# Great Barrier Reef Point Source Metadata Collection Project

## Final Report

*Prepared for Office of the Great Barrier Reef,*
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## Project background

Point source nutrient loads are commonly considered small relative to diffuse source loads, particularly at a scale such as the Great Barrier Reef (Reef) catchment. However, information on the location and nature of point source activities and the quantities and quality of nutrient releases is not readily available for the Reef catchment. Also, one or more point source activities have the potential to contribute a significant proportion of nutrients to local waters on an annual basis, particularly where they are large activities and release wastewater continuously to the environment. As a result of the focus on reducing nutrient loads to the Reef catchment, the Queensland Government has committed to review activities licensed under the *Environmental Protection Act 1994* (EP Act) that release nutrients, with a view to quantifying these loads and the potential need to review monitoring and release standards. Consequently, the Point Source Metadata Project was proposed and undertaken by the Science and Technology Division of the Department of Environment and Science (DES), on behalf of the Department's Office of the Great Barrier Reef, the unit tasked with addressing actions under the Reef 2050 Long-Term Sustainability Plan and Reef 2050 Water Quality Improvement Plan.

This project aimed to collate and provide information on point sources in the Reef catchment, including locations, release conditions and nutrient loads and concentrations. The ultimate aim is to help inform and prioritise future monitoring, management and regulation of point source activities. However, this three-year project is seen as only a first major step in benchmarking the current status of nutrient point sources and focusses predominantly on readily available information. In addition, recommending changes to management and regulation requires broader consideration of technical, social and economic factors, is potentially complex and requires specific work on each industry sector. This project has focussed predominantly on sewage treatment plants (STPs) with a secondary focus on aquaculture activities. Further building and maintaining this information and making it available will also be important future tasks.

This report is a major product of the three-year project and outlines the methods and findings from the work which investigated nutrient-related point source activities within the Reef catchment. It was found that monitoring and release conditions for point source activities in Queensland can vary significantly depending on the activity, the nature of the release and the location. In addition, Environmental Authorities (EAs) or approvals can be difficult to interpret given the potentially complex relationship between approvals, activities, facilities, release points and release conditions. As a result, a framework was developed and applied in this project to review point source nutrient loads and regulation in the Reef catchment. The review was focused at an industry level and involved the following steps: (1) Defining the industry sector, types and regions; (2) Environmental approval review; (3) A risk assessment to identify higher risk point source activities; (4) Monitoring data review; and (5) Technology and sustainability considerations demonstration for STPs.

A risk assessment approach was adopted for this report. Point source activities likely to pose higher risk to the Reef catchment included continuous or routine releases, release to coastal waters within close proximity to tidal influenced water, and release of high nutrient load, considering both concentration and volume. Point source nutrient loads were determined in the first instance from release monitoring data, as reported to the Department's Water Tracking and Electronic Reporting System (WaTERS).

## Point source activity review

Point source activities were reviewed to determine the locations, approval conditions, release characteristics and nutrient loads in the Reef catchment. The industry sectors for this review were defined under the EP Act. The key information sources used were the Environmentally Relevant Activities (ERA) categories, the

Department's emission profiles, Reef catchment/region boundaries and the public register that contains approval information. Based on this work, the activities that potentially release nutrients to the Reef catchment, called nutrient activities, were identified. The 13 nutrient activities groups included, in order of emissions scoring, aquaculture, sewage treatment, chemical manufacturing, metals smelting/refining, meat processing, milk processing, seafood processing, waste disposal, electrical generation, mineral processing, petroleum, mining and oil refining/processing.

Over 3,000 approvals were reviewed manually. Of these, 530 were linked to 1145 nutrient activities and 867 facilities distributed across the six Reef catchment regions and islands. Within this group, only 302 facilities were identified as being authorised to release to waters. Facilities that are authorised to release to water were classified by their primary activity, 35% of these facilities were STPs, 29% were mines, 9% were aquaculture and 7% were mineral handling sites. A digital and spatial database was developed to capture approval conditions for facilities that carry out a nutrient activity and potentially release nutrients to the Reef catchment.

To get an indication of the upper bounds for potential point source nutrient load released in the Reef catchment, catchment estimates were derived from approval conditions for the 302 facilities that release to water. From the available approvals, estimates of authorised maximum nutrient load were only possible for those facilities that had specified limits for release quantity (loads) or for both quality (concentrations) and flow volume in the approval conditions. This scenario only applied to 97 facilities for total nitrogen (TN) and 86 facilities for total phosphorus (TP). Based on the estimated maximum loads, relatively speaking, STPs and aquaculture activities have the potential to release the most significant proportion of point source nutrients to the Reef catchment. Meat processing and chemical manufacturing were identified as also having the capacity to release relatively high nutrient loads to the Reef catchment compared to other point source nutrient activities, but not nearly to the same extent as aquaculture and sewage treatment activities.

A manual review of approval conditions was undertaken to determine how release limits vary within and between ERA's as part of a standards review process. However, there were a range of challenges with this process, such as determining facilities and locations from approvals. For those approvals reviewed, release conditions varied significantly and were often complex. Some approval conditions were not able to be interpreted.

The majority of sewage treatment and aquaculture facilities are required to monitor TN and TP for their release to water. Release limits for these activities typically involve maximum or long-term median (or mean) concentration limit. Nutrient limits for STPs typically involved median of weekly samples taken over twelve months while nutrient limits for aquaculture facilities involve means of samples taken over 6 weeks to 6 months. Monitoring and limits were also often required for the volume of wastewater released, particularly for continuous releases. Often, separate limits for volume were applied for wet weather periods to account for rainfall or infiltration. In some cases, a maximum nutrient load limit was applied, usually assessed over an annual period.

Out of the 302 facilities identified as being authorised release to water in the Reef catchment, 143 were STPs and 27 were aquaculture facilities. Approximately a third of the STPs were private and non-council STPs and were smaller facilities that generally did not release to water. The remainder (92 facilities) were owned and operated by councils and included all of the medium to large sized STPs.

End-of-pipe (release) nutrient concentration limits were available for 50 of the above 143 STPs, while approximately 30 STPs had load limits for TN and TP. The values for STP limits varied over the different activity classifications, which relate to facility size. The long-term median TN concentration limit ranged from 3 to 20 mg/L. The long-term median TP concentrations limit ranged from 1 to 10 mg/L. Some facilities in the

two smaller STP activity classifications had higher nutrient concentration limits. Maximum ammonia concentration limits ranged from 1 to 10 mg-N/L. Maximum TSS concentration limits varied from around 30 to 180 mg/L.

Of the 27 operational aquaculture facilities identified in this project, 25 have long-term mean limits for TN and TP concentrations. For these facilities, the long-term TN mean concentration limits ranged from 0.6 to 2.5 mg/L across the different activity classifications, while long-term TP mean concentration limits ranged from 0.05 to 0.4 mg/L. Only two aquaculture facilities have TN and TP load limits. The maximum TSS limit imposed on aquaculture facilities varied from 20 to 200 mg/L.

Point source release monitoring data was reviewed to evaluate its completeness and quality. Data from 125 facilities were obtained from WaTERS. As part of a specific monitoring data request for this project, 81 facilities, including 46 STPs, 33 aquaculture facilities and two meat processing facilities, were contacted to obtain the last five years of release monitoring data as they were not previously setup to provide monitoring data to WaTERS. Monitoring data was received from 85% of these facilities. Across all facilities, there were some incomplete data sets because of change of staff, lost records, or monitoring not being undertaken as required in the approval. Data quality was also an issue, such as unit errors or data not QA/QC'd correctly by operators. Recent monitoring data sets for 2017 and 2018 were the most complete. Accordingly, the 2017 and 2018 monitoring data were used to determine release nutrient loads and concentrations which are discussed below.

## Point source nutrient loads

Characterising point source nutrient loads is important to assess the relative contribution of different point source activities and facilities to the overall nutrient inputs to the Reef catchment and regions and determine if they are significant. Firstly, a risk assessment approach was used in this review and when assessing nutrient loads. Point source activities likely to pose higher risk to the Reef catchment included continuous or routine releases, release to coastal waters within close proximity to tidal influenced water, and release of high nutrient load, considering both concentration and volume. Point source nutrient loads were determined in the first instance from release monitoring data sourced from WaTERS or through separate monitoring data requests.

Nutrient loads were determined for 75 facilities based on available release monitoring data for volume, TN and TP. This included one meat processing plant, eight aquaculture facilities and 66 council STPs. The combined TN loads for council STPs, aquaculture facilities and the meat processing plant in the coastal zone for 2017 and 2018 were approximately 406 and 397 tonnes, respectively. The combined TP loads for 2017 and 2018 were approximately 123 and 104 tonnes, respectively.

The above calculated point source nutrient loads were compared to anthropogenic diffuse nutrient loads for the Reef catchment. Anthropogenic diffuse loads were estimated based on the Department's catchment modelling data used for the Reef Water Quality Report Card based on Source modelling. The anthropogenic TN and TP load for each Reef catchment region was estimated by combining the inorganic and organic dissolved components of the Source modelling. Overall, the 75 facilities (66 being STPs) in the coastal zone of the Reef catchment for which nutrient load was calculated accounted for approximately 3.6% of the total Reef catchment TN load and approximately 8.8% of the total Reef catchment TP load. The exact point source activity contributions to Reef wide TN and TP loads could not be calculated at this point in time, but it is worth noting that monitoring data was not available for over 200 facilities with associated activities that release to water, so the contributions presented in this report are lower than the expected actual contributions.

Based on available nutrient release monitoring data for 2018, the greatest TN loads were released in the Burdekin region while the greatest TP loads were released in the Fitzroy region. The Wet Tropics and Burnett-Mary regions also received relatively high point source nutrient loads, while the Mackay Whitsundays region had the lowest point source nutrient loads, other than islands, for which, nutrient loads were extremely low. The relative point source nutrient load contribution to each Reef catchment region was also investigated using available Source modelling load data. For point source TN loads, this varied from 2% for the Wet Tropics, Mackay Whitsunday and Burnett-Mary regions to 12% for the Burdekin region. The point source TN load in the Burdekin region was also the highest of any region at 146 tonnes per year, followed by the Fitzroy region at 97 tonnes per year, which was 6% of the anthropogenic load for that region. For point source TP loads, this varied from 2% in the Mackay Whitsundays region to 16% for the Burdekin region. Interestingly, the Burdekin region is estimated as having a diffuse anthropogenic TP load of only 23 tonnes per year, significantly lower than other regions. The point source TP load in the Fitzroy region was the highest of any region at 46 tonnes per year, followed by the Burdekin region at 28 tonnes per year. Point sources contributed approximately 9% of the anthropogenic TP load for the Fitzroy region and 55% for the Burdekin region.

## Sewage Treatment Plant review

STPs were identified as the major contributor of point source nutrient loads to the Reef catchment. Therefore, a detailed review of the wastewater characteristics and current environmental management practices will help identify opportunities for management of nutrient releases. Based on the release monitoring data obtained, 50% of the council STPs are achieving better than 3.3 mg/L TN and 0.71 mg/L TP. This suggests an extremely high level of nutrient treatment for these facilities. There is information to suggest that the overall nutrient release concentrations in 2018 and 2019 have improved because of improved treatment and nutrient removal.

Release monitoring data collected for council STPs located on islands was found to have a substantially different treatment type and/or operating performance compared to those on the mainland, for example, very high concentrations of ammonia was observed. However, the island STPs only contribute very minor point source nutrient loads to the Reef catchment. As a result, STPs located on islands were not included in subsequent analysis in this report.

Information obtained from operators of council STPs located in the Reef catchment was used to help assess technology and sustainability. As treatment level is determined by the type of treatment technology used, a STP treatment technology classification was developed to help benchmark nutrient loads released to water by council STPs in a way that is meaningful. Council STPs for which nutrient loads were available, were allocated to advanced, high, medium, low and very low treatment level categories. The majority of STPs were classed as advanced, high or medium treatment level systems. Limited nutrient monitoring data was available to benchmark the release quality of the STPs in the low to very low treatment categories.

As expected, the council STPs that used chemical addition achieved very low TP concentrations in their wastewater. Chemicals added to remove phosphorus included alum and polyelectrolytes, but low TP concentrations were only achieved when alum was used. Data was collected on the usage of these chemicals but was not investigated in detail in this review.

The amounts of off-site reuse, on-site reuse and disposal to land was analysed. Overall, off-site reuse via third parties was the most common alternative used instead of release to water, although disposal to land was more common for the smaller STPs. Council STPs in categories (1g) (greater than 100,000 equivalent persons (EP)), (1d) (between 4,000 to 10,000 EP), and (1b) (between 100 to 1,500 EP) had the lowest levels of reuse/land disposal. Off-site reuse of bio-solids is the most common practice performed for managing bio-

solids for council STPs within the Reef catchment and larger facilitates generally achieve 100% bio-solid reuse. Bio-solid reuse includes composting/fertiliser, agriculture, mine rehabilitation, commercial landscaping, and forestry. However, STPs less than 4,000 EP ((1b) and (1c)), generally had 100% disposal to landfill.

Operating and capital costs for STPs were standardised using design EP levels. The average operating cost for STPs ranged from approximately $50 per EP per year for larger faciltiies (i.e. above 50,000 EP) to nearly $600 per EP per year for the smallest facilities (i.e. below 1,500 EP). For capital costs, there was a substantial difference between very small (1b) and very large (i.e. category (1g)) STPs. However, the capital cost for STPs in the range of 1,500 to 100,000 EP (i.e. categories (1c) to (1f)) was in the order of $1,000 per EP.

## Aquaculture review

Aquaculture activities were identified as the second highest contributor of point source nutrient loads to the Reef catchment, after STPs. Therefore, investigation into the management of nutrient releases from aquaculture facilities was undertaken. Approximately a third of the aquaculture facilities were identified as not operational and have not been for several years, despite having an active approval. For the aquaculture facilities that were contacted, the monitoring data sets provided were often incomplete. This was possibly linked to change in staff or operation and challenges with record keeping and data management.

All of the aquaculture facilities reviewed involved intake water. However, the available monitoring data on input flows and water quality was relatively limited at the time of this review. It should be noted that nutrient content of the intake water was not considered as part of the aquaculture nutrient load estimate but could be considered in the future where the nutrient concentrations and intake volumes are also monitored.

There was insufficient release monitoring data to assess the nutrient loads from aquaculture facilities in the Reef catchment reliably. However, the loads estimated from approval limits generally over-estimated the calculated loads based on monitoring data, sometimes by a considerable margin. This is likely to do with the seasonally cyclic nature of the aquaculture industry or that production is not at full capacity compared to the approval granted.

## Key recommendations and further work

From the work done in this project, it is recommended that all facilities with nutrient activities, that are authorised to release to water, monitor nutrient concentrations and daily volumes for release water, and intake water if applicable. As a minimum, nutrient monitoring should include TN and TP concentrations on a weekly basis (current industry standard) and, for continuous releases to coastal waters, routine monitoring of dissolved nutrients such as ammonia and nitrate/nitrite (oxidised nitrogen) and filterable reactive phosphorus should also be carried out.

To assist with obtaining an up to date understanding of point sources nutrient loads released to the Reef catchment, it is recommended that all facilities authorised to release to water in the Reef catchment provide their monitoring data to the Department in a digital format and on a regular basis (minimum annually). Some approval conditions may require changes to support this recommendation. Ideally, WaTERS should be used as the portal to submit such monitoring data to the Department.

Given approval conditions are continually changing, ongoing maintenance and updating of the current nutrient metadata database and spatial layer is required. This could also include sourcing of missing information identified in this stage of the project, in particular the spatial location of release and monitoring

points and the indicators monitored. Ideally, further work should be undertaken to ensure approval conditions are digitally available and clearly identify facilities, location and release conditions.

It is also recommended that a communication portal be developed to convey information to industry, other government agencies and the public on point source activities in the Reef catchment. The portal could capture information and products from this project and provide the latest up-to-date monitoring data and information.

Monitoring of the local receiving environment appears to be the standard for point source activities of all sizes that are authorised to release to water, particularly for continuous releases to coastal waters. However, receiving environment monitoring is not undertaken in all cases. Further work is required to develop guidance to ensure that receiving water monitoring can be done efficiently and cost-effectively, while still allowing for potential environmental impacts to be identified. For STPs, the monitoring programs is also linked to a range of partnership monitoring that is done collaboratively with other parties such as state government or regional organisations. To assist with a review of these monitoring programs and providing better linkages with waterway reporting and assessment, we recommend that this receiving environment monitoring data is collated and reviewed. Ideally, this monitoring data should be regularly submitted to WaTERS.

Although the nutrient removal of many council STPs in each activity classification was good, some high release concentrations were observed. For example, some facilities in ERA category 63-(1e) and 63-(1c) had high release nutrient concentrations and could be investigated further to determine the potential for improved nutrient removal and nutrient load reduction at these facilities. Additional information on release nutrient concentrations is also required for some STPs.

Substantial information was collected in this project on council STP environmental management, including chemical usage for phosphorus removal but further work is required to analyse these data and benchmark practices and standards. For those privately owned STPs that were identified to involve a release to water, future work could be undertaken to collect relevant information and monitoring data about their releases.

Although preliminary information was obtained on aquaculture facilities, significantly more information is needed, particularly given the complexity and nature of these activities and releases. This information would need to be obtained in close collaboration with the industry and relevant industry associations. Also, WaTERS should be implemented to the aquaculture industry to assist with data management and analysis for both release and intake water. Further work is also required, similar to that undertaken for STPs, to understand the specific processes involved in the industry for both prawn and barramundi farming, and to benchmark leading practice environmental management for the industry.

Further investigation into phosphorus released to water from meat processing plants should also be considered. Other areas of further work include review of nutrient activities identified as having a release (disposal) to land in the Reef catchment. In coastal areas, these could be a potential contributor to nutrient loads, particularly where they are not managed well or occur on sandy soils.

# 1. Introduction

## 1.1 Policy context

It is recognised in the 2017 Scientific Consensus Statement that the decline of marine water quality associated with land-based run-off from the adjacent catchments is a major cause of the current poor state of many of the coastal and marine ecosystems of the Great Barrier Reef (Reef) catchment. While all land-based pollutant sources, including urban diffuse, point source and industrial, have been considered as part of this 2017 Scientific Consensus Statement, the main source of the primary pollutants (nutrients, fine sediments and pesticides) is diffuse source pollution from agriculture.

These primary pollutants pose a risk to Reef catchment coastal and marine ecosystems. It is, however, important to note the scale at which the different pollutant sources pose the greatest risk. Diffuse source pollution from agriculture is important at a regional and Reef-wide scale. Whereas, other land uses, including urban areas, contribute relatively small but concentrated pollutant loads, which may be important at local scales.

The Independent Science Panel noted in the 2017 Scientific Consensus Statement that point sources (e.g. urban, industrial and ports) require more information to understand the level of risk[1]. The 2017 Scientific Consensus Statement stated that "Information on the pollutant contributions from non-agricultural sources (e.g. urban, industrial and ports) and other pollutants should be compiled as a priority to support whole-of-catchment management approaches." Point sources are generally regulated activities; however, monitoring and approval information is not always easily accessible. In some cases, no monitoring data exist[2].

The revised Reef 2050 Long-Term Sustainability Plan (July 2018)[3] identifies priorities for immediate attention and new actions to protect the values of the Reef and improve the Reef's resilience. The water quality theme under the Reef 2050 Long-Term Sustainability Plan includes foundational programs and activities, targets (2025) and objectives (2035). One of the 2035 Water Quality Objectives within the Reef 2050 Long-Term Sustainability Plan is that "Over successive decades the quality of water in or entering the Great Barrier Reef from all sources including industrial, aquaculture, port (including dredging), urban waste and stormwater sources has no detrimental impact on the health and resilience of the Great Barrier Reef."

A major component of the Water Quality Foundational Programs and Activities within the Reef 2050 Long-Term Sustainability Plan is the Reef 2050 Water Quality Improvement Plan 2017–2022[4] (Reef 2050 WQIP). In particular, the Reef 2050 WQIP seeks to improve the quality of water flowing from the catchments adjacent to the Reef. The Reef 2050 WQIP includes:

- all sources of land-based water pollution: agriculture, industry, urban and public lands, while recognising that the majority of water pollution still arises from agricultural activities,
- applying minimum practice standards across all industries and land uses,
- supporting industries and communities to build a culture of innovation and stewardship that takes them beyond minimum standards,
- restoring catchments through works to improve or repair riparian vegetation, streambanks, gullies, waterways and wetlands,
- implementing regional approaches for specific catchments, and

[1] http://www.reefplan.qld.gov.au/about/assets/2017-scientific-consensus-statement-summary.pdf
[2] http://www.reefplan.qld.gov.au/about/assets/2017-scientific-consensus-statement-summary-chap02.pdf
[3] https://www.environment.gov.au/system/files/resources/35e55187-b76e-4aaf-a2fa-376a65c89810/files/reef-2050-long-term-sustainability-plan-2018.pdf
[4] https://www.reefplan.qld.gov.au/__data/assets/pdf_file/0017/46115/reef-2050-water-quality-improvement-plan-2017-22.pdf

- setting individual targets for reducing water pollution from the catchments, enabling better prioritising where the most management action is needed.

The Reef 2050 Long-Term Sustainability Plan also recognises the role of the Queensland Government in enforcing current regulations designed to reduce nutrient and sediment pollution under the EP Act. The Water Quality Foundational programs and activities also lists ongoing activities to reduce nutrients including nominated STP upgrades and implementing regulatory standards for stormwater run-off, dredging, sewage outfalls, mine releases and industrial contaminants. This also aligns with the Reef 2050 WQIP.

In May 2016 the Great Barrier Reef Water Science Taskforce (the Taskforce) made a series of recommendations to the Queensland Government on how to meet water quality targets under the Reef 2050 Long-Term Sustainability Plan. The Taskforce recommended that the Queensland Government implement staged regulations to reduce water pollution throughout the Reef catchment regions. As part of this, the Queensland Government agreed, or agreed in principle, to review environmental approvals issued under the EP Act for point source nutrient and sediment contributors (such as sewage treatment plants, aquaculture facilities, mining, dredging and quarrying), by 2020, to ensure they meet modern water quality standards.

While there is a legislative standard for the consideration of a proposal to release pollution to waters[5], there is no recognised modern water quality standard when approving point source releases. Approval standards and release conditions vary by industry, location, climate, known environmental values and by when they were imposed. As contemporary science and technology improves, the EP Act allows for operating licenses to be updated, however this is seldom carried out in practice as approvals in Queensland are issued in perpetuity.

In response to the Taskforce report, the Office of the Great Barrier Reef requested information from the Department's Environmental Services and Regulation (ESR) Division about current standards for regulated activities in the Reef catchment. More specifically, information was requested in relation to:

- where each facility is located,
- which Environmentally Relevant Activity (ERA or activity) is carried out at each facility,
- whether there is an authorised point source release at the facility,
- where the release point is located on the facility (EAs can cover thousands of hectares),
- the release conditions attached to the specific environmental approval, and
- the actual nutrient loads being released.

The ESR Division of DES manages the public register that holds information on approvals including operator details, activity types, location, and copies of the approvals. Approval conditions are generally kept as hard-copy documents (or pdfs) with limited searching capability. In order to assess nutrient releases to waters in the Reef catchment, every relevant record in the public register has to be analysed.

To delivery on the aspects of the Reef 2050 Long-Term Sustainability Plan, the Reef 2050 WQIP and the above Taskforce recommendations related to land-based water pollution from point sources, the Point Source Metadata Project was proposed and undertaken by the Science and Technology Division of DES.

[5] As per ss175-176 of the EP Act, decisions on applications for an Environmental Authority (EA) to carry out an environmentally relevant activity (ERA) must comply with the regulatory requirements and have regard to the standard criteria.

## 1.2 Point source regulation

Point source activities that are classified as ERA are regulated in Queensland using EAs or approvals issued under the EP Act. These approvals set out a range of conditions in terms of how the point source activity has to be operated and monitored and what release standards need to be achieved. Information on EAs in Queensland can be obtained from the Public Register[6].

Although there are generally similarities in approval conditions for an activity type, the release conditions for a facility can vary significantly depending on the activity, the nature of the release and the location. A diagrammatic representation of the possible relationships between facility, activity, release point/s and release conditions in approvals in Queensland is provide in Figure 1-1.


