and 175 L/s.

The calculated operating points correlated reasonably well with the drawdown test undertaken in August 2007. It is noted that the pump operates away from its best efficiency point (BEP), with an efficiency of between 60 and 70 % (compared with 80 % at BEP). Further investigation is recommended to assess the merits of and ways to improve energy efficiency of this pump station (outside the scope of work for this Study).

The concept design has been developed based on maintaining the existing pump station capacity. A DN375 DICL common rising main was selected to service pump stations SPS 5009 and SPS 5004 for the transfer pipeline extending from OSSTP to BVSTP.

The SPS5009 system hydraulics are governed by a high point in the rising main at an elevation of approximately 47 m. Due to this high point, extending the SPS 5009 rising main to the BV STP would have limited impact on the operating point for the pumps.

SPS 5004

Figure 12 shows the system curves for the SPS 5004 system. The estimated operating range for a single pump is between 62 - 72 L/s. This is higher than the measured flow rate of approximately 25 L/s for single pump operation and 40 L/s for parallel pump operation. The reason for the deviation has not been identified and requires further investigation.

For the purposes of this Study, the concept design has been progressed on the basis of maintaining a similar flow rate. The existing pumps would need to be upgraded to extend the rising main from OSSTP to BVSTP and cater for pumping in parallel with SPS 5009 in the new section of common rising main. The preliminary pump selection is a Flygt NP 3202 HT 30 kW (60 L/s @ 26 m head). Prior to detailed design, consideration should to be given to providing variable speed drives for the new pumps, along with on-line pressure detection and control logic to optimise pump operation and energy efficiency.

The existing wet well has a diameter of 1800 mm and would be too small to cater for the larger pumps. The capital cost estimate in this Study allows for construction of a new concrete wet well in addition to new pumps and switchboard.

Note on timing of SPS 5004 upgrade

It is noted that BSC is currently planning for an upgrade SPS 5004 as part of its asset renewable program, and to meet operational requirements for increased wet well capacity to deal with weather flows. Considering timing, the pump station upgrade currently being planned is likely to take place before the transfer of flows from OSSTP to BVSTP, assuming the latter goes ahead. The design and estimated capital costs for the planned upgrade of SPS 5004 were not available at the time of writing this report. Therefore, in in terms of interface with the possible STP transfer, the following points are noted:

- For the purposes of this Study, capital costs for the upgrade of SPS 5004 were estimated to meet the concept requirements for the STP transfer (see Table 17) but a detailed design was not developed. On the basis that the actual SPS 5004 is likely to precede the STP transfer, the SPS upgrade capital cost estimates were separately listed and excluded from the total capital cost of the STP transfer and associated BVSTP upgrade proposed here (refer to Section 11).
- The detailed design for the upgrade of SPS5004 (to be commissioned by BSC) will need to make provision for the proposed STP transfer considered in this Study, assuming that it goes ahead.

8.1.2 Summary of upgrade requirements

The proposed works to divert flows from OSSTP to BVSTP are summarised in Table 17.

Item	Existing equipment	Upgrade requirements	Notes
SPS 5009	2 no. 170 kW pumps, both variable speed	None	Pumps currently operate below Best Efficiency Point; further investigation required
SPS 5004	2 no. 13.5 kW pumps, both fixed speed	Upgrade pumps to 30 kW (2 no. new) New 1800 mm diameter wet well required to accommodate new pumps	Opportunity to optimise pump operation and energy efficiency with pump upgrade, by including optional variable speed drives and on-line pressure detection.
Rising main extension (OSSTP to BVSTP)	None	New common rising main, 3.25 km, DN375 DICL pipe	Air valves and scour valves to be provided to suit final pipe grading.

Table 17 Proposed upgrade works

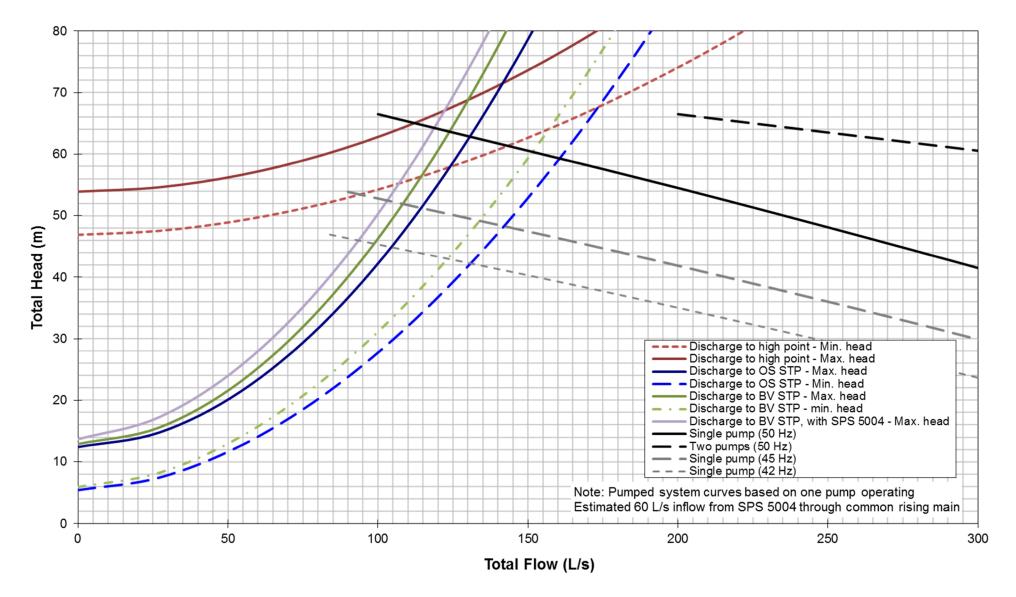


Figure 11 SPS 5009 System Curves

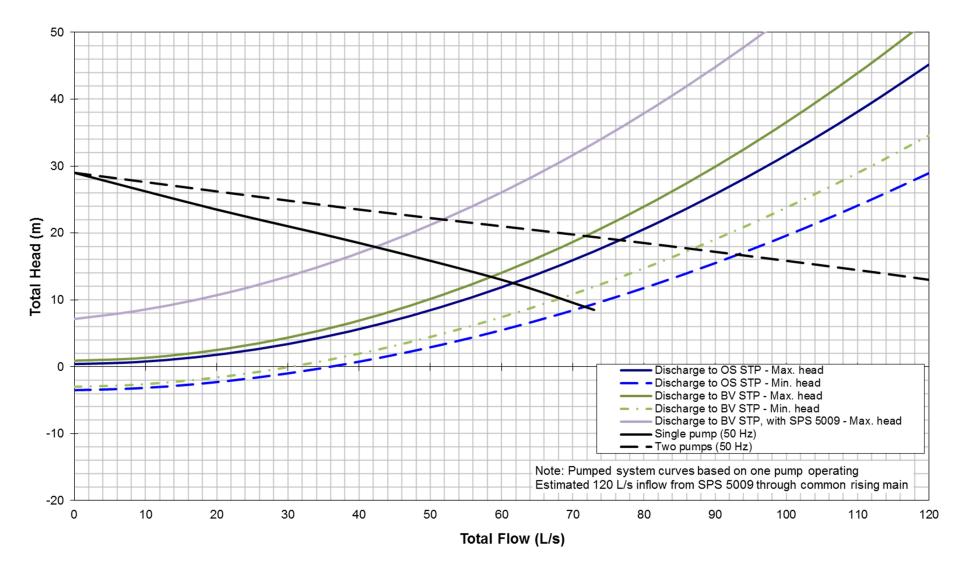


Figure 12 SPS 5004 System Curves (existing pumps)

8.2 Treatment capacity requirements for BVSTP

This section, describes the requirements for capacity augmentation at BVSTP (strategy Option A – refer to Section 7.2.1) for a full upgrade (i.e. base case), namely:

- A 50% increase in bioreactor and digester capacity from design ADWF 3.8 ML/d (currently) to 5.7 ML/d;
- A 100% increase in clarifier capacity to address current issues with solids removal performance under sustained peak flow conditions;
- A duplication of sludge dewatering and biosolids storage facilities to provide redundancy and additional capacity to meet future plant loads;
- Provision of a wet weather storage to take peak flows in excess of plant capacity to treat sustained peak flows
- Provision of a tertiary constructed wetland to act as a 'buffer' or effluent 'polishing' step before river discharge, with ancillary environmental/aesthetic/community benefits.

Figure 13 shows the projected peak day ADWF (from population projections, including tourist/day tripper loads, as discussed in Section 2.2.1) and nominal plant capacity before and after augmentation.

The rationale behind the upgrade or augmentation of each of the plant process components is discussed in the sub-sections below.

Options to defer the upgrade or augmentation of plant process components are discussed in Section 8.3.

A summary of options, including the base case from this section, is presented in Section 8.4.

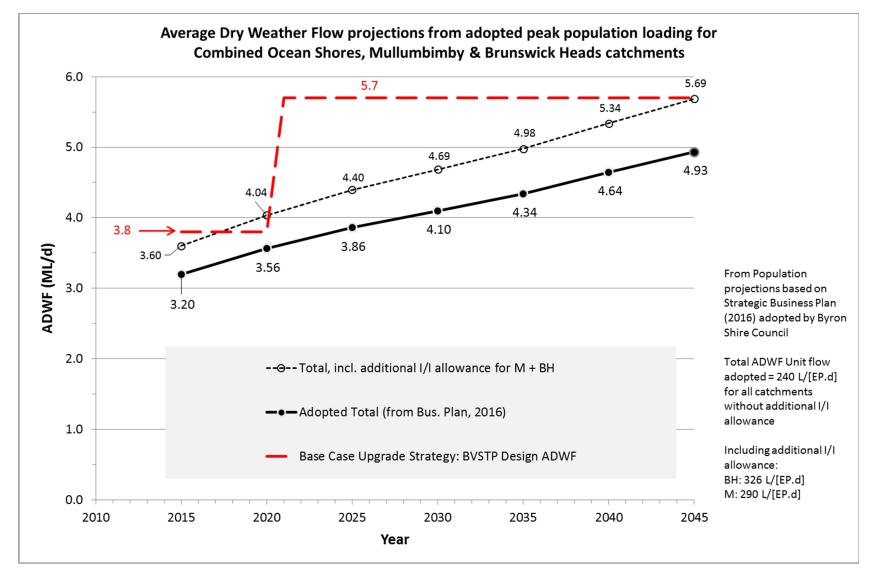


Figure 13 Projected peak day ADWF based on population projections, showing timing of BVSTP upgrade (base case, in 2020-21)

8.2.1 Primary flow splitter

A new primary flow splitter is proposed upstream of the existing inlet works. The existing raw sewage rising mains, along with the new rising main proposed from Ocean Shores, will be relocated from the existing inlet structure to the collection chamber for this new flow splitter. The new flow splitter will serve the following purposes:

- Split the flows to the downstream treatment trains (existing and new) to meet process requirements, as outlined in Section 6.5.2.
- Divert surplus wet weather flow to the proposed wet weather storage facility, as discussed in Section 6.5.2.
- Have the capability to adjust the proportion of flows split to wet weather storage, in accordance with process requirements, as outlined in Section 6.5.2.

It is envisaged that the flow splitter will be fitted with four equally-sized fixed weirs discharging via four discharge lines, each fitted with one actuated knife-gate valve. The following arrangement is proposed:

- Two of these lines will feed the existing activated sludge and clarifier (2 no.) process train. This will typically allow 50% of incoming flows to be fed to that process train, or a minimum of 33% under conditions where one of the existing clarifiers is off line; and zero flow (with both feed valves shut to the existing train) under emergency conditions where equipment failure or maintenance needs dictate it. Each of the discharge lines will be hydraulically sized for up to one quarter (25%) of the peak (instantaneous maximum) flow into the plant (i.e. nominally 154 L/s each for a total 614 L/s)³⁸
- Two of these lines will feed the new process train (with new clarifiers) but one of these lines will typically remain shut under dry weather conditions, and will only be opened under wet weather conditions. This will typically allow 33% of incoming flows to be fed to that process train, but up to 50% of incoming flow under wet weather conditions; and zero flow (with both feed valves shut to the new train) under emergency conditions where equipment failure or maintenance needs dictate it.

It is envisaged that the new flow splitter will also be fitted with an actuated downward-opening penstock (weir) for diversion of a variable proportion of flow to the wet weather storage facility. The proportion of flow diverted to storage will be adjustable (operator configurable via SCADA/PLC control of the actuator setting the weir position) from zero to 100% of the incoming flow. That is, the discharge line for wet weather flow diversion from the flow splitter to the storage facility will be sized for the peak (instantaneous maximum) flow of nominally 614 L/s from the combined catchments³⁸. This will allow the full flow (up to design PWWF) to be diverted to the storage facility under emergency conditions such as plant failure or a complete shutdown for maintenance purposes.

The flow spitter structure will incorporate provision for screening of flows diverted to wet weather storage. A 'self-cleaning' ('hydrosieve' or similar curved) screen with a nominal aperture max. 5 mm is envisaged for this purpose.

8.2.2 Existing inlet works

The existing equipment will be retained. The only modification is that the existing RAS line recycle via the inlet works will be discontinued. The existing RAS pipeline to inlet works can be

³⁸ Based on nominal instantaneous PWWF requirements of 314 L/s (Mullumbimby SPS 4000 + Brunswick Heads SPS 2000) and up to 300 L/s provision for Ocean Shores (SPS 5009 = SPS 5004), subject to confirmation prior to detailed design.

retained, but a T-intersection into the RAS line, with suitable valve arrangements, will be required to divert all RAS from the existing clarifiers and RAS pump discharge to the new RAS flow splitter (see 8.2.8 below). The existing arrangement can be retained (by changing valve settings) as a fall-back option if preferred, or for ease of construction.

8.2.3 New inlet works

A new inlet works with a nominal capacity of 314 L/s (to duplicate the peak wet weather raw wastewater hydraulic capacity of the existing inlet works) will be required. Duplication of capacity is required to match the peak flow split philosophy of the primary flow splitter, stemming from the need identified to increase the process clarification capacity of the plant with two new clarifiers, with associated peak hydraulic capacity (refer to Section 6.5.2). There are also constraints posed by the existing plant hydraulic grade line for splitting flows downstream of the existing inlet works. That is, greater use of the hydraulic capacity of the existing inlet works (as a result of diversion of the RAS flow – see Section 8.2.2) will be difficult to 'access' in terms of civil design.

Duplication of inlet works capacity will provide a nominal total peak (instantaneous) hydraulic capacity of 628 L/s for combined inlet works. This will be sufficient for at least 7 x ADWF, well beyond the projected ultimate flows within the planning horizon of this Study (i.e. beyond 2050). It also makes sufficient provision for the combined peak capacity of the rising mains and pump stations proposed to be served by the augmented plant in the immediate future (614 L/s being a conservative estimate – refer to footnote 38 on page **Error! Bookmark not defined.**).

8.2.4 New bioreactor

A new oxidation ditch bioreactor (including an anaerobic 'selector' zone with three compartments) will be required. The design capacity of the new bioreactor is proposed to be 50% of that of the existing bioreactor. In most respects, the design of the new bioreactor will mirror that of the existing bioreactor.

The required process volume of the new bioreactor will be 1.85 ML (half the existing bioreactor volume of 3.7 ML). The new anaerobic selector zone will total 185 kL in volume (62 kL per compartment, 3 no.). The new oxidation ditch will have a volume of 1.65 ML.

For reasons related to internal recycle rate (due to circulation of mixed liquor around the oxidation ditch channel) and associated aeration, the geometry of the new oxidation ditch will be somewhat different from that the existing ditch. The new oxidation ditch is proposed to have a channel width and water depth both of 3.6 m (slightly shallower and significantly narrower than the existing ditch³⁹). The new bioreactor will have a similar length (approximately 59 m straight length or 66 m overall), compared with the existing bioreactor⁴⁰.

The new bioreactor will be equipped with mechanical equipment and a diffused aeration system analogous to that of the existing bioreactor, but appropriately sized for the smaller reactor volume (refer to Table 18).

³⁹ The existing oxidation ditch has a channel width of 6.0 m and a water depth of 4.0 m.

⁴⁰ The straight length of the existing oxidation ditch is approximately 60 m and overall length approximately 72.5 m.

Item	Existing OD bioreactor	New OD bioreactor	Notes		
Anaerobic zone mixers	3 no. (1 kW) for 123 kL compartments (one mixer per compartment)	3 no. (0.5 kW assumed) for 62 kL compartments (one mixer per compartment)	Conservative estimate with relatively poor mixing efficiency due to small reactor compartment volume		
Oxidation ditch mixers	2 no. 5 kW (for channel 6 wide x 4 m water depth), OD volume 3.33 ML	2 no. 3 kW (for channel 6 wide x 4 m water depth), OD volume 1.67 ML	Conservative estimate allowing 20% decrease in mixing efficiency due to narrower channel width		
Oxidation ditch scum harvester	1 no. 0.6 kW, suitable for 6 m wide channel	1 no. 0.6 kW, suitable for 3.6 m wide channel	Chain and flight scraper system with helical rotor scum pump		
OD aeration	Diffused aeration system SOTR 175 kg/h Submerged depth assumed 3.7 m	Diffused aeration system SOTR 87 kg/h Submerged depth assumed 3.3 m	Cascade DO control via DO, ammonia and nitrate probes located downstream of the Aeration zone; PID auto-control to DO setpoint via VSD blower speed.		
OD blowers	3 no. 30 kW SAE 2.9 kgO ₂ / kWh (at max. airflow)	3 no. 15 kW SAE 2.9 kgO ₂ / kWh (at max. airflow)	2 no. Duty/1 no. standby positive displacement blowers. SAE for new process conservatively assumed to be unchanged (decreased oxygen transfer efficiency due to shallower depth traded off against reduced header air pressure requirement)		

Table 18Summary of mechanical equipment requirements of existing and
proposed new oxidation ditch (OD) bioreactor

8.2.5 New clarifiers

Two new circular clarifiers (23 m diameter) are proposed, with the same surface area and of similar design to the existing clarifiers. Refer to Section 6.5.2 for the rationale behind doubling the clarifier capacity for increased process robustness under wet weather flow conditions (i.e. sustained flows up to 6 times ADWF).

8.2.6 New mixed liquor flow splitter

A new flow splitter for mixed liquor is proposed. This flow splitter will serve to combine the mixed liquor (i.e. inflow + RAS) from the two bioreactors (i.e. parallel process trains) and re-divide it equally among the operational clarifiers. The new mixed liquor flow splitter will be designed with the following process aims:

- Minimise the potential for unequal distribution of flow and RAS between the operational clarifiers (i.e. to equalise upflow rates and solids loading rates between the clarifiers as far as possible) for optimum clarification performance.
- Increase overall plant clarifier capacity (i.e. doubling the existing capacity) by
 redistributing clarifier capacity over the whole process (existing and new process trains).
 This also enables the plant to operate with a smaller augmentation of the bioreactor (only
 50% capacity increase required) in order to reduce capital costs.
- Enable ease of control and operation for taking one or more clarifiers offline without having to take either of the bioreactors offline.

In order to facilitate the design and operation of the proposed new mixed liquor flow splitter, it is recommended that the existing mixed liquor flow splitter be retained but closed. The existing flow splitter is in the form of two adjustable weirs at the outlet of the existing oxidation ditch. To close this system, these weirs can be wound to their uppermost positions and left there, but retained for operation in emergency conditions (e.g. a potential shutdown of the new system).

Given the anticipated hydraulic grade line constraints of the existing system, it is proposed that a new pipe penetration be constructed within the existing oxidation ditch to interconnect the existing and new systems. The new pipeline will be fitted with a bell mouth in the existing oxidation ditch to direct mixed liquor to the new flow splitter. The modification to install this new pipework will need to be carried out with the existing bioreactor offline. It is anticipated that this will be possible after the new bioreactor has been built and commissioned to treat the existing load. Since the current plant dry weather flows and loads are typically less than half the design values (refer to Sections 2.2.2 and 5.1.1), this should be feasible given that the new bioreactor is proposed to have half the capacity of the existing bioreactor (see above).

The new mixed liquor flow splitter will combine flows from the two bioreactors (existing and new) via a common chamber and the split the flow via four fixed-weir overflows feeding four discharge pipes. Each of these discharge pipes will be fitted with an actuated knife-gate valve that will be operated in either a fully opened or fully-closed position. When fully closed, the relevant overflow weir at the flow splitter, associated with that given discharge line, will 'drown' and therefore be taken out of service. Mixed liquor flow will be divided among the remaining open weirs and discharge lines.

One mixed liquor discharge line will be directed to each of the four clarifiers (2 no. proposed new and 2 no. existing). Hence the flow split to each of the operational clarifiers will always be in equal proportion.

Under conditions when one or more of the clarifiers is taken out of service, the valves on relevant mixed liquor feed lines to those clarifiers will be closed. That is, the mixed liquor will be equally split between the remaining clarifiers that are in operation. Under extreme conditions (during times of minimum flow), the plant could potentially be operated with just one clarifier in operation; however this would be highly unusual and only for maintenance reasons.

Control of the actuated valves on the mixed liquor feed lines downstream of the mixed liquor flow splitter will be via SCADA/ PLC. The operator will inform the system (via an appropriate check box or similar on SCADA) when one or more clarifiers is taken out of service. Alternatively, the mixed liquor feed valve position programming can be based on automation via a 'fail' or 'off' signal from one or more of the clarifier scraper drives.

8.2.7 New RAS pump station

The new clarifiers will be served by a set of RAS pumps (2 no. per clarifier) in a similar arrangement to that for the existing clarifiers. For modelling purposes (refer to Section 6.2.2), a maximum RAS rate of 77 L/s per clarifier was assumed. This is the same design assumption as

for the existing clarifiers (i.e. maximum RAS rate 3.5 times design ADWF or 154 L/s in total for two clarifiers). The existing clarifiers are fitted with variable speed RAS pumps rated for a nominal maximum duty of 150 L/s with all 4 no. pumps operating (2 no. per clarifier) and a minimum of 20 L/s with 2 no. pumps running. The RAS rate minimum of 20 L/s (for 2 no. clarifiers) or 40 L/s for 4 no. clarifiers represents a RAS ratio of 0.6 times revised design ADWF (5.7 ML/d) for the augmented plant, or a ratio of 0.9 times ADWF at startup (approximately 3.8 ML/d) for the augmented plant (with Ocean Shores load). A RAS ratio in excess of 1:1 relative to minimum (night time) flows can be tolerated or energy consumption minimised at night by means of intermittent RAS pump operation at times of minimum flow, with suitable programming via SCADA/PLC.

8.2.8 New RAS flow splitter

A new RAS flow splitter will be required. The purpose of the new flow splitter will be to:

- Combined RAS flows from the existing and new clarifiers
- Re-divide the combined RAS flows, in proportion to process requirements, between the existing and new process trains. It is noted that the new process train (see above) will have a bioreactor with 50% of the capacity of the existing bioreactor but up to 100% (i.e. doubling) of the existing clarifier capacity.
- Enable the two process trains to operate with a common mixed liquor biomass, for ease of process control and operation.
- Facilitate ease of operation to take either of the bioreactors off line, or one or more of the clarifiers off line, for maintenance purposes.

The new RAS splitter will include a new RAS screen. The existing RAS line will be redirected from the inlet works to discharging via this new screen into the RAS splitter. Similarly, the new RAS line (from new clarifiers) will be directed to discharge via this new screen.

The new RAS splitter will combine flows from the RAS pump discharge lines (existing and new) via a common chamber and then split the flow via four fixed-weir overflows feeding four discharge pipes. Each of these discharge pipes will be fitted with an actuated knife-gate valve that will be operated in either a fully opened or fully-closed position. When fully closed, the relevant overflow weir at the flow splitter, associated with that given discharge line, will 'drown' and therefore be taken out of service. RAS flow will be divided among the remaining open weirs and discharge lines.

Two RAS discharge lines each will be directed to the bioreactor (anaerobic zone/oxidation ditch) associated with each of the two parallel treatment trains (new and existing).

Under conditions when either of the two clarifiers associated with either of the two parallel treatment trains (new and existing) is taken out of service, one of the two RAS lines associated with that treatment train will be closed. That is, the RAS flow split will always be in proportion to the number of clarifiers on line in each process train.

The actuated valves on the RAS lines downstream of the RAS flow splitter will be under automated control via the plant SCADA/PLC system. The operator will inform the system (via an appropriate check box or similar on SCADA) when one or more clarifiers is taken out of service. Alternatively, RAS valve position programming can be based on automation via a 'fail' or 'off' signal from one or more of the clarifier scraper drives.

8.2.9 New aerobic digester

Additional aerobic digester capacity is recommended for the proposed plant augmentation. Although aerobic digestion adds to the plant total energy consumption, for a small plant of this type it represents a viable and appropriate method of sludge stabilisation, given the type of process and the need for advanced nutrient removal.

The existing aerobic digester has a process volume of 500 kL (0.5 ML) served by 2 no. 15 kW positive displacement blowers (duty/standby) with a SOTR capacity of 27 kg/h at 2.7 m minimum water depth and 45 kg/h at 4.5 m maximum water depth.

The new aerobic digester is proposed to add 50% additional aerobic digester capacity. It is envisaged that the new aerobic tank (250 kL) will be positioned immediately adjacent to the existing tanks. Additional blowers (2 no. 7.5 kW) are envisaged.

Prior to detailed design, it is recommended that process concept alternatives to providing an additional aerobic digester be investigated. For example, providing the existing aerobic digester can be taken off line for a period of time (e.g. by dewatering and separately disposing of sludge by wasting mixed liquor directly to the belt filter press), it might be feasible to raise the walls of the existing digester and operate it at a water depth of up to 6.75 m to provide additional capacity. This will increase oxygen transfer efficiency but will significantly increase air pressure requirements for aeration. Blower compatibility and/or the need for replacing the existing blowers to meet the increased pressure requirement should be investigated. The overall potential for lower capital costs can then be assessed and compared with augmentation by extension of the existing design.

8.2.10 Disinfection

Treated flows via the secondary clarifiers will be such that the combined secondary effluent from both the existing and the new process treatment trains will be disinfected via the UV disinfection facility. The existing UV facility will be expanded to provide both additional peak hydraulic capacity and increased process capacity for full disinfection catering for the requirements of the augmented plant.

It was assumed that the UV system will remain in its existing location and that it will be possible for flow to gravitate from this system to the proposed tertiary wetland. It was further assumed that, in terms of the environmental licence requirements, the point of compliance with bacteriological limits will be upstream of the proposed wetland. Additional (i.e. tertiary) disinfection downstream of the wetland was assumed to be not required under the future environmental licence requirements for the plant, after upgrading (refer to Section 3.3.1).

Further details in this respect for the upgrade of the UV disinfection system will be developed during extended concept and detailed design, in consultation with equipment suppliers and the EPA in respect of licence requirements.

8.2.11 Effluent Pump Station and Effluent Storage

The plant currently has an effluent lift pump station that takes disinfected effluent (from downstream of the UV system) to an effluent storage tank on site, which supplies an effluent reuse system. It was assumed that this system is adequate and serves the current and expected effluent reuse system requirements for the foreseeable future. No augmentation of this system after the transfer of flow from Ocean Shores was planned as part of this Study. This aspect may require further investigation prior to detailed design and subject to BSC requirements.

8.2.12 Sludge dewatering

The existing sludge dewatering building has one installed belt filter press. There is sufficient room (in theory) for installation of a second belt filter press. However, the building was designed with free space provided for maintenance of the existing press, taking into account the position of the roller door and the need for sufficient room in the building for access to the press from the

side to remove rollers etc. Space for maintenance will be highly constrained with a second press installed; the building would need modification, or preferably expansion with a second roller door provided. Furthermore, the building floor will need to be modified to provide a sump and drainage pipework, power supply etc. for the second belt press. A further complication could be integration of the second belt press with the existing conveyor system for dewatered sludge cake to reach the biosolids storage area(s), both existing or new (see below).

Given the above-mentioned constraints, this aspect will require further investigation during detailed design.

An alternative strategy could be to avoid (or defer) installing a second belt filter press and to extend the operating times of the existing belt filter press. The existing press was designed to operate 35 hours per week for waste activated sludge (WAS) from the existing process train. Increasing operational times to around 53 hours per week (7.5 hours per day, 7 days per week) would theoretically be sufficient to cater for the augmented plant capacity (to ADWF of 5.7 ML/d). The manpower or automated operation adjustments (e.g. for automated shutdown) required would need to be confirmed to ensure that these met BSC preferences. Without a second belt press, the plant will have no dewatering redundancy, meaning that mobile dewatering equipment would need to be brought to site when the existing belt filter press is taken out of service for a major overhaul. The existing mobile dewatering plant from OSSTP could possibly be refurbished and used for this purpose.

For developing base case capital costs in this Study, it was assumed that a new dewatering building of similar proportions to the existing building would be provided adjacent to the new process train, equipped with a second belt filter press that provides full redundancy to the existing dewatering plant. Subject to the acceptability of the above-mentioned alternative strategy, the capital cost savings associated with deferring (or not providing) new dewatering facilities were identified (refer to Section 8.3).

8.2.13 Sludge storage

The existing storage area for dewatered sludge (biosolids) is in the form of a semi-circular covered area adjacent to the dewatering building. Biosolids cake is moved into the area via a system of conveyors directly off the belt filter press.

The sludge storage area will require expansion to cater for the augmented plant capacity. There is no obvious way to increase the size of the existing storage area, given its semi-circular form and the pattern of conveyor operation, relative to the adjacent building and road access for trucks etc. Expansion of the existing area in the same form will require significant re-building and provision of a longer-radius inclined conveyor. Alternatively, provision of a similar facility of the same design (e.g. to the north of the existing covered area) will require a longer transverse conveyor to reach that point, along with modifications to the peripheral road for truck access etc.

Given the above-mentioned constraints, this aspect will require further investigation during detailed design.

For developing base case capital costs in this Study, it was assumed that a new sludge storage area of similar design to the existing area would be provided. This would be adjacent to the new dewatering building (refer to Section 8.2.12 above). In other words, this approach would mirror the existing system with a new sludge dewatering and storage facility of similar design. If the new dewatering facility is not built (or deferred – refer to Section 8.3) then it was assumed that an alternative method of providing additional sludge storage in a covered area (at similar capital cost) would be developed.

8.2.14 Additional requirements

Wet weather storage facility

Previous studies

Previous studies (GHD, 2008a,b) for the concept and detailed design of the BVSTP (as originally conceived) included an effluent storage dam in the south-eastern corner of the site (i.e. south of the STP process treatment units). The detailed design for this dam was for a facility with the following dimensions and specifications:

- Footprint 150 x 150 m (2.25 ha)
- A maximum working volume of 35.9 ML
- Freeboard of 1.0 m (berm crest to maximum water level)
- Berm crest level at 7.0 m AHD (i.e. well above the nominated 100-year ARI flood level of 3.30 m)
- A cross section with 3H:1V batters in both cut and fill and a 4 m wide crest was adopted
- An impermeable liner was incorporated in the embankment cross section to reduce the risk of contamination of the groundwater and river by percolation of the effluent. The liner covers the entire base of the storage and the inner faces of the embankments up to the crest level. Compacted clay liner (with geotextile under layer) was selected for the concept design.

The effluent storage dam was not built. Alternative effluent storage in a steel tank was provided instead. For this Study, a wet weather storage facility for surplus raw sewage is proposed (see below). It was assumed that the location and design of this facility would be similar to that proposed for effluent storage (see above), except that the dimensions would be smaller in order to minimise cost, as discussed below.

This Study

An open lagoon-type storage facility is proposed to receive plant raw sewage inflows that exceed available process capacity. This facility will be located to the south of the existing STP works (refer to layout in Appendix H). Typically, this facility will receive wet weather flows greater than a sustained 6 x design ADWF⁴¹ (e.g. >396 L/s, see discussion below). Sustained flow will be measured on a time-averaged basis (e.g. moving average calculated over a time period of 30 to 120 min., which can be operator-adjustable via the SCADA system and calculated in the plant PLC), using inputs from the flow meters connected to the rising mains.

Flow will be diverted to the wet weather storage facility via a downward-opening penstock at the new raw influent flow splitter. The operators will have the ability (via SCADA and PLC automatic control system) to set an override on the time-averaged flow setpoint at which the penstock opens, and by what margin it opens, so as to divert more or less flow to the storage facility. This will enable the storage facility to be invoked earlier and to receive more diverted flow in the event that the plant process capacity is constrained at less than 6 times design ADWF (e.g. if one or more clarifiers is off line).

Flows diverted to the wet weather storage facility will be screened (to <3 mm aperture), preferably using a 'self-cleaning' screen design such as a curved wedge-wire 'hydrosieve' screen, or equivalent.

⁴¹ Augmented design ADWF = 5.7 ML/d (66 L/s)

For this Study, a high-level assessment of the required volume for wet weather storage was made, based on the following assumptions:

- Existing BVSTP influent flow meter data⁴² for the period 1/6/2012 to 16/5/2015, taken as average (totalised) daily flows
- Current ADWF = 2.15 ML/d (median for the 2012-15 period) based on population projections and related assumptions, as described Section 2
- Incoming flows >6 times ADWF diverted to the wet weather storage facility
- Flows pumped back from the wet weather storage facility at an average rate of 0.5 times (design) ADWF (i.e. 33 L/s return rate) on days when plant inflow is <2 times ADWF
- Simple water balance in the wet weather storage lagoon ignores evaporation and rainfall capture⁴³

This approach has inherently assumed that the flow records of 2012-15 for the existing BVSTP are reasonably representative of the current and future flow patterns, including wet weather and I/I effects. That is, it is assumed that the existing I/I issues will not become manifestly worse in future and will apply equally across the combined catchments of Mullumbimby, Brunswick Heads and Ocean Shores for the foreseeable future.

Different ADWF scenarios were modelled using a simple water balance approach, based on the above assumptions. The results are summarised in Table 19, Figure 14 and Figure 18.

Using a conservative approach⁴⁴ and based on the results presented in Table 19 (and Figure 14), for the base case costing in this Study, a provisional wet weather storage volume of 20 ML capacity is recommended. Provision should be made in the plant layout for potentially doubling this capacity in the distant future (beyond 2045).

Alternatively, using a less conservative approach (see Table 19), for the alternative case costing in this Study, a provisional wet weather storage volume of 10 ML capacity is recommended, also with the provision in the plant layout for potentially doubling this capacity in the distant future (beyond 2045).

Up to at least the years 2035-37 (indicatively), providing the STP can process up to 6 times ADWF (or 397 L/s sustained flow), a storage volume of 20 ML will provide sufficient capacity such that the probability of discharge occurring from the wet weather lagoon (to the wetland or river) will be minimised to approximately <2% of the time (typically <7 peak wet weather days in total per annum), whilst reserving up to approximately 6 ML for rainfall capture in the lagoon⁴⁵.

Alternatively (and less conservatively), up to at least the year 2035-36, if the STP can only process up to approximately 5 times ADWF (or 265 L/s sustained flow for the existing plant), a storage volume of 10 ML will provide sufficient capacity such that the probability of discharge occurring from the wet weather lagoon (to the wetland or river) will be minimised to approximately <4% of the time (typically <15 peak wet weather days in total per annum), whilst reserving up to approximately 2.5 ML for rainfall capture in the lagoon. This caters for the

⁴² Sum of PS1 and PS2 flow meters from operations records, data supplied to GHD by BSC (email R Collins to D de Haas dated 17/6/2015).

⁴³ The return rate (0.5 times ADWF) is relatively conservative and could be either increased (indicatively to 1 times ADWF) or return pump run time extended on dry weather days to take into account volumes of rainwater captured in the lagoon that will need to be recycled via the treatment process. Subject to more detailed analysis, as an approximate guide, at 75 mm/d rainfall (99th percentile from BOM rainfall records) over 3 consecutive days, the wet weather storage facility will accumulate approximately 5.7 ML of rainfall, reducing its useful volume for wastewater storage by this margin.

⁴⁴ Conservative assumptions: divert >6 times ADWF to wet weather storage; return flow 0.5 times ADWF when inflow <2 ADWF.

⁴⁵ Refer to Footnote 43 on page 47.

scenario where upgrading the plant process infrastructure (bioreactors and clarifiers) is deferred until ca. 2035-36.

A 20 ML capacity storage lagoon will require a facility with the following approximate dimensions: 1.5 m water depth (assumed) with 1 m vertical freeboard to top of bank; earth banks batter max. 1:2 slope; length 180 m at base (190 m at top of inner bank); width 72 m at base (82 m at top of inner bank). Subject to detailed design, and allowing for a 'turkey's nest' lagoon arrangement with earth berm perimeter walls (including 5 m berm crest to allow access by road vehicle), the total footprint is estimated to be 1.9 ha (204 m long x 96 m wide). The lagoon will be clay-lined (or similar design) for water retention. Refer to the proposed plant layout in Appendix H for the conceptual location of the proposed lagoon.

It is recommended that a more detailed water balance model be applied to this analysis prior to detailed design for the purposes of confirming the capacity requirements for the wet weather storage facility.

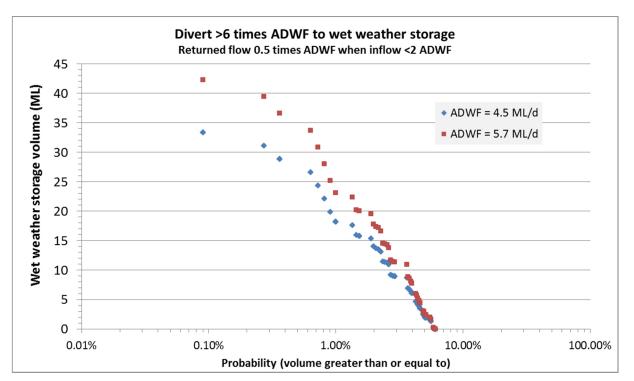
ADWF (ML/d)	Nominal year from population projections Indicative only (see Section 2)	Diverted PWWF (> y times ADWF)	Returned Flows (> z times ADWF)	Storage Volume (ML) at n th percentile Note 2	Storage Volume (ML) at 99.7 th percentile Note 3
4.5	2035-37	6 (>314 L/s) Conservative	0.5	99.1%: 20 ML 99%: 18 ML 98%: 14 ML 97%: 10 ML	99.7%: 31 ML
		5.1 (>265 L/s) Less conservative	1	97.5%: 20 ML 97.1%: 18 ML 96.5%: 10 ML 95.8%: 7.5 ML	99.7%: 40 ML
5.7	Beyond 2045	6 (>397 L/s) Conservative	0.5	98.5%: 20 ML 98%: 18 ML 97.5%: 14 ML 96.4%: 10 ML	99.7%: 39 ML
		4.75 (>314 L/s) Less conservative	1	96.7%: 20 ML 95.3%: 10 ML 94.8%: 8 ML	99.7%: 57 ML

Table 19Wet weather storage volume requirements for different scenariosbased on simple water balance model

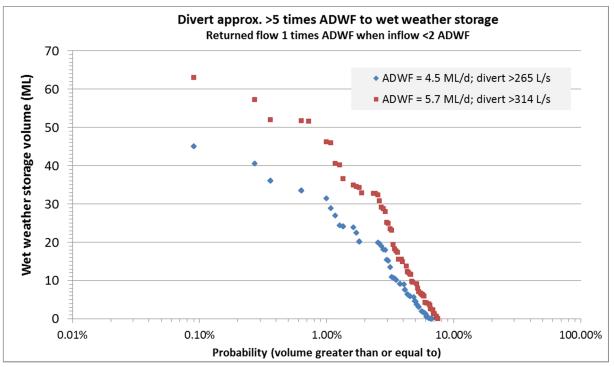
Note 1: Flows returned from wet weather storage when plant inflow is <2 ADWF (assumption). Assumptions for returned flow rate: 0.5 times ADWF (conservative) to 1 times ADWF (less conservative)

Note 2: Nominated (nth) percentile. Example 99th percentile, there is a probability of 1% or less that the required storage volume will be greater than the tabulated figure. A 1% probability is a likelihood of a discharge event from the wet weather storage facility occurring on typically approximately 3.7 days per year.

Note 3: At the 99.7th percentile there is a probability of 0.3% or less that the required storage volume will be greater than the tabulated figure. A 0.3% probability is a likelihood of a discharge event from the wet weather storage facility occurring on typically 1 day per year.









Tertiary Wetlands

A previous study (GHD, 2003) highlighted the benefits of a constructed wetland for the tertiary treatment of effluent (including surplus wet weather flow) for the BVSTP site. We understand that wetlands used for this purpose carry broad community support within BSC's jurisdiction due to number of associated benefits to environmental, aesthetic and amenity values⁴⁶. The wetland proposed as part of the original concept design (GHD, 2003) was not constructed with the new STP in 2009-10 due to financial constraints.

As part of the plant capacity augmentation proposed here, it is recommended that a constructed wetland be considered for inclusion in the upgrade, subject to cost considerations.

In view of the relatively large wet weather storage facility proposed (see above), and reserving space for possible future plant expansion, the available space on the site on the southern side (closest to the river) is approximately 3.3 ha (\sim 133 x \sim 250 m). This surface area is substantially smaller than the wetland area originally proposed (3 no. cells, totalling approx. 10 ha)⁴⁷. Nevertheless, a wetland surface area of 3 ha is sufficient to be within the practical range of hydraulic conductivities for horizontal-flow sub-surface wetlands planted in coarse gravel sand medium at flow rates up to nominally 6 x design ADWF for the augmented plant (i.e. 6 x 5.7 ML/d or 34.2 ML/d).

Given the smaller area, the wetland proposed here will have more limited nutrient removal capacity than that originally proposed (see above). However, this is of minor significance since the STP main treatment process achieves advanced nutrient removal (refer to Sections 5.2.1 and 6.5.1). The proposed wetland will still provide a useful tertiary ('backup' or 'polishing') function, particularly for trapping and degrading suspended solids that might be carried over from the clarifiers on the activated sludge (secondary) process.

Further modelling work for the wetland will be required prior to detailed design. For the purposes of assessing feasibility in this Study, a constructed wetland area of 3 ha was adopted, with a maximum water depth of 0.8 m (typical operating range approx. 0.4 to 0.6 m).

Refer to the proposed plant layout in Appendix H for the conceptual location of the proposed wetland.

Flood implications

BSC has previously undertaken a flood assessment study (Webb, McKeown & Associates, 2008) to assess the implications of construction of the (then proposed) new BVSTP. At the time, the STP concept included three wetland cells with a total area close to 10 ha positioned in on the north-west side of the property (i.e. west of the STP) and an effluent storage lagoon (1 ha area) positioned in the south-eastern corner of the property (i.e. south of the STP).

The criteria adopted for the previous flood study (Webb et al., 2008) were as follows:

• The final dimensions of the works are such that there should be no increase in flood level greater than +0.01 m in the 100-year ARI event. A change in flood level of +0.01 m is considered to be within the accuracy of the hydraulic modelling approach and can effectively be ignored.

The conclusions from this previous flood study included the following:

• The 100-year ARI flood level on the site was assessed to be at 3.30 m AHD.

⁴⁶ Peter Rees (BSC Water & Sewerage Dept., Pers. Comm. to GHD, May 2015).

⁴⁷ Refer to Figure 5-3 in GHD (2003) conceptual plant layout.

- The effluent storage lagoon (maximum dimensions 150 m x 150 m) and proposed wetland (3 no. cells, max. 10 ha area) along with the rest of the STP site would allow the above-mentioned flood criteria to be met provided the following conditions are met:
 - The crest of the wetland berm walls (or any other earthworks associated with the wetlands) remains below 2.30 m AHD.
 - The crest of the effluent storage lagoon berm walls was assumed to be at a minimum 3.30 AHD (the 100-year ARI flood level)⁴⁸.
 - An open drainage channel (4m wide) is constructed along the north-western side of the proposed wetland cells and along the western side of the site) to promote drainage in the direction toward the river.

The wet weather storage facility and wetlands area proposed in this Study are expected to be of similar dimensions to (or smaller than) those proposed in 2008 (but never built). Therefore, flood implications are expected to be similar provided the design criteria and conditions summarised above are observed.

As a precaution, a repeat of the flood study for the area is recommended prior to final detailed design in order to confirm these conclusions.

8.3 Potential to defer new infrastructure at BVSTP

The following items could potentially be deferred as part of a capital infrastructure program for this proposed project:

Defer one new clarifier: build one of two clarifiers at the outset and the second in ca. 2035-36 when projected ADWF = 4.5 ML/d (approximately). This approach has the disadvantage that the existing constraints around settleability and clarifier capacity (refer to Sections 5.1.3, 5.2.2 & 6.4.2) under peak wet weather flow conditions will remain and will not be relieved. The combined PWWF instantaneous pumping rate from Ocean Shores (i.e. SPS 5004 and 5009 currently) will also need to be limited⁴⁹ to around 157 L/s in order to remain within the original design parameters⁵⁰ of the existing clarifiers. Alternatively, allowing for more conservative sludge settleability design parameters proposed in this Study⁵¹, a greater proportion of PWWF will need to be diverted to the wet weather storage facility. With only three clarifiers (two existing plus one new until ca. 2035-36), and to be consistent with the revised clarifier design parameters proposed in this Study (refer to Section 6.5.2), PWWF indicatively >300 L/s (as opposed to >400 L/s with 4 no. clarifiers) will need to be diverted to wet weather storage. Based on the simplified water balance calculations outlined in Section 8.2.14, the probability of the wet weather storage facility filling and discharging to the environment (e.g. via the proposed constructed wetland) under these conditions (i.e. 20 ML storage capacity with flows >300 L/s diverted to it, being 5.7 times ADWF of 4.5 ML/d projected for year 2035-36) will be approximately 1.5% (i.e. a 98.5% ile storage requirement close to 20 ML). This might be acceptable to meet BSC and EPA requirements, being the same probability as that proposed in this Study for the ultimate case (i.e. 20 ML storage capacity for the ultimate design ADWF = 5.7 ML/d with PWWF >6 ADWF or >400 L/s diverted to it).

⁴⁸ The detailed design of the proposed effluent storage dam (GHD, 2008b) set the crest at 7.0 m AHD (i.e. well above the 100year ARI flood level).

⁴⁹ Limits would need to be set on variable speed drives for SPS 5009 (SPS 5004 currently has fixed speed pumps and might have to be converted to VSDs with limits as well).

⁵⁰ Original clarifier design parameters based on better settleability typically than currently observed at BVSTP – refer to Section 5.1.3

⁵¹ Refer to Sections 6.2.2 & 6.5.2

- Decrease the size of the wet weather storage facility: provide 10 ML capacity at the outset and defer constructing the remainder of the wet weather storage until ca. 2035-36 (i.e. deferring until that date construction of additional wet weather storage capacity of at least another 10 ML for an ultimate total capacity of at least 20 ML). Up to ca. 2035-36 (projected ADWF 4.5 ML/d, diverting flows >6 ADWF to storage) this will increase the probability of the wet weather storage facility filling and discharging to the environment (e.g. via the constructed wetland proposed) indicatively from 1% to 3% (i.e. for a 97%ile storage requirement of 10 ML) (refer to Figure 14). This might be acceptable to meet BSC and EPA requirements, given that partial treatment of the surplus wet weather flows will occur in the proposed wetlands and that the wet weather flows typically make a small contribution to annual nutrient load limits. Before being adopted, this approach will require further investigation (with more accurate modelling, if required) confirm that licence maximum limits on nutrient concentrations and/or disinfection (bacteriological indicator organisms, if applicable) will not be exceeded at the relevant plant final licence compliance point(s)⁵².
- Defer additional bioreactor and clarifier capacity: Retain the size of the wet weather storage facility built as 20 ML capacity at the outset but defer augmenting both the bioreactor capacity (new bioreactor) and additional clarifiers until ca. 2035-36. Peak wet weather flows >265 L/s (i.e. the existing plant capacity to treat sustained flow, using the existing plant design criteria) or approximately >5 times ADWF (4.5 ML/d projected indicatively for year 2037) will be diverted to the wet weather storage. Based on the less conservative assumption for sizing the wet weather storage facility (including return pumping at a higher rate - refer to Section 8.2.14), the 20 ML storage (with up to 5 ML reserved for rainfall capture) will be sufficient up to indicatively the 97th percentile (i.e. storage will typically overflow 3% of the time or indicatively on 11 days in a typical year). In this scenario, the existing process will technically be loaded to approximately 18% more than its design ADWF on peak days (with peak tourist populations). Refer to Figure 16. To compensate for the higher-than-design loading on peak days, the bioreactor will need to be operated at a shorter sludge age (indicatively 16 days instead of the original design 20 days) during peak (i.e. tourist season) periods in order to remain within the design envelope of the existing clarifiers, and without adopting more conservative design settleability criteria⁵³ (refer to Section 6.5.2). The disadvantage of this approach is that the existing sludge settleability limitations (i.e. potential for solids carryover during sustained wet weather events) will need to be accepted and the tertiary wetlands relied upon to 'polish' the secondary effluent by trapping solids carried over from the clarifiers. A further disadvantage of this scenario is that effluent quality might be compromised in terms of nitrogen removal by aeration system capacity limitations of the existing bioreactor under peak loading conditions (diurnal peak on peak days with tourist loads). The existing aeration system will, on average be operating at 85% of its design capacity (with 2 no. duty blowers operating). Additional (dynamic) modelling will be required to accurately quantify the effluent quality impacts under this scenario. The steady-state model predictions carried out as part of this Study suggest that the average (not peak) oxygen requirements will be met at ADWF 4.3 ML/d (projected for year 2035-36) and the average effluent quality will still be below 5 mgN/L Total N. Dynamic modelling will be required to confirm whether the licence requirements for ammonia (<2 mgN/L 90%ile; 4 mgN/L max.) and Total N (<10 mgN/L 90%ile) are achievable under this scenario. The constructed

⁵² The current license (refer to Appendix C) only applies limits to bacteriological indicators for disinfection at 'Point 1' being the discharge pipeline from the mainstream treatment process, and not at 'Point 2', which is the discharge from wet weather overflow as defined in the license.

⁵³ Based on the original process design (Hartley, 2013a & b), sludge settleability is expected to improve with increased plant loading (relative to current performance at loadings typically averaging below 50% of design loading).

wetland (if built) is expected to have a 'polishing' (tertiary treatment) effect on effluent nutrient concentrations, which will help with achieving licence requirements. The impact of the shorter operating sludge age in the bioreactor on biosolids stabilisation in the aerobic digester will also need to be modelled for this scenario. The available information from steady-state modelling suggests that the digester solids retention time can be increased by approximately 25% by means of operating the existing supernatant withdrawal valves during the 'air off' times of digester cyclic aeration. Given the digester design concentrations (RAS feed MLSS 8000 mg/L), sludge gravity thickening by this means appears to be feasible (i.e. increasing average operating MLSS in the digester from approx. 7800 to 9750 mg/L). Biosolids stabilisation criteria (e.g. specific oxygen uptake rate target <1.5 mgO₂/(gTSS.h) are expected to be achievable (subject to confirmation by more detailed modelling prior to implementation).

- Defer/eliminate the wet weather storage facility: In this case, as with the existing plant, all peak wet weather flows will be passed directly through the treatment process, with the risk of process constraints (sludge settleability) leading to solids carryover to the secondary effluent. Either this risk to final effluent quality is accepted or the constructed wetland (assuming it is built) would be relied to provide a 'buffer' or capture of solids carried over from the clarifiers.
- **Defer/eliminate the construction of the wetland**: In that case, surplus wet weather flows that might spill from the wet weather storage facility (under extreme wet conditions) will be combined with treated (disinfected) secondary effluent and flow directly to the river. Licence conditions in this respect will need to be checked with the EPA for the necessary environmental approvals. The risk of solids carry over to the final effluent from the clarifiers will be similar to the existing plant (or tempered by the more conservative clarifier design proposed above, assuming both new clarifiers are built).
- Defer/eliminate building new sludge dewatering facilities: In this case, the operating times for the existing belt filter press will be extended to cater for the sludge wasting requirements of both the existing and new process trains. Some level of risk associated with the lack of redundancy in sludge dewatering equipment will have to be accepted, but but this risk can be mitigated by the provision of mobile dewatering equipment as back-up, when required (e.g. refurbish and make available the existing mobile dewatering plant at OSSTP for this purpose). Further the most practical and cost-effective way of providing additional covered storage space for dewatered biosolids will need to be investigated, either adjacent to (or by expansion of) the existing covered area, at a similar (or lower) capital cost to the existing system used to estimate costs in the base case for this Study (Section 11.1).

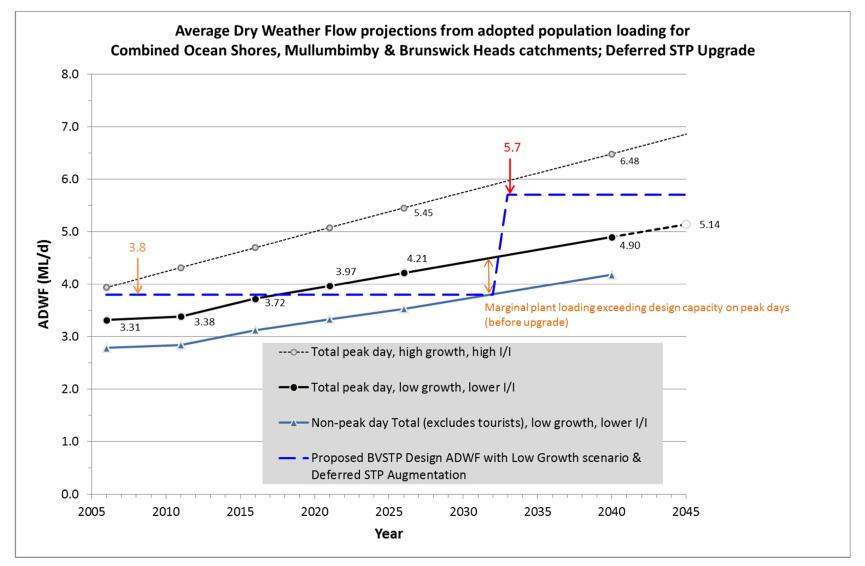


Figure 16 Projected peak and non-peak day ADWF based on population projections, showing timing of deferred plant upgrade (Option 4) in 2035-36.

8.4 Summary of augmentation strategy options for BVSTP

The plant augmentation strategy options discussed above, including potential for deferment of some items, is summarised in Table 20, with the main risks highlighted.

Item	Option 1 Full upgrade Base case	Option 2 Defer one new clarifier	Option 3 Decrease wet weather storage size	Option 4 Defer new bioreactor and both new clarifiers	Option 5 Defer/ eliminate wet weather storage	Option 6 Defer/ eliminate wetland	Option 7 Defer/ eliminate new sludge dewatering facilities
Design Flow ADWF	5.7 ML/d (66 L/s)	4.8 ML/d (55 L/s)	5.7 ML/d (66 L/s)	3.8 ML/d (44 L/s)	5.7 ML/d (66 L/s)	5.7 ML/d (66 L/s)	5.7 ML/d (66 L/s)
Full treatment (L/s)	396	300	396	256	396	396	396
Hydraulic Max ⁵⁴ (L/s)	628	471	628	314	628	628	628
Wet weather storage	√ (20 ML)	√ (20 ML)	√ (10 ML)	√ (20 ML)	×	√ (20 ML)	√ (20 ML)
Inlet Works	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Bioreactors	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark
Clarifiers	\checkmark	(✓) 1 no. only	\checkmark	×	\checkmark	\checkmark	\checkmark
UV Disinfection	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark
Chemical Storage & Dosing	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark
Constructed Wetland	✓ (3 ha)	✓ (3 ha)	✓ (3 ha)	✓ (3 ha)	✓ (3 ha)	x	√ (3 ha)
Aerobic Digester	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark
Sludge Dewatering & Biosolids Storage	\checkmark	\checkmark	\checkmark	(✓) (investigate further)	\checkmark	\checkmark	(✓) (investigate further)

Table 20 Summary of strategy options for plant capacity augmentation

⁵⁴ Hydraulic maximum (peak instantaneous) flows can be passed through treatment process but will not receive full treatment. Flows greater than nominated value to full treatment intended to be diverted to wet weather storage (if provided).

Item	Option 1 Full upgrade Base case	Option 2 Defer one new clarifier	Option 3 Decrease wet weather storage size	Option 4 Defer new bioreactor and both new clarifiers	Option 5 Defer/ eliminate wet weather storage	Option 6 Defer/ eliminate wetland	Option 7 Defer/ eliminate new sludge dewatering facilities
Switch Room & Blower Room	V	×	×	×	V	×	\checkmark
Other Pump Stations	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark
Plant Pipework & Valves	V	(✓) reduced	×	×	V	(✓) reduced	\checkmark
Roads, Fencing & Landscaping	✓	(✓) marginally reduced	(\checkmark) reduced	(\checkmark) reduced	✓	(✓) marginally reduced	(✓) marginally reduced
General Site Works	✓	(✓) reduced	(\checkmark) reduced	(\checkmark) reduced	(\checkmark) reduced	(✓) reduced	(✓) marginally reduced
Electrical, Instrumentation & Control	✓	(✓) marginally reduced	\checkmark	(✓) reduced	✓	✓	(✓) reduced

Item	Option 1 Full upgrade Base case	Option 2 Defer one new clarifier	Option 3 Decrease wet weather storage size	Option 4 Defer new bioreactor and both new clarifiers	Option 5 Defer/ eliminate wet weather storage	Option 6 Defer/ eliminate wetland	Option 7 Defer/ eliminate new sludge dewatering facilities
Main risks		Greater reliance on diversion of peak wet weather flows to storage and/or more frequent discharges from storage (adding indicative 6 days per annum up to ca. 2035-37)	Increased frequency of discharges from storage to wetland/ final effluent (adding indicative 6 days per annum up to ca. 2035-37; or 9 days per annum ultimately)	Greater reliance on diversion of peak wet weather flows to storage and/or more frequent discharges from storage (adding indicative 11 days per annum up to ca. 2035-37); more constrained plant operation (e.g. higher loading; peak aeration requirements not met on peak days); impacts on effluent quality (further modelling required to simulate); longer dewatering times and sludge storage space constraints (to be further investigated)	(Similar to current plant operation) No facility to shut down treatment plant Limited operational flexibility to manage peak wet weather flows (e.g. due to capacity constraints with equipment off line or poor sludge settleability)	(Similar to current plant operation) No formal 'buffer' or (tertiary) effluent 'polishing' step before river discharge Less environmentally responsible No added community/ natural aesthetic value associated with wetland	Longer operating times on existing dewatering equipment. No standby equipment/ less flexible dewatering options Mobile dewatering plant to be brought to site to allow major overhaul of existing dewatering equipment Sludge storage space constraints (to be further investigated)

8.5 Augmentation requirements for OSSTP (Alternative strategy)

In the alternative strategy (Option B – refer to Section 7.2) the augmentation requirements for OSSTP, defined as 'Option 2 (Oxidation Ditch)' in the previous planning study (GHD, 2014b), was adopted for comparative purposes in this Study.