**Figure 1-1. Relationship between facility, activity, release point/s and release conditions**

[6] https://www.qld.gov.au/environment/pollution/licences-permits/public-register

## 1.3 Project outline

The project aims to collate and provide information on point sources in the Reef catchment, including locations, release conditions and nutrient loads and concentrations. The ultimate aim is to help inform and prioritise future monitoring, management and regulation of point source activities. However, this three year project is only a first major step in benchmarking the current status of nutrient point sources. It focusses predominantly on readily available information. For example, the assessment of releases is heavily reliant on approval conditions and existing requirements for monitoring. Although the need for additional monitoring may be identified, undertaking this monitoring is outside the scope of this project. Similarly, recommending changes to management and regulation requires broader consideration of technical, social and economic factors, and often site-specific assessment. This is potentially complex and specific work is needed on each industry area. This project has focussed predominantly on STPs and further work is needed on STPs and other activities such as aquaculture. Regardless, management and regulation will benefit significantly from having better available information on point source activities in the Reef catchment. Further building and maintaining of this information and making it available will also be important future tasks beyond this project.

This report outlines the methodology and findings of the project. Because of the variability and complexity of point source regulation in Queensland, a monitoring and release standards review framework was first developed and then applied to point source activities in the Reef catchment. This involved the following key elements: (1) Defining the industry sector, types and regions; (2) Environmental approval review (3) A risk assessment to identify higher risk activities; (4) Monitoring data review; and (5) Technology and sustainability considerations demonstration with STPs. The contents in this report are designed to provide evidence-based information to support DES and industry when reviewing monitoring and release standards with the view to better understanding and lowering the potential risk from nutrient releases to water, while also considering broader economic and environmental factors.

As part of this project, over 3,000 approvals located in the Reef catchment were identified and reviewed. Those facilities that have authorised releases to water, and potentially contributing nutrient loads to the Reef catchment, were then identified. Using this information, a digital and spatial (“metadata”) database was developed and captured approval conditions for facilities that release nutrients in the Reef catchment.

The Science and Technology Division also used information from WaTERS, which holds monitoring data for point source releases for over 300 locations across Queensland. This information and additional monitoring data collected as part of this project was used, along with approval information, to estimate the annual loads of nutrients released from these activities to the Reef catchment and to explore nutrient release concentrations.

A questionnaire was also prepared and undertaken by councils in the Reef catchment to help obtain information on sustainability aspects of STP environmental management. The key areas of information included alternatives to release to water, including reuse and disposal to land, management of bio-solids, energy usage, capital and operating costs, and environmental monitoring. This important information should be considered when making decisions in relation to point source release monitoring and standards.

A number of key recommendations and areas of further work are also provided based on the outcomes of the project.

# 2. Monitoring and release standards review framework

This section presents a monitoring and release standards review framework that has been developed for an industry-level review of point source nutrient loads regulation in the Reef catchment. The framework will be used to help assess the suitability of current approvals in the context of protecting the Great Barrier Reef, given release conditions currently vary by industry (or activity), location, climate, environmental values and by when they were imposed. Although some type of site-specific assessment will always be required with point source release, a greater understanding of current and minimum release standards for point source activities will help ensure regulation is undertaken effectively. A further issue is that for most industries, the current or leading-practice (sometimes called best-practice) level of environmental management is not commonly known or documented. Understanding of the broader environmental, feasibility and financial implications is also important.

The framework has been applied to activities in the Reef catchment in subsequent sections of this report. The framework brings together information at a facility-level based on the approvals, release monitoring data and operational information to develop an industry-level view of point source regulation. The information compiled through this process will also help with more detailed site-specific assessment, as needed in the future. For activities which are categorised as a potentially significant source of nutrients to the Reef catchment, overall recommendations will be provided to help inform future release standards and regulation, support the industry with decision making and focus resources to reduce water pollution in the Reef catchment.

## 2.1 Framework overview

A framework to assist the review of point source releases and regulation has been developed (see Figure 2-1). The framework is focused on water release standards, but also considers current industrial practice and broader environmental management and sustainability issues. The framework incorporates a risk categorisation step which take into account the nature, the scale and location of the point source activity. At the completion of these steps, recommendations can be made in regard to priority activities in terms of monitoring and release standards, improved regulation, and areas of further work.

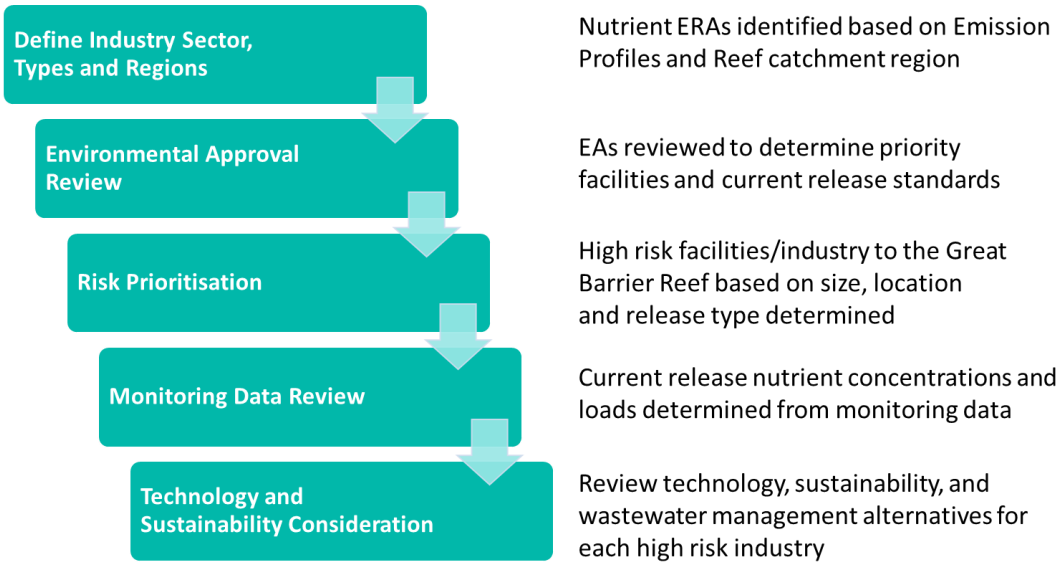



**Figure 2-1. Monitoring and Release Standards Review Framework used to assess point sources in the Reef catchment**

### 2.1.1 Define industry sector, types and regions

This step is undertaken for all activities in the Reef catchment as outlined in Section 3 of this report. The key information sources are the ERA categories, emission profiles, catchment/region boundaries and the public register that contains approval information. Based on this work, the activities that potentially release nutrients to the Reef catchment, called nutrient activities, can be identified.

### 2.1.2 Environmental approval review

The next stage of the framework was to review the approvals for nutrient activities identified in the Reef catchment to determine priority facilities. This work is summarised in Section 4 of this report and was based largely on a manual review of approvals. Details of the relevant facilities including approval conditions for release to water in the Reef catchment is captured in a nutrient metadata database and Power BI Metadata Tool. Information includes approval number, facility name and location, release locations and release details, including monitored indicators and limits. This was used to estimate maximum authorised nutrient loads to help identify priority activities and facilities for further risk prioritisation.

### 2.1.3 Risk prioritisation

Point source facilities may pose a risk to the environment as a result of the contaminants present in the wastewater that is released. Generally, this is most likely to be highest at locations closest to the release, often termed the local or near-field receiving environment. In some cases where the loads of contaminants released are significant, these may potentially impact on the broader environment. In addition, when a number of activities are located within the same catchment, their combined effect, often termed cumulative impact, can also potentially impact on the broader environment. This is the basis for assessing the nutrient releases from point source activities in the Reef catchment. However, risk criteria need to be developed to help assess the relative risk. For example, point source activities that are not known to release nutrients, those that are small in nature, or those located a significant distance away from the coast, pose a low risk to the Reef lagoon in relation to nutrients.

There are a number of key risk factors when assessing point source releases. These have been summarised in Table 2-1 based on the Departments guideline on *Wastewater release to Queensland waters*[7]. These should be considered when assessing potential environmental impact (or regulatory release criteria) for any point source release. The activity size can be specified in production quantities such as equivalent persons in the case of sewage treatment, area of production for aquaculture facilities, or tonnes of throughput for processing activities. It is important to identify the current and future (e.g. ultimate) sizes that are relevant to the approval. Additionally, an understanding the potential nature of contaminants is important. Different release types also exist including continuous, event or wet weather-based or tidally restricted. All of these factors, along with the relevant environmental assessment typically done at a local scale, are generally used to assess potential impact and determine the release limits specified in environmental approvals in Queensland.

**Table 2-1. Typical risk factors for point source releases**

| |
|---|
| • Industry type and size |
| • Use of waste avoidance |
| • Nature of contaminants |

[7] Department of Environment and Science. 2016. Wastewater release to Queensland waters. Technical Guideline. ESR/2015/1654. https://environment.des.qld.gov.au/__data/assets/pdf_file/0031/88636/pr-gl-wastewater-to-waters.pdf

- Release volume
- Frequency, timing and variability
- Relative location to receptors
- Type or configuration of the release

The major focus of this review is on nutrients, which include dissolved, particulate, organic and inorganic forms of nitrogen and phosphorus, though many activities are regulated based on total concentrations of nitrogen or phosphorus. Information on dissolved nutrient concentrations is less frequently available, although large STPs often monitor ammonia, a key component of dissolved inorganic nitrogen that can be toxic to aquatic life if concentrations are high enough. The nutrient indicators associated with release monitoring are discussed in more detail in Section 5.

To understand the pathways of potential impact for specific hazards, it is recommended that a good conceptual understanding is developed for the activity and how it potentially interacts with the environment. A conceptual model can be developed to help identify, characterise, or priorities potential hazards, the pathway for impact and the potential risk.

The initial focus of this review is on point sources with nutrient activities that are authorised to release wastewater within the Reef catchment. The key focus is on activities that are most likely to release TN and TP, particularly dissolved inorganic nitrogen, which is recognised as having the greatest significance in terms of nutrient-related impacts to the Reef catchment. The highest potential risk is likely to be from those facilities that are permitted to release continuously to waterways, compared to event releases, as well as those of greater magnitude and/or located closer to the Reef lagoon. In addition, the risk can also be higher for facilities located in catchments where nutrient inputs are already well above what is sustainable.

### 2.1.4 Monitoring data review

Monitoring of point source releases is generally a requirement of the operation of an ERA under the approval. Monitoring can include monitoring within the activity, monitoring of the release and monitoring of the receiving waters. In many cases, monitoring is undertaken on the quality and quantity (e.g. volume) of the release. However, the indicators and frequency of monitoring will vary significantly between activities and facilities as a function of the age of the approval, the receiving water environmental values and the nature and magnitude of the hazards the potential risks involved.

The important information that is needed to assess point source facilities includes the concentrations and loads of key contaminants. In this review, the primary focus is on nutrient concentrations. However, some consideration should also be given to other contaminants that might cause local or human health impacts, such as toxicants or pathogens. This is because the management and treatment of wastewater to remove nutrients will also potentially affect concentrations of other contaminants. For assessing nutrient impacts at a catchment or regional scale, it is generally recommended that average loads are used. Information on release volumes or rates, along with nutrient concentrations, over the time period being assessed, are essential for determining nutrient loads. This review will generally focus on annual loads. Short term fluctuations in loads (and concentrations) are more relevant for assessing acute affects, such as for toxicants, and this is outside the scope of this review.

Section 6 of this report assesses the release monitoring data currently available on point source with nutrient activities in the Reef catchment, as gleaned from WaTERS and information requests carried out specifically as part of this project. Monitoring information is available mainly for STPs and aquaculture facilities. Gathering water quality and quantity data have been used to characterise the release quality for different

types and sizes of facilities and help benchmark current monitoring and release standards. This also allows an estimate of the nutrient loads from specific facilities based on monitoring data and current release concentrations to help develop an estimate of their contributions to the Reef catchment and recommendations in terms of point source regulation.

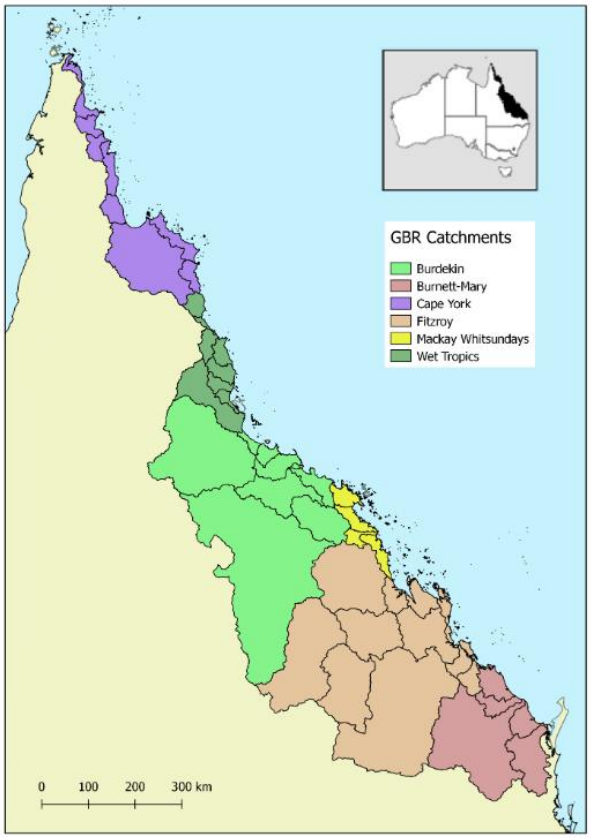
### 2.1.5 Technology and sustainability considerations

Potential risk to the Reef catchment from point source facilities is assessed in terms of release nutrient concentrations and loads. However, the setting of release standards will indirectly determine the types or level of management (including reuse and treatment) that will be required. Higher levels of treatment technology are more likely to achieve a better environmental outcome in terms of nutrient release quality and loads but may have broader environmental implications, particularly from energy use, chemical usage and production of $CO_2$ and greenhouse gases. Other environmental considerations include the fate of solid waste or biosolids. These considerations are important to assess the overall environmental sustainability of technological solutions. Understanding these factors requires detailed information about the industry sector and, ideally, good conceptual understanding of the management processes involved. Other important sustainability considerations include cost in terms of capital and operating expenditure. Important factors, particularly in rural or remote areas, include the technical capacity of the staff needed to operate and maintain the treatment. For STPs, the costs associated with building and operating high technological treatment plants needs to be worn by the council and ultimately the community. A further consideration for new management or technological approaches is business risk, particularly in terms cost and performance to meet regulatory standards.

Technology, alternative management and sustainability considerations should be developed for each industry area prior to changing monitoring and release standards for an industry. In reality, whole of life cycle and cost benefit analysis is required in relation to specific technological solutions for facilities, but this is outside the scope of this report.

# 3. Industry sector, types and regions

The state of Queensland is split into a number of natural resource management regions, six of these drain into the Reef lagoon. These six regions make up the Reef catchment. The six regions were further divided into 44 sub-catchments (listed below) based on the Drainage Basins GIS layer and the 2017 Scientific Consensus Statement management units[8] (Figure 3-1). Islands within the Torres Strait and Reef lagoon were also included in the review.




| | | | |
|---|---|---|---|
| **Cape York** | Endeavour | **Wet Tropics** | Barron |
| | Jacky Jacky | | Daintree |
| | Jeanie | | Herbert |
| | Lockhart | | Johnstone |
| | Normanby | | Mossman |
| | Olive Pascoe | | Mulgrave-Russell |
| | Stewart | | Murray |
| | | | Tully |
| | | **Mackay Whitsundays** | O'Connell |
| **Burdekin** | Belyando | | Pioneer |
| | Black | | Plane Creek |
| | Bowen | | Proserpine |
| | Don | | |
| | Haughton | | |
| | Lower Burdekin | **Burnett-Mary** | Baffle Creek |
| | Ross | | Burnett |
| | Suttor | | Burrum |
| | Upper Burdekin | | Kolan |
| | | | Mary |
| **Fitzroy** | Boyne | | |
| | Calliope | | |
| | Comet | | |
| | Curtis island | | |
| | Dawson | | |
| | Fitzroy | | |
| | Isaac | | |
| | Mackenzie | | |
| | Nogoa | | |
| | Shoalwater | | |
| | Styx | | |
| | Waterpark Creek | | |

**Figure 3-1. Reef catchment regions and sub-catchments used to assess point source releases**

The metadata collection was divided into the following major steps that were developed as part of this project (also see Figure 3-2):

1. **Obtain EAs for ERAs in the Reef catchment**- The initial step included the collection of approvals for all regulated activities in Reef catchments. Only Granted approvals for the period up and including December 2018 are included in the nutrient metadata database.
2. **Define nutrient activities** - This step involved the selection of activity classification groups regarded as potential risk based on the review of Environmental Emission Profiles (EEPs) for ERAs.
3. **Determine nutrient approvals, activities and facilities for the Reef catchment** – This step involved selecting a subset of approvals for the Reef catchment that involved nutrient activities. Each separate location with a nutrient activity was defined as a facility.

[8] Bartley, R., Waters, D., Turner, R., Kroon, F., Wilkinson, S., Garzon-Garcia, A., Kuhnert, P., Lewis, S., Smith, R., Bainbridge, Z., Olley, J., Brooks, A., Burton, J., Brodie, J., Waterhouse, J., 2017. Scientific Consensus Statement 2017: A synthesis of the science of land-based water quality impacts on the Great Barrier Reef, Chapter 2: Sources of sediment, nutrients, pesticides and other pollutants to the Great Barrier Reef. State of Queensland, 2017.

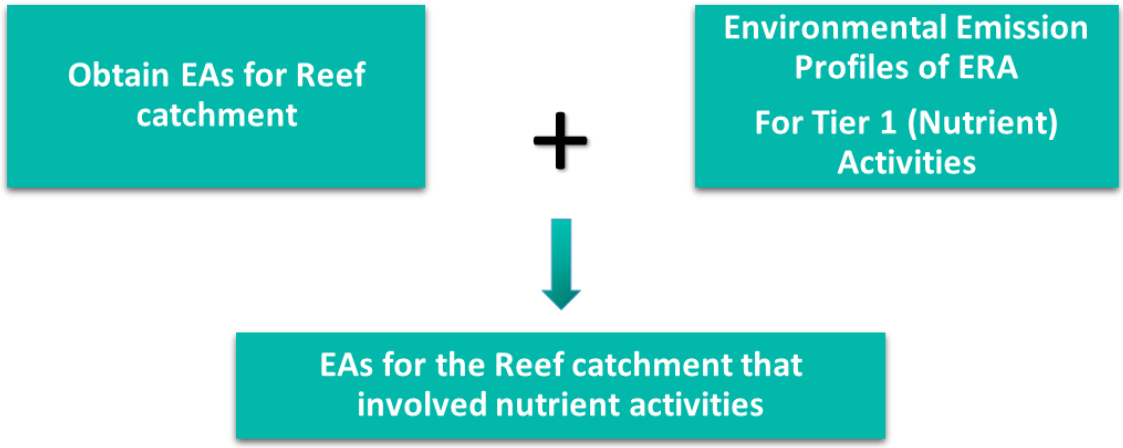



**Figure 3-2. Nutrient activities and approval identification steps**

The selection of relevant nutrient activities was based on an analysis of the former Department of Environment and Heritage Protection's EEPs for ERAs. The EEPs provided an indication of environmental risk to receiving environments from these activities and underpins the current classification of ERAs. In the EEPs, emission values are scored for each Tier (i.e. Tier 1 to 4) covering receiving environment/sectors air, land and water. The focus of this project was on activities that fall within the 'water' sector and categorised as 'Tier 1', which consists of TN and TP as nutrient indicators. These activities are described as a 'nutrient activities'.

From this analysis, 21 nutrient activity groups were determined. The 21 nutrient activity groups were then classified into 'higher risk' with Tier 1 score higher than 2 (two) and 'potential risk' with score ≤ 2 and >0 (Table 3-1). In selecting the ERA groups, ERA codes recorded in the EEPs file were checked and compared to the Environmental Protection Regulation 2008 (EP Regulation). Some of the ERA codes have been amended in the current EP Regulation[9], thus only the present codes were used in this project. No gas refining activities (9c) were identified in the Reef catchment, therefore only 20 nutrient activities are present in the Power BI Metadata Tool.

**Table 3-1. Nutrient activities for Point Source Metadata project**

| High Risk (Tier 1 Score > 2) | | | Potential Risk (Tier 1 Score ≤ 2) | | |
|---|---|---|---|---|---|
| Nutrient Activity Group (Code) | Activity Classification | Tier 1 Score (max) | Nutrient Activity Group (Code) | Activity Classification | Tier 1 Score (max) |
| Aquaculture (A) | 1-(1a), 1-(1b), 1(1c), 1-(2a), 1-(2b), 1-(2c) | 10 | Bulk material handling (MH) | 50-(1a), 50 (2) | 2 |
| Sewage treatment (STP) | 63-(1), 63-(1a)(i), 63-(1a)(ii), 63-(1b)(i), 63- (1b)(ii), 63-(1c), 63-(1d), 63-(1e), 63-(1f), 63-(1g) | 8 | Tanning (T) | 39 | 2 |
| Chemical manufacturing (CM) | 7-(4a), 7-(4b), 7-(6a), 7-(6b), 7-(6c), 7-(6d) | 7 | Cement manufacturing (C) | 41 | 2 |
| Metal smelting & refining (Met) | 30-(a), 30-(c), 30-(d) | 7 | Gas refining (GR) | 9-(c) | 1 |
| Meat processing (Me) | 25-(2a), 25-(2b), 25-(2c) | 6 | Gas producing (G) | 10 | 1 |
| Milk processing (Mi) | 26 | 6 | Fuel burning (F) | 15 | 1 |
| Seafood processing (SF) | 27 | 6 | Sugar milling or refining (Su) | 28 | 1 |
| Waste disposal (WD) | 60-(1a), 60-(1b), 60-(1c), 60-(1d), 60-(2a), 60-(2b), 60-(2c), 60-(2d), 60-(2e), 60-(2f), 60-(2g), 60-(2h) | 6 | Composting & soil conditioner manufacturing (Co) | 53 | 1 |
| Electricity generation (E) | 14-(1), 14-(2b) | 5 | | | |
| Mineral processing (MP) | 31-(2a), 31-(2b) | 5 | | | |
| Petroleum (P) | Petroleum, Petroleum – 3, Petroleum – 7, Petroleum – 8 | 5 | | | |
| Mining (M) | ML black Coal – 13, ML gold ore – 16, ML iron ore – 14, ML lead, silver or zinc – 18, ML mineral sand – 12, ML nickel ore – 15, ML other metal ore - 19 | 5 | | | |
| Oil refining or processing (O) | 11-(b) | 4 | | | |

Note: Activity classification is based on the 2008 Environmental Protection Regulation.

[9] https://www.legislation.qld.gov.au/view/pdf/inforce/2019-09-01/sl-2019-0155

Metadata was gathered in an electronic format from the Public Register, which describes facility details (site name, lot & plan and location), approval details (approval number, status, effective date and approval holders), activity classification (ERAs), Local Government Area (LGA) information, and catchment/sub-catchments.

However, no digitised information is provided in the Public Register related to approval conditions such as whether or not there is a release and if so, what water quality limits are associated with the release. This information needed to be sourced from the pdf versions of the approval.

Each granted approval in the Reef catchment with a nutrient activity was reviewed to determine if there was an authorised release to water and/or land. If the nutrient activity was authorised to release to water additional details were collected. This included relevant release limits specified in the approval, the maximum authorised nutrient release load where this could be estimated (see Appendix D), and any receiving environment monitoring details.

The approvals were also reviewed in terms of Receiving Environment Monitoring Program (REMP) requirements, either as specified in the approval conditions, or where a separate plan (often called Site Based Management Plan or REMP) is required to be developed. In addition, preliminary metadata was also captured around whether activities were permitted to release wastewater to land and, if so, what the monitoring requirements were for this type of release.

The spatial location of the release to water point and the receiving environment monitoring points was added to the nutrient metadata database, where available. Ongoing maintenance of the nutrient metadata database is required to ensure that the metadata remains current. Between January and December 2019, 61 approval were updated and would require review to ensure that the information in the nutrient metadata database is up to date. These have not been captured and considered as part of the information presented in this report.

One of the main challenges in reviewing the approvals was the limited information describing the exact location of the facility. Site information is often given as a reference to lot and plan and not the physical address or geographical coordinates (latitude and longitude) of the facility. Initially, a polygon and point spatial layer was determined for each facility with a nutrient activity was determined by using publicly available spatial layers. The polygon represented the boundary of the lot and plan or the lease for each facility. The facility location was determined as the centroid of the polygon. This means that the spatial information did not accurately represent the location of the facility within the spatial boundary of the polygon. This can be an issue for large facilities such as mine sites which can extend over more than one catchment. Later in the project, the spatial location of the facility was refined and the actual release point and the receiving environment monitoring points were included at a finer spatial resolution, if available. Therefore, the location of the release was able to be more accurately attributed to a Reef catchment region and sub catchment. This is important because load contributions to the Reef catchment and their management are considered at the region and sub-catchment scale.

Further details regarding the products and methodology are provided in Appendices A and B.

## 3.1 Summary of nutrient point sources

A total of 530 separate approvals that have activities likely to involve nutrient emissions/releases were identified in the Reef catchment across 6 regions and the islands (Figure 3-3). The majority of the approvals are within the Fitzroy region and, of these approvals, the greatest number are located in the Dawson and Isaac sub-catchments within the Fitzroy region. The number of approvals in each sub-catchment is provided in Table 3-2.

It is important to note that an individual approval may contain multiple facilities which may be located across different regions and sub-catchments. In addition, an individual facility may contain multiple activities.

Within the 530 separate approvals, there were a total of 1145 activities that were likely to involve nutrient releases. Only granted and operational activities were included in this report. Granted approvals that were not effective[10] and suspended approvals were not included in the summary information provided below or in the Power BI Metadata Tool.

Table 3-3 lists the nutrient activities along with the number of each nutrient activity type identified in the Reef catchment. The most frequent were sewage treatment, followed by waste disposal and then mining. Each of these activity groups include a further sub-category, called activity classification, which is typically based on size or production throughput (see Table 3-3 for an example). For STPs, this is based on the number of equivalent persons (EP) and is for authorised release to surface water. In the case for STPs <1500EP, a release to infiltration trench (IT) or to land via an irrigation scheme (RL) is also included in the activity classification.

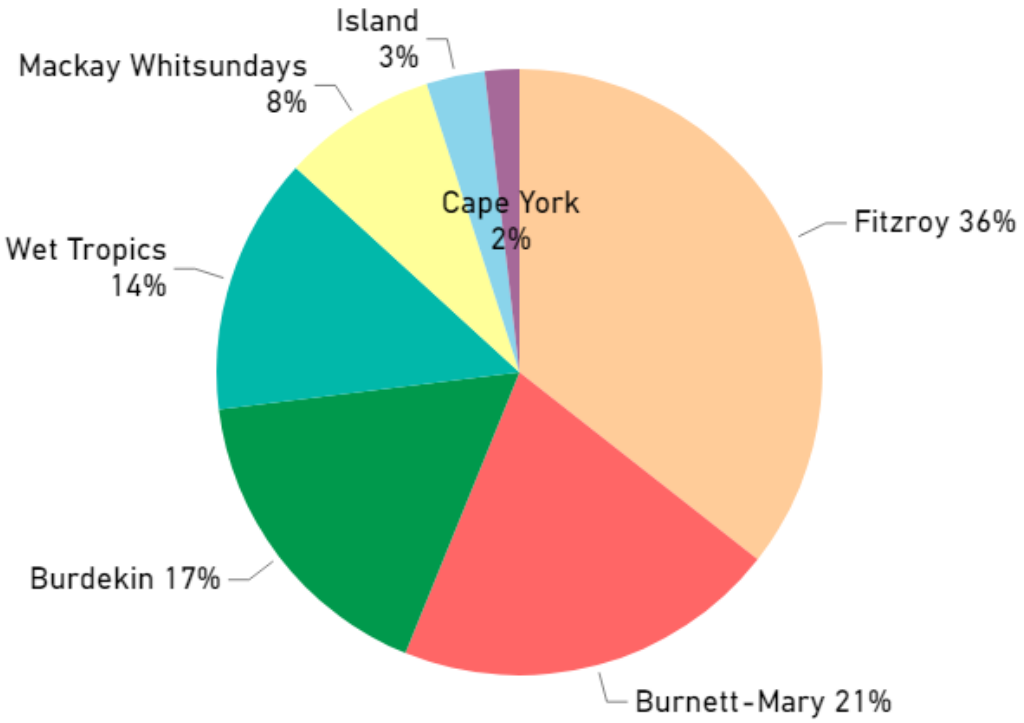



**Figure 3-3. The percentage of approvals in each Reef catchment region**

[10] EAs that are not effective refer to EAs that have been issued, however, the conditions in the approval are yet to come into effect.

**Table 3-2. Number of approvals (EAs) with nutrient activities in each sub-catchment**

| Sub-catchment | Number of EAs |
|---|---|
| Baffle Creek | 11 |
| Barron | 15 |
| Belyando | 2 |
| Black | 9 |
| Bowen | 12 |
| Boyne | 10 |
| Burnett | 44 |
| Burrum | 15 |
| Calliope | 15 |
| Comet | 12 |
| Curtis Island | 3 |
| Daintree | 6 |
| Dawson | 55 |
| Don | 14 |
| Endeavour | 2 |
| Fitzroy | 23 |
| Fraser Island | 7 |

| Sub-catchment | Number of EAs |
|---|---|
| Hamilton Island | 1 |
| Herbert | 12 |
| Isaac | 43 |
| Jeannie | 2 |
| Johnstone | 20 |
| Kolan | 7 |
| Lockhart | 4 |
| Long Island | 1 |
| Lower Burdekin | 12 |
| Mackenzie | 20 |
| Magnetic Island | 2 |
| Mary | 44 |
| Mossman | 4 |
| Mulgrave-Russell | 17 |
| Murray | 6 |
| Nogoa | 16 |
| Normanby | 3 |

| Sub-catchment | Number of EAs |
|---|---|
| O'Connell | 14 |
| Palm Island | 1 |
| Pioneer | 6 |
| Plane Creek | 22 |
| Proserpine | 7 |
| Ross | 31 |
| Ross | 1 |
| Shoalwater | 1 |
| South Molle Island | 1 |
| Styx | 2 |
| Suttor | 11 |
| Thursday Island | 1 |
| Torres Strait | 3 |
| Tully | 2 |
| Upper Burdekin | 8 |
| Waterpark Creek | 2 |

**Table 3-3. Number of nutrient activities within the Reef catchment and STP Activity Classification example**

| Activity | Count |
|---|---|
| Sewage Treatment | 395 |
| Waste Disposal | 251 |
| Mining | 100 |
| Mineral Processing | 67 |
| Bulk mineral Handling | 63 |
| Petroleum | 49 |
| Fuel burning | 45 |
| Composting | 42 |
| Aquaculture | 32 |
| Chemical Manufacturing | 24 |
| Sugar milling or refining | 20 |
| Electricity generation | 18 |
| Meat processing | 10 |
| Metal | 9 |
| Gas producing | 7 |
| Seafood | 6 |
| Milk processing | 4 |
| Cement manufacturing | 2 |
| Tanning | 1 |
| **Total** | **1145** |

| Activity | Activity Classification | Count |
|---|---|---|
| Sewage Treatment | 63-(1a)(i) | 144 |
| Sewage Treatment | 63-(1a)(ii) | 11 |
| Sewage Treatment | 63-(1b)(i) | 85 |
| Sewage Treatment | 63-(1b)(ii) | 60 |
| Sewage Treatment | 63-(1c) | 38 |
| Sewage Treatment | 63-(1d) | 25 |
| Sewage Treatment | 63-(1e) | 26 |
| Sewage Treatment | 63-(1f) | 4 |
| Sewage Treatment | 63-(1g) | 2 |
| **Total** | | **395** |

63-(1a)(i) Sewage treatment >21 to 100EP - IT or IR
63-(1a)(ii) Sewage treatment >21 to 100EP - No IT or IR
63-(1b)(i) Sewage treatment >100 to 1500EP - IT or IR
63-(1b)(ii) Sewage treatment >100 to 1500EP - no IT or IR
63-(1c) Sewage treatment >1500 to 4000EP
63-(1d) Sewage treatment >4000 to 10000EP
63-(1e) Sewage treatment >10000 to 50000EP
63-(1f) Sewage treatment >50000 to 100000EP
63-(1g) Sewage treatment >100000EP

As some facilities can have multiple activities, these 1145 activities were distributed across 867 facilities. The number of approvals, facilities and activities in each region is provided in Table 3-4. The type and number of each activity in each region is provided in Table 3-5 below. Sewage treatment, waste disposal and mining/mineral process represent the majority of the nutrient activities.

**Table 3-4. Number of approvals (EAs), facilities and activities in each region**

| Region | Number of EAs | Number of Facilities | Number of Activities |
|---|---|---|---|
| Fitzroy | 194 | 283 | 449 |
| Burnett-Mary | 112 | 206 | 231 |
| Burdekin | 92 | 120 | 176 |
| Wet Tropics | 75 | 125 | 146 |
| Mackay Whitsundays | 45 | 65 | 72 |
| Island | 17 | 52 | 52 |
| Cape York | 10 | 16 | 19 |
| **Total** | **530** | **867** | **1145** |

**Table 3-5. Type and number of activities in each region**

| Activity | Burdekin | Burnett-Mary | Cape York | Fitzroy | Island | Mackay Whitsundays | Wet Tropics | **Total** |
|---|---|---|---|---|---|---|---|---|
| Sewage Treatment | 48 | 103 | 9 | 127 | 31 | 27 | 50 | **395** |
| Waste Disposal | 28 | 64 | 8 | 83 | 20 | 14 | 34 | **251** |
| Mining | 25 | 9 | 1 | 61 | | | 4 | **100** |
| Mineral Processing | 14 | 4 | 1 | 44 | | 1 | 3 | **67** |
| Bulk mineral Handling | 16 | 5 | | 19 | | 10 | 13 | **63** |
| Petroleum | 2 | | | 47 | | | | **49** |
| Fuel burning | 8 | 7 | | 24 | 1 | 1 | 4 | **45** |
| Composting | 4 | 21 | | 5 | | 5 | 7 | **42** |
| Aquaculture | 4 | 4 | | 1 | | 5 | 18 | **32** |
| Chemical Manufacturing | 11 | 2 | | 10 | | 1 | | **24** |
| Sugar milling or refining | 4 | 4 | | | | 6 | 6 | **20** |
| Electricity generation | 3 | 1 | | 14 | | | | **18** |
| Meat processing | 1 | 3 | | 3 | | 1 | 2 | **10** |
| Metal | 6 | 1 | | 2 | | | | **9** |
| Gas producing | | | | 7 | | | | **7** |
| Seafood | 2 | | | | | 1 | 3 | **6** |
| Milk processing | | 1 | | 1 | | | 2 | **4** |
| Cement manufacturing | | 1 | | 1 | | | | **2** |
| Tanning | | 1 | | | | | | **1** |
| **Total** | **176** | **231** | **19** | **449** | **52** | **72** | **146** | **1145** |

Figure 3-4 summarises the total number of approvals in Queensland, the number of approvals in the Reef catchment, the number of approvals with nutrient activities and the number of individual facilities with nutrient activities and the total number of nutrient activities in the Reef catchment.

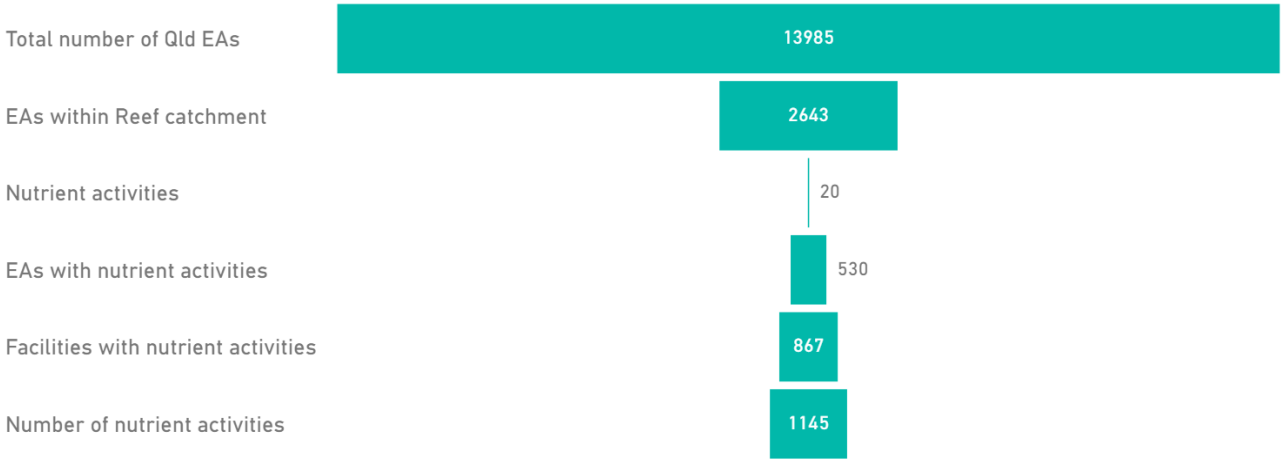



**Figure 3-4. Approval (EA), activity and facility summary for the Reef catchment**

# 4. Environmental approval review

The approval conditions for the 530 approvals and 867 facilities with nutrient activities were reviewed. All metadata related to release to water and land from the nutrient activities were collected into a metadata database.

After a review of possible alternatives, Power BI with a backend Excel spreadsheet was chosen as the preferred method for storing and visualising the **nutrient metadata database**. Although Power BI provides some spatial presentation of data, separate spatial products were developed as part of this project. This includes an online ArcGIS map, which displays a polygon for each location (based on lot & plan, lease) with a range of attributes, as well as release to water points and receiving environment monitoring points.

## 4.1 Release to water

Of the 867 facilities, 302 had an authorised release to water (see Figure 4-1) with 125 of these facilities authorised to release to either water or land and 177 authorised to release to water only. Facilities that are authorised to release to water have been classified by their primary activity and presented in Figure 4-2. It shows that approximately 35% were STPs, 29% were mines and 9% were aquaculture facilities and 7% were mineral handling plants.

Details of the release and monitoring points and the indicators monitored are included in approval conditions and REMPs. It should be noted that a facility that is authorised to release to water may release from more than one release point. Across all 867 facilities, there were 1728 monitoring points and, of those, 741 are ‘authorised release to water monitoring’ points. However, the information collated is not complete, as the spatial location of some monitoring points was missing from the approvals. In addition, the text descriptions or diagrams provided in approvals in relation to monitoring points were often difficult to interpret. To date, not all release to land monitoring points or groundwater quality monitoring bores have been included in the nutrient metadata database.

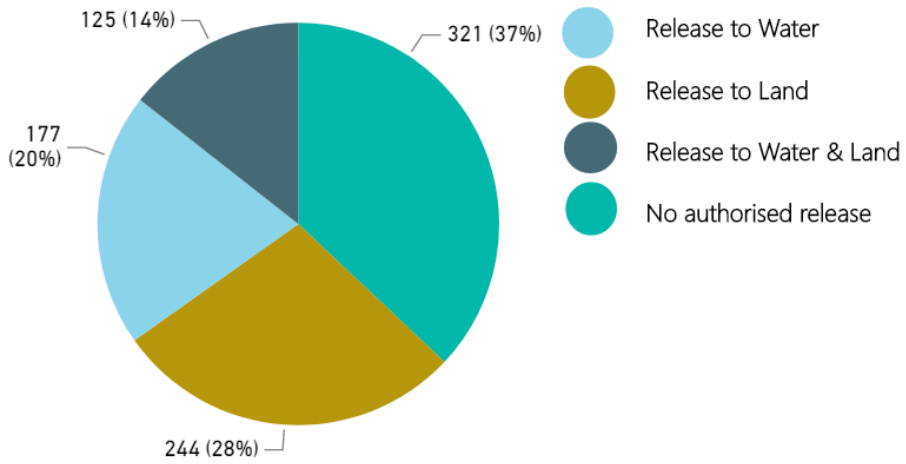



**Figure 4-1. Number (percentage) of facilities in the Reef catchment that are authorised to release to either water, land or both**

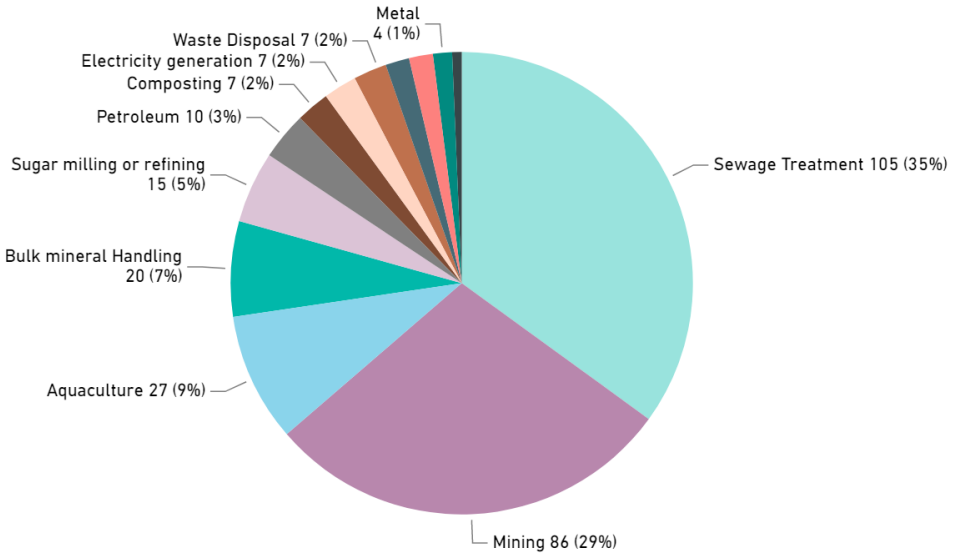



**Figure 4-2. The number (percentage) of facilities in the Reef catchment authorised to release to water, based on primary activity**

The type of waterbody (marine, estuarine and freshwater) that wastewater is released into and the type of release (continuous, event, tidal) can influence the risk to the Great Barrier Reef. The waterbody and release type has been determined for each facility with authorised release to water. The majority of facilities release to freshwater and during rainfall/wet weather events (Figure 4-3).

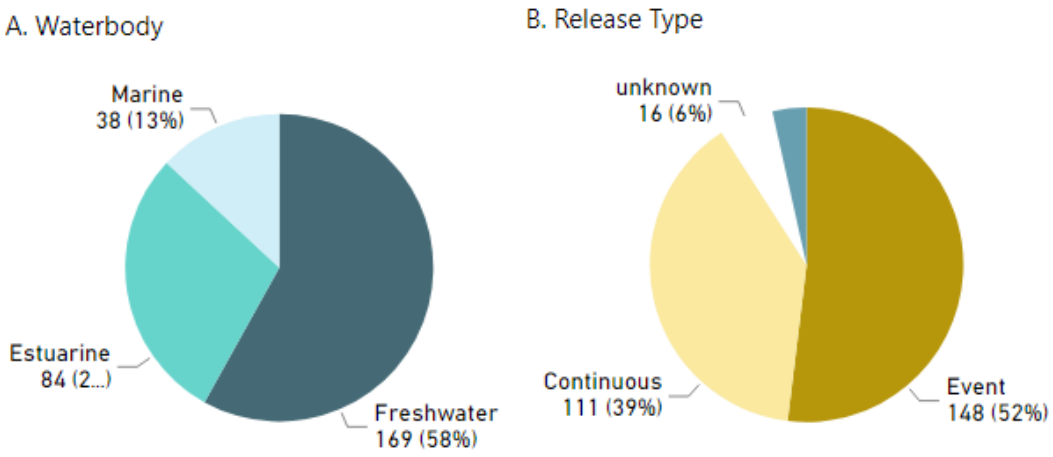



**Figure 4-3. Facilities with authorised release to water in the Reef catchment: A. The number (percentage) of facilities releasing to different waterbodies, and B. The number (percentage) of facilities per release type.**

## 4.2 Indicators monitored

Indicators that are monitored at the release and receiving environment monitoring points are often specified in approval conditions. The indicators monitored varies across the different activities and facilities. The number of different nutrient indicators monitored for facilities and release points in Reef catchments is summarised in Table 4-1. TN, TP and ammonia are the most common indicators monitored. However, there

is significant variability across activities with regards to the indicators monitored. Table 4-2 shows the number facilities for different activities that monitor nutrient indicators at their release points.

Approximately two thirds of the 302 facilities authorised to release to water undertake nutrient monitoring. Sewage treatment, mining and aquaculture activities have the most facilities monitoring nutrient indicators for their authorised releases. The majority of sewage treatment and aquaculture facilities monitor TN and TP for their releases. Approximately half of the STPs monitor ammonia but very few monitor nitrate, nitrite or filterable reactive phosphorous. In other words, the dissolved inorganic nutrient components are generally not monitored. In the case of mining, not many facilities monitor TN and TP but monitoring of ammonia and nitrate is more common.

**Table 4-1. Number of nutrient indicators monitored across all facilities and release points in the Reef catchment**

| Indicator | Number of Facilities | Number of Release Point |
|---|---|---|
| Phosphorus - Total | 130 | 174 |
| Nitrogen - Total | 129 | 178 |
| Ammonia | 121 | 373 |
| Nitrate | 55 | 313 |
| Nitrite | 4 | 8 |
| Nitrogen - Oxidised | 4 | 5 |
| Nitrogen - Total - Kjeldhal Method | 2 | 2 |
| Filterable Reactive Phosphorus | 1 | 3 |

**Table 4-2. Number of facilities in the Reef catchment that are required to monitor nutrient indicators at their release points.**

| Activity | Number of Facilities |
|---|---|
| Sewage Treatment | 86 |
| Mining | 52 |
| Aquaculture | 25 |
| Composting | 7 |
| Meat processing | 4 |
| Petroleum | 4 |
| Bulk mineral Handling | 3 |
| Chemical Manufacturing | 3 |
| Metal | 3 |
| Sugar milling or refining | 3 |
| Mineral Processing | 2 |
| Waste Disposal | 2 |
| Electricity generation | 1 |
| Seafood | 1 |
| Tanning | 1 |
| **Total** | **196** |

## 4.3 Limits and triggers

For all facilities or activities, the limits and triggers for the authorised release to water specified in the approval have been reviewed. Of the 302 facilities authorised to release to water, 247 had specified limit and trigger conditions for nutrients and/or volume. There may be multiple release points per one set of release conditions.

From the 247 facilities mentioned above, TN concentration or load limits were available for 110 facilities, TP concentration or load limits were available for 106 facilities and volume limits for were available for 118 facilities. This information has been used to assess the consistency of standards that are applied for different activities and in different regions. Table 4-3 shows the release to water approval limits for selected facilities in the Reef catchment.

From the specified limits for release quantity or quality in the approval conditions, an estimate of maximum authorised nutrient load was possible for some facilities for TN (97 facilities) and TP (86 facilities). Quantification of maximum authorised loads for many activities was not possible where limits were not included for nutrient concentration, release volume/flow or both.

The maximum authorised nutrient loads were estimated based on the following hierarchy using available approval information limits: (i) the annual nutrient load, (ii) the average nutrient concentration and average dry weather daily flow; (iii) the average nutrient concentration and peak/wet weather daily flow; (iv) the maximum nutrient concentration and average daily flow; (v) maximum nutrient concentration and peak/wet weather daily flow; and (vi) the maximum ammonia concentration and average daily flow. More information on calculation of loads is provided in Appendix D.

Based on the maximum authorised nutrient load estimates, the activities which have the potential to contribute the greatest load of nutrient to the Reef lagoon are associated with sewage treatment, aquaculture and meat processing (Table 4-4). The nutrient loads presented in this section are estimates only and are not based on actual monitoring data. They are determined from release limits specified in approval conditions and may be an overestimate in many cases. It should also be noted that the nutrient load estimates presented are only for a sub-set of nutrient activities, given release limits are not specified in all approvals that have an authorised release to water.

Figure 4-4 summarises the number of facilities that are authorised to release to water, that have conditions and limits and the number of load estimates that were possible.