The projected peak day ADWF (from population projections, as discussed in Section 2.2.1) and nominal plant capacity before and after augmentation⁵⁵ at OSSTP are shown in Figure 17.

Further details can be obtained from the OSSTP planning study (GHD, 2014a,b).

(<u>Note</u>: The Addendum report (GHD, 2016) to this Study, which reviewed OSSTP capacity augmentation requirements to cater for lower population growth projections, is superseded by the adoption of the latest population projections from the BSC Strategic Business Plan (2016) – refer to Section 2.1.3).

⁵⁵ The previous planning study for OSSTP (GHD, 2014b) adopted a design population loading of 10,700 EP at a unit flow rate of 215 L/[EP.d], which equates to a design ADWF = 2.3 ML/d. For consistency with the planning work in this Study (based on unit flows of 590 L/[ET.d] or 240 L/[EP.d]), the equivalent design ADWF required for a projected ultimate population of 9,091 EP (2045) (based on latest projections from BSC Strategic Bus. Plan, 2016 - see Section 2.1.3) is 2.18 ML/d. This gives a close match to the planning study (GHD, 2014b) design basis and therefore the OSSTP augmentation requirements considered to be appropriate for comparative purposes in the alternative strategy under consideration here.

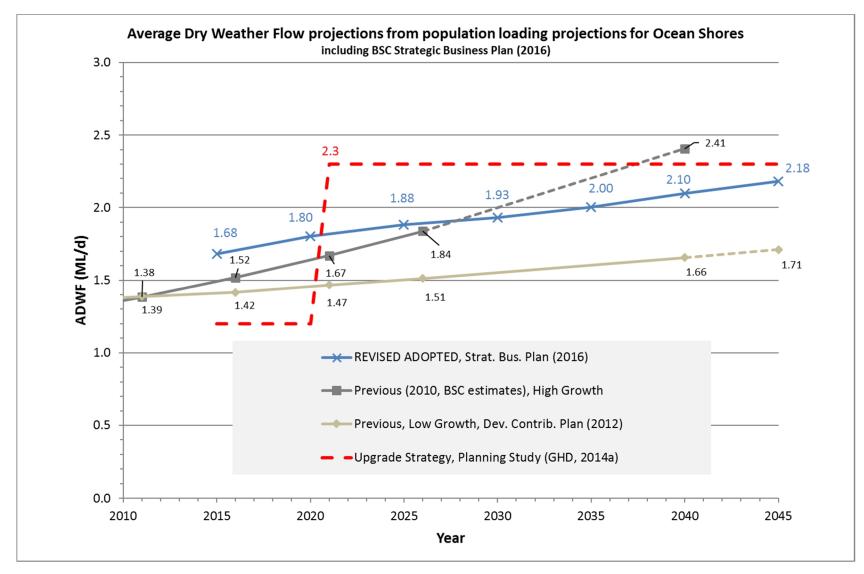


Figure 17 Projected peak day ADWF based on population projections for OSSTP (alternative strategy, with upgrade in 2020-21)

9. Safety in Design

9.1 What is 'Safety in Design'?

Safe design is a process defined as:

"The integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of the product being designed."

A safety in design approach begins in the conceptual and planning phases within a design's lifecycle, with an emphasis on making choices about design, materials and methods of manufacture or construction, to enhance safety. The designer needs to consider how safety can best be achieved in each of the lifecycle phases (construction, use, maintenance, demolition).

Safety in design is part of a broader range of design objectives, including practicality, aesthetics, cost and the functionality of the plant, building or structure. A safety in design approach involves successfully achieving a balance of these sometimes competing objectives, without compromising the health and safety of those potentially affected by the plant, building or structure over its lifecycle.

9.2 What are the Principles of Safety in Design?

The key elements that impact on implementing safety in design are:

Principle 1: Persons with Control – persons who make decisions affecting the design of products, facilities or processes are able to promote health and safety at the source.

Principle 2: Product Lifecycle – safe design applies to every stage in the lifecycle from conception through to demolition. It involves eliminating hazards or minimising risks as early in the lifecycle as possible.

Principle 3: Systematic Risk Management– the application of hazard identification, risk assessment and risk control processes to achieve safe design.

Principle 4: Safe Design Knowledge and Capability – should be either demonstrated or acquired by persons with control over design and should reflect the knowledge that a competent designer would be expected to have.

Principle 5: Information Transfer – effective communication and documentation of design and risk control information between all persons involved in the phases of the lifecycle is essential for the safe design approach.

9.3 Context for this Report

The inclusion of safety in design principles within legislation means that it is no longer sufficient to assume that compliance with a code or standard is enough.

If engaged to undertake detailed design, GHD can implement safety in design processes to identify those health and safety issues in the design phase of a job that may have an effect on the construction, maintenance or end use of the final product. In some cases, the safety in design risk assessment will take the form of a HAZOP study.

Under Health and Safety legislation, a client who commissions construction work must consult with the designer of the structure about how to ensure that risks arising from the design during the construction work are eliminated or minimised. The designer of a structure must give the

client a written report that specifies the hazards associated with the particular design and not with other designs of the same type of structure.

As the current scope of work is very preliminary, structures have yet to be designed and this document does not specify safety issues in detail. A more formal risk assessment associated with deferment of capacity augmentation for some STP process components has been recommended in this study, with possible areas worthy of consideration including:

- Construction
- Installation and Commissioning
- Operation
- Maintenance

10. Layout

Refer to Appendix H for the preliminary layout associated with concept put forward in this Study for the plant capacity augmentation.

11. Cost Estimates

11.1 Capital cost

11.1.1 Basis of estimates

The capital cost estimates presented in this section have been developed for planning purposes and may be used for preliminary budgeting. However, the scope and quality of the works has not been fully defined and therefore the estimates are not warranted by GHD. These estimates have been developed based on cost curves, extrapolation from recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 25% for the items described in this report. A functional design is recommended for budget setting purposes.

The capital cost estimates given below exclude GST. All costs are in 2nd Qtr 2015 AUD; this is the estimate base date, with no allowance for any escalation.

Estimate costs are based on all the site works for each Option being carried out in one contract. Should this condition change, cost increases are anticipated to cater for additional construction facilities and contract letting/administration works.

Cost elements are based upon limited geotechnical and survey information. Additional geotechnical and survey information would be required to confirm design parameters.

The cost estimates for this project were developed in 2015, and had a validity⁵⁶ period to December 2015. While the costs presented here give an approximation of likely project costs, they should be reviewed and refined at functional design

The cost estimates exclude:

- SPS5004 upgrade (separately listed refer to Section 8.1)
- Decommissioning costs for Ocean Shores STP (where applicable, for options where the site will be closed to wastewater treatment operations).
- Costs associated with upgrading services to the site (services excluded are power supply, potable water supply and telecommunications)
- Council project team and related costs
- Costs of transferred risk
- Subsidies, finance and insurance costs
- Permits and licence fees, legal fees and compensation
- Roadworks/access improvement and traffic management control
- No allowance has been made for foreign currency risk. The project includes a number of mechanical and electrical equipment items that would probably be imported e.g. screens, mixers, pumps, motors, blowers, diffusers, instruments, electrical components etc.

The rationale for excluding (i.e. separately listing) the SPS5004 upgrade was that is likely to be required for asset renewal/ operational reasons irrespective of the STP transfer, as explained in the note regarding timing in Section 8.1.

The rationale for excluding decommissioning costs at the OSSTP site was as follows⁵⁷:

⁵⁶ Validity set at the time the draft version (revision A) of this report was developed.

⁵⁷ As agreed with BSC Water & Sewerage representatives at meeting held 6 August 2015.

- The site is not ideal for redevelopment (low-lying and flood-prone; situated within a nature reserve)
- A number of uncertainties relating to possible future uses of the site, including timing; type of use; and the associated net cost (or revenue).

Capital costs were developed for:

- The seven BVSTP capacity augmentation options identified in this Study (refer to summary in Table 20 of Section 8.4); together with
- The sewage transfer system augmentation/upgrade requirements from Ocean Shores to BVSTP (refer to Section 8.1), which is common to all these STP options. However, the estimated capital cost of the SPS5004 upgrade was separately listed and not included in the total for the STP transfer project considered here (see below).

On-cost/overhead item	Percentage For BVSTP	Percentage For OSSTP	Notes
Indirect Job Costs (IJC) (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%	20%	of Direct Job Cost (DJC)
Risk and Contingency	25%	30%	of DJC + IJC See Footnote ⁵⁸
Head Contractor Margin	5%	5%	of DJC See Footnote ⁵⁹

The capital cost estimates include on-costs as follows:

11.1.2 Estimates for proposed OS-BVSTP transfer strategy (OSSTP closure)

The capital cost estimates for the Ocean Shores to Brunswick Valley STP raw wastewater transfer and upgrade of BVSTP are summarised in Table 21. A detailed breakdown is given in Appendix I.

The estimates in Table 21 show that a total capital cost budget in the range \$26.7 to \$30.8 Million is required for this project.

The biggest opportunity for deferment of capital lies in Option 4, where the majority of the STP capacity augmentation is deferred until ca. 2035-36. By that time the existing plant will be nominally operating at 115% of its current design capacity (in average dry weather flow terms on peak days, including tourist loads, based on population projections) – refer to Section 8.3. There are some process-related risks associated with this option (Option 4), as discussed in Section 8.3. However, the required capital cost in the immediate term (nominally 2016-17) is significantly lower (\$10.6 M) and the deferred capital cost is \$22.7 M (nominally to 2035-36).

⁵⁸ Higher Risk and Contingency allowance for OSSTP due to greater uncertainty. BVSTP estimate (this Study) includes provision for \$1.28 M in bulk earthworks (site pre-loading and flood mitigation measures included), based on actual contract prices for existing plant constructed in ca. 2009-10. Less certainty around earthworks requirements for OSSTP, due to lack of geotechnical and detailed design for OSSTP upgrade concept (refer to previous Planning Study, GHD, 2014a,b). Additional 5% for Risk & Contingency adds approx. \$1.1 M to OSSTP estimate to allow for possible additional earthworks and related civils costs.

⁵⁹ OSSTP Planning Study (GHD, 2014b) allowed for 10% head contractor margin. Lower margin (5%) adopted here to be compatible with BVSTP estimate in this Study.

Other options, each carrying different risk profiles, present opportunities to defer (potentially indefinitely, or eliminate) capital costs in the range \$1.2 M to \$4.2 M.

11.1.3 Estimates for alternative strategy (retention and upgrade of OSSTP)

This Study has investigated the feasibility of the transfer of raw wastewater from the Ocean Shores catchment to BVSTP for treatment. In this strategy, Ocean Shores STP (OSSTP) would be closed (refer to Section 7).

The alternative strategy would be to retain and upgrade OSSTP. That strategy was previously investigated in a Planning Study (GHD, 2014a,b). If Ocean Shores raw wastewater loads are not transferred to BVSTP, then:

- The raw sewage transfer system extension/ upgrade (OS to BVSTP) will not be required.
- BVSTP will not require upgrading until after 2045 (refer to Appendix B). Hence, if Ocean Shores loads are not transferred, the augmentation of BVSTP is effectively deferred until beyond the planning horizon of this Study.
- To be consistent with current planning initiatives for recycled water (effluent reuse) (refer to GHD 2014b), and for consistency here in terms of capital cost estimates, treated effluent from OSSTP would be pumped to BVSTP to add to supply for the existing Mullumbimby recycled water scheme, which could be extended in future. The cost of the pipeline to transfer treated effluent from OSSTP to BVSTP therefore has been factored into the comparison between strategies, using the same easement.

The capital cost estimates for the upgrade of Ocean Shores STP and treated effluent transfer from OSSTP to BVSTP are summarised in Table 22. These estimates were based on the plant upgrade proposed in the Planning Study (refer to GHD, 2014b) "Option 2", namely, a similar oxidation ditch process configuration to that at BVSTP. The estimates adopted include deferment of capital costs associated with tertiary effluent filtration, subject to licence and recycled water quality requirements⁶⁰. Refer to the breakdown of capital costs in Appendix J.

11.1.4 Discussion

A comparison of capital costs between the strategies (OS-BVSTP transfer/ OSSTP closure vs. alternative of retaining and upgrading OSSTP) in Table 21 and Table 22 shows that:

- The transfer from OS to BVSTP and full upgrade/augmentation (base case, Option 1) proposed for BVSTP is potentially approximately \$2.74 M more expensive in terms of total capital cost than the alternative (retaining and upgrading OSSTP⁶¹) due to a combination of the following factors:
 - Inclusion of wet weather storage facility
 - Inclusion of tertiary constructed wetland
 - Inclusion of redundancy in dewatering facilities and additional biosolids storage capacity
 - Provision of additional clarifier capacity (to compensate for apparent shortfall in clarification capacity, due to more aggressive design basis in terms of sludge settleability assumed used for the existing BVSTP clarifiers⁶²)

⁶⁰ Tertiary effluent filters were included in the OSSTP Planning Study (GHD, 2014b) to be conservative in the absence of specific information on future license or recycled water quality requirements. For a valid comparison with Brunswick Valley, (where unfiltered post UV-disinfected effluent is pumped to effluent reuse), the filters may be removed from the base capital cost estimates for OSSTP here.

⁶¹ Excluding Filters at OSSTP in this comparison.

⁶² Refer to Sections 4.5, 5.1.3 and 6.4.2.

- Ample provision for future growth of the combined catchments (to beyond year 2045)⁶³ in the proposed BVSTP augmentation.
- The transfer from OS to BVSTP and augmentation of BVSTP <u>excluding the wet weather</u> <u>storage (deferred/eliminated, Option 5) is cheaper (by \$1.42 M) in terms of capital cost</u> than the alternative (retaining and upgrading OSSTP). However, this option carries a degree of greater risk (refer to Section 8.4 and Table 20).
- The transfer from OS to BVSTP and augmentation of <u>BVSTP excluding both the wet</u> weather storage and the constructed wetland (both deferred/eliminated, by a combination of Options 5&6) potentially saves \$2.82 M in capital cost, compared with the alternative (retaining and upgrading OSSTP). However, this option also carries greater risks (refer to Section 8.4 and Table 20).
- Additional opportunities for deferral of capital costs appear at BVSTP, but <u>not</u> at OSSTP, in the form of:
 - Deferral of one new clarifier (Option 2, i.e. removing provision of additional clarification capacity and accepting the risk of a more aggressive existing design basis – see above) until ca. 2035-36 potentially defers \$2.38 M in capital; and
 - Deferring new sludge dewatering facilities (Option 7, i.e. accepting risks associated with lack of redundancy and longer operating times on existing mechanical equipment, with reliance on mobile dewatering as backup) at least until ca. 2035-36 or potentially indefinitely, defers \$1.83 M in capital.
- There is a major opportunity for deferral of \$22.66 M in capital costs at BVSTP (at least until ca. 2035-36), if risks associated with marginal (up to 15%) overloading of the existing plant is accepted on peak days, after transfer of the Ocean Shores loads (refer to Section 11.1.2 above). This opportunity does not exist at OSSTP, due to the plant already being marginally overloaded in its existing form at current Ocean Shores loads and presenting a number of operational issues (refer to GHD, 2014a & b).

Overall, on a comparable basis (excluding provision of wet weather storage and constructed wetland, both of which increase process reliability and robustness but are not critical items), the proposed strategy (i.e. transfer from OS to BVSTP and augmentation of the latter) offers the best potential to minimise and/or defer capital costs by centralising STP treatment operations for the Mullumbimby, Brunswick Heads and Ocean Shores combined catchments.

⁶³ In the Low Growth, low I/I scenario. Refer to Appendix B.

ITEM	Scenario	CAPITAL COST (2020-21)	CAPITAL COST DEFERRED (TO 2035-36)	TOTAL CAPITAL COST*	CAPITAL COST DEFERRED INDEFINITELY (OR ELIMINATED)
OS TO BVSTP RAW SEWAGE TRANSFER SYSTEM - PUMP STATION (5004) UPGRADE	Not included in Project Totals here	\$0.74 M	-	\$0.74 M	
OS TO BVSTP RAW SEWAGE TRANSFER SYSTEM - PIPELINE	Common to All BVSTP Options	\$2.41 M	-	\$2.41 M	-
BVSTP CAPACITY AUGMENTATION					
Option 1	Full upgrade, Base case	\$30.82 M	-	\$30.82 M	-
Option 2	Defer* one new clarifier	\$28.44 M	\$2.38 M	\$30.82 M	-
Option 3	Decrease wet weather storage size	\$29.67 M	\$1.15 M	\$30.82 M	-
Option 4	Defer* new bioreactor and both new clarifiers	\$8.16 M	\$22.66 M	\$30.82 M	-
Option 5	Defer**/eliminate wet weather storage	\$26.66 M	-	\$26.66 M	\$4.16 M
Option 6	Defer** eliminate wetland	\$29.42 M	-	\$29.42 M	\$1.40 M
Option 7	Defer**/eliminate new sludge dewatering facilities	\$28.99 M	-	\$28.99 M	\$1.83 M
PROJECT TOTAL (TRANSFER + BVS	TP)				
Option 1	(As above)	\$33.23 M	-	\$33.23 M	-
Option 2		\$30.85 M	\$2.38 M	\$33.23 M	-
Option 3		\$32.08 M	\$1.15 M	\$33.23 M	-
Option 4		\$10.57 M	\$22.66 M	\$33.23 M	-
Option 5		\$29.07 M	-	\$29.07 M	\$4.16 M
Option 6		\$31.83 M	-	\$31.83 M	\$1.40 M
Option 7		\$31.40 M	-	\$31.40 M	\$1.83 M

Table 21 Summary of Capital Cost estimates for OS-BVSTP transfer (strategy proposed in this Study)

*Defer until 2035-36 (Options 2, 3 and 4)

**Defer indefinitely (Options 5, 6 and 7)

All Capital Costs include On-costs/ Overheads, Risk & Contingency allowance (refer to Section 11.1.1)

ITEM	Scenario	CAPITAL COST* (2020-21)	CAPITAL COST* DEFERRED (TO 2035-36)	TOTAL CAPITAL COST*	CAPITAL COST* DEFERRED INDEFINITELY (OR ELIMINATED)	
OS TO BVSTP TREATED EFFLUENT TRANSFER SYSTEM (PIPELINE only)	Required for comparative purposes relating to effluent reuse (Mullumbimby scheme), if OSSTP is retained & upgraded	\$1.56 M	-	\$1.56 M	-	
OSSTP UPGRADE/ CAPACITY AUGM	ENTATION					
Option 2, Previous Planning Study (GHD, 2014b)	Full upgrade comparable to BVSTP Option 1 (Base case), with Filtration deferred	\$28.93 M	-	\$28.93 M	\$1.95 M	
PROJECT TOTAL (OSSTP + EFFLUENT TRANSFER)						
	(From above)	\$30.49 M	-	\$30.49 M	\$1.95 M	

Table 22 Summary of Capital Cost estimates for OSSTP upgrade (alternative strategy)

All Capital Costs include On-costs/Overheads, Risk & Contingency allowance (refer to Section 11.1.1)

11.2 Operating cost

11.2.1 Basis of estimates

Operating costs were estimated using the following approach and assumptions:

- Staff costs, assuming half of one full-time equivalent (0.5 FTE) operator plus 0.5 FTE for all support staff <u>per STP⁶⁴</u> whilst both STPs (OSSTP and BVSTP) are operational (i.e. before the transfer). Thereafter (with OSSTP closed and flows transferred to BVSTP), assume one full-time equivalent (1 FTE) operator plus 0.5 FTE support staff for BVSTP. Staff costs for pump stations were assumed to be external to this analysis and common to all options. One FTE was assumed to cost \$120,000 per annum.
- Unit power cost: \$0.19 per kWh average, based on recent 2014-16 electricity accounts data⁶⁵ for BVSTP and OSSTP.
- Power costs were scaled to flow and load based on population projections using an inhouse model for with specific power use ranging 460 to 733 kW/ML, depending on plant loading. The power model used was previously calibrated to 2013 yearly data⁶⁶ for (West) Bryon STP and agreed reasonably well with 2014-16 yearly data for BVSTP (similar process configuration); the model was recalibrated for OSSTP (existing, before upgrade) to reflect the higher specific power use for that plant, based on 2014-16 yearly data⁶⁵. Allowance for incremental power requirements for pumping was made as follows:
 - For SPS 5004 (raw sewage) upgrade to pump to BVSTP: additional 55 kWh/ML (or additional 12 kW pump power at a pump rate of ~60 L/s or 0.216 ML/h)
 - For effluent reuse transfer from OSSTP to BVSTP (for comparative purposes in alternative strategy): additional 45 kWh/ML (nominal max. 10 m head and 60% pump efficiency).
- Unit chemical costs⁶⁷ as follows:
 - Alum: \$271 per tonne solution (min. 46% w/w; SG 1.31 kg/L)
 - Polymer (dry powder): \$9 per kg
 - Sodium hydroxide (caustic soda): \$660 per tonne (50% w/w, SG 1.50 kg/L)
 - Ferric sulphate: \$623 per tonne (50% w/w, SG 1.58 kg/L)
- Chemical use was scaled to flow (ADWF) based on population projections (refer to Appendix B), as follows:
 - Supplementary chemical P removal (using alum and alkalinity correction with sodium hydroxide) assuming 2 mgP/L removal for all options, except:
 - Option 4 before BVSTP augmentation (assumed 3 mgP/L removal due to higher loading of existing plant until 2035-36)
 - OSSTP before upgrading in the alternative scenario without transfer to BVSTP (assumed 4.5 mgP/L removal, due to lack of bio-P removal process configuration at the existing plant).

⁶⁴ Revised from 1 FTE and 0.8 FTE for support staff per STP (c.f. previous OSSTP Planning Study - GHD, 2014b) following meeting held on 6 Oct. 2016 with BSC Water & Sewerage representatives.

⁶⁵ Based on Electricity Accounts data for 2014-15 and 2015-16 Financial Years supplied by BSC (B Green) to GHD (D de Haas) dated 11/7/2016: average 18.4 c/kWh for BVSTP; 19.4 c/kWh for OSSTP.

⁶⁶ Based on email communication from BSC (Ray Collins) to GHD (D de Haas) dated 19/11/2014.

⁶⁷ Based on email communication from BSC (Ray Collins) to GHD (D de Haas) dated 22/07/2015. Liquid polymer cost information provided was \$13,500 per 3,000 L (assumed equivalence to dry powder based on 50% w/w solution).

- Ferric sulphate assuming an average dissolved sulphide removal⁶⁸ of 3 mgS/L for the existing BVSTP (without OS transfer) or 5 mgS/L (with OS transfer). No ferric sulphate dosing is applied at the existing OSSTP and this was assumed to continue to be the case in the alternative scenario without transfer to BVSTP.
- Polymer at 4.5 kg/tonne dry solids (biosolids cake)
- Biosolids production based on steady-state modelling undertaken (refer to Section 6) and assumptions above regarding supplementary chemical P removal.
- Biosolids disposal⁶⁹: \$40 per wet tonne
- Other operating costs: \$85,000 pa allowance, for a range of miscellaneous costs, including: water; inspection & testing; licences; process monitoring; cleaning; air conditioning service; waste & sanitation (screenings & grit disposal).
- Maintenance costs Approach (1) for NPV analysis:
 - For all options prior to capacity augmentation at BVSTP: 0.5% of Civil; 3% of M&E Construction Direct Job Cost
 - For BVSTP options after capacity augmentation and transfer from OSSTP, including economies of scale⁷⁰: 0.4% of Civil; 2.4% of M&E Construction Direct Job Cost
- Maintenance costs Approach (2) for NPV sensitivity analysis:
 - For all options (no economies of scale): 0.5% of Civil; 3% of M&E Construction Direct Job Cost.

Maintenance costs using Approach (2) and other operating cost assumptions were crosschecked against actual operating costs incurred by BSC (FY 2014-15 and 2015-16 data), excluding staff and biosolids disposal costs, for the existing STPs. A summary of the comparative costs is given in Table 23. The agreement between actual and adopted operating costs was reasonable.

⁶⁸ Original design (Fulton Hogan, 2010) assumed an average of 3 mgS/L removal for BVSTP. Increased here to 5 mgS/L to allow for likely increase septicity of combined raw wastewater with the transfer from Ocean Shores (due to proposed rising main extension).

⁶⁹ Based on email communication from BSC (Brian Green via Dean Baulch) to GHD (D de Haas) dated 1/12/2014 for Byron SC STPs. Conservative estimate for agricultural disposal. Current costs range up to approximately \$38/ cubic metre.

⁷⁰ It was assumed that consolidation of treatment at BVSTP (with capacity augmentation using similar process configuration to existing plant) will offer economies of scale for maintenance (e.g. planned maintenance of similar items in both process trains; similarity of equipment, spares etc.). This assumption was tested in the NPV Analysis – refer to Approach (2).

Plant	Year	Power	Chemicals	Other operating costs	Planned maintenance	Reactive maintenance	TOTAL	Comparative TOTAL used in this Study (adopted)
BVSTP	2015	\$117,800	\$87,900	\$125,300	\$102,700	\$105,300	\$539,000	\$509,300
	2016	\$102,800	\$105,200	\$84,400	\$87,400	\$110,200	\$490,000	
OSSSTP	2015	\$113,300	\$110,300	\$143,700	\$81,100	\$122,700	\$571,100	\$565,700*
	2016	\$95,400	\$93,000	\$114,000	\$66,100	\$75,900	\$444,400	

Table 23 Comparison of recent STP actual operating costs with comparative total adopted for this Study

Note: Excludes Staff and Biosolids Disposal costs

Costs given are \$/ annum for operation of each STP separately (i.e. existing)

* OSSTP maintenance adopted costs shown here are for the plant after proposed upgrading (i.e. in alternative scenario, no transfer to BVSTP).

11.2.2 Estimates

The operating cost estimates at design flows (or year 2035-6, where relevant) are contained in Appendix K. Refer to Appendix L for the scaled operating costs used in the Net Present Value Analysis.

For comparative purposes, Ocean Shores STP operating costs were estimated on the basis of the plant upgrade proposed in the Planning Study "Option 2" (refer to GHD, 2014b), namely, a similar oxidation ditch process configuration to that at BVSTP.

The operating costs for the two STPs (upgraded Ocean Shores and Brunswick Valley) are broadly similar, given their similarity in terms of size and adopted process configurations. Minor differences arise from assumptions relating to chemical use and plant loading. The most significant opportunity for cost savings arises from operator manpower and maintenance requirements with consolidation of treatment at one STP site rather than two sites. Based on the assumptions made (refer to Section 11.2.1):

- There is no potential to save on operator staff costs, given the recent reduction in STP operator staffing levels at BSC. One FTE (currently split equally between two STPs) will be dedicated to the consolidated operations at BVSTP.
- Limited potential to save on staff overhead costs (assuming 0.5 FTE for consolidated operations at BVSTP, compared with 1 FTE assumed to be equally split between two STPs): \$60,000 pa saving.
- Significant savings potential of approximately \$300,000 pa in reduced maintenance costs from having treatment consolidated at one STP, particularly if economies of scale can be realised from having similar plant and equipment configurations in the existing and proposed new treatment process train at BVSTP. Even without the economies-of-scale factoring, the savings potential in reduced maintenance costs significant (approximately \$250,000 pa).

11.3 Net Present Value Analysis

11.3.1 Basis of analysis

Two approaches to Net Present Value (NPV) Analysis were taken, with the following assumptions:

Approach 1 – NPV(1) Analysis

- Discount rate: 4.5%
- Base date: 2016
- Period: 30 years
- No escalation or inflation
- Variable operating costs (power, chemicals, biosolids disposal) indexed to dry weather flow predictions (from population growth)
- Maintenance costs for options prior to BVSTP capacity augmentation: 0.5% of Civil; 3% of M&E Construction Direct Job Cost

• Maintenance costs for BVSTP options after OS transfer and capacity augmentation, including economies of scale: 0.4% of Civil; 2.4% of M&E Construction Direct Job Cost

Approach 2 – NPV(2) Analysis (sensitivity)

As above for Approach 1, except:

 Maintenance costs for all options (no economies of scale): 0.5% of Civil; 3% of M&E Construction Direct Job Cost

11.3.2 Comparison of options in the proposed strategy

The strategy proposed in this Study is to consolidate treatment at BVSTP and to close OSSTP. The options within this strategy were summarised in Section 8.4 and capital costs for these options were discussed in Section 11.1.2.

Taking into account both capital and operating costs, the results of the NPV analysis for these options are summarised in Table 24. Refer to Appendix L for details.

Using *Approach 1* (see section 11.3.1), the results show an NPV of \$48.49 M for Option 1 (Base Case) with potential to save between approximately \$0.6 M and \$3.2 M in NPV terms by reduced size or deferment of individual process units (one new clarifier, wet weather storage, wetland or new sludge dewatering facilities). Deferment of the major process capacity augmentation (Option 4) until 2035-36 offers the potential to save approximately \$12.6 M in NPV terms.

Comparing the results for *Approach 1 with Approach 2* in Table 24 illustrates the sensitivity of NPV to maintenance cost assumptions. Assuming no economies of scale for maintenance costs at one plant (BVSTP) (*Approach 2*) adds: about 1% to the NPV for options that have either no deferment of capital or deferment of one process item (i.e. all options except Option 4); or about 0.6% additional NPV where major capacity augmentation at BVSTP is deferred until 2035-36 (Option 4).

Table 24 Net Present Value Summary for Proposed Strategy

ITEM	Scenario	NPV (1)	NPV (2)	NPV (1)	NPV (2)
OS TO BVSTP RAW SEWAGE TR AND BVSTP CAPACITY AUGMEN	Saving relative to Alternative Strategy of retaining both OSSTP & BVSTP (refer to				
PROJECT TOTAL (TRANSFER + STP)				Section 11.3	3.3):
BVSTP Option 1	Full upgrade, Base case	\$48.49 M	\$49.03 M	-\$5.53 M	-\$4.99 M
BVSTP Option 2	Defer* one new clarifier	\$47.05 M	\$47.57 M	-\$6.97 M	-\$6.45 M
BVSTP Option 3	Decrease wet weather storage size	\$47.90 M	\$48.44 M	-\$6.12 M	-\$5.58 M
BVSTP Option 4	Defer* new bioreactor and both new clarifiers	\$35.92 M	\$36.13 M	-\$18.10 M	-\$17.89 M
BVSTP Option 5	Defer**/eliminate wet weather storage	\$45.33 M	\$45.83 M	-\$8.69 M	-\$8.19 M
BVSTP Option 6	Defer**/eliminate wetland	\$47.19 M	\$47.72 M	-\$6.83 M	-\$6.30 M
BVSTP Option 7	Defer**/eliminate new sludge dewatering facilities	\$46.69 M	\$47.19 M	-\$7.33 M	-\$6.83 M

*Defer until 2035-36 (Options 2, 3 and 4)

**Defer indefinitely (Options 5, 6 and 7)

Refer to text for definition of approaches in NPV(1) & NPV(2) (sensitivity to Maintenance Costs)

11.3.3 Comparison with alternative strategy

For a comparison of costs, the alternative strategy will be to retain both BVSTP and OSSTP. BVSTP will not need to be upgraded until after 2045 but OSSTP will require a major upgrade (GHD, 2014a,b) in the near future (nominally 2020-21). A transfer pipeline from OSSTP to BVSTP for effluent reuse will replace the raw sewage transfer rising main, but will follow the same easement. Refer to Sections 7.2.2 and 8.5 for a further discussion of the rationale adopted for this alternative strategy.

The capital costs for the alternative strategy were discussed in Section 11.1.3.

The NPV calculations for the alternative strategy followed Approach 2 – refer to Section 11.3.2.

In the absence of capital costs in this strategy for BVSTP (no upgrade), the NPV component for BVSTP is made up of the aggregate discounted operating costs. For OSSTP a major upgrade is required (as identified by the GHD (2014b) planning study), and a comparable approach was used to estimate the associated capital and operating costs as for BVSTP.

The results of the NPV calculation in this strategy are summarised in Table 25.

The Total NPV for both STPs in this strategy is estimated to be \$54.02 M. This provides the basis against which to compare the NPV estimates for the proposed strategy for the transfer to BVSTP (refer to Table 24).

The results in Table 24 show that for all the options considered, the proposed strategy of transfer from Ocean Shores to BVSTP offers savings in terms of NPV (project whole of life cost). The NPV savings are at least approximately \$5 M (for Option 1, base case, assuming full augmentation of capacity at BVSTP including the wet weather storage, wetland and additional bioreactor and clarifier capacity). If the additional bioreactor and clarifier capacity is deferred to 2035-36, then very significant NPV savings of approximately \$18 M are possible.

The NPV estimates were not very sensitive to the maintenance costs assumptions relating to economies of scale associated with consolidating operations at BVSTP using a similar process configuration and/or equipment (compare NPV(1) and NPV(2) estimates in Table 24).

Table 25 Net Present Value Summary for Alternative Strategy

ITEM	Scenario	NPV (2)
NO RAW SEWAGE TRANSFER SYSTEM / NO B	VSTP CAPACITY AUGMENTATION; UPGRADE OSSTP	
PROJECT TOTAL		
Maintain Existing BVSTP Operations	No Capacity Augmentation; No Upgrade	\$17.23 M
Retain OSSTP and Upgrade	Capacity Augmentation and Upgrade (No Filters); including New Effluent Reuse Transfer Pipeline to BVSTP	\$36.79 M
TOTAL FOR BOTH STPs		\$54.02 M

Refer to text for definition of approach in NPV(2) calculation.

12. Conclusions

The following main conclusions may be drawn from this Study:

- It is technically feasible and cost-effective in the long term (on a whole-of-life cost basis) to transfer raw wastewater from Ocean Shores to Brunswick Valley STP (BVSTP) for treatment. If this proposed strategy is implemented, then treatment at the Ocean Shores STP (OSSTP) will permanently cease and the STP can be closed.
- 2. There is sufficient space at the BVSTP site to treat the combined flows and loads from the Mullumbimby, Brunswick Heads and Ocean Shores catchments in the long term, using a similar process format to the existing plant at this site. There is also sufficient space to incorporate optional additional process components in the form of a wet weather storage facility for raw wastewater and a constructed wetland for tertiary effluent treatment. Taking into account requirements for the combined catchments, including Ocean Shores, and site space constraints, the sizes of these additional components proposed in this Study differ from those proposed in the original concept design (ca. 2008). Final selection of sizes will need to be confirmed by additional investigation, as part of the revised concept and detailed design for the plant capacity augmentation.
- 3. The most recent population estimates (from the Byron Shire Council Strategic Business Plan, 2016) have lower growth projections for the future. The latest estimates are indicatively 5 to 15% lower than those previously adopted from the original planning and concept designs for both STPs (GHD, 2003; 2007; 2008a,b; 2014a,b) and the previous Byron Shire Developer Contribution Plan (2012). Based on the latest projections and adopted unit flows per population equivalent (or tenement) the following conclusions were drawn:
 - The combined average dry weather flow (ADWF) on peak days (including tourists) from the Mullumbimby and Brunswick Heads catchments currently treated at BVSTP (excluding Ocean Shores) is expected to reach somewhere between 2.75 and 3.51 ML/d by 2045, depending on the flow allowance made for Inflow/Infiltration (I/I). That is the existing BVSTP design capacity (3.8 ML/d ADWF) is not expected to be exceeded within the planning horizon (30 years) of this Study unless a higher growth scenario materialises. Hence, if Ocean Shores flow is not transferred then BVSTP will not require a capacity augmentation in the foreseeable future.
 - If Ocean Shores wastewater flow is not transferred to BVSTP then OSSTP will need to be upgraded, based on the latest population projections and a previous planning study for that plant (GHD, 2014a&b). The projected ADWF for OSSTP is projected to reach 2.2 ML/d by 2045, which is approximately double the existing treatment capacity of the existing OSSTP (last upgraded more than twenty years ago and currently experiencing a number of operational issues or capacity constraints).
 - The combined ADWF on peak days (including tourists) from the combined catchments of Mullumbimby, Brunswick Heads and Ocean Shores (i.e. after transfer from Ocean Shores to BVSTP) is projected to reach just under 5 ML/d by 2045 without additional allowance for I/I in the long-term I/I, or approximately 5.7 ML/d by 2045 including additional allowance for I/I. The ADWF on non-peak days (excluding tourists) from the combined catchments is expected to reach the existing design capacity of BVSTP (3.8 ML/d) indicatively by 2035-36. That is, if the raw wastewater transfer from Ocean Shores is implemented, then the existing BVSTP will need to have its process capacity augmented to meet peak day treatment capacity requirements, including peak wet weather flow requirements. Provided a minimum plant upgrade is put in

place to meet peak (hydraulic) flow requirements in wet weather, the plant can be operated close to its design capacity on non-peak days, and marginally over its design capacity on peak dry weather days. In this proposed strategy, the major capital works for process augmentation (i.e. including additional bioreactor and clarifiers) can be deferred until no later than 2035-36, by which time the plant is projected to be operating close to 100% design capacity on non-peak days and up to 115% of design capacity on peak days under dry weather conditions.

- 4. This Study identified the following major risks in terms of planning for the transfer of wastewater loads from the Ocean Shores catchment to the Brunswick Valley plant:
 - BVSTP currently has no wet weather storage facilities, which means there is no fallback (or backup) operational strategy for managing flows at the plant (e.g. high wet weather flows or dry weather flows, particularly if the need arises to take critical process units offline for maintenance).
 - BVSTP currently has no tertiary wetland, unlike Council's other STPs at (West) Byron and Ocean Shores. Wetlands can serve useful effluent quality 'polishing' or buffering process functions and also have aesthetic benefits (e.g. bird habitat) that typically carry broad stakeholder support.
 - The existing BVSTP has hydraulic capacity constraints (posed by inlet works and downstream pipework) at less than the combined peak pumping capacity from the Mullumbimby, Brunswick Heads and Ocean Shores catchments. To varying extents, all of these catchments tend to be prone to high peak weather flows, due to on-going issues with infiltration and inflow.
 - Peak wet weather flows from the combined catchments (Mullumbimby, Brunswick Heads and Ocean Shores) are expected to exceed the hydraulic capacity of the existing treatment plant. Therefore, peak wet weather flows will need to be separately managed (via diversion to a new storage facility and return pumping when plant inflows permit), in order to operate within the hydraulic capacity constraints posed by the existing plant. The existing arrangement in which return activated sludge is pumped via inlet works will also need to be modified in order maximise the hydraulic capacity of the existing inlet works. This will help to minimise the risk of the new wet weather storage facility filling and discharging partially-treated or treated wastewater from being discharged to the environment.
 - A new environmental licence will likely be required for the plant to incorporate approval for the proposed new wet weather storage and wetland facilities, as well as the increased plant capacity and effluent quality targets.
 - A full duplication of the bioreactor capacity at BVSTP will provide surplus treatment capacity that poses risks of over-capitalisation and long-term operational issues (e.g. on-going poor sludge settleability; over-aeration; reduced energy efficiency).
 - No upgrade of BVSTP poses long-term risks of significant overloading and compromised plant operation (e.g. aeration and clarification capacity constraints; deterioration in effluent quality; decreased biosolids stabilisation and associated odour).
 - The proposed strategy, with deferment of the main process augmentation at BVSTP until no later than 2035-36, has some process risk associated with effluent quality due to the main biological treatment units (bioreactors and clarifiers) being marginally overloaded, relative to their nominal design capacity, from ca. 2024-25 until the upgrade in 2035-36. However, the level of this risk is expected to be acceptable, subject to confirmation of new licence requirements for effluent quality and further investigation using dynamic process modelling during detailed planning and design.

- There is anecdotal operational experience (and theoretical evidence from flux theory) of constraints on current clarification capacity at BVSTP posed by worse-than-design sludge settleability performance. According to the original designer (Hartley, 2013a&b), settleability is expected to improve with increased plant loading, considering that the existing plant is currently operating at around 50% of its design loading, or less at times. However, the operators have little control over sludge settleability in practice. A more conservative approach to clarifier design sizing for future capacity augmentation is proposed to significantly reduce risks of gross solids loss from the plant under peak wet weather flow conditions. This is particularly relevant considering that the existing peak (wet weather) pumping capacity from Ocean Shores is potentially up to approximately 10 times ADWF (projected), compared with the process design philosophy of 5.8 times ADWF for full treatment (including clarification) at BVSTP.
- 5. A number of options for capacity augmentation/upgrade of BVSTP were identified in this Study, catering for transfer of flows and loads from Ocean Shores as well as future growth in the existing catchments. The base case option (Option 1) reduces risks to the minimum and involves provision of the following:
 - Lagoon-type wet weather storage (20 ML) with return pumping facilities
 - Tertiary constructed wetland
 - 50% bioreactor capacity augmentation (3-stage 'Phoredox' concept oxidation ditch similar to that existing)
 - 100% clarifier capacity augmentation (2 no. clarifiers of same dimensions to existing)
 - New sludge dewatering and additional (covered) biosolids storage facilities, essentially duplicating those existing.
 - Capital cost (assuming implementation within the next 5 years or indicatively in 2016-17) of \$33.2 M and NPV of \$48.5 M (over 30 years at 4.5% pa discount rate).
- 6. Other options involving minor deferment of capital costs (either until ca. 2035-36 or potentially indefinitely) have a slightly increased risk profile, which will need to be managed. These involve the deferment of capital costs and lower NPV in the range approximately \$1.15 M to \$4.2 M (relative to the base case).
- 7. If the Ocean Shores-BVSTP transfer strategy is be implemented, the biggest opportunity to reduce capital costs (indicatively within the next 20 years) and reduce whole-of-life cost (NPV) comes from deferring the BVSTP capacity augmentation for major process components until no later than 2035-36 (i.e. Option 4 identified in this Study). This option has the potential to defer up to \$22.7 M in capital (until 2035-36) and reduce NPV by approximately \$12.6 M, compared with the base case (see above). However, further study is recommended to better understand and quantify the risks associated with this strategy and to ensure that the sizing and staging of the proposed BVSTP upgrades are appropriate and acceptable to BSC. A risk assessment of the proposed strategy should be carried out and should involve the BSC team responsible for operating the BVSTP plant at or beyond its nominal design capacity in the medium term after the transfer from Ocean Shores.
- 8. All of the options proposed for the Ocean Shores- BVSTP transfer offered lower whole-of-life (NPV) costs than the alternative strategy of retaining both STPs and upgrading OSSTP as per a previous planning study for that plant (GHD, 2014b). The NPV analysis was tested for sensitivity to assumptions around maintenance costs. Even without economies of scale (assumed for maintenance costs associated with one plant instead of two plants), the proposed strategy (Ocean Shores-BVSTP transfer) had a lower whole-of-life (NPV) cost profile for all options and is therefore recommended.

13. Recommendations

The following recommendations can be made from this Study:

- Commence planning for the capacity augmentation at Brunswick Valley STP (BVSTP), transfer of wastewater flows and loads from the Ocean Shores catchment and closure of Ocean Shores STP
- 2. For the transfer of Ocean Shores flows and loads, a rising main pipeline extension from OSSTP to BVSTP will be required. A potentially suitable easement for this pipeline has already been identified by Byron Shire Council. Further negotiation with existing landholders and the necessary planning approvals will need to be put in place. To enable the proposed transfer, it is recommended that these negotiations and planning approval applications be progressed further.
- 3. Given constraints on capital expenditure faced by Byron Shire Council in the short to medium term, the option with lowest capital and whole-of-life costs (NPV) identified in this Study (Option 4) involves the transfer of wastewater from Ocean Shores to BVSTP but deferral of a major process capacity augmentation at BVSTP. Based on the current lowgrowth population projections for all three catchments (Mullumbimby, Brunswick Heads and Ocean Shores), capacity augmentation at BVSTP can be deferred until ca. 2035-36 at the latest. By then, the loading on the plant will reach indicatively up to 115% of design loads on peak days (including tourist loads) or 100% of non-peak days (nominally excluding tourists). This deferral option is expected to carry a marginally increased risk profile (see below). Subject to these risks being further studied and found to be acceptable to Council, this option is recommended. It will require an estimated capital budget of \$11.3 M within an indicative timeframe of less than four years (nominally 2020-21), including the cost of the raw wastewater transfer from Ocean Shores and the provision of wet weather storage and tertiary wetland facilities at BVSTP. The capital cost (in 2015 dollars), deferred indicatively until 2035-36, will be \$22.7 M. The Net Present Value (NPV) of this option is estimated to be \$35.9 M, which represents a significant saving of \$12.6 M in whole-of-life terms, compared with the base case (lowest risk) option.
- 4. The lowest risk approach identified in this Study was the base case for full augmentation of treatment capacity at BVSTP (Option 1) at the same time as the transfer of loads from Ocean Shores (nominally in 2020-21). It will require an estimated capital budget of \$33.2 M, including the cost of the raw wastewater transfer from Ocean Shores, within an indicative timeframe of less than four years. The Net Present Value (NPV) of this option is estimated to be \$48.5 M. This option is not recommended due to the significantly higher whole-of-life cost and the risk of providing additional process treatment capacity that is well in excess of requirements (i.e. under-loading) in the short-medium term (<10 years, indicatively). Option 1 is only recommended if the risks associated with the other options (including the recommended Option 4, see above) are found to be unacceptable after further investigation.</p>
- 5. Before implementation of the lowest capital and whole-of-life costs (NPV) option recommended from this Study (Option 4, see above), it is recommended that additional studies be undertaken to better understand and quantify the associated risks. These risks may be grouped and summarised as follows:
 - Operational risks relating to hydraulic treatment capacity, which can be managed through staged implementation of inlet works and wet weather storage/return pumping facilities and tertiary wetland. It is recommended that more detailed water balance

model simulations of peak wet weather events for the combined catchments be undertaken. This will assist in confirming wet weather storage and return pumping requirements, and will enable appropriate risk mitigation.

- Operational risks relating to process treatment capacity (e.g. aeration, clarification, biosolids handling) and plant peak loading. These risks can be partly managed by use of the wet weather storage/return pumping facilities on peak (dry weather) days but will need to be largely absorbed by careful plant operation (e.g. increased solids wasting for sludge age control; aeration settings for use of full duty and/or standby blower capacity to maximise air supply on peak days). It is recommended that more detailed dynamic process model simulations of peak and average dry weather events for the combined catchments be undertaken. This will enable the residual risks associated with the existing STP operating in the range of approximately 100-120% of its design loading (in terms of effluent quality compliance) to be more fully quantified. These simulations will need to take into account the ability of the proposed tertiary wetland to 'polish' effluent quality (including nutrient removal) prior to discharge to the receiving water (river).
- 6. For detailed process modelling and future design purposes, it is recommended that Ocean Shores raw wastewater quality be fully characterised (no recent characterisation data available). At the same time, consideration should also be given to repeating the characterisation of raw wastewater from the Mullumbimby and Brunswick Heads catchments (characterisation last carried out in 2006-7).
- 7. Prior to implementation, it is recommended that agreement in principle and future licence requirements for BVSTP be negotiated with the regulatory agencies (notably NSW EPA). Careful consideration of the licence compliance point is required. For example, it is recommended that the final plant licence compliance point for nutrients be set downstream of the proposed constructed wetland for combined flows (i.e. fully treated plus surplus wet weather flows). Conversely, from a cost point of view, it would be preferred that the licence compliance point for bacteriological indicators (if limits are set) be upstream of the constructed wetlands (post-secondary treatment). If limits for bacteriological indicators are set downstream of wetlands, then the risk of pathogen recontamination due to wildlife in wetlands will need to be recognised in the new licence conditions. The design will then also require tertiary disinfection (UV or similar), which was not included in the cost estimates for this study.

Note that the current licence for BVSTP only applies limits to bacteriological indicators at 'Point 1', being the discharge pipeline from the mainstream treatment process, and not at 'Point 2', which is the discharge from any wet weather overflow. In this respect, when negotiating with regulating agencies, it is recommended that Council seeks to achieve conformity around future licence requirements between its treatment plants at Brunswick Valley and Byron Bay. These two STPs will have similar process formats if the recommendations of this Study are implemented.

- 8. Future effluent reuse requirements were not examined as part of this Study. It was assumed that the existing infrastructure at BVSTP is adequate to serve effluent reuse requirements in the area for the foreseeable future. It is recommended that this assumption be tested by further investigation, prior to detailed design and subject to BSC requirements.
- 9. This Study relied on information from previous flood assessments (ca. 2008) for the BVSTP site. Once the scope of work for the major earthworks associated with the proposed BVSTP capacity augmentation has been detailed, it is recommended a flood assessment of the site be repeated before adoption of the final design. This will be

particularly important where the proposed wet weather storage facility and constructed wetlands have different dimensions to those previously proposed in ca. 2008.

14. References

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Appendices

GHD | Report for Byron Shire Council - Ocean Shores to Brunswick Valley STP Transfer, 41/28941

Appendix A – Population projections breakdown

Year	Residential OS, low growth	OS Business & Industrial zones	OS*	Μ	ВН	M + BH	Tourists (Overnight + Day Trippers)	M + BH + Tourists	TOTAL
2,006	5,581	52	5,633	3,125	1,613	4,738	4,037	8,775	14,408
2,011	5,667	113	5,780	3,172	1,639	4,811	4,120	8,931	14,712
2,016	5,717	184	5,901	3,434	2,180	5,614	4,538	10,152	16,053
2,021	5,851	265	6,116	3,701	2,413	6,114	4,833	10,947	17,063
2,026	5,951	355	6,306	3,971	2,647	6,618	5,175	11,793	18,099
2,040	6,241	657	6,898	4,838	3,431	8,268	5,252	13,521	20,419

Table 26 Population Projections for Low Growth Scenario derived from previous studies (Section 2.1.1)

Table 27 Population Projections for High Growth Scenario derived from previous studies (Section 2.1.1)

Year	Residential OS, low growth	OS Business & Industrial zones	OS*	Μ	BH	M + BH	Tourists (Overnight + Day Trippers)	M + BH + Tourists	TOTAL
2,006	5,280	52	5,332	2,722	3,425	6147	3,652	9,799	15,131
2,011	5,764	113	5,877	3,129	3,625	6755	4,006	10,761	16,639
2,016	6,323	184	6,507	3,493	3,826	7318	4,329	11,647	18,154
2,021	6,955	265	7,220	3,811	4,026	7837	4,619	12,456	19,676
2,026	7,661	355	8,016	4,085	4,226	8311	4,877	13,188	21,204
2,040	10,032	657	10,690	4,615	4,787	9402	5,428	14,830	25,519

OS: Ocean Shores; M: Mullumbimby; BH: Brunswick Heads

Year	BH (ET)	M (ET)	OS (ET)	Total (ET)	BH (EP)	M (EP)	OS (EP)	Total (EP)	Tourists (Overnight + Day Trippers), allowance, included in Total EP (persons ⁷¹)
2015	1,028	1,541	2,848	5,417	2,527	3,788	7,001	13,317	4,400
2020	1,213	1,771	3,055	6,039	2,982	4,354	7,510	14,846	4,700
2025	1,433	1,918	3,189	6,540	3,523	4,715	7,840	16,078	5,000
2030	1,561	2,109	3,276	6,946	3,837	5,185	8,054	17,076	5,300
2035	1,696	2,269	3,395	7,360	4,169	5,578	8,346	18,093	5,350
2040	1,850	2,466	3,553	7,869	4,548	6,062	8,734	19,345	5,400
2045	2,021	2,645	3,698	8,364	4,968	6,502	9,091	20,562	5,450

Table 28 Adopted population projections for this Study

Assumed EP/ET ratio = 2.46 (except allowance for Tourists, see footnote and refer to Section 2.2.1)

⁷¹ Flow per person for Tourists (Overnight & Day Trippers) varies (refer to Section 2.2.1).

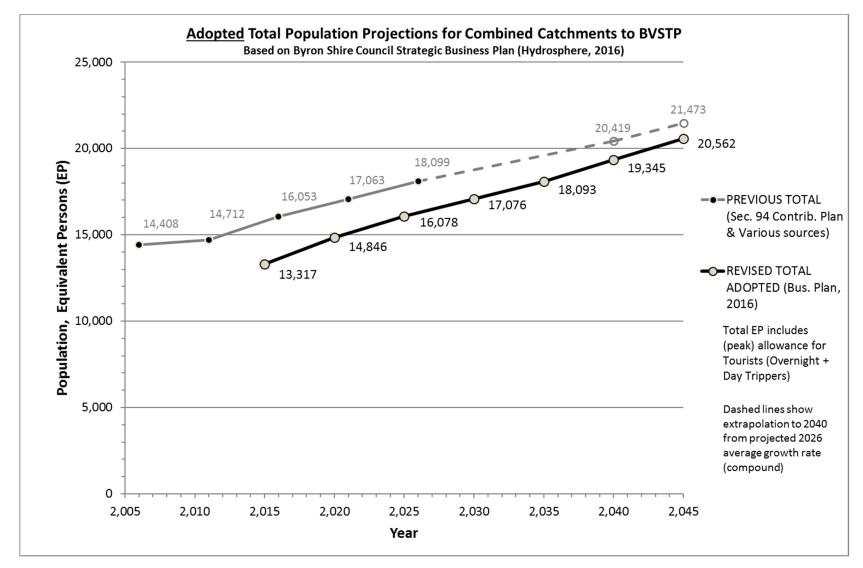


Figure 18 Adopted Total Population Projections, showing comparison to previous projections

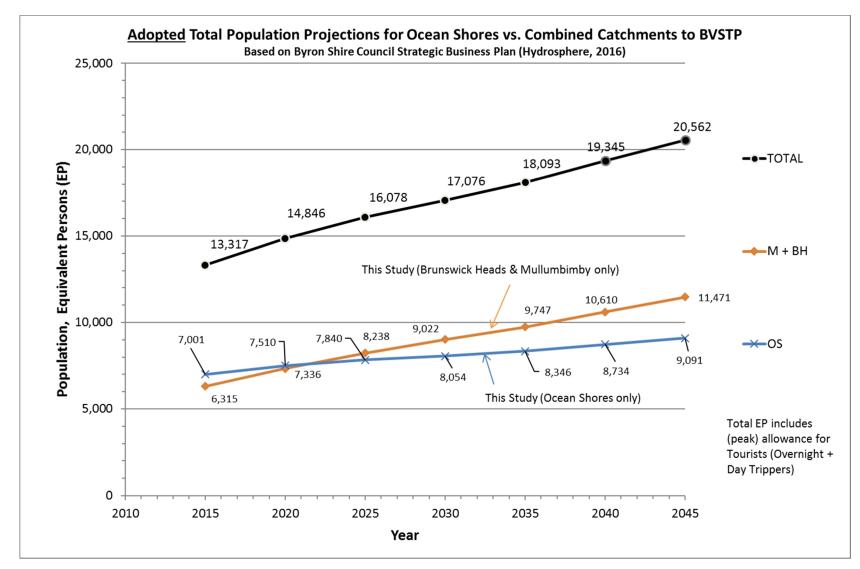


Figure 19 Adopted Population Projections, showing breakdown by catchment

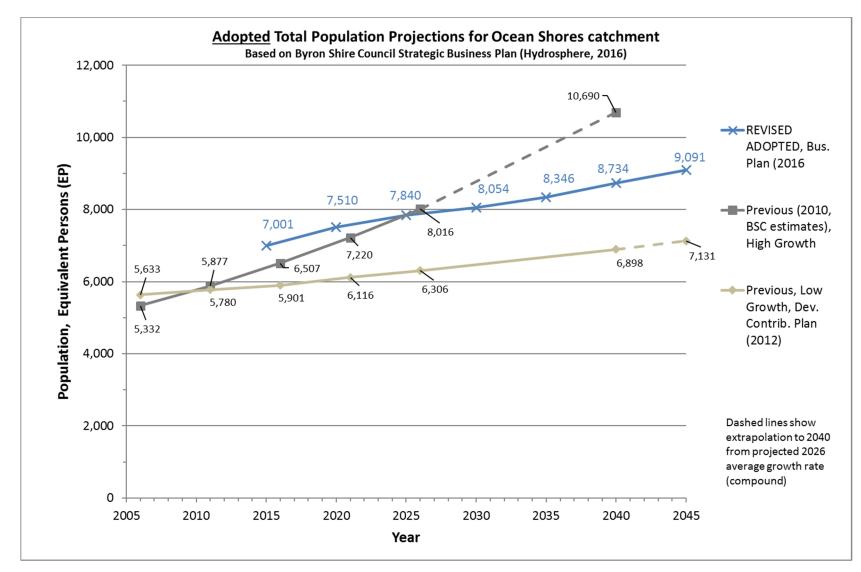


Figure 20 Adopted Population Projections for Ocean Shores catchment, showing comparison to previous projections

Appendix B Flow projection breakdown

Year	BH (ML/d)	M (ML/d)	OS (ML/d)	TOTAL ADWF (ML/d)	BH + M (ML/d)	Overnight Tourists (ML/d)	Day Tripper Tourists (ML/d)	BH + M' ADWF minus Tourists (Overnight + Day Trippers) (ML/d)	TOTAL ADWF minus Tourists (Overnight + Day Trippers) (ML/d)
2015	0.61	0.91	1.68	3.20	1.52	0.43	0.068	1.020	2.70
2020	0.72	1.04	1.80	3.56	1.76	0.46	0.072	1.231	3.03
2025	0.85	1.13	1.88	3.86	1.98	0.49	0.077	1.413	3.29
2030	0.92	1.24	1.93	4.10	2.17	0.52	0.082	1.568	3.50
2035	1.00	1.34	2.00	4.34	2.34	0.52	0.082	1.736	3.74
2040	1.09	1.45	2.10	4.64	2.55	0.53	0.083	1.938	4.03
2045	1.19	1.56	2.18	4.93	2.75	0.53	0.084	2.139	4.32

Table 29ADWF (ML/d) flow projections from adopted population projections and design unit flow assumptions (see Section2.2.1)

OS: Ocean Shores; M: Mullumbimby; BH: Brunswick Heads

Year	BH (ML/d), incl. additional I/I allowance	M (ML/d), incl. additional I/I allowance	OS (ML/d) (no additional I/I allowance)	TOTAL ADWF (ML/d), incl. additional I/I allowance	BH + M (ML/d), incl. additional I/I allowance
2015	0.82	1.10	1.68	3.60	1.92
2020	0.97	1.26	1.80	4.04	2.23
2025	1.15	1.37	1.88	4.40	2.52
2030	1.25	1.50	1.93	4.69	2.75
2035	1.36	1.62	2.00	4.98	2.98
2040	1.48	1.76	2.10	5.34	3.24
2045	1.62	1.89	2.18	5.69	3.51

Table 30 ADWF (ML/d) flow projections from adopted population projections and design unit flow assumptions, *including additional I/I allowance* (see Section 2.2.1)

Appendix C Existing BVSTP Environmental Licence

Licence Variation

Licence - 13266



BYRON SHIRE COUNCIL ABN 14 472 131 473 PO BOX 219 MULLUMBIMBY NSW 2482

Attention: Phil Warner

Notice Number 1511708

File Number LIC10/577

Date 11-Feb-2013

NOTICE OF VARIATION OF LICENCE NO. 13266

BACKGROUND

- A. BYRON SHIRE COUNCIL ("the licensee") is the holder of Environment Protection Licence No. 13266 ("the licence") issued under the *Protection of the Environment Operations Act 1997* ("the Act"). The licence authorises the carrying out of activities at VALLANCES ROAD, MULLUMBIMBY, NSW, 2481 ("the premises").
- B. This variation is issued in order to amend the licence to correct anomalies resulting from the transfer of the licence from ISEMS to the PALMS licence management system.
- C. Other changes shown on the Licence Variation Summary are a result of correcting errors associated with an update of the EPA's licensing system and are not new additions to the licence. As a result of this update, some conditions are now located in different sections to the previous licence version. Some obsolete conditions have also been removed.