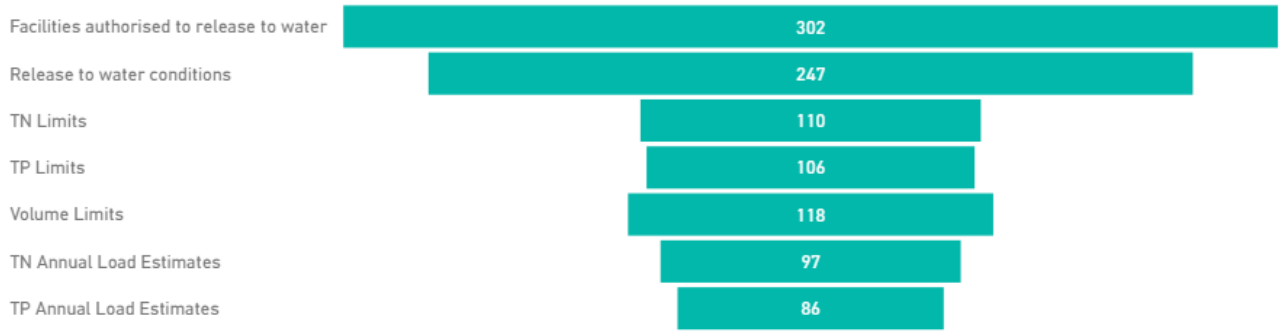



**Figure 4-4. Summary of the number of facilities authorised to release to water in the Reef catchment and with relevant nutrient conditions needed to estimate nutrient loads**

**Table 4-3. EA release limits for selected facilities in the Reef catchment used for nutrient load estimation**

| Facility ID | Activity Classification | Average Release volume/ Flow Limit (ML/day) | Wet/ Peak Release volume/ Flow Limit (ML/day) | Median TN Limit (mgN/L) | Median TP Limit (mgP/L | Maximum TN Limit (mgN/L) | Maximum TP Limit (mgP/L) |
|---|---|---|---|---|---|---|---|
| 535 | 63-(1b)(ii) | 0.2 | 0.5 | 20 | 10 | 40 | 15 |
| 536 | 63-(1b)(ii) | 0.2 | 0.5 | 20 | 10 | 40 | 15 |
| 168 | 63-(1c) | 0.4 | 1.9 | 20 | 10 | 30 | 15 |
| 537 | 63-(1b)(ii) | 0.2 | 1.0 | 20 | 10 | 30 | 15 |
| 539 | 63-(1b)(ii) | 0.2 | 0.5 | 20 | 10 | 40 | 15 |
| 540 | 63-(1b)(ii) | 0.2 | 0.5 | 20 | 10 | 40 | 15 |
| 541 | 63-(1b)(ii) | 0.3 | 1.4 | 20 | 10 | 30 | 15 |
| 538 | 63-(1b)(ii) | 0.1 | 0.2 | 15 | 8 | 30 | 15 |
| 542 | 63-(1b)(ii) | 0.1 | 0.4 | 15 | 8 | 30 | 15 |
| 457 | 63-(1c) | 0.5 | 2.5 | 13 | 8 | 30 | 30 |
| 460 | 63-(1e) | 9.1 | 27.3 | 13 | 8 | 30 | 30 |
| 880 | 63-(1e) | 3.0 | | 10 | 3 | 30 | 9 |
| 462 | 63-(1e) | 6.8 | 20.4 | 10 | 8 | 30 | 30 |
| 609 | 63-(1e) | 2.0 | 6.0 | 10 | 7 | 15 | 10 |
| 170 | 63-(1d) | 1.5 | 4.5 | 10 | | 20 | |
| 610 | 63-(1c) | 0.2 | 0.8 | 10 | 10 | 20 | 12 |
| 661 | 63-(1c) | 0.2 | | 7 | 2 | 20 | 8 |
| 467 | 63-(1d) | 2.2 | | 5 | 1 | 10 | 2 |
| 250 | 63-(1d) | 3.5 | 18.0 | 5 | | | 2 |
| 321 | 63-(1e) | 6.3 | 31.3 | 5 | 1 | 15 | 3 |

**Table 4-4. Maximum authorised nutrient loads per activity based on approval limits. Includes the number of facilities authorised to release to water and the number of facilities with nutrient load estimates**

| Activity | Release to Water | No. with TN Load Estimate | TN Estimate (kg/year) | No. with TP Load Estimate | TP Estimate (kg/year) |
|---|---|---|---|---|---|
| Sewage Treatment | 143 | 59 | 608,883 | 58 | 225,551 |
| Aquaculture | 27 | 26 | 385,193 | 26 | 45,256 |
| Meat processing | 5 | 3 | 52,144 | 2 | 54,433 |
| Chemical Manufacturing | 12 | 1 | 36,000 | | |
| Mining | 87 | 6 | 2,119 | | |
| Petroleum | 14 | 1 | 207 | | |
| Electricity generation | 8 | 1 | 169 | | |
| Bulk mineral Handling | 29 | | | | |
| Cement manufacturing | 1 | | | | |
| Composting | 11 | | | | |
| Fuel burning | 29 | | | | |
| Gas producing | 5 | | | | |
| Metal | 9 | | | | |
| Mineral Processing | 62 | | | | |
| Seafood | 6 | | | | |
| Sugar milling or refining | 15 | | | | |
| Tanning | 1 | | | | |
| Waste Disposal | 53 | | | | |
| **Total** | **302** | **97** | **1,084,715** | **86** | **325,241** |

## 4.4 Online map

An online ArcGIS map which provides the facility location, land parcel (e.g. lot & plan, mining lease) and monitoring point locations with associated metadata has been developed based on the nutrient metadata database. The online ArcGIS map can be accessed here. An example of the online map is provided in Figure 4-5.

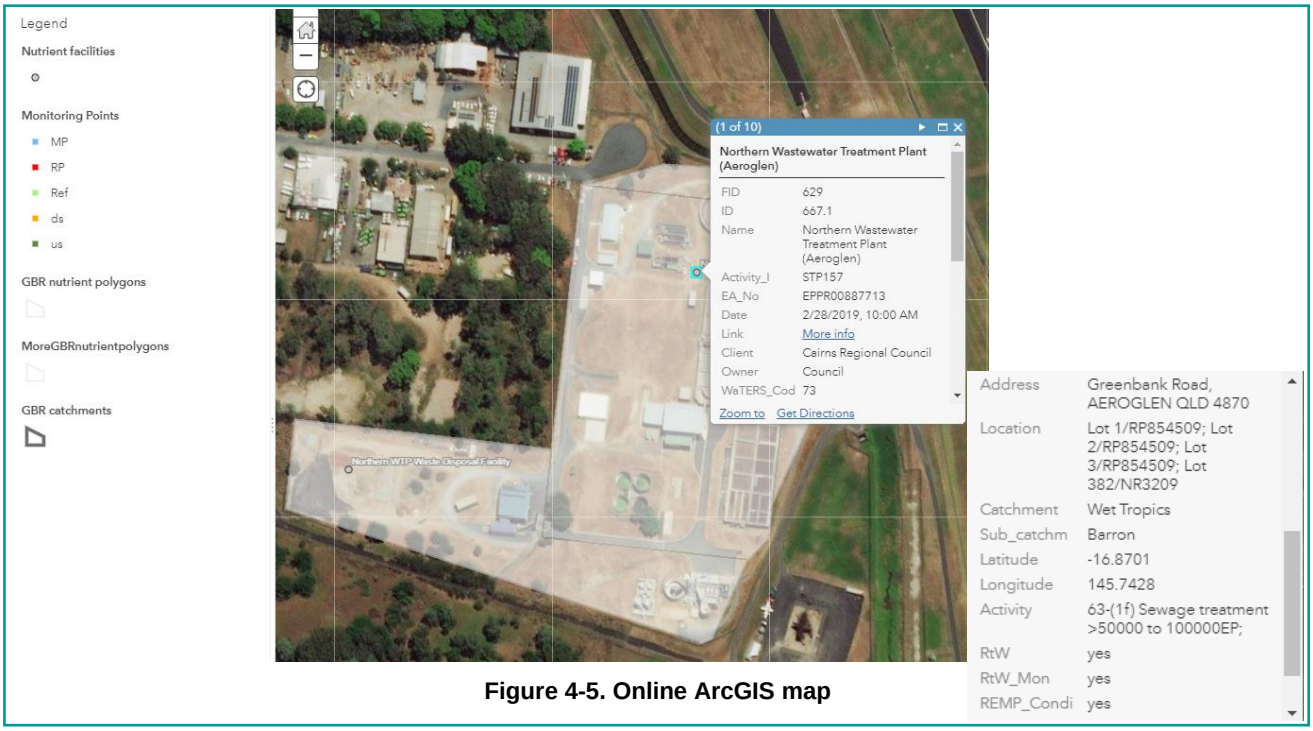



**Figure 4-5. Online ArcGIS map**

## 4.5 Sewage Treatment Plant approval review

### 4.5.1 All STP facilities

STPs were identified as the industry with the largest number of facilities that are authorised to release to water (See Figure 4-2) and the potential to contribute the greatest load of nutrient to the Reef lagoon in terms of authorised load limit (See Table 4-4). There are 395 STPs within the Reef catchment as shown in Figure 4-6. These facilities can be divided into council owned (Council), other government agency (Gov) and privately owned (Private), as shown in Figure 4-7. Note that STPs operated by water utility organisations are also classified as council STPs in this report. There are more privately owned STPs than STPs owned by councils and these related to private activities such as caravan parks, resorts, other commercial activities as well as other activties such as coal mines, sugar mills, ports, quarries etc. The council facilities located north of the tip of Queensland are remote island communities and are part of Queensland. For the purposes of this review, they were considered part of the Reef catchment.


**Figure 4-6. Sewage treatment plants within the Reef catchment owned by councils (Council), other Government agencies (Gov) and private operators (Private)**

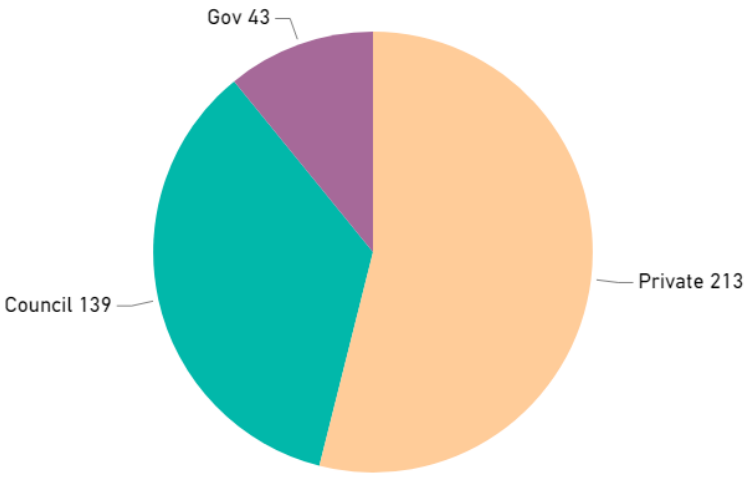



**Figure 4-7. Proportion of STPs owned by councils (Council), other Government agencies (Gov) and private operators (Private) within the Reef catchment. Numbers shown are number of facilities**

Figure 4-8 shows the proportion of STPs owned by councils, other government and private operators for different activity classifications (size). These activity classifications are defined in the approval according to Queensland legislation. This figure shows that the majority of private and other government STPs are usually small, while councils operate the majority of the medium to large facilities. Another observation is that the majority of non-council facilities do not directly release to water, instead relying on an irrigation trench or irrigation to land (release to land), given the majority of these facilities are classified as 63-(1a)(i) >21 to 100 EP or 63-(1b)(i) >100 to 1,500 EP – IT (infiltration trench) or IR (irrigation).

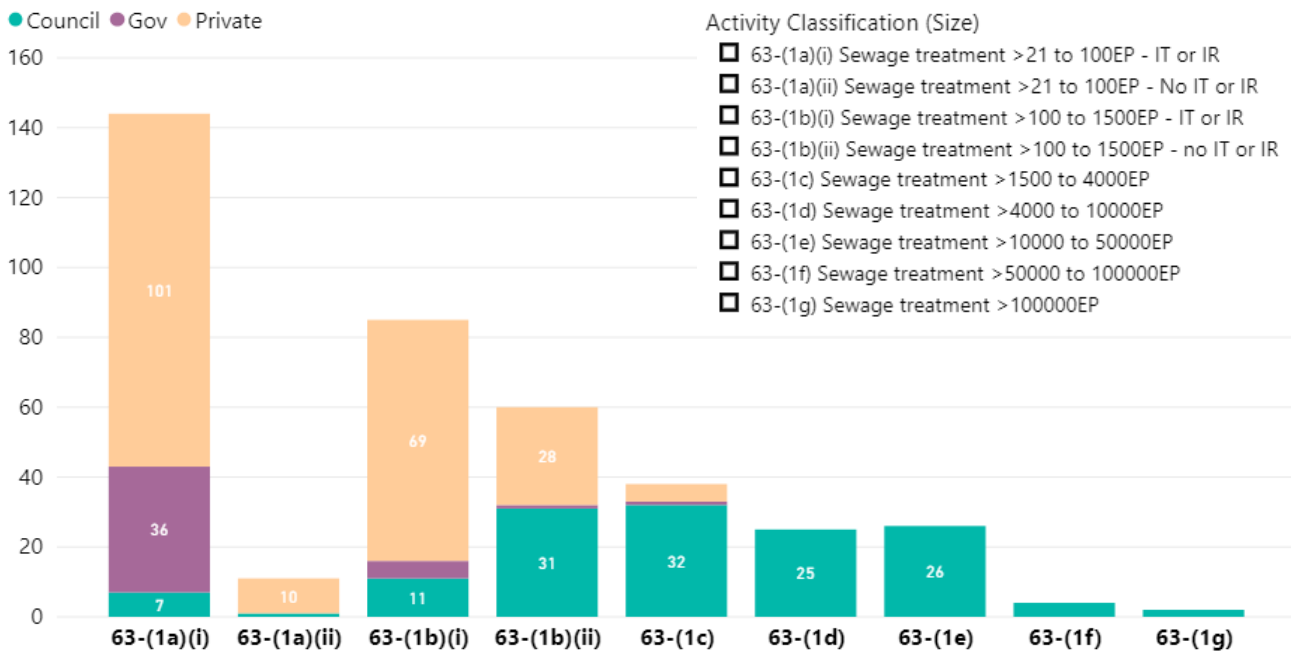



**Figure 4-8. Proportion of STPs owned by councils (Council), other Government agencies (Gov) and private operators (Private) for each activity classification within the Reef catchment.**

Based on the approval information that was collected, Table 4-5 shows the number of STPs within each region within the Reef catchment, how many facilities are authorised to release to either water or land and the number of facilities that are required to undertake environment monitoring programs as part of their approval conditions. Approximately one third of facilities have an authorised release to water. Of these, two-thirds were council STPs. Additionally, a similar number of STPs that release to water are also undertaking a receiving environment program. It implies that the majority of STPs licensed to release to water are required to carry out receiving water monitoring.

**Table 4-5. Number of STPs with release to water and/or release to land and environment monitoring conditions in their approval for different regions within the Reef catchment**

| Regions | Number of Facilities | Number of Activities | Release to Water | Release to Land | Environment Monitoring Programs |
|---|---|---|---|---|---|
| Fitzroy | 127 | 127 | 39 | 101 | 40 |
| Burnett-Mary | 103 | 103 | 31 | 86 | 37 |
| Wet Tropics | 50 | 50 | 22 | 39 | 28 |
| Island | 31 | 31 | 19 | 16 | 16 |
| Burdekin | 48 | 48 | 18 | 34 | 16 |
| Mackay Whitsundays | 27 | 27 | 10 | 22 | 12 |
| Cape York | 9 | 9 | 4 | 6 | 4 |
| **Total** | **395** | **395** | **143** | **304** | **153** |

### 4.5.2 STPs that release to water

Table 4-6 shows the number of STPs within the Reef catchment that are authorised to release to water for each activity classification (size) and different type of nutrient release limits. Of the 143 STPs that are authorised to release to water, 103 STPs have release conditions. Seventy-six STPs have specified average or peak daily limit for release volume. Of these 76 facilities, approximately 60 have long-term median or other similar limits on their release TN and TP concentrations. A similar number of facilities have ammonia concentration limits, although none have limits for oxidised nitrogen or filterable reactive phosphorus (the other dissolved nutrient measures in wastewater). A slightly larger number of facilities have maximum limits for TN and TP concentrations. A bit less than half of the STPs with volume limits have TN and TP load limits, many of these also have other nutrient limits. The generally adopted nutrient load limit in STP approvals is based on the annual median concentration of TN or TP multiplied by the average dry weather day volume multiplied by 365. Each approval generally has a definition for what is deemed an average dry weather day based on local rainfall.

**Table 4-6. Number of facilities for each limit type for STPs within the Reef catchment per activity classification.**

| Activity Classification | Number of Facilities | Average Release Volume Limit | Wet/ Peak Release Volume Limit | Median TN Limit | Maximum TN Limit | Maximum Ammonia Limit | TN Load Limit | Median TP Limit | Maximum TP Limit | TP Load Limit |
|---|---|---|---|---|---|---|---|---|---|---|
| 63-(1b)(ii) | 33 | 17 | 23 | 15 | 19 | 15 | | 14 | 19 | |
| 63-(1e) | 22 | 17 | 15 | 10 | 13 | 8 | 15 | 10 | 13 | 13 |
| 63-(1d) | 18 | 15 | 13 | 12 | 11 | 8 | 7 | 10 | 11 | 7 |
| 63-(1c) | 24 | 13 | 12 | 9 | 14 | 12 | 3 | 9 | 14 | 2 |
| 63-(1f) | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 4 |
| 63-(1g) | 2 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Total** | **103** | **65** | **68** | **51** | **63** | **49** | **31** | **48** | **63** | **28** |

### 4.5.3 Council STPs that release to water

The primary focus for the remainder of this review will be on council STPs as these were the largest facilities that involved release to water. The 139 council STPs within the Reef catchment are spread across six regions (39 sub-catchments) and are operated by 35 organisations, which are operating under 43 approvals. Three of these STPs became non-operational at some time after early 2018. Ninety-two council STPs are authorised to release to water.

A more detailed analysis has been undertaken of the median nutrient limits for council STPs that release to water (see Figure 4-9 and Figure 4-10). Median TN and TP limits were available for 51 and 48 council STPs, respectively. The TN and TP limits are categorised based on the activity classification (size). These limits are long-term nutrient concentrations permitted in the release water, typically as a median concentration of weekly samples taken over a 12-month period. These limits also indicate the level of wastewater treatment that exists at the STP. For nitrogen removal, this typically involves significant physical infrastructure, although removal can be optimised for many STPs through operational improvements. For phosphorus, although physical infrastructure for biological removal is used, low levels of phosphorus often requires chemical addition, for example of alum, ferric chloride or other similar chemicals. Along with the volumes of wastewater released, these long-term median limits ultimately set the long-term loads of nutrients that are permitted to be released from the STPs. The lowest limits for median TN concentrations are either 3 or 5 mg/L depending on the activity classification. The highest TN limit is 20 mg/L and was for the two smaller sized activity classifications. The lowest limits for median TP concentrations are generally 1 mg/L with the highest TP limit of 10 mg/L, also corresponding to the two smaller sized activity classifications.

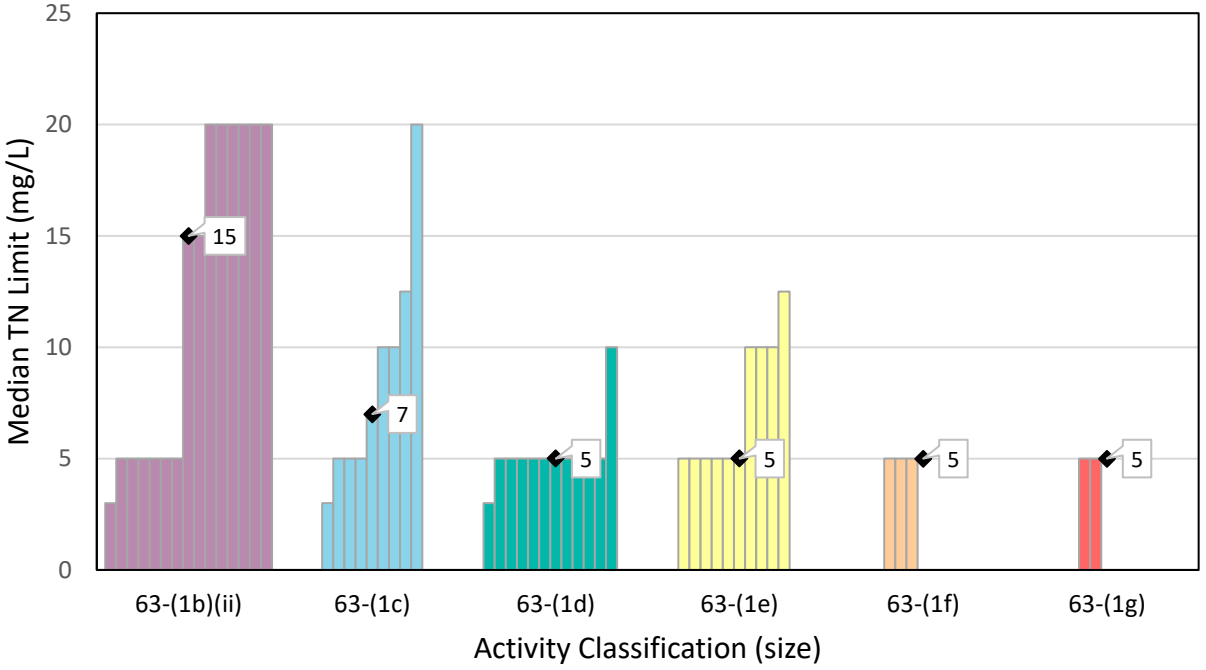



**Figure 4-9. TN limits for council STPs that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show annual median limits for each facility. Black dots show middle value of each activity classification.**

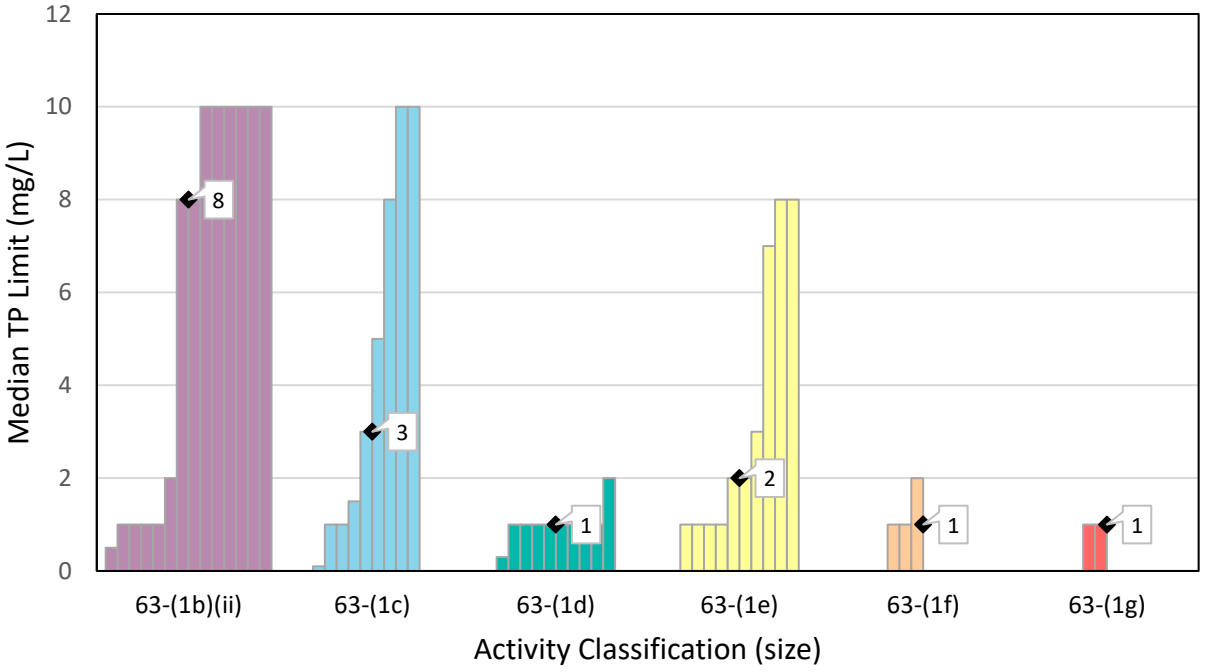



**Figure 4-10. TP limits for council STPs that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show annual median limits for each facility. Black dots show middle value of each activity classification.**

The short-term changes for ammonia are important for environmental regulation of releases from STPs, as ammonia is a toxicant and can potentially cause toxicity in the near-field of the receiving waters. Figure 4-11 shows maximum ammonia release limits for STPs in the Reef catchment for different activity classifications (sizes). Maximum ammonia release limits were available for 49 facilities. The lowest ammonia limits are in the order of 1 mg/L while the highest limits are 10 mg/L.

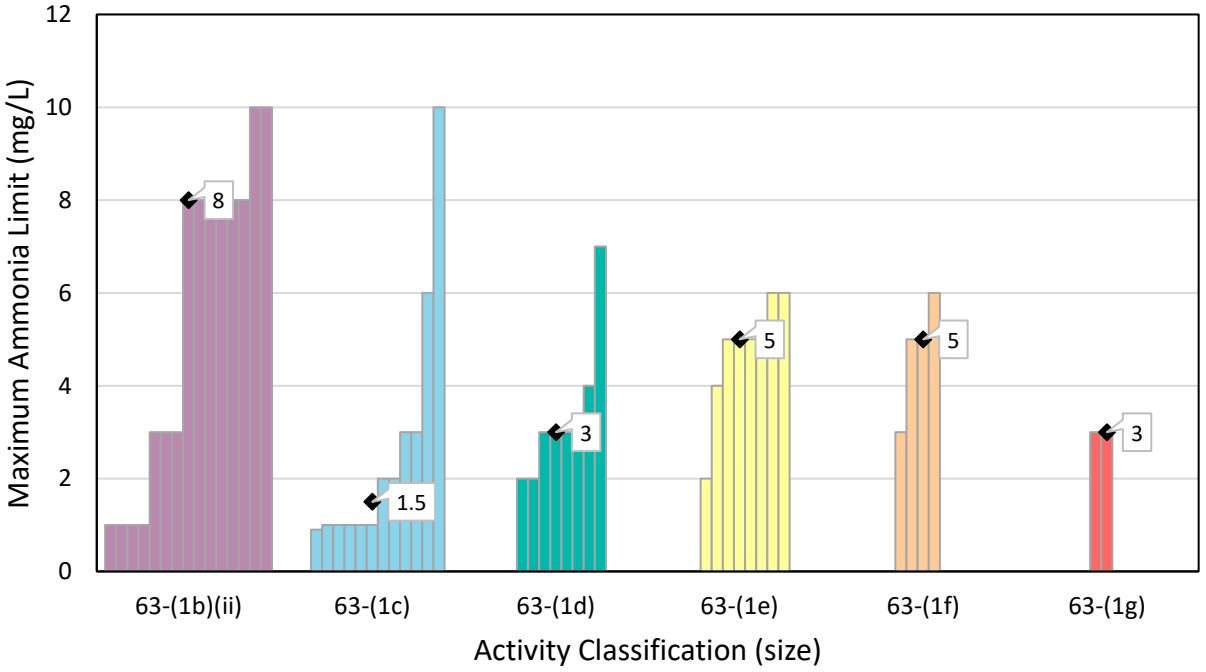



**Figure 4-11. Ammonia ($NH_3$-N) limits for council STPs that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show maximum limits for each facility. Black dots show middle value of each activity classification.**

Total suspended solids (TSS) concentration is another indicator that is regulated for STP releases using maximum limits. TSS is potentially relevant to assessing nutrients as nutrients can be bound up in a particulate form. Maximum TSS release limits were available for 97 facilities. Figure 4-12 shows maximum TSS release limits for STPs in the Reef catchment for different activity classifications. The lowest maximum TSS limits are generally in the order of 30 mg/L for each activity classification while the highest was 180 mg/L and related to the two smaller activity classifications.

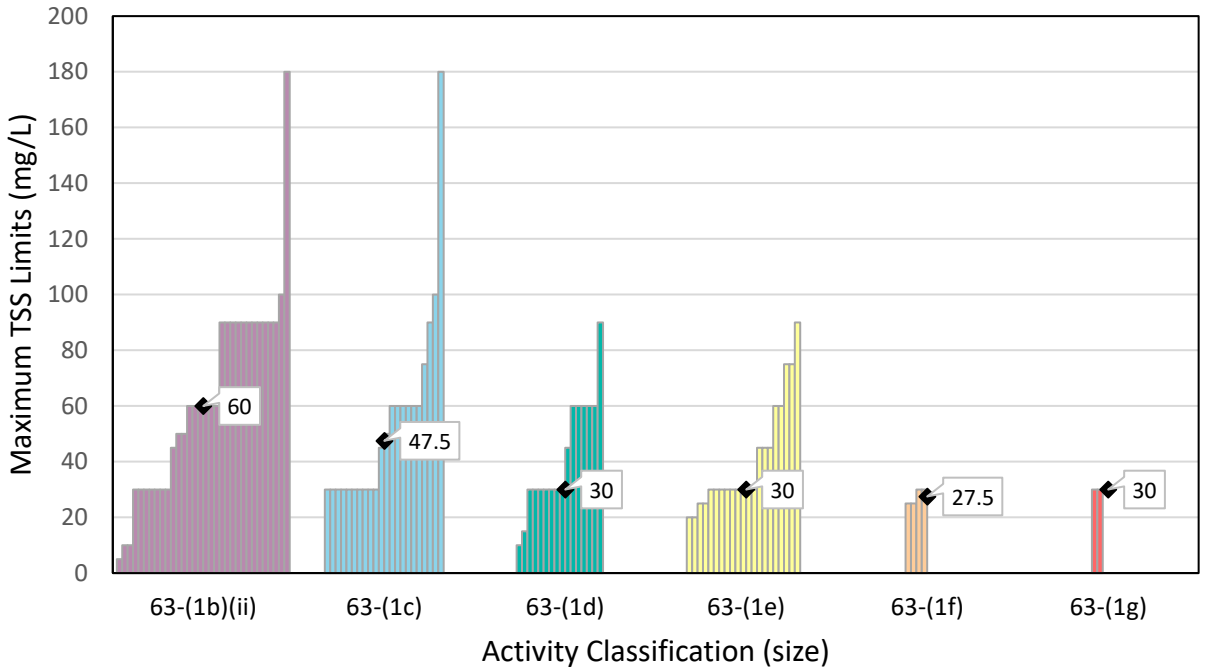



**Figure 4-12. TSS limits for council STPs that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show maximum limits for each facility. Black dots show middle value of each activity classification.**

## 4.6 Aquaculture approval review

Based on the nutrient load estimates for point sources, aquaculture activities have the potential to contribute the second greatest load of nutrient to the Reef lagoon (Table 4-4). The aquaculture industry was also identified as having the second highest number of facilities, after STPs, which required TN and TP to be monitored at the release points (see Table 4-2).

Aquaculture activities are classified as either cultivating or holding crustaceans in enclosures that are on land (1.1) or cultivating or holding marine, estuarine or freshwater organisms, other than crustaceans, in enclosures that are on land (1.2). The activity classification is then based on the size of the facility (Table 4-7). In general, based on approval information, the majority of aquaculture activities involving release to water are either prawn or barramundi facilities.

**Table 4-7. Aquaculture activity classifications**

| Activity Classification | Description |
|---|---|
| 1.1(a) | 1-(1a) Aquaculture >100m2 but <10ha land |
| 1.1(b) | 1-(1b) Aquaculture >10ha but <100ha land |
| 1.1(c) | 1-(1c) Aquaculture >100ha land |
| 1.2(a) | 1-(2a) Aquaculture >100m2 but <10ha land |
| 1.2(b) | 1-(2b) Aquaculture >10ha but <100ha land |
| 1.2(c) | 1-(2c) Aquaculture >100ha land |

Thirty-three aquaculture facilities were contacted as part of the project, 22 facilities were confirmed as operational and five facilities could not be contacted, so their status remains unknown, but were considered as operational for the purpose of this review. Across the 27 aquaculture facilities, there were 32 aquaculture activities spread across five regions and 12 sub-catchments, as shown in Figure 4-13.

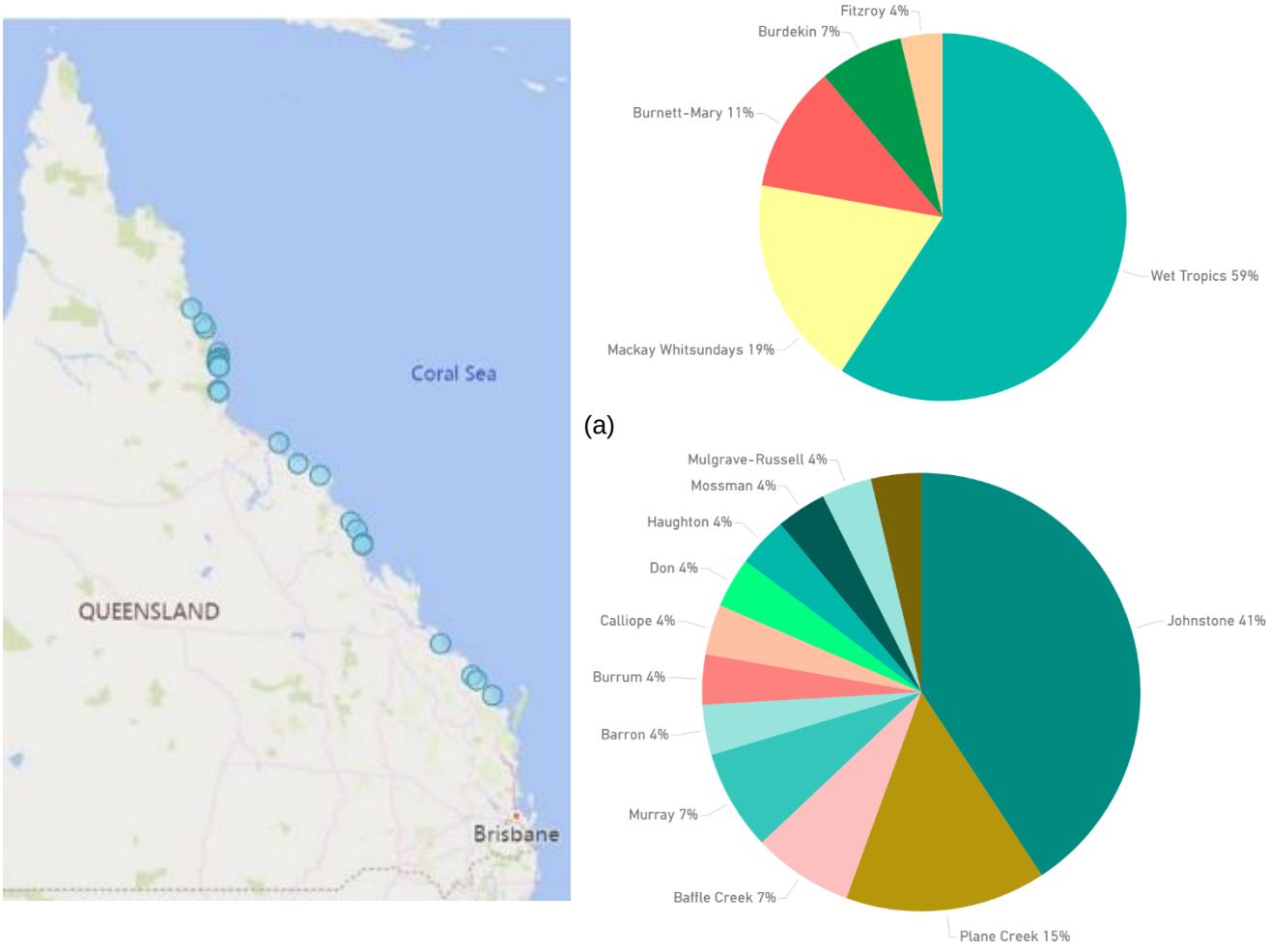



**Figure 4-13. Location of operational aquaculture facilities in the Reef catchment (a) across regions and (b) sub-catchments**

Based on the approval information, Table 4-8 shows the number of aquaculture facilities within each region, how many facilities are authorised to release to either water or land and the number of facilities that are required to undertake environment monitoring programs as part of their approval conditions. Approximately half of the aquaculture facilities are required to carry out receiving water monitoring.

**Table 4-8. Number of aquaculture facilities and activities that are authorised to release to water and/or release to land and have environment monitoring conditions in their approvals for different regions within the Reef catchment**

| Regions | Number of Facilities | Number of Activities | Release to Water | Release to Land | Environment Monitoring Programs |
|---|---|---|---|---|---|
| Wet Tropics | 16 | 18 | 18 | 2 | 8 |
| Mackay Whitsundays | 5 | 5 | 5 | | 3 |
| Burdekin | 2 | 4 | 4 | | 2 |
| Burnett-Mary | 3 | 4 | 4 | | 2 |
| Fitzroy | 1 | 1 | 1 | | |
| **Total** | **27** | **32** | **32** | **2** | **15** |

Table 4-9 shows the number of aquaculture facilities within the Reef catchment for each activity classification and different type of nutrient release limits. Of the 32 activities, 28 have specified limits for volume or nutrients. Twenty-five have long-term median or other similar limits on their release TN and TP concentrations. A slightly larger number of facilities have maximum limits for TN and TP concentrations. Only two facilities have TN and TP load limits.

**Table 4-9. The type and number of different nutrient release limits for aquaculture facilities within the Reef catchment for each activity classification**

| Activity Classification | Number of Facilities | Number of Activities | Average Discharge volume Limit | Wet/ Peak Discharge Volume Limit | Median TN Limit | Median TP Limit | Maximum TN Limit | Maximum TP Limit | Maximum Ammonia Limit | TN Load Limit | TP Load Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1(a) | 3 | 3 | | 3 | 3 | 3 | 3 | 3 | | | |
| 1.1(b) | 12 | 13 | 2 | 10 | 11 | 11 | 13 | 13 | | 2 | 2 |
| 1.1(c) | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | | | |
| 1.2(a) | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | | | |
| 1.2(b) | 4 | 5 | 3 | 4 | 5 | 5 | 5 | 5 | | | |
| 1.2(c) | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | |
| **Total** | **25** | **28** | **8** | **23** | **25** | **25** | **28** | **28** | | **2** | **2** |

A more detailed analysis has been undertaken of the long-term nutrient limits for aquaculture activities which, in the majority of approvals, is typically based on the mean of samples collected over a period of 6 to 12 months. The TN and TP limits are categorised based on the activity classification (see Figure 4-14 and Figure 4-15). Table 4-10 shows the range of release limits for a number of aquaculture facilities. The long-term TN mean limit ranged from 0.6 to 2.5 mg/L across the different activity classifications while long-term TP mean limits ranged from 0.05 to 0.4 mg/L. The maximum TN and TP limits imposed on these facilities varies from 0.8 to 5 mg/L and from 0.08 to 0.8 mg/L, respectively.

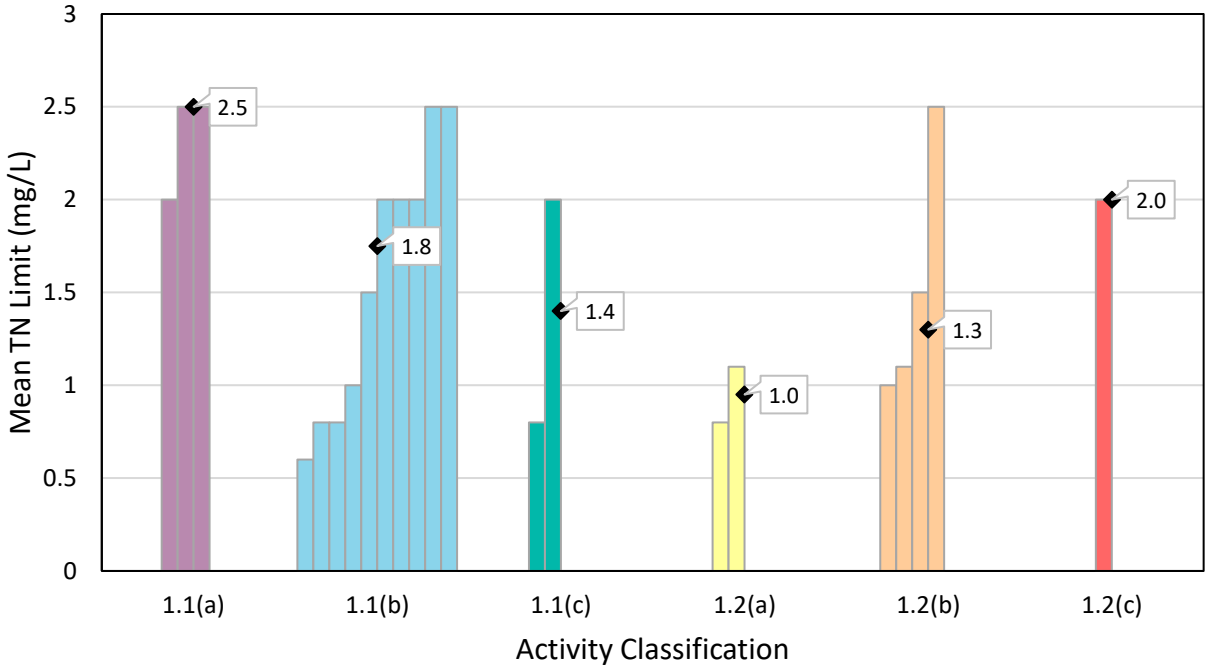



**Figure 4-14. TN limits for each aquaculture facilities that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show annual mean limits for each facility. Black dots show middle value for the activity classification.**

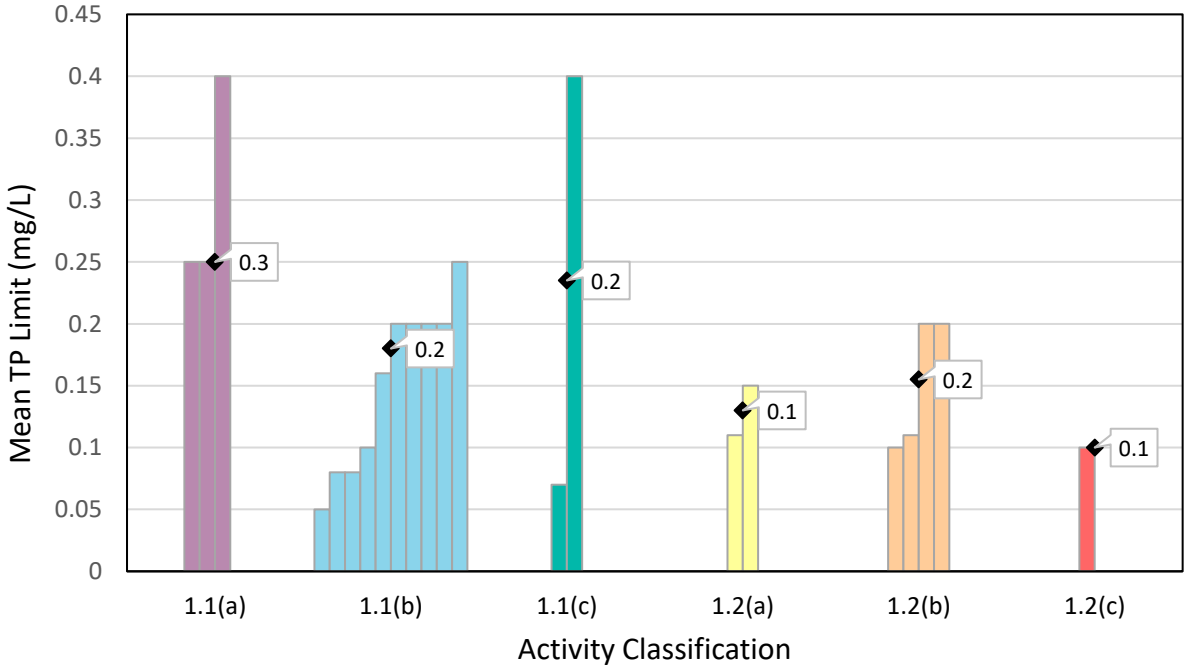



**Figure 4-15. TP limits for each aquaculture facilities that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show annual mean limits for each facility. Black dots show middle value for the activity classification.**

**Table 4-10. Release to water approval limits for aquaculture facilities within the Reef catchment**

| Facility ID | Activity Classification | Average Discharge (ML/day) | Wet/ Peak Discharge (ML/day) | Average TN (mg/L) | Average TP (mg/L) | Maximum TN (mg/L) | Maximum TP (mg/L) |
|---|---|---|---|---|---|---|---|
| 206 | 1.1(c) | 105.0 | 135.0 | 2.0 | 0.40 | 4.0 | 0.60 |
| 656 | 1.2(a) | 73.5 | 88.5 | 1.1 | 0.11 | 3.5 | 0.45 |
| 275 | 1.2(b) | 68.3 | 188.0 | 2.5 | 0.20 | 3.0 | 0.30 |
| 285 | 1.1(b) | 30.1 | 64.5 | | | 3.0 | 0.40 |
| 254 | 1.2(b) | 11.3 | 23.3 | 1.1 | 0.11 | 3.5 | 0.45 |
| 194 | 1.1(b) | 7.5 | 22.5 | 0.8 | 0.08 | 3.2 | 0.27 |
| 2079 | 1.1(b) | | 243.7 | 0.6 | 0.05 | 0.8 | 0.08 |
| 521 | 1.2(a) | | 1.0 | 0.8 | 0.15 | 1.0 | 0.20 |
| 2077 | 1.1(c) | | 116.0 | 0.8 | 0.07 | 2.0 | 0.28 |
| 259 | 1.2(c) | | 9.8 | 2.0 | 0.10 | 3.0 | 0.30 |
| 237 | 1.2(b) | | 6.3 | 1.5 | 0.10 | 3.5 | 0.25 |
| 209 | 1.1(b) | | 17.0 | 1.5 | 0.10 | 4.0 | 0.50 |
| 163 | 1.1(b) | | 45.0 | 1.0 | 0.20 | 4.0 | 0.80 |
| 2004 | 1.2(b) | | 120.0 | 1.0 | 0.20 | 4.0 | 0.80 |
| 695 | 1.1(b) | | 195.0 | 2.5 | 0.08 | 5.0 | 0.25 |
| 235 | 1.1(b) | | 35.0 | 2.0 | 0.20 | 5.0 | 0.60 |
| 309 | 1.1(b) | | 12.0 | 2.0 | 0.20 | 5.0 | 0.60 |
| 225 | 1.1(a) | | 6.0 | 2.5 | 0.25 | 5.0 | 0.60 |
| 234 | 1.1(a) | | 0.2 | 2.5 | 0.25 | 5.0 | 0.60 |
| 2078 | 1.1(b) | | 0.4 | 2.5 | 0.25 | 5.0 | 0.60 |
| 208 | 1.1(a) | | 6.2 | 2.0 | 0.40 | 5.0 | 0.60 |

Total suspended solids (TSS) concentration is another indicator that is regulated for aquaculture facilities using means and maximum limits. Figure 4-16 shows maximum TSS release limits for aquaculture facilities in the Reef catchment for different activity classifications. The maximum TSS limit imposed on these facilities varies from 20 to 200 mg/L.

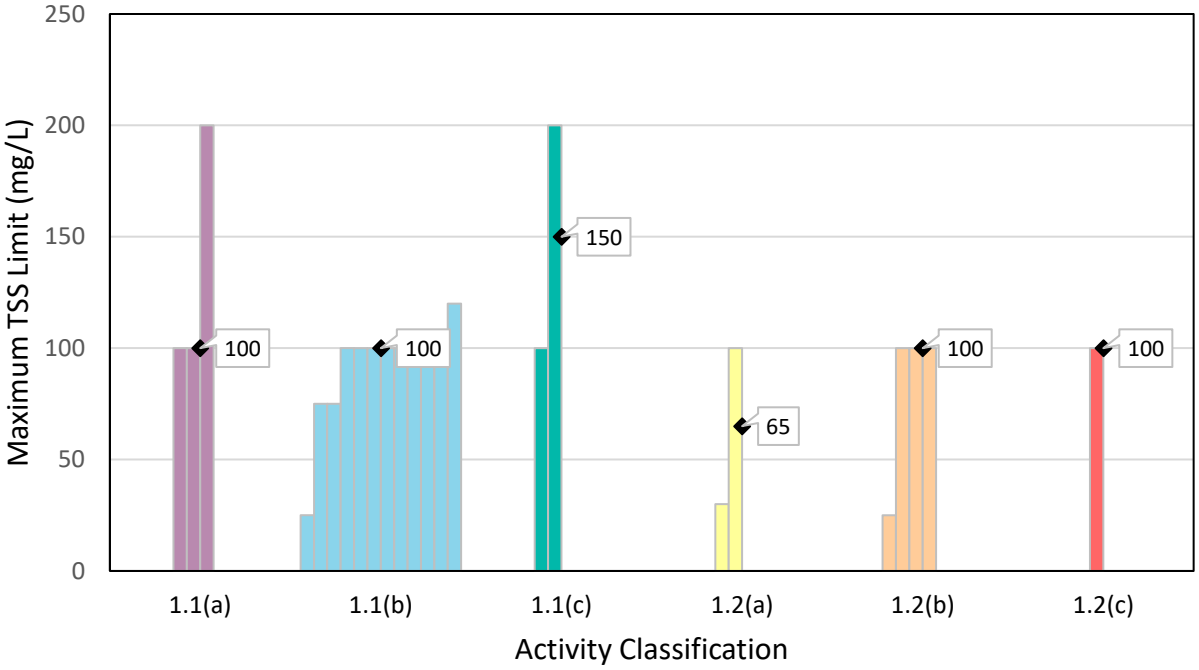



**Figure 4-16. TSS limits for aquaculture facilities that are authorised to release water to the Reef catchment, grouped per activity classification. Bars show maximum limits for each facility. Black dots show middle value for the activity classification.**

For the 27 operational aquaculture facilities identified, there are 39 release points to water described in the approvals. However, this information is not complete, as the spatial location of most release points was missing from the approvals. A text description or diagram are often provided, which can be difficult to interpret. For the 39 aquaculture release points, 10 different indicators are monitored. The number and type of indicators monitored varied across the different facilities, as shown in Table 4-11.