VARIATION OF LICENCE NO. 13266

- 1. By this notice the EPA varies licence No. 13266. The attached licence document contains all variations that are made to the licence by this notice.
- 2. The following variations have been made to the licence:
 - Most of the variations to this licence are detailed in the attached Licence Variation Summary.

Licence Variation



Graeme Budd Head Environmental Management Unit North - North Coast (by Delegation)

.....

INFORMATION ABOUT THIS NOTICE

- This notice is issued under section 58(5) of the Act.
- Details provided in this notice, along with an updated version of the licence, will be available on the EPA's Public Register (<u>http://www.environment.nsw.gov.au/prpoeo/index.htm</u>) in accordance with section 308 of the Act.

Appeals against this decision

• You can appeal to the Land and Environment Court against this decision. The deadline for lodging the appeal is 21 days after you were given notice of this decision.

When this notice begins to operate

- The variations to the licence specified in this notice begin to operate immediately from the date of this notice, unless another date is specified in this notice.
- If an appeal is made against this decision to vary the licence and the Land and Environment Court directs that the decision is stayed the decision does not operate until the stay ceases to have effect or the Land and Environment Court confirms the decision or the appeal is withdrawn (whichever occurs first).

Licence Variation Summary

Licence - 13266



This Summary serves merely to highlight changes made to areas of this licence. Changes made to tables within the licence are indicated using underline (for additions) and Strikethrough (for deletions). While changes to conditions are indicated under subheadings such as 'New condition', 'Old condition', 'Replaced by', and ' Removed condition.

The attached licence document contains all the changes made to this licence by the attached variation notice.

4 **Operating Conditions**

Effluent application to land

New condition:

The irrigation of treated effluent must be conducted in accordance with: Environmental Guidelines - Use of Effluent by Irrigation (DEC, 2004).

5 Monitoring and Recording Conditions

Testing methods - load limits

New condition:

Division 3 of the *Protection of the Environment Operations (General) Regulation 2009* requires that monitoring of actual loads of assessable pollutants listed in L2.2 must be carried out in accordance with the relevant load calculation protocol set out for the fee-based activity classification listed in the Administrative Conditions of this licence.

Requirement to record overflow or bypass incidents

Removed condition:

The licensee must record the following details in respect of each bypass of any of the appropriate treatment processes required by condition O3 which may be reasonably expected to adversely affect the quality of the final discharge:

- a) the EPA point identification number through which the bypass discharged;
- b) the date, estimated start time and estimated duration of the bypass;
- c) the estimated volume of the bypass;
- d) the level of treatment of the sewage at the STP prior to discharge;
- e) the probable cause of the bypass;
- f) any actions taken to stop the bypass happening; and
- g) any actions taken to prevent the bypass happening again.

Removed condition:

In addition to the details listed in the previous condition, the licensee must also record classification as a wet or dry weather bypass in respect of each bypass referred to in the previous condition. A dry weather bypass is a bypass that occurs when the flow rate of sewage at the inflow volume monitoring point of the STP does not exceed 6 x ADWF and a wet weather bypass occurs when this flow is

Licence - 13266



equalled or exceeded at any time during the bypass event.

New condition:

The licensee must record the following details in respect of each bypass of any of the treatment processes at the premises, which may be reasonably expected to adversely affect the quality of the final discharge:

- a) the EPA point identification number through which the bypass discharged;
- b) the date, start time and duration of the bypass;
- c) the estimated volume of the bypass;
- d) the level of treatment of the sewage at the premises prior to discharge;
- e) classification as a dry or wet weather bypass;
- f) the probable cause of the bypass;
- g) the name(s) of the treatment process or processes bypassed;
- h) any actions taken to stop the bypass happening;

i) any actions taken to prevent the bypass happening again.

New condition:

The licensee must record the following details in relation to each observed or reported overflow from the reticulation system and from the sewage treatment plant:

- a) the location of the overflow;
- b) the date, estimated start time and estimated duration of the overflow;
- c) the estimated volume of the overflow;
- d) a description of the receiving environment of the overflow;
- e) classification as a dry or wet weather overflow;
- f) the probable cause of the overflow;
- g) any actions taken to stop the overflow happening;
- h) any actions taken to clean up the overflow; and
- i) any actions taken to prevent the overflow happening again.

Licence - 13266

Licence Details Number: Anniversary Date:

13266 27-September

Licensee

BYRON SHIRE COUNCIL

PO BOX 219

MULLUMBIMBY NSW 2482

Premises

BRUNSWICK VALLEY SEWAGE TREATMENT PLANT

VALLANCES ROAD

MULLUMBIMBY NSW 2482

Scheduled Activity

Sewage Treatment

Fee Based Activity

Sewage treatment processing by small plants

<u>Region</u>

North - North Coast NSW Govt Offices, 49 Victoria Street GRAFTON NSW 2460 Phone: (02) 6640 2500 Fax: (02) 6642 7743

PO Box 498 GRAFTON

NSW 2460

<u>Scale</u>

> 1000-5000 ML discharged



Licence - 13266



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Licence - 13266



Information about this licence

Dictionary

A definition of terms used in the licence can be found in the dictionary at the end of this licence.

Responsibilities of licensee

Separate to the requirements of this licence, general obligations of licensees are set out in the Protection of the Environment Operations Act 1997 ("the Act") and the Regulations made under the Act. These include obligations to:

- ensure persons associated with you comply with this licence, as set out in section 64 of the Act;
- control the pollution of waters and the pollution of air (see for example sections 120 132 of the Act); and
- report incidents causing or threatening material environmental harm to the environment, as set out in Part 5.7 of the Act.

Variation of licence conditions

The licence holder can apply to vary the conditions of this licence. An application form for this purpose is available from the EPA.

The EPA may also vary the conditions of the licence at any time by written notice without an application being made.

Where a licence has been granted in relation to development which was assessed under the Environmental Planning and Assessment Act 1979 in accordance with the procedures applying to integrated development, the EPA may not impose conditions which are inconsistent with the development consent conditions until the licence is first reviewed under Part 3.6 of the Act.

Duration of licence

This licence will remain in force until the licence is surrendered by the licence holder or until it is suspended or revoked by the EPA or the Minister. A licence may only be surrendered with the written approval of the EPA.

Licence review

The Act requires that the EPA review your licence at least every 5 years after the issue of the licence, as set out in Part 3.6 and Schedule 5 of the Act. You will receive advance notice of the licence review.

Fees and annual return to be sent to the EPA

For each licence fee period you must pay:

- an administrative fee; and
- a load-based fee (if applicable).

Licence - 13266



The EPA publication "A Guide to Licensing" contains information about how to calculate your licence fees. The licence requires that an Annual Return, comprising a Statement of Compliance and a summary of any monitoring required by the licence (including the recording of complaints), be submitted to the EPA. The Annual Return must be submitted within 60 days after the end of each reporting period. See condition R1 regarding the Annual Return reporting requirements.

Usually the licence fee period is the same as the reporting period.

Transfer of licence

The licence holder can apply to transfer the licence to another person. An application form for this purpose is available from the EPA.

Public register and access to monitoring data

Part 9.5 of the Act requires the EPA to keep a public register of details and decisions of the EPA in relation to, for example:

- licence applications;
- licence conditions and variations;
- statements of compliance;
- load based licensing information; and
- load reduction agreements.

Under s320 of the Act application can be made to the EPA for access to monitoring data which has been submitted to the EPA by licensees.

This licence is issued to:

BYRON SHIRE COUNCIL

PO BOX 219

MULLUMBIMBY NSW 2482

subject to the conditions which follow.

Licence - 13266



1 Administrative Conditions

A1 What the licence authorises and regulates

A1.1 This licence authorises the carrying out of the scheduled activities listed below at the premises specified in A2. The activities are listed according to their scheduled activity classification, fee-based activity classification and the scale of the operation.

Unless otherwise further restricted by a condition of this licence, the scale at which the activity is carried out must not exceed the maximum scale specified in this condition.

Scheduled Activity	Fee Based Activity	Scale
Sewage Treatment	Sewage treatment processing by small plants	> 1000 - 5000 ML discharged

A2 Premises or plant to which this licence applies

A2.1 The licence applies to the following premises:

Premises Details
BRUNSWICK VALLEY SEWAGE TREATMENT PLANT
VALLANCES ROAD
MULLUMBIMBY
NSW 2482
LOT 1 DP 129374

A3 Information supplied to the EPA

A3.1 Works and activities must be carried out in accordance with the proposal contained in the licence application, except as expressly provided by a condition of this licence.

In this condition the reference to "the licence application" includes a reference to:

a) the applications for any licences (including former pollution control approvals) which this licence replaces under the Protection of the Environment Operations (Savings and Transitional) Regulation 1998; and

b) the licence information form provided by the licensee to the EPA to assist the EPA in connection with the issuing of this licence.

2 Discharges to Air and Water and Applications to Land

P1 Location of monitoring/discharge points and areas

P1.1 The following points referred to in the table are identified in this licence for the purposes of the monitoring

Licence - 13266



and/or the setting of limits for discharges of pollutants to water from the point.

P1.2 The following utilisation areas referred to in the table below are identified in this licence for the purposes of the monitoring and/or the setting of limits for any application of solids or liquids to the utilisation area.

		Water and land	
EPA Identi- fication no.	Type of Monitoring Point	Type of Discharge Point	Location Description
1	Discharge to Waters	Discharge to Waters	Discharge pipe on eastern arm of western billabong of Brunswick River at 550568E and 6842193N
2	Discharge to Waters - Wet Weather Overflow	Discharge to Waters - Wet Weather Overflow	Treated Effluent Storage Overflow pipe at 548989E and 6842386N at old Mullumbimby STP.
3		Discharge to Land - Effluent Reuse	Discharge to Irrigation Storage Pond at Lot 2 DP 1010894. 544853E and 6842756N.
4		Discharge to Land - Effluent Reuse	Discharge to Irrigation Storage Pond at Lot 2 DP 839178. 544462E and 6843175N.
5	Total Volume Monitoring		Two magflow meters on Inlet Works @ 551002E and 6841820N
6	Volume Monitoring (Effluent Reuse)		Magflow meter on Mainarm reuse pump well at 548984E and 6842320N
7	Total Volume Monitoring		Discharge volume monitoring via Magflow meter @ 550856E and 6842333N
8	Effluent Quality Monitoring (Reuse)		Tap on Effluent Reuse Line at corner of Main Arm Rd and Johnstones Ln Main Arm. 545057E and 6843676N

3 Limit Conditions

L1 Pollution of waters

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

L2 Load limits

- L2.1 The actual load of an assessable pollutant discharged from the premises during the reporting period must not exceed the load limit specified for the assessable pollutant in the table below.
- L2.2 The actual load of an assessable pollutant must be calculated in accordance with the relevant load calculation protocol.

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Assessable Pollutant	Load limit (kg)
BOD (Estuarine Water)	15818.00
Nitrogen (total) (Estuarine Water)	15818.00
Oil and Grease (Estuarine Water)	3163.00
Phosphorus (total) (Estuarine Water)	475.00
Total suspended solids (Estuarine Water)	23726.00

Note: An assessable pollutant is a pollutant which affects the licence fee payable for the licence.

L3 Concentration limits

- L3.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.
- L3.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.
- L3.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.
- L3.4 Water and/or Land Concentration Limits

Pollutant	Units of Measure	N/A	90 percentile concentration limit	N/A	100 percentile concentration limit
Ammonia	milligrams per litre		2		4
BOD	milligrams per litre		10		20
Faecal Coliforms	colony forming units per 100 millilitres		200		600
Nitrogen (total)	milligrams per litre		10		15
Oil and Grease	milligrams per litre		5		10
рН	рН		6.5 - 8.5		6.5 - 8.5

POINT 1

Licence - 13266



Phosphorus (total)	milligrams per litre	0.3	1
Total suspended solids	milligrams per litre	15	30

L4 Volume and mass limits

L4.1 For each discharge point or utilisation area specified below (by a point number), the volume/mass of: a) liquids discharged to water; or;

b) solids or liquids applied to the area;

must not exceed the volume/mass limit specified for that discharge point or area.

Point	Unit of Measure	Volume/Mass Limit
1	kilolitres per day	22040

L5 Waste

- L5.1 The licensee must not cause, permit or allow any waste generated outside the premises to be received at the premises for storage, treatment, processing, reprocessing or disposal or any waste generated at the premises to be disposed of at the premises, except as expressly permitted by the licence.
- L5.2 This condition only applies to the storage, treatment, processing, reprocessing or disposal of waste at the premises if those activities require an environment protection licence.
- L5.3 The licensee may receive, store, treat, process or reprocess and/or transfer at the premises sewage products generated or stored outside the premises by the licensee's other sewage treatment systems. Sewage products must be received, treated, processed or reprocessed in accordance with this licence.

L6 Potentially offensive odour

- L6.1 No condition in this licence identifies a potentially offensive odour for the purposes of section 129 of the Protection of the Environment Operations Act 1997.
- Note: Section 129 of the Protection of the Environment Operations Act 1997 provides that the licensee must not cause or permit the emission of any offensive odour from the premises but provides a defence if the emission is identified in the relevant environment protection licence as a potentially offensive odour and the odour was emitted in accordance with the conditions of a licence directed at minimising odour.

4 Operating Conditions

Licence - 13266



O1 Activities must be carried out in a competent manner

O1.1 Licensed activities must be carried out in a competent manner. This includes:

a) the processing, handling, movement and storage of materials and substances used to carry out the activity; and

b) the treatment, storage, processing, reprocessing, transport and disposal of waste generated by the activity.

- Note: The requirements of O1.1 apply to the whole of the premises, including the reticulation system.
- O1.2 Biosolids at the premises must be stored, treated, processed, classified, transported and disposed in accordance with the Biosolids Guidelines, or as otherwise approved in writing by the EPA.
- Note: This condition does not apply to the reuse or disposal of biosolids by the licensee at locations other than the premises.

O2 Maintenance of plant and equipment

- O2.1 All plant and equipment installed at the premises or used in connection with the licensed activity:a) must be maintained in a proper and efficient condition; andb) must be operated in a proper and efficient manner.
- Note: The requirements of O2.1 apply to the whole of the premises, including the reticulation system.
- O2.2 For the purposes of this condition, "plant and equipment" includes drainage systems, infrastructure, pollution control equipment and fuel burning equipment, but does not refer to equipment which has been decommissioned but is still on site.

O3 Effluent application to land

- O3.1 The irrigation of treated effluent must be conducted in accordance with: Environmental Guidelines Use of Effluent by Irrigation (DEC, 2004).
- O3.2 The quantity of effluent applied to the utilisation area(s) must not exceed the capacity of the utilisation area(s) to effectively utilise the effluent.

For the purpose of this condition, "effectively utilise" includes the ability of the soil to absorb the nutrient, salt and hydraulic loads and the applied organic material without causing harm to the environment.

- O3.3 Effluent application to the utilisation area(s) must not occur in a manner that causes surface run-off from the utilisation area(s).
- O3.4 Spray from effluent application to the utilisation area(s) must not drift beyond the boundary of the utilisation area(s) to which it has been applied.

Licence - 13266



5 Monitoring and Recording Conditions

M1 Monitoring records

- M1.1 The results of any monitoring required to be conducted by this licence or a load calculation protocol must be recorded and retained as set out in this condition.
- M1.2 All records required to be kept by this licence must be:
 - a) in a legible form, or in a form that can readily be reduced to a legible form;
 - b) kept for at least 4 years after the monitoring or event to which they relate took place; and
 - c) produced in a legible form to any authorised officer of the EPA who asks to see them.
- M1.3 The following records must be kept in respect of any samples required to be collected for the purposes of this licence:
 - a) the date(s) on which the sample was taken;
 - b) the time(s) at which the sample was collected;
 - c) the point at which the sample was taken; and
 - d) the name of the person who collected the sample.

M2 Requirement to monitor concentration of pollutants discharged

- M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:
- M2.2 Water and/ or Land Monitoring Requirements

POINT 1

Pollutant	Units of measure	Frequency	Sampling Method
Ammonia	milligrams per litre	Special Frequency 1	Representative sample
BOD	milligrams per litre	Special Frequency 1	Representative sample
Faecal Coliforms	colony forming units per 100 millilitres	Special Frequency 1	Representative sample
Nitrogen (total)	milligrams per litre	Special Frequency 1	Representative sample
Oil and Grease	milligrams per litre	Special Frequency 1	Representative sample
pН	рН	Special Frequency 1	Representative sample
Phosphorus (total)	milligrams per litre	Special Frequency 1	Representative sample
Total suspended solids	milligrams per litre	Special Frequency 1	Representative sample

POINT 8

Pollutant	Units of measure	Frequency	Sampling Method
Ammonia	milligrams per litre	Special Frequency 1	Representative sample

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BOD	milligrams per litre	Special Frequency 1	Representative sample
Faecal Coliforms	colony forming units per 100 millilitres	Special Frequency 1	Representative sample
Nitrogen (total)	milligrams per litre	Special Frequency 1	Representative sample
Oil and Grease	milligrams per litre	Special Frequency 1	Representative sample
рН	рН	Special Frequency 1	Representative sample
Phosphorus (total)	milligrams per litre	Special Frequency 1	Representative sample
Total suspended solids	milligrams per litre	Special Frequency 1	Representative sample

M2.3 For the purposes of the table(s) above Special Frequency 1 means the collection of samples at least once every fortnight and at a minimum of ten day intervals.

M3 Testing methods - concentration limits

M3.1 Subject to any express provision to the contrary in this licence, monitoring for the concentration of a pollutant discharged to waters or applied to a utilisation area must be done in accordance with the Approved Methods Publication unless another method has been approved by the EPA in writing before any tests are conducted.

M4 Testing methods - load limits

Note: Division 3 of the *Protection of the Environment Operations (General) Regulation 2009* requires that monitoring of actual loads of assessable pollutants listed in L2.2 must be carried out in accordance with the relevant load calculation protocol set out for the fee-based activity classification listed in the Administrative Conditions of this licence.

M5 Recording of pollution complaints

- M5.1 The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.
- M5.2 The record must include details of the following:
 - a) the date and time of the complaint;
 - b) the method by which the complaint was made;

c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;

d) the nature of the complaint;

e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant; and

f) if no action was taken by the licensee, the reasons why no action was taken.

M5.3 The record of a complaint must be kept for at least 4 years after the complaint was made.

M5.4 The record must be produced to any authorised officer of the EPA who asks to see them.

Licence - 13266



M6 Telephone complaints line

- M6.1 The licensee must operate during its operating hours a telephone complaints line for the purpose of receiving any complaints from members of the public in relation to activities conducted at the premises or by the vehicle or mobile plant, unless otherwise specified in the licence.
- M6.2 The licensee must notify the public of the complaints line telephone number and the fact that it is a complaints line so that the impacted community knows how to make a complaint.
- M6.3 The preceding two conditions do not apply until 3 months after:
 a) the date of the issue of this licence or
 b) if this licence is a replacement licence within the meaning of the Protection of the Environment Operations (Savings and Transitional) Regulation 1998, the date on which a copy of the licence was served on the licensee under clause 10 of that regulation.

M7 Requirement to monitor volume or mass

- M7.1 For each discharge point or utilisation area specified below, the licensee must monitor: a) the volume of liquids discharged to water or applied to the area;
 - b) the mass of solids applied to the area;
 - c) the mass of pollutants emitted to the air;
 - at the frequency and using the method and units of measure, specified below.

Frequency	Unit of Measure	Sampling Method	
Daily	kilolitres per day	Magnetic flow meter	
POINT 6			
Frequency	Unit of Measure	Sampling Method	
Daily	kilolitres per day	Magnetic flow meter	
POINT 7			
Frequency	Unit of Measure	Sampling Method	
Daily	kilolitres per day	Magnetic flow meter	

M7.2 In the event that the licensee cannot comply with a volume monitoring method as required by this licence solely due to the failure or malfunction of essential monitoring equipment, volume may be estimated using another agreed method approved in writing by the EPA. This provision only applies for the duration of the failure or malfunction. The licensee is to rectify the failure or malfunction as soon as practicable.

M7.3 The licensee must:

POINT 5

a) submit in writing to the EPA a proposal for a method of volume estimation; or

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b) use a method of volume estimation already approved in writing by the EPA,

to be used in the event that essential monitoring equipment referred to in the previous condition has failed or malfunctioned.

M8 Requirement to record overflow or bypass incidents

- M8.1 The licensee must record the following details in respect of each bypass of any of the treatment processes at the premises, which may be reasonably expected to adversely affect the quality of the final discharge:
 - a) the EPA point identification number through which the bypass discharged;
 - b) the date, start time and duration of the bypass;
 - c) the estimated volume of the bypass;
 - d) the level of treatment of the sewage at the premises prior to discharge;
 - e) classification as a dry or wet weather bypass;
 - f) the probable cause of the bypass;
 - g) the name(s) of the treatment process or processes bypassed;
 - h) any actions taken to stop the bypass happening;
 - i) any actions taken to prevent the bypass happening again.
- M8.2 The licensee must record the following details in relation to each observed or reported overflow from the reticulation system and from the sewage treatment plant:
 - a) the location of the overflow;
 - b) the date, estimated start time and estimated duration of the overflow;
 - c) the estimated volume of the overflow;
 - d) a description of the receiving environment of the overflow;
 - e) classification as a dry or wet weather overflow;
 - f) the probable cause of the overflow;
 - g) any actions taken to stop the overflow happening;
 - h) any actions taken to clean up the overflow; and
 - i) any actions taken to prevent the overflow happening again.

M9 Other monitoring and recording conditions

- M9.1 Biosolids at the premises must be recorded, monitored and classified in accordance with the Biosolids Guidelines, to the extent that those Guidelines are applicable, or as otherwise approved in writing by the EPA.
- Note: This condition does not apply to the reuse or disposal of biosolids by the licensee at locations other than the premises.

6 Reporting Conditions

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R1 Annual return documents

R1.1 The licensee must complete and supply to the EPA an Annual Return in the approved form comprising: a) a Statement of Compliance; and

b) a Monitoring and Complaints Summary.

At the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.

- R1.2 An Annual Return must be prepared in respect of each reporting period, except as provided below.
- R1.3 Where this licence is transferred from the licensee to a new licensee:
 a) the transferring licensee must prepare an Annual Return for the period commencing on the first day of the reporting period and ending on the date the application for the transfer of the licence to the new licensee is granted; and
 b) the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence to the new licensee must prepare an Annual Return for the period commencing on the date the application for the transfer of the licence is granted and ending on the last day of the reporting period.
- R1.4 Where this licence is surrendered by the licensee or revoked by the EPA or Minister, the licensee must prepare an Annual Return in respect of the period commencing on the first day of the reporting period and ending on:

a) in relation to the surrender of a licence - the date when notice in writing of approval of the surrender is given; or

b) in relation to the revocation of the licence - the date from which notice revoking the licence operates.

- R1.5 The Annual Return for the reporting period must be supplied to the EPA by registered post not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').
- R1.6 Where the licensee is unable to complete a part of the Annual Return by the due date because the licensee was unable to calculate the actual load of a pollutant due to circumstances beyond the licensee's control, the licensee must notify the EPA in writing as soon as practicable, and in any event not later than the due date. The notification must specify:

a) the assessable pollutants for which the actual load could not be calculated; and

b) the relevant circumstances that were beyond the control of the licensee.

- R1.7 The licensee must retain a copy of the Annual Return supplied to the EPA for a period of at least 4 years after the Annual Return was due to be supplied to the EPA.
- R1.8 Within the Annual Return, the Statement of Compliance must be certified and the Monitoring and Complaints Summary must be signed by:
 a) the licence holder; or
 b) by a nearest complexity of the licence holder.
 - b) by a person approved in writing by the EPA to sign on behalf of the licence holder.
- R1.9 A person who has been given written approval to certify a certificate of compliance under a licence issued under the Pollution Control Act 1970 is taken to be approved for the purpose of this condition until the date of first review of this licence.
- Note: The term "reporting period" is defined in the dictionary at the end of this licence. Do not complete the Annual Return until after the end of the reporting period.

Note: An application to transfer a licence must be made in the approved form for this purpose.

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R2 Notification of environmental harm

- R2.1 Notifications must be made by telephoning the Environment Line service on 131 555.
- R2.2 The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.
- Note: The licensee or its employees must notify all relevant authorities of incidents causing or threatening material harm to the environment immediately after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.

R3 Written report

R3.1 Where an authorised officer of the EPA suspects on reasonable grounds that:

a) where this licence applies to premises, an event has occurred at the premises; or

b) where this licence applies to vehicles or mobile plant, an event has occurred in connection with the carrying out of the activities authorised by this licence,

and the event has caused, is causing or is likely to cause material harm to the environment (whether the harm occurs on or off premises to which the licence applies), the authorised officer may request a written report of the event.

- R3.2 The licensee must make all reasonable inquiries in relation to the event and supply the report to the EPA within such time as may be specified in the request.
- R3.3 The request may require a report which includes any or all of the following information:
 - a) the cause, time and duration of the event;
 - b) the type, volume and concentration of every pollutant discharged as a result of the event;

c) the name, address and business hours telephone number of employees or agents of the licensee, or a specified class of them, who witnessed the event;

d) the name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort;

e) action taken by the licensee in relation to the event, including any follow-up contact with any complainants;

f) details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and

g) any other relevant matters.

R3.4 The EPA may make a written request for further details in relation to any of the above matters if it is not satisfied with the report provided by the licensee. The licensee must provide such further details to the EPA within the time specified in the request.

7 General Conditions

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G1 Copy of licence kept at the premises or plant

- G1.1 A copy of this licence must be kept at the premises to which the licence applies.
- G1.2 The licence must be produced to any authorised officer of the EPA who asks to see it.
- G1.3 The licence must be available for inspection by any employee or agent of the licensee working at the premises.

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Dictionary

General Dictionary

3DGM [in relation to a concentration limit]	Means the three day geometric mean, which is calculated by multiplying the results of the analysis of three samples collected on consecutive days and then taking the cubed root of that amount. Where one or more of the samples is zero or below the detection limit for the analysis, then 1 or the detection limit respectively should be used in place of those samples
Act	Means the Protection of the Environment Operations Act 1997
activity	Means a scheduled or non-scheduled activity within the meaning of the Protection of the Environment Operations Act 1997
actual load	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 2009
АМ	Together with a number, means an ambient air monitoring method of that number prescribed by the <i>Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales</i> .
AMG	Australian Map Grid
anniversary date	The anniversary date is the anniversary each year of the date of issue of the licence. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
annual return	Is defined in R1.1
Approved Methods Publication	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 2009
assessable pollutants	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 2009
BOD	Means biochemical oxygen demand
СЕМ	Together with a number, means a continuous emission monitoring method of that number prescribed by the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales.
COD	Means chemical oxygen demand
composite sample	Unless otherwise specifically approved in writing by the EPA, a sample consisting of 24 individual samples collected at hourly intervals and each having an equivalent volume.
cond.	Means conductivity
environment	Has the same meaning as in the Protection of the Environment Operations Act 1997
environment protection legislation	Has the same meaning as in the Protection of the Environment Administration Act 1991
EPA	Means Environment Protection Authority of New South Wales.
fee-based activity classification	Means the numbered short descriptions in Schedule 1 of the Protection of the Environment Operations (General) Regulation 2009.
general solid waste (non-putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997

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flow weighted composite sample	Means a sample whose composites are sized in proportion to the flow at each composites time of collection.
general solid waste (putrescible)	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environmen t Operations Act 1997
grab sample	Means a single sample taken at a point at a single time
hazardous waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
licensee	Means the licence holder described at the front of this licence
load calculation protocol	Has the same meaning as in the Protection of the Environment Operations (General) Regulation 2009
local authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
material harm	Has the same meaning as in section 147 Protection of the Environment Operations Act 1997
MBAS	Means methylene blue active substances
Minister	Means the Minister administering the Protection of the Environment Operations Act 1997
mobile plant	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
motor vehicle	Has the same meaning as in the Protection of the Environment Operations Act 1997
O&G	Means oil and grease
percentile [in relation to a concentration limit of a sample]	Means that percentage [eg.50%] of the number of samples taken that must meet the concentration limit specified in the licence for that pollutant over a specified period of time. In this licence, the specified period of time is the Reporting Period unless otherwise stated in this licence.
plant	Includes all plant within the meaning of the Protection of the Environment Operations Act 1997 as well as motor vehicles.
pollution of waters [or water pollution]	Has the same meaning as in the Protection of the Environment Operations Act 1997
premises	Means the premises described in condition A2.1
public authority	Has the same meaning as in the Protection of the Environment Operations Act 1997
regional office	Means the relevant EPA office referred to in the Contacting the EPA document accompanying this licence
reporting period	For the purposes of this licence, the reporting period means the period of 12 months after the issue of the licence, and each subsequent period of 12 months. In the case of a licence continued in force by the Protection of the Environment Operations Act 1997, the date of issue of the licence is the first anniversary of the date of issue or last renewal of the licence following the commencement of the Act.
restricted solid waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
scheduled activity	Means an activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997
special waste	Has the same meaning as in Part 3 of Schedule 1 of the Protection of the Environment Operations Act 1997
тм	Together with a number, means a test method of that number prescribed by the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales.

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TSP	Means total suspended particles
TSS	Means total suspended solids
Type 1 substance	Means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements
Type 2 substance	Means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements
utilisation area	Means any area shown as a utilisation area on a map submitted with the application for this licence
waste	Has the same meaning as in the Protection of the Environment Operations Act 1997
waste type	Means liquid, restricted solid waste, general solid waste (putrescible), general solid waste (non - putrescible), special waste or hazardous waste

Mr Graeme Budd

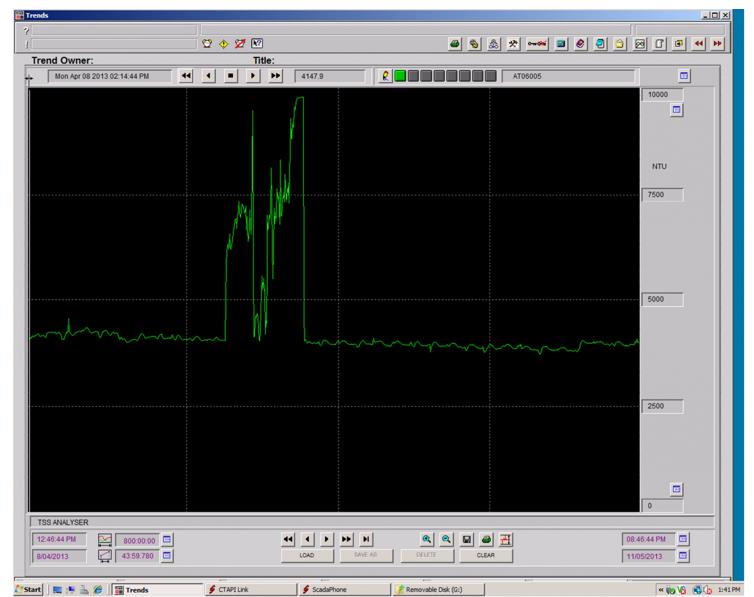
Environment Protection Authority

(By Delegation)

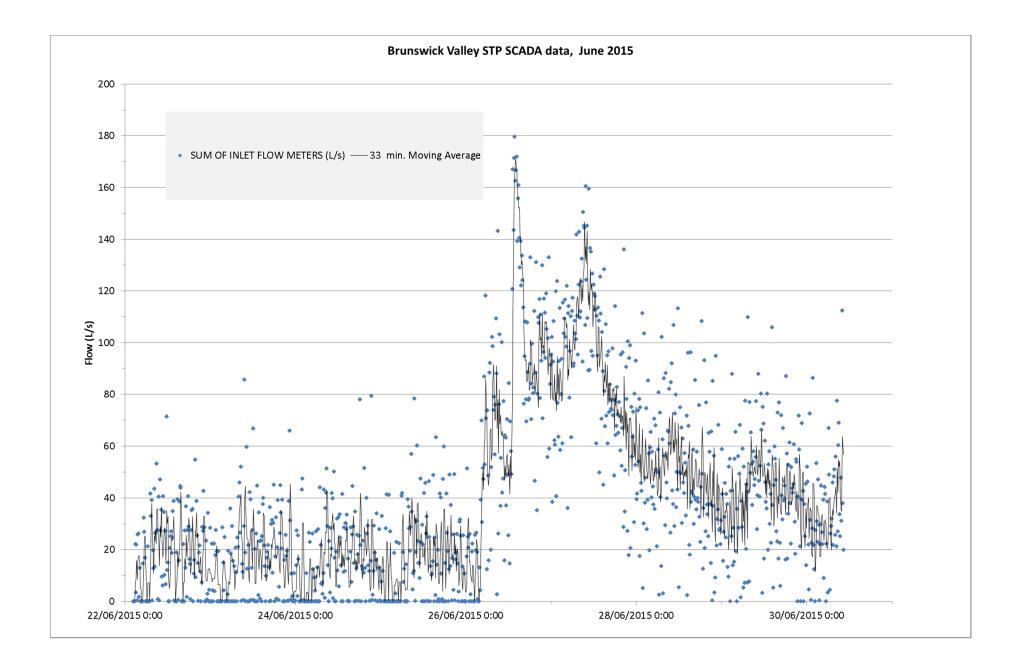
Date of this edition: 27-September-2010

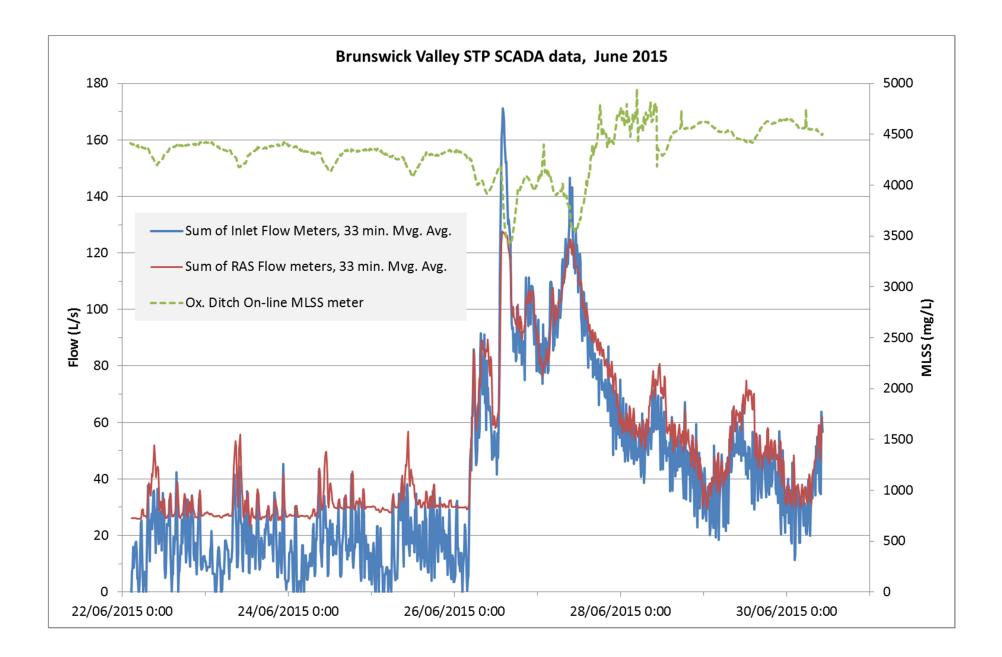
End Notes

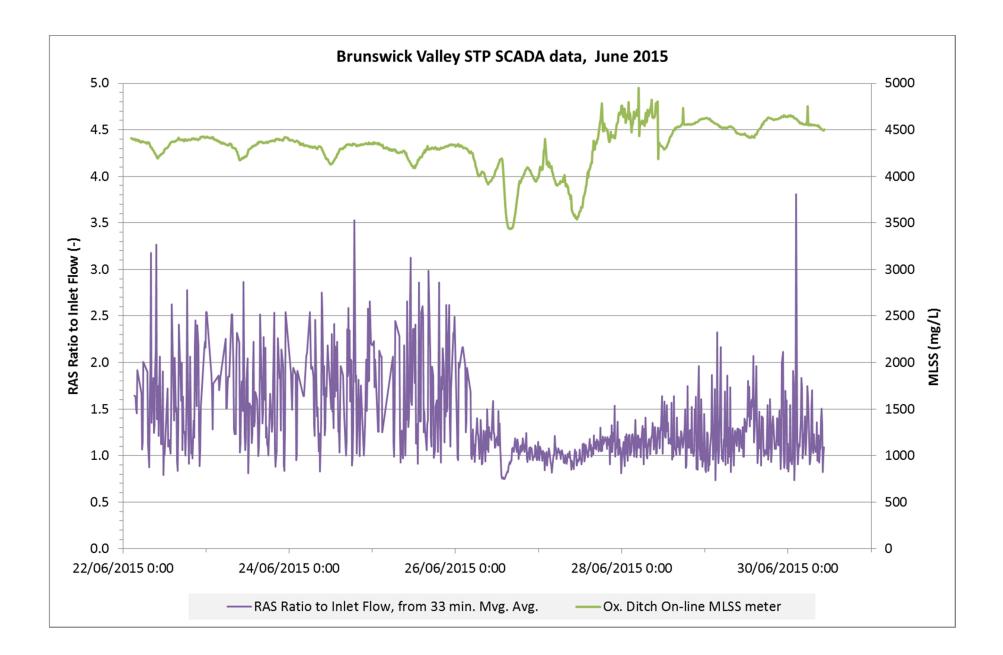
Appendix D Example of flow and online MLSS meter output from plant SCADA for minor wet weather event at BVSTP, ca. 10 April 2013.



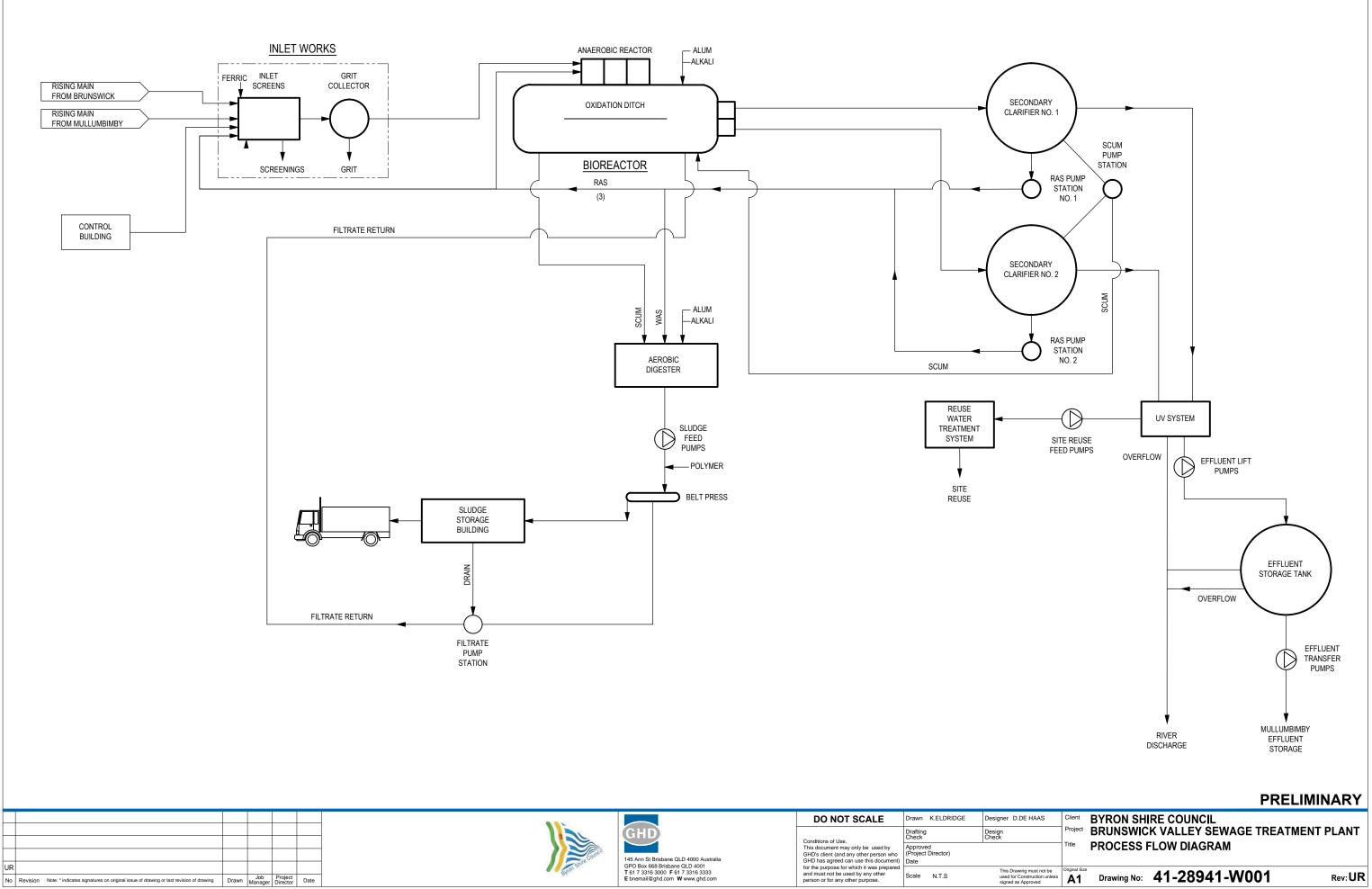
BVSTP MLSS (TSS) on-line meter SCADA trend from 8/4/2013 to 11/5/2013 (Note: units given in NTU on SCADA but requires checking)



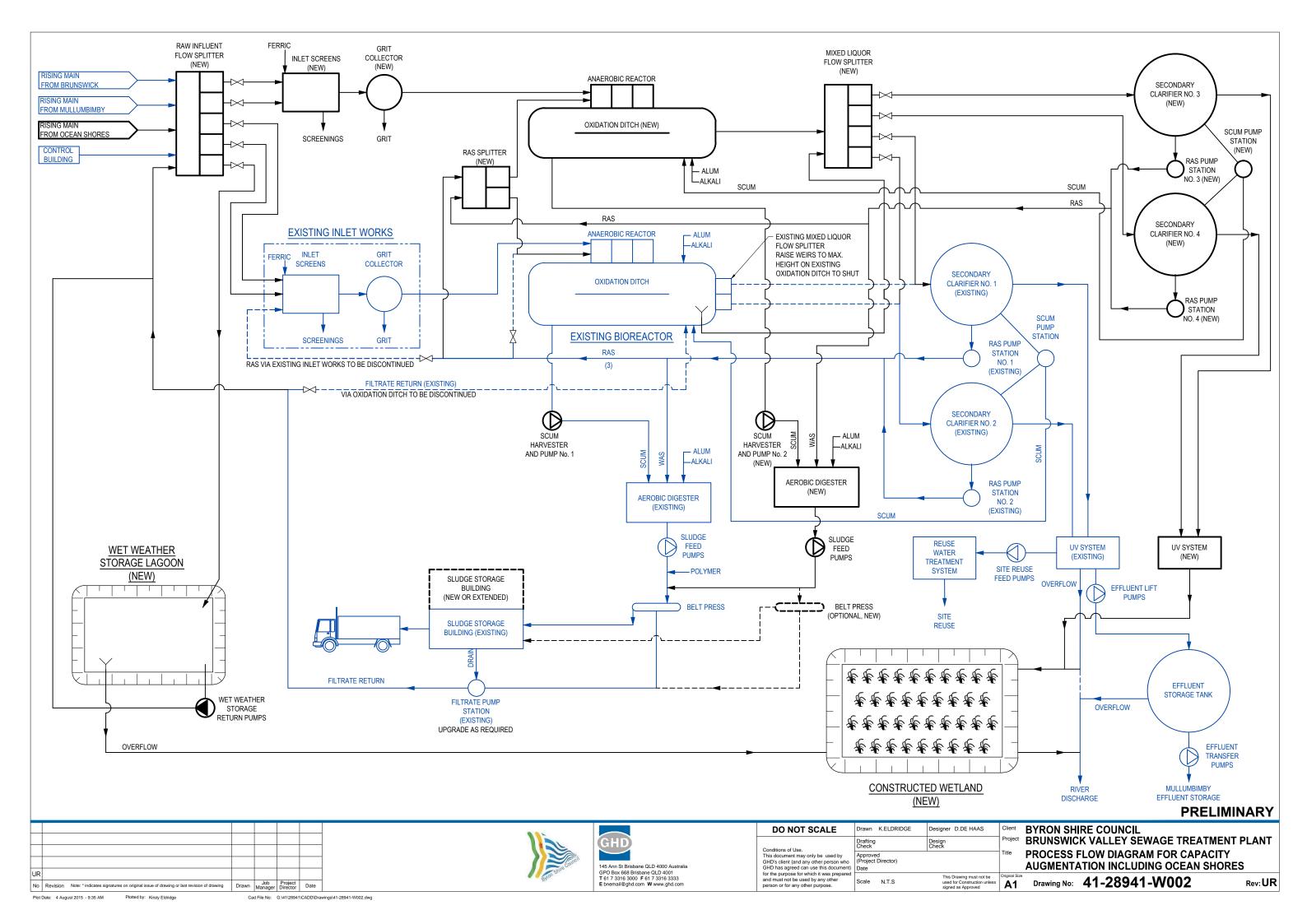




Appendix E Process Flow Diagram – Existing Plant



Appendix F Process Flow Diagram – Proposed Plant Augmentation



Appendix G Results of Process Modelling

Insert here from PDF of Excel Workbook

EXISTING BRUN	SWICK	VALLEY STP)																
ANALYSIS OF OX	IDATION [DITCH PROCES	SS FOR NDE	BEPR															
This worksheet calculates p	process N & P	performance for a																	
given set of wastewater, pro																			
The process modelled is the Mass fraction of the anaero	e mechanically	aerated oxidation ditc	h with RAS return	ed to an upstre	am anaerobic	reactor.													
REFERENCES																			
1. WRC "Theory, Design an	nd Operation of	I Nutrient Removal Act	ivated Sludge Pro	cesses" 1984.															
2. Wentzel, Ekama & Marai Water SA, 16, 1, 29 (is "Biological E: Jan 1990).	xcess Phosphorus Rei	moval-Steady Stat	te Process Des	ign"														
Water SA, 16, 1, 29 (3. Clayton, Ekama, Wentzel	I & Marais "Der	nitrification Kinetics in al Waste Waters" Pro	Biological Nitroge	n and Phospho	rus Removal														
Hartley "Hydraulics of Ho	orizontal Shaft (Oxidation Ditches" Jnl	WPCF, 59, 7, 686	(Jul 1987).															
5. Hartey "Tuning Biological	I Nutrient Remo	oval Plants, IWA Publi	shing, 2013.																
NOTES																			
Nomenclature is as per the	references.																		
Modified denitrification kinet	tics are used a	s per Ref 3, in which																	
the K2 denitrification rate sp is applied to the heterotrop	hic sludge mas	is only.																	
Denitrification of the s-recyc available RBCOD occurs in	de to a maximu	Im equivalent to the																	
Temperature is taken into a																			
The model allows dosing of	COD to the an	aerobic and/or primar	y anoxic zones.																
Point source oxygen additio	on is assumed t	to occur at each aerate	pr.																
In using this model, give co	nsideration to t	he effects of changes	in the various para	ameters,															
and operation under variabl	le operating co	nditions and at lower ti I	han design load.																
Note that in using the works Sections 2,3 & 4 as explain	sheet three iter	ative calculations are i	nvolved in																
				1		ļ	İ												
CONTENTS	<u> </u>			<u> </u>															
1. Flow & Process Parameter Flow]					
Wastewater Characteri Process Parameters	stics																		
Biomass Parameters	1					ļ —													
 Solids Inventory & P Ren Oxygen Demand and DC 	Levels			<u> </u>		<u> </u>													
4. Nitrification 5. Denitrification																			
	LIES IN LIES	N BOYES																	
OTHER VAL	UES IN HEAV	Y BOXES CULATED AUTOMAT	ICALLY	<u> </u>															
SECTION 1. FLOW	N & PROC	ESS PARAME	TERS								-								
FLOW RATE,Q, ML/d			3.8	15833 240	EP L/EP.d				<u> </u>										
WASTEWATER CHARACT	TERISTICS			240															
COD total, Sti, mg/L	<u> </u>		540				L												
TKN, Nti, mg/L TP, Pti, mg/L			54																
RBCOD/COD biodegradabl	le, fbs(ts)		0.150																
RBCOD/COD biodegradabl Unbiodegradable particulate	e fraction of CC	DD total,fup	0.200																
Unbiodegradable soluble fra Unbiodegradable soluble fra	action of COD t	total,fus	0.05	Sus	27														
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Ammonia fraction of TKN, fr	na		0.027	Nus Nai	40.50					Eqn in Row 8									
N content of VSS_Np/VSS	na Cxn		0.75	Nus Nai Noi	40.50 7.66	with zero alur Note: Effluent							mmonificat	ion calculati	on), see R	ow 275			
Ammonia fraction of TKN, fr N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbsi, mg/L	na Cxn		0.75	Nai Noi fac	40.50 7.66 0.19								mmonificat	ion calculati	on), see R	ow 275			
N content of VSS_Np/VSS	na Cxn g/L		0.75	fac VFA	40.50 7.66								mmonificat	ion calculati	on), see Ri	ow 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbsi, mg/L I Total Alkalinity, mg/L CaCO PROCESS PARAMETERS	na Cxn ig/L J3		0.75 0.06 405 81	fac VFA	40.50 7.66 0.19								mmonificat	on calculati	on), see R	ow 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbsi, mg/L Total Alkalinity, mg/L CaCO PROCESS PARAMETERS Process:	na Cxn 1g/L 33		0.75 0.06 405 81	Nai Noi Ifac VFA	40.50 7.66 0.19 15.1								mmonificat	on calculati	on), see R	w 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, mg/L NBCOD, Sbsi, mg/L Total Alkalinity, mg/L CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Siudge age, Rs, d	na Cxn g/L 03		0.75 0.06 405 81 230 	fac VFA	40.50 7.66 0.19 15.1	Note: Effluent							mmonificat	on calculati	on), see Ri	ow 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbsi, mg/L Total Alkalinity, mg/L CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, MI Sludge age, Rs, d Anaerobic mass fraction, fx No. of anaerobic reactors in	na Cxn Cxn Ig/L J J J L L a a series, N		0.75	Nai Noi Ifac VFA	40.50 7.66 0.19 15.1	Note: Effluent							mmonificat	on calculati	on), see Ri	ow 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbai, mg/L Total Alkalinity, mg/L CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Sludge age, Rs, d Anaerobic mass fraction, fx No. of anaerobic reactors in Primary Anoxic mass fraction	na Cxn gyL J J J J J J J J J J J J J J J J J J J		0.75 0.06 405 81 230 	Nai Noi VFA See Ditches	40.50 7.66 0.19 15.1	Note: Effluent	Total N inclus						mmonificat	on calculati	on), see R	ow 275			
N content of VSS, Np/VSS, COD biodegradable, Sbi, m RBCOD, Sbai, mg/L Total Alkalinty, mg/L CaCO PROCESS PARAMETERS Process; Biorasetor Volume, Vr, ML Sludge age, Rs, d Anaerobic mass fraction, fx No. of anaerobic reactors in Primary Anoxic mass fract Secondary Anoxic mass fract Secondary Anoxic mass fract	na Cxn Cxn g/L 133 L L a 1 series, N n, fxTm ction, fx3m xic mass fractif		0.75 0.06 405 81 230 230 230 230 230 230 230 230 230 230	Nai Noi VFA See Ditches	40.50 7.66 0.19 15.1	Note: Effluent	Total N inclus						mmonificat	on calculati	on), see Rr	w 275			
N content of VSS. NpVSS. COD biodgradable, Sbi, mg/L. CoD biodgradable, Sbi, mg/L. Total Alkaininy, mg/L.CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, MI Sludge age, Rs, d Anaerobic mass fraction, ba Umagradiary Anoxic mass fraction. Secondary Anoxic mass fraction. RAS recycle ratio, s	na Cxn Cxn g/L 133 L L a 1 series, N n, fxTm ction, fx3m xic mass fractif		0.75 0.06 405 81 230 	Nai Noi VFA See Ditches Assumed to b	40.50 7.66 0.19 15.1	Note: Effluent	Total N inclus						mmonificat	on calculat	on), see Rr	w 275			
N content of VSS. Np/VSS. COD biodgrandble, SBL m RBCOO, Sbul, mg/L Total Alkaling, mg/L CaCO PROCESS PARAMETERS PROCESS PARAMETERS Process: Bioraector Volume, Vr, ML Sludge age, Rs. d Anaerobie mass fraction, bo No. of anaerobie reactors in Primary Anaous fraction Sum of Primary & Sec. Ano. Colai unaeranted mass fraction RAS recycle ratio. s Do In a recycle, Oa, mg/L	na Cxn Cxn g/L 133 L L a 1 series, N n, fxTm ction, fx3m xic mass fractif		0.75 0.06 405 81 230 230 230 230 230 230 230 230 230 230	Nai Noi VFA See Ditches Assumed to b	40.50 7.66 0.19 15.1	Note: Effluent	Total N inclus						mmonificat	on calculat	on), see Ri	w 275			
N content of VSS. NpVSS. COD biodgradbab, Sbi. mg/L COD biodgradbab, Sbi. mg/L Cod Alkaling, mg/L Total Alkaling, mg/L CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Sludge age, Rs. d Anaerobie mass fraction, bo No. of anaerobie reactors in Codal unaerobie reactors in Codal unaerobie reactors in Codal unaerobie mass fraction, RAS recycle ratio, s Do In a recycle, Os, mg/L DO In a recycle, Os, mg/L DO In a recycle, Os, mg/L	na Cxn bg/L D3 D3 a series, N n, fx1 m, fx1 ction, fx3 ction, fx3 ction, fx3		0.75 0.06 405 81 230 230 200 0.1 3 0.3 200 0.0 3 0.3 200 0.0 3 0.0 5 0.0 5 0.0 6 0.0 0.0 0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0 0.0 0 0.0 0 0.0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Nai Noi VFA See Ditches Assumed to b	40.50 7.66 0.19 15.1	Note: Effluent	Total N incluc	les residual or	g, biodegran	Jable soluble	TKN in effi	Juent (from a							
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N content of VSS. Np.VSS. COD bedgeradebias, Sb. m RSC00, Seal, mg1. Cell Akalaniy, mg1. CaCO PROCESS PARAMETERS Process: Bioreactor Volume, Vr, MI Studge age, Rs, d actor, based and the state of the No. of anaredbias mass fraction RSS recycle ratio, s On a recycle ratio, s On a recycle callo, s Of an areadotic das mass fraction RSS recycle ratio, s Of an areadotic das mass fraction RSS recycle ratio anareadotic das s COD dose to anareadotic das s COD dose to anareadotic das	na Cxn cyl 30 33 33 4 4 53 53 54 54 54 54 54 54 54 54 54 54 54 54 54	ons	0.75 0.06 405 81 230 230 200 0.1 3 0.3 200 0.0 3 0.3 200 0.0 3 0.0 5 0.0 5 0.0 6 0.0 0.0 0 0.0 0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0 0.0 0 0.0 0 0.0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Nai Noi VFA See Ditches Assumed to b	40.50 7.66 0.19 15.1	Note: Effluent	Total N incluc	les residual or	g, biodegran	Jable soluble	TKN in effi	Juent (from a					above at Da=	0)	
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N content of VSS. NpVSS. RECORD bedgrandbab, SB. m RECOD, Seai, mg1. CoD bedgrandbab, SB. m RECOD, Seai, mg1. Colar Akalaniy, mg1. CaCO PROCESS PRAMETERS Process Bioraector Volume, V, ML Bioraector Volume, V, ML Bioraector Volume, V, ML Samo F Primary Assic mass fraction, to secondary Anoxic mass fractions Sum of Primary & Sec. Ano. Colar ansertation assis fraction, te Samo F Primary & Sec. Ano. Colar ansertation assis fraction, te Samo F Primary & Sec. Ano. COD dose to ansertable col, mg1. Effluent SQL exposite and. Dos nor srecycle ratio. CoD dose to ansertable col, mg1. Effluent SQL exposite and. CoD dose to ansertable col, mg1. Effluent SQL exposite and. CoD dose to ansertable col, mg1. Effluent SQL exposite and. CoD dose to ansertable col, mg1. Effluent SQL exposite and. Channel water depth. y m Average circulating velocity. Channel water depth. y m Mixed layor recycle ratio. Emfortable and SQL Emfortable and SQL Emfortable and SQL Emfortable and SQL Particition of VSS. Mixed SQL emfortable and SQL Particition of VSS. In Proceeding and participations a	na Con	ons	0.75 0.06 0.05 0.05 0.05 0.05 0.05 0.05 0.0	Nai Noi VFA See Ditches i Assumed to b Assumed to b C in Eqn: C in Eqn: See Ditches Adjust to get t	40.50 7.66 0.19 15.1 compare dime e in the clarific e in the clarific e zero for oxic 0.005	Note: Effluent nsions.xds ation ditch D in Eqn:	Otal N includ Total N includ Otal N	les residual or	g, biodegran	Jable soluble	TKN in effi	Juent (from a					above at Da-	0	
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	SECTION 2. SOLIDS INVEN	TORY & P RE	NOVAL																	
	alculate the process solids inventory and	l I biological P removal.																		
	ased on Ref. 2 equations (1) to (27).		20 deg Č																	
	wo iterative calculations are involved in *Adjust NO2s, then adjust Shop, until I	Sections 2 and 4:																		
	compatible with NO3s allowing for de	nitrification in the seco	ondary clarifier.				l													
	*Adjust Sbsn assumed until Sbsn calci	ilated agrees.																		
	IO3-N recycled to the anaerobic zone, N	D3s, mg/L	0.000	Assumed	Effluent nitrat	e, T=20:	0.26995535													
	BCOD exiting the anaerobic zone, Sbsn	mg/L	11.100	Assumed																
	fluent RBCOD available, S.bsi		81	2077	1622															
	BCOD exiting the anaerobic zone, Sbsn	mg/L		Calculated																
				and recalculat	alculated into \$ te until the two	Sbsn assumed agree.														
	ubstrate sequestered by poly-P organism	ns, MSseq, kg/d	231.876			-														
			1	1																
	oly-P organisms active mass, MXbg, kg oly-P organisms endogenous mass, MX	a ka																		
	leterotroph active mass, MXbh, kg	ſ.	2028																	
	eterotroph endogenous mass, Mixen, kg hert mass, MXi, kg		1947		Vp, ML:	3.70	See Ditches	compare dime	nsions.xls											
					Average VSS	2949	mg/L													
	otal SS, MXt, kg		14765	A	verage MLSS	3991	mg/L	3791	mg/L	If Sec. Anoxi	c mass frac	tion is assu	med to be i	n the clarifie	H					
	eak month COD load factor		1.30	Peak	Month MLSS	5188	mg/L	4928	mg/L	Ditto										
	in the set of the set	I																		
Single Partner Part W Single Partner Partne Partner Partner Partner Partner Partner Partner Partne	removal by beterotrophs dPh mg/l	ì	1.57																	
Set Provide Pro	removal by inert mass, dPi, mg/L		2.19	From K IH boy	ok p64															
	otal P removal, dP, mg/L		9.93																	
Inter the Phy or U Out 000000000000000000000000000000000000																				
Mart Mart Mart Mart Mart Mart Mart Mart	ffluent soluble P, Pse, mg/L (before cher	nical dosing)			Target Ps:	0.1	mgP/L	qm:	0.864	mgP/mgAl	Kp:	0.175	mgP/L	q (calc):	0.31	mgP/mgAl	for Alum stoic	hiometry from	KJH book p63	-64
	Ikalnity depletion due to alum dosed, mg	L CaCO3	4.11	Alkalinity	depletion (mg0	CaCO3/ mg dr	/ alum dosed)	Ta:	0.411	From KJH bo	ook Eqn 3.1	6, p64								
		<u> </u>	1																	
	SECTION 3. OXYGEN DEM					ļ														
	alpha (F): 0.6	Cs (20°C, 1 atm):	9.08 Cs @ Tmin:	9,26																
				0.20	7.73															
			0.05																	
	ittuser mounting neight (from floor), m	Cs inf (20°C, 1 atm):	10.40																	
			Cs_inf @ Tmin:	10.60																
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Numl max. showed local Image Network of Six Sime anglike of position Image Network of Six Sime anglike of posit Sime anglike of position Image Ne	tartup load demand factor		0.55	Assumed																
			1.33	Assumes 0.33	 33 times ampli	tude of peak T	OD													
Bits in the Number of Data State of Data	iurnal min. demand factor		0.70	Assumed																
Dame Teal Teal <th< td=""><td>ffluent NH3-N, Naea, mg/L</td><td></td><td>0.69</td><td>Assumed. Ad</td><td>j. to match Nar</td><td>T20 calc. belo</td><td>l ow:</td><td>0.69</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	ffluent NH3-N, Naea, mg/L		0.69	Assumed. Ad	j. to match Nar	T20 calc. belo	l ow:	0.69												
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Wange OTRSOTF, diffaced antion 0.487 <	verage DO at each rotor, Cr, mg/L			0.475	0.483															
Name Do a such rotor, Cr., mgL 1.91 Image of the such construct and the such con	verage OTR/SOTR, diffused aeration		0.487	0.487	0.400															
Nake Dot sech rotor, Gr. mgL 1.91 Image of the sech rotor, Gr. mgL 1.91 Image of the sech rotor, Gr. mgL 1.91 Image of the second position (sech rotor)	eak total oxygen demand, peak MOt, kg	c	1854				does NOT inc	lude 1/PFpm I] because full	design popu	l lation loadir	ng is alread	/ for the pea	ik month						
Name Operation Ope	eak DO at each rotor, Cr, mg/L		1.91	0.444	0.444															ļ
Desk D0 are schröter, Gr., mg/L 0.77 0.138 <	eak OTR/SOTR, diffused aeration																			
Deal D0 areah-rotor, Cr. mgL 0.77 0 </td <td>linimum total oxygen demand, peak MC</td> <td>I t, kg/d</td> <td></td> <td></td> <td></td> <td></td> <td>includes 1/PF</td> <td>pm for off-pea</td> <td>l Ik season po</td> <td>pulation load</td> <td>l lings</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>L</td> <td></td> <td></td>	linimum total oxygen demand, peak MC	I t, kg/d					includes 1/PF	pm for off-pea	l Ik season po	pulation load	l lings							L		
Min OTHSOTR, efflued analon 0.525 0.524 0.548 Image of the second	eak DO at each rotor, Cr, mg/L	· · · · · · · · · · · · · · · · · · ·	0.77		0.600															
verage Or at dark (MC, MC, MC, MC, MC, MC, MC, MC, MC, MC,	In OTR/SOTR, diffused aeration		0.519	0.518	0.538															
verage Or at dark (MC, MC, MC, MC, MC, MC, MC, MC, MC, MC,	t STARTUP LOAD																			
wrange OTRSOTR, suffice aeration 0.519 0.517 0.588	verage total oxygen demand, MOt, kg/d																			
verage OTRSOTR, diffued available 0.524 0.523 0.544 0 </td <td>verage OTR/SOTR, surface aeration</td> <td></td> <td>0.518</td> <td>0.517</td> <td>0.536</td> <td></td>	verage OTR/SOTR, surface aeration		0.518	0.517	0.536															
Bake Dire acchinger. 1.05 0	verage OTR/SOTR, diffused aeration		0.524	0.523	0.544															
Name Open Open <th< td=""><td>eak total oxygen demand, peak MOt, kg</td><td>c</td><td>1020</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td> </td><td> </td><td></td></th<>	eak total oxygen demand, peak MOt, kg	c	1020																	
Name Open Open <th< td=""><td>eak OTR/SOTR, surface aeration</td><td></td><td>0.500</td><td>0.500</td><td>0.515</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	eak OTR/SOTR, surface aeration		0.500	0.500	0.515															
Vertage 0.42 0.44 0.42 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.57 0.44 0.45 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44 0.57 0.44	eak OTR/SOTR, diffused aeration		0.509	0.508	0.526															
Name Open Open <th< td=""><td>linimum total oxygen demand, peak MC</td><td>t, kg/d</td><td></td><td></td><td></td><td></td><td>includes 1/PF</td><td>pm for off-pea</td><td>k season po</td><td>pulation load</td><td>lings</td><td></td><td></td><td></td><td></td><td></td><td></td><td> </td><td></td><td></td></th<>	linimum total oxygen demand, peak MC	t, kg/d					includes 1/PF	pm for off-pea	k season po	pulation load	lings									
In OTRSOPR, diffued areanon 0.545 0.54 0.570 0	In OTR/SOTR, surface aeration		0.542	0.540	0.566															
verage i <td>Iin OTR/SOTR, diffused aeration</td> <td></td> <td>0.545</td> <td>0.544</td> <td>0.570</td> <td></td> <td></td> <td></td> <td> </td> <td></td> <td></td> <td> </td> <td></td> <td></td> <td></td> <td></td> <td></td> <td> </td> <td></td> <td></td>	Iin OTR/SOTR, diffused aeration		0.545	0.544	0.570															
verage i <td>tandard Oxygen Transfer Rate (SOTR</td> <td><u>, kg/h</u></td> <td>FOR SURFACE</td> <td>AERATION - N</td> <td>ote: THIS CAL</td> <td>CULATION D</td> <td>OES <u>NOT</u> TA</td> <td>KE INTO ACC</td> <td>OUNT DIF</td> <td>USER SUBI</td> <td>IERGENC</td> <td>DO conc</td> <td>entration at</td> <td>a fraction o</td> <td>f submerge</td> <td>d depth)</td> <td></td> <td></td> <td></td> <td>-</td>	tandard Oxygen Transfer Rate (SOTR	<u>, kg/h</u>	FOR SURFACE	AERATION - N	ote: THIS CAL	CULATION D	OES <u>NOT</u> TA	KE INTO ACC	OUNT DIF	USER SUBI	IERGENC	DO conc	entration at	a fraction o	f submerge	d depth)				-
basic basic <th< td=""><td>verage</td><td></td><td>122</td><td>122</td><td>120</td><td> </td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	verage		122	122	120															
137ATUPLOAC	aximum		174	174	174															
verage i <td></td> <td></td> <td>60</td> <td>60</td> <td>58</td> <td></td>			60	60	58															
Add Add <td>t STARTUP LOAD</td> <td></td> <td>63</td> <td>69</td> <td>50</td> <td></td>	t STARTUP LOAD		63	69	50															
Add Add <td>laximum</td> <td></td> <td>85</td> <td>85</td> <td>83</td> <td></td>	laximum		85	85	83															
Handard Oxygen Transfer Rete (SOTR), kgh FOR DIFFUSED AERATION Image: Constraint of the constraint			32	32	30															
International (Second Cond Cond Cond Cond Cond Cond Cond C	1 1	ka/b	1	AFRATION																
verage Image: Section of the section of t	t FULL DESIGN LOAD																			<u> </u>
Infinum Infinum <thinfinum< th=""> <thinfinum< th=""> <thi< td=""><td>verage</td><td></td><td></td><td></td><td>116</td><td></td><td> </td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thi<></thinfinum<></thinfinum<>	verage				116															
verage 61 61 59	finimum		59	60	57															
verage 61 61 59	t STARTUP LOAD													1						
Ainimum 31 32 30	verage				59															
			31	32																
International Control of the second																				1

Existing BVSTP 3.8 ADWF

SECTION 4. NITRIFICATIO	N																		
								-											
		20 deg C	Tmin	Tmax													1		
		20 deg C	Imin	Timax			-							<u> </u>					
																			L
Adjust nitrification parameters for tempe	rature, pH and ditch DO	profile:																	
Nitrifier growth rate, unT, d-1		0.490																	
Nitrifier ammonia half-saturation coeffici	ent, KnT, mgN/L	1.292	1.151	3.671															
Calculate effluent NH3-N and soluble Th	(N:																		
Effluent NH3-N, NaeT, mg/L		0.69	0.72		Calculated												1		
Effluent residual sol. biodegradable org.	N, NoeT, mg/L	0.58	0.59														1		
Effluent soluble TKN, NteT, mg/L		2.33	2.38	2.11													1		
SECTION 5. DENITRIFICA	TION						1	1											1
N incorporated in biomass, Ns, mg/L		14.36																	
N content of biomass MLSS, mgN/mgM	LSS	0.074																	
				Tmax				1											
Nitrification capacity, NcT, mg/L		37.31	37.27	37.53				1											
Primary denitrification potential, Dpp, m	g/L	43.81	41.65	69.04	Assumes Sbs	N fully used fi	or DN; adopts	fxdm (refer t	o WRC, Eqn	6.24 for Ba	rdenpho sy	stem; here 1	ve have as	sumed Sec	. Anoxic fra	ction is in the	clarifier sludge	blanket)	
							1					[1		
Effluent NO3-N, NneT, mg/L		0.27	0.27	0.27	Calculated														
Effluent Total N, mg/L		2.89	2.94	2.67	includes Sse														
				L			1									1			
		Deduct an allowar																	
		clarifier sludge bla	anket and inse	rt in NO3s ass	umed in Sectio	in 2.													
		Adjust Sbsn and r	repeat until cal	culated NneT	s														
		compatible with a	ssumed NO3s																
SECTION 6. OUTPUT SUN	IMARY							1											
			Tmin	Tmax							1						1		
		20 deg C	19	29				1			1						1		
								1			1						1		
Average MLSS concentration, mg/L		3791																	
Peak month MLSS concentration, mg/L		4928						T			1						1		
Average Actual Total Oxygen demand, I	(g/d	1391					1	1											1
Average SOTR, kg/h (diffused air)		119					1												
Maximum SOTR, kg/h (diffused air)		168	168	166			1												
SOTR turndown required		5.6																	
Alum dose, mg/L as dry alum		10									L						l		
Alkalinity depletion due to alum dosed, r	ng/L CaCO3	4									L			L			I		
Effluent Ammonia, mgN/L		0.7		0.6			1				L			L					
Effluent Nitrate, mgN/L		0.3	0.3	0.3															
Effluent Total N, mgN/L		2.9	2.9	2.7				1											
Effluent soluble P, mgP/L		0.07																	
Effluent Total P, mgP/L		0.27																	
Effluent TSS, mg/L (assumed)		4																	

	EXISTING BVSTP PROCESS AUGM	ENTED (INC	ORPOR	ATING C	CEAN SHO	ORES)												
	· · · · · · · · · · · · · · · · · · ·	ESS FOR NDI	BEPR															
	This worksheet calculates process N & P performance for a given set of wastewater, process and kinetic parameters.																	
		itch with RAS return	ed to an upstre	am anaerobic	reactor.													
	Mass fraction of the anaerobic reactor can be set to zero.																	
	REFERENCES 1. WRC "Theory, Design and Operation of Nutrient Removal A	Activated Sludge Pro	cesses" 1984.															
	2 Wentzel Ekama & Marais "Biological Excess Phosphorus I	emoval-Steady Sta	to Process Des	sign" I														
	 Clayton, Ekama, Wentzel & Marais "Denitrification Kinetics Activated Systems Treating Municipal Waste Waters" F 	in Biological Nitroge roc IAWPRC Kvoto	n and Phospho Conf. July 199	orus Removal														
			5 (Jul 1987).															
	NOTES																	
		+													-			
	the K2 denitrification rate specific to the process format																	
	Denitrification of the s-recycle to a maximum equivalent to the																	
		agual																
			1															
		1																
	and operation under variable operating conditions and at lower	r than design load.	anieters,															
	Note that in using the worksheet three iterative calculations a		1															
			1															
		+																
	Flow]					
	Process Parameters						T	T										
	Biomass Parameters 2. Solids Inventory & P Remova																	
	3. Oxygen Demand and DO Levels 4. Nitrification	1																
	5. Denitrification																	
	SELECT VALUES IN HEAVY BOXES OTHER VALUES ARE CALCULATED AUTOM	ATICALLY																
			-															
		LIERO																
		3.8																
	COD total, Sti, mg/L TKN, Nti, mg/L		5															
	TP, Pti, mg/L	9.9																
	RBCOD/COD biodegradable, fsbs	0.200	2															
	Unbiodegradable soluble fraction of COD total, fus	0.200		28														
	Unbiodegradable soluble fraction of TKN, fnu Ammonia fraction of TKN, fna	0.75		43.13				elow from E	qn in Row 8									
Bar Allowing and Labora Decision Decision <thdecision< th=""> <thdecision< td=""><td>N content of VSS. Np/VSS. Cxn</td><td></td><td></td><td></td><td>N . 50 . T .</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thdecision<></thdecision<>	N content of VSS. Np/VSS. Cxn				N . 50 . T .													
se Alazine mil ColO second man finance in a second ma	COD biodegradable. Shi mg/l			0.20	Note: Effluent 1 ota	tal N includes r	residual org	I. biodegrada	able soluble	TKN in effl	uent (from a	ammonificati	on calculatio	on), see Ro	ow 275			
	COD biodegradable, Sbi, mg/L RBCOD, Sbsi, mg/L	420	fac	0.18	Note: Emuent 1 ota	tal N includes r	residual org	. biodegrada	able soluble	TKN in effl	uent (from a	ammonificati	on calculatio	on), see Ro	ow 275			
Barrenet Monte, Y. M. Image Monte Mont	COD biodegradable, Sbi, mg/L RBCOD, Sbsi, mg/L Total Alkalinity, mg/L CaCO3	420	fac VFA	0.18	Note: Emuent Tota	tal N includes r	residual org	. biodegrada	able soluble	TKN in effl	uent (from a	mmonificati	on calculatio	on), see Ro	ow 275			
namble manufactor, ha in anote busines in a construction of the second o	COD biodegradable, Sbi, mg/L RECOD, Sbsi, mg/L Total Alkalinity, mg/L CaCO3 PROCESS PARAMETERS	420	fac VFA	0.18	Note: Emuent Tota	tal N includes r	residual org	i. biodegrada	able soluble	TKN in effl	uent (from a	ammonificati	on calculatio	on), see Ro	w 275			
Image Alore main finders. Min 3.33 Aumanta to in the dutter studye form Image Alore main finders. Image Al	COD biodegnadable, Sbi, mgL RRCOD, Sbi, mgL Total Alkaliniy, mg/L CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML	420 84 230) VFA See Ditches	0.18 15.1	nsions.xls		residual org	. biodegrada	able soluble	TKN in effl	uent (from a	ammonificati	on calculation	on), see Ro	ow 275			
and Phome 4 See. Anoo: maximum C.23 Image: mail of the second se	COD biodegradable, Ski, mgL RRCDD, Ski, mgL Total Alkalnity, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Sludge age, Rs, d Anaerobic mass fraction, toa	42(84 230 3.7(19.5) VFA See Ditches	0.18 15.1	nsions.xls		residual org	. biodegrad	able soluble	TKN in effl	uent (from a	mmonificati	on calculati	on), see Ro	ow 275			
AS model mains in a market mains in a sector matched market water and to ma	COD biodegnadable, Ski, mgL RECOD, Ski, mgL Trata Akalinty, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Vol.me, Vr, ML Bioreactor Vol.me, Vr, ML Nacrobic mes fraction, fina Na of anaerobic mest fraction, fina Na of anaerobic meators in series. N	42(84 230 3.7(19.5	fac VFA See Ditches To match pee	0.18 15.1 compare dime k MLSS to exi	nsions.xts sting design for cla		residual org	. biodegrada	able soluble	TKN in effl	uent (from a	mmonificati	on calculatio	on), see Ro	275			
Ohe all equipes Out, During L. Out all equipes All equipes and all equipes All equipes and All equipes and All equipes All equipes and All equipes All equipes and All equipes All equ	COD biodegradable, SB, mgL RECDD, SSb, imgL Total Akalinky, mgL CaCO3 PROCESS PARAMETERS PROCESS: Bioreactor Volume, Vr, ML Sludge age, Rs, d Anaerobic mass fraction, foa No. d'anaerobic meators in series, N	42(84 230 3.7(19.5	fac VFA See Ditches To match pee	0.18 15.1 compare dime k MLSS to exi	nsions.xts sting design for cla		residual org	. biodegrada	able soluble	TKN in effl	uent (from a	mmonificati	on calculatio	on), see Ro	275			
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harmet wäch, n	COD biodegradable, SBL mgL COD biodegradable, SBL mgL Total Alkaliny, mgL CaCO3 Total Alkaliny, mgL CaCO3 Total Alkaliny, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Sludge age, R4, G Anaerobic mass fraction, for Anaerobic mass fraction, for Sacondary Anoxic mass fraction, for Sac recycle age. Sac Anoxic mass fractions DO in a-recycle, 0a, mgL DO in a-recycle, 0a, mgL DD in a-recycle, 0a, m	422 8 8 233 237 19 0 0 3 7 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 7 0 3 7 7 19 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	fac VFA See Ditches To match pee	0.18 15.1 compare dime k MLSS to exi e in the clarifie ne zero for oxio	nsions.xls sting design for cla r sludge blanket dation ditch D in Eqn:	arifiers										above at Da=		
unrege 137 40ait 928 1	COD biodegradable, Ski, mgL RCCOL, Ski, mgL Tetal Akalimiy, mgL CaCO3 PROCESS PARAMETERS PROCESS PARAMETERS Process: Bioreactor Volume Vr, ML Bioreactor Volume Volume Vr, ML Bioreactor Volume Volu	422 8 8 233 237 19 0 0 3 7 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 0 0 3 7 0 3 7 7 19 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	fac VFA See Ditches To match pee	0.18 15.1 compare dime k MLSS to exi e in the clarifie ne zero for oxio	nsions.xls sting design for cla r sludge blanket dation ditch D in Eqn:	arifiers										above at Da=		
Interligent regular regular regular regular regular regular regular re	COD biodegradable, Sbl. mgL RECOD, Stai, mgL Tetal Alkalinty, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Bioreactor Volume, Vol	422 8 8 3.7 19.0 0.0 3.7 0.0 3.0 0.0 3.0 0.0 1.0 0.0 1.5 0.0 4.0 0 0.0 1.5 0.0 1.5 0.0 1.5 0.0 1.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	Fac VFA See Dirches To match pee To match pee Assumed to b Assumed to b C in Eqn:	0.18 15.1 compare dime k MLSS to exi e in the clarific e in the clarific ne zero for oxi 0.005	nsions.xks sting design for cla r sludge blanket dation ditch D in Eqn:	arifiers										above at Da=	0)	
min, dig C 20	COD biodegradable, Sbl. mgL RECOD, Stai, mgL Total Alkalinst, mgL CaCO3 Total Alkalinst, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Bioreactor Volume, Volume, Vr, ML Bioreact	422 8 8 3.7 19.0 0.0 3.7 0.0 3.0 0.0 3.0 0.0 1.0 0.0 1.5 0.0 4.0 0 0.0 1.5 0.0 1.5 0.0 1.5 0.0 1.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	fac VFA See Ditches To match pee Assumed to b Aways assum Alum not requ	0.18 15.1 compare dime k MLSS to exi e in the clarific e in the clarific ne zero for oxic 0.005	r sludge blanker dation diich D in Egn er influent COD	arifiers										above at Da=	0)	
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ryyr ugwenn, ur (1997)	COD biodegradable, Ski, mgL RCDO, Ski, mgL Total Akaliny, mgL CaCO3 Total Akaliny, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Skodpa ag, RA, G Marchon mass fraction, that Anaenobe mass fraction, that Skoondary Anoxic mass fraction, thin Secondary Anoxic on the secondary and the secondary CoD done to anoxic zone, Doczt, mgL of Influent COD done to anoxic zone, Doczt, mgL of Influent Fereinforder Influent Heterotophic active mass, Mohp Heterotophic active mass, Mohp PolyP andspenous mass, Istap PolyP andspenous mass, Istap PolyP andspenous mass, Istap PolyP andspenous mass, Istap PolyP andspenous contents, K of 1 PolyP andspenous mase, K	8 442 8 422 8 42 8	fac fac fac VFA fac VFA fac VFA Sea Ditc/bcs To match pee Assumed to b Assumed to b C in Eqn: Alum not required Adjust to get 1 Adjust to get 1 Adjust to get 1 Adjust to get 2 Termin Constraint Constraint Constraint Constraint Constraint Constraint Constraint Constraint Constraint Constraint Constraint Constraint	0.18 15.1 Compare dime is MLSS to exi	Adj, for pH	arifiers	ak. Depends									above at Da-		
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	SECTION 2. SOL	IDS INVEN	TORY & P REM	IOVAL																		
	Based on Ref. 2 equations	(1) to (27).	biological P Terrioval.																			
	Two iterative calculations	are involved in 3	Sections 2 and 4:	20 deg C																		
	*Adjust NO3s, then adj	ust Sbsn, until M	IneT20 calculated in S	ection 5 is																		
	*Adjust Sbsn assumed	until Sbsn calci	ulated agrees.																			
	*If fxa is zero the assur	ned values of N	O3s and Sbsn are irre	levant.																		
	An iterative calculation is a	lso required in	Section 3 but this is no	t as sensitive.																		
	NO3-N recycled to the ans	erobic zone. N]]3s.ma/l	0.000	Assumed	Effluent nitrate	T-20:	0.28716054														
		1				Childen hittak		0.20710000														
	RBCOD exiting the anaero Influent RBCOD available	bic zone, Sbsn S bsi	, mg/L		Assumed																	
	Heterotroph active mass, I	MXbh, kg		2090	2139	1683																
	RBCOD exiting the anaero	bic zone, Sbsn	, mg/L	11.160	Calculated Insert Shan ca	alculated into S	hsn assumed															
				0.10.030																		
	Substrate sequestered by Substrate available to hete	poly-P organisr rotrophs. MSbl	ns, MSseq, kg/d 1. kg/d										<u> </u>				<u> </u>					
			1	ĺ																		
	Poly-P organisms active m Poly-P organisms endoge	iass, MXbg, kg nous mass, MX	l Ba. ka	1199																		
	Heterotroph active mass, I	//Xbh, kg		2090																		
	heterotroph endogenous r Inert mass. MXi. ka	nass, mixen, kg				Vp. ML:	3.70	See Ditches	compare dime	nsions.xls												
	Total VSS, MXv, kg	AVe he		11087		Average VSS	2996	mg/L	1									İ				
	Total SS_MXt_kg	1		14746	A	verage MLSS	3985	mg/L	3786	mg/L	If Sec. Anox	i c mass frac	tion is assu	I med to be i	n the clarifie	er 🛛						
	Peak month COD load fac	tor		1.30	Peak	Month MLSS	5181	mg/L	4922	mg/L	Ditto											
		1		<u> </u>	<u> </u>																	
	P removal by poly-P organ	isms, dPg, mg/	L	6.24											-							
	P removal by inert mass, o	IPi, ma/L		2.27																		
Gale Control Control <thcontrol< th=""> <thcontrol< th=""> <thcont< td=""><td>P removal by alum, dPc, n Total P removal dP mol</td><td>ng/L</td><td></td><td>0.00</td><td>From KJH bo</td><td>ok p64</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></thcont<></thcontrol<></thcontrol<>	P removal by alum, dPc, n Total P removal dP mol	ng/L		0.00	From KJH bo	ok p64																
Characterize / Pained Data Description	Total P content of MLSS, I	ngP/mgMLSS		0.05	İ			1			1	1		1	i							
				0.04		Target Po-	0.4	maP/l	am	0.864	maP/maAl	Ke	0 175	maP/	a (calc):	0.94	maP/ma^1	for Alum stoic	hiometry from	KIH book ne?	-64	
	Effluent Total P, Pe, mg/L	, _ (ocidie chel	(0.21	includes Sse	. Jigut F b.	0.1		ym:	0.004		πp:	0.1/5		q (calc):	0.31						
		alum dosed mo	L CaCO3			depletion (mot	aCO3/ mn dn	alum dosed	Tar	0.411	From K.IH N	ook Erin 3.1	6. p64									
				0.00					. a.	0.411												
	SECTION 3 OVV			EVELS]											<u> </u>					
	SECTION 3. UXY	JEN DEMA																				
	alpha (F): 0.6		Cs (20 C, Talin).		9.26																	
b b C						7.73																
b b C <thc< th=""> C <thc< th=""> <thc< th=""></thc<></thc<></thc<>	Diffuser mounting baicht (rom floer) m		0.26																		
Appl. Table 3 minute intermed to a minute of part 1000 Appl. Sec. 10000 Appl. Sec. 1000 App	Dinubur mounting height (Cs_inf (20°C, 1 atm):	10.40																		
Picels Control Control <th< td=""><td></td><td></td><td></td><td>Cs_inf @ Tmin:</td><td>10.60</td><td>0.00</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>				Cs_inf @ Tmin:	10.60	0.00																
	Peak factors for A	eration (svr	thesis only):	Cs_III @ IIIIaX		0.00																
Base of the inder direct Image of the inder direct Ima																						
During and ensure factor Like ensure 2 days anone 2 days	Startup load demand facto	r		0.55	Assumed																	
Number of sequence from the Protect balance of a protect of	Peak month demand facto Diurnal max, demand facto	r		1.3	Assumes 0.33	33 times amplit	ude of peak T	OD														
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Blank ROAL None myl D.232 Ausmanne A.E. meet Netto 2014 Part of the p	Effluent NH3-N Naea mo	4		0.67	Assumed Ad	to match Nae	T20 calc held		0.69													
Arrange mitogened any spok month, With App Total Image of any spok month, With App Total Total	Effluent NO3-N, Nnea mg/	L.			Assumed. Ad	. to match Nne	T20 calc. belo	ow:														
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Arrange mitogened any spok month, With App Total Image of any spok month, With App Total Total	A+ EULI DECIGIULOTE		1	20 dog C	Tmin	Tmax																
Average book enclosed influence rouge: Constrained provide in action of the sector of th	ALFULL DESIGN LOAD	eactor OTR)			Tmin	Tmax																
Non-base or substrate and the section 0.471 0.411 0.411 0.411	Average carbonaceous ox Average pitrogenous oxyo	ygen demand, I	MOc, kg/d	1180	Tmin	Tmax																
Average OT ROUTE, surface anatom 0.471 0.471 0.473	Average nitrogenous oxyg Average denitrification oxy	en demand, MC gen recoverv. 1	In, kg/c IOd. ka/c	1180 700 435	Tmin	Tmax																
Pack Bolt and upper hermal park MDC type: 1927 Image of the second of the park month Image of the park month I	Average nitrogenous oxyg Average denitrification oxy Average total oxygen dem Average DO at each roto	en demand, MC gen recovery, 1 and, MOt, kg/d r. Cr. mg/L	In, kg/c IOd. ka/c	1180 700 435 1445	Tmin	Tmax																
Pask Of Hassel existion 0.403 0.40	Average nitrogenous oxyg Average denitrification oxy Average total oxygen dem Average DO at each roto	en demand, MC gen recovery, 1 and, MOt, kg/d r. Cr. mg/L	In, kg/c IOd. ka/c	1180 700 435 1445 1.49 0.471	0.471	0.479																
Part Olif Solf, suffice attaining O. 439 O. 448 O. 4	Average nitrogenous oxyg Average denitrification oxy Average total oxygen dem Average DO at each roto Average OTR/SOTR, surfi Average OTR/SOTR, diffu	en demand, MC gen recovery, I and, MOt, kg/d r, Cr, mg/L ace aeration sed aeration	/n, kg/c /Od, kg/c	1180 700 435 1445 1.49 0.471 0.484	0.471	0.479																
Pick OTK-0TK-0THund metric Pick OTK-0TK-0THund metric Pick OTK-0TK-0THUND-004 Pick OTK-0THUND-004 Pick OTK-0THUND-004 Pick OTK-0THUND-004 Pick OTK-0THUND-004 Pick OTK-0THUND-004	Average nitrogenous oxyg Average denitrification oxy Average total oxygen dem Average DO at each roto Average OTR/SOTR, surfi Average OTR/SOTR, diffu	en demand, MC gen recovery, I and, MOt, kg/d r, Cr, mg/L ace aeration sed aeration	/n, kg/c /Od, kg/c	1180 700 435 1445 1.49 0.471 0.484 1927	0.471	0.479		does NOT in	clude 1/PFpm l	Decause ful	design popu	ation loadir	ng is alread	y for the pea	ak month							
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A TARTUP Load No	Average entification oxy Average total oxygen dem Average Otal oxygen dem Average Otal each rotot Average OTR/SOTR, surfa Average OTR/SOTR, surfa Average OTR/SOTR, surface Peak OTR/SO	en demand, MC gen recovery. I and, MOt, kg/d r, Cr, mg/L ace aeration sed aeration i, peak MOt, kg r, mg/L aeration aeration aeration	In, kg/c NOd, kg/c c c	1180 700 435 1445 0.471 0.484 1927 1.99 0.439 0.439 0.455 7778	0.471 0.484 0.439	0.479 0.494							ng is alread	y for the pea	ak month							
Average total oxygon demand, MOL tog's 755 6	Average nitrogenous oxyg Average total oxygen dem Average total oxygen dem Average OTR/SOTR, surf/ Average OTR/SOTR, diftu Peak total oxygen deman Peak Dot a each rotor, C Peak OTR/SOTR, surface Peak OTR/SO	en demand, MC gen recovery, F and, MCt, kg/d r, Cr, mg/L ace aeration sed aeration l, peak MOt, kg r, mg/L aeration aeration mand, peak MC 	In, kg/c NOd, kg/c c c	1180 700 435 1445 1445 1445 1927 1.99 0.455 0.455 778 0.80	0.471 0.484 0.439 0.439	0.479 0.494 0.438 0.438							ig is alread	y for the pee	ak month							
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Average OTR/SOTR, diffused areation 0.523 0.521 0.542 Image: control on the cont	Average entification or solver and a series of the action	en demand, MC gen recovery, 1 and, MOt, kg/a r, Cr, mg/L cec aeration sed aeration i, peak MOt, kg r, mg/L aeration aeration aeration ieration ieration aeration aeration aeration	In, kg/c NOd, kg/c c c	1180 700 435 1445 149 0.471 0.471 1927 199 0.439 0.439 0.439 0.455 778 0.6455 778 0.6517 0.524	0.471 0.484 0.439 0.439	0.479 0.494 0.438 0.438							ıg is alread	r for the pee	ak month							
Peak OlifySOIR, diffued arration 0.507 0.508 0.523 Image: Control of the set season population loading: Image: Controo	Average entirtication or waverage entirtication or Average DD at each rotor Average DD at each rotor Peak total oxygen demain Peak total oxygen demain Peak total oxygen demain each OTR/SOTR, surface each OTR/SOTR, surface each OTR/SOTR, surface Minimum total oxygen dem Min. DD at each rotor, Ct Min. DTR/SOTR, surface Average DTR/SOTR, surface Average DD at each rotor.	en demand, MC gen recovery, 1 and, MOt, kg/c r, Cr, mg/L ccc aeration sed aeration i, peak MOt, kg r, mg/L aeration aeration aeration eration eration eration d, mg/L eration cr, cr, mg/L cc aeration	In, kg/c NOd, kg/c c c	1180 700 435 1445 0.471 0.484 1927 1929 0.489 0.489 0.489 0.489 0.489 0.489 0.459 778 0.524 0.517	0.471 0.484 0.439 0.456 0.516 0.522	0.479 0.494 0.438 0.459 0.535 0.543							ıg is alread	/ for the pee	ak month							
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Maximum 87 64 64 64 66 67 64 67 66 66 66 66 66 66 66 66 66 66 66 66	Average Dia Average Dia Average Dia Average Dia Average Dia Sech Todayon demonstrative and the second diagram of the second dia	en demand, M. en demand, M. en demand, M. en demand, M. es aeration sed aeration beak MCr. kg/ r, mg/L aeration aerat	n. kgć COL kg/c C	1160 700 4035 1465 149 0.671 149 149 149 149 149 149 149 14	0.471 0.484 0.486 0.486 0.516 0.522 0.522 0.522 0.522 0.522 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.522 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.523 0.533	0.479 0.491 0.493 0.493 0.493 0.595 0.593	CULATION D	includes 1/PF	pm for off-pea	k season p	opulation load	ings		for the pee	e fraction o	/ submerge	4 depth)					
Minimum 33 33 31	Wereign einstruktionsenden Stephensen Wereign einstruktionen und seine Stephensen Average DD al sech roto Strik Wereign OTRSOTR, stilt and seine Stephensen Pask DD al sech roto Stephensen Pask DD al sech roto Stephensen Pask DD al sech roto Stephensen Minimum stall ausgehet Stephensen Minimum staller	en demand, M. en demand, M. en demand, M. en demand, M. es aeration sed aeration beak MCr. kg/ r, mg/L aeration aerat	n. kgć COL kg/c C	1160 7000 435 1465 1467 149 149 149 149 149 149 149 149 149 149	0.477 0.484 0.484 0.456 0.516 0.522 0.522 0.522 0.522 0.522 0.523 0.555 0.521 0.555	0.479 0.494 0.459 0.459 0.535 0.543 0.544 0.545 0.544 0.545 0.544 0.545 0.544 0.545 0.544 0.545 0.544 0.545 0.555	CULATION D	includes 1/PF	pm for off-pea	k season p	opulation load	ings		for the pes	k month	/ submerge	d depth)					
Aeration Turndown regured 5.6	Average of the a	en demand, M. en demand, M. en demand, M. en demand, M. es aeration sed aeration beak MCr. kg/ r, mg/L aeration aerat	n. kgć COL kg/c C	1160 7000 4635 1465 1469 467 149 0.677 199 0.635 0.627 778 0.627 778 0.627 778 0.627 778 0.627 778 0.627 785 0.627	0.471 0.439 0.439 0.456 0.516 0.522 0.555 0.522 0.555 0.522 0.555	0.41% 0.44% 0.44% 0.44% 0.45% 0.54% 0.54% 0.54% 0.54% 0.54% 0.55%	CULATION D	includes 1/PF	pm for off-pea	k season p	opulation load	ings		l l l l l l l l l l l l l l l l l l l	k month	submerge						
	Wendge full opgenue on systeming full opgenue on systeming full opgenue form and the series of the system full of the series of the system of the syste	en demand, Mc en demand, Mc and the second s	n. kgć COL kg/c C	1165 7000 4055 1465 1492 1492 1492 0.635 0.645 0.655 0.555 0.655 0.555 0.	0.471 0.484 0.486 0.486 0.516 0.522 0.522 0.522 0.522 0.522 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.522 0.523 0.555 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.523 0.523 0.523 0.553 0.523 0.553 0.523 0.553 0.523 0.555 0.555	0.479 0.491 0.493 0.493 0.459 0.543 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.555	CULATION D	includes 1/PF	pm for off-pea	k season p	opulation load	ings		For the pee	k month	f submerge						
	Wendge full opgenue on systeming full opgenue on systeming full opgenue form and the series of the system full of the series of the system of the syste	en demand, Mc en demand, Mc and the second s	n. kgć COL kg/c C	1165 7000 4055 1465 1492 1492 1492 0.635 0.645 0.655 0.555 0.655 0.555 0.	0.471 0.484 0.486 0.486 0.516 0.522 0.522 0.522 0.522 0.522 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.521 0.522 0.523 0.555 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.522 0.523 0.523 0.523 0.553 0.523 0.553 0.523 0.553 0.523 0.555 0.555	0.479 0.491 0.493 0.493 0.459 0.543 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.554 0.555	CULATION D	includes 1/PF	pm for off-pea	k season p	opulation load	ings		for the pee	k month	f submerge	d depth)					

OS+BVSTP 3.8 ADWF (existing)

SECTION 4	I. NITR	FICATION	1	1																	
		1																			<u> </u>
				20 deg C	Tmin	Tmax									············						+
				20 deg 0		Tillax															
Adjust nitrificatio	on paramete	ers for temperat	ture, pH and ditch DC) profile:																	
Nitrifier growth r				0.496		1.408															
Nitrifier ammonia	a half-satura	ation coefficien	t, KnT, mgN/L	1.292	1.151	3.671															
Calculate effluer										ļ											
Effluent NH3-N,	Nae1, mg/L			0.69			Calculated														
Effluent residual	sol. biodeg	radable org. N	Noe1, mg/L	0.61	0.62																
Effluent soluble	TKN, NteT,	mg/L		2.85	2.90	2.62															
										ļ											
SECTION 5	5. DENI	TRIFICAT	ION		1				1												
					1																
N incorporated in				14.96					1												
N content of bior	mass MLSS	, mgN/mgMLS	s	0.075					1	T			1					1			
				20 deg C	Tmin	Tmax				1			1						1		
Nitrification capa	acity, NcT, n	na/L		39.69	39.64	39.92															
Primary denitrific	cation poter	tial, Dpp, mg/L		45.06	42.84	71.12	Assumes Sba	N fully used f	or DN; adopts	fxdm (refer t	o WRC, Eqn	6.24 for Ba	rdenpho sy	stem; here	we have as	umed Sec.	Anoxic fra	ction is in the o	larifier sludge	blanket)	
		T						1	1	T	[1				[1	l i	
Effluent NO3-N,		<u> </u>		0.29	0.29		Calculated			1							i	1			
Effluent Total N.	ma/L	1		3.43	3.48	3.21	includes Sse										i				
		1																			
				Deduct an allowa	nce for denitrif	ication in the s	econdary	1													
				clarifier sludge bla	anket and inse	rt in NO3s ass	umed in Section	on 2.													1
				Adjust Sbsn and	repeat until cal	culated NneT	s	1													
				compatible with a	ssumed NO3s		1												1		1
					1																
SECTION 6		MILES TIL	MADY	1	1			1	1								i				1
SECTION	. 0011	01 300			Tmin	Tmax															
				20 deg C	19	29															-
August MILCO		1		3786																	
Average MLSS Peak month ML	concentratio	n, mg/L		4922	l																+
Average Actual	Total Owner	nauon, mg/L		4922																	
Average SOTR,	ka/b (diffue	en uemdhu, ky	u	124		122															
Maximum SOTR	Kg/TI (UIITUS	eu dil)		124																	
SOTR turndown	, kyri (dillu	iseu aii)		5.6		1/5		-													
Alum dose, mg/l		<u> </u>		5.6																	
Alum dose, mg/l Alkalinity depleti	L as ury alu	111 human alamana di ana an	1.0-002																		
Effluent Ammon	un què to a	ium ausea, mg	/L 08003	0.7	0.7	0.6															
Effluent Ammon Effluent Nitrate.										l											+
Effluent Nitrate, Effluent Total N,	mgrv/L			0.3																	
Effluent soluble	ngiv/L			0.01		3.2											<u> </u>				
Effluent Total P,	P, mgP/L			0.01													<u> </u>				
Enuent Total P,	ingr/L	1		0.21																	
Effluent TSS, m	g/L (assume	3 0)		1 4		1		1	1	1			1	1	1			1	1	1	

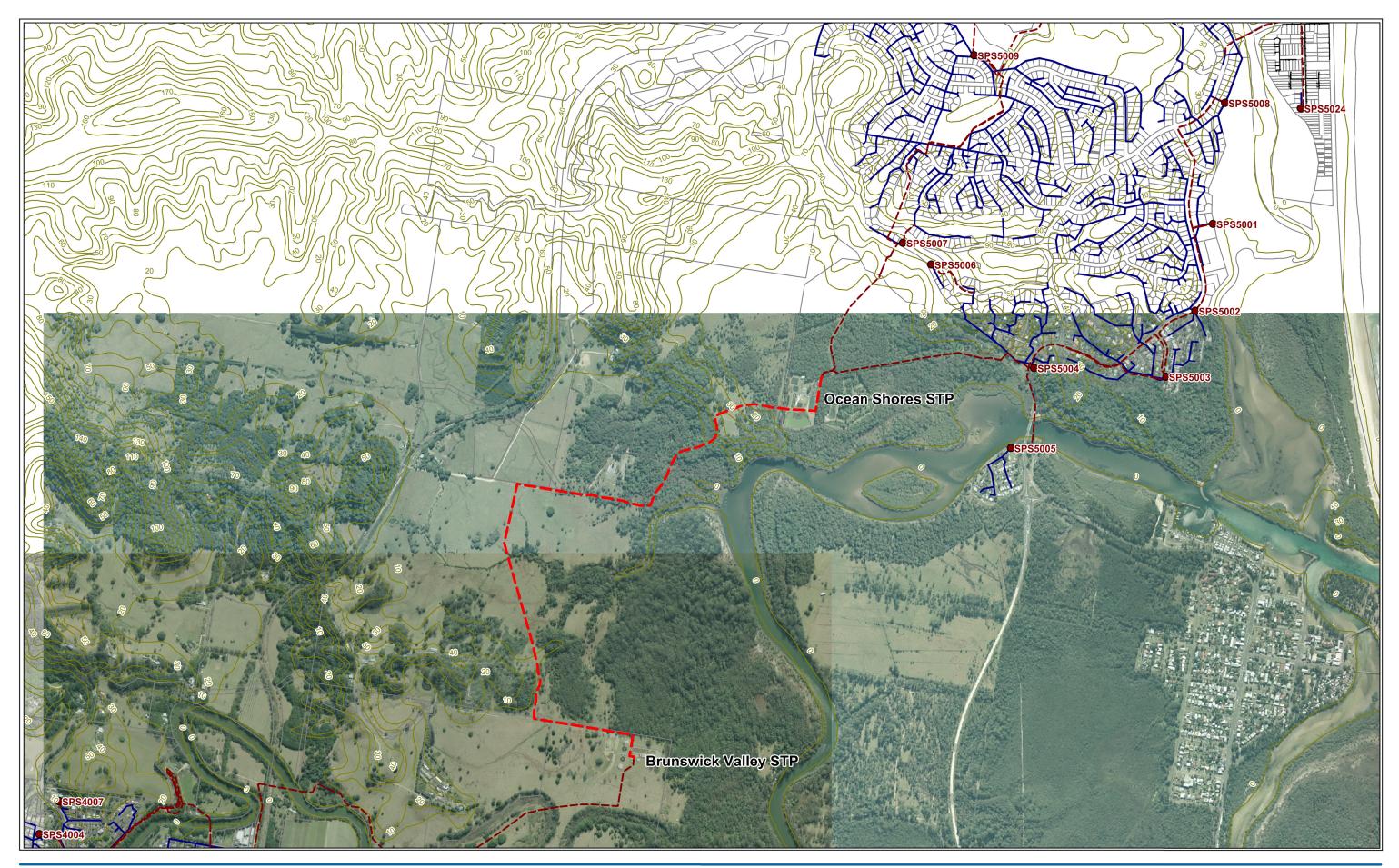
NEW BVSTP PROCESS AUGMENTE	D (INCORPO	RATIN	G OCEA	N SHORES													
ANALYSIS OF OXIDATION DITCH PROCE	SS FOR NDBE	:PR															
This worksheet calculates process N & P performance for a given set of wastewater, process and kinetic parameters.																	
The process modelled is the mechanically aerated oxidation dite	h with RAS returned	l to an upstre	am anaerobio	reactor.													
Mass fraction of the anaerobic reactor can be set to zero. REFERENCES																	
1. WRC "Theory, Design and Operation of Nutrient Removal Ac	mount Stondy State	Procose Doc	tian"														
 Venizer, Exama evidate anological Excess reloging to the Water SA, 16, 1, 20 (Jan 1990). Clayton, Ekama, Wentzel & Marais "Denitrification Kinetics in Activated Systems Treating Municipal Waste Waters" Pro- 4. Hartley "Hydraulics of Horizontal Shaft Oxidation Ditches" Jnl 	Biological Nitrogen a	and Phosobo	nus Removal														
Activated Systems Treating Municipal Waste Waters" Pro 4. Hartley "Hydraulics of Horizontal Shaft Oxidation Ditches". In	c IAWPRC Kyoto Co WPCE 59 7 686 (J	onf, July 1990	0.														
5. Hartey "Tuning Biological Nutrient Removal Plants, IWA Publ	ishing, 2013.																
NOTES																	
Nomenclature is as per the references.																	
Modified denitrification kinetics are used as per Ref 3, in which the K2 denitrification rate specific to the process format																	
is applied to the heterotrophic sludge mass only. Denitrification of the s-recycle to a maximum equivalent to the																	
available RBCOD occurs in the anaerobic zone.																	
The model allows dosing of COD to the anaerobic and/or prima																	
Point source oxygen addition is assumed to occur at each aerat	1 1																
In using this model, give consideration to the effects of changes		neters															
and operation under variable operating conditions and at lower	han design load.																
Note that in using the worksheet three iterative calculations are Sections 2,3 & 4 as explained in those Sections.	involved in																
CONTENTS	-																
1. Flow & Process Parameters																	
Flow Wastewater Characteristics																	
Process Parameters Biomass Parameters																	
2. Solids Inventory & P Remova 3. Oxygen Demand and DO Levels																	
4. Nitrification 5. Denitrification																	
SELECT VALUES IN HEAVY BOXES	CALLY.																
OTHER VALUES ARE CALCULATED AUTOMAT																	
SECTION 1. FLOW & PROCESS PARAME	TERS																
FLOW RATE,Q, ML/d	1.9	7917 240	EP L/EP.d														
WASTEWATER CHARACTERISTICS																	
COD total, Sti, mg/L TKN, Nti, mg/L	560 57.5							İ		İ							
TP, Pti, mg/L RBCOD/COD biodegradable, fbs(ts)	9.9 0.150																
RBCOD/COD biodegradable, fsbs Unbiodegradable particulate fraction of COD total,fup	0.200																
Unbiodegradable soluble fraction of COD total, fus Unbiodegradable soluble fraction of TKN, fnu	0.05	Sus															
			1.55	with zero alum. Note: Nue is	recalculated t	elow from	Fan in Row 8	9 from Alu	m dase								
Ammonia fraction of TKN, fna	0.027	Nus Nai	43.13	with zero alum. Note: Nue is						mmonificati	on colculati		W 27E				
Ammonia fraction of TKN, fna	0.75 0.06 420	Nai Noi	43.13 8.28	with zero alum. Note: Nue is Note: Effluent Total N includ						mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, fna N content of VSS, Np/VSS, Cxn COD biodegradable, Ski, mg/L RBCOD, Sbsi, mg/L	0.75 0.06 420 84	Nai	43.13							mmonificati	on calculati	on), see Ro	w 275				
Armonia fraction of TKN, fna N content of VSS, Np/VSS, Cxn COD biodegradable, Sbi, mgL RBCOD, Sbsi, mgL Total Alkalinity, mgL CaCO3	0.75 0.06 420	Nai Noi fac	43.13 8.28 0.18							mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ina Norotnet of VSR, NovSR, Con COD biodegradable, SN, mgL RECOD, SSi, mgL Total Alkaliny, mgL Total Alkaliny, mgL PROCESS PARAMETERS Process:	0.75 0.06 420 84	Nai Noi fac	43.13 8.28 0.18 15.1							mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ina Noronteri of VSR, NpVSR, Con COD biodogradable, SN, mgL RECOD, SSI, mgL Total Akaliny, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Studge age, Rs, d	0.75 0.06 420 84 230	Nai Noi Fac VFA See Ditches o	i 43.13 i 8.28 0.18 15.1 compare dime							mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN. Ina Noortent of VSR, NovSR, Con COD biodogradable, Sb. mg/L RBCOD, Sob, mg/L Total Akalmiy, mg/L CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, vr, ML	0.75 0.06 420 84 230 	Nai Noi Fac VFA See Ditches o	i 43.13 i 8.28 0.18 15.1 compare dime	Note: Effluent Total N includ						mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ina Norotent of VS, NVSS, Con COD biodegradable, Sb. NyGS, Con ERCOD, Sbi, nyGL Total Akalniy, mgL CaCO3 PROCESS PARAMETERS Bioreactor Volume, Vr, ML Studge age, R. d Anaerobic mass fraction, Ina No. of anaerobic mass fraction, Infim Primary Anoxic mass fraction, Infim	0.75 0.06 420 84 230 1.85 5 19.5 7 0.1 3 0.32	Nai Noi VFA See Ditches o o match pea	i 43.13 i 8.28 0.18 15.1 compare dime k MLSS to ex	Note: Effluent Total N includ						mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ine Nootnet of VSR, NVSR, Con COD biodegradable, Sb. nygL RECOD, Sb. nygL Total Akalehy, mgL CaCO3 PROCESS PARAMETERS Bioreactor Volume, Vr. ML Studge age, Rs. d Anaerobic mass fraction, Isn No. of anaerobic mass fraction, Isn Primary Anoxic mass fraction, Isn Sum of Primary & See. Anoxic mass fractions Total unaerated mass fraction, Isn	0.75 0.06 420 84 230 1.85 5 19.5 7 0.1 3 0.32	Nai Noi VFA See Ditches o o match pea	i 43.13 i 8.28 0.18 15.1 compare dime k MLSS to ex	Note: Effluent Total N includ						mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ina Nootnett UTSS, NVVSS, Con COD biodegradable, Sk. ngL BECOD, Ska, ngL Total Akalinty, ngL CaCO3 PROCESS PARAMETERS Process: Proc	0.75 0.06 420 44 230 1.88 3 1.88 3 1.89 3 1.99 4 1.99 3 1.99 4 1.99 4 1.99 3 1.99 4 1.99	Nai Noi VFA See Ditches of o match pea	i 43.13 i 8.28 0.18 15.1 compare dime k MLSS to ex	Note: Effluent Total N includ						mmonificati	on calculati	on), see Ro	w 275				
Ammonia fraction of TKN, Ina Nootnet of VSN, Ina Nootnet of VSN, NovSS, Con COD biodegradable, Sk. mgL RECOD, Skai, mgL RECOD, Skai, mgL RECOD, Skai, mgL RECOD, Skai, mgL RECOD, Skai, mgL RECOD, REC	0.75 0.06 420 44 230 1.88 3 1.88 3 1.89 3 1.99 4 1.99 3 1.99 4 1.99 4 1.99 3 1.99 4 1.99	Nai Noi fac VFA See Ditches (o match pea sssumed to b	43.13 8.28 0.18 15.1 compare dime ak MLSS to ex	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-))		
Ammonia fraction of TKN, Ina Norotent of VSX, Ina Norotent of VSX, NVSS, Con COD biodigradable, Sb. mgL RECOD, Ssa, mgL Test at Akainity, mgL CaCO3 and the second state of the second sta	0.75 0.06 420 230 1.85 5 185 7 0.1 0.1 0.32 0.05 A 0.37 0.47 0.47 0.47 0.47 0.47 0.47	Nai Noi VFA See Ditches of o match pea	43.13 8.28 0.18 15.1 compare dime ak MLSS to ex	Note: Effluent Total N includ		j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=))		
Ammonia fraction of TKN, Ina Norotent of VSN, Ina Norotent of VSN, NVSS, Con COD biodigradable, Sb, NyGL, RECOD, Sol, NyGL, CACO3 Net Control (Control	0.75 0.06 420 84 1.82 1.85 1.85 1.85 0.3 0.3 0.3 0.3 0.3 0.3 0.05 0.05 0.05	Nai Noi fac VFA See Ditches of or match pea assumed to b assumed to b dways assum C in Eqn:	43.13 8.28 0.18 15.1 compare dime compare dime compare dime the land	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=))		
Ammonia fraction of TKN, Ina Norotent of VS, NVSS, Con COD biodigradable, Sk. mgL RECOD, Ski, mgL tata Akalimiy, mgL CaCO3 PROCESS PARAMETERS Process; Bioreactor Volume, Vr, ML Studge age, Rs, d Anaerobic mass fraction, Kon Mond frauncido: La Skica, Anota Cacha Anaerobic mass fraction, Isa Mond frauncido: Skica, Anota Cacha Ski Mond Skica, Anota Cacha Man of Prinary Skica, Anota Cacha Ski Mond Skica, Skica, Anota Cacha Ski Mond Skica, Skica, Anota Cacha Ski Mond Skica, Skica, Anota Cacha Skica, Skica,	0.75 0.06 420 84 1.82 1.85 1.85 1.85 0.3 0.3 0.3 0.3 0.3 0.3 0.05 0.05 0.05	Nai Noi fac VFA See Ditches of or match pea assumed to b assumed to b dways assum C in Eqn:	43.13 8.28 0.18 15.1 compare dime compare dime compare dime the land	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=))		
Ammonia fizaction of TKN, Ina Norotent of VSR, Ina Norotent of VSR, NyVSR, Con COD biodisgradable, Sk. mg1. RECOD, Skii, mg1. Total Akalimy, mg1. CaCO3 Total Akalimy, mg1. CaCO3 PROCESS PARAMETERS Process: I Bioreactor Volume, Vr, NL. Studge aga, R., d Anaerotic mass fraction, for Association of the sector of	0.75 0.06 420 2300 2300 2300 2300 2300 2300 2300	Nai Noi VFA See Ditches o o match pea sssumed to b uways assum C in Eqn:	43.13 8.28 0.18 15.1 compare dime compare dime compare dime the land	Note: Effluent Total N includ reactions.xl6 isting design for clarifiers er aludge blanket dation ditch D in Egn: D 0.0220 er influent COD	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=))		
Ammonia fraction of TKN, Ine Norotent of VSR, NovSR, Con COD biodegradable, SB, mgL MCCOD SBs, mgL Total Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL Catols From Akalimity, mgL	0.75 0.06 420 84 230 230 1.65 S 1.65 S 1.65 S 0.1 3.032 0.037 0.037 0.047 0.67 0.047 0.67 0.047 0.67 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.0	Nai Noi VFA See Ditches o o match pea ssumed to b ssumed to b uways assum C in Eqn: Jum not requillent	43.13 8.28 0.18 15.1 compare dime ki MLSS to ex- be in the clarifi ne zero for oxi 0.002 0.002	Note: Effluent Total N includ reactions.xl6 isting design for clarifiers er aludge blanket dation ditch D in Egn: D 0.0220 er influent COD	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=)		
Ammonia fraction of TKN, Ine Norotent USS, NVSS, Con COD biodegradable, Sk. mgL RECOD, Ska, mgL Total Aklainky, mgL RECOD, Ska, mgL Total Aklainky, mgL ROCESS PARAMETERS Bioreascor Vounce, MgL Bioreascor , MgL Bioreascore, MgL	0.75 0.06 420 230 230 1.88 1.88 1.88 1.88 1.88 1.88 1.83 1.0.17 0.07 0.07 0.07 0.07 0.07 0.07 0.	Nai Noi VFA See Ditches o o match pea ssumed to b ssumed to b uways assum C in Eqn: Jum not requillent	43.13 8.28 0.18 15.1 compare dime ki MLSS to ex- be in the clarifi ne zero for oxi 0.002 0.002	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da			
Ammonia fraction of TKN, Ina Nontent of VSX, NVSS, Con COD biodegradable, Sk. mgL BECOD, Ska, mgL Total Aklainty, mgL Total Aklainty, mgL PROCESS PARAMETERS Process: Process: Statum Y, mgL DO In serveycle, OS, mgL Effluent Soluble organic N cone, Nue, mgL Effluent Soluble organic N cone, Nue, mgL Effluent Soluble organic N cone, Nue, mgL Effluent Soluble organic N cone, Nue, mgL Effluent Soluble organic N cone, Nue, mgL CoD dotes to anocic zon	0.75 0.06 420 230 230 1.85 2 1.85 2 3.032 0.85 0.37 0.47 0.47 0.47 0.47 0.47 0.47 0.47 0.4	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-))		
Ammonia fraction of TKN, Ina Norotent UTSS, NVISS, Con COD biodegradable, Sb. mgL RECOD, Ssa, mgL Tetal Akalinty, mgL CaCO3 PROCESS PARAMETERS Process: Bioreactor Volume, Vr, ML Bioreactor Volume, Vr, ML Science Status, Science, S	0.75 0.06 420 230 230 1.85 2 1.85 2 3.032 0.85 0.37 0.47 0.47 0.47 0.47 0.47 0.47 0.47 0.4	Nai Noi VFA See Ditches o o match pea ssumed to b ssumed to b uways assum C in Eqn: Jum not requillent	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da			
Ammonia fraction of TKN, Ina Nontent of VSR, NVSS, Con COD biodegradable, Sb. mgL RECOL, Skai, mgL Total Akalmbr, mgL Total Akalmbr, mgL Total Akalmbr, mgL Bioreactor Volume, Vr, ML Studge age, R. et al. Processi and the study of	0.75 0.06 420 84 230 230 1.65 1.65 1.65 1.65 1.65 1.65 1.65 1.65	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-)		
Ammonia fraction of TKN, Ine Norther Links, Navish, Con COD biodegradable, Sk. mgL McCOD: Ske, MrgL Total Akalenky, mgL PROCESS JPANAMETERS Bioreactor Youme, Yr. ML Sludge age, Rs. d Amaerobic mass fraction, Ital No. of namerobic reactors in series, N Marco Status, Schultz	0.75 0.06 420 84 230 1.65 S 1.85 S 1.85 S 0.1 3.032 0.037 0.037 0.047 0.87 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.045	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=)		
Ammonia fraction of TKN, Ina Nontent of VSR, NVSS, Con COD biodegradable, Sb. mgL RECOLD, Ssa, ImgL Total Akalimity, mgL Total Akalimity, mgL PROCESS PARAMETERS Process: Biorsactor Volume, Vr, ML Stadga age, Ro, Stadion, ImgL Biorsactor Volume, Vr, ML Stadga age, Ro, Stadion, ImgL Stadga age, Ro, Stadion, ImgL No, of paramy & Sec. Anoxic mass fraction, Itim Secondary Anoxic mass fraction, Itim Secondary Anoxic mass fraction, Itim Secondary Anoxic construction, ImgL COD dase to anoxic zone, Doord, mgL Effibert soluble organic N conc, Nue, mgL Efficient soluble organic N conc, Mult, mgL of Influent COD dase to anoxic zone, Docat, mgL of Influent COD dase to anoxic zone, Docat, mgL of Influent CD mass matic age, N, m Aurm Doce, mgL as Al2SOQ431:4120, Da Difficit: Charmed water donty, m Average circulating welcoly, r. m's No. of rotos operating. N More lago cryptic stratus Mare lago LPI, HERE BIOXARSS PARAMETERS <t< th=""><th>0.75 0.06 420 84 230 230 1.85 3.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02</th><th>Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is</th><th>43.13 8.28 0.18 15.1 compare dime co</th><th>Note: Effluent Total N includ</th><th>es residual org</th><th>j. biodegrad</th><th>lable soluble</th><th>TKN in effli</th><th>Lent (from a</th><th></th><th></th><th></th><th></th><th>above at Da-</th><th>))</th><th></th><th></th></t<>	0.75 0.06 420 84 230 230 1.85 3.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-))		
Ammonia fraction of TKK, Ina Noorten U KS, NVSS, Cun COD biodegradable, SB, mgL MCCDD, SBa, MyLS, Cun ECOD, SBa, MyLS, Cun ECOD, SBa, MyLS, Cun ECOD, SB, MyLS, Cun Fig. 2007, SB, SB, SB, SB, SB, SB, SB, SB, SB, SB	0.75 0.06 420 84 230 230 1.65 8 1.85 8 0.1 3.0.32 0.05 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.045 0.045 0.045 0.035	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-			
Ammonia fraction of TKN, Ina Norotech US, Novisk, Con Scotter of USS, Novisk, Con COD biodegradable, Sk. mgL BECOD: Skai, mgL Tetal Alkalmiy, mgL PROCESS FARAMETERS Biotecher Verlager, Skainer, S	0.75 0.06 420 84 230 230 1.68 5.5 0.57 0.57 0.57 0.57 0.57 0.57 0.57	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-))		
Ammonia fraction of TKN, Ina Nontent of VSR, NovSR, Con COD biolognadable, Sk. mgL BECOD, Ska, mgL Total Alkalmiy, mgL Total Alkalmiy, mgL PROCESS Process: Proc	0.75 0.06 420 84 230 230 1.65 1 0.51 0.52 0.53 0.53 0.53 0.53 0.64 0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.0	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=			
Ammonia fraction of TKN, Ine Norotect USA Novise, Con COD biodegradable, Sk. mgL RECOU, Ska, mgL Total Akalanky, mgL CACCG PROCESS PARAMETERS Process Bioreacor Volume Vr, ML Bioreacor Volume Vr, ML Bioreacor Volume Vr, ML Bioreacor Volume Vr, ML Bioreacor Volumes (Tation, Ine No. of nararok): reactors in series, N Primary Anozie mass fraction, IsT Secondary Anoxie mass fraction, IsT Secondary Anoxie mass fraction, IsT Bioreacor Volumes (Tation, IsT Secondary Anoxie mass fraction, r>Secondary Second	0.75 0.06 420 84 230 230 1.68 5.5 0.57 0.57 0.57 0.57 0.57 0.57 0.57	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=			
Ammonia fraction of TKN, Ine Norotent USS, NVSS, Con COD biodegradable, Sb. mgL RECOD, Sse, mgL Total Akalenky, mgL PROCESS PARAMETERS PROCESS PARAMETERS Process: Bioreactor Votume, ML Bioreactor Votume, ML DO as exception, Data March Teach, See, Anold, Tabus, ML DO as exception, Data March Teach, Data ML Bioreactor Votume, ML Bioreactor Votume, ML Coll doce to anonchic zone, Docci, mgL, of Influent COD doce to anonchic zone, Docci, mgL, of Influent COD doce to anonchic zone, Docci, mgL, of Influent COD doce to anonchic zone, Docci, mgL, of Influent COD doce to anonchic zone, Docci, mgL, of Influent ReCOD Total Coll of closed market, Indo Alum Dese, mgL, Ba Al2(SO4)31:41/20, Da Differ. Diffe	0.75 0.06 420 84 1.83 1.83 0.33 0.03 0.03 0.03 0.03 0.04 1.00 0.00 0.00 0.00 0.00 0.00 0.00	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=			
Ammonia fraction of TKN, Ine Norther Links, Norther, J. VS, NUYSS, C.M. COD biolognatable, SB, mgL NOCCO: SB, mgL NUYSS, C.M. SCOLO: SB, Market R, SK, Market R, SK, Market R, SK, SK, SK, SK, SK, SK, SK, SK, SK, SK	0.75 0.06 420 84 230 230 1.67 K 0.91 3.032 0.034 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.045 0.033 0.03 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.034 0.0370	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 15.1 compare dime co	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Dg=))		
Ammonia fraction of TKK, Ina Norder 1748, Ina Nordert of VSK, Ina Nordert of VSK, NVSS, Com COD biodignatable, Sk. mgL RedDot. Skai, mgL R	0.75 0.06 420 84 230 230 1.68 8 0.11 3.032 0.058 0.33 0.058 0.34 0.04 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Nail Noi VFA See Disches o metch peer o metch peer o metch peer sesumed to b ways assumed to b ways assumed to b metch peer sesumed to b ways assumed to b metch peer sesumed to b to ch peer sesumed to b metch peer sesumed to b sesumed	A 3.3 S.28 O.18 S.28 O.18 S.28 O.18 S.2 O.18 S.2 O.18 S.2 O.19 O.19 O.00	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-			
Ammonia fraction of TKK, Ina Norment of VSK, NV/SK, Con COD biodegradable, Sk. mgL RECOUX. Skal, mgL RECOUX. Skal, mgL Teal Alkalimiy, mgL CaCCO3 PROCESS PROCESS PARAMETERS Process: Process: Process: Subgr age, Ri, d. Secondary Anoxic mass fraction, Rim Secondary Anoxic mass fraction, Rim Secondary Anoxic mass fraction, Rim DO in a stropic & G. ang.L DO in a stropic & B. angl X-144414420, Da Damone water depth, y.m Channel width, I.m Ammone and B. all XS/M314420, Da Down and Damone and B. all XS/M314420, Da Down and Damone and B. all XS/M314420, Da Down and Damone and B. all XS/M314420, Da	0.75 0.06 420 84 230 230 1.67 K 0.91 3.032 0.034 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.047 0.045 0.033 0.03 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.033 0.034 0.0370000000000	Nai Noi Fac VFA See Ditches d o match pea issumed to b issumed to b is	43.13 8.28 0.18 0.18 15.1 compare dime compar	Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-			
Ammonia fraction of TKK, Ina No.context USS, NVSS, Con COD biodegradable, Sk. mgL RECOU, Ska, mgL Total Aklainky, mgL RECOU, Ska, mgL Total Aklainky, mgL RECOUSS, Market RESS PROCESS PARAMETERS Process: Biological Context of the State State Biological Context of the State State Context of the State State State State Biological Context of the State State Context of the State State State State Context of the State State State State Context of the State State State State Context of the State State State State Context of the State State State State Context of the State State State State Context of the State State State State State Context of the State State State State State Context of the State State State State State Context of the State State State State State Context of the State State State State State State Context of the State State State State State State State Context of the State State State State State State State Context of the State St	0.75 0.06 420 84 30 30 30 30 30 30 30 30 30 30 30 30 30	Nail Nei Ser Diches S Ser S	As.13 S.28 O.18 S.28 O.18 IS.1 Note: Effluent Total N includ	es residual org	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da=				
Ammonia fraction of TKN, Ine No. content of VSK, Ine No. Content of VSK, Ine No. Content of VSK, NovSK, Con COD biodegradable, Sk. mgL RECOD, Ska, IngL RECOD, IngL RECOD, I	0.75 0.06 420 84 30 30 30 30 30 30 30 30 30 30 30 30 30	Nail Noi Noi Ser Dichos sumed to b assumed to b c in Eqn: C in Eqn	A 3.13 A 3.2 A 3.2 A 3.2 A 3.2 A 3.3	Note: Effluent Total N includ Indiana Jala	es residual or es residual or calc. Depend	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-			
Ammonia fraction of TKK, Ina Ammonia fraction of TKK, Ina CoD biodegradable, Sk. mgL COD biodegradable, Sk. mgL COD biodegradable, Sk. mgL COD Status, mgL Total Akalenky, mgL COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD COD Status, mgL COD Status, mgL COD Cod Status, mgL COD Status, mgL COD Cod Status, mgL COD Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL COD Cod Status, mgL Cod Status, mgL COD Cod Status, mgL Cod Statu	0.75 0.06 420 84 230 165 K 105	Naila Noi Noi VFA See Diches sumed to b o match pea- communication o match pea- communication o match pea- communication summer and summer phb7 2, ence digital to get 1 phb7 2, ence digi	A 3.13 S.28 A 3.23 S.28 A 3.3 S.28 A 3.3 S.28 A 3.3 S.28 A 3.3 A 3.	Note: Effluent Total N includ international and	es residual or es residual or calc. Depend	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at De-			
Ammonia fraction of TKK, Ina Ammonia fraction of TKK, Ina No content of VSK, NPVSS, Con COD biologradable, Sk. mgL RECOD, Ska, Myrus, C. CacCol Teat Alkalminy, mgL RECOD, Ska, Market ERS Process: Pro	0.75 0.06 420 84 230 230 1.85 E 0.57 0.32 0.32 0.32 0.37 0.47 0.47 0.47 0.47 0.47 0.47 0.47 0.4	Nail Noi Noi Ser Diches so o mutch pes assumed to b wheys assumed to fin Eqn. C in Eqn	A 3.13 A 3.2 A 3.2 A 3.2 A 3.2 A 3.3	Note: Effluent Total N includ	es residual or es residual or calc. Depend	j. biodegrad	lable soluble	TKN in effli	Lent (from a					above at Da-			