**Table 4-11. Indicators monitored at aquaculture facilities within the Reef catchment**

| Indicator | Number of Monitoring Point |
|---|---|
| Nitrogen - Total | 38 |
| Suspended Solids | 38 |
| Phosphorus - Total | 37 |
| Volume | 35 |
| D.O. | 4 |
| pH | 4 |
| Biological Oxygen Demand | 2 |
| Chlorophyll a | 2 |
| Phosphorus -Total | 1 |
| Turbidity | 1 |

# 5. Risk Assessment

## 5.1 Risk from point source releases to the Reef catchment

To understand the potential risk of nutrient releases from point sources to the Reef catchment, a conceptual model was developed (Figure 5-1). The conceptual model provides a facility level assessment. A facility is based on the main activity at the location and this could include a mine, sugar mill, STP or aquaculture farm. At each facility there may be multiple ERAs that occur at that location. For example, at a mine facility, there can be mining, bulk mineral handling, sewage treatment and waste disposal activities.

Some of these activities such as aquaculture, take in water from the environment to use in their process. Other activities, such as STPs, receive water via urban sewers as a result of reticulated water use. Most activities are also influenced by rainfall and stormwater systems are used to help manage this water. Regardless, the facilities can be authorised to release water to the environment, either on an event basis, often associated with rainfall, or continuously. These releases can occur to coastal areas or to in-land freshwater streams. The potential impact from these releases will often depend on the nature and scale of the activity involved, or more specifically the contaminants concentrations and the volume and duration of the releases. Facilities that have a potential to impact on receiving water are typically required to undertake mitigation measures, such as treatment or adopting land disposal, to help reduce the risk. However, residual wastewater often needs to be released. Where releases are smaller in size, low in nutrients (and other contaminants), and intermittent in nature, they are unlikely to impact on the Reef catchment, particularly if they are not located near coastal areas. Often such activities may not even be required to monitor their release for nutrients. Conversely, facilities continuously releasing nutrient rich wastewater are more likely to pose a risk to the Great Barrier Reef, particularly where located within coastal areas. Ultimately, to estimate this potential risk, further information is needed in regards to the nature of these point source releases and a comparison to other nutrient inputs to the Reef catchment.

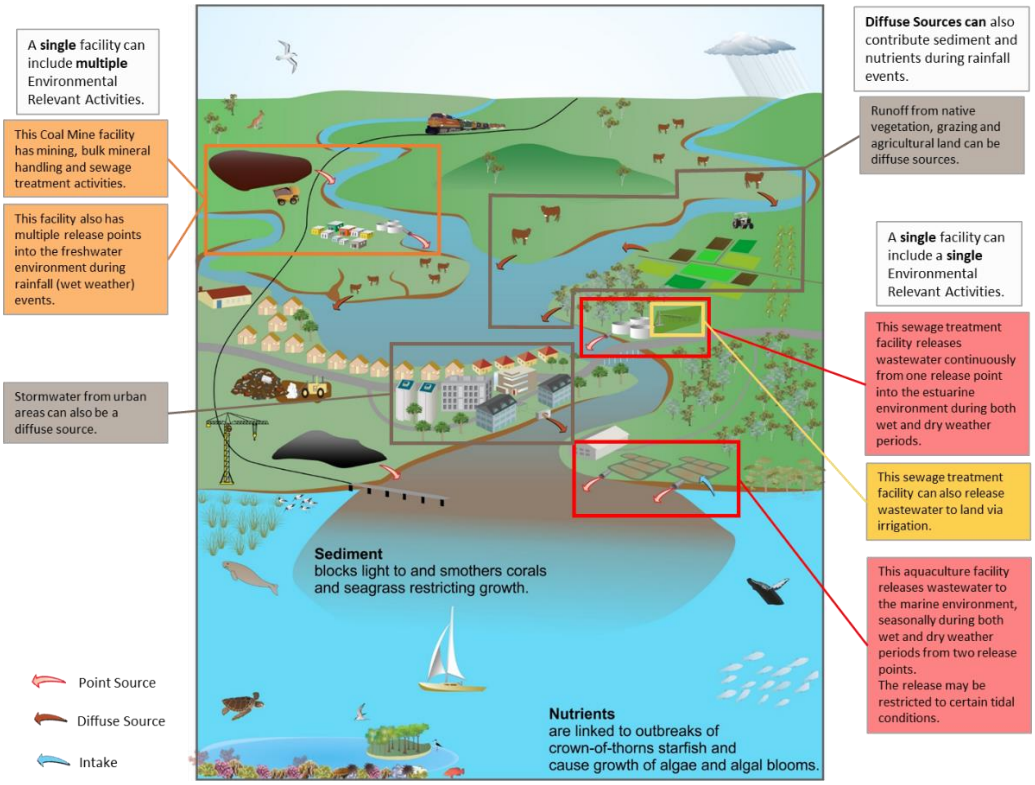



**Figure 5-1. Conceptual model of risk to the Reef catchment. Adapted from the Reef 2050 WQIP.**

Point source and diffuse source nutrients both have the potential to impact on the Great Barrier Reef but can vary significantly in terms of the type of nutrients, the timing of delivery, the location and the quantity of nutrients. Therefore, a direct comparison between nutrient loads from diffuse sources and point sources is difficult. Although this project is focused on point source activities, some consideration of the differences is needed to help draw conclusions about the contribution of point sources to the overall nutrient load to the Reef catchment and the relative risk.

The risk to the Great Barrier Reef from nutrients and the Reef targets in the Reef 2050 WQIP are based on the dissolved inorganic nitrogen (DIN)[11] and particulate nitrogen and phosphorus. As mentioned previously, the regulation of point source releases is generally based on TN and TP. TN is the sum of nitrate-nitrogen ($NO_3$-N), nitrite-nitrogen ($NO_2$-N), ammonia-nitrogen ($NH_3$-N) and organically bonded nitrogen. Both TN and TP includes a soluble and particulate components.

DIN is used for the Reef Annual Report Cards[12] and targets because dissolved inorganic nitrogen is thought to pose the largest risk to the Reef ecosystems[13] as it is readily available for uptake by marine plants such as phytoplankton, macroalgae and algal symbionts in corals. Particulate nitrogen is reported on as the largest amount of terrestrial nitrogen. It is thought that most of the particulate nitrogen is deposited near river mouths or incorporated into suspended organic aggregates. However, the bioavailability of terrestrially derived particulate nitrogen in the marine environment is still unclear. For point sources, there is limited readily available information on the levels of dissolved and particulate TN and TP in releases. However, in this report, we assume that the majority of TN and TP is readily available for uptake by marine plants, at least in comparison to particulate nitrogen from diffuse runoff. This approach is considered precautionary for assessing the relative risk of point source releases. Therefore, we will compare the quantities of total nutrient from point sources to the total nutrients from diffuse sources, based on the addition of dissolved inorganic and dissolved organic components.

In terms of timing of delivery, point source activities can deliver nutrients to coastal waters during both wet and dry periods. In general, relative quantity release from point sources during wet periods is likely to be small compared to diffuse source. In addition, many releases such as bypasses from STPs or sewer overflow are not measured, in terms of both concentration and release volume. Therefore, point source releases that only release during rainfall events (wet period/event), although identified in this report, will not be used to compare to diffuse source nutrients. The focus for the comparison of nutrient loads will be on point source activities that are permitted to release continuously or routinely to receiving waters, such as for tidal releases. Nutrient loads will generally be discussed in terms of annual periods.

In terms of location, continuous release from point source activities located within close proximity to the coast are much more likely to influence Reef water quality compared to those located inland. This is because nutrients delivered to inland systems may be contained within those system or travel slowly through the systems, except for periods of high rainfall. As a consequence, significant nutrient uptake and processing could be expected. Although all point source activities in the Reef catchment are considered in this report, those facilities located within 10 kilometres of tidal waters will be the primary focus of a detailed assessment and are referred to as “coastal activities”. It should also be noted that the environmental risk is greater if the point source activity releases to a high ecological values area or where sensitive receptors are present.

[11] DIN is a measure of ammonia ($NH_3$) plus oxidised nitrogen (NOx) which is nitrite plus nitrate.

[12] https://www.reefplan.qld.gov.au/tracking-progress/reef-report-card

[13] Brodie, J., Waterhouse, J., Schaffelke, B., Furnas, M. Maynard, J., Collier, C., Lewis, S., Warne, M., Fabricius, K., Devlin, M., McKenzie, L., Yorkston, H., Randall, L., Bennett, J., Brando, V. 2013. 2013 Scientific Consensus Statement. Chapter 3. Relative risks to the Great Barrier Reef from degraded water quality. State of Queensland, 2013.

However, risk assessment of local impacts is not the main focus of this report and will not be discussed in detail.

In terms of the quantity of nutrients, consideration of both nutrient concentrations and release volume is important. Ideally, the annual loads of TN and TP will be derived using all available information. For point sources, this is predominantly based on the historical monitoring data of releases. Where monitoring data is not available, the maximum authorised nutrient loads authorised under the approval will be used (See Section 4.3 for details). For diffuse nutrient load estimates, these will be based on the anthropogenic components of modelling work undertaken for the purposes of Reef Annual Report Cards[14]. Comparisons will be made on a Reef and sub-catchment basis for TN and TP loads.

In summary, point source activities likely to pose the highest risk to the Reef include continuous or routine releases, release to coastal waters within close proximity to tidal influenced water, and release of high nutrient load, considering both concentration and volume.

## 5.2 Identification of higher risk activities

Table 5-1 lists the waterbody and release type for each nutrient activity within the Reef catchment. All mining activities release to freshwater environments and most only release during rainfall events, therefore these activities are lower risk when compared to sewage treatment, aquaculture and meat processing activities that release continuously to estuarine and marine environments.

Each facility was also classified as coastal, non-coastal or island. The coastal zone was defined as 10 km inland from the highest astronomical tide, as referred to above.

**Table 5-1. Receiving waterbody and release type of release points from facilities with authorised release to water for each nutrient activity in the Reef catchment**

Waterbody

| Activity | Estuarine | Freshwater | Marine | **Total** |
|---|---|---|---|---|
| Mining | | 400 | | **400** |
| Sewage Treatment | 36 | 58 | 20 | **114** |
| Bulk mineral Handling | 15 | 2 | 28 | **45** |
| Aquaculture | 34 | 5 | | **39** |
| Chemical Manufacturing | 16 | 7 | 8 | **31** |
| Sugar milling or refining | 7 | 21 | | **28** |
| Mineral Processing | 3 | 14 | 4 | **21** |
| Electricity generation | | 11 | | **11** |
| Petroleum | 3 | 5 | 3 | **11** |
| Metal | 2 | 4 | 3 | **9** |
| Composting | 1 | 6 | | **7** |
| Waste Disposal | 2 | 5 | | **7** |
| Cement manufacturing | 6 | | | **6** |
| Meat processing | 4 | 1 | | **5** |
| Fuel burning | 1 | 1 | | **2** |
| Tanning | | 2 | | **2** |
| Seafood | 1 | | | **1** |
| **Total** | **131** | **542** | **66** | **739** |

Type of release from release points

| Activity | Continuous | Event | Tidal | unknown | **Total** |
|---|---|---|---|---|---|
| Mining | | 394 | | 6 | **400** |
| Sewage Treatment | 93 | 18 | | 3 | **114** |
| Bulk mineral Handling | | 36 | | 9 | **45** |
| Aquaculture | 26 | 1 | 11 | 1 | **39** |
| Chemical Manufacturing | 6 | 23 | | 2 | **31** |
| Sugar milling or refining | | 26 | | 2 | **28** |
| Mineral Processing | | 21 | | | **21** |
| Electricity generation | 3 | 5 | | 3 | **11** |
| Petroleum | 2 | 9 | | | **11** |
| Metal | 2 | 7 | | | **9** |
| Composting | | 6 | | 1 | **7** |
| Waste Disposal | | 6 | | 1 | **7** |
| Cement manufacturing | 6 | | | | **6** |
| Meat processing | 3 | 1 | 1 | | **5** |
| Fuel burning | | 2 | | | **2** |
| Tanning | | 2 | | | **2** |
| Seafood | 1 | | | | **1** |
| **Total** | **142** | **557** | **12** | **28** | **739** |

[14] https://www.reefplan.qld.gov.au/tracking-progress/reef-report-card

The nutrient activities identified as the highest potential risk to the Great Barrier Reef are aquaculture, meat processing and sewage treatment. This is based on: (i) their continuous releases during dry periods; (ii) their release to coastal waters within close proximity to tidal influenced water; and (iii) their potential to release a high nutrient load. The number of sewage treatment, aquaculture and meat processing facilities for each activity classification is provided in Table 5-2.

**Table 5-2. Number of sewage treatment, aquaculture and meat processing facilities in the Reef catchment for each activity classification with an authorised release to water.**

| Activity | Activity Classification | Number of Facilities |
|---|---|---|
| Aquaculture | 1.1(a) | 6 |
| Aquaculture | 1.1(b) | 14 |
| Aquaculture | 1.1(c) | 2 |
| Aquaculture | 1.2(a) | 4 |
| Aquaculture | 1.2(b) | 5 |
| Aquaculture | 1.2(c) | 1 |
| Meat processing | 25.2(b) | 1 |
| Meat processing | 25.2(c) | 3 |
| Meat processing | 25.3(b) | 1 |
| Sewage Treatment | 63-(1a)(ii) | 2 |
| Sewage Treatment | 63-(1b)(ii) | 42 |
| Sewage Treatment | 63-(1c) | 23 |
| Sewage Treatment | 63-(1d) | 19 |
| Sewage Treatment | 63-(1e) | 22 |
| Sewage Treatment | 63-(1f) | 4 |
| Sewage Treatment | 63-(1g) | 2 |
| **Total** | | **146** |

# 6. Monitoring data review

In order to assess the actual nutrient concentrations and loads released into the Reef catchment and to review release standards for the priorities activities identified in Chapter 5, release monitoring data was sourced from WaTERS and from information provided by operators of selected point source facilities via a monitoring data request. Additional information regarding monitoring data sources is provided in Appendix C.

## 6.1 Monitoring data sources

Monitoring data is submitted by approval holders to the Department via WaTERS either quarterly or annually depending on whether releases are continuous or periodic (i.e. event-based). Monitoring data submitted to WaTERS is in a raw electronic format and can easily be used for data analysis and reporting. The data includes any monitoring results of the quality or quantity of the releases or associated receiving environment.

WaTERS receives monitoring data from medium to large STPs across Queensland, major industries in South East Queensland and the Gladstone area, coal mines, coal seam gas activities, and some mineral mines, meat processing facilities and power plants. Most large STPs have been submitting monitoring data to WaTERS since 2006, and as far back as 2000 in some cases.

As part of the project, a number of facilities were contacted, and some implemented to WaTERS. The facilities were prioritised based on approval limit details, such as whether they include nutrients load, maximum TN concentration or peak release flow limits. For STPs, the selection included facilities with nutrient monitoring requirements.

A total of 81 facilities were contacted regarding wastewater release monitoring data as part of this review, including 46 STPs, 33 aquaculture facilities and two meat processing facilities. Overall, monitoring data was received from 85% of the facilities that were contacted. Across all industries, there were some incomplete data sets because of change of staff, lost records, or monitoring was not undertaken as required in the approval. Data quality was also an issue due to unit errors or data not checked by approval holders prior to providing the data. The most recent monitoring data provided, such as for 2017 and 2018, were the most complete.

As identified in Section 4.1, 302 facilities had an authorised release to water. The WaTERS database holds monitoring data from 187 facilities in the Reef catchments that are considered nutrient activities. Monitoring data from 2013 to 2018 for 139 facilities that are authorised to release to water was extracted from WaTERS and assessed. The number of facilities with available monitoring data for volume, ammonia, TN or TP per year and per activity classification (size) is provided in Table 6-1 and Table 6-2, respectively. Based on the best availability of monitoring data, the subsequent more detailed review focussed on the years 2017 and 2018 only.

**Table 6-1. Number of facilities with available release monitoring data for volume, ammonia, TN and TP for 2013 to 2018.**

| Indicator (unit) | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| Ammonia as N (mg/L) | 33 | 51 | 62 | 76 | 86 | 68 |
| Daily Volume (ML) | 37 | 67 | 83 | 103 | 108 | 96 |
| Nitrogen - Total (mg/L) | 39 | 56 | 70 | 77 | 82 | 85 |
| Phosphorus - Total (mg/L) | 41 | 57 | 67 | 76 | 82 | 85 |

**Table 6-2. Number of facilities with available release monitoring data for volume, ammonia, TN and TP per activity (for 2013 to 2018).**

| Activity | Ammonia as N (mg/L) | Daily Volume (ML) | Nitrogen - Total (mg/L) | Phosphorus - Total (mg/L) |
|---|---|---|---|---|
| Aquaculture | | 10 | 11 | 11 |
| Meat processing | 1 | 1 | 1 | 1 |
| Mining | 29 | 32 | 5 | 3 |
| Petroleum | 4 | 5 | 2 | 1 |
| Sewage Treatment | 66 | 83 | 68 | 69 |
| **Total** | **84** | **114** | **85** | **84** |

## 6.2 Nutrient loads

### 6.2.1 Point source facilities with nutrient activities

Of the 139 facilities that release to water with available monitoring data for volume, TN and TP, nutrient loads were calculated for 75 facilities (See Appendix D for methodology). This includes one meat processing plant, eight aquaculture facilities and 66 council STPs. It should be noted that aquaculture loads were calculated as gross loads, as nutrients loads for intake were not considered and therefore may be an overestimation of net load contributions from aquaculture facilities. However, monitoring data was not available for all aquaculture facilities and may therefore underestimate gross loads.

A comparison of TN and TP loads for council STPs, aquaculture facilities and meat processing plant for 2017 and 2018 is provided in Figure 6-1. The TN loads for 2017 and 2018 were approximately 430 and 424 tonnes, respectively. The TP loads for 2017 and 2018 were approximately 131 and 114 tonnes, respectively. The majority of the nutrient load was released into the coastal zone with TN loads for 2017 and 2018 approximated at 406 and 397 tonnes, respectively, while TP loads for 2017 and 2018 were approximately 123 and 104 tonnes, respectively (see Figure 6-2).

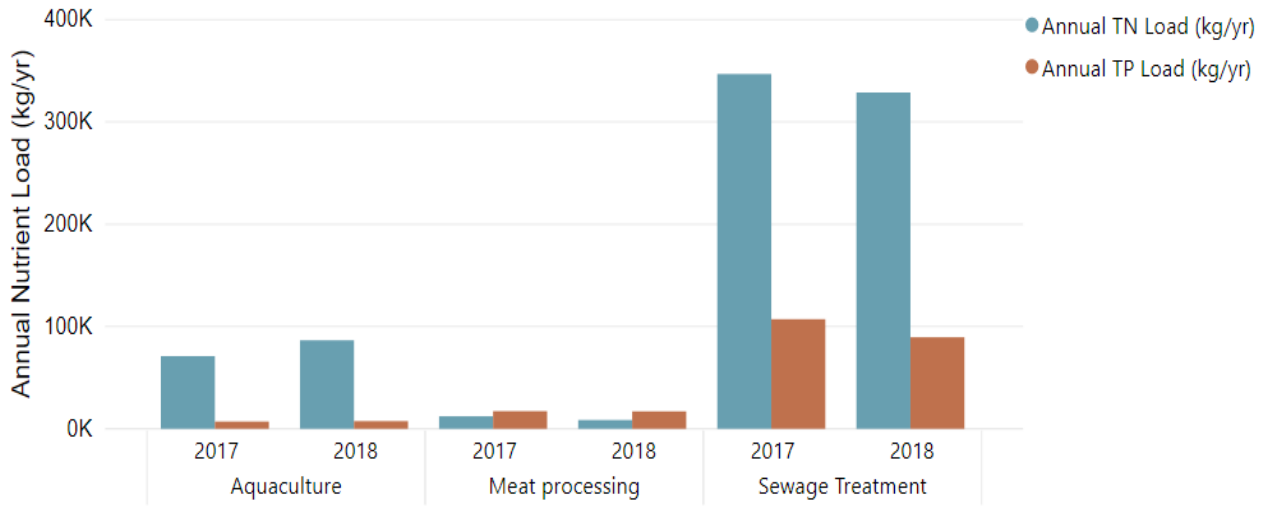



**Figure 6-1. Annual TN and TP release loads for 8 aquaculture facilities, 1 meat processing plant and 66 council sewage treatment facilities with available monitoring data for 2017 and 2018.**

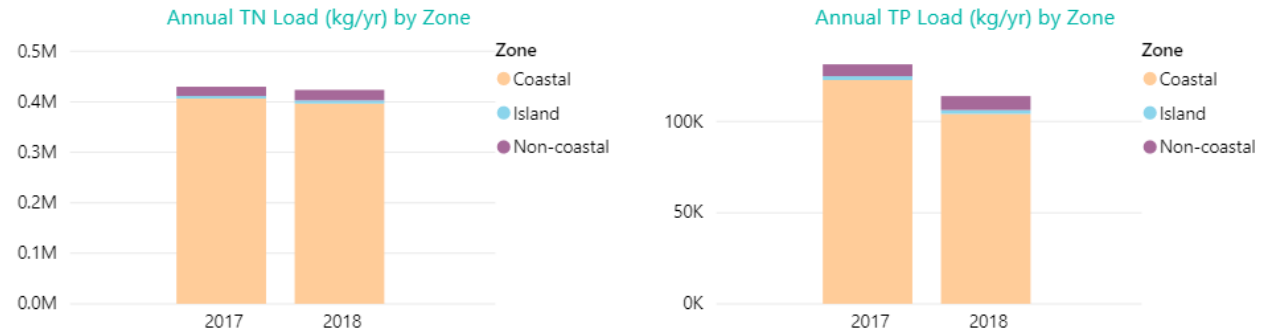



**Figure 6-2. Annual TN and TP release loads for 8 aquaculture facilities, 1 meat processing plant and 66 council sewage treatment facilities with available monitoring data by zone for 2017 and 2018.**

Figure 6-3 shows the point source nutrient load estimates for the various Reef catchment regions for 2017 and 2018. For 2018, the greatest TN loads were released in the Burdekin region while the greatest TP loads were released in the Fitzroy region. The Wet Tropics and Burnett-Mary regions also received high point source nutrient loads while the Mackay Whitsundays region had the lowest point source nutrient loads, other than Islands, which were extremely low.

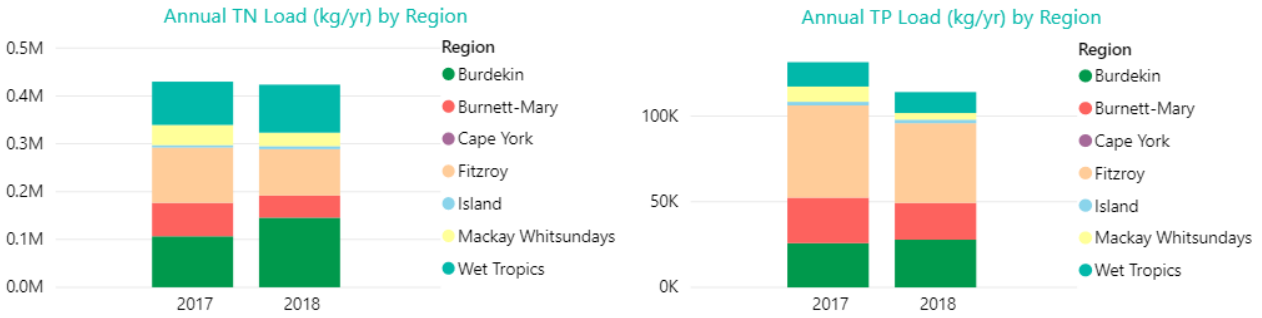



**Figure 6-3. Annual TN and TP release loads for eight aquaculture facilities, one meat processing plant and 66 council STPs with available data per region for 2017 and 2018.**

### 6.2.2 Point source nutrient loads compared to anthropogenic diffuse loads

The point source nutrient loads calculated for the 75 facilities identified with monitoring data in this project were compared to anthropogenic diffuse loads for the Reef catchment. Anthropogenic diffused loads were estimated based on the Department's catchment modelling data used for the Reef Water Quality Report Card for 2018/2019. Firstly, the anthropogenic load for dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP), dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) for each region was determined for the year and the point source load component was excluded. Secondly, the anthropogenic nitrogen and phosphorus load for each region was estimated by combining the inorganic and organic dissolved component. In other words, the modelled anthropogenic particulate component of nitrogen and phosphorus was excluded from the calculation, based on the assumption that this component is unlikely to be readily biodegradable, at least in comparison to point source nutrients. Further information on this calculation is provided in Appendix D.

A comparison of the annual anthropogenic TN load for point source and anthropogenic diffuse sources[15] is shown in Table 6-3 for each region for 2018. Overall, if all 75 nutrient point sources for which monitoring data were available are considered, they account for approximately 3.8% of the total Reef catchment TN load but 3.6% if only coastal facilities are considered. The relative point source contribution to each region varied from 2% for the Wet Tropics, Mackay Whitsunday and Burnett-Mary regions to 12% for the Burdekin region. Interesting, the Burdekin region is estimated as having the lowest diffuse anthropogenic TN load. The point source TN load in the Burdekin region was the highest of any region at 146 tonnes per year, followed by the Fitzroy region at 97 tonnes per year. Point sources in the coastal zone contributed approximately 6% of the anthropogenic TN load for the Fitzroy region and 12% for the Burdekin region.