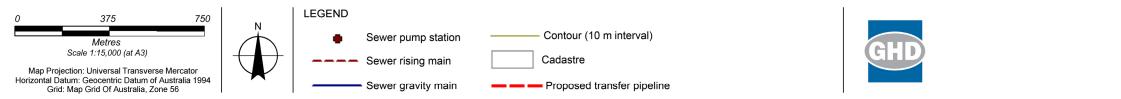
SECTION 2. SOLI	DS INVEN	TORY & P REM	IOVAL																	
Calculate the process solids	s inventory and	biological P removal.																		
ased on Ref. 2 equations (1		20 deg Č																	
*Adjust NO3s, then adjust	st Shsn until N	neT20 calculated in S	ection 5 is																	
*Adjust Shan assumed u	allowing for de intil Shsn calci	lated agrees	ndary claritier.																	
*If fxa is zero the assume	ed values of N	D3s and Sbsn are irre																		
n iterative calculation is als	so required in	Section 3 but this is no	t as sensitive.																	
IO3-N recycled to the anae	robic zone, N	D3s, mg/L	0.000	Assumed	Effluent nitrat	e, T=20:	0.26598288													
RBCOD exiting the anaerob	oic zone, Sbsn	mg/L	11.100	Assumed																-
nfluent RBCOD available, S Heterotroph active mass, M2	S.bsi		84 1045	1070	841															
RBCOD exiting the anaerob	oic zone, Sbsn	mg/L	11.160	Calculated																
				and recalcula	alculated into s te until the two	agree.														
Substrate sequestered by po Substrate available to heter	oly-P organism otrophs, MSbh	is, MSseq, kg/d , kg/d	121.638 676.362																	
Poly-P organisms active ma	ass. MXba. ka		600																	
Poly-P organisms endogeno Heterotroph active mass, M	ous mass, MX	g, kg	117 1045																	
Heterotroph endogenous ma	ass, MXeh, kg		978					compare dime												
nert mass, MXi, kg Fotal VSS, MXv, kg			2804 5543		Vp, ML Average VSS	1.85 2996	mg/L	compare dime	nsions.xis											1
Chemical ppt inert mass, MX Total SS, MXt, kg Peak month COD load facto	Xc, kg		7373	A	verage MLSS	3984	mg/L	3785	ma/l	If Sec. Anoxi	c mass frac	tion is assu	med to be i	the clarifie	r					
Peak month COD load facto	or		1.30	Peak	Month MLSS	5180	mg/L	4921	mg/L	Ditto										
Premoval by poly-P organis Premoval by heterotrophs,	dPh, mg/L		6.24 1.64													<u> </u>				1
P removal by inert mass, dP P removal by alum dPc mo	Pi, mg/L 1/I		2.27	From KJH bo	ok p64															
Total P removal, dP, mg/L Total P content of MLSS, mg	gP/mgMLSS		10.15											_						-
ffluent soluble P, Pse, mg/		ical desine'	0.03		Target Ps:	-	maR/l	qm:		maB/m-Al	Kp:		mgP/L	n (n-l-)		maB/**	for Alum -* .	hiometry from	K he=!: = ^^	64
Effluent soluble P, Pse, mg/l Effluent Total P, Pe, mg/L	L (Delore cher	iicai dusing)	0.01	includes Sse	rarger PS:	0.1	mgP/L	qm:	0.864	mgP/mgAl	Kp:	0.175	mgr/L	q (calc):	0.31	mgr/mgAl	IN AIUM STOIC	anometry from	кып цоок р63	-04
Alkalnity depletion due to alu	um dosed, mg	L CaCO3	0.00	Alkalinity	depletion (mg	CaCO3/ mg dr	y alum dosed)	Ta:	0.411	From KJH bo	ook Eqn 3.1	6, p64					Ditto			
SECTION 3. OXYG	EN DEMA																			
alpha (F): 0.6		Cs (20°C, 1 atm):	9.08 Cs @ Tmin:	9.26												<u> </u>				-
beta: 0.95			Cs @ Tmax:		7.73															
Diffuser mounting height (fro	om floor). m		0.25																	
		Cs_inf (20°C, 1 atm):	10.26	40.10																1
	<u> </u>		Cs_inf @ Tmin: Cs_inf @ Tmax	10.46	8.73			<u> </u>												
Peak factors for Aer	ration (syr	thesis only):																		
Startup load demand factor			0.55	Assumed																+
Peak month demand factor Diurnal max. demand factor			1.3	Accumos 0.2	33 times ampli	udo of poak T	00													
Diurnal min. demand factor			0.70	Assumed	55 times ampli	lube of peak 1														
Effluent NH3-N, Naea, mg/L	I		0.70	Assumed. Ad	j. to match Nar	T20 calc. belo	ow:	0.71												
Effluent NO3-N, Nnea mg/L			0.27	Assumed. Ad	i. to match Nn	eT20 calc. belo	ow:	0.27												
Oxygen Transfer Rate (Re	actor OTR)		20 deg C	Tmin	Tmax															
Oxygen Transfer Rate (Re) At FULL DESIGN LOAD Average carbonaceous oxyg	gen demand, f	IOc, kg/d	590																	
Average nitrogenous oxyger Average denitrification oxyg	n demand. MC	in, ka/c	350 217 722																	
Average total oxygen demar Average DO at each rotor,	nd, MOt, kg/d		722																	
Average OTR/SOTR, surfac	ce aeration		0.479	0.479	0.488															
Average OTR/SOTR, diffuse Peak total oxygen demand,			0.403	0.405	0.501															
Peak DO at each rotor, Cr,	, mg/L		1.84				does NOT inc	clude 1/PFpm b	lecause tui	design popu	lation loadir	ig is airead	/ for the pea	K month						
Peak OTR/SOTR, surface a Peak OTR/SOTR, diffused a	aeration aeration		0.448		0.450											<u> </u>				
Vinimum total oxygen dem	and neak MO	ka/d	389				includes 1/PF	pm for off-pea	k season n	pulation load	linas									
Peak DO at each rotor. Cr.	ma/l		0.74	0.500	0.540						<u>.</u>									1
Min OTR/SOTR, surface aei Min OTR/SOTR, diffused ae	eration		0.521	0.520	0.540 0.547															
AL STARTUP LOAD																				
verage total oxygen demar verage DO at each rotor,	, Cr, mg/L		397						L											
werage OTR/SOTR, surfac werage OTR/SOTR, diffuse			0.76				1													
			0.520	0.519	0.539															
	e aeration ed aeration		0.520	0.519	0.539 0.546															
Peak total oxygen demand, Peak DO at each rotor, Cr,	ed aeration ed aeration peak MOt, kg , mg/L		0.520 0.526 530 1.01	0.519 0.524	0.546															
Peak total oxygen demand, Peak DO at each rotor, Cr, Peak OTR/SOTR, surface a Peak OTR/SOTR, diffused a	ce aeration ed aeration peak MOt, kg , mg/L aeration	d 	0.520 0.526 530	0.519 0.524 0.502																
eeak total oxygen demand, eeak DO at each rotor, Cr, eak OTR/SOTR, surface a eak OTR/SOTR, diffused a l linimum total oxygen dema	ce aeration ed aeration peak MOt, kg , mg/L aeration aeration		0.520 0.526 530 1.01 0.503 0.511 214	0.519 0.524 0.502 0.510	0.546		includes 1/PF	pm for off-pea	k season bi	pulation load	lings									
leak total oxygen demand, eak DO at each rotor, Cr, leak OTR/SOTR, surface a leak OTR/SOTR, diffused a linimum total oxygen dema leak DO at each rotor, Cr,	ce aeration ed aeration peak MOt, kg , mg/L aeration aeration aand, peak MO , mg/L		0.520 0.526 530 1.01 0.503 0.511	0.519 0.524 0.502 0.510	0.546		includes 1/PF	pm for off-pea	k season p	pulation load	ings									
eak total oxygen demand, teak DO at each rotor, Cr, eak OTR/SOTR, surface a teak OTR/SOTR, diffused a linimum total oxygen dem teak DO at each rotor, Cr, in OTR/SOTR, surface aei	ce aeration ed aeration peak MOt, kg, , mg/L aeration aeration and, peak MO , mg/L ;ration		0.520 0.526 530 1.01 0.503 0.511 214 0.41 0.543 0.543	0.519 0.524 0.502 0.510 0.510 0.541 0.544	0.546 0.518 0.528 0.567 0.571						ings									
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OS+BVSTP 1.9 ADWF (new)

SECTION 4. NITRIFICATION																		
							-											
	20 deg C	Tmin	Tmax															
	20 deg C	imin	Tmax			-												
Adjust nitrification parameters for temperature, pH and of	ditch DO profile:																	
Nitrifier growth rate, unT, d-1	0.484	0.431	1.375															
Nitrifier ammonia half-saturation coefficient, KnT, mgN/L	1.292	1.151	3.671															
Calculate effluent NH3-N and soluble TKN:																		
Effluent NH3-N, NaeT, mg/L	0.71	0.75		Calculated														
Effluent residual sol. biodegradable org. N, NoeT, mg/L	0.61	0.62																
Effluent soluble TKN, NteT, mg/L	2.87	2.92	2.63															
							ļ											
SECTION 5. DENITRIFICATION						1										1		1
	İ		1	1			1			1				i		1	i i	1
N incorporated in biomass, Ns, mg/L	14.96		i i	1			1			1				i	1	1	1	
N content of biomass MLSS, mgN/mgMLSS	0.075						1			1								
			Tmax				1			1								
Nitrification capacity, NcT, mg/L	39.67	39.61	39.91			1												
Primary denitrification potential, Dpp, mg/L	45.06	42.84	71.12	Assumes Sbs	N fully used fi	or DN; adopts	fxdm (refer t	o WRC, Eqn	6.24 for Ba	rdenpho sy	stem; here 1	ve have ass	umed Sec.	Anoxic fra	ction is in the c	larifier sludge	blanket)	
					1	1	T	[1				[1	l i	
Effluent NO3-N, NneT, mg/L	0.27	0.27	0.27	Calculated		1	1							1	1			
Effluent Total N, mg/L	3.44	3.49	3.20	includes Sse		1	1			1				i	1			1
							1			1								
	Deduct an allowar						1			1								
	clarifier sludge bla	inket and inser	rt in NO3s ass	umed in Sectio	in 2.													
	Adjust Sbsn and r	epeat until cal	culated NneT	s			1			1								
	compatible with as	ssumed NO3s					1			1								
							1			1								
SECTION 6. OUTPUT SUMMARY						1	1			1				i				1
OLOHON C. COTTOT COMMANY		Tmin	Tmax															
	20 deg C	19																+
	20 deg C	19	29															+
Average MLSS concentration, mg/L	3785																	+
Peak month MLSS concentration, mg/L	4921					I	1	l								1		<u>├</u> ────┤
Average Actual Total Oxygen demand, kg/d	722					+	1					·			l			+
Average SOTR, kg/h (diffused air)	62	62	60			1	-			1					1	1		
Maximum SOTR, kg/h (diffused air)	87	87																
SOTR turndown required	5.6																	+
Alum dose, mg/L as dry alum	3.0						1											
Alkalinity depletion due to alum dosed, mg/L CaCO3							1									1		+
Effluent Ammonia, mgN/L	0.7	0.8	0.6				1											
Effluent Nitrate, mgN/L	0.3	0.3					1			1								+
Effluent Total N, mgN/L	3.4	3.5					1									1		+
Effluent soluble P, mgP/L	0.01	3.5	3.2			1										1		<u> </u>
Effluent Total P. mgP/L	0.01					-										1		<u> </u>
Effluent TSS, mg/L (assumed)	4					1	1			1					1	1		

Appendix H Proposed augmented plant layout





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Level 9, 145 Ann Street Brisbane QLD 4000 Australia

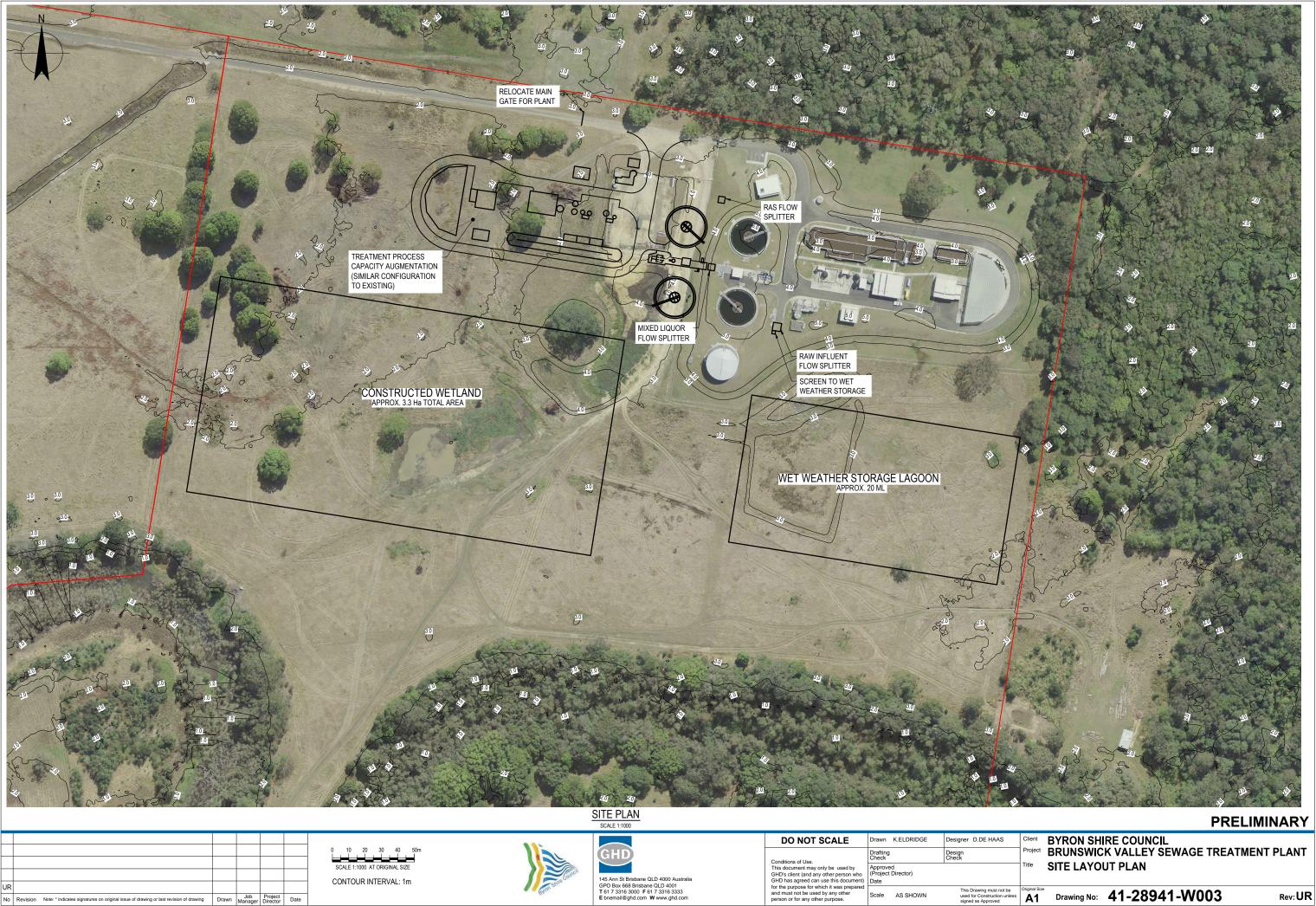
Byron Shire Council Ocean Shores to Brunswick Valley STP Transfer

Job Number | 41-28941 Revision A Date

24 Jun 2015

Transfer Pipeline

41-28941-SK004



145 Ann St Brisbane QLD 4000 Australia GPO Box 668 Brisbane QLD 4001 T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

No	Revision	Note: * indicates signatu	es on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date
Plot	Date: 10 Augu	ist 2015 - 11:53 AM	Plotted by: Kirsty Eldridge	Ca	d File No:	G:\41\28941	\CADD\Dra

LUR

Cad File No: G:\41\28941\CADD\Drawings\41-28941-W003.dwg

CONTOUR INTERVAL: 1m

be nless	Original Size	Drawing No:	41-28941-W003	Rev: UR
	Title	SITE LAYO	UT PLAN	
	Project		K VALLEY SEWAGE TREATM	ENT PLANT
	Client	BYRON SH		

This Drawing must not used for Construction signed as Approved

Scale AS SHOWN

Appendix I Capital cost estimates breakdown for BVSTP augmentation

Ocean Shores STP - Transfer to Brunswick Valley STP

Capital Cost Estimate

Concept Design Option

Construction Year 2016-17

Common to all options

Extend raw sewage rising main for SPS 5009 and SPS 5004 to BV STP

		ITEM	Qty	Unit	Size	Rate	Civil	M&E		Total	
1.0	Pipeline									\$	1,555,000
1.1		Pipe supply DN375 DICL PN20	3250	m	DN375	\$ 200	\$ 650,000	\$ -	\$ 650,000		
		Pipe install incl excavate, lay, backfill and test DN375 DICL									
		(trench 1 - 2 m deep, rural, high water table, acid sulfate									
1.2		soils)	3250	m	DN375	\$ 220	\$ 715,000	\$ -	\$ 715,000		
1.3		Allowance for air valves	1	Item	Allowance	\$ 100,000	\$ 100,000	\$ -	\$ 100,000		
1.4		Allowance for scour valves	1	Item	Allowance	\$ 50,000	\$ 50,000	\$ -	\$ 50,000		
1.5		Connection to existing rising mains	2	no.	Allowance	\$ 15,000	\$ 30,000	\$ -	\$ 30,000		
1.6		Isolation valves	2	no.	DN250 gate valves	\$ 5,000	\$ 10,000	\$ -	\$ 10,000		
1.7											
		Direct Job Costs (Sub-Total 1)					\$ 1,555,000	\$ -		\$	1,555,000
	Indirect Job	o Costs (Engineering, Site Costs, Project Administration etc.)	20%	of DJC)		\$ 311,000	\$ -		\$	311,000
		Risk and Contingency		of DJC	C + IJC		\$ 467,000	\$ -		\$	467,000
		Head Contractor Margin	5%	of DJC	;		\$ 78,000	\$ -		\$	78,000
		PROJECT SUB-TOTAL (Sub-Total 2)					\$ 2,411,000	\$ -		\$	2,411,000
		TOTAL PROJECT BUDGET					\$ 2,411,000	\$ -			\$2,411,000

Ocean Shores STP - Transfer to Brunswick Valley STP

Capital Cost Estimate

Concept Design Option

Construction Year 2016-17

Common to all options

Upgrade SPS 5004

	ITEM	Qty	Unit	Size	Rate		Civil		M&E		Total	
2.0	SPS 5004 upgrade										\$	475,000
2.1	Construct reinforced concrete pump well (Caisson type)	1	Item	3 m dia, 5 m deep	\$ 200,000	\$	200,000	\$	-	\$ 200,000		
2.2	Construct RC valve pit	1	Item	2.5 m x 3 m	\$ 75,000	\$	75,000	\$	-	\$ 75,000		
2.3	Supply & Install 2 No 30kw pumps, discharge pipework & ancilliaries; including guide rails, lifting chains, wet well washer and backflow prevention, discharge pipework (incl Valve Pit), instrumentation etc.	1	Item	30kW pumps duty/standby	\$ 100,000	\$		\$	100,000	\$ 100,000		
2.4	Supply & Install 2 No 30kw pump switchboard, cabling & associated works; inclusive of all field wiring, consumer mains, control software installation & wiring, installation & commissioning of telemetry	1	Item	30kW pumps duty/standby	\$ 100,000	\$	-	\$	100,000	\$ 100,000		
2.5						\$	-	\$	-	\$ -		
	Direct Job Costs (Sub-Total 1) Indirect Job Costs (Engineering, Site Costs, Project Administration etc.) Risk and Contingency Head Contractor Margin	20% 25%	of DJC of DJC of DJC	+ IJC		\$ \$ \$ \$	275,000 55,000 83,000 14,000	\$ \$ \$	200,000 40,000 50,000 10,000		\$ \$ \$ \$	475,000 95,000 143,000 24,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$	427,000	\$	300,000		\$	737,000
	TOTAL PROJECT BUDGET					\$	427,000	\$	300,000			\$737,000

Capital Cost Estimate

Concept Design Option

Option 1: OD

Construction Year 2016-17

NO DEFERMENT OF CAPITAL ITEMS

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) augmentation

25,000 EP (Nominal) Capacity Augmentation

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
1.0	Wet Weather Storage												\$	2,526,000
1.1	1 no. 20 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$	2,110,000	\$	2,110,000	\$	-	\$	2,110,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$	375	\$	141,000	\$	-	\$	141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$	150,000	\$	150,000	\$	-	\$	150,000		
	Other minor civils, including overflow structure, culverts,													
1.3	headwalls etc.	1	No.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	2040	m2	Estimate	\$	22	\$	44,880	\$	-	\$	44,880		
2.0	Inlet Works												¢	1,185,000
2.0	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$	270,000	\$	220,000	\$	50,000	\$	270,000	φ	1,105,000
2.1			110.	Allowance	Ψ	210,000	Ψ	220,000	Ψ	30,000	Ψ	210,000		
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	\$	142,000	\$	-	\$	142,000	\$	142,000		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$	349,000	\$	349,000		-	\$	349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$	72,000	\$	72,000	\$	-	\$	72,000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$	298,000		-	\$	298,000	\$	298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$	54,000	\$	36,000	\$	18,000	\$	54,000		
3.0	Bioreactors												\$	2,463,000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$	215,000	\$	175,000	\$	40,000	\$	215,000		
	New Oxidation Ditch bioreactors (includes Anaerobic & Ox.									· · · · ·				
	Ditch reactors) - CIVILS			185 kL Anaerobic; 1665	•		•	4 000 000	•		•			
3.2		1	no.	kL Ox. Ditch (estimate)	\$	1,298,000	\$	1,298,000	\$	-	\$	1,298,000		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox.	4	-	Estimate	\$	47.000	¢		¢					
3.3	Ditch reactors) - METALWORK New RAS screen and conveyor/ press	- 1	no.	Estimate	Э	47,000	Э	-	\$	-				
3.4	New RAS screen and conveyor/ press	1	no.	Allowance, Max. 300 L/s	\$	161,000	\$	-	\$	161,000	\$	161,000		
-	Aeration equipment, Mixers, RAS & WAS pumps -			,		- ,						- ,		
3.5	MECHANICAL	1	no.	Estimate	\$	515,000	\$	-	\$	515,000	\$	515,000		
3.6	Aeration testing	1	no.	Allowance	\$	42,000		-	\$	42,000	\$	42,000		
	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL			Allowance, 3.6 m long to										
3.7		1	no.	span channel width	\$	132,000	\$	132,000	\$	-	\$	132,000		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	1	no.	Allowance	\$	100,000	\$	100,000	\$	-	\$	100,000		

		ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
4.0	Clarifiers													\$	2,246,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$	215,000	\$	215,000	\$	-	\$	215,000		
		Secondary Clarifiers - CIVILS (incl. METALWORK)			23 m dia, 1.45 ML each	<u>^</u>		â	1 5 40 000	•		•			
4.2		Secondary Clarifier & RAS P/Stn- MECHANICAL	2	no.	(Estimate)	\$	770,000		1,540,000	\$	-		1,540,000		
4.3		-	1	no.	Estimate	\$	427,000	\$	-	\$	427,000	\$	427,000		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	1	no.	Max. 150 L/s (Estimate)	\$	64,000	\$	64,000	\$	_	\$	64,000		
						Ŧ	,	Ŧ		•		Ŧ	- ,		
5.0	UV Disinfe	ection												\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$	198,000	\$	198,000	\$	-	\$	198,000		
					314 L/s (Estimate); dose	•		•		•	100.000	•			
5.2		UV disinfection equipment	1	no.	30 mJ/cm^2	\$	490,000	\$	-	\$	490,000	\$	490,000		
5.3		UV control/ switchroom building	1	no.	Estimate (Colourbond building, airconditioned)	\$	57,000	\$	57,000	\$	_	\$	57,000		
0.0					bananig, anoonaniorioa)	Ť	01,000	÷	01,000	÷		Ť	01,000		
6.0	Chemical	Storage & Dosing												\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$	12,000	\$	12,000	\$	-	\$	12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$	134,000	\$	134,000	\$	-	\$	134,000		
6.3		Building structure	1	no.	Allowance	\$	108,000		108,000	\$	-	\$	108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$	57,000	\$	57,000	\$	-	\$	57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$	79,000	\$	79,000	\$	-	\$	79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$	35,000	\$	15,000	\$	90,000	\$	105,000		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)												\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$	20		210,000		-	\$	210,000		
6.2		Main distributor pipe	300	m	DN 750	\$	800	\$	240,000		-	\$	240,000		
6.3		Valves	3	no.	DN 750	\$	10,000	\$	30,000	\$	-	\$	30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$	420	\$	63,000	\$		\$	63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$	20	\$	48,000	\$	-	\$	48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$	60,000	\$	60,000	\$	-	\$	60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$	110,000	\$	110,000	\$	-	\$	110,000		

	ITEM	Qty	Unit	Size		Rate	Civil		M&E			Total	
7.0	Aerobic Digester											\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$ 264,000	\$	-	\$	264,000	Ť	
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000		\$	169,000	\$	169,000		
8.0	Sludge Dewatering & Biosolids Storage											\$	1,687,000
	New Gravity Drainage Deck, Belt Filter Press & Feed												
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	1	no.	200 kg/h feed (Estimate)		550,000	*	\$	550,000	\$	550,000		
8.2	Sludge dewatering equipment - METALWORK	1	no.	Estimate	\$	24,000	\$ 24,000	\$	-	\$	24,000		
8.3	Sludge dewatering building - CIVILS	1	no.	Estimate	\$	288,000	\$ 288,000	\$	-	\$	288,000		
8.4	Polymer Make-up and Dosing System	1	no.	Estimate	\$	50,000		\$	50,000	\$	50,000		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$ 775,000	\$	-	\$	775,000		
9.0	Switch Room & Blower Room											\$	411.000
9.0 9.1	Switch Room & Blower Room Switchroom building	1	no.	Estimate	\$	96,000	\$ 96,000	\$		\$	96,000	Þ	411,000
9.1	Blower room building	1	no.	Estimate	φ \$	315,000				φ \$	315,000		
0.2		· ·	110.	LStinate	Ψ	515,000	φ 515,000	Ψ		Ψ	515,000		
10.0	Pump Stations (where not included above)											\$	210,000
10.0	Scum Pump Station	1	No.	incl.	\$	_	\$-	\$	_	\$	_	Ψ	210,000
10.1	Service Water System	1	No.	~5 L/s	φ \$	92.000	\$ 30,000	\$	62,000	φ \$	92.000		
10.2	General Purpose (Filtrate/ Site Utility) pump station	1	No.	~5 L/s	φ \$	46,000		,	30,000	\$	46,000		
10.3	Wet Weather Storage Return pump station	1	no.	~42 L/s ~33 L/s max.	ֆ \$				30,000	ֆ \$	46,000		
10.4	P/Stns Miscellaneous - METALWORK	1	No.		φ \$	26,000	\$ 26,000			φ \$	26,000		
10.5			INO.	Allowance	φ	20,000	\$ 20,000	φ	-	φ	20,000		
11.0	Plant Pipework & Valves											\$	1,860,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$ 248,000	\$	_	\$	248,000		, ,
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65,000	\$ 65,000	\$	_	\$	65,000		
11.3	Bioreactor to Clarifiers	1	No.	Allowance	\$	140,000			-	\$	140,000		
11.4	Clarifiers to UV Treatment	1	No.	Allowance	\$	46,000			-	\$	46,000		
11.5	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$ 540,000		_	\$	540,000		
11.6	RAS Pipework	1	No.	Allowance	\$	214,000			-	\$	214,000		
11.7	WAS Pipework	1	No.	Allowance	\$	46,000			_	\$	46,000		
11.8	Chemical Dosing Pipework	1	No.	Allowance	\$	34,000	\$ 34,000	\$	-	\$	34,000		
11.9	Service Water Pipework	1	No.	Allowance	\$	78,000	\$ 78,000		-	\$	78,000		
11.10	Odour Pipework	1	No.	Allowance	\$	36,000	\$ 36,000			\$	36,000		
11.10	Scum Pipework	1	No.	Allowance	φ \$	75,000	\$ 75,000	,		φ \$	75,000		
11.12	Effluent Transfer Pipework	1	No.		φ \$	150,000	\$ 150,000			φ \$	150,000		
11.12		1	NO.	Allowance	ֆ \$	130,000			-	ծ \$	130,000		
	Sludge Dewatering Pipework	· ·	-	Allowance					-				
11.14	Drainage Pipework	1	No.	Allowance	\$	27,000	\$ 27,000	· · ·	-	\$	27,000		
11.15	Roadworks Drainage Pipework	1	No.	Allowance	\$	31,000	\$ 31,000	\$	-	\$	31,000		

	ITEM	Qty	Unit	Size	Rate	Civil	M&E		Total	
12.0	Roads, Fencing & Landscaping								\$	442,000
12.1	Earthworks	1	No.	Allowance	\$ 150,000	\$ 150,000	\$ -	\$ 150,000		
12.2	Paving	1	No.	Allowance	\$ 66,000	\$ 66,000	\$ -	\$ 66,000		·
12.3	Other roadworks, incl. temporary gravel roads	1	No.	Allowance	\$ 35,000	\$ 35,000	\$ -	\$ 35,000		
12.4	Stormwater drains	1	No.	Allowance	\$ 92,000	\$ 92,000	\$ -	\$ 92,000		
12.5	Fencing	1	No.	Allowance	\$ 17,000	\$ 17,000	\$ -	\$ 17,000		
12.6	Landscaping	1	No.	Allowance	\$ 82,000	\$ 82,000	\$ -	\$ 82,000		
13.0	General Site Works								\$	1.640.000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	1	No.	Allowance	\$ 1,280,000	\$ 1,280,000	\$ -	\$ 1,280,000	<u> </u>	
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$ 330,000	\$ 165,000	\$ 165,000	\$ 330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$ 30,000	\$ -	\$ 30,000	\$ 30,000		
14.0	Electrical. Instrumentation & Control								\$	2.699.000
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$ 207,000		\$ 207,000	\$ 207,000	•	
14.2	Motor Control Centres, supply & install	1	No.	Allowance	\$ 409,000		\$ 409.000	\$ 409,000		
14.3	Distribution Boards and Local Control Stations & VSD's	1	No.	Allowance	\$ 198.000		\$ 198,000	\$ 198,000		
14.4	Miscellaneous Control Panels - install	1	No.	Allowance	\$ 16,000		\$ 16,000	16,000		
14.5	Conduits and Pits, supply and install	1	No.	Allowance	\$ 181,000		\$ 181,000	\$ 181,000		
14.6	Supply, install and terminate Cabling	1	No.	Allowance	\$ 232,000		\$ 232,000	\$ 232,000		
14.7	Other Cabling (Lighting & Earthing)	1	No.	Allowance	\$ 112,000		\$ 112,000	\$ 112,000		
14.8	Instrumentation and Control Cabling	1	No.	Allowance	\$ 87,000		\$ 87,000	\$ 87,000		
14.9	Instrumentation	1	No.	Allowance	\$ 307,000		\$ 307,000	\$ 307,000		
14.10	PLC and interface with existing SCADA system	1	No.	Allowance	\$ 171,000		\$ 171,000	\$ 171,000		
14.11	Software and programming	1	No.	Allowance	\$ 129,000		\$ 129,000	\$ 129,000		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$ 36,000		\$ 36,000	\$ 36,000		
14.13	SCADA system	1	No.	Allowance	\$ 254,000		\$ 254,000	\$ 254,000		
14.14	Standby Generator	1	No.	Allowance	\$ 360,000		\$ 360,000	\$ 360,000		
	Direct Job Costs (Sub-Total 1)					\$ 13,825,000	\$ 6,058,000		\$	19,883,000
Indire	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%	of DJC			\$ 2,765,000	1,211,600		\$	3,977,000
	Risk and Contingency		of DJC			\$ 4,147,500	1,817,400		\$	5,965,000
	Head Contractor Margin	5%	of DJC			\$ 691,250	302,900		\$	995,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$ 21,429,000	\$ 9,390,000		\$	30,820,000
										<u> </u>
	TOTAL PROJECT BUDGET					\$ 21,429,000	\$ 9,390,000		9	\$30,820,00

Capital Cost Estimate

Concept Design Option

Option 2: OD

Construction Year

2016-17

DEFERMENT OF ONE NEW CLARIFIER

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester; One New Clarifier only

19,000 EP (Nominal) Capacity Augmentation

4.30 ML/d Design ADWF

4.0		Qty	Unit	Size	Rate	Civil	M&E			Total	
1.0	Wet Weather Storage									\$	2,526,000
1.1	1 no. 20 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$ 2,110,000	\$ 2,110,000	\$ -	\$ 3	2,110,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$ 375	\$ 141,000	\$ -	\$	141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$ 150,000	\$ 150,000	\$ -	\$	150,000		
1.3	Other minor civils, including overflow structure, culverts, headwalls etc.	1	No.	Allowance	\$ 80,000	80,000	_	\$	80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	2040	m2	Estimate	\$ 22	\$ 44,880	\$ -	\$	44,880		
2.0	Inlet Works									\$	1,185,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$ 270,000	\$ 220,000	\$ 50,000	\$	270,000		
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	142,000		\$ 142,000	\$	142,000		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$ 349,000	349,000	\$ -	\$	349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$ 72,000	72,000	\$ -	\$	72,000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$ 298,000	-	\$ 298,000	\$	298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$ 54,000	\$ 36,000	\$ 18,000	\$	54,000		
3.0	Bioreactors									\$	2,463,000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$ 215,000	\$ 175,000	\$ 40,000	\$	215,000		, ,
3.2	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - CIVILS	1	no.	185 kL Anaerobic; 1665	\$ 1,298,000	1,298,000	-	\$	1,298,000		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - METALWORK	1	no.	Estimate	\$ 47,000	\$ -	\$ _				
3.4	New RAS screen and conveyor/ press	1	no.	Allowance, Max. 300 L/s	\$ 161,000	\$ -	\$ 161,000	\$	161,000		
3.5	Aeration equipment, Mixers, RAS & WAS pumps - MECHANICAL	1	no.	Estimate	\$ 515,000	-	\$ 515,000	\$	515,000		
3.6	Aeration testing	1	no.	Allowance	\$ 42,000	\$ -	\$ 42,000	\$	42,000		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	1	no.	Allowance, 3.6 m long to span channel width	\$ 132,000	132,000	-	\$	132,000		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	1	no.	Allowance	\$ 100,000	\$ 100,000	\$ -	\$	100,000		

		ITEM	Qty	Unit	Size	Rate	Civil	M&E		Total	
4.0	Clarifiers									\$	1,231,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$ 215,000	\$ 215,000	\$ -	\$ 215,000		
4.2		Secondary Clarifiers - CIVILS (incl. METALWORK)	1	no.	23 m dia, 1.45 ML each (Estimate)	\$ 770,000	\$ 770,000	\$ -	\$ 770,000		
4.3		Secondary Clarifier & RAS P/Stn- MECHANICAL	1	no.	Estimate	\$ 427,000	\$ -	\$ 214,000	\$ 214,000		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	0.5	no.	Max. 150 L/s (Estimate)	\$ 64,000	\$ 32,000	\$ -	\$ 32,000		
5.0	UV Disinfe	ection								\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$ 198,000	\$ 198,000	\$ -	\$ 198,000		
5.2		UV disinfection equipment	1	no.	314 L/s (Estimate); dose 30 mJ/cm^2	\$ 490,000	\$ -	\$ 490,000	\$ 490,000		
5.3		UV control/ switchroom building	1	no.	Estimate (Colourbond building, airconditioned)	\$ 57,000	\$ 57,000	\$ -	\$ 57,000		
6.0	Chemical	Storage & Dosing								\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$ 12,000	\$ 12,000	\$ -	\$ 12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$ 134,000	\$ 134,000	\$ -	\$ 134,000		
6.3		Building structure	1	no.	Allowance	\$ 108,000	\$ 108,000	\$ -	\$ 108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$ 57,000	\$ 57,000	\$ -	\$ 57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$ 80,000	\$ 80,000	\$ -	\$ 80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$ 79,000	79,000	-	\$ 79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$ 35,000	\$ 15,000	\$ 90,000	\$ 105,000		
6.0		onstructed Wetland (total area ~3 ha)								\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$ 20	\$ 210,000	\$ -	\$ 210,000		
6.2		Main distributor pipe	300	m	DN 750	\$ 800	\$ 240,000	\$ -	\$ 240,000		
6.3		Valves	3	no.	DN 750	\$ 10,000	\$ 30,000	\$ -	\$ 30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$ 420	\$ 63,000	\$ _	\$ 63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$ 20	\$ 48,000	\$ -	\$ 48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$ 60,000	\$ 60,000	\$ -	\$ 60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$ 110,000	\$ 110,000	\$ -	\$ 110,000		

	ITEM	Qty	Unit	Size		Rate	Civil		M&E			Total	
7.0	Aerobic Digester											\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$ 264,000	\$	-	\$	264,000		,
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000		\$	169,000	\$	169,000		
8.0	Sludge Dewatering & Biosolids Storage											\$	1,687,000
	New Gravity Drainage Deck, Belt Filter Press & Feed												
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	1	no.	200 kg/h feed (Estimate)	\$	550,000	*	\$	550,000	\$	550,000		
8.2	Sludge dewatering equipment - METALWORK	1	no.	Estimate	\$	24,000	\$ 24,000	\$	-	\$	24,000		
8.3	Sludge dewatering building - CIVILS	1	no.	Estimate	\$	288,000	\$ 288,000	\$	-	\$	288,000		
8.4	Polymer Make-up and Dosing System	1	no.	Estimate	\$	50,000	\$-	\$	50,000	\$	50,000		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$ 775,000	\$	-	\$	775,000		
												•	
9.0	Switch Room & Blower Room				•	00.000	<u> </u>	^		•	00.000	\$	411,000
9.1 9.2	Switchroom building Blower room building	1	no.	Estimate	\$ \$	96,000 315,000			-	\$ \$	96,000 315,000		
9.2			no.	Estimate	Þ	315,000	\$ 315,000	Ф	-	Э	315,000		
10.0	Pump Stations (where not included above)											\$	210,000
10.0	Scum Pump Station	1	No.	incl.	\$		\$-	\$		\$	_	Ψ	210,000
10.1	Service Water System	1	No.		э \$	92.000		э \$	62,000	э \$	92.000		
-	General Purpose (Filtrate/ Site Utility) pump station	1	-	~5 L/s		- 1				,			
10.3 10.4	Wet Weather Storage Return pump station	1	No. no.	~42 L/s ~33 L/s max.	\$ \$	46,000 46,000			30,000 30,000	\$ \$	46,000 46,000		
	P/Stns Miscellaneous - METALWORK		-		· ·								
10.5		1	No.	Allowance	\$	26,000	\$ 26,000	\$	-	\$	26,000		
11.0	Plant Pipework & Valves				-							\$	1,671,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$ 248,000	\$	-	\$	248,000	+	.,,
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65,000	\$ 65,000	\$		\$	65,000		
11.3	Bioreactor to Clarifiers	0.75	No.	Allowance	\$	140,000		-	-	\$	105,000		
11.4	Clarifiers to UV Treatment	0.5	No.	Allowance	\$	46,000	\$ 23,000	\$		\$	23,000		
11.4	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$ 540,000	↓ \$		\$	540,000		
11.6	RAS Pipework	0.5	No.	Allowance	φ \$	214,000		\$ \$		φ \$	107,000		
11.0	WAS Pipework	1	No.		φ \$	46,000		Ψ \$		φ \$	46,000		
11.7	Chemical Dosing Pipework	1	NO.	Allowance	ֆ \$	34,000	\$ 46,000	Դ Տ	-	ֆ \$	34,000		
11.8	Service Water Pipework	1	-	Allowance	ֆ \$	78,000	\$ <u>34,000</u> \$ 78,000			ֆ \$	78,000		
			No.	Allowance	· ·				-				
11.10	Odour Pipework	1	No.	Allowance	\$	36,000	\$ 36,000	\$	-	\$	36,000		
11.11	Scum Pipework	0.752	No.	Allowance	\$	75,000	\$ 56,400	\$	-	\$	56,400		
11.12	Effluent Transfer Pipework	1	No.	Allowance	\$	150,000	\$ 150,000	\$	-	\$	150,000		
11.13	Sludge Dewatering Pipework	1	No.	Allowance	\$	130,000			-	\$	130,000		
11.14	Drainage Pipework	0.8	No.	Allowance	\$	27,000	\$ 21,600		-	\$	21,600		
11.15	Roadworks Drainage Pipework	1	No.	Allowance	\$	31,000	\$ 31,000	\$	-	\$	31,000		

	ITEM	Qty	Unit	Size	Rate	Civil		M&E			Total	
12.0	Roads, Fencing & Landscaping										\$	420,000
12.1	Earthworks	0.95	No.	Allowance	\$ 150,000	\$ 142,500	\$	-	\$	142,500		
12.2	Paving	0.95	No.	Allowance	\$ 66,000	\$ 62,700	\$	-	\$	62,700		
12.3	Other roadworks, incl. temporary gravel roads	0.95	No.	Allowance	\$ 35,000	\$ 33,250	\$	-	\$	33,250		
12.4	Stormwater drains	0.95	No.	Allowance	\$ 92,000	\$ 87,400	\$	-	\$	87,400		
12.5	Fencing	0.95	No.	Allowance	\$ 17,000	\$ 16,150		-	\$	16,150		
12.6	Landscaping	0.95	No.	Allowance	\$ 82,000	\$ 77.900	\$	-	\$	77.900		
-			-		- ,	, ,	· ·			,		
13.0	General Site Works										\$	1,384,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	0.8	No.	Allowance	\$ 1,280,000	\$ 1,024,000	\$	-	\$	1,024,000		
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$ 330,000	\$ 165,000	\$	165,000	\$	330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$ 30,000	\$-	\$	30,000	\$	30,000		
14.0	Electrical, Instrumentation & Control										\$	2,644,000
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$ 207,000		\$	207,000	\$	207,000		
14.2	Motor Control Centres, supply & install	0.95	No.	Allowance	\$ 409,000		\$	389,000	\$	389,000		
14.3	Distribution Boards and Local Control Stations & VSD's	0.95	No.	Allowance	\$ 198,000		\$	188,000		188,000		
14.4	Miscellaneous Control Panels - install	1	No.	Allowance	\$ 16,000		\$	16,000		16,000		
14.5	Conduits and Pits, supply and install	0.95	No.	Allowance	\$ 181,000		\$	172,000	\$	172,000		
14.6	Supply, install and terminate Cabling	0.95	No.	Allowance	\$ 232,000		\$	220,000	\$	220,000		
14.7	Other Cabling (Lighting & Earthing)	1	No.	Allowance	\$ 112,000		\$	112,000	\$	112,000		
14.8	Instrumentation and Control Cabling	0.95	No.	Allowance	\$ 87,000		\$	83,000		83,000		
14.9	Instrumentation	1	No.	Allowance	\$ 307,000		\$	307,000	\$	307,000		
14.10	PLC and interface with existing SCADA system	1	No.	Allowance	\$ 171,000		\$	171,000	\$	171,000		
14.11	Software and programming	1	No.	Allowance	\$ 129,000		\$	129,000		129,000		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$ 36,000		\$	36,000	\$	36,000		
14.13	SCADA system	1	No.	Allowance	\$ 254,000		\$	254,000		254,000		
14.14	Standby Generator	1	No.	Allowance	\$ 360,000		\$	360,000	\$	360,000		
	Direct Jak Oceta (Oct. Total 4)					¢ 40.550.000	<i>•</i>	E 700 000	_		¢	40.240.000
India	Direct Job Costs (Sub-Total 1)	20%	of DJC			\$ 12,556,000 \$ 2,511,200		5,790,000	1		\$ \$	18,346,000 3,670,000
maire	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.) Risk and Contingency	20% 25%	of DJC			\$ 2,511,200 \$ 3,766,800		1,158,000 1,737,000			ծ Տ	3,670,000 5,504,000
	Head Contractor Margin	25% 5%	of DJC			\$ 3,766,800 \$ 627,800		289,500			ծ Տ	5,504,000 918,000
	nead Contractor Margin	570	0 000			φ 027,000	φ	209,000			φ	910,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$ 19,462,000	\$	8,975,000			\$	28,438,000
						÷ 10,402,000	¥	0,010,000			Ψ	23,400,000
	TOTAL PROJECT BUDGET					\$ 19,462,000	\$	8,975,000				\$28,438,000
	ICTAL FROJECT BUDGET					ψ 15,402,000	φ	0,979,000				×0,400,00

Capital Cost Estimate

Concept Design Option

Option 3 OD

Construction Year

2016-17

DECREASE WET WEATHER STORAGE VOLUME

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester; Smaller Wet Weather Storage

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) augmentation

25,000 EP (Nominal) Capacity Augmentation

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
1.0	Wet Weather Storage												\$	1,783,000
1.1	1 no. 10 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$	1,380,000	\$	1,380,000	\$	-	\$	1,380,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$	375	\$	141,000	\$	-	\$	141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$	150,000	\$	150,000	\$	-	\$	150,000		
	Other minor civils, including overflow structure, culverts,													
1.3	headwalls etc.	1	No.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	1440	m2	Estimate	\$	22	\$	31,680	\$	-	\$	31,680		
2.0	Inlet Works												\$	1,185,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$	270,000	\$	220,000	\$	50,000	\$	270,000		
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	\$	142,000	\$	_	\$	142,000	\$	142,000		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$	349,000		349,000	\$	-	\$	349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$	72,000		72,000		_	\$	72,000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$	298,000		-	\$	298,000	\$	298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$	54,000	\$	36,000	\$	18,000	\$	54,000		
3.0	Bioreactors												\$	2,463,000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$	215,000	\$	175,000	\$	40,000	\$	215,000		
	New Oxidation Ditch bioreactors (includes Anaerobic & Ox.													
3.2	Ditch reactors) - CIVILS	1	no.	185 kL Anaerobic; 1665 kL Ox. Ditch (estimate)	¢	1,298,000	¢	1,298,000	\$		¢	1,298,000		
3.2	New Oxidation Ditch bioreactors (includes Anaerobic & Ox.	I	110.	KL OX. DIGH (estimate)	φ	1,290,000	φ	1,290,000	φ	-	φ	1,290,000		
3.3	Ditch reactors) - METALWORK	1	no.	Estimate	\$	47,000	\$	-	\$	_				
0.0	New RAS screen and conveyor/ press	•	110.	Loundo	Ψ	11,000	Ψ		Ŷ		-			
3.4		1	no.	Allowance, Max. 300 L/s	\$	161,000	\$	-	\$	161,000	\$	161,000		
	Aeration equipment, Mixers, RAS & WAS pumps -													
3.5	MECHANICAL	1	no.	Estimate	\$	515,000		-	\$	515,000	\$	515,000		
3.6	Aeration testing	1	no.	Allowance	\$	42,000	\$	-	\$	42,000	\$	42,000		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	1	n 0	Allowance, 3.6 m long to	\$	132,000	¢	132.000	\$		¢	132.000		
3.7	Pipework modifications to outlet of Existing Ox. Ditch	1	no. no.	span channel width Allowance	ծ Տ	132,000		132,000		-	\$ \$	132,000		
5.0		I	110.	Allowance	φ	100,000	φ	100,000	φ		φ	100,000		
L					L									

		ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
4.0	Clarifiers													\$	2,246,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$	215,000	\$	215,000	\$	-	\$	215,000		
		Secondary Clarifiers - CIVILS (incl. METALWORK)			23 m dia, 1.45 ML each	<u>^</u>		â	1 5 4 9 9 9 9	•		•			
4.2		Secondary Clarifier & RAS P/Stn- MECHANICAL	2	no.	(Estimate)	\$	770,000		1,540,000	\$	-		1,540,000		
4.3		-	1	no.	Estimate	\$	427,000	\$	-	\$	427,000	\$	427,000		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	1	no.	Max. 150 L/s (Estimate)	\$	64,000	\$	64,000	\$	_	\$	64,000		
						Ť	,	Ŧ		•		Ŧ	- ,		
5.0	UV Disinfe	ection												\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$	198,000	\$	198,000	\$	-	\$	198,000		
					314 L/s (Estimate); dose	•		•		•	100.000	•			
5.2		UV disinfection equipment	1	no.	30 mJ/cm^2	\$	490,000	\$	-	\$	490,000	\$	490,000		
5.3		UV control/ switchroom building	1	no.	Estimate (Colourbond building, airconditioned)	\$	57,000	\$	57,000	\$	_	\$	57,000		
0.0					bananig, anoonaniorioa)	Ť	01,000	÷	01,000	÷		Ť	01,000		
6.0	Chemical	Storage & Dosing												\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$	12,000	\$	12,000	\$	-	\$	12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$	134,000	\$	134,000	\$	-	\$	134,000		
6.3		Building structure	1	no.	Allowance	\$	108,000		108,000	\$	-	\$	108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$	57,000	\$	57,000	\$	-	\$	57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$	79,000	\$	79,000	\$	-	\$	79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$	35,000	\$	15,000	\$	90,000	\$	105,000		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)												\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$	20		210,000		-	\$	210,000		
6.2		Main distributor pipe	300	m	DN 750	\$	800	\$	240,000		-	\$	240,000		
6.3		Valves	3	no.	DN 750	\$	10,000	\$	30,000	\$	-	\$	30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$	420	\$	63,000	\$		\$	63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$	20	\$	48,000	\$	-	\$	48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$	60,000	\$	60,000	\$	-	\$	60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$	110,000	\$	110,000	\$	-	\$	110,000		

	ITEM	Qty	Unit	Size		Rate	Civil		M&E			Total	
7.0	Aerobic Digester											\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$ 264,000	\$	-	\$	264,000	Ť	
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000		\$	169,000	\$	169,000		
8.0	Sludge Dewatering & Biosolids Storage											\$	1,687,000
	New Gravity Drainage Deck, Belt Filter Press & Feed												
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	1	no.	200 kg/h feed (Estimate)		550,000	*	\$	550,000	\$	550,000		
8.2	Sludge dewatering equipment - METALWORK	1	no.	Estimate	\$	24,000	\$ 24,000	\$	-	\$	24,000		
8.3	Sludge dewatering building - CIVILS	1	no.	Estimate	\$	288,000	\$ 288,000	\$	-	\$	288,000		
8.4	Polymer Make-up and Dosing System	1	no.	Estimate	\$	50,000		\$	50,000	\$	50,000		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$ 775,000	\$	-	\$	775,000		
9.0	Switch Room & Blower Room											\$	411.000
9.0 9.1	Switch Room & Blower Room Switchroom building	1	no.	Estimate	\$	96,000	\$ 96,000	\$		\$	96,000	Þ	411,000
9.1	Blower room building	1	no.	Estimate	φ \$	315,000				φ \$	315,000		
0.2		· ·	110.	LStinate	Ψ	515,000	φ 515,000	Ψ		Ψ	515,000		
10.0	Pump Stations (where not included above)											\$	210,000
10.0	Scum Pump Station	1	No.	incl.	\$	_	\$-	\$	_	\$	_	Ψ	210,000
10.1	Service Water System	1	No.	~5 L/s	φ \$	92.000	\$ 30,000	\$	62,000	φ \$	92.000		
10.2	General Purpose (Filtrate/ Site Utility) pump station	1	No.	~5 L/s	φ \$	46,000		,	30,000	\$	46,000		
10.3	Wet Weather Storage Return pump station	1	no.	~42 L/s ~33 L/s max.	ֆ \$				30,000	ֆ \$	46,000		
10.4	P/Stns Miscellaneous - METALWORK	1	No.		φ \$	26,000	\$ 26,000			φ \$	26,000		
10.5			INO.	Allowance	φ	20,000	\$ 20,000	φ	-	φ	20,000		
11.0	Plant Pipework & Valves											\$	1,860,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$ 248,000	\$	_	\$	248,000		, ,
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65,000	\$ 65,000	\$	_	\$	65,000		
11.3	Bioreactor to Clarifiers	1	No.	Allowance	\$	140,000			-	\$	140,000		
11.4	Clarifiers to UV Treatment	1	No.	Allowance	\$	46,000			-	\$	46,000		
11.5	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$ 540,000		_	\$	540,000		
11.6	RAS Pipework	1	No.	Allowance	\$	214,000			-	\$	214,000		
11.7	WAS Pipework	1	No.	Allowance	\$	46,000			_	\$	46,000		
11.8	Chemical Dosing Pipework	1	No.	Allowance	\$	34,000	\$ 34,000	\$	-	\$	34,000		
11.9	Service Water Pipework	1	No.	Allowance	\$	78,000	\$ 78,000		-	\$	78,000		
11.10	Odour Pipework	1	No.	Allowance	\$	36,000	\$ 36,000			\$	36,000		
11.10	Scum Pipework	1	No.	Allowance	φ \$	75,000	\$ 75,000	,		φ \$	75,000		
11.12	Effluent Transfer Pipework	1	No.		φ \$	150,000	\$ 150,000			φ \$	150,000		
11.12		1	NO.	Allowance	ֆ \$	130,000			-	ծ \$	130,000		
	Sludge Dewatering Pipework	· ·	-	Allowance					-				
11.14	Drainage Pipework	1	No.	Allowance	\$	27,000	\$ 27,000	· · ·	-	\$	27,000		
11.15	Roadworks Drainage Pipework	1	No.	Allowance	\$	31,000	\$ 31,000	\$	-	\$	31,000		

	ITEM	Qty	Unit	Size		Rate		Civil		M&E		Tota	l
12.0	Roads, Fencing & Landscaping											\$	442,000
12.1	Earthworks	1	No.	Allowance	\$	150,000	\$	150,000	\$	-	\$ 150,000		
12.2	Paving	1	No.	Allowance	\$	66,000		66,000		-	\$ 66,000		
12.3	Other roadworks, incl. temporary gravel roads	1	No.	Allowance	\$	35,000	\$	35,000	\$	-	\$ 35,000		-
12.4	Stormwater drains	1	No.	Allowance	\$	92,000	\$	92,000	\$	-	\$ 92,000		
12.5	Fencing	1	No.	Allowance	\$	17,000	\$	17,000	\$	-	\$ 17,000		
12.6	Landscaping	1	No.	Allowance	\$	82,000	\$	82,000	\$	-	\$ 82,000		
13.0	General Site Works											\$	1,640,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	1	No.	Allowance	\$	1,280,000	\$	1,280,000	\$	-	\$ 1,280,000		
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$	330.000		165,000		165,000	\$ 330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$	30,000	\$	-	\$	30,000	\$ 30,000		
14.0	Electrical, Instrumentation & Control				_							\$	2,699,000
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$	207,000			\$	207,000	\$ 207,000	Ψ	2,000,000
14.2	Motor Control Centres, supply & install	1	No.	Allowance	\$	409,000			\$	409,000	\$ 409,000		
14.3	Distribution Boards and Local Control Stations & VSD's	1	No.	Allowance	\$	198,000			\$	198,000	198,000		
14.4	Miscellaneous Control Panels - install	1	No.	Allowance	\$	16,000			\$	16,000	16,000		
14.5	Conduits and Pits, supply and install	1	No.	Allowance	\$	181,000			\$	181,000	\$ 181,000		
14.6	Supply, install and terminate Cabling	1	No.	Allowance	\$	232,000			\$	232,000	\$ 232,000		
14.7	Other Cabling (Lighting & Earthing)	1	No.	Allowance	\$	112,000			\$	112,000	112,000		
14.8	Instrumentation and Control Cabling	1	No.	Allowance	\$	87.000			\$	87,000	\$ 87.000		
14.9	Instrumentation	1	No.	Allowance	\$	307,000			\$	307,000	\$ 307,000		
14.10	PLC and interface with existing SCADA system	1	No.	Allowance	\$	171,000			\$	171,000	\$ 171,000		
14.11	Software and programming	1	No.	Allowance	\$	129,000			\$	129,000	\$ 129,000		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$	36,000			\$	36,000	\$ 36,000		-
14.13	SCADA system	1	No.	Allowance	\$	254,000			\$	254,000	\$ 254,000		
14.14	Standby Generator	1	No.	Allowance	\$	360,000			\$	360,000	\$ 360,000		
	Direct Job Costs (Sub-Total 1)						\$	13,082,000	\$	6,058,000		\$	19,140,000
Indire	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%	of DJC	:			\$	2,616,400		1,211,600		\$	3,828,000
	Risk and Contingency		of DJC				\$	3,924,600		1,817,400		\$	5,742,000
	Head Contractor Margin	5%	of DJC				\$	654,100		302,900		\$	957,000
	PROJECT SUB-TOTAL (Sub-Total 2)						\$	20,278,000	\$	9,390,000		\$	29,667,000
							Ť		Ŧ			Ť	
	TOTAL PROJECT BUDGET						\$	20,278,000	\$	9,390,000			\$29,667,000

Capital Cost Estimate

Option 4: OD

Concept Design Option

16,700 EP (Nominal) Capacity Augmentation

Construction Year 2016-17

DEFERMENT OF TREATMENT CAPACITY AUGMENTATION

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Existing treatment plant process capacity, with wet weather storage, tertiary wetland & increased biosolids storage capacity

3.80 ML/d Design ADWF

314 L/s PWWF (nominal) with remainder (up to 628 L/s) diverted to wet weather storage

	ITEM	Qty	Unit	Size	Rate		Civil		M&E			Total	
1.0	Wet Weather Storage											\$	2,526,000
1.1	1 no. 20 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$ 2,110,000	\$	2,110,000	\$	-	\$	2,110,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$ 375		141,000		-	\$	141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$ 150,000	\$	150,000	\$	-	\$	150,000		
1.3	Other minor civils, including overflow structure, culverts, headwalls etc.	1	No.	Allowance	\$ 80,000		80,000		_	\$	80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	2040	m2	Estimate	\$ 22	\$	44,880	\$	-	\$	44,880		
2.0	Inlet Works									-		\$	412,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$ 270,000	\$	220,000	\$	50,000	\$	270,000	Ψ	412,000
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	142,000			\$	142,000	\$	142,000		
2.2	New inlet channel, grit tank & related - CIVILS	0	no.	Max. 314 L/s	\$ 349,000		_	\$	-	\$	-		
2.3	New inlet channel, grit tank & related - METALWORK	0	no.	Ditto	\$ 72,000		_	\$	_	\$	-		
2.4	New inlet channel, grit tank & related - MECHANICAL	0	no.	Ditto	\$ 298,000		-	\$	_	\$	-		
2.5	Odour Control (odour bed or equivalent filter)	0	no.	Estimate	\$ 54,000		-	\$	-	\$	-		
					,								
3.0	Bioreactors											\$	-
3.1	RAS Flow influent splitter, downstream of inlet works	0	no.	Allowance	\$ 215,000	-\$	40,000	\$	40,000	\$	-		
3.2	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - CIVILS	0	no.	185 kL Anaerobic; 1665 kL Ox. Ditch (estimate)	\$ 1,298,000	\$	-	\$	-	\$	-		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - METALWORK	0	no.	Estimate	\$ 47,000	\$	-	\$	_				
3.4	New RAS screen and conveyor/ press	0	no.	Allowance, Max. 300 L/s	\$ 161,000	\$	-	\$	-	\$	-		
3.5	Aeration equipment, Mixers, RAS & WAS pumps - MECHANICAL	0	no.	Estimate	\$ 515,000	\$	-	\$	_	\$	-		
3.6	Aeration testing	0	no.	Allowance	\$ 42,000	\$	-	\$	-	\$	-		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	0	no.	Allowance, 3.6 m long to span channel width	\$ 132,000	\$	-	\$	_	\$	-		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	0	no.	Allowance	\$ 100,000	\$	100,000	-\$	100,000	\$	-		

		ITEM	Qty	Unit	Size	Rate	Civil		M&E		Total	
4.0	Clarifiers										\$	-
4.1		Mixed liquor flow splitter	0	no.	Allowance	\$ 215,000	\$ -	\$	-	\$ -		
4.2		Secondary Clarifiers - CIVILS (incl. METALWORK)	0	no.	23 m dia, 1.45 ML each (Estimate)	\$ 770,000	\$ -	\$	-	\$ -		
4.3		Secondary Clarifier & RAS P/Stn- MECHANICAL	0	no.	Estimate	\$ 427,000	\$ -	\$	-	\$ -		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	0	no.	Max. 150 L/s (Estimate)	\$ 64,000	\$ -	\$	-	\$ -		
5.0	UV Disinfe	ection									\$	-
5.1		UV channels - CIVILS (incl. METALWORK)	0	no.	314 L/s (Estimate)	\$ 198,000	\$ -	\$	-	\$ -		
5.2		UV disinfection equipment	0	no.	314 L/s (Estimate); dose 30 mJ/cm ²	\$ 490,000	\$ -	\$	-	\$ -		
5.3		UV control/ switchroom building	0	no.	Estimate (Colourbond building, airconditioned)	\$ 57,000	\$ -	\$	-	\$ -		
6.0		Storage & Dosing									\$	-
6.1		Earthworks & Drainage for bunded areas	0	no.	Allowance	\$ 12,000	\$ -	\$	-	\$ -		
6.2		Concrete for bunded areas	0	no.	Allowance	\$ 134,000	\$ -	\$	-	\$ -		
6.3		Building structure	0	no.	Allowance	\$ 108,000	\$ -	\$	-	\$ -		
6.4		Ferric sulphate storage tanks	0	no.	Allowance	\$ 57,000	\$ -	\$	-	\$ -		
6.5		Alum storage tanks	0	no.	Allowance	\$ 80,000	\$ -	\$	-	\$ -		
6.6		Sodium hydroxide storage tanks	0	no.	Allowance	\$ 79,000	\$ -	\$	-	\$ -		
6.7		Chemical dosing skids (pumps and pipework)	0	no.	Allowance	\$ 35,000	\$ 15,000	-\$	15,000	\$ -		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)									\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$ 20	\$ 210,000	\$	-	\$ 210,000		
6.2		Main distributor pipe	300	m	DN 750	\$ 800	\$ 240,000	\$	-	\$ 240,000		
6.3		Valves	3	no.	DN 750	\$ 10,000	\$ 30,000	\$	-	\$ 30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$ 420	\$ 63,000	\$	-	\$ 63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$ 20	\$ 48,000	\$	-	\$ 48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$ 60,000	\$ 60,000	\$	-	\$ 60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$ 110,000	\$ 110,000	\$	-	\$ 110,000		

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
7.0	Aerobic Digester	-											\$	-
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	0	no.	0.25 ML (Estimate)	\$	264,000	\$	-	\$	-	\$	-		
7.2	Aeration System (incl. Blowers) - MECHANICAL	0	no.	Estimate	\$	169,000	\$	-	\$	-	\$	-		
8.0	Sludge Dewatering & Biosolids Storage												\$	885,000
	New Gravity Drainage Deck, Belt Filter Press & Feed													·
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	0.2	no.	200 kg/h feed (Estimate)	\$	550,000		-	\$	110,000	\$	110,000		
8.2	Sludge dewatering equipment - METALWORK	0	no.	Estimate	\$			-	\$	-	\$	-		
8.3	Sludge dewatering building - CIVILS	0	no.	Estimate	\$	288,000	\$	-	\$	-	\$	-		
8.4	Polymer Make-up and Dosing System	0	no.	Estimate	\$	50,000	\$	-	\$	-	\$	-		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$	775,000	\$	-	\$	775,000		
9.0	Switch Room & Blower Room												\$	-
9.1	Switchroom building	0	no.	Estimate	\$	96,000	\$	-	\$	-	\$	-		
9.2	Blower room building	0	no.	Estimate	\$	315,000	\$	-	\$	-	\$	-		
10.0	Pump Stations (where not included above)												\$	46,000
10.1	Scum Pump Station	0	No.	incl.	\$	-	\$	-	\$	-	\$	-		
10.2	Service Water System	0	No.	~5 L/s	\$	92,000	\$	-	\$	-	\$	-		
10.3	General Purpose (Filtrate/ Site Utility) pump station	0	No.	~42 L/s	\$	46,000	\$	-	\$	-	\$	-		
10.4	Wet Weather Storage Return pump station	1	no.	~33 L/s max.	\$	46,000		16,000	\$	30,000	\$	46,000		
10.5	P/Stns Miscellaneous - METALWORK	0	No.	Allowance	\$	26,000	\$	-	\$	-	\$	-		
11.0	Plant Pipework & Valves												\$	354.000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$	248,000	\$		\$	248,000	Ŷ	554,000
11.2	Inlet works to Bioreactor	0	No.	Allowance	φ \$	-		240,000	φ \$		φ \$	240,000		
11.3	Bioreactor to Clarifiers	0	No.	Allowance	φ \$	140,000			φ \$		\$ \$	-		
11.4	Clarifiers to UV Treatment	0	No.		ֆ Տ			-	φ \$		φ \$			
11.5	Treated Effluent Pipework	0	No.	Allowance	ֆ Տ	540.000	φ \$	-	φ \$		φ \$	-		
11.6	RAS Pipework	0	No.	Allowance	φ \$	214,000	· ·	-	φ \$		φ \$	-		
11.7	WAS Pipework	0	No.	Allowance	ֆ Տ	46,000	φ \$	-	φ \$		φ \$	-		
11.8	Chemical Dosing Pipework	0	No.	Allowance	ֆ Տ	34,000		-	φ \$		э \$			
11.9	Service Water Pipework	0	No.	Allowance	ֆ \$	78.000	ֆ Տ	-	ֆ \$		ф \$			
11.10	Odour Pipework	0	No.		ֆ \$	36,000	φ \$	-	φ \$	-	э \$	-		
11.10	Scum Pipework	0	No.	Allowance	ֆ \$			-	ֆ \$		э \$	-		
11.12	Effluent Transfer Pipework	0.67	NO.	Allowance	ֆ \$	150,000	ֆ \$	- 100,000	ծ Տ	-	Դ Տ	- 100,000		
			-	Allowance				100,000	<u> </u>			100,000		
11.13	Sludge Dewatering Pipework	0	No.	Allowance	\$	130,000		-	\$	-	\$	-		
11.14 11.15	Drainage Pipework	0.1	No.	Allowance	\$	27,000	\$	2,700	\$	-	\$	2,700		
11.15	Roadworks Drainage Pipework	0.1	No.	Allowance	\$	31,000	\$	3,100	\$	-	\$	3,100		

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
12.0	Roads, Fencing & Landscaping												\$	45,000
12.1	Earthworks	0.1	No.	Allowance	\$	150,000	\$	15,000	\$	-	\$	15,000		
12.2	Paving	0.1	No.	Allowance	\$	66,000	\$	6,600	\$	-	\$	6,600		-
12.3	Other roadworks, incl. temporary gravel roads	0.1	No.	Allowance	\$	35,000	\$	3,500	\$	-	\$	3,500		
12.4	Stormwater drains	0.1	No.	Allowance	\$	92,000	\$	9,200	\$	-	\$	9,200		-
12.5	Fencing	0.1	No.	Allowance	\$	17,000	\$	1,700	\$	-	\$	1,700		-
12.6	Landscaping	0.1	No.	Allowance	\$	82,000	\$	8,200	\$	-	\$	8,200		-
13.0	General Site Works												\$	128,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	0.1	No.	Allowance	\$	1,280,000	\$	128,000	\$	-	\$	128,000		
13.2	Plant commissioning & performance testing	0	No.	Allowance	\$	330,000	\$	-	\$	-	\$	-		
13.3	Spare parts for mechanical equipment	0	No.	Allowance	\$	30,000	\$	-	\$		\$	-		
													Ļ	
14.0	Electrical, Instrumentation & Control				-	007.000			^		<u>^</u>		\$	104,000
14.1	Main Switchboard, supply & install Motor Control Centres, supply & install	0	No.	Allowance	\$	207,000			\$	-	\$	-	<u> </u>	
14.2	Distribution Boards and Local Control Stations & VSD's	0.06	No.	Allowance	\$	409,000			\$	25,000	\$	25,000	<u> </u>	
14.3		0.06	No.	Allowance	\$	198,000			\$	12,000	\$	12,000		
14.4	Miscellaneous Control Panels - install	0.06	No.	Allowance	\$	16,000			\$	1,000	\$	1,000		
14.5	Conduits and Pits, supply and install	0.06	No.	Allowance	\$	181,000			\$	11,000	\$	11,000		
14.6	Supply, install and terminate Cabling	0.06	No.	Allowance	\$	232,000			\$	14,000	\$	14,000	<u> </u>	
14.7	Other Cabling (Lighting & Earthing)	0	No.	Allowance	\$	112,000			\$	-	\$	-	<u> </u>	
14.8	Instrumentation and Control Cabling	0.06	No.	Allowance	\$	87,000			\$	5,000	\$	5,000	\vdash	
14.9	Instrumentation	0.06	No.	Allowance	\$	307,000			\$	18,000	\$	18,000	\vdash	
14.10	PLC and interface with existing SCADA system	0.06	No.	Allowance	\$	171,000			\$	10,000	\$	10,000		
14.11	Software and programming	0.06	No.	Allowance	\$	129,000			\$	8,000	\$	8,000		
14.12	UPS for all essential equipment and controls	0	No.	Allowance	\$	36,000			\$	-	\$	-		
14.13	SCADA system	0	No.	Allowance	\$	254,000			\$	-	\$	-		
14.14	Standby Generator	0	No.	Allowance	\$	360,000			\$	-	\$	-		
													Ļ	
India	Direct Job Costs (Sub-Total 1) ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%	of DJC				\$	4,899,000 979,800		361,000 72,200			\$ \$	5,261,000 1,053,000
mulle	Risk and Contingency	20%					φ S	1,469,700		108,300			ֆ Տ	1,053,000
	Head Contractor Margin	5%	of DJC				\$	244,950		18,050			φ \$	264,000
							·	,					·	- ,
	PROJECT SUB-TOTAL (Sub-Total 2)						\$	7,594,000	\$	560,000			\$	8,157,000
	TOTAL PROJECT BUDGET						\$	7,594,000	\$	560,000			1	\$8,157,000

Capital Cost Estimate

Concept Design Option

Option 5: OD

Construction Year

2016-17

DEFERMENT OF WET WEATHER STORAGE

25,000 EP (Nominal) Capacity Augmentation
 Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester; Excludes Wet Weather Storage

5.70 ML/d Design ADWF

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
1.0	Wet Weather Storage												\$	-
1.1	1 no. 20 ML clay-lined earthern storage lagoon	0	no.	Estimate	\$	2,110,000	\$	-	\$	-	\$	-		
1.2	Concrete paved drainage area	0	m2	Estimate	\$	375	\$	-	\$	-	\$	-		
1.2	Inlet/ Outlet Pipework & Valves	0	No.	Allowance	\$	150,000	\$	-	\$	-	\$	-		
1.3	Other minor civils, including overflow structure, culverts, headwalls etc.	0	No.	Alla	\$	80,000	¢		\$	_	\$	-		
1.3	Embankment gravel road. 150 mm thick, 4 m wide	0	-	Allowance	φ \$	22		-	φ \$		φ \$	-		
1.4		U	m2	Estimate	\$	22	\$	-	\$	-	\$	-		
2.0	Inlet Works												\$	1,043,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$	270,000	\$	220,000	\$	50,000	\$	270,000		
2.2	Screen on by-pass flow to Wet Weather Storage	0	no.	Estimate for Max. 628 L/s	\$	142,000	\$	-	\$	-	\$	-		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$	349,000	\$	349,000	\$	-	\$	349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$	72,000	\$	72,000	\$	-	\$	72,000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$	298,000	\$	-	\$	298,000	\$	298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$	54,000	\$	36,000	\$	18,000	\$	54,000		
3.0	Bioreactors												\$	2.463.000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$	215,000	\$	175,000	\$	40.000	\$	215,000	Ŧ	
3.2	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - CIVILS	1	no.	185 kL Anaerobic; 1665 kL Ox. Ditch (estimate)	\$,		1,298,000			\$	1,298,000		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - METALWORK	1	no.	Estimate	\$	47,000	\$	-	\$	-				
3.4	New RAS screen and conveyor/ press	1	no.	Allowance, Max. 300 L/s	\$	161,000	\$	-	\$	161,000	\$	161,000		
3.5	Aeration equipment, Mixers, RAS & WAS pumps - MECHANICAL	1	no.	Estimate	\$	515,000		_	\$	515,000	\$	515,000		
3.6	Aeration testing	1	no.	Allowance	\$	42,000	\$	-	\$	42,000	\$	42,000		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	1	no.	Allowance, 3.6 m long to span channel width	\$	132,000	\$	132,000	\$	-	\$	132,000		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	1	no.	Allowance	\$	100,000	\$	100,000	\$	-	\$	100,000		

		ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
4.0	Clarifiers													\$	2,246,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$	215,000	\$	215,000	\$	-	\$	215,000		
		Secondary Clarifiers - CIVILS (incl. METALWORK)			23 m dia, 1.45 ML each	<u>^</u>		<u>^</u>	1 5 40 000	•		•			
4.2		Secondary Clarifier & RAS P/Stn- MECHANICAL	2	no.	(Estimate)	\$	770,000		1,540,000	\$	-		1,540,000		
4.3		-	1	no.	Estimate	\$	427,000	\$	-	\$	427,000	\$	427,000		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	1	no.	Max. 150 L/s (Estimate)	\$	64,000	\$	64,000	\$	_	\$	64,000		
						Ť	,	Ŧ		•		Ŧ	- ,		
5.0	UV Disinfe	ection												\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$	198,000	\$	198,000	\$	-	\$	198,000		
					314 L/s (Estimate); dose	•		•		•	100.000	•			
5.2		UV disinfection equipment	1	no.	30 mJ/cm^2	\$	490,000	\$	-	\$	490,000	\$	490,000		
5.3		UV control/ switchroom building	1	no.	Estimate (Colourbond building, airconditioned)	\$	57,000	\$	57,000	\$	_	\$	57,000		
0.0					bananig, anoonaniorioa)	Ť	01,000	÷	01,000	÷		Ť	01,000		
6.0	Chemical	Storage & Dosing												\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$	12,000	\$	12,000	\$	-	\$	12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$	134,000	\$	134,000	\$	-	\$	134,000		
6.3		Building structure	1	no.	Allowance	\$	108,000		108,000	\$	-	\$	108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$	57,000	\$	57,000	\$	-	\$	57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$	79,000	\$	79,000	\$	-	\$	79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$	35,000	\$	15,000	\$	90,000	\$	105,000		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)												\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$	20		210,000		-	\$	210,000		
6.2		Main distributor pipe	300	m	DN 750	\$	800	\$	240,000		-	\$	240,000		
6.3		Valves	3	no.	DN 750	\$	10,000	\$	30,000	\$	-	\$	30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$	420	\$	63,000	\$		\$	63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$	20	\$	48,000	\$	-	\$	48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$	60,000	\$	60,000	\$	-	\$	60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$	110,000	\$	110,000	\$	-	\$	110,000		

	ITEM	Qty	Unit	Size		Rate	Civil		M&E			Total	
7.0	Aerobic Digester											\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$ 264,000	\$	-	\$	264,000	· ·	
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000	\$ -	\$	169,000	\$	169,000		
8.0	Sludge Dewatering & Biosolids Storage											\$	1,687,000
	New Gravity Drainage Deck, Belt Filter Press & Feed												
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	1	no.	200 kg/h feed (Estimate)	- · ·	550,000		\$	550,000	\$	550,000		
8.2	Sludge dewatering equipment - METALWORK	1	no.	Estimate	\$	24,000	\$ 24,000	\$	-	\$	24,000		
8.3	Sludge dewatering building - CIVILS	1	no.	Estimate	\$	288,000	\$ 288,000		-	\$	288,000		
8.4	Polymer Make-up and Dosing System	1	no.	Estimate	\$	50,000		\$	50,000	\$	50,000		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$ 775,000	\$	-	\$	775,000		
9.0	Switch Room & Blower Room											\$	444.000
<u>9.0</u> 9.1	Switch Room & Blower Room Switchroom building	1	no.	Estimate	\$	96,000	\$ 96,000	¢		\$	96.000	Þ	411,000
9.1	Blower room building	1	no.	Estimate	φ \$	315,000				φ \$	315,000		
0.2		1	110.	LStinate	Ψ	010,000	φ 515,000	Ψ		Ψ	515,000		
10.0	Pump Stations (where not included above)											\$	210,000
10.1	Scum Pump Station	1	No.	incl.	\$	-	\$ -	\$	-	\$	-	Ť	
10.2	Service Water System	1	No.	~5 L/s	\$	92.000	\$ 30.000	\$	62.000	\$	92.000		
10.2	General Purpose (Filtrate/ Site Utility) pump station	1	No.	~42 L/s	\$	46,000	,,	-	30,000	\$	46,000		
10.3	Wet Weather Storage Return pump station	1	no.	~33 L/s max.	Ψ \$	46,000	\$ 16,000		30,000	Ψ \$	46,000		
10.5	P/Stns Miscellaneous - METALWORK	1	No.	Allowance	\$	26,000	\$ 26,000		-	\$	26,000		
				,	Ť	_0,000	¢ _0,000	÷		Ť	_0,000		
11.0	Plant Pipework & Valves											\$	1,845,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$ 248,000	\$	-	\$	248,000		
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65,000	\$ 65,000	\$	-	\$	65,000		
11.3	Bioreactor to Clarifiers	1	No.	Allowance	\$	140,000	\$ 140,000	\$	-	\$	140,000		
11.4	Clarifiers to UV Treatment	1	No.	Allowance	\$	46,000	\$ 46,000	\$	-	\$	46,000		-
11.5	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$ 540,000	\$	-	\$	540,000		-
11.6	RAS Pipework	1	No.	Allowance	\$	214,000	\$ 214,000		-	\$	214,000		
11.7	WAS Pipework	1	No.	Allowance	\$	46,000	\$ 46,000	\$	-	\$	46,000		
11.8	Chemical Dosing Pipework	1	No.	Allowance	\$	34,000	\$ 34,000		_	\$	34,000		
11.9	Service Water Pipework	1	No.	Allowance	\$	78,000	\$ 78,000			\$	78,000		
11.10	Odour Pipework	1	No.	Allowance	\$	36,000	\$ 36,000		-	\$	36,000		
11.10	Scum Pipework	1	No.	Allowance	\$	75,000	\$ 75,000		_	\$	75,000		
11.12	Effluent Transfer Pipework	0.9	No.	Allowance	\$	150,000			_	\$	135,000		
11.13	Sludge Dewatering Pipework	1	No.	Allowance	\$	130,000		\$	_	\$	130,000		
11.14	Drainage Pipework	1	No.	Allowance	\$	27,000	\$ 27,000	•	-	Ψ \$	27,000	<u> </u>	
11.14	Roadworks Drainage Pipework	1	No.	Allowance	φ \$	31,000				φ \$	31,000		
11.15			140.	Allowdlice	Ψ	51,000	φ 31,000	φ	-	Ψ	51,000		

	ITEM	Qty	Unit	Size	Rate		Civil		M&E			Tota	l
12.0	Roads, Fencing & Landscaping											\$	442,000
12.1	Earthworks	1	No.	Allowance	\$ 150,000	\$	150,000	\$	-	\$	150,000		
12.2	Paving	1	No.	Allowance	\$ 66,000		66,000		-	\$	66,000		
12.3	Other roadworks, incl. temporary gravel roads	1	No.	Allowance	\$ 35,000	\$	35,000	\$	-	\$	35,000		
12.4	Stormwater drains	1	No.	Allowance	\$ 92,000	\$	92,000	\$	-	\$	92,000		
12.5	Fencing	1	No.	Allowance	\$ 17,000	\$	17,000	\$	-	\$	17,000		
12.6	Landscaping	1	No.	Allowance	\$ 82,000	\$	82,000	\$	-	\$	82,000		
13.0	General Site Works											\$	1,640,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	1	No.	Allowance	\$ 1,280,000	\$	1,280,000	\$	-	\$	1,280,000	-	
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$ 330.000		165,000		165.000	\$	330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$ 30,000	\$	-	\$	30,000	\$	30,000		
14.0	Electrical, Instrumentation & Control											\$	2,699,000
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$ 207,000			\$	207,000	\$	207,000	Ψ	2,000,000
14.2	Motor Control Centres, supply & install	1	No.	Allowance	\$ 409,000			\$	409,000	\$	409,000		
14.3	Distribution Boards and Local Control Stations & VSD's	1	No.	Allowance	\$ 198,000			\$	198,000		198,000		
14.4	Miscellaneous Control Panels - install	1	No.	Allowance	\$ 16,000			\$	16,000		16,000		
14.5	Conduits and Pits, supply and install	1	No.	Allowance	\$ 181,000			\$	181,000	\$	181,000		
14.6	Supply, install and terminate Cabling	1	No.	Allowance	\$ 232,000			\$	232,000	\$	232,000		
14.7	Other Cabling (Lighting & Earthing)	1	No.	Allowance	\$ 112,000			\$	112,000		112,000		
14.8	Instrumentation and Control Cabling	1	No.	Allowance	\$ 87.000			\$	87,000	\$	87.000		
14.9	Instrumentation	1	No.	Allowance	\$ 307,000			\$	307,000	\$	307,000		
14.10	PLC and interface with existing SCADA system	1	No.	Allowance	\$ 171,000			\$	171,000	\$	171,000		
14.11	Software and programming	1	No.	Allowance	\$ 129,000			\$	129,000	\$	129,000		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$ 36,000			\$	36,000	\$	36,000		
14.13	SCADA system	1	No.	Allowance	\$ 254,000			\$	254,000	\$	254,000		
14.14	Standby Generator	1	No.	Allowance	\$ 360,000			\$	360,000	\$	360,000		
	Direct Job Costs (Sub-Total 1)					\$	11,284,000	\$	5,916,000	<u> </u>		\$	17,200,000
Indire	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%	of DJC	:		\$	2,256,800		1,183,200			\$	3,440,000
	Risk and Contingency		of DJC			\$	3,385,200		1,774,800			\$	5,160,000
	Head Contractor Margin	5%	of DJC			\$	564,200		295,800			\$	860,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$	17,491,000	\$	9,170,000	-		\$	26,660,000
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	TOTAL PROJECT BUDGET					\$	17,491,000	\$	9,170,000				\$26,660,000

Capital Cost Estimate

Concept Design Option

Option 6: OD

Construction Year

2016-17

DEFERMENT OF TERTIARY CONSTRUCTED WETLAND

25,000 EP (Nominal) Capacity Augmentation Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester; Excludes Constructed Wetland

5.70 ML/d Design ADWF

	ITEM		Unit	Size	Rate	Civil		M&E				Total	
1.0	Wet Weather Storage											\$	2,526,000
1.1	1 no. 20 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$ 2,110,000	\$	2,110,000	\$	-	\$ 3	2,110,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$ 375	\$	141,000	\$	-	\$	141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$ 150,000	\$	150,000		-	\$	150,000		
	Other minor civils, including overflow structure, culverts,												
1.3	headwalls etc.	1	No.	Allowance	\$ 80,000	\$	80,000	\$	-	\$	80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	2040	m2	Estimate	\$ 22	\$	44,880	\$	-	\$	44,880		
2.0	Inlet Works											\$	1,185,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$ 270,000	\$	220,000	\$	50,000	\$	270,000	+	.,,
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	\$ 142,000	\$	_	\$	142,000	\$	142,000		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$ 349,000		349,000	\$	-	\$	349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$ 72.000		72,000	Ŧ	_	\$	72.000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$ 298,000	•	-	\$	298,000	\$	298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$ 54,000	\$	36,000	\$	18,000	\$	54,000		
3.0	Bioreactors											\$	2,463,000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$ 215,000	\$	175,000	\$	40,000	\$	215,000		
	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - CIVILS			185 kL Anaerobic; 1665					· · · · · · · · · · · · · · · · · · ·		· · ·		
3.2	Dich reactors) - Civilos	1	no.		\$ 1,298,000	\$	1,298,000	\$	-	\$	1,298,000		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - METALWORK	1	no.	Estimate	\$ 47,000	\$	-	\$	_				
3.4	New RAS screen and conveyor/ press	1	no.	Allowance, Max. 300 L/s	\$ 161,000		-	\$	161,000	\$	161,000		
3.5	Aeration equipment, Mixers, RAS & WAS pumps - MECHANICAL	1	no.	Estimate	\$ 515,000		_	\$	515,000	\$	515,000		
3.6	Aeration testing	1	no.	Allowance	\$ 42,000	\$	-	\$	42,000	\$	42,000		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	1	no.	Allowance, 3.6 m long to span channel width	\$ 132,000	\$	132,000	\$	_	\$	132,000		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	1	no.	Allowance	\$ 100,000		102,000		-	\$	100,000		

		ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
4.0	Clarifiers													\$	2,246,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$	215,000	\$	215,000	\$	-	\$	215,000		
4.0		Secondary Clarifiers - CIVILS (incl. METALWORK)	0		23 m dia, 1.45 ML each	¢	770.000	¢	4 5 4 0 0 0 0	¢		¢	4 5 4 0 0 0 0		
4.2		Secondary Clarifier & RAS P/Stn- MECHANICAL	2	no.	(Estimate)	\$	770,000		1,540,000		-	· · ·	1,540,000		
4.3		RAS Pump Station - CIVILS (incl. METALWORK)	1	no.	Estimate	\$	427,000	\$	-	\$	427,000	\$	427,000		
4.4		RAS Pump Station - CIVIES (Incl. METALWORK)	1	no.	Max. 150 L/s (Estimate)	\$	64,000	\$	64,000	\$	-	\$	64,000		
							•								
5.0	UV Disinfe	ection												\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$	198,000	\$	198,000	\$	-	\$	198,000		
5.0					314 L/s (Estimate); dose	•	400.000	•		•	100.000	•	400.000		
5.2		UV disinfection equipment	1	no.	30 mJ/cm ² Estimate (Colourbond	\$	490,000	\$	-	\$	490,000	\$	490,000		
5.3		UV control/ switchroom building	1	no.	building, airconditioned)	\$	57,000	\$	57,000	\$	_	\$	57,000		
					, , , , , , , , , , , , , , , , , , ,		- ,			,			- ,		
6.0	Chemical	Storage & Dosing												\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$	12,000	\$	12,000	\$	-	\$	12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$	134,000	\$	134,000	\$	-	\$	134,000		
6.3		Building structure	1	no.	Allowance	\$	108,000	\$	108,000		-	\$	108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$	57,000	\$	57,000	\$	-	\$	57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$	79,000		79,000		-	\$	79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$	35,000	\$	15,000	\$	90,000	\$	105,000		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)												\$	-
6.1		Earthmoving	-	m3	Allowance	\$	20	•	-	\$	-	\$	-		
6.2		Main distributor pipe	0	m	DN 750	\$	800	\$	-	\$	-	\$	-		
6.3		Valves	0	no.	DN 750	\$	10,000	\$	-	\$	-	\$	-		
6.4		Minor distributor pipes	0	m	DN 450	\$	420	\$	-	\$	-	\$	-		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	0	m2	Allowance	\$	20	\$	-	\$	-	\$	-		
6.6		Planting and initial maintenance	0	no.	Allowance	\$	60,000	\$	-	\$	-	\$	-		
6.7		Other Civils (incl. gravel roads)	0	no.	Allowance	\$	110,000	\$	-	\$	-	\$	-		

	ITEM	Qty	Unit	Size		Rate	Civil		M&E			Total	
7.0	Aerobic Digester											\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$ 264,000	\$	-	\$	264,000	· •	
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000		\$	169,000	\$	169,000		
8.0	Sludge Dewatering & Biosolids Storage											\$	1,687,000
	New Gravity Drainage Deck, Belt Filter Press & Feed												
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	1	no.	200 kg/h feed (Estimate)	· ·	550,000	*	\$	550,000	\$	550,000		
8.2	Sludge dewatering equipment - METALWORK	1	no.	Estimate	\$	24,000	\$ 24,000	\$	-	\$	24,000		
8.3	Sludge dewatering building - CIVILS	1	no.	Estimate	\$	288,000	\$ 288,000	\$	-	\$	288,000		
8.4	Polymer Make-up and Dosing System	1	no.	Estimate	\$	50,000		\$	50,000	\$	50,000		
8.5	Biosolids Storage Facility (Building) - CIVILS	1	no.	Estimate	\$	775,000	\$ 775,000	\$	-	\$	775,000		
9.0	Switch Room & Blower Room											\$	411.000
9.0 9.1	Switch Room & Blower Room Switchroom building	1	no.	Estimate	\$	96,000	\$ 96,000	\$	-	\$	96,000	Þ	411,000
9.1	Blower room building	1	no.	Estimate	φ \$	315,000				φ \$	315,000		
5.2			110.	LStinate	Ψ	515,000	φ 515,000	Ψ		Ψ	515,000		
10.0	Pump Stations (where not included above)											\$	210,000
10.0	Scum Pump Station	1	No.	incl.	\$		\$-	\$	_	\$	-	Ψ	210,000
10.1	Service Water System	1	No.	~5 L/s	\$	92.000	\$ 30,000	\$	62,000	φ \$	92.000		
10.2	General Purpose (Filtrate/ Site Utility) pump station	1	No.	~5 L/s	φ \$	46,000		•	30,000	\$	46,000		
10.3	Wet Weather Storage Return pump station	1	no.	~42 L/s ~33 L/s max.	э \$	46,000			30,000	ֆ \$	46,000		
10.4	P/Stns Miscellaneous - METALWORK	1	No.		φ \$	26,000	\$ 26,000			φ \$	26,000		
10.5		1	INO.	Allowance	φ	20,000	\$ 20,000	φ	-	φ	20,000		
11.0	Plant Pipework & Valves											\$	1,845,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$ 248,000	\$	_	\$	248,000	Ŧ	.,,
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65,000	\$ 65,000	\$		\$	65,000		
11.2	Bioreactor to Clarifiers	1	No.	Allowance	\$	140,000			-	\$	140,000		
11.4	Clarifiers to UV Treatment	1	No.	Allowance	\$	46,000			-	\$	46,000		
11.5	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$ 540,000		-	\$	540,000		
11.6	RAS Pipework	1	No.	Allowance	\$	214,000			_	\$	214,000		
11.7	WAS Pipework	1	No.	Allowance	\$	46,000				\$	46,000		
11.7	Chemical Dosing Pipework	1	No.	Allowance	φ \$	34,000	\$ 34,000	φ \$		φ \$	34,000		
11.8	Service Water Pipework	1	No.		φ \$	78,000	\$ 78,000			φ \$	78,000		
11.10	Odour Pipework	1	No.	Allowance	ֆ \$	36,000				э \$	36,000		
		1	-	Allowance	\$ \$			•	-				
11.11 11.12	Scum Pipework Effluent Transfer Pipework	0.9	No.	Allowance	\$ \$	75,000	\$ 75,000 \$ 135,000	\$ \$	-	\$ \$	75,000 135,000		
			No.	Allowance		150,000			-				
11.13	Sludge Dewatering Pipework	1	No.	Allowance	\$	130,000		\$	-	\$	130,000		
11.14	Drainage Pipework	1	No.	Allowance	\$	27,000	\$ 27,000	\$	-	\$	27,000		
11.15	Roadworks Drainage Pipework	1	No.	Allowance	\$	31,000	\$ 31,000	\$	-	\$	31,000		

	ITEM	Qty	Unit	Size	Rate		Civil		M&E		Total	
12.0	Roads, Fencing & Landscaping										\$	442,000
12.1	Earthworks	1	No.	Allowance	\$ 150,000	\$	150,000	\$	-	\$ 150,000		
12.2	Paving	1	No.	Allowance	\$ 66,000	\$	66,000	\$	-	\$ 66,000		
12.3	Other roadworks, incl. temporary gravel roads	1	No.	Allowance	\$ 35,000	\$	35,000	\$	-	\$ 35,000		
12.4	Stormwater drains	1	No.	Allowance	\$ 92,000	\$	92,000	\$	-	\$ 92,000		
12.5	Fencing	1	No.	Allowance	\$ 17,000	\$	17,000	\$	-	\$ 17,000		
12.6	Landscaping	1	No.	Allowance	\$ 82,000	\$	82,000	\$	-	\$ 82,000		
13.0	General Site Works										\$	1,512,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	0.9	No.	Allowance	\$ 1,280,000	\$	1,152,000	\$	-	\$ 1,152,000	Ψ	1,012,000
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$ 330,000		165,000	\$	165,000	\$ 330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$ 30,000		-	\$	30,000	\$ 30,000		
14.0	Electrical, Instrumentation & Control										\$	2,699,000
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$ 207,000			\$	207,000	\$ 207,000		
14.2	Motor Control Centres, supply & install	1	No.	Allowance	\$ 409,000			\$	409,000	409,000		
14.3	Distribution Boards and Local Control Stations & VSD's	1	No.	Allowance	\$ 198,000			\$	198,000	\$ 198,000		
14.4	Miscellaneous Control Panels - install	1	No.	Allowance	\$ 16,000			\$	16,000	\$ 16,000		
14.5	Conduits and Pits, supply and install	1	No.	Allowance	\$ 181,000			\$	181,000	\$ 181,000		
14.6	Supply, install and terminate Cabling	1	No.	Allowance	\$ 232,000			\$	232,000	\$ 232,000		
14.7	Other Cabling (Lighting & Earthing)	1	No.	Allowance	\$ 112,000			\$	112,000	\$ 112,000		
14.8	Instrumentation and Control Cabling	1	No.	Allowance	\$ 87,000			\$	87,000	\$ 87,000		
14.9	Instrumentation	1	No.	Allowance	\$ 307,000			\$	307,000	\$ 307,000		
14.10	PLC and interface with existing SCADA system	1	No.	Allowance	\$ 171,000			\$	171,000	\$ 171,000		
14.11	Software and programming	1	No.	Allowance	\$ 129,000			\$	129,000	\$ 129,000		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$ 36,000			\$	36,000	\$ 36,000		
14.13	SCADA system	1	No.	Allowance	\$ 254,000			\$	254,000	\$ 254,000		
14.14	Standby Generator	1	No.	Allowance	\$ 360,000			\$	360,000	\$ 360,000		
	Direct Job Costs (Sub-Total 1)					¢	12,921,000	¢	6,058,000		¢	18,979,000
India		20%	of DJC			¢ P			1,211,600		φ Φ	
maine	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.) Risk and Contingency		of DJC			¢ ¢	2,584,200 3,876,300		1,817,400		ֆ Տ	3,796,00
	Risk and Contingency Head Contractor Margin	25% 5%	of DJC			¢	3,876,300 646,050				ծ Տ	5,694,000
	neau Contractor Margin	J%	OLD JC			φ	646,050	ф	302,900		φ	949,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$	20,028,000	\$	9,390,000		\$	29,418,000
	TOTAL PROJECT BUDGET					\$	20,028,000	\$	9,390,000			\$29,418,00

Capital Cost Estimate

Concept Design Option

Construction Year 2016-17

DEFERMENT OF NEW SLUDGE DEWATERING FACILITIES

Option 7: OD 25,000 EP (Nominal) Capacity Augmentation Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

Includes new Aerobic Digester; Excludes new Sludge Dewatering Facilities (but Includes New Sludge Storage Area)

5.70 ML/d Design ADWF

ITEM		Qty	Unit	Size	Rate	Civil	M&E		Total	
1.0	Wet Weather Storage								\$	2,526,000
1.1	1 no. 20 ML clay-lined earthern storage lagoon	1	no.	Estimate	\$ 2,110,000	\$ 2,110,000	\$ -	\$ 2,110,000		
1.2	Concrete paved drainage area	375	m2	Estimate	\$ 375	\$ 141,000	\$ -	\$ 141,000		
1.2	Inlet/ Outlet Pipework & Valves	1	No.	Allowance	\$ 150,000	\$ 150,000	\$ -	\$ 150,000		
	Other minor civils, including overflow structure, culverts,									
1.3	headwalls etc.	1	No.	Allowance	\$ 80,000	80,000	-	\$ 80,000		
1.4	Embankment gravel road. 150 mm thick, 4 m wide	2040	m2	Estimate	\$ 22	\$ 44,880	\$ -	\$ 44,880		
2.0	Inlet Works								\$	1,185,000
2.1	Raw influent flow splitter, upstream of inlet works	1	no.	Allowance	\$ 270,000	\$ 220,000	\$ 50,000	\$ 270,000		
2.2	Screen on by-pass flow to Wet Weather Storage	1	no.	Estimate for Max. 628 L/s	\$ 142,000	\$ -	\$ 142,000	\$ 142,000		
2.2	New inlet channel, grit tank & related - CIVILS	1	no.	Max. 314 L/s	\$ 349,000	\$ 349,000	\$ -	\$ 349,000		
2.3	New inlet channel, grit tank & related - METALWORK	1	no.	Ditto	\$ 72,000	\$ 72,000	\$ -	\$ 72,000		
2.4	New inlet channel, grit tank & related - MECHANICAL	1	no.	Ditto	\$ 298,000	\$ -	\$ 298,000	\$ 298,000		
2.5	Odour Control (odour bed or equivalent filter)	1	no.	Estimate	\$ 54,000	\$ 36,000	\$ 18,000	\$ 54,000		
3.0	Bioreactors								\$	2,463,000
3.1	RAS Flow influent splitter, downstream of inlet works	1	no.	Allowance	\$ 215,000	\$ 175,000	\$ 40,000	\$ 215,000		
3.2	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - CIVILS	1	no.	185 kL Anaerobic; 1665 kL Ox. Ditch (estimate)	\$ 1,298,000	\$ 1,298,000	\$ -	\$ 1,298,000		
3.3	New Oxidation Ditch bioreactors (includes Anaerobic & Ox. Ditch reactors) - METALWORK	1	no.	Estimate	\$ 47,000	\$ -	\$ _			
3.4	New RAS screen and conveyor/ press	1	no.	Allowance, Max. 300 L/s	\$ 161,000	\$ -	\$ 161,000	\$ 161,000		
3.5	Aeration equipment, Mixers, RAS & WAS pumps - MECHANICAL	1	no.	Estimate	\$ 515,000	_	\$ 515,000	515,000		
3.6	Aeration testing	1	no.	Allowance	\$ 42,000	\$ -	\$ 42,000	\$ 42,000		
3.7	Scum harvester & Scum Pump for Ox. Ditch - MECHANICAL	1	no.	Allowance, 3.6 m long to span channel width	\$ 132,000	132,000	\$ -	\$ 132,000		
3.8	Pipework modifications to outlet of Existing Ox. Ditch	1	no.	Allowance	\$ 100,000	\$ 100,000	\$ -	\$ 100,000		

		ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
4.0	Clarifiers													\$	2,246,000
4.1		Mixed liquor flow splitter	1	no.	Allowance	\$	215,000	\$	215,000	\$	-	\$	215,000		
		Secondary Clarifiers - CIVILS (incl. METALWORK)	_		23 m dia, 1.45 ML each	<u>^</u>		â	1 5 40 000	•		•			
4.2		Secondary Clarifier & RAS P/Stn- MECHANICAL	2	no.	(Estimate)	\$	770,000		1,540,000	\$	-		1,540,000		
4.3		-	1	no.	Estimate	\$	427,000	\$	-	\$	427,000	\$	427,000		
4.4		RAS Pump Station - CIVILS (incl. METALWORK)	1	no.	Max. 150 L/s (Estimate)	\$	64,000	\$	64,000	\$	_	\$	64,000		
			-			Ŧ	,	Ŧ		•		Ŧ	- ,		
5.0	UV Disinfe	ection												\$	745,000
5.1		UV channels - CIVILS (incl. METALWORK)	1	no.	314 L/s (Estimate)	\$	198,000	\$	198,000	\$	-	\$	198,000		
					314 L/s (Estimate); dose	•		•		•	100.000	•			
5.2		UV disinfection equipment	1	no.	30 mJ/cm^2	\$	490,000	\$	-	\$	490,000	\$	490,000		
5.3		UV control/ switchroom building	1	no.	Estimate (Colourbond building, airconditioned)	\$	57,000	\$	57,000	\$	_	\$	57,000		
0.0					Sananig, an contaition ou	Ť	01,000	÷	01,000	÷		Ť	01,000		
6.0	Chemical	Storage & Dosing												\$	575,000
6.1		Earthworks & Drainage for bunded areas	1	no.	Allowance	\$	12,000	\$	12,000	\$	-	\$	12,000		
6.2		Concrete for bunded areas	1	no.	Allowance	\$	134,000	\$	134,000	\$	-	\$	134,000		
6.3		Building structure	1	no.	Allowance	\$	108,000		108,000	\$	-	\$	108,000		
6.4		Ferric sulphate storage tanks	1	no.	Allowance	\$	57,000	\$	57,000	\$	-	\$	57,000		
6.5		Alum storage tanks	1	no.	Allowance	\$	80,000	\$	80,000	\$	-	\$	80,000		
6.6		Sodium hydroxide storage tanks	1	no.	Allowance	\$	79,000	\$	79,000	\$	-	\$	79,000		
6.7		Chemical dosing skids (pumps and pipework)	3	no.	Allowance	\$	35,000	\$	15,000	\$	90,000	\$	105,000		
6.0	Tertiary Co	onstructed Wetland (total area ~3 ha)												\$	761,000
6.1		Earthmoving	10,500	m3	Allowance	\$	20		210,000		-	\$	210,000		
6.2		Main distributor pipe	300	m	DN 750	\$	800	\$	240,000		-	\$	240,000		
6.3		Valves	3	no.	DN 750	\$	10,000	\$	30,000	\$	-	\$	30,000		
6.4		Minor distributor pipes	150	m	DN 450	\$	420	\$	63,000	\$		\$	63,000		
6.5		HDPE (2mm) liner under berms, lineal length x 3 m wide	2400	m2	Allowance	\$	20	\$	48,000	\$	-	\$	48,000		
6.6		Planting and initial maintenance	1	no.	Allowance	\$	60,000	\$	60,000	\$	-	\$	60,000		
6.7		Other Civils (incl. gravel roads)	1	no.	Allowance	\$	110,000	\$	110,000	\$	-	\$	110,000		

	ITEM		Unit	Size		Rate	Ci	vil		M&E				
7.0	Aerobic Digester												\$	433,000
7.1	Aeration Tank (incl. internal peipwork & valves) - CIVILS	1	no.	0.25 ML (Estimate)	\$	264,000	\$	264,000	\$	-	\$	264,000		
7.2	Aeration System (incl. Blowers) - MECHANICAL	1	no.	Estimate	\$	169,000	\$	-	\$	169,000	\$	169,000		
													•	
8.0	Sludge Dewatering & Biosolids Storage New Gravity Drainage Deck, Belt Filter Press & Feed												\$	885,000
8.1	Pumps, Conveyors to Sludge Storage - MECHANICAL	0.2	no.	200 kg/h feed (Estimate)	\$	550,000	\$	-	\$	110,000	\$	110,000		
8.2	Sludge dewatering equipment - METALWORK	0	no.	Estimate	\$	24.000	\$	_	\$	-	\$	-		
8.3	Sludge dewatering building - CIVILS	0	no.	Estimate	\$	288,000	•	-	\$		\$	-		
8.4	Polymer Make-up and Dosing System	0	no.	Estimate	\$	50,000	-		\$		\$			
8.5	Biosolids Storage Facility (Building) - CIVILS	1			\$	775,000	\$	775,000	Ψ \$		\$	775,000		
0.0		1	no.	Estimate	φ	775,000	φ	775,000	φ		φ	775,000		
9.0	Switch Room & Blower Room												\$	411,000
9.1	Switchroom building	1	no.	Estimate	\$	96,000	\$	96,000	\$	-	\$	96,000		
9.2	Blower room building	1	no.	Estimate	\$	315,000	\$	315,000	\$	-	\$	315,000		
10.0	Pump Stations (where not included above)										-		\$	210,000
10.1	Scum Pump Station	1	No.	incl.	\$	-	\$	-	\$	-	\$	-		
10.2	Service Water System	1	No.	~5 L/s	\$	92,000			\$	62,000	\$	92,000		
10.3	General Purpose (Filtrate/ Site Utility) pump station	1	No.	~42 L/s	\$	46,000		16,000		30,000	\$	46,000		
10.4	Wet Weather Storage Return pump station P/Stns Miscellaneous - METALWORK	1	no.	~33 L/s max.	\$	46,000		16,000		30,000	\$	46,000		
10.5	P/Sths Miscellaneous - METALWORK	1	No.	Allowance	\$	26,000	\$	26,000	\$	-	\$	26,000		
11.0	Plant Pipework & Valves												\$	1,729,000
11.1	Pipework to Inlet works	1	No.	Allowance	\$	248,000	\$	248,000	\$		\$	248,000	Ŧ	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
11.2	Inlet works to Bioreactor	1	No.	Allowance	\$	65.000	\$	65,000	\$ \$	-	\$	65,000		
11.3	Bioreactor to Clarifiers	1	No.	Allowance	\$	140,000	\$	140,000	\$	-	\$	140,000		
11.4	Clarifiers to UV Treatment	1	No.	Allowance	\$	46,000		46,000	\$ \$	-	\$	46,000		
11.5	Treated Effluent Pipework	1	No.	Allowance	\$	540,000	\$	540,000	\$	_	\$	540,000		
11.6	RAS Pipework	1	No.	Allowance	\$	214,000		214,000	\$	_	\$	214,000		
11.7	WAS Pipework	1	No.	Allowance	\$	46,000	\$	46,000	\$	_	\$	46,000		
11.8	Chemical Dosing Pipework	1	No.	Allowance	\$	34,000	\$	34,000	\$	-	\$	34,000		
11.9	Service Water Pipework	1	No.	Allowance	\$	78,000	\$	78,000	\$	_	\$	78,000		
11.10	Odour Pipework	1	No.	Allowance	\$	36,000	\$	36,000	\$	-	\$	36,000		
11.10	Scum Pipework	1	No.	Allowance	Ψ \$	75,000	\$	75,000	\$		Ψ \$	75,000		
11.12	Effluent Transfer Pipework	1	No.	Allowance	Ψ \$	150,000	\$	150,000	\$	_	Ψ \$	150,000		
11.12	Sludge Dewatering Pipework	0	No.	Allowance	\$	130,000		-	\$ \$	_	\$	-		
11.14	Drainage Pipework	0.95	No.	Allowance	\$	27,000	\$	26,000	\$	-	\$	26,000		
11.15	Roadworks Drainage Pipework	1	No.	Allowance	\$	31,000		31,000	\$ \$	<u> </u>	\$	31,000		
		+ '	110.	7 110 17 01 100	Ψ	01,000	Ψ	01,000	¥		Ψ	01,000		