**Table 6-3. Comparison of point sources nitrogen (N) loads for 2018 to anthropogenic diffuse loads for 2018/19 for regions**

| Region | Diffuse Anthropogenic N Load[10] (tonnes/yr) | Point Source N Load (tonnes/yr) | Point Source N Load (%) | Coastal Point Source N Load (tonnes/yr) | Coastal Point Source N Load (%) |
|---|---|---|---|---|---|
| Wet Tropics | 4,067 | 100 | 2 | 89 | 2 |
| Burdekin | 1,087 | 146 | 12 | 146 | 12 |
| Mackay Whitsunday | 1,781 | 28 | 2 | 28 | 2 |
| Fitzroy | 1,500 | 97 | 6 | 97 | 6 |
| Burnett-Mary | 2,103 | 46 | 2 | 37 | 2 |
| **Total** | **10,537** | **424** | **3.8** | **397** | **3.6** |

A comparison of the annual anthropogenic TP load from point sources and anthropogenic diffuse loads[10] is shown in Table 6-4 for each region for 2018. Overall, if all nutrient point sources in the Reef catchment are considered, they account for approximately 9.6% of the Reef catchment TP load but 8.8% if only coastal facilities are considered. The relative point source contribution to each region varied from 2% in the Mackay Whitsundays region to 16% for the Burdekin region. Interestingly, the Burdekin region is estimated as having a diffuse anthropogenic TP load of only 23 tonnes per year, significantly lower than other regions. The point source TP load in the Fitzroy region was the highest of any region at 46 tonnes per year, followed by the Burdekin region at 28 tonnes per year. Point sources in the coastal zone contributed approximately 9% of the anthropogenic TN load for the Fitzroy region and 55% for the Burdekin region.

**Table 6-4. Comparison of point source phosphorus (P) loads for 2018 to anthropogenic diffuse loads for 2018/19 for regions**

| Region | Diffuse Anthropogenic P Load[10] (tonnes/yr) | Point Source P Load (tonnes/yr) | Point Source P Load (%) | Coastal Point Source P Loads (tonnes/yr) | Coastal Point Source P Loads (%) |
|---|---|---|---|---|---|
| Wet Tropics | 250 | 12 | 5 | 8 | 3 |
| Burdekin | 23 | 28 | 55 | 28 | 55 |
| Mackay Whitsunday | 205 | 4 | 2 | 4 | 2 |
| Fitzroy | 493 | 46 | 9 | 46 | 9 |
| Burnett-Mary | 108 | 21 | 16 | 18 | 14 |
| **Total** | **1,079** | **114** | **9.6** | **104** | **8.8** |

[15] Diffuse anthropogenic nutrient loads are based on GBR report card modelling results for 2018/19 and were calculated by combining the dissolved inorganic and dissolved organic anthropogenic load for nitrogen and phosphorus with the particulate component excluded.

### 6.2.3 Council Sewage Treatment Plants

The annual TN and TP loads were determined for council STPs for 2017 and 2018. Figure 6-4 shows TN and TP loads for the 66 council STPs for 2017 and 2018. The graph includes reference to ultimate nutrient loads which is estimated from monitoring data scaled for 100% design throughput capacity and 100% release to water. The ultimate nutrient load is unlikely to be reached where reuse or land irrigation is adopted and would only change if STP hydraulic capacity was increased.

The annual load of TN from council STPs for 2017 and 2018 was approximately 347 and 329 tonnes respectively. The annual load of TP for 2017 and 2018 was approximately 107 and 89 tonnes respectively. The proportion of TN and TP load from council STPs which are attributed to those in the coastal zone, the non-coastal zone and on islands is shown in Figure 6-5.

For coastal zone releases, the annual load of TN from STPs for 2017 and 2018 was approximately 323 and 301 tonnes respectively while the annual load of TP for 2017 and 2018 was approximately 98 and 80 tonnes respectively. Coastal council STPs contributed more than 90% of the STP nutrient release load during 2017 and 2018. STPs contributed between 78 to 80% of the calculated point source nitrogen load and 77 to 80% of the point source phosphorus load for these years.

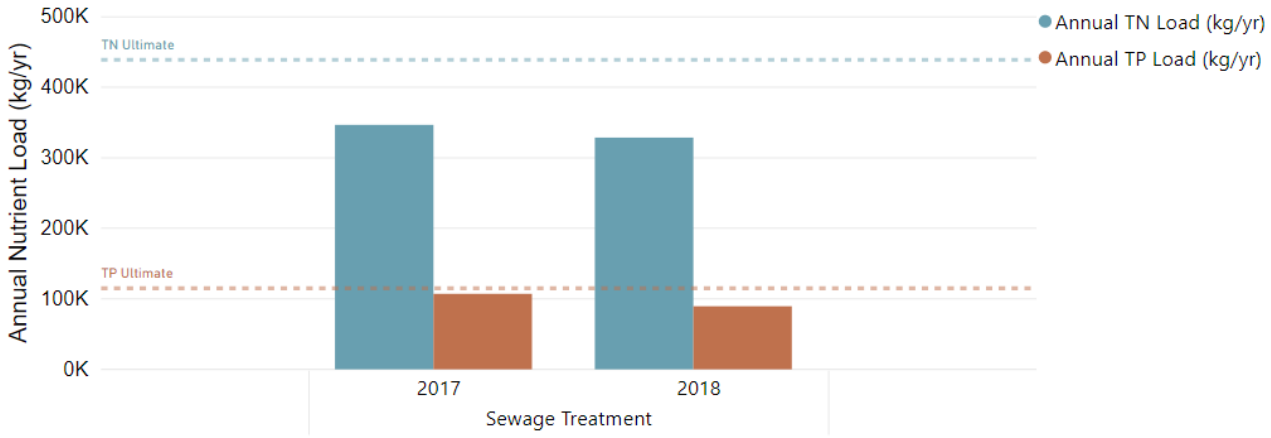



**Figure 6-4. Annual TN and TP loads for council STPs with available monitoring data for 2017 and 2018**

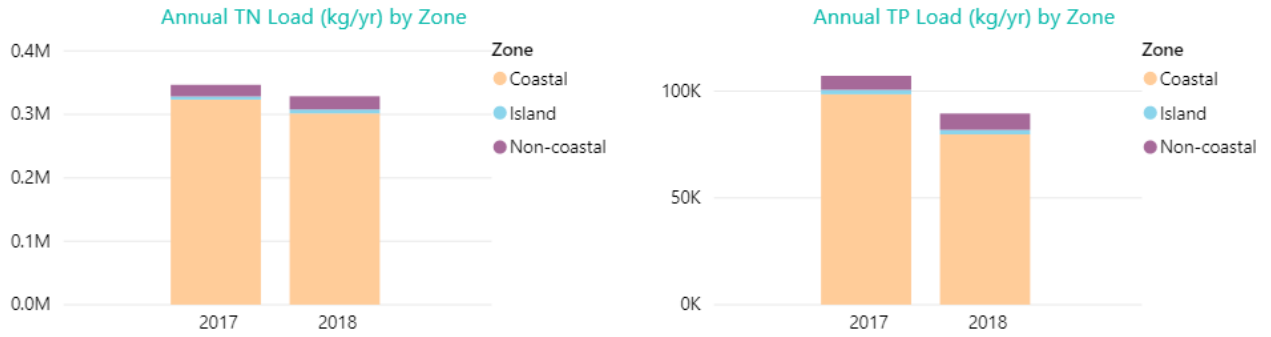



**Figure 6-5. Annual TN and TP loads by zone for council STPs with available monitoring data for 2017 and 2018**

The nutrient loads presented above are comparable with those reported in the Queensland State of Environment (SOE) 2020 Report[16] for coastal STPs for 2018 and 2019. The nutrient loads in this report are slightly higher as they consider monitoring data from a larger number of STPs. The SOE report is also based on monitoring data reported since 2010 and includes annual wastewater release volumes in addition to annual TN and TP loads. The report states that about 60 gigalitres of treated sewage is annually released to coastal waters in the Reef catchment, which is about 20% of the total volume released from STPs in Queensland. The report also states that in general for the years reported, the loads of TN are closely correlated with the annual release volume. However, loads of TN reported for 2018 and 2019 were found to be lower than previous years despite continued high annual release volumes. This suggests that the lower TN load in 2018 and 2019 was due to improved treatment and nitrogen removal. The report also shows an overall reduction in TP loads in 2018 and 2019 compared to previous years, which is also attributed to improved treatment.

### 6.2.4 Aquaculture facilities

From 27 aquaculture facilities, only eight complete monitoring data sets were provided by approval holders. Only two facilities provided intake volume and concentrations, so net load release could generally not be calculated. In general, monitoring and assessment of net loads are not a requirement of approvals for aquaculture facilities within the Reef catchment.

Nutrient loads were determined for the eight aquaculture facilities. The annual load for TN and TP from aquaculture facilities is shown in Figure 6-6. For 2017, TN and TP loads were approximately 70 tonnes and 7 tonnes, respectively and for 2018, were approximately 86.5 tonnes and 7.5 tonnes, respectively. The greatest annual nutrient load from aquaculture facilities is released in the Burdekin region (related to two facilities), followed by the Wet Tropics region with five facilities (Figure 6-7). For the coastal zone, aquaculture facilities contributed approximately 17 to 22% of the calculated point source nitrogen loads and 6 to 7% of the calculated point source phosphorus loads for these years.

In general, calculated nutrient loads were lower than those estimated based on maximum authorised nutrient load limits (See Table 4-4). It is difficult to draw any conclusions on the overall contribution of aquaculture point sources to nutrient loads in the Reef catchment, as the release monitoring dataset for this industry is not complete.

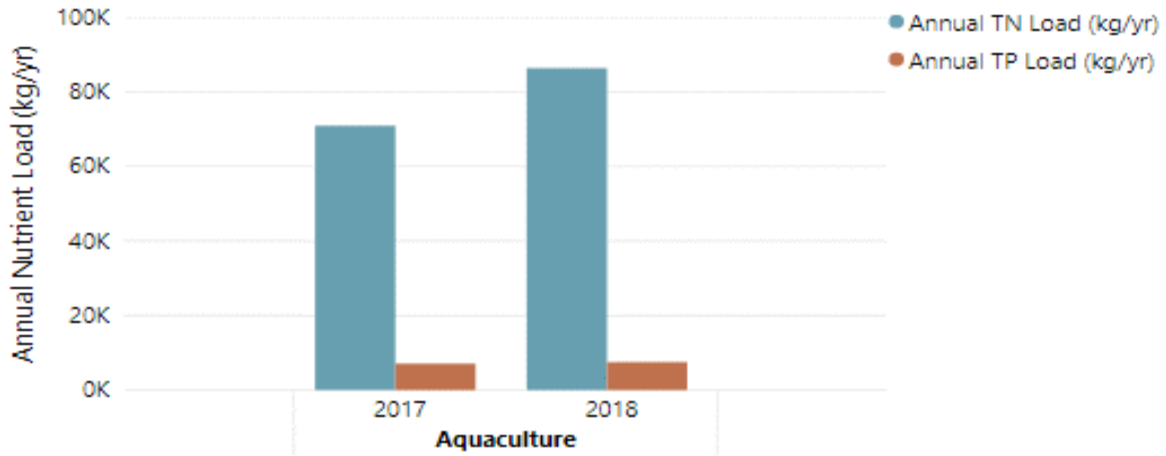



**Figure 6-6. Annual TN and TP loads for aquaculture facilities with available monitoring data for 2017 and 2018**

[16] see https://www.stateoftheenvironment.des.qld.gov.au/pollution/water-quality/volume-and-load-of-sewage-treatment-plants

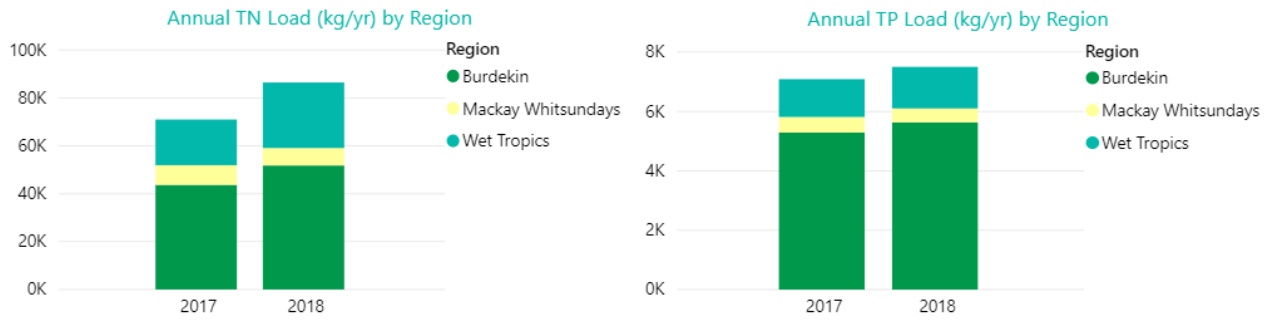



**Figure 6-7. Annual TN and TP loads for aquaculture facilities with available monitoring data per region for 2017 and 2018.**

### 6.2.5 Meat Processing

Nutrient loads were determined for the one meat process facility that releases to water. The annual load of TN and TP from this facility for 2017 was approximately 12 and 17 tonnes, respectively, and for 2018, was approximately 9 and 17 tonnes, respectively. This facility is located in the Fitzroy region. For the coastal zone, meat processing contributed approximately 2 to 3% of the calculated point source nitrogen loads and 14 to 16% of the calculated point source phosphorus loads for these years.

## 6.3 Nutrient concentration

Of the 139 facilities with available monitoring data on release volume for 2017 and 2018, TN and TP concentration data is available for 83 facilities across five primary activities (STP, aquaculture, meat processing, mining and petroleum), of which 68 facilities were STPs and 16 other facilities. Considering nutrient concentrations is important, in addition to loads, as concentrations are generally used to benchmark operation and treatment performance and approvals generally specify concentration limits.

### 6.3.1 Sewage Treatment Plant

As identified in Section 4.1, 143 STPs are authorised to release to water, of which 92 were council STPs. Overall TN and TP monitoring data was available for 68 STP facilities, of which 67 were owned by councils. The total number of STPs for each activity classification together with the number of STPs with TN and TP data for 2017 and 2018 is presented in Figure 6-8.

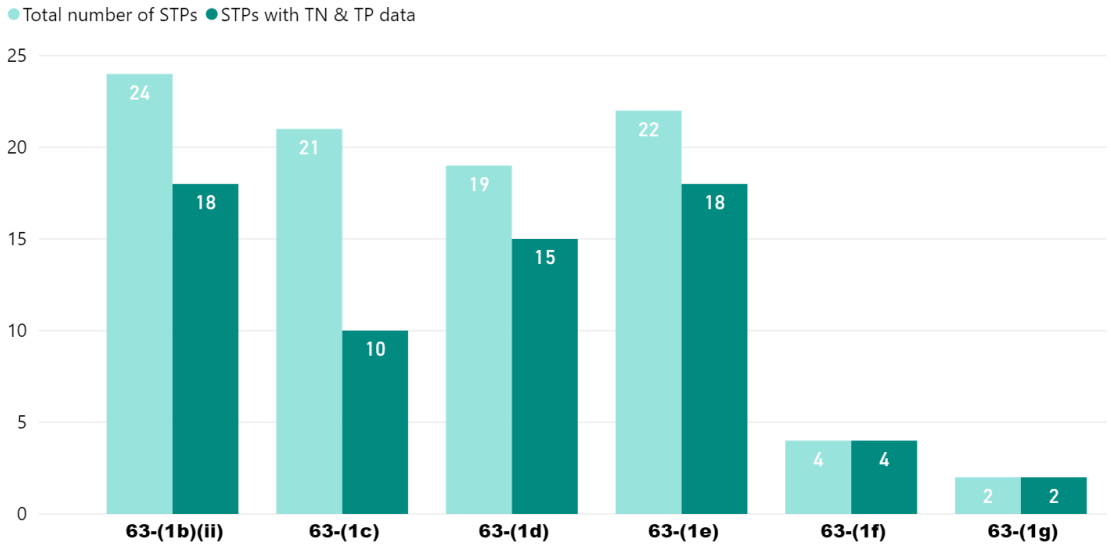



**Figure 6-8. The number of council STPs authorised to release to water for each activity classification compared to the number of council STPs with TN and TP monitoring data for 2017 and 2018.**

Using the combined release monitoring data for 2017 and 2018, the median facility concentrations for TN, TP and ammonia for council STPs are presented in Figure 6-9, Figure 6-10 and Figure 6-11, respectively. Note that these plots show a selection of facilities focussing on those with higher values. The middle and average values are presented based on all facilities with data.

The median concentrations of half of the council STPs was below 3.5 mg/L and 0.76 mg/L for TN and TP, respectively. Best practice release concentrations for modern STPs in Queensland is often considered as 5 mg/L TN and 2 mg/L TP. Approximately 30 STPs facilities had median release concentration above 5 mg/L for TN, however, 10 of these facilities were located on islands. Similarly, approximately 30 STPs had median release concentrations above 2 mg/L TP and again 10 of these facilities were located on islands. This is consistent with the results reported in the Queensland State of Environment Report 2020 where the overall average TN concentration in 2019 was approximately 3.7 mg/L, compared to an average of 4.7 mg/L in 2016. The average TP concentration for 2019 was approximately 1 mg/L, compared to an average 1.6 mg/L in 2016. These results suggest a higher level of nutrient removal for coastal STPs in the Reef catchment in recent years.

Ammonia is a dissolved inorganic nutrient and is highly bioavailable. Ammonia is also a toxicant and a useful indicator of the level of treatment in terms of nutrient removal. Modern STPs may have spikes of ammonia but generally have low concentrations on average. Figure 6-11 shows that the majority of STPs have very low concentrations with half less than 0.17 mg/L suggesting that ammonia is generally a minor component of the nitrogen loads. These levels also suggest a high level of wastewater treatment for many facilities. Eleven facilities had median ammonia concentrations above 2 mg/L and seven of these facilities were located on the islands, with five of these facilities having median ammonia concentrations of above 20 mg/L.

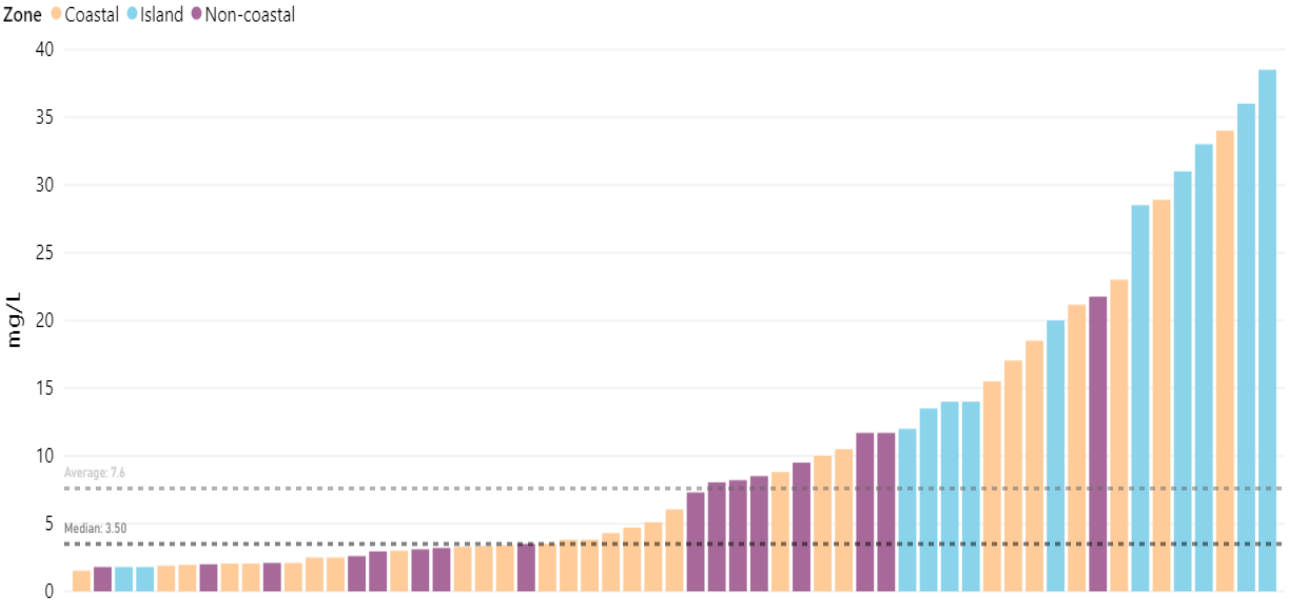



**Figure 6-9. Selection of TN release concentrations for council STPs in the Reef catchment. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. The dotted lines show the middle and average TN concentration value of all facilities (3.5 mg/L and 7.6 mg/L, respectively)**

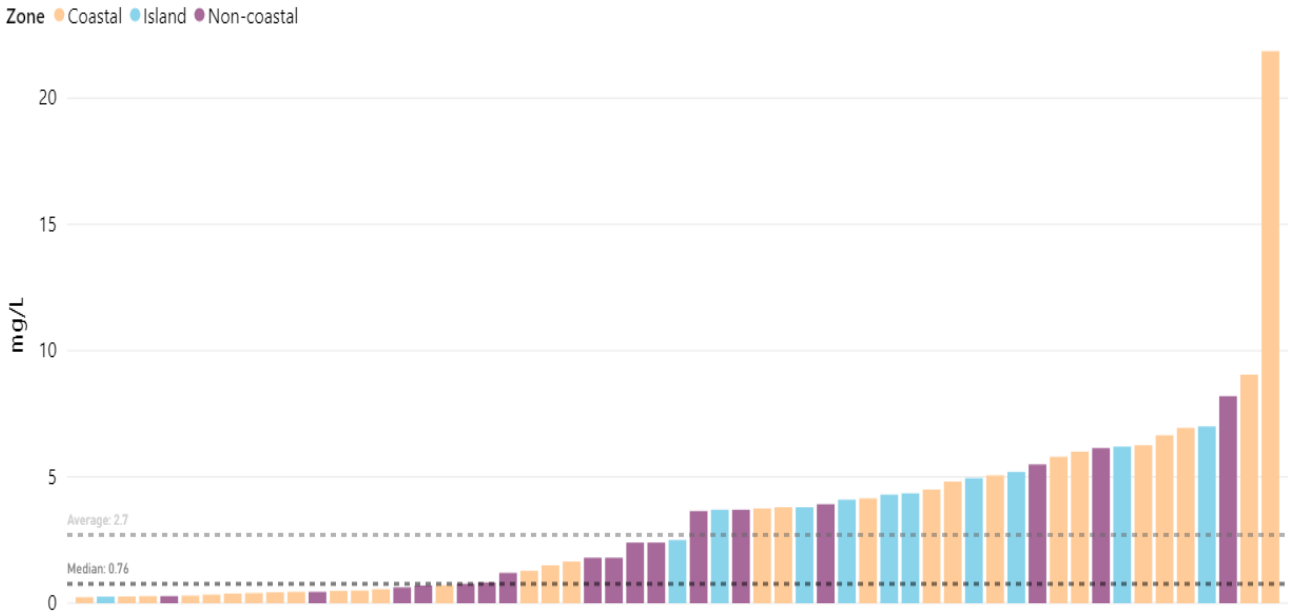



**Figure 6-10. Selection of TP release concentrations for council STPs in the Reef catchment. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. The dotted lines show the middle and average TN concentration value of all facilities (0.76 mg/L and 2.7 mg/L, respectively)**

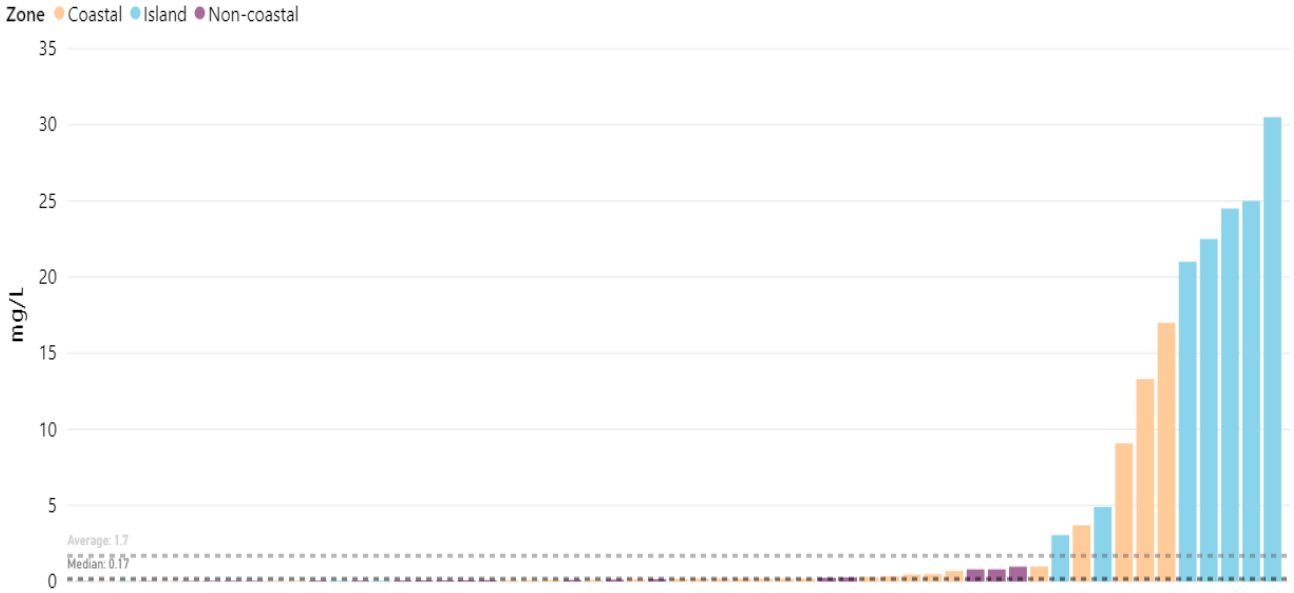



**Figure 6-11. Selection of ammonia release concentrations for council STPs in the Reef catchment. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. The dotted lines show the middle and average TN concentration value of all facilities (0.17 mg/L and 1.7 mg/L, respectively)**

The above monitoring data suggests that the council STPs located on the islands have a substantially different treatment types and/or operating performance compared to those on the mainland. In addition, the Island STPs do not appear to be a major contributor to point source nutrient loads in the Reef catchment, and many are located north of the tip of Queensland. As a result, STPs located on islands are not included in subsequent analysis in this report.