	ITEM	Qty	Unit	Size		Rate		Civil		M&E			Total	
12.0	Roads, Fencing & Landscaping												\$	442,000
12.1	Earthworks	1	No.	Allowance	\$	150,000	\$	150,000	\$	-	\$	150,000		
12.2	Paving	1	No.	Allowance	\$	66,000	\$	66,000	\$	-	\$	66,000		
12.3	Other roadworks, incl. temporary gravel roads	1	No.	Allowance	\$	35,000	\$	35,000	\$	-	\$	35,000		
12.4	Stormwater drains	1	No.	Allowance	\$	92,000	\$	92,000	\$	-	\$	92,000		
12.5	Fencing	1	No.	Allowance	\$	17,000		17,000		-	\$	17,000		
12.6	Landscaping	1	No.	Allowance	\$	82,000	\$	82,000	\$	-	\$	82,000		
													•	
13.0	General Site Works				_		_		-				\$	1,576,000
13.1	Bulk earthworks of site (incl. preloading/ flood mitigation)	0.95	No.	Allowance		1,280,000		1,216,000		-	·	1,216,000		
13.2	Plant commissioning & performance testing	1	No.	Allowance	\$	330,000		165,000		165,000	\$	330,000		
13.3	Spare parts for mechanical equipment	1	No.	Allowance	\$	30,000	\$	-	\$	30,000	\$	30,000		
14.0	Electrical. Instrumentation & Control												\$	2,514,800
14.1	Main Switchboard, supply & install	1	No.	Allowance	\$	207.000			\$	207.000	\$	207.000	φ	2,514,600
14.2	Motor Control Centres, supply & install	0.9	No.	Allowance	\$	409,000			φ \$	368,100	φ \$	368,100		
14.3	Distribution Boards and Local Control Stations & VSD's	0.9	No.		\$	198,000			φ \$	178,200	φ \$	178,200		
	Miscellaneous Control Panels - install	0.9	-	Allowance	э \$,			Ŧ	,				
14.4	Conduits and Pits, supply and install		No.	Allowance		16,000			\$	14,400	\$	14,400		
14.5		0.9	No.	Allowance	\$	181,000			\$	162,900	\$	162,900		
14.6	Supply, install and terminate Cabling	0.9	No.	Allowance	\$	232,000			\$	208,800	\$	208,800		
14.7	Other Cabling (Lighting & Earthing)	0.9	No.	Allowance	\$	112,000			\$	100,800	\$	100,800		
14.8	Instrumentation and Control Cabling	0.9	No.	Allowance	\$	87,000			\$	78,300	\$	78,300		
14.9	Instrumentation	0.9	No.	Allowance	\$	307,000			\$	276,300	\$	276,300		
14.10	PLC and interface with existing SCADA system	0.9	No.	Allowance	\$	171,000			\$	153,900	\$	153,900		
14.11	Software and programming	0.9	No.	Allowance	\$	129,000			\$	116,100	\$	116,100		
14.12	UPS for all essential equipment and controls	1	No.	Allowance	\$	36,000			\$	36,000	\$	36,000		
14.13	SCADA system	1	No.	Allowance	\$	254,000			\$	254,000	\$	254,000		
14.14	Standby Generator	1	No.	Allowance	\$	360,000			\$	360,000	\$	360,000		
									-				-	
	Direct Job Costs (Sub-Total 1)						\$	13,318,000		5,384,000			\$	18,702,000
Indire	ect Job Costs (Preliminaries, Engineering, Site Costs, Project Admin. etc.)	20%					\$	2,663,600		1,076,800			\$	3,741,000
	Risk and Contingency	25% 5%	of DJC				\$	3,995,400		1,615,200			\$	5,611,000
	Head Contractor Margin	5%	of DJC	•			\$	665,900	\$	269,200			\$	936,000
	PROJECT SUB-TOTAL (Sub-Total 2)						\$	20,643,000	\$	8,346,000			\$	28,990,000
	······································						-	,,	Ŧ	-,,-			Ŧ	-,,•••
	TOTAL PROJECT BUDGET						\$	20,643,000	\$	8,346,000			9	28,990,000

Appendix J Capital cost estimates breakdown for OSSTP upgrade

Ocean Shores STP (Values here from GHD 2014 Planning Study; GHD Job no. 41/27528 Doc. 462193)

Cost Estimate Concept Design Option

 Option 2:
 OD
 New 5-stage 'Phoredox' Oxidation Ditch Process
 2016-17

 With Anaerobic, Secondary Anoxic & Secondary Aerobic Reactors
 Includes Effluent Filtration, Effluent Storage (in modified existing IAT), and Aerobic Digester (modified existing DAT)

 2.30
 ML/d Design ADWF

232 L/s PWWF

ITEM		Qty	Unit	Size	Rate	Civil	M&E	Total	
1.0	Inlet Works								\$ 509,000
1.1	New Step Screen & Conveyor/ Press	1	no.	Max. 270 L/s	\$ 155,000	\$-	\$ 155,000	\$ 155,000	
1.2	New Grit Tank (concrete)	1	no.	3.05 m diameter	\$ 178,000	\$ 178,000	\$ -	\$ 178,000	
	New Grit Tank mechanical equipment and pipework (Airlift			To suit grit tank, Max.					
1.3	Pumps & related)	1	no.	270 L/s	\$ 150,000	\$-	\$ 150,000	\$ 150,000	
1.4	New bins and bagging systems for screenings and grit	2	no.	2 kL bins	\$ 13,000	\$ 22,000	\$ 4,000	\$ 26,000	
2.0	Flow Splitter								\$ 204,000
2.1	Refurbishment (weirs, penstocks etc.)	1	no.	Allowance	\$ 99,000	\$ 99,000	\$ -	\$ 99,000	
2.2	Pipework modifications	1	no.	Allowance	\$ 50,000	\$ 50,000	\$ -	\$ 50,000	
2.3	Valves	4	no.	DN 375 gate valves	\$ 10,000	\$ -	\$ 40,000	\$ 40,000	
2.4	Grating and handrails (modifications)	1	no.	Allowance	\$ 12,000	\$ 12,000	\$ -	\$ 12,000	
2.5	Level transmitter	1	no.	Allowance	\$ 3,000	\$-	\$ 3,000	\$ 3,000	
3.0	Stormflow (wet weather storage)								\$ 231,000
3.1	Cleanout of existing Catch Pond	1	no.	Allowance	\$ 28,000	\$ 28,000	\$ -	\$ 28,000	
3.2	Floor slab modifications for return pump station	1	no.	Allowance	\$ 34,000	\$ 34,000	\$ -	\$ 34,000	
3.3	Return pump station	1	no.	13 L/s, ~10 m head, ~3 kW	\$ 93,000	\$ 74,000	\$ 19,000	\$ 93,000	
3.4	Elevated walkway to return p/stn, incl. handrails etc.	1	no.	Allowance	\$ 65,000	\$ 65,000	\$ -	\$ 65,000	
3.5	Davits for return pumps on walkway	2	no.	Estimate	\$ 4,000	\$-	\$ 8,000	\$ 8,000	
3.6	Level transmitter	1	no.	Allowance	\$ 3,000	\$-	\$ 3,000	\$ 3,000	

Construction Year

4.0	Bioreactor													\$ 4,378,000
		New Oxidation Ditch bioreactors (includes Anaerobic, Ox.												
		Ditch and Sec. Anoxic & Sec. Aerobic reactors)			190 kL Anaerobic; 2320									
					kL Ox. Ditch; 190 kL each Sec. Anoxic & Sec.									
4.1			1	no.	Aerobic Tanks (Estimate)	\$	2,980,000	\$	2,980,000	\$	-	\$	2,980,000	
4.2		New RAS screen and conveyor/ press	1	no.	Max. 100 L/s	\$	108,000	\$	108,000	\$	-	\$	108,000	
		RAS valves & pipework for alternative process			DN 300 gate valves, tee								· · · ·	
		configurations (UCT/ Phoredox)			piece, pipe penetrations	•	440.000	•		•		_		
4.3	-	Minere for Arrentic and the	2	no.	etc.		116,000		232,000	\$	-	\$	232,000	
4.4		Mixers for Anaerobic reactor Aeration system for Ox. Ditch	3	no.	0.375kW Max. 2050 Nm3/h	\$	5,000	\$	-	\$	15,000	\$	15,000	
4.5		Aeration system for Ox. Ditch	1	no.	(Estimate)	\$	400,000	\$	-	\$	400,000	\$	400,000	
4.6		Aeration testing	1	no.	Allowance	\$	42,000	\$	-	\$	42,000		42,000	
4.7		Blowers for Ox. Ditch	3	no.	22 kW (estimate)	\$	45,000	\$	-	\$	135,000	\$	135,000	
4.8		Submersible aerators for Sec. Aerobic reactor	2	no.	11 kW (estimate)	\$	31,000	\$	-	\$	62,000	\$	62,000	
4.9		Mixers for Ox. Ditch	4	no.	5.5 kW	\$	34,000	\$	-	\$	136,000		136,000	
4.10		Mixers for Sec. Anoxic reactor	1	no.	1.1 kW	\$	11,000	\$	8,800	\$	2,200	\$	11,000	
		Scum harvester for Ox. Ditch	4		4.5m long to span	¢	111.000	¢	07 000	¢	17.000	<u>م</u>	111.000	
4.11		WAS nume station	1	no.	channel width	\$ \$	114,000 125,000	\$ \$	97,000 107,000	\$ \$	17,000 18,000		114,000 125,000	
		WAS pump station Instrumentation (DO, pH, Temp, Susp. Solids meters)	•	no.	4 L/s (estimate)	Ŧ			107,000			-		
4.13			6	no.	Estimate	\$	3,000	\$	-	\$	18,000	\$	18,000	
5.0	Clarifiers													\$ 2.272.000
5.1		Mixed liquor flow splitter (incl. penstocks)	1	no.	Allowance	\$	82,000	\$	82,000	\$	-	\$	82.000	, , ,
-		Secondary Clarifiers		_	21 m dia, 1.4 ML each				,			,	-)	
5.2		-	2	no.	(Estimate)	\$	744,000	\$	1,042,000	\$	446,000	\$	1,488,000	
5.3		Piles for Secondary Clarifiers (2 no.)	44	no.	Estimate	\$	4,400	\$	194,000	\$	-	\$	194,000	
F 4		RAS Pump Stations			Max. 80 L/s each	•	0.45 000	¢	000 000	¢	00.000	•	400.000	
5.4 5.5		RAS flow meters	2	no. no.	(Estimate)	\$ \$	245,000	\$ \$	392,000	\$ \$	98,000 12.000		490,000 12,000	
	1	RAS low meters		-	Estimate		- ,		-	Ŧ	1		-	
5.6		INAS suspended solids meters	2	no.	Estimate	\$	3,000	\$	-	\$	6,000	\$	6,000	
6.0	Effluent Fi	iltration												\$ 1,174,000
6.1		Preliminary earthworks	1	no.	Allowance	\$	30,000	\$	30,000		-	\$	30,000	
6.2		Secondary Effluent Pump Station	1	no.	Allowance	\$	141,000	\$	112,800	\$	28,200	\$	141,000	
6.3		Secondary Effluent Wet Well/ Flow Splitter	1	no.	incl.	\$	-	\$	-	\$	-	\$	-	
6.4		Cloth Media Disc Filters (incl. Backwash Pumps)	1	no.	Max. 108 L/s (Estimate)	\$	824,000	\$	-	\$	824,000	\$	824,000	
		Elevated support structure for filters, incl. fabricated				-		Ŧ		Ŧ		-	,	
6.5		steelwork for handrails, stairs etc.	1	no.	Allowance	\$	175,000	\$	50,000	\$	125,000	\$	175,000	
	1	Deeleweek line flow meter	1			•				\$	4.000	\$	4,000	
6.6		Backwash line flow meter		no.	Estimate	\$	4,000	\$	-	J D	4,000	Φ	4,000	

7.0	Effluent Storage Tank											\$	513,000
	Modifications to existing tank (IAT) internals (pipework &												
7.1	ex-aerator supports)	1	no.	Allowance	\$	23,000	\$ 23,0	000	\$-	\$	23,000		
	New colorbond roof covers on existing IAT, incl. steel roof												
7.2	truss supports	570	m2	Estimate	\$	790	\$ 450,0	000	\$-	\$	450,000		
7.3	Modifications to IAT tank outlet/ Pit no. 3 and removal of	1	no.	Allowance	\$	20,000	\$ 20,0	000	\$-	\$	20,000		
7.4	New Pipework connections	1	no.	Allowance	\$	20,000	\$ 20,0	000	\$-	\$	20,000		
8.0	UV Disinfection											\$	1,063,000
8.1	UV channels	1	no.	240 L/s (Estimate)	\$	258,000	\$ 258,0	000	\$ -	\$	258,000	+	
8.2	UV disinfection equipment	1	no.	240 L/s (Estimate); dose 30 mJ/cm^2	\$	720,000	, , ,		\$ 720,000	\$	720,000		
0.2		1	110.	Estimate (Colourbond	Ψ	720,000	Ψ	-	φ 720,000	Ψ	720,000	-	
8.3	UV control/ switchroom building	1	no.	building, airconditioned)	\$	85,000	\$ 85,0	000	\$-	\$	85,000		
9.0	Chemical Storage & Dosing											\$	402,000
9.1	Alum Storage Facility (incl. Bunding)	1	no.	Estimate	\$	189,000	\$ 189,0	000	\$-	\$	189,000		
9.2	Alum Dosing Pumps, skid & pipework	1	no.	Estimate	\$	29,000	\$	-	\$ 29,000	\$	29,000		
9.3	Alum Bund Sump Pump	1	no.	Estimate	\$	5,000	\$	-	\$ 5,000	\$	5,000		-
9.4	Sodium Hydroxide Storage Facility (incl. Bunding)	1	no.	Estimate	\$	147,000	\$ 147,0	000	\$ -	\$	147,000		
9.5	Sodium Hydroxide Dosing Pumps, skid & pipework	1	no.	Estimate	\$	27,000	\$	-	\$ 27,000	\$	27,000		
9.6	Sodium Hydroxide Sump Pump	1	no.	Estimate	\$	5,000	\$	-	\$ 5,000	\$	5,000		
10.0	Aerobic Digester											\$	469.000
10.1	Modifications to existing tank (DAT) internals (pipework & ex-aerator supports)	1	no.	Allowance	\$	23,000	\$ 23,0	000	\$-	\$	23,000		
10.2	Aeration System	1	no.	Max. 418 Nm3/h (Estimate)	\$	228,000	\$	-	\$ 228,000	\$	228,000		
10.3	Blowers for digester	2	no.	7.5 kW (Estimate)	\$	23,000	\$	-	\$ 46,000	\$	46,000		
10.4	Decanter mechanism (for supernatant withdrawal)	1	no.	~11 L/s, Allowance	\$	82,000	\$	-	\$ 82,000	\$	82,000		
10.5	Internal pipework & valves	1	no.	Allowance	\$	90,000	\$ 90,0	000	\$-	\$	90,000		

10.0	Sludge Dewatering & Biosolids Storage												\$	1,327,000
10.1	New Gravity Drainage Deck & Belt Filter Press	1	no.	175 kg/h feed (Estimate)	\$	330,000	\$	-	\$	330,000	\$	330,000		
10.2	Sludge Feed Pump Station	1	no.	6 L/s (Estimate)	\$	125,000		100,000	\$	25,000	\$	125,000		
10.3	Washwater Pump Station	1	no.	3 L/s (Estimate)	\$	70,000	\$	56,000	\$	14,000		70,000		
10.4	Polymer Make-up and Dosing System	1	no.	4 kg/d, 4 L/min (Estimate)	\$	50,000	\$	-	\$	50,000	\$	50,000		
10.5	Dewatering Building	1	no.	200 m2 (Allowance)	\$	400,000	\$	400,000	\$	-	\$	400,000		
10.6	Biosolids Cake Conveyors (to Storage Facility)	2	no.	10 m L (Allowance)	\$	20,000	\$	-	\$	40,000	\$	40,000		
10.7	Biosolids Storage Facility	1	no.	200 m2 (Allowance)	\$	312,000	\$	312,000	\$	-	\$	312,000		
11.0	Switchroom & Blower Room										-		\$	800,000
11.1	Switchroom building	1	no.	150 m2	\$	360,000	\$	360,000	\$	-	\$	360,000	Ŧ	
11.2	Blower room building	1	no.	250 m2	\$	440,000	\$	440,000	\$	-	\$	440,000		
12.0	Pump Stations (where not included above)												\$	259,000
12.1	Scum Pump Station	1	No.	~1 L/s	\$	44,000	\$	35,000	\$	9,000	\$	44,000		
12.2	Service Water System	1	No.	~5 L/s	\$	97,000	\$	78,000	\$	19,000	\$	97,000		-
12.3	General Purpose (Site Utility) pump station	1	No.	~20 L/s	\$	118,000	\$	94,000	\$	24,000	\$	118,000		
13.0	Plant Pipework & Valves												\$	1,441,000
13.1	Flow splitter to Anaerobic Reactor	60	m	DICL DN 450	\$	720	\$	43,200	\$	-	\$	43,200		
13.2	Flow splitter to Stormflow Lagoon (wet weather by-pass)	100	m	DICL DN 450	\$	720	\$	72,000	\$	-	\$	72,000		
13.3	Anaerobic Reactor to Ox Ditch	1	no.	Allowance	\$	50,000	\$	50,000	\$	-	\$	50,000		
13.4	Oxidation Ditch to Anoxic Reactor	1	no.	Allowance	\$	50,000	\$	50,000	\$	-	\$	50,000		
13.5	Secondary Reactor to Flow Splitter	35	m	DICL DN 500	\$	900	\$	31,500	\$	-	\$	31,500		
13.6	Flow Splitter to Sec. Clarifiers (2 no.)	40	m	DICL DN 450	\$	720	\$	28,800	\$	-	\$	28,800		
13.7	Sec. Clarifiers (2 no.) to UV	40	m	DICL DN 300	\$	400	\$	16,000	\$	-	\$	16,000		
13.8	Sec. Clarifiers (Combined) to UV	20	m	DICL DN 450	\$	720	\$	14,400	\$	-	\$	14,400		
13.9	UV to Effluent Outfall	150	m	DICL DN 500	\$	900	\$	135,000	\$	-	\$	135,000		
14.00	Allowance for all other pipework & valves on plant	1	No.	Allowance	\$	1,000,000	\$	1,000,000	\$	-	\$	1,000,000		
14.0	Roads, Car Park, Fencing & Landscaping												\$	480,000
14.1	Earthworks	1	No.	Allowance	\$	79,000		79,000		-	\$	79,000		
14.2	Paving	1	No.	Allowance	\$	233,000	\$	233,000		-	\$	233,000		
14.3	Road Kerbing	1	No.	Allowance	\$	51,000	\$	51,000		-	\$	51,000		
14.4 14.5	Signs Fencing	1	No. No.	Allowance	\$ \$	3,000 50,000	\$ \$	3,000 50,000	ֆ Տ	-	\$ \$	3,000 50,000		
14.5	Landscaping	1	No.	Allowance Allowance	Դ Տ	64,000	ֆ \$	64,000	•	-	ֆ \$	64,000		
14.0			110.	Allowalloc	Ψ	0,000	Ψ	04,000	Ψ		Ψ	0,000		

15.0	General Site Works										\$	300,000
15.1	Plant commissioning	1	No.	Allowance	\$ 300,000	\$	150,000	\$	150,000	\$ 300,000		· · · ·
16.0	Electrical and Instrumentation										\$	2,781,000
16.1	Conduits (100mm PVC)	2%						\$	47,000	\$ 47,000		. <u> </u>
16.2	Pits	3%						\$	85,000	\$ 85,000		
16.3	Supply, Install and Terminate Cables	21%						\$	579,000	\$ 579,000		
16.4	Switchboards	3%						\$	84,000	\$ 84,000		
16.5	Motor Control Centres (MCC's)	13%						\$	359,000	\$ 359,000		
16.6	Motor Starters	5%						\$	129,000	\$ 129,000		
16.7	Local Controls	2%						\$	54,000	\$ 54,000		
16.8	Instrumentation	9%						\$	248,000	\$ 248,000		
16.9	PLCs	3%						\$	73,000	\$ 73,000		
16.10	SCADA system incl. programming	4%						\$	107,000	\$ 107,000		
16.11	PCs in Control Room	1%						\$	17,000	\$ 17,000		
16.12	Substation	1%						\$	19,000	\$ 19,000		
16.13	Standby Generator	20%						\$	548,000	\$ 548,000		
16.14	Lighting	4%						\$	101,000	\$ 101,000		
16.15	Other Items	12%						\$	331,000	\$ 331,000		
	Direct Job Costs (Sub-Total 1)					\$	11,249,000	\$	7,355,000		\$	18,603,000
	Indirect Job Costs (Engineering, Site Costs, Project Administration etc.)					\$	2,249,800	\$	1,471,000		\$	3,721,000
	Risk and Contingency	30%	of DJC	+ IJC		\$	4,049,640	\$	2,647,800		\$	6,698,000
	Head Contractor Margin	10%	of DJC			\$	1,124,900	\$	735,500		\$	1,861,000
	PROJECT SUB-TOTAL (Sub-Total 2)					\$	18,674,000	\$	12,210,000		\$	30,883,000
						Ŷ		Ŷ	,_ 10,000		Ŧ	
	TOTAL PROJECT BUDGET					\$	18,674,000	\$	12,210,000			\$30,883,000

Appendix K Operating cost estimates

BVSTP Operating Cost Estimate at Design Flow & Load

Option 1: OD 25,000 EP (Nominal) Capacity Augmentation Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration) Includes new Aerobic Digester 5.70 ML/d Design ADWF 628 L/s PWWF (nominal) augmentation

	ITEM				Qty/Yr	Unit	F	Rate		1	otal		Comments
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	ls)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer		-	5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
			-										
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	k٧	/Vh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,1	24,266	\$	213,611			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	¢	40	\$	152,083			Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs
4.1	Contractor studge disposar	50	1270	1250	3602	wet tonne	φ	40	φ	152,065			
5.0	Other Oresting Costs										•	05 000	
5.0	Other Operating Costs Allowance (for various)								¢	05 000	Þ	85,000	
5.1	Allowance (for various)								\$	85,000			
	Maintenana Francesa										•	226,000	
6.0 6.1	Maintenance Expenses Civil maintenance (new)	Total Civils	\$ 13,825,000			_	C	0.4%	\$	55,300	Þ	226,000	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000					2.4%	φ \$	145,392			M&E/I maintenance costs assumed to be 0.4% of capital costs (new Structures)
6.3	Lagoon/ wetland maintenance	Allowance	φ 0,000,000		1	no.	\$	25,000	ф \$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
0.5		Allowalice			1	110.	Ψ	20,000	φ	25,000			Approx. weitand maintenance costs (2013-14) at Byton STP
						I	L	TOTAL			\$ 1	,082,000	per vear
								al \$/ML			\$		per kL
L							1010	2. ψ/ IVIΕ			Ŧ	010	P++ ··-

Page 1 of 10

BVSTP Operating Cost Estimate at Flow & Load in year 2035-36 (projected)

 Option 1: OD
 18,000 EP (Nominal) Loading in year 2035-36

 Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); one clarifier deferred Includes new Aerobic Digester

 4.32
 ML/d Design ADWF

 Ox. Ditch with Second to the second

1.0 Staff Exponses 1 Operator salary (Includes Orheads) 1 no. \$ 120,000 \$ 120,000 \$ 120,000 Part-time of one FTE full-time operators 1.2 Other staff costs Ave Lid SG kg/L Ave kg/d 243 forme \$ 120,000 \$ 120,000 \$ 171,000 Part-time of one FTE full-time operators 2.1 Alum 509 1.31 666 243 forme \$ 9,000 \$ 45,525 forme \$ 9,000 \$ 44,783 Forme \$ 9,000 \$ 44,493 Forme \$ 9,000 \$ 14,783 \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 \$ 100,000 \$ 100,000 \$ 100,000		ITEM				Qty/Yr	Unit		Rate		Т	otal		Comments
1.1 Operator salary (includes Ofheads) 1 no. \$ 120,000 \$ 120,000 \$ 120,000 \$ 120,000 Partime of one FTE ful-lime operators 2.0 Chemical Expenses Ave L/d SS kg/L Ave kg/d 243 tonne \$ 5, 200,00 \$ 142,000 \$ 142,000 \$ 142,000 Partime of one FTE ful-lime operators 2.1 Alum 509 1,31 666 243 tonne \$ 6,000 \$ 147,030 2.2 Polymer 134 1,50 201 73 tonne \$ 6623 \$ 48,449 Ferric Sulphate 14 1,58 180 666 tonne \$ 623 \$ 221,03 \$ 222,000 \$ 222,000 \$ 48,449 \$ 44,49 \$ 44,49 \$ 44,49 \$ 44,49 \$ 44,49 \$ 44,49 \$ 44,49 \$ 50,90 \$ 48,449 \$ 50,90 \$ 48,449 \$ 50,90 \$ 44,49 \$ 50,90 \$ 44,49 \$ 50,90 \$ 44,49 \$ 50,90 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100 \$ 50,100														
1.2 Other staff costs 0.5 no. \$ 120,000 \$ 60,000 Part-time of one FTE for support staff (collectively) 2.0 Chemical Expenses Ave L/d SG kg/L Ave kg/d 24 Tonne \$ 271 \$ 65,925 \$ 171,000 \$ 171,0	1.0	Staff Expenses										\$	180,000	
2.0 Chemical Expenses Ave L/d SG kg/L Ave kg/d Ave kg/d S 1.31 6666 243 tonne \$ 2.71 \$ 65.925 171,000 2.1 Alum 509 1.31 6666 243 tonne \$ 9,000 \$ 14.783 <td< td=""><td>1.1</td><td>Operator salary (Includes O'head</td><td>ls)</td><td></td><td></td><td>1</td><td>no.</td><td>\$</td><td>120,000</td><td>\$</td><td>120,000</td><td></td><td></td><td>One FTE full-time operators</td></td<>	1.1	Operator salary (Includes O'head	ls)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
2.1 Alum 509 1.31 666 243 tonne \$ 271 \$ 65.925 1 2.2 Polymer 4.5 1.6 tonne \$ 9.000 \$ 14,783 14.783 2.4 Ferric Sulphate 114 1.58 180 666 tonne \$ 623 \$ 48,449 3.0 Electricity Expenses PP Ave kW Hrs/yr KWh/(EP.y) \$rkWh \$kWh/Yr \$ 221,063 \$ 222,000 4.0 Sludge Disposal Expenses Ave g/(EP/d) Cake ds Ave.kg/d ds \$ 0.190 1,163,488 \$ 221,063 \$ 122,000 4.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne \$ 121,667 Conservative estimate, range -\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.1 Allowance (for various) 5 13,825,000 - - 0.4% \$ 55,300 Civil maintenance costs assumed to be 0.4% of capital costs (new structures) 6.1 Civil maintenance (new) Total Civils \$ 13,825,000 - - - 0.4% \$ 55,300 Civil maintenance costs assumed t	1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.1 Alum 509 1.31 666 243 tonne \$ 271 \$ 65.925 1 2.2 Polymer 4.5 1.6 tonne \$ 9.000 \$ 14,783 14.783 2.4 Ferric Sulphate 114 1.58 180 666 tonne \$ 623 \$ 48,449 3.0 Electricity Expenses PP Ave kW Hrs/yr KWh/(EP.y) \$rkWh \$kWh/Yr \$ 221,063 \$ 222,000 4.0 Sludge Disposal Expenses Ave g/(EP/d) Cake ds Ave.kg/d ds \$ 0.190 1,163,488 \$ 221,063 \$ 122,000 4.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne \$ 121,667 Conservative estimate, range -\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.1 Allowance (for various) 5 13,825,000 - - 0.4% \$ 55,300 Civil maintenance costs assumed to be 0.4% of capital costs (new structures) 6.1 Civil maintenance (new) Total Civils \$ 13,825,000 - - - 0.4% \$ 55,300 Civil maintenance costs assumed t														
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2.3 Sodium Hydroxide 134 1.50 201 73 tome \$\$ 660 \$\$ 4,449 \$\$ 40.911 \$\$ 0 0 0 0 133 8,760 \$\$ \$\$ 0 0 0 0 133 8,760 \$\$ \$\$ 0.900 133 8,760 \$\$ \$\$ 221,063 \$\$ 222,000 \$\$ 0	2.1		509	1.31	666	243	tonne	\$	271	\$	65,925			
2.4 Ferric Sulphate 114 1.58 180 66 tonne \$ 623 \$ 40,911 3.0 Electricity Expenses Total plant power $Operating20,000 EP133 Ave kW17s/r20,000 Hrs/yr133 kWh/(EP.y)58.2 $ 0.190 1,163,488 $ 221,063 $ 222,000 Conservative estimate, range ~$20 to $35/ wet tonne based on informationsupplied by Byron Shire Council for current disposal costs 4.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne $ 40 $ 121,667 Conservative estimate, range ~$20 to $35/ wet tonne based on informationsupplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs 50 12% 1000 3042 wet tonne $ 40 $ 121,667 Conservative estimate, range ~$20 to $35/ wet tonne based on informationsupplied by Byron Shire Council for current disposal costs 6.0 Maintenance Expenses - - 0.4% $ 55,300 - - 0.4% - - 0.4% - - 0.4% - - 0.4% - - 0.4% - - 0.4% 5 50,300 - - - 0.4% 5 50,300 -$	2.2	Polymer		_		1.6	tonne	\$	9,000	\$	14,783			
3.0 Electricity Expenses Total plant power Operating EP 20,000 Ave. kW Hrs/yr 133 kWh/(EP.y) 58.2 \$/kWh/ 58.2 \$/kWh/ 58.2 kWh/(Yr 1,163,488 \$ 222,000 conservative estimate, range -\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 4.0 Sludge Disposal Expenses Ave. g/(EP/d) Cake ds Ave. kg/d ds 3042 wet tonne \$ 122,000 Conservative estimate, range -\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs 50 12% 1000 3042 wet tonne \$ \$ 122,000 Conservative estimate, range -\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs 50 12% 1000 3042 wet tonne \$ \$ \$ 226,000 Civil maintenance costs assumed to be 0.4% of capital costs (new structures) \$ 6.1 Civil maintenance (new) Total Civils<\$ 13,825,000	2.3	Sodium Hydroxide	134	1.50	201	73	tonne	\$	660	\$	48,449			
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3.0 Electricity Expenses EP Ave kW Hrs/yr kWh/(EP.y) \$/kWh kWh/Yr \$ 222,000 4.0 Sludge Disposal Expenses Ave. g/(EP/d) Cake ds Ave. kg/d ds \$ 0.190 1,163,488 \$ 221,063 Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 4.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne \$ 40 \$ 121,667 Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs 50 12% 1000 3042 - - 0.4% \$ 55,000 S S 56,000 S S 56,000 S 55,300 S S 55,300 S 55,300 S 145,392 S 56,000 S 145,392 S 145,392 Approx. wetland maintenance costs assumed to be 0.4% of capital costs (new M&E/I) 6.2 M&E maintenance (new) Total M&E \$ 6,058,000 1 - 2.4% 25,000 S 145,392 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>														
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A.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne \$ 40 \$ 121,667 Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs 5.1 Allowance (for various) 4.1 Contactor sludge disposal Total Civils \$ 13,825,000 \$ 85,000 \$ 85,000 \$ 226,000 \$ wet tonne \$ 40 \$ 55,300 \$ Maintenance costs assumed to be 0.4% of capital costs (new structures) 6.1 Civil maintenance (new) Total M&E \$ 6,058,000 - - 0.4% \$ 55,300 Civil maintenance costs assumed to be 0.4% of capital costs (new structures) M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I) - 2.4% \$ 25,000 \$ 25,000 M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I) Approx. wetland maintenance costs (2013-14) at Byron STP TOTAL TOTAL Total M&E \$ 6,058,000 1 - 2.4% \$ 25,000 * 40 ME/I Approx. wetland maintenance costs (2013-14) at Byron STP Total M&E \$ 6,058,000 1 - 2.4% \$ 25,000 * 1006,000 </td <td>4.0</td> <td>Chudna Diananal Emanana</td> <td></td> <td>Calva da</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>¢</td> <td>400.000</td> <td></td>	4.0	Chudna Diananal Emanana		Calva da								¢	400.000	
4.1 Contractor sludge disposal 50 12% 1000 3042 wet tonne \$ 40 \$ 121,667 supplied by Byron Shire Council for current disposal costs 5.0 Other Operating Costs - - - - \$ 85,000 \$ -<	4.0	Sludge Disposal Expenses	Ave. g/(EP/d)		Ave. kg/a as							Þ	122,000	Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
5.0 Other Operating Costs 5.1 Allowance (for various) 6.0 Maintenance Expenses 6.1 Civil maintenance (new) 6.2 M&E maintenance (new) 7.1 Allowance 6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 5.3 Total Civils 5.4 0.4% 5.5 5,300 6.1 Civil maintenance (new) 7.4 2.4% 5 145,392 6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 25,000 \$ 1 no. 5 25,000 5 1,006,000 per year	4.1	Contractor sludge disposal	50	12%	1000	3042	wet tonne	\$	40	\$	121.667			
5.1 Allowance (for various) 6.0 Maintenance Expenses 6.1 Civil maintenance (new) 6.2 M&E maintenance (new) 7.1 no. 5.1 Civil maintenance (new) 7.1 0.4% 5.2 M&E maintenance (new) 7.1 1 1 no. 5.1 Civil maintenance (new) 7.2.4% \$ 145,392 6.3 Lagoon/ wetland maintenance Allowance 1 1 no. 5 25,000 5 25,000 5 25,000 5 25,000 5 25,000 5 25,000 5 25,000 5 25,000 5 1,006,000 per year		. .		1				•		Ť	,			
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6.0 Maintenance Expenses 6.1 Civil maintenance (new) Total Civils \$ 13,825,000 6.2 M&E maintenance (new) Total M&E \$ 6,058,000 6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 25,000 \$ 1,006,000 Per year										\$	85.000	•	,	
6.1 Civil maintenance (new) Total Civils \$ 13,825,000 6.2 M&E maintenance (new) Total M&E \$ 6,058,000 6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 25,000 \$ 145,392 Approx. wetland maintenance costs (2013-14) at Byron STP TOTAL TOTAL	0.1									Ť	00,000			
6.1 Civil maintenance (new) Total Civils \$ 13,825,000 6.2 M&E maintenance (new) Total M&E \$ 6,058,000 6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 25,000 \$ 145,392 Approx. wetland maintenance costs (2013-14) at Byron STP TOTAL TOTAL	6.0	Maintenance Expenses										\$	226.000	
6.3 Lagoon/ wetland maintenance Allowance 1 no. \$ 25,000 \$ 25,000 Approx. wetland maintenance costs (2013-14) at Byron STP TOTAL TOTAL \$ 1,006,000 per year			Total Civils	\$ 13,825,000			-		0.4%	\$	55,300	•	,	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
TOTAL \$ 1,006,000 per year	6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000			-	:	2.4%	\$	145,392			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
	6.3	Lagoon/ wetland maintenance	Allowance			1	no.	\$	25,000	\$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
		y								Ľ				
						•	•		TOTAL			\$ 1	,006,000	per year
								Tot	al \$/ML			\$		

BVSTP Operating Cost Estimate at Design Flow & Load

Option 2: OD 25,000 EP (Nominal) Capacity Augmentation Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration) Includes new Aerobic Digester 5.70 ML/d Design ADWF 628 L/s PWWF (nominal) augmentation

	ITEM				Qty/Yr	Unit		Rate		1	otal		Comments
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	is)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer		_	5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
			-										
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	k١	Wh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,1	124,266	\$	213,611			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	¢	40	\$	152,083			Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs
4.1	Contractor studge disposar	50	1270	1250	3002	wet torme	φ	40	φ	152,065			supplied by Byron Shire Council for current disposal costs
5.0	Other Oresting Costs											85,000	
5.0	Other Operating Costs Allowance (for various)								¢	05 000	Þ	85,000	
5.1	Allowance (for various)								\$	85,000			
6.0	Maintenance Expenses										¢	226,000	
6.0 6.1	Civil maintenance (new)	Total Civils	\$ 13.825.000			_		0.4%	\$	55,300	Þ	220,000	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000					2.4%	\$	145,392			M&E/I maintenance costs assumed to be 2.4% of capital costs (new structures)
6.3	Lagoon/ wetland maintenance	Allowance	\$ 0,000,000		1	no.	\$	25,000	φ \$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
0.5		Allowalice			'	10.	φ	25,000	φ	25,000			Approx. wettand maintenance costs (2013-14) at Byton STP
						I	I,	TOTAL			\$ 1	,082,000	per vear
								al \$/ML			ŝ.		per kL
L							. 01	α. φ. ΙΝΙΕ			7	010	[F*: ··=

BVSTP Operating Cost Estimate at Flow & Load in year 2035-36 (projected)

Option 2: OD 18,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); one new clarifier deferred Includes new Aerobic Digester

4.32 ML/d Design ADWF

	ITEM				Qty/Yr	Unit		Rate			Total		Comments
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	ls)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	170,000	
2.1	Alum	509	1.31	666	243	tonne	\$	271	\$	65,925		-	
2.2	Polymer		1	4.3	1.6	tonne	\$	9,000	\$	14,043			
2.3	Sodium Hydroxide	134	1.50	201	73	tonne	\$	660	\$	48,449			
2.4	Ferric Sulphate	114	1.58	180	66	tonne	\$	623	\$	40,911			
			1										
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	ŀ	kWh/Yr			\$	159,000	
	Total plant power	19,000	95	8,760	44.0	\$ 0.190	8	335,442	\$	158,734			
			Calva da								•		
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	116,000	Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	50	12%	950	2890	wet tonne	\$	40	\$	115,583			supplied by Byron Shire Council for current disposal costs
	÷ .		I				·		Ċ	-,			
5.0	Other Operating Costs										\$	85,000	
5.1	Allowance (for various)								\$	85,000		,	
6.0	Maintenance Expenses										\$	215,000	
6.1	Civil maintenance (new)	Total Civils	\$ 12,556,000			-		0.4%	\$	50,224		-	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 5,790,000			-		2.4%	\$	138,960			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
6.3	Lagoon/ wetland maintenance	Allowance			1	no.	\$	25,000	\$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
1								TOTAL			\$		per year
							To	tal \$/ML			\$	587	per kL

BVSTP Operating Cost Estimate at Design Flow & Load

Option 3: OD 25,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); decreased wet weather storage volume Includes new Aerobic Digester 5.70 ML/d Design ADWF

	ITEM				Qty/Yr	Unit	F	Rate			Total		Comments
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	s)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer			5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
		F											
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	k٧	Wh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,1	24,266	\$	213,611			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	
	Contractor oludgo dianogol	50	12%	1250	3802		¢	40	¢	450.000			Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	50	12%	1250	3002	wet tonne	Э	40	\$	152,083			supplied by Byron Shire Council for current disposal costs
											•		
5.0	Other Operating Costs										\$	85,000	
5.1	Allowance (for various)								\$	85,000			
											•		
6.0 6.1	Maintenance Expenses Civil maintenance (new)	Total Civils	\$ 13.082.000					0.4%	\$	52,328	\$	223,000	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
						-							
6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000			-		2.4%	\$	145,392			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
6.3	Lagoon/ wetland maintenance	Allowance			1	no.	\$	25,000	\$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
							· -	TOTAL			¢	1,079,000	por year
								al \$/ML			φ ¢		
							i Ola	ai ə/IVIL			Ф	519	per kL

BVSTP Operating Cost Estimate at Design Flow & Load

Option 4: OD 25,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); major plant process capacity upgrade deferred (to 2032-33)

Includes new Aerobic Digester

5.70 ML/d Design ADWF

	ITEM				Qty/Yr	Unit		Rate			Total		Comments
					-								
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	ls)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer		_	5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
			-										
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	I	kWh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,	,124,266	\$	213,611			
			.										
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	\$	40	\$	152,083			supplied by Byron Shire Council for current disposal costs
7.1	Contractor biologe disposal		12/0	1200	0002	wettonne	Ψ	-10	Ψ	102,000			
5.0	Other Operating Costs										¢	85,000	
5.1	Allowance (for various)								\$	85,000	φ	05,000	
5.1	Allowance (for various)								φ	85,000			
6.0	Maintenance Expenses										¢	226,000	
6.1	Civil maintenance (new)	Total Civils	\$ 13,825,000			-		0.4%	\$	55,300	Ψ	220,000	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000			-		2.4%	\$	145,392			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
6.3	Lagoon/ wetland maintenance	Allowance	,		1	no.	\$	25,000	\$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
					-			- 1	Ť				
								TOTAL			\$ '	1,082,000	per year
1							То	tal \$/ML			\$		per kL

BVSTP Operating Cost Estimate at Flow & Load in year 2035-36 (projected)

Option 4: OD 18,000 EP (Nominal) Loading in year 2035-36 on Existing plant (~114% of Existing Design Load) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

4.32 ML/d Design ADWF

628 L/s PWWF (nominal) augmentation (by-pass of flows >314 L/s to wet weather storage)

	ITEM				Qty/Yr	Unit		Rate			То	tal		Comments
1.0	Staff Expenses										:	\$	180,000	
1.1	Operator salary (Includes O'head	is)			1	no.	\$	120,000		120,00				One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,00	00			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							:	\$	171,000	
2.1	Alum	509	1.31	666	243	tonne	\$	271	\$	65,92	25			
2.2	Polymer			4.7	1.7	tonne	\$	9,000	\$	15,3	74			
2.3	Sodium Hydroxide	134	1.50	201	73	tonne	\$	660	\$	48,44	49			
2.4	Ferric Sulphate	114	1.58	180	66	tonne	\$	623	\$	40,9	11			
			1											
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	k	(Wh/Yr			:	\$	167,000	
	Total plant power	20,000	100	8,760	43.9	\$ 0.190	8	378,518	\$	166,9 [.]	18			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	\$	127,000	
														Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	52	12%	1040	3163	wet tonne	\$	40	\$	126,53	33			supplied by Byron Shire Council for current disposal costs
5.0	Other Operating Costs										:	\$	85,000	
5.1	Allowance (for various)								\$	85,00	00			
6.0	Maintenance Expenses											\$	61,000	
6.1	Civil maintenance (new)	Total Civils	\$ 4,899,000			-		0.5%	\$	24,49	95	•		Civil maintenance costs assumed to be 0.5% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 361,000			-		3.0%	\$	10,83	30			M&E/I maintenance costs assumed to be 3.0% of capital costs (new M&E/I)
6.3	Lagoon/ wetland maintenance	Allowance			1	no.	\$	25,000	\$	25,00				Approx. wetland maintenance costs (2013-14) at Byron STP
							Ť	0	Ē	,0				······································
					I	1		TOTAL				\$	791.000	per year
							Tot	tal \$/ML				Ś.	•	per kL
L								····				4		F

BVSTP Operating Cost Estimate at Design Flow & Load

Option 5: OD 25,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); indefinitely defer/ eliminate wet weather storage Includes new Aerobic Digester

5.70 ML/d Design ADWF

	ITEM				Qty/Yr	Unit		Rate	Total					Comments
1.0	Staff Expenses											\$	180,000	
1.1	Operator salary (Includes O'head	ds)			1	no.	\$	120,000	\$	12	20,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	6	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d								\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	8	86,984		,	
2.2	Polymer			5.6	2.1	tonne	\$	9,000	\$	1	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	6	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	5	53,979			
			-											
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh		kWh/Yr				\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,	124,266	\$	21	13,611			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds								\$	153,000	
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	¢	40	\$	4.5	50.000			Conservative estimate, range ~\$20 to \$35/ wet tonne based on information supplied by Byron Shire Council for current disposal costs
4.1	Contractor sludge disposal	50	1270	1250	3602	wet tonne	Э	40	Ф	10	52,083			supplied by Byron Shire Council for current disposal costs
5.0	Other Operating Costs											\$	85,000	
5.1	Allowance (for various)								\$	8	85,000			
														
6.0 6.1	Maintenance Expenses Civil maintenance (new)	Total Civils	\$ 11,284,000			_		0.4%	\$		45,136	\$	213,000	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 11,284,000 \$ 5,916,000			-		0.4% 2.4%	ֆ Տ		45,136 41,984			M&E/I maintenance costs assumed to be 0.4% of capital costs (new Structures)
6.3	Lagoon/ wetland maintenance	Allowance	φ 5,910,000		1		\$	2.4%	ֆ Տ		41,964 25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
0.3		Allowance			I	no.	φ	25,000	φ	4	20,000			Approx. wettand maintenance costs (2013-14) at byton STP
-					1	1		TOTAL				\$1	,069,000	per year
							To	tal \$/ML				\$	514	per kL

BVSTP Operating Cost Estimate at Design Flow & Load

Option 6: OD 25,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); indefinitely defer/ eliminate wetland Includes new Aerobic Digester

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) augmentation

	ITEM		Qty/Yr Unit Rate Total					Comments					
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'hea	ds)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d							\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer		_	5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
			-										
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh		Wh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,1	24,266	\$	213,611			
			0.1	A									
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	\$	40	\$	152,083			supplied by Byron Shire Council for current disposal costs
			1				•		Ť	,			·····
5.0	Other Operating Costs										\$	85,000	
5.1	Allowance (for various)								\$	85,000	•	,	
									*	,			
6.0	Maintenance Expenses										\$	198,000	
6.1	Civil maintenance (new)	Total Civils	\$ 12,921,000			-	C	0.4%	\$	51,684	•	,	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 6,058,000			-	2	2.4%	\$	145,392			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
								TOTAL			\$ ·	1,054,000	
							Tota	al \$/ML			\$	507	per kL

Byron SC 41/28941

BVSTP Operating Cost Estimate at Design Flow & Load

Option 7: OD 25,000 EP (Nominal) Capacity Augmentation

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration); indefinitely defer/ eliminate new sludge dewaterting facilities Includes new Aerobic Digester

5.70 ML/d Design ADWF

	ITEM			Qty/Yr	Unit	Rate			Total			Comments	
1.0	Staff Expenses										\$	180,000	
1.1	Operator salary (Includes O'head	is)			1	no.	\$	120,000	\$	120,000			One FTE full-time operators
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d				074			\$	224,000	
2.1	Alum	671	1.31	879	321	tonne	\$	271	\$	86,984			
2.2	Polymer			5.6	2.1	tonne	\$	9,000	\$	18,478			
2.3	Sodium Hydroxide	177	1.50	265	97	tonne	\$	660	\$	63,926			
2.4	Ferric Sulphate	150	1.58	237	87	tonne	\$	623	\$	53,979			
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh	kV	Nh/Yr			\$	214,000	
	Total plant power	25,000	128	8,760	45.0	\$ 0.190	1,1:	24,266	\$	213,611			
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds							\$	153,000	
4.0	Sludge Disposal Expenses	Ave. g/(EF/u)		Ave. ky/u us							φ	153,000	Conservative estimate, range ~\$20 to \$35/ wet tonne based on information
4.1	Contractor sludge disposal	50	12%	1250	3802	wet tonne	\$	40	\$	152,083			supplied by Byron Shire Council for current disposal costs
			1				-		Ŧ	,			
5.0	Other Operating Costs										\$	85,000	
5.1	Allowance (for various)								\$	85,000	*	,	
0.1									Ψ	00,000			
6.0	Maintenance Expenses										\$	208,000	
6.1	Civil maintenance (new)	Total Civils	\$ 13,318,000			-	0	0.4%	\$	53,272	•	,	Civil maintenance costs assumed to be 0.4% of capital costs (new structures)
6.2	M&E maintenance (new)	Total M&E	\$ 5,384,000			-		2.4%	\$	129,216			M&E/I maintenance costs assumed to be 2.4% of capital costs (new M&E/I)
6.3	Lagoon/ wetland maintenance	Allowance	÷ 0,00 .,000		1	no.		25,000	\$	25,000			Approx. wetland maintenance costs (2013-14) at Byron STP
0.0		/				110.	Ψ	20,000	Ψ	20,000			
					1		1	TOTAL			\$ 1	,064,000	per year
							Tota	al \$/ML			\$		per kL
L								ΨE			Ŧ	.	F

Ocean Shores STP (Values here from GHD (2014b) Planning Study; except Maintenance costs adjusted to align with the BVSTP Transfer Feasibility Study here) Operating Cost Estimate at Design Flow & Load

Option 2: OD New 5-stage 'Phoredox' Oxidation Ditch Process

With Anaerobic, Secondary Anoxic & Secondary Aerobic Reactors <u>Excludes</u> Effluent Filtration, but includes Effluent Storage (in modified existing IAT), and Aerobic Digester (modified existing DAT) 2.30 ML/d Design ADWF 232 L/s PWWF

ITEM	ITEM				Qty/Yr	Unit	nit Rate			Total			Comments			
1.0	Staff Expenses										\$	120,000				
1.1	Operator salary (Includes O'head	ls)			0.5	no.	\$	120,000	\$	60,000			One FTE full-time operators			
1.2	Other staff costs				0.5	no.	\$	120,000	\$	60,000			Part-time of one FTE for support staff (collectively)			
2.0	Chemical Expenses	Ave L/d	SG kg/L	Ave kg/d	100						\$	68,000				
2.1	Alum	271	1.31	355	130	tonne	\$	271	\$	35,099			After upgrading, 2 mgP/L removal; Before upgrading, 4.5 mgP/L using alum			
2.2	Polymer		1	2.0	0.7	tonne	\$	9,000	\$	6,726			Assuming 4.5 kg poly/ t d.s. biosolids procecessed			
2.3	Sodium Hydroxide	71	1.50	107	39	tonne	\$	660	\$	25,795			To match alkalinity loss from alum dosing (see above)			
3.0	Electricity Expenses	Design EP	Ave kW	Hrs/yr	kWh/(EP.y)	\$/kWh		kWh/Yr			\$	85,000				
0.0	Total plant power	9,100	47	8.760	45.0	\$ 0.190		409,233	\$	77,754	Ŷ		After upgrading			
		0,100		0,100	71.5	¢ 0.100			Ť	,			Before upgrading			
		ADWF, ML/d	Ave kW	Hrs/yr	kWh/ML											
	Effluent transfer	2.18	12	2,920	45.0	\$ 0.190		35,872	\$	6,816						
4.0	Sludge Disposal Expenses	Ave. g/(EP/d)	Cake ds	Ave. kg/d ds	1001						\$	141,000				
4.1	Contractor sludge disposal	50	12%	455	1384	wet tonne	\$	40	\$	55,358			supplied by Byron Shire Council for current disposal costs			
5.0	Other Operating Costs										\$	85.000				
5.1	Allowance (for various)								\$	85,000	Ŷ	00,000				
5.1	Allowance (for various)								Ψ	00,000						
5.0	Maintenance Expenses										\$	265,000	After plant upgrade			
5.1	Civil maintenance (new)	Total Civils	\$ 10,346,000			-		0.5%	\$	51,730			Civil maintenance costs assumed to be 0.5% of capital costs (new structures)			
5.2	M&E maintenance (new)	Total M&E	\$ 6,146,000			-		3.0%	\$	184,380			M&E/I maintenance costs assumed to be 3.0% of capital costs (new M&E/I)			
5.3	Civil maintenance (existing)	Civils	\$ 1,600,000					0.5%	\$	8,000			Civil maintenance costs assumed to be 0.5% of replacment capital cost			
5.4	Lagoon/ wetland maintenance	Allowance			1	no.	\$	20,000	\$	20,000			Approx. 80% of wetland maintenance costs (2013-14) at Byron STP			
								TOTAL			\$	764,000	per year			
							То	otal \$/ML			\$	910	per kL			

Appendix L Net Present Value Analysis

NO DEFERMENT OF CAPITAL ITEMS **Construction Year**

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF 628 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Va
Year Descriptio	on				Сарас	city				(years)	(\$)	(\$)	(\$)	(\$)
2020 BVSTP (\$	Stage 2) Augmentation Works - Civil	8,333 EP			•					50	13,825,000	21,429,000	17,969,531	2,746,341
2020 Raw sewa	age transfer system OS to BVSTP - Civil									50	1,555,000	2,411,000	2,021,771	308,994
2020 BVSTP (S	Stage 2) Augmentation Works - M&E	8,333 EP								20	6,058,000	9,390,000	7,874,091	0
2020 Raw sewa	age transfer system OS to BVSTP - M&E									20	0	0	0	0
2030 BVSTP R	Replace Stage 1 M&E	16,667 EP								20	6,710,000	10,401,000	5,616,258	555,413
2040 BVSTP R	Replace Stage 2 M&E	8,333 EP								20	6,058,000	9,390,000	3,264,936	1,754,991
	· •		OPERATI	NG COSTS at proj	jected ADWF									
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
Year	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	n	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558	
2017	n	108,264	24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
2018	n	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
2019		109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
2020	u	185,953	53,858	39,581	35,568	10,869	85,000	89,457	349,822	180,000		1,030,108	863,809	
2021	п	186,792	54,714	40,210	36,134	11,042	85,000	90,880	349,822	180,000		1,034,594	830,211	
2022	п	187,632	55,571	40,840	36,700	11,215	85,000	92,303	349,822	180,000		1,039,082	797,907	
2023	п	188,474	56,428	41,470	37,265	11,388	85,000	93,725	349,822	180,000		1,043,572	766,846	
2024	n	189,318	57,284	42,099	37,831	11,561	85,000	95,148	349,822	180,000		1,048,064	736,983	
2025	n	190,163	58,141	42,729	38,397	11,733	85,000	96,571	349,822	180,000		1,052,557	708,270	
2026	"	191,011	58,998	43,358	38,963	11,906	85,000	97,994	349,822	180,000		1,057,052	680,665	
2027	"	191,860	59,855	43,988	39,528	12,079	85,000	99,417	349,822	180,000		1,061,549	654,125	
2028	"	192,711	60,711	44,617	40,094	12,252	85,000	100,840	349,822	180,000		1,066,048	628,610	
2029	"	193,564	61,568	45,247	40,660	12,425	85,000	102,263	349,822	180,000		1,070,549	604,081	
2030	"	194,418	62,425	45,877	41,226	12,598	85,000	103,686	349,822	180,000		1,075,052	580,499	
2031	n	195,275	63,281	46,506	41,791	12,771	85,000	105,109	349,822	180,000		1,079,556	557,829	
2032	"	196,133	64,138	47,136	42,357	12,944	85,000	106,532	349,822	180,000		1,084,062	536,035	
2033	"	196,993	64,995	47,765	42,923	13,117	85,000	107,955	349,822	180,000		1,088,570	515,086	
2034	"	197,855	65,851	48,395	43,489	13,289	85,000	109,378	349,822	180,000		1,093,080	494,947	
2035	"	198,719	66,708	49,025	44,055	13,462	85,000	110,801	349,822	180,000		1,097,591	475,588	
2036	"	199,584	67,565	49,654	44,620	13,635	85,000	112,224	349,822	180,000		1,102,105	456,980	
2037	"	200,451	68,421	50,284	45,186	13,808	85,000	113,647	349,822	180,000		1,106,620	439,093	
2038	11	201,320	69,278	50,913	45,752	13,981	85,000	115,070	349,822	180,000		1,111,137	421,900	
2039	11	202,191	70,135	51,543	46,318	14,154	85,000	116,493	349,822	180,000		1,115,656	405,374	
2040	"	203,064	70,992	52,173	46,883	14,327	85,000	117,916	349,822	180,000		1,120,176	389,489	
2041	"	203,938	71,848	52,802	47,449	14,500	85,000	119,339	349,822	180,000		1,124,699	374,222	
2042	n	204,815	72,705	53,432	48,015	14,673	85,000	120,762	349,822	180,000		1,129,223	359,547	
2043	"	205,693	73,562	54,061	48,581	14,845	85,000	122,185	349,822	180,000		1,133,749	345,443	
2044	n	206,572	74,418	54,691	49,146	15,018	85,000	123,607	349,822	180,000		1,138,276	331,888	
2045	n	207,454	75,275	55,321	49,712	15,191	85,000	125,030	349,822	180,000		1,142,806	318,860	
2046	n	208,338	76,132	55,950	50,278	15,364	85,000	126,453	349,822	180,000		1,147,337	306,339	
		200,000	10,102	00,000	00,210	10,004	00,000	1 120,700	010,022	100,000		1,117,007	53,853,336	5,365,739

2020-21

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 1:

Concept Design Option

Option 2:

Concept Design Option

DEFER ONE NEW CLARIFIER

Construction Years 2020-21 / 2035-36

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Val
Year Descripti	lion				Capad	city				(years)	(\$)	(\$)	(\$)	(\$)
2020 BVSTP ((Stage 2a) Augmentation Works - Civil	4,167 EP	4th clarifier deferre	ed						50	12,556,000	19,462,000	16,320,081	2,494,250
2020 Raw sew	wage transfer system OS to BVSTP - Civil									50	1,555,000	2,411,000	2,021,771	308,994
2020 BVSTP ((Stage 2a) Augmentation Works - M&E	4,167 EP	4th clarifier deferre	ed						20	5,790,000	8,975,000	7,526,088	0
2020 Raw sew	wage transfer system OS to BVSTP - M&E									20	0	0	0	0
2030 BVSTP	Replace Stage 1 M&E	16,667 EP								20	6,710,000	10,401,000	5,616,258	555,413
2035 BVSTP ((Stage 2a) Augmentation Works - Civil	8,333 EP	Add 4th clarifier							50	1,269,000	1,967,000	852,305	409,647
2035 BVSTP ((Stage 2a) Augmentation Works - M&E	8,333 EP	Add 4th clarifier							20	268,000	415,000	179,820	49,862
2040 BVSTP	Replace Stage 2a M&E	4,167 EP								20	5,790,000	8,975,000	3,120,639	1,677,428
			OPERATI	NG COSTS at proj	ected ADWF					-				
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
'ear	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
016	"	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558	
017	"	108,264	24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
018	"	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
019	n	109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
020	"	171,966	53,858	39,581	35,568	10,869	85,000	89,457	341,022	180,000		1,007,321	844,700	
021	n	172,805	54,714	40,210	36,134	11,042	85,000	90,880	341,022	180,000		1,011,807	811,925	
022	n	173,645	55,571	40,840	36,700	11,215	85,000	92,303	341,022	180,000		1,016,295	780,409	
2023	n	174,487	56,428	41,470	37,265	11,388	85,000	93,725	341,022	180,000		1,020,785	750,102	
2024	n	175,330	57,284	42,099	37,831	11,561	85,000	95,148	341,022	180,000		1,025,276	720,959	
2025	"	176,176	58,141	42,729	38,397	11,733	85,000	96,571	341,022	180,000		1,029,770	692,937	
2026	n	177,023	58,998	43,358	38,963	11,906	85,000	97,994	341,022	180,000		1,034,265	665,992	
2027	n	177,873	59,855	43,988	39,528	12,079	85,000	99,417	341,022	180,000		1,038,762	640,084	
2028	н	178,724	60,711	44,617	40,094	12,252	85,000	100,840	341,022	180,000		1,043,261	615,173	
2029	"	179,576	61,568	45,247	40,660	12,425	85,000	102,263	341,022	180,000		1,047,762	591,222	
2030	н	180,431	62,425	45,877	41,226	12,598	85,000	103,686	341,022	180,000		1,052,264	568,194	
2031	п	181,288	63,281	46,506	41,791	12,771	85,000	105,109	341,022	180,000		1,056,769	546,054	
2032	п	182,146	64,138	47,136	42,357	12,944	85,000	106,532	349,822	180,000		1,070,075	529,119	
033	п	183,006	64,995	47,765	42,923	13,117	85,000	107,955	349,822	180,000		1,074,583	508,467	
2034	п	183,868	65,851	48,395	43,489	13,289	85,000	109,378	349,822	180,000		1,079,093	488,614	
035	n	198,719	66,708	49,025	44,055	13,462	85,000	110,801	349,822	180,000		1,097,591	475,588	
036	n	199,584	67,565	49,654	44,620	13,635	85,000	112,224	349,822	180,000		1,102,105	456,980	
037	п	200,451	68,421	50,284	45,186	13,808	85,000	113,647	349,822	180,000		1,106,620	439,093	
2038	п	201,320	69,278	50,913	45,752	13,981	85,000	115,070	349,822	180,000		1,111,137	421,900	
2039	п	202,191	70,135	51,543	46,318	14,154	85,000	116,493	349,822	180,000		1,115,656	405,374	
2040	n	203,064	70,992	52,173	46,883	14,327	85,000	117,916	349,822	180,000		1,120,176	389,489	
041	n	203,938	71,848	52,802	47,449	14,500	85,000	119,339	349,822	180,000		1,124,699	374,222	
2042	n	204,815	72,705	53,432	48,015	14,673	85,000	120,762	349,822	180,000		1,129,223	359,547	
2043	n	205,693	73,562	54,061	48,581	14,845	85,000	122,185	349,822	180,000		1,133,749	345,443	
2044	n	206,572	74,418	54,691	49,146	15,018	85,000	123,607	349,822	180,000		1,138,276	331,888	
2045	н	207,454	75,275	55,321	49,712	15,191	85,000	125,030	349,822	180,000		1,142,806	318,860	
2046	"	208,338	76,132	55,950	50,278	15,364	85,000	126,453	349,822	180,000		1,147,337	306,339	
				,000	,•		,000	,	,	,	1	.,,	52,541,759	5,495,595

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 3:

Concept Design Option SMALLER/ DEFERRED WET WEATHER STORAGE 15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d)

Construction Year 2020-21 / 2035-36

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) capacity (existing)

			CAPIT	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Val
rear De	escription				Capac	city				(years)	(\$)	(\$)	(\$)	(\$)
2020 B	VSTP (Stage 2) Augmentation Works - Civil	8,333 EP								50	13,082,000	20,278,000	17,004,347	2,598,829
2020 Ra	aw sewage transfer system OS to BVSTP - Civil									50	1,555,000	2,411,000	2,021,771	308,994
2020 B	VSTP (Stage 2) Augmentation Works - M&E	8,333 EP								20	6,058,000	9,390,000	7,874,091	0
2020 Ra	aw sewage transfer system OS to BVSTP - M&E									20	0	0	0	0
2030 B	VSTP Replace Stage 1 M&E	16,667 EP								20	6,710,000	10,401,000	5,616,258	555,413
2035 Ad	dditional Wet Weather Storage - Civil									50	743,000	1,151,000	498,730	239,707
2040 B	VSTP Replace Stage 2 M&E	8,333 EP								20	6,058,000	9,390,000	3,264,936	1,754,991
			OPERATIN	NG COSTS at proj	ected ADWF									
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
/ear	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	11	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558	
2017	11	108,264	24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
2018	n	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
2019	n	109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
2020	n	185,953	53,858	39,581	35,568	10,869	85,000	89,457	347,422	180,000		1,027,708	861,796	
2021	11	186,792	54,714	40,210	36,134	11,042	85,000	90,880	347,422	180,000		1,032,194	828,285	
2022	n	187,632	55,571	40,840	36,700	11,215	85,000	92,303	347,422	180,000		1,036,682	796,064	
2023	n	188,474	56,428	41,470	37,265	11,388	85,000	93,725	347,422	180,000		1,041,172	765,083	
2024	n	189,318	57,284	42,099	37,831	11,561	85,000	95,148	347,422	180,000		1,045,664	735,295	
2025	"	190,163	58,141	42,729	38,397	11,733	85,000	96,571	347,422	180,000		1,050,157	706,655	
2026	n	191,011	58,998	43,358	38,963	11,906	85,000	97,994	347,422	180,000		1,054,652	679,120	
2027	н	191,860	59,855	43,988	39,528	12,079	85,000	99,417	347,422	180,000		1,059,149	652,647	
2028	п	192,711	60,711	44,617	40,094	12,252	85,000	100,840	347,422	180,000		1,063,648	627,195	
2029	п	193,564	61,568	45,247	40,660	12,425	85,000	102,263	347,422	180,000		1,068,149	602,726	
2030	н	194,418	62,425	45,877	41,226	12,598	85,000	103,686	347,422	180,000		1,072,652	579,203	
2031	н	195,275	63,281	46,506	41,791	12,771	85,000	105,109	347,422	180,000		1,077,156	556,589	
2032	н	196,133	64,138	47,136	42,357	12,944	85,000	106,532	347,422	180,000		1,081,662	534,849	
2033	n	196,993	64,995	47,765	42,923	13,117	85,000	107,955	347,422	180,000		1,086,170	513,950	
2034	п	197,855	65,851	48,395	43,489	13,289	85,000	109,378	347,422	180,000		1,090,680	493,860	
2035	п	198,719	66,708	49,025	44,055	13,462	85,000	110,801	347,422	180,000		1,095,191	474,548	
2036	n	199,584	67,565	49,654	44,620	13,635	85,000	112,224	347,422	180,000		1,099,705	455,985	
2037	п	200,451	68,421	50,284	45,186	13,808	85,000	113,647	347,422	180,000		1,104,220	438,141	
2038	n	201,320	69,278	50,913	45,752	13,981	85,000	115,070	347,422	180,000		1,108,737	420,988	
2039	n	202,191	70,135	51,543	46,318	14,154	85,000	116,493	347,422	180,000		1,113,256	404,502	
2040	"	203,064	70,992	52,173	46,883	14,327	85,000	117,916	347,422	180,000		1,117,776	388,655	
2041	n	203,938	71,848	52,802	47,449	14,500	85,000	119,339	347,422	180,000		1,122,299	373,423	
2042	n	204,815	72,705	53,432	48,015	14,673	85,000	120,762	347,422	180,000		1,126,823	358,783	
2043	11	205,693	73,562	54,061	48,581	14,845	85,000	122,185	347,422	180,000		1,131,349	344,712	
2044	н	206,572	74,418	54,691	49,146	15,018	85,000	123,607	347,422	180,000		1,135,876	331,188	
2045	n	207,454	75,275	55,321	49,712	15,191	85,000	125,030	347,422	180,000		1,140,406	318,190	
2046	"	208,338	76,132	55,950	50,278	15,364	85,000	126,453	347,422	180,000		1,144,937	305,698	
			.,			.,	1,		. ,			, .,	53,354,386	5,457,934

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 4:

Concept Design Option

DEFER MAJOR PROCESS AUGMENTATION

Construction Years 2020-21 / 2035-36

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Val
Year Descriptio	n				Сарас	city				(years)	(\$)	(\$)	(\$)	(\$)
2020 BVSTP (S	Stage 2a) Augmentation Works - Civil	4,167 EP	Major Process aug	mentation deferred	1					50	4,899,000	7,594,000	6,368,035	973,247
2020 Raw sewa	age transfer system OS to BVSTP - Civil									50	1,555,000	2,411,000	2,021,771	308,994
2020 BVSTP (S	Stage 2a) Augmentation Works - M&E	4,167 EP	Major Process aug	mentation deferred	1					20	361,000	560,000	469,594	0
2020 Raw sewa	age transfer system OS to BVSTP - M&E									20	0	0	0	0
2030 BVSTP Re	eplace Stage 1 M&E	16,667 EP								20	6,710,000	10,409,000	5,620,578	555,841
2035 BVSTP (S	Stage 2b) Augmentation Works - Civil	8,333 EP	Major Process aug	gmentation						50	8,926,000	13,835,000	5,994,730	2,881,277
2035 BVSTP (S	Stage 2b) Augmentation Works - M&E	8,333 EP	Major Process aug	gmentation						20	5,697,000	8,830,000	3,826,055	1,060,925
2040 BVSTP Re	eplace Stage 2a M&E	4,167 EP								20	361,000	560,000	194,714	104,664
				NG COSTS at proj				•						
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
Year	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	n	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558	
2017	"	108,264	24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
2018	Π	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
2019	п	109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
2020	п	141,661	80,786	59,371	35,568	11,521	85,000	94,824	320,597	180,000		1,009,329	846,384	
2021	"	142,499	82,072	60,315	36,134	11,704	85,000	96,332	320,597	180,000		1,014,654	814,210	
2022	"	143,339	83,357	61,260	36,700	11,888	85,000	97,841	320,597	180,000		1,019,981	783,239	
2023	I	144,181	84,642	62,204	37,265	12,071	85,000	99,349	320,597	180,000		1,025,310	753,427	
2024	I	145,025	85,927	63,149	37,831	12,254	85,000	100,857	320,597	180,000		1,030,640	724,731	
2025	II.	145,870	87,212	64,093	38,397	12,437	85,000	102,366	320,597	180,000		1,035,973	697,111	
2026	"	146,718	88,497	65,037	38,963	12,621	85,000	103,874	320,597	180,000		1,041,307	670,526	
2027	n	147,567	89,782	65,982	39,528	12,804	85,000	105,382	320,597	180,000		1,046,643	644,940	
2028	"	148,418	91,067	66,926	40,094	12,987	85,000	106,891	320,597	180,000		1,051,981	620,315	
2029	"	149,271	92,352	67,871	40,660	13,170	85,000	108,399	320,597	180,000		1,057,320	596,616	
2030	n	150,125	93,637	68,815	41,226	13,354	85,000	109,907	320,597	180,000		1,062,662	573,808	
2031	n	150,982	94,922	69,759	41,791	13,537	85,000	111,416	320,597	180,000		1,068,005	551,860	
2032	n	151,840	96,207	70,704	42,357	13,720	85,000	112,924	320,597	180,000		1,073,350	530,739	
2033	n	152,700	97,492	71,648	42,923	13,904	85,000	114,432	320,597	180,000		1,078,697	510,414	
2034	n	153,562	98,777	72,593	43,489	14,087	85,000	115,941	320,597	180,000		1,084,045	490,856	
2035	H	198,719	66,708	49,025	44,055	13,462	85,000	110,801	435,278	180,000		1,183,047	512,616	
2036	H	199,584	67,565	49,654	44,620	13,635	85,000	112,224	435,278	180,000		1,187,560	492,413	
2037	n	200,451	68,421	50,284	45,186	13,808	85,000	113,647	435,278	180,000		1,192,076	473,001	
2038	11	201,320	69,278	50,913	45,752	13,981	85,000	115,070	435,278	180,000		1,196,592	454,347	
2039	11	202,191	70,135	51,543	46,318	14,154	85,000	116,493	435,278	180,000		1,201,111	436,424	
2040	11	203,064	70,992	52,173	46,883	14,327	85,000	117,916	435,278	180,000		1,205,632	419,202	
2041	Π	203,938	71,848	52,802	47,449	14,500	85,000	119,339	435,278	180,000		1,210,154	402,655	
2042	Π	204,815	72,705	53,432	48,015	14,673	85,000	120,762	435,278	180,000		1,214,678	386,757	
2043	Π	205,693	73,562	54,061	48,581	14,845	85,000	122,185	435,278	180,000		1,219,204	371,481	
2044	н	206,572	74,418	54,691	49,146	15,018	85,000	123,607	435,278	180,000		1,223,732	356,804	
2045	T	207,454	75,275	55,321	49,712	15,191	85,000	125,030	435,278	180,000		1,228,262	342,703	
2046	n	208,338	76,132	55,950	50,278	15,364	85,000	126,453	435,278	180,000		1,232,793	329,156	
					•	-	•						41,808,335	5,884,947

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 5:

Concept Design Option

DEFER/ ELIMINATE WET WEATHER STORAGE

Construction Year 2020-21

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) capacity (existing)

Year Description 2020 BVSTP (Stage 2) Augu 2020 Raw sewage transfer s 2020 BVSTP (Stage 2) Augu 2020 BVSTP (Stage 2) Augu 2020 Raw sewage transfer s 2030 BVSTP Replace Stage 2040 BVSTP Replace Stage 2016	system OS to BVSTP - Civil mentation Works - M&E system OS to BVSTP - M&E e 1 M&E	8,333 EP 16,667 EP	No Wet Weather S	Storage	Capac	sity				(years) 50 50 20	Cost (\$) 11,284,000 1,555,000 5,916,000	(\$) 17,491,000 2,411,000	(\$) 14,667,276 2,021,771	(\$) 2,241,647 308,994					
2020 Raw sewage transfer s 2020 BVSTP (Stage 2) Augi 2020 Raw sewage transfer s 2020 Raw sewage transfer s 2020 Raw sewage transfer s 2030 BVSTP Replace Stage 2040 BVSTP Replace Stage Year 2016 2017 2018 2019 2020 2021 2022 2023	system OS to BVSTP - Civil mentation Works - M&E system OS to BVSTP - M&E e 1 M&E e 2 M&E Description " "	8,333 EP 16,667 EP 8,333 EP Power (\$/yr) 107,773	No Wet Weather S	Storage Storage NG COSTS at proj	ected ADWF					50	1,555,000	, ,							
2020 BVSTP (Stage 2) Augr 2020 Raw sewage transfer s 2030 BVSTP Replace Stage 2040 BVSTP Replace Stage 2016	mentation Works - M&E system OS to BVSTP - M&E e 1 M&E e 2 M&E Description " "	16,667 EP 8,333 EP Power (\$/yr) 107,773	No Wet Weather S OPERATI Alum	Storage NG COSTS at proj	ected ADWF							2,411,000	2,021,771	308,994					
2020 Raw sewage transfer s 2030 BVSTP Replace Stage 2040 BVSTP Replace Stage Year 2016 2017 2018 2020 2020 2021 2022 2023	system OS to BVSTP - M&E e 1 M&E e 2 M&E Description " "	16,667 EP 8,333 EP Power (\$/yr) 107,773	No Wet Weather S OPERATI Alum	Storage NG COSTS at proj	ected ADWF					20	1								
2030 BVSTP Replace Stage 2040 BVSTP Replace Stage Year	e 1 M&E e 2 M&E Description " "	8,333 EP Power (\$/yr) 107,773	No Wet Weather S OPERATI Alum	NG COSTS at proj	ected ADWF				8,333 EP No Wet Weather Storage 20										
2040 BVSTP Replace Stage Year	e 2 M&E Description " " "	8,333 EP Power (\$/yr) 107,773	No Wet Weather S OPERATI Alum	NG COSTS at proj	ected ADWF														
Year 2016 2017 2018 2019 2020 2021 2022 2022 2023	Description " "	Power (\$/yr) 107,773	OPERATI Alum	NG COSTS at proj	ected ADWF					20	6,710,000	10,401,000	5,616,258	555,413					
2016 2017 2018 2019 2020 2021 2022 2023	- 	(\$/yr) 107,773	Alum		ected ADWF					20	5,916,000	9,170,000	3,188,441	1,713,873					
2016 2017 2018 2019 2020 2021 2022 2023	- 	(\$/yr) 107,773	-	Caustic soda										I					
2016 2017 2018 2019 2020 2021 2022 2023	- 	107,773	(\$/yr)	1	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				I					
2017 2018 2019 2020 2021 2022 2023	n n			(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)									
2018 2019 2020 2021 2022 2023	и	108,264	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558						
2019 2020 2021 2022 2023			24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547						
2020 2021 2022 2023	n	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535						
2021 2022 2023		109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483						
2022	"	185,953	53,858	39,581	35,568	10,869	85,000	89,457	339,422	180,000		1,019,708	855,088	1					
2023	n	186,792	54,714	40,210	36,134	11,042	85,000	90,880	339,422	180,000		1,024,194	821,866						
	"	187,632	55,571	40,840	36,700	11,215	85,000	92,303	339,422	180,000		1,028,682	789,921	1					
2024	n	188,474	56,428	41,470	37,265	11,388	85,000	93,725	339,422	180,000		1,033,172	759,204	1					
	н	189,318	57,284	42,099	37,831	11,561	85,000	95,148	339,422	180,000		1,037,664	729,670						
2025	n	190,163	58,141	42,729	38,397	11,733	85,000	96,571	339,422	180,000		1,042,157	701,272						
2026	n	191,011	58,998	43,358	38,963	11,906	85,000	97,994	339,422	180,000		1,046,652	673,968						
2027	u	191,860	59,855	43,988	39,528	12,079	85,000	99,417	339,422	180,000		1,051,149	647,717						
2028	u	192,711	60,711	44,617	40,094	12,252	85,000	100,840	339,422	180,000		1,055,648	622,478						
2029	"	193,564	61,568	45,247	40,660	12,425	85,000	102,263	339,422	180,000		1,060,149	598,212						
2030	"	194,418	62,425	45,877	41,226	12,598	85,000	103,686	339,422	180,000		1,064,652	574,883						
2031	"	195,275	63,281	46,506	41,791	12,771	85,000	105,109	339,422	180,000		1,069,156	552,455						
2032	n	196,133	64,138	47,136	42,357	12,944	85,000	106,532	339,422	180,000		1,073,662	530,893						
2033	II	196,993	64,995	47,765	42,923	13,117	85,000	107,955	339,422	180,000		1,078,170	510,165						
2034	II	197,855	65,851	48,395	43,489	13,289	85,000	109,378	339,422	180,000		1,082,680	490,238						
2035	II	198,719	66,708	49,025	44,055	13,462	85,000	110,801	339,422	180,000		1,087,191	471,082						
2036	n	199,584	67,565	49,654	44,620	13,635	85,000	112,224	339,422	180,000		1,091,705	452,668						
2037	n	200,451	68,421	50,284	45,186	13,808	85,000	113,647	339,422	180,000		1,096,220	434,966						
2038	u .	201,320	69,278	50,913	45,752	13,981	85,000	115,070	339,422	180,000		1,100,737	417,951						
2039	u .	202,191	70,135	51,543	46,318	14,154	85,000	116,493	339,422	180,000		1,105,256	401,595						
2040	"	203,064	70,992	52,173	46,883	14,327	85,000	117,916	339,422	180,000		1,109,776	385,873						
2041	"	203,938	71,848	52,802	47,449	14,500	85,000	119,339	339,422	180,000		1,114,299	370,761						
2042	"	204,815	72,705	53,432	48,015	14,673	85,000	120,762	339,422	180,000		1,118,823	356,236						
2043	"	205,693	73,562	54,061	48,581	14,845	85,000	122,185	339,422	180,000		1,123,349	342,275						
2044	n	206,572	74,418	54,691	49,146	15,018	85,000	123,607	339,422	180,000		1,127,876	328,856						
2045	"	207,454	75,275	55,321	49,712	15,191	85,000	125,030	339,422	180,000		1,132,406	315,958						
2046	n	208,338	76,132	55,950	50,278	15,364	85,000	126,453	339,422	180,000		1,136,937	303,562						
						,		,		,		.,,	000,00L	1					

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 6:

Concept Design Option 15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d)

DEFER/ ELIMINATE WETLAND

Construction Year 2020-21

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

628 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Val
Year Des	scription				Capa	city				(years)	(\$)	(\$)	(\$)	(\$)
	STP (Stage 2) Augmentation Works - Civil	8,333 EP	No wetland			-				50	12,921,000	20,028,000	16,794,707	2,566,789
2020 Rav	w sewage transfer system OS to BVSTP - Civil									50	1,555,000	2,411,000	2,021,771	308,994
2020 BVS	STP (Stage 2) Augmentation Works - M&E	8,333 EP								20	6,058,000	9,390,000	7,874,091	0
2020 Rav	w sewage transfer system OS to BVSTP - M&E									20	0	0	0	0
	STP Replace Stage 1 M&E	16,667 EP								20	6,710,000	10,401,000	5,616,258	555,413
	STP Replace Stage 2 M&E	8,333 EP								20	6,058,000	9,390,000	3,264,936	1,754,991
	· · · · · · · · · · · · · · · · · · ·		OPERATI	NG COSTS at proj	ected ADWF				•					
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
Year	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	n	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	120,000		669,558	669,558	
2017	n	108,264	24,848	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
2018	n	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
2019	н	109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
2020	н	185,953	53,858	39,581	35,568	10,869	85,000	89,457	327,422	180,000		1,007,708	845,025	
2021	n	186,792	54,714	40,210	36,134	11,042	85,000	90,880	327,422	180,000		1,012,194	812,236	
2022	n	187,632	55,571	40,840	36,700	11,215	85,000	92,303	327,422	180,000		1,016,682	780,706	
2023	n	188,474	56,428	41,470	37,265	11,388	85,000	93,725	327,422	180,000		1,021,172	750,386	
2024	n	189,318	57,284	42,099	37,831	11,561	85,000	95,148	327,422	180,000		1,025,664	721,231	
2025	"	190,163	58,141	42,729	38,397	11,733	85,000	96,571	327,422	180,000		1,030,157	693,197	
2026	"	191,011	58,998	43,358	38,963	11,906	85,000	97,994	327,422	180,000		1,034,652	666,241	
2027	"	191,860	59,855	43,988	39,528	12,079	85,000	99,417	327,422	180,000		1,039,149	640,323	
2028	"	192,711	60,711	44,617	40,094	12,252	85,000	100,840	327,422	180,000		1,043,648	615,402	
2029	"	193,564	61,568	45,247	40,660	12,425	85,000	102,263	327,422	180,000		1,048,149	591,441	
2030	"	194,418	62,425	45,877	41,226	12,598	85,000	103,686	327,422	180,000		1,052,652	568,403	
2031	"	195,275	63,281	46,506	41,791	12,771	85,000	105,109	327,422	180,000		1,057,156	546,254	
2032	"	196,133	64,138	47,136	42,357	12,944	85,000	106,532	327,422	180,000		1,061,662	524,959	
2033	"	196,993	64,995	47,765	42,923	13,117	85,000	107,955	327,422	180,000		1,066,170	504,487	
2034	u.	197,855	65,851	48,395	43,489	13,289	85,000	109,378	327,422	180,000		1,070,680	484,804	
2035	u.	198,719	66,708	49,025	44,055	13,462	85,000	110,801	327,422	180,000		1,075,191	465,882	
2036	u.	199,584	67,565	49,654	44,620	13,635	85,000	112,224	327,422	180,000		1,079,705	447,692	
2037	u.	200,451	68,421	50,284	45,186	13,808	85,000	113,647	327,422	180,000		1,084,220	430,205	
2038	u.	201,320	69,278	50,913	45,752	13,981	85,000	115,070	327,422	180,000		1,088,737	413,394	
2039	n	202,191	70,135	51,543	46,318	14,154	85,000	116,493	327,422	180,000		1,093,256	397,235	
2040	W	203,064	70,992	52,173	46,883	14,327	85,000	117,916	327,422	180,000		1,097,776	381,701	
2041	W	203,938	71,848	52,802	47,449	14,500	85,000	119,339	327,422	180,000		1,102,299	366,768	
2042	n	204,815	72,705	53,432	48,015	14,673	85,000	120,762	327,422	180,000		1,106,823	352,415	
2043	W	205,693	73,562	54,061	48,581	14,845	85,000	122,185	327,422	180,000		1,111,349	338,618	
2044	"	206,572	74,418	54,691	49,146	15,018	85,000	123,607	327,422	180,000		1,115,876	325,357	
2045	n	207,454	75,275	55,321	49,712	15,191	85,000	125,030	327,422	180,000		1,120,406	312,610	
2046	n	208,338	76,132	55,950	50,278	15,364	85,000	126,453	327,422	180,000		1,124,937	300,358	
1		1	-,					,	,	.,		, ,	52,375,217	5,186,187

5.70 ML/d Design ADWF

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Option 7:

Concept Design Option

DEFER/ ELIMINATE NEW SLUDGE DEWATERING

Construction Year 2020-21

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

5.70 ML/d Design ADWF

628 L/s PWWF (nominal) capacity (existing)

YearControlOpenantNo </th <th>Discounted Value</th> <th>Total Cost</th> <th>Direct Job Tota Cost</th> <th>Estimated Life</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>AL COSTS</th> <th>CAPI</th> <th></th> <th></th> <th></th>	Discounted Value	Total Cost	Direct Job Tota Cost	Estimated Life						AL COSTS	CAPI			
100010	(\$)	(\$)		(years)				ty		cription	Year Descrip			
Not worker<	0 17,310,422	20,643,000	13,318,000 20,64	50						watering Facilties	No New Sludge De	8,333 EP	TP (Stage 2) Augmentation Works - Civil	2020 BVSTF
1200120112	2,021,771	2,411,000	1,555,000 2,41	50									sewage transfer system OS to BVSTP - Civil	2020 Raw se
20392039204920492049204920492049000 <td>6,998,633</td> <td>8,346,000</td> <td>5,384,000 8,34</td> <td>20</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>watering Facilties</td> <td>No New Sludge De</td> <td>8,333 EP</td> <td>TP (Stage 2) Augmentation Works - M&E</td> <td>2020 BVSTF</td>	6,998,633	8,346,000	5,384,000 8,34	20						watering Facilties	No New Sludge De	8,333 EP	TP (Stage 2) Augmentation Works - M&E	2020 BVSTF
ColsC	0	0	0	20									sewage transfer system OS to BVSTP - M&E	2020 Raw se
Verify Description Power Single Description Mann Construction Mathermance Mathermance<	5,616,258	10,401,000	6,710,000 10,40	20								16,667 EP	TP Replace Stage 1 M&E	2030 BVSTF
ProblemProvemNumCaudia colorPerformagePolymemOther ConsentingSubger DispontMathemateSuite0100571	2,901,933	8,346,000	5,384,000 8,34	20						torage	No Wet Weather S	8,333 EP	TP Replace Stage 2 M&E	2040 BVSTF
Description (By)									ected ADWF	IG COSTS at proje	OPERATI			
1 1				Staff	Maintenance	Sludge Disposal	Other Operating	Polymer	Ferric sulphate	Caustic soda	Alum	Power		
Bins Dir Dir<				(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	Description	Year
01 100,25 22,000 100,05 20,000 120,000	669,558	669,558	669	120,000	260,000	40,250	85,000	4,890	9,602	17,809	24,233	107,773	n	2016
019 - 108246 28.079 19.168 10.334 5.263 85.000 43.317 280.000 120.000 020 - 168.563 5.3.686 39.861 35.662 10.680 65.000 69.477 33.422 160.000 1.02.0194 021 - 167.632 55.571 40.940 36.104 11.142 85.000 59.376 33.5422 160.000 1.024.682 022 - 168.518 57.284 44.2099 37.831 11.561 65.000 95.71 33.5422 160.000 1.024.682 026 - 169.163 55.141 42.079 38.937 11.733 85.000 96.571 33.5422 160.000 1.024.682 026 - 169.111 85.986 43.986 39.828 11.205 65.000 190.40 33.5422 160.000 1.142.682 027 - 169.544 61.568 45.977 41.282 12.286 85.000 102.83 33.5422 160.000 1.066.149 1.056.149 1.056.149 1.056.149 1.056.149	643,547	672,507	672	120,000	260,000	41,272	85,000	5,015	9,846	18,261	24,848	108,264	n	017
01 108,248 2,0078 19,084 19,084 19,084 2,035 5,000 42,317 2,0000 10,000 020 - 166,085 53,648 35,668 10,080 65,000 69,457 335,422 160,000 10,157,09 10,157,09 10,157,09 10,224 85,000 53,252 180,000 10,024,82 11,215 85,000 50,30 335,422 180,000 10,224,82 10,224,82 11,224,88 11,254 85,000 56,148 335,422 180,000 10,224,82 10,224,82 10,224,82 10,226 10,224,82 10,226 10,224,82 10,200,00 10,224,82 10,226	618,535	675,455	675	120,000	260,000	42,295	85,000	5,139	10,090	18,714	25,464	108,755	n	018
base 185.853 33.868 39.861 33.868 10.869 63.000 68,877 33.8742 180.000 106 197.92 64.714 40.210 36.134 11.42 88.000 90.800 33.5422 180.000 1022 - 188.474 56.571 40.840 37.265 11.388 85.000 92.303 33.5422 180.000 1.024.82 1024 - 188.474 56.428 41.470 37.265 11.388 85.000 96.511 335.422 180.000 1.024.82 1.029.172 1024 - 191.011 58.984 43.368 39.837 11.733 85.000 96.511 335.422 180.000 1.042.652 1027 - 191.061 58.654 43.868 39.524 12.079 85.000 100.840 335.422 180.000 1.042.652 1027 - 191.448 62.425 45.677 41.225 85.000 100.846 335.422 180.000 1.066.622	594,483	678,404	678	120,000	260,000	43,317	85,000	5,263	10,334	19,166	26,079	109,246	"	2019
2822 • • 187,632 55,571 40,640 36,700 11,215 85,000 92,303 335,422 180,000 0203 • 188,474 66,428 41,470 37,265 11,388 85,000 93,725 335,422 180,000 10,24,822 180,000 0204 • 190,163 58,141 42,729 38,397 11,733 85,000 96,571 335,422 180,000 1,038,644 0205 • 191,011 59,984 43,356 38,663 11,006 85,000 96,571 335,422 180,000 1,042,652 0207 • 191,860 56,554 43,888 38,563 11,026 85,000 100,840 335,422 180,000 1,051,648 0203 • 192,751 63,281 46,567 41,226 12,568 85,000 105,860 335,422 180,000 1,056,643 1,056,149 1,056,149 1,056,168 1,056,168 1,056,149 1,056,149 1,056,149 <t< td=""><td>851,733</td><td>1,015,708</td><td>1,01</td><td>180,000</td><td>335,422</td><td>89,457</td><td>85,000</td><td>10,869</td><td>35,568</td><td>39,581</td><td>53,858</td><td>185,953</td><td>u</td><td>2020</td></t<>	851,733	1,015,708	1,01	180,000	335,422	89,457	85,000	10,869	35,568	39,581	53,858	185,953	u	2020
1023 • 188.474 56.428 41.470 37.266 11.388 85.000 93.725 335.422 180.000 1024 • 189.318 57.284 42.099 37.831 11.561 85.000 95.148 335.422 180.000 025 • 191.011 58.984 43.355 38.633 11.906 85.000 96.571 335.422 180.000 026 • 191.011 58.985 43.385 38.633 11.906 85.000 99.417 335.422 180.000 027 • 191.601 59.855 43.988 39.528 12.079 85.000 190.283 335.422 180.000 029 • 193.564 61.568 45.247 40.060 12.425 85.000 100.283 335.422 180.000 0301 • 196.513 64.547 41.266 12.598 85.000 100.512 335.422 180.000 0302 • 196.513 64.138 47.136 42.337 12.944 85.000 109.513 354.422 180.000	818,656	1,020,194	1,02	180,000	335,422	90,880	85,000	11,042	36,134	40,210	54,714	186,792	u	2021
N224 - 189,318 57,284 42,099 37,831 11,561 85,000 95,148 335,422 180,000 0205 - 190,163 58,141 42,729 38,397 11,733 85,000 96,571 335,422 180,000 0206 - 191,011 58,998 43,388 39,528 12,079 85,000 99,417 335,422 180,000 0207 - 191,680 59,856 43,988 39,528 12,079 85,000 190,840 335,422 180,000 0208 - 192,711 60,711 44,617 40,094 12,252 85,000 102,863 335,422 180,000 0300 - 194,418 65,457 41,226 12,588 85,000 105,108 335,422 180,000 0301 - 196,275 63,281 46,566 41,791 12,711 85,000 107,955 335,422 180,000 0303 - 196,933 64,985	786,849	1,024,682	1,02	180,000	335,422	92,303	85,000	11,215	36,700	40,840	55,571	187,632	u	2022
N225 ··· 190,163 58,141 42,729 38,397 11,733 85,000 96,571 335,422 180,000 026 ··· 191,011 58,986 43,988 38,963 11,066 85,000 97,994 335,422 180,000 1,042,652 027 ··· 191,860 59,855 43,988 39,528 12,079 85,000 100,840 336,422 180,000 028 ··· 192,711 60,711 44,617 40,094 12,425 85,000 100,840 336,422 180,000 030 ··· 194,418 62,425 45,877 41,226 12,596 85,000 105,863 336,422 180,000 0301 ··· 196,133 64,138 47,136 42,357 12,944 85,000 106,553 336,422 180,000 0303 ··· 196,933 64,995 47,755 42,923 13,147 85,000 110,81 336,422 180,000 0304 ··· <td>756,265</td> <td>1,029,172</td> <td>1,02</td> <td>180,000</td> <td>335,422</td> <td>93,725</td> <td>85,000</td> <td>11,388</td> <td>37,265</td> <td>41,470</td> <td>56,428</td> <td>188,474</td> <td>n</td> <td>2023</td>	756,265	1,029,172	1,02	180,000	335,422	93,725	85,000	11,388	37,265	41,470	56,428	188,474	n	2023
N226 · 191.011 56.998 43.358 38.963 11.906 85.000 97.994 335.422 180.000 0207 · 191.800 59.855 43.988 39.528 12.079 85.000 99.417 335.422 180.000 0202 · 192.711 60.711 44.617 40.094 12.252 85.000 100.840 335.422 180.000 0209 · 193.664 61.568 45.247 40.600 12.425 85.000 103.868 335.422 180.000 0201 · 194.418 62.425 45.877 41.226 12.598 85.000 106.510 335.422 180.000 0203 · 196.533 64.138 47.136 42.357 12.944 85.000 109.378 335.422 180.000 0203 · 197.855 65.851 48.395 43.489 13.289 85.000 110.91 335.422 180.000 0203 · 199.854	726,857	1,033,664	1,03	180,000	335,422	95,148	85,000	11,561	37,831	42,099	57,284	189,318	n	2024
0.000 19,011 35,930 43,368 39,542 10,000 33,342 10,000 0207 " 191,800 59,855 43,988 39,528 12,079 85,000 99,477 335,422 180,000 0208 " 192,711 60,711 44,617 40,060 12,425 85,000 100,840 335,422 180,000 0208 " 194,818 62,425 45,877 41,226 12,598 85,000 100,840 335,422 180,000 0203 " 196,133 64,138 47,136 42,357 12,944 85,000 106,532 335,422 180,000 0203 " 196,133 64,195 47,765 42,923 13,117 85,000 106,532 335,422 180,000 1,074,170 0203 " 198,719 66,768 49,625 44,055 13,462 85,000 110,811 335,422 180,000 1,087,176 02037 " 200,451 68,241	698,580	1,038,157	1,03	180,000	335,422	96,571	85,000	11,733	38,397	42,729	58,141	190,163	n	2025
2028 " 192,711 60,711 44,617 40,094 12,252 85,000 100,840 335,422 180,000 2029 " 193,564 61,568 45,247 40,660 12,425 85,000 102,263 335,422 180,000 2030 " 194,418 62,425 45,607 41,226 12,785 85,000 103,686 335,422 180,000 2031 " 196,133 64,138 47,136 42,357 12,944 85,000 106,532 335,422 180,000 2033 " 196,933 64,995 47,765 42,923 13,117 85,000 107,955 335,422 180,000 1,074,170 2034 " 199,854 67,565 49,025 44,620 13,625 85,000 110,81 335,422 180,000 1,074,170 2035 " 199,854 67,565 49,025 44,620 13,625 85,000 112,24 35,422 180,000 1,087,705 <t< td=""><td>671,393</td><td>1,042,652</td><td>1,04</td><td>180,000</td><td>335,422</td><td>97,994</td><td>85,000</td><td>11,906</td><td>38,963</td><td>43,358</td><td>58,998</td><td>191,011</td><td>n</td><td>2026</td></t<>	671,393	1,042,652	1,04	180,000	335,422	97,994	85,000	11,906	38,963	43,358	58,998	191,011	n	2026
2029 - 193,564 61,568 45,247 40,660 12,425 85,000 102,263 335,422 180,000 2030 - 194,418 62,425 45,877 41,226 12,598 85,000 103,686 335,422 180,000 2031 - 195,275 63,281 46,506 41,791 12,771 85,000 106,532 335,422 180,000 2032 - 196,133 64,138 47,765 42,923 13,117 65,000 106,532 335,422 180,000 2033 - 197,855 65,851 48,395 43,489 13,289 85,000 109,378 335,422 180,000 1,074,170 199,584 67,565 49,654 44,620 13,635 85,000 110,801 335,422 180,000 1,087,705 200,451 68,421 50,284 45,186 13,808 85,000 111,677 335,422 180,000 1,087,705 201,320 69,278 50,913 45,752 13,981 85,000 116,433 335,422 180,000 <t< td=""><td>645,252</td><td>1,047,149</td><td>1,04</td><td>180,000</td><td>335,422</td><td>99,417</td><td>85,000</td><td>12,079</td><td>39,528</td><td>43,988</td><td>59,855</td><td>191,860</td><td>n</td><td>2027</td></t<>	645,252	1,047,149	1,04	180,000	335,422	99,417	85,000	12,079	39,528	43,988	59,855	191,860	n	2027
02.029 193,584 61,586 45,247 40,680 12,423 65,000 102,263 33,54,22 160,000 02030 194,418 62,425 45,877 41,226 12,598 85,000 103,686 335,422 180,000 1,066,152 02031 196,133 64,138 47,136 42,257 12,944 85,000 106,532 335,422 180,000 0203 196,993 64,995 47,765 42,923 13,117 85,000 106,532 335,422 180,000 0203 199,855 65,851 48,995 43,489 13,289 85,000 100,813 335,422 180,000 0203 199,719 66,708 49,025 44,050 13,635 85,000 110,801 335,422 180,000 1,081,191 2004 199,584 67,565 49,654 44,620 13,635 85,000 113,647 335,422 180,000 1,082,191 200,451 68,421 50,284 45,752 13,961	620,119	1,051,648	1,05	180,000	335,422	100,840	85,000	12,252	40,094	44,617	60,711	192,711	n	2028
2031 • 195,275 63,281 46,506 41,791 12,771 85,000 105,109 335,422 180,000 1,065,156 2032 • 196,133 64,138 47,136 42,357 12,944 85,000 106,532 335,422 180,000 1,069,662 2033 • 196,993 64,995 47,765 42,923 13,117 85,000 107,955 335,422 180,000 1,074,170 2034 • 197,855 65,811 48,395 44,620 13,829 85,000 110,801 335,422 180,000 1,074,170 2036 • 199,584 67,565 49,654 44,620 13,835 85,000 110,801 335,422 180,000 1,081,191 2037 • 200,451 66,421 50,284 45,166 13,808 85,000 113,647 335,422 180,000 1,092,220 2038 • 201,320 69,278 50,913 45,752 13,981 85,000 115,070 335,422 180,000 1,109,2705 2038 •	595,955	1,056,149	1,05	180,000	335,422	102,263	85,000	12,425	40,660	45,247	61,568	193,564	n	2029
2032 - 196,133 64,138 47,136 42,357 12,944 85,000 106,532 335,422 180,000 2033 - 196,993 64,995 47,765 42,923 13,117 85,000 107,955 335,422 180,000 2034 - 197,855 65,851 48,395 43,489 13,289 85,000 110,801 335,422 180,000 2035 - 198,719 66,708 49,025 44,055 13,462 85,000 110,801 335,422 180,000 2036 - 199,584 67,565 49,654 44,620 13,635 85,000 112,24 335,422 180,000 2037 - 200,451 68,421 50,284 45,186 13,808 85,000 115,070 335,422 180,000 2038 - 201,320 69,278 50,913 45,752 13,981 85,000 116,493 335,422 180,000 2040 - 202,191 70,192 52,173 46,833 14,327 85,000 117,916 335,422	572,723	1,060,652	1,06	180,000	335,422	103,686	85,000	12,598	41,226	45,877	62,425	194,418	n	2030
2033·196,99364,99547,76542,92313,11785,000107,955335,422180,0002034·197,85565,85148,39543,48913,28985,000109,378335,422180,0002035·198,71966,70849,02544,05513,46285,000110,801335,422180,0002036·199,58467,56549,65444,62013,63585,000112,244335,422180,0002037·200,45168,21150,28445,18613,80885,000113,647335,422180,0002038·201,32069,27850,91345,75213,98185,000115,070335,422180,0002039·202,19170,13551,54346,31814,15485,000116,493335,422180,0002041·203,06470,99252,17346,88314,32785,000119,39335,422180,0002041·204,81572,70553,43248,01514,67385,000120,762335,422180,0002043·204,81572,70553,43248,01514,67385,000122,185335,422180,0002044·206,57274,41854,69149,14615,01885,000122,867335,422180,0001,112,84062045·207,45475,27555,32149,71215,19185,000123,607<	550,388	1,065,156	1,06	180,000	335,422	105,109	85,000	12,771	41,791	46,506	63,281	195,275	n	2031
0003 196,993 64,995 44,765 42,923 13,177 68,000 107,955 335,422 180,000 1,074,170 2034 " 197,855 66,581 48,395 43,489 13,289 85,000 109,378 335,422 180,000 1,078,680 2035 " 199,584 67,565 49,654 44,620 13,635 85,000 111,847 335,422 180,000 2036 " 199,584 67,565 49,654 44,620 13,635 85,000 111,847 335,422 180,000 2037 " 200,451 68,421 50,284 45,186 13,808 85,000 1115,070 335,422 180,000 2038 " 201,320 69,278 50,913 45,752 13,981 85,000 115,070 335,422 180,000 1,096,737 2039 " 202,191 70,135 51,543 46,318 14,154 85,000 117,916 335,422 180,000 1,105,776	528,915	1,069,662	1,06	180,000	335,422	106,532	85,000	12,944	42,357	47,136	64,138	196,133	n	2032
0.04197,63566,53144,99543,46913,26985,000109,376335,422180,0001,076,8802005*198,71966,70849,02544,05513,46285,000110,224335,422180,0001,083,1912006*199,58467,56549,65444,62013,63585,000112,224335,422180,0001,087,7052007*200,45168,42150,28445,18613,80885,000115,070335,422180,0001,092,2202008*201,32069,27850,91345,75213,98185,000116,493335,422180,0001,096,7372039*202,91170,13551,54346,31814,15485,000116,493335,422180,0001,096,7372040*203,06470,99252,17346,88314,32785,000117,916335,422180,0001,105,7762041*203,93871,84852,80247,44914,50085,000119,339335,422180,0001,110,2992042*204,81572,70553,43248,01514,67385,000122,185335,422180,0001,114,8232043*206,57274,41854,69149,14615,01885,000123,607335,422180,0001,112,3762044*206,57274,41854,69149,14615,01885,000123,607335,422180,	508,272	1,074,170	1,07	180,000	335,422	107,955	85,000	13,117	42,923	47,765	64,995	196,993	n	2033
2036 " 199,584 67,565 49,654 44,620 13,635 85,000 112,224 335,422 180,000 2037 " 200,451 68,421 50,284 45,186 13,808 85,000 113,647 335,422 180,000 2038 " 201,320 69,278 50,913 45,752 13,981 85,000 115,070 335,422 180,000 2039 " 202,191 70,135 51,543 46,318 14,154 85,000 116,493 335,422 180,000 1,096,737 203,064 70,992 52,173 46,883 14,327 85,000 117,916 335,422 180,000 1,101,256 " 203,938 71,848 52,802 47,449 14,500 85,000 119,339 335,422 180,000 1,101,259 204,815 72,705 53,432 48,015 14,673 85,000 122,185 335,422 180,000 1,114,823 204,815 72,705 53,3432 48,015 14,673 85,000 122,185 335,422 180,000	488,427	1,078,680	1,07	180,000	335,422	109,378	85,000	13,289	43,489	48,395	65,851	197,855	n	2034
2037"200,45168,42150,28445,18613,80885,000113,647335,422180,0002038"201,32069,27850,91345,75213,98185,000115,070335,422180,0002039"202,19170,13551,54346,31814,15485,000116,493335,422180,0002040"203,06470,99252,17346,88314,32785,000117,916335,422180,0002041"203,93871,84852,80247,44914,50085,000119,339335,422180,0002042"204,81572,70553,43248,01514,67385,000120,762335,422180,0002043"205,69373,56254,06148,58114,84585,000122,185335,422180,0002044"206,57274,41854,69149,14615,01885,000123,607335,422180,0002045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406	469,349	1,083,191	1,08	180,000	335,422	110,801	85,000	13,462	44,055	49,025	66,708	198,719	n	2035
2007200,451200,45130,224449,16613,06685,000115,047335,422160,0002038"201,32069,27850,91345,75213,98185,000115,070335,422180,0002039"202,19170,13551,54346,31814,15485,000116,493335,422180,0002040"203,06470,99252,17346,88314,32785,000117,916335,422180,0002041"203,93871,84852,80247,44914,50085,000119,339335,422180,0002042"204,81572,70553,43248,01514,67385,000120,762335,422180,0002043"205,69373,56254,06148,58114,84585,000122,185335,422180,0002044"206,57274,41854,69149,14615,01885,000123,607335,422180,0002045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406	451,009	1,087,705	1,08	180,000	335,422	112,224	85,000	13,635	44,620	49,654	67,565	199,584	n	2036
2030"201,32030,91330,91340,73210,98150,000110,010335,422160,0001,101,2561,101,2561,101,2561,101,2561,101,2561,101,2561,101,2561,102,9761,102,9761,102,9761,102,9761,102,991,110,2991,110,3991,123,6761,123,8761,123,8761,123,8761,123,8761,123,8761,128,4061,128,4061,128,4062045"207,45475,27555,32149,71215,191 </td <td>433,379</td> <td>1,092,220</td> <td>1,09</td> <td>180,000</td> <td>335,422</td> <td>113,647</td> <td>85,000</td> <td>13,808</td> <td>45,186</td> <td>50,284</td> <td>68,421</td> <td>200,451</td> <td>n</td> <td>2037</td>	433,379	1,092,220	1,09	180,000	335,422	113,647	85,000	13,808	45,186	50,284	68,421	200,451	n	2037
2039"202,19170,13551,54346,31814,15485,000116,493335,422180,0002040"203,06470,99252,17346,88314,32785,000117,916335,422180,0002041"203,93871,84852,80247,44914,50085,000119,339335,422180,0002042"204,81572,70553,43248,01514,67385,000120,762335,422180,0002043"205,69373,56254,06148,58114,84585,000122,185335,422180,0002044"206,57274,41854,69149,14615,01885,000123,607335,422180,0002045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406				,	,	,	,	,	,	,	,	· · · · ·	п	
2040"203,06470,99252,17346,88314,32785,000117,916335,422180,0002041"203,93871,84852,80247,44914,50085,000119,339335,422180,0002042"204,81572,70553,43248,01514,67385,000120,762335,422180,0002043"205,69373,56254,06148,58114,84585,000122,185335,422180,0002044"206,57274,41854,69149,14615,01885,000123,607335,422180,0002045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406							1 1		i i				п	
2041"203,93871,84852,80247,44914,50085,000119,339335,422180,0001,110,2992042"204,81572,70553,43248,01514,67385,000120,762335,422180,0001,114,8232043"205,69373,56254,06148,58114,84585,000122,185335,422180,0001,119,3492044"206,57274,41854,69149,14615,01885,000123,607335,422180,0001,123,8762045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406							1 1						п	
2042"204,81572,70553,43248,01514,67385,000120,762335,422180,0001,114,8232043"205,69373,56254,06148,58114,84585,000122,185335,422180,0001,119,3492044"206,57274,41854,69149,14615,01885,000123,607335,422180,0001,123,8762045"207,45475,27555,32149,71215,19185,000125,030335,422180,0001,128,406							1						n	
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2044 " 206,572 74,418 54,691 49,146 15,018 85,000 123,607 335,422 180,000 1,123,876 2045 " 207,454 75,275 55,321 49,712 15,191 85,000 125,030 335,422 180,000 1,123,876							1 1		i i				п	
2045 " 207,454 75,275 55,321 49,712 15,191 85,000 125,030 335,422 180,000 1,128,406							1 1						n	
							1 1						n	
		1,132,937		180,000	335,422	126,453	85,000	15,364	50,278	55,950	76,132	208,338	n	2046
	51,760,791	.,,	1,10	,	,	,	,000	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,	,000		,		

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

Net Present Value EstimateConFrom Previous Planning Study (GHD, 2014b), Option 2 :

Concept Design Option

Construction Year 2020-21

15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) With Anaerobic, Secondary Anoxic & Secondary Aerobic Reactors

2.30 ML/d Design ADWF 232 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Value
Year Descriptior	1				Capa	city				(years)	(\$)	(\$)	(\$)	(\$)
2020 Stage 2 W	orks - Civil	10,700 EP (at 215	L/EP/d as originally	y planned) (or 9,60	0 EP at 240 L/EP/d)					50	11,056,000	18,353,000	15,390,116	2,352,121
2020 Effluent rei	use pipeline to BVSTP - Civil	See above								50	1,003,000	1,556,000	1,304,801	199,417
2020 Stage 2 W	orks - M&E	See above								20	6,374,000	10,581,000	8,872,818	0
2040 Replace St	tage 2 M&E	See above								20	6,374,000	10,581,000	3,679,050	1,977,589
			OPERATI	NG COSTS at proj	ected ADWF									
		Power	Alum	Caustic soda	Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
Year	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	11	108,051	58,996	43,357	0	5,291	85,000	43,551	265,000	120,000		729,246	729,246	
2017	"	108,605	59,538	43,756	0	5,340	85,000	43,952	265,000	120,000		731,191	699,705	
2018	"	109,159	60,081	44,155	0	5,389	85,000	44,353	265,000	120,000		733,136	671,355	
2019	"	109,712	60,624	44,554	0	5,438	85,000	44,754	265,000	120,000		735,082	644,150	
2020	n	110,266	61,167	44,953	0	5,486	85,000	45,155	265,000	120,000		737,027	618,042	
2021	"	102,655	27,427	20,156	0	5,535	85,000	45,555	265,000	120,000		671,328	538,708	
2022	п	103,209	27,668	20,334	0	5,584	85,000	45,956	265,000	120,000		672,750	516,602	
2023	п	103,763	27,909	20,511	0	5,632	85,000	46,357	265,000	120,000		674,172	495,401	
2024	п	104,317	28,151	20,688	0	5,681	85,000	46,758	265,000	120,000		675,594	475,068	
2025	п	104,871	28,392	20,866	0	5,730	85,000	47,158	265,000	120,000		677,016	455,567	
2026	п	105,425	28,633	21,043	0	5,778	85,000	47,559	265,000	120,000		678,438	436,865	
2027	n	105,979	28,874	21,220	0	5,827	85,000	47,960	265,000	120,000		679,860	418,929	
2028	n	106,533	29,116	21,398	0	5,876	85,000	48,361	265,000	120,000		681,283	401,728	
2029	n	107,086	29,357	21,575	0	5,925	85,000	48,762	265,000	120,000		682,705	385,231	
2030	n	107,640	29,598	21,752	0	5,973	85,000	49,162	265,000	120,000		684,127	369,410	
2031	"	108,194	29,840	21,930	0	6,022	85,000	49,563	265,000	120,000		685,549	354,237	
2032	"	108,748	30,081	22,107	0	6,071	85,000	49,964	265,000	120,000		686,971	339,686	
2033	n	109,302	30,322	22,284	0	6,119	85,000	50,365	265,000	120,000		688,393	325,731	
2034	n	109,857	30,564	22,462	0	6,168	85,000	50,766	265,000	120,000		689,815	312,349	
2035	"	110,411	30,805	22,639	0	6,217	85,000	51,166	265,000	120,000		691,237	299,514	
2036	"	110,965	31,046	22,816	0	6,265	85,000	51,567	265,000	120,000		692,660	287,206	
2037	"	111,519	31,287	22,994	0	6,314	85,000	51,968	265,000	120,000		694,082	275,403	
2038	H	112,073	31,529	23,171	0	6,363	85,000	52,369	265,000	120,000		695,504	264,083	
2039	H	112,627	31,770	23,348	0	6,411	85,000	52,769	265,000	120,000		696,926	253,228	
2040	"	113,181	32,011	23,526	0	6,460	85,000	53,170	265,000	120,000		698,348	242,818	
2041	"	113,735	32,253	23,703	0	6,509	85,000	53,571	265,000	120,000		699,771	232,835	
2042		114,289	32,494	23,880	0	6,558	85,000	53,972	265,000	120,000		701,193	223,262	
2043	"	114,844	32,735	24,058	0	6,606	85,000	54,373	265,000	120,000		702,615	214,081	
2044	n	115,398	32,977	24,235	0	6,655	85,000	54,773	265,000	120,000		704,038	205,277	
2045	n	115,952	33,218	24,412	0	6,704	85,000	55,174	265,000	120,000		705,460	196,834	
2046	n	116,506	33,459	24,590	0	6,752	85,000	55,575	265,000	120,000		706,882	188,738	
- 1		,	,	,	-	- ,	85,000		,	.,			41,318,075	4,529,127
							85,000	1				NET PRES	SENT VALUE:	

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

No upgrade of BVSTP

BVSTP Status quo 15,800 EP (Nominal) Capacity (existing @ 240 L/EP/d) **Construction Year** 2010

Ox. Ditch with Anaerobic Reactor ('3-Stage Phoredox' process configuration)

3.80 ML/d Design ADWF 314 L/s PWWF (nominal) capacity (existing)

			CAPI	TAL COSTS						Estimated Life	Direct Job Cost	Total Cost	Discounted Value	Discounted Residual Valu
Year Description					Сарас	city				(years)	(\$)	(\$)	(\$)	(\$)
2030 BVSTP Replac	ce Stage 1 M&E	16,667 EP								20	6,710,000	10,401,000	5,616,258	555,413
		Power	OPERATII Alum	NG COSTS at proj Caustic soda	ected ADWF Ferric sulphate	Polymer	Other Operating	Sludge Disposal	Maintenance	Staff				
Year	Description	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)	(\$/yr)				
2016	"	107,773	24,233	17,809	9,602	4,890	85,000	40,250	260,000	(\$,y1) 120,000		669,558	669,558	
017	"	108,264	24,233	18,261	9,846	5,015	85,000	41,272	260,000	120,000		672,507	643,547	
018	"	108,755	25,464	18,714	10,090	5,139	85,000	42,295	260,000	120,000		675,455	618,535	
2019	n	109,246	26,079	19,166	10,334	5,263	85,000	43,317	260,000	120,000		678,404	594,483	
2020	n	109,737	26,694	19,618	10,578	5,387	85,000	44,339	260,000	120,000		681,353	571,357	
2021	n	110,228	27,310	20,070	10,821	5,511	85,000	45,361	260,000	120,000		684,303	549,119	
2022	n	110,720	27,925	20,523	11,065	5,636	85,000	46,383	260,000	120,000		687,252	527,738	
2023	"	111,211	28,541	20,975	11,309	5,760	85,000	47,406	260,000	120,000		690,201	507,179	
2024	"	111,703	29,156	21,427	11,553	5,884	85,000	48,428	260,000	120,000		693,151	487,413	
2025	"	112,194	29,771	21,879	11,797	6,008	85,000	49,450	260,000	120,000		696,100	468,409	
2026	"	112,686	30,387	22,332	12,041	6,132	85,000	50,472	260,000	120,000		699,050	450,138	
2027	"	113,178	31,002	22,784	12,285	6,257	85,000	51,494	260,000	120,000		702,000	432,571	
2028	н	113,670	31,618	23,236	12,528	6,381	85,000	52,516	260,000	120,000		704,950	415,683	
2029	н	114,162	32,233	23,689	12,772	6,505	85,000	53,539	260,000	120,000		707,900	399,448	
2030	н	114,654	32,849	24,141	13,016	6,629	85,000	54,561	260,000	120,000		710,850	383,839	
2031	n	115,146	33,464	24,593	13,260	6,753	85,000	55,583	260,000	120,000		713,800	368,835	
2032	n	115,639	34,079	25,045	13,504	6,878	85,000	56,605	260,000	120,000		716,750	354,411	
2033	n	116,131	34,695	25,498	13,748	7,002	85,000	57,627	260,000	120,000		719,700	340,545	
2034	n	116,624	35,310	25,950	13,991	7,126	85,000	58,650	260,000	120,000		722,651	327,217	
2035	n	117,116	35,926	26,402	14,235	7,250	85,000	59,672	260,000	120,000		725,601	314,404	
2036	n	117,609	36,541	26,854	14,479	7,374	85,000	60,694	260,000	120,000		728,552	302,089	
2037	n	118,102	37,156	27,307	14,723	7,499	85,000	61,716	260,000	120,000		731,502	290,251	
2038	"	118,595	37,772	27,759	14,967	7,623	85,000	62,738	260,000	120,000		734,453	278,873	
2039	"	119,088	38,387	28,211	15,211	7,747	85,000	63,760	260,000	120,000		737,404	267,936	
2040	"	119,581	39,003	28,664	15,455	7,871	85,000	64,783	260,000	120,000		740,355	257,424	
2041	"	120,074	39,618	29,116	15,698	7,995	85,000	65,805	260,000	120,000		743,306	247,321	
2042	"	120,567	40,233	29,568	15,942	8,119	85,000	66,827	260,000	120,000		746,257	237,610	
2043	"	121,060	40,849	30,020	16,186	8,244	85,000	67,849	260,000	120,000		749,208	228,277	
2044	"	121,553	41,464	30,473	16,430	8,368	85,000	68,871	260,000	120,000		752,160	219,308	
2045	"	122,047	42,080	30,925	16,674	8,492	85,000	69,894	260,000	120,000		755,111	210,687	
2046	"	122,540	42,695	31,377	16,918	8,616	85,000	70,916	260,000	120,000		758,062	202,403	
													17,782,865	555,413

DISCOUNT RATE:	4.5%
BASE DATE:	2016
RESIDUAL DATE:	2046

GHD

145 Ann Street Brisbane QLD 4000 GPO Box 668 Brisbane QLD 4001 T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

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Document Status

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D	D de Haas	A de Hesse				17.10.16				
0	D de Haas	P Ochre	Rip alm	Poche	Rp alm	23.11.16				

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