*Council STPs in Coastal Zone*

As outlined above in Section 6.2.3, the majority of the nutrient load from council STPs is released into the coastal zone. Of the 67 council STPs, 37 council STPs that release to water were located in the coastal zone. Figure 6-12 shows the median TN concentration for each of these facilities where release monitoring data was available for that facility for 2017 and 2018. The facilities are also grouped based on activity classification. The TN removal of many coastal council STPs, based on the release TN concentrations, was very good, with less than 5 mg/L often observed. A number of facilities in categories below 50,000 EP, i.e. (1e), and smaller had significantly higher TN release concentrations. The exception to this was category (1d). The STPs in category (1e), and possibly category (1c), with higher TN release concentrations could be investigated further in terms of their TN load contribution, given they are of a larger size and likely to release larger nutrient loads.

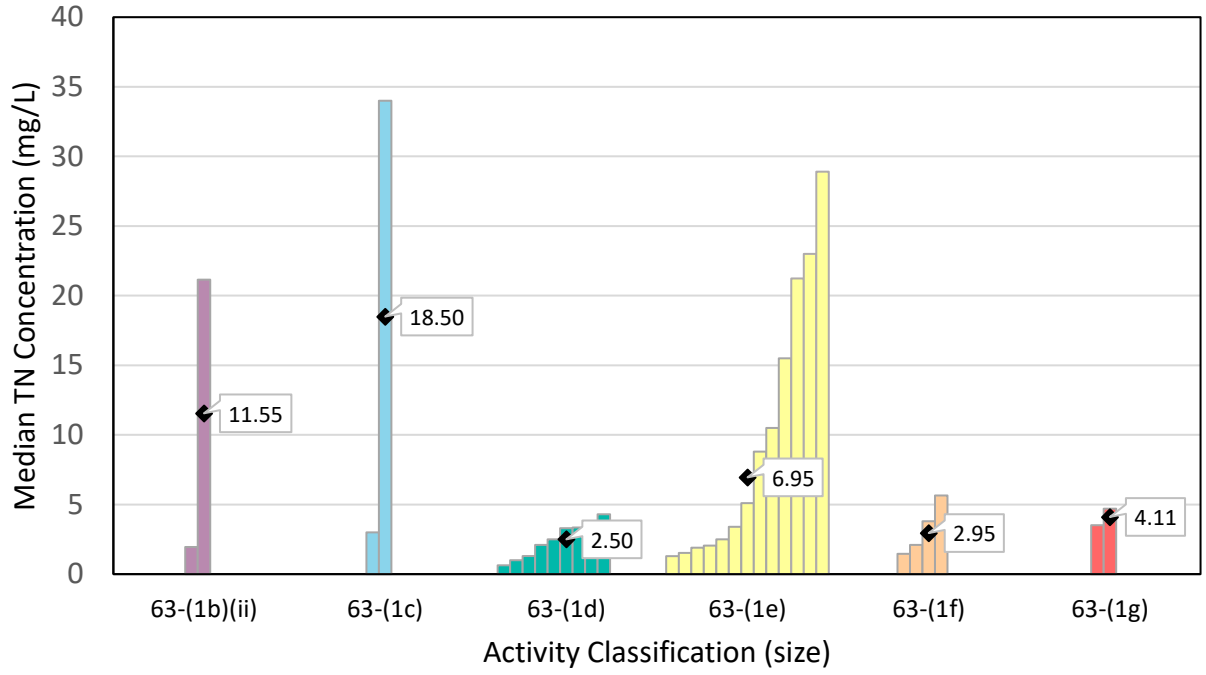



**Figure 6-12. TN concentrations for council STPs located in the coastal zone, grouped per activity classification. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. Black dots show the middle value for each activity classification.**

Similarly, Figure 6-13 shows the TP concentration for each council STPs located in coastal zone based on the median of all release monitoring data for that facility for 2017 and 2018. TP removal, based on the release TP concentration of less than 2 mg/L, is very good for more than 50% of the council STPs. A number of council STPs within the category (1e) for 10,000 to 50,000 EP are also achieving a release TP concentration of around 5 mg/L with only one council STP with a high release TP concentration of over 20 mg/L. These STPs with higher TP release concentrations could be investigated further in terms of their TP load contribution, given they are of a larger size and likely to release larger nutrient loads.

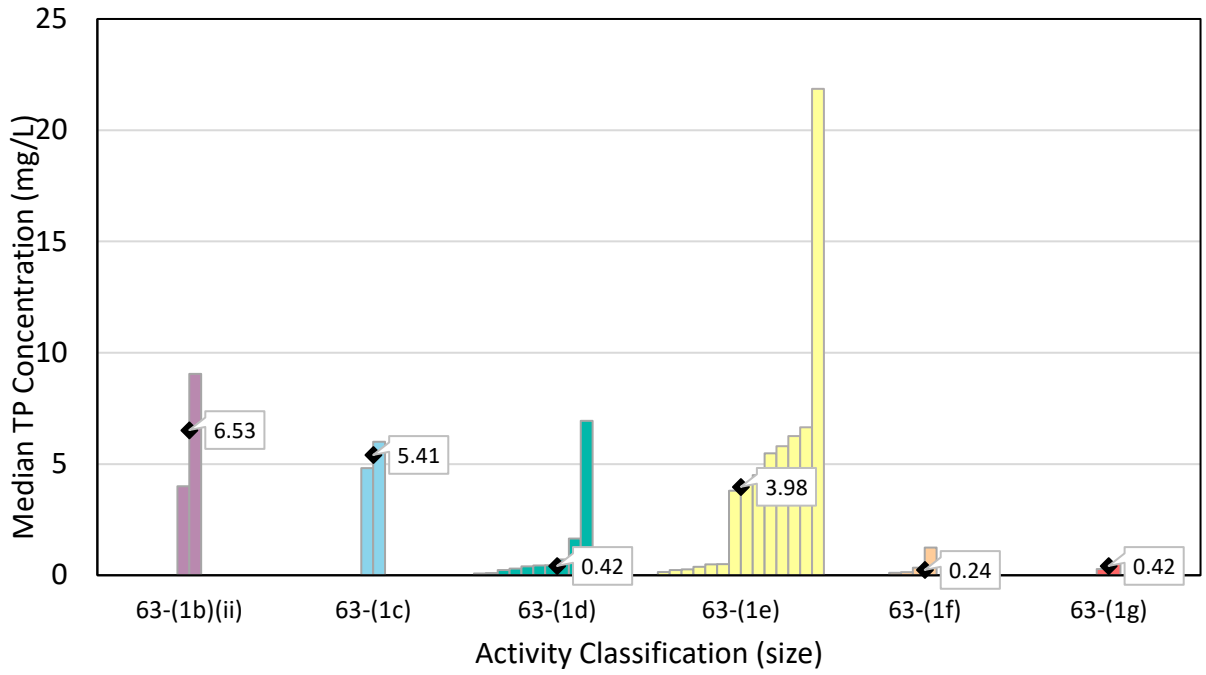



**Figure 6-13. TP concentrations for council STPs located in the coastal zone, grouped per activity classification. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. Black dots show the middle value for each activity classification.**

Ammonia is both a dissolved nutrient and toxicant that is assimilated in the local receiving environment. According to National Water Quality Guidelines[17], ammonia has a toxicity trigger value of 0.9 mg/L for fresh and marine water based on the 95% level of species protection for slightly-moderately disturbed systems. High ammonia concentrations can also indicate low levels of treatment or poorly operating facilities. Figure 6-14 shows the ammonia concentration for each of the council STPs located in coastal zone, based on the median of all release monitoring data for that STP for 2017 and 2018. Firstly, it should be noted that ammonia data was not available for as many STPs as was for TN and TP. For the council STPs with ammonia data, all but three were found to have low ammonia levels, i.e. less than 1 mg/L. The three council STPs with high ammonia concentration were in category (1e) and could be investigated further in terms of their level of treatment and operation.

Dissolved nutrients such as ammonia, nitrate/nitrite and filterable reactive phosphorus are not often measured as part of STP regulation. These dissolve nutrients are however considered important in terms of understanding the potential nutrient inputs to the Reef catchment. For this reason, greater effort for measuring these dissolved nutrients in STPs involving release to coastal waters in the Reef catchment should be considered.

[17] see https://www.waterquality.gov.au/anz-guidelines

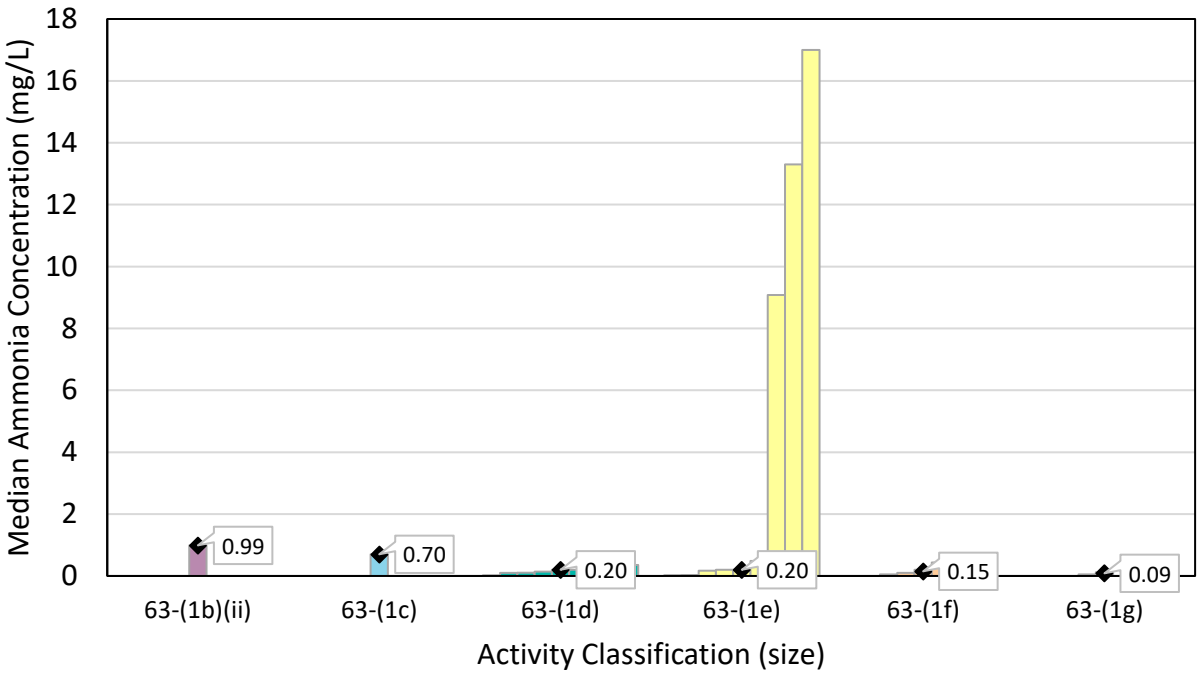



**Figure 6-14. Ammonia concentration for council STPs located in the coastal zone, grouped per activity classification. Values are the median of all release monitoring data collected for that STP from 2017 and 2018. Black dots show the middle value for each activity classification.**

### 6.3.2 Other facilities

TN and TP monitoring data was obtained from 11 aquaculture, one meat processing, three mining and one petroleum facility for 2017 and 2018. The aquaculture and meat processing facilities are located in the coastal zone and the mining and petroleum facilities are located in the non-coastal zone. The median TN and TP concentrations varied across facilities as shown in Figure 6-15.

Generally, levels of nutrients in aquaculture, mining and petroleum releases were lower than those in STP releases. The level of TP in the meat processing release was greater than all other facilities, including STPs. However, there was no information on the dissolved nutrient component of the aquaculture or meat processing releases.

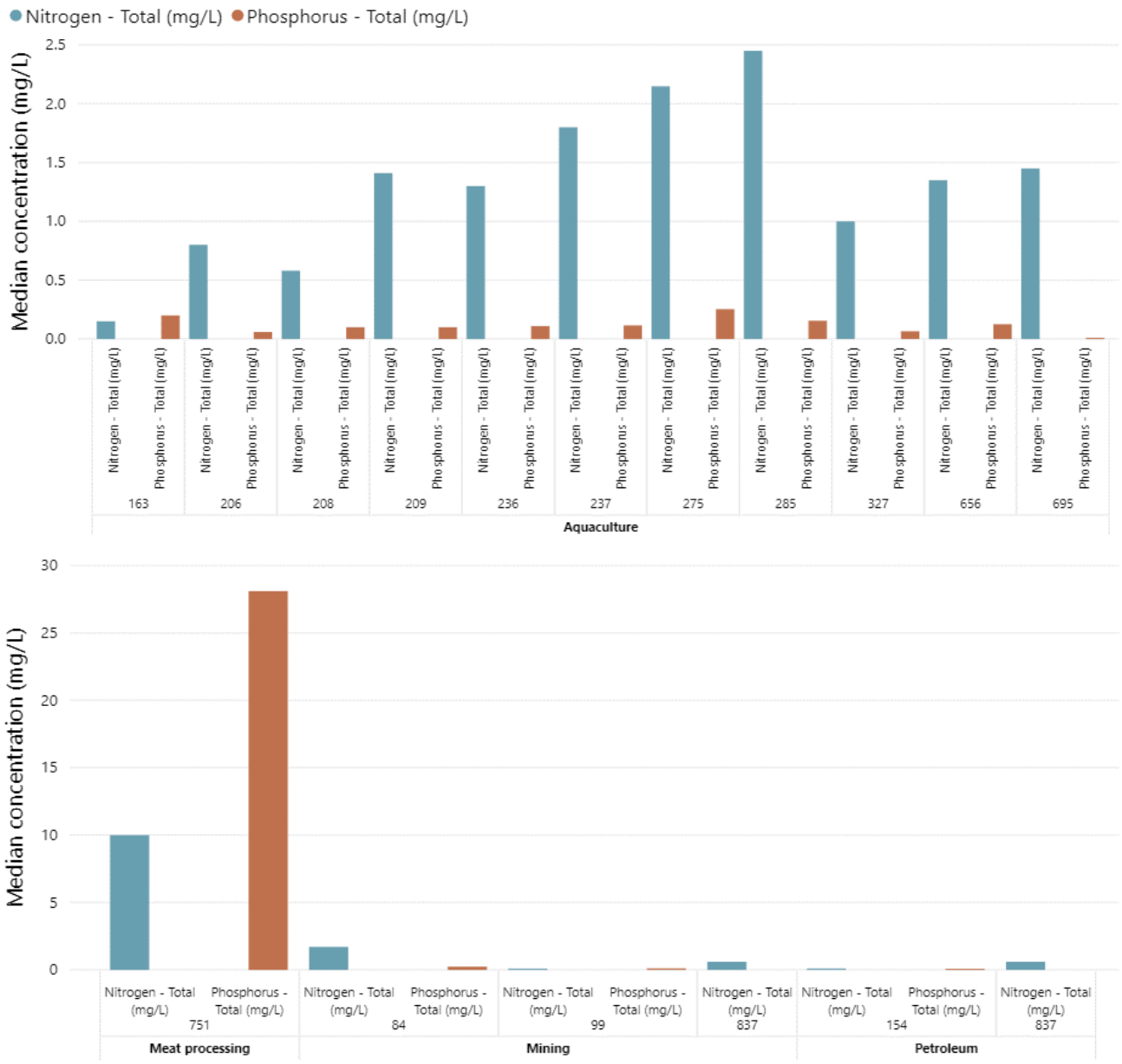



**Figure 6-15. TN and TP release concentration for each aquaculture, mining, petroleum and meat processing facility where release monitoring data is available for 2017 and 2018. Values are medians of all monitoring data collected during that period.**

# 7. Technology & sustainability considerations

In previous sections, the potential risk from point source facilities to the Reef catchment has been assessed based on release concentrations and loads. However, setting of release standards will indirectly determine the types or level of management intervention required, such as the amount of reuse or the level of wastewater treatment needed. These management interventions will have broader environmental and social implications including energy and chemical usage, the amount of waste produced, production of $CO_2$ and other greenhouse gases, and the cost and technical feasibility of undertaking these interventions. Therefore, the last step of the regulatory framework adopted for this report is to review the waste management technology and sustainability considerations for each industry. To achieve this, detailed information is required about the industry sector. Firstly, we recommend developing a good conceptual understanding (and model) of wastewater management for the industry considering the broader management options and interaction with the environment. We also recommend developing a good understanding of the various mitigation or treatment technology options that are available. Significant business risk can occur in terms of meeting regulation, particularly when adopting new management or technological approaches. Other important considerations include cost in terms of capital and operating expenditure.

Technology and sustainability considerations for STPs is discussed in detail in this section of the report, given the industry was identified as the activity with the largest authorised nutrient release to the Reef catchment. However, a similar review should be taken for all key point source activities but is outside the scope of this review. The review of STPs is hoped to assist with guiding regulation of the industry but also as a case study on the importance of considering technology and sustainability issues when reviewing point source regulation. In reality, a whole of life cycle and cost benefit analysis is required in relation to specific technological solutions for facilities but this is also outside the scope of this review.

## 7.1 Process description

In this review, sewage treatment is defined as the process of reducing or removing contaminants from wastewater derived from sewer networks managed by councils or water utilities. The source of sewage can be from residential, institutional, commercial and industrial establishments but is predominantly residential in most cases. Residential or “household” wastewater is derived from toilets, baths, showers, kitchens, and sinks that drain to the sewer systems. The wastewater derived from industrial and commercial sources will vary depending on the activities involved and is typically managed through council “trade waste” agreements.

A conceptual model of a generalised STP wastewater management has been developed and is presented in Figure 7-1. This describes the overarching sewage treatment and management processes including sources, treatment, different types of reuse and the environmental fate of the treated wastewater under different scenarios. The elements of STP management may vary significantly with size (activity classification) and location. Larger STPs are often located in coastal zones of Queensland, close to estuarine or marine areas. Some STPs are located more inland adjacent to freshwater systems. Some STPs are located on islands, often very remote, within the Reef lagoon or broader catchment. Treated effluent may be reused by third parties such as on golf courses or on agricultural areas, be reused on the STP site, or be disposed to land via irrigation. Where a release to wastewater to local surface water is required, this may be continuously or only during or after rain events when reuse or land irrigation is not possible. Other types of sewage releases include sewer overflows and STP by-passes. Both of these include little or no treatment and are most common during wet-weather events. Ultimately, if in the Reef catchment, all of the releases of wastewater to the environment have the potential to contribute to nutrients loads exported to the Reef catchment.

Apart from generating treated effluent, a STP also generates a semi-solid waste or slurry, called sewage sludge, which has to undergo further treatment, such as through a sludge digester and filter press/drying beds, before being suitable for disposal or reuse to land as bio-solids. Some sewage sludge or bio-solids is disposed of to landfill. In addition, gases (biogas) which may include methane, carbon dioxide and nitrous oxide, may be reused, removed or released to the atmosphere. Biogas can be used as a heat source, electric power, and other power generator, but is currently only economically feasible for very large plants. In comparison to a centralised STP, some communities manage sewage through on-site wastewater treatment, most commonly via septic tank - soil absorption systems. In coastal sandy areas, these systems are a potential source of nutrients via groundwater seepage. However, on-site wastewater treatment is outside the scope of this review.

In Queensland, there is currently a policy in relation to nutrient offsets for point source releases[18]. The main example currently of nutrient offsets involves streambank stabilisation. However, there are currently no examples of nutrient offsets in the Reef catchment.

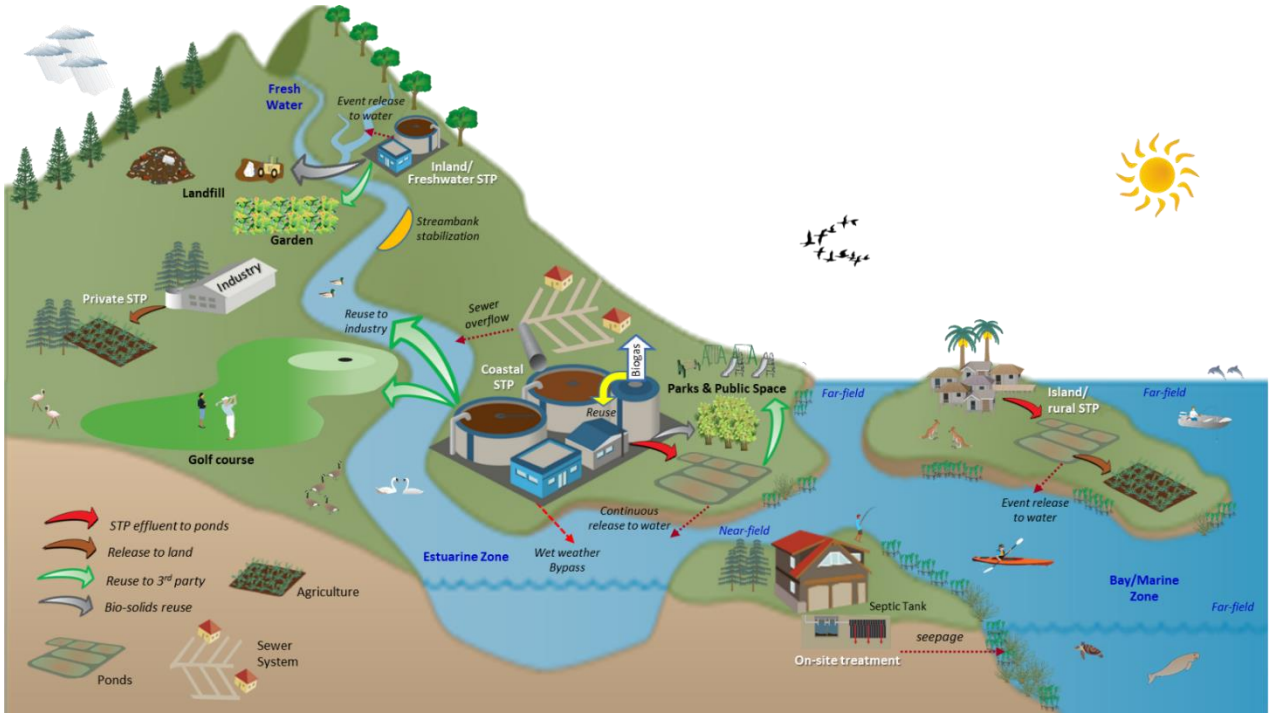



**Figure 7-1. STP wastewater management and release conceptual model for the Reef catchment**

## 7.2 Environmental and technological review

As part of this project, a STP environmental management benchmarking questionnaire was developed and sent to all operators of council STPs in the Reef catchment. Although focussed primarily on the management and treatment of nutrients, the information collected also looked at broader environmental management considerations such as wastewater reuse, bio-solids, energy, chemical usage, monitoring and costs. Of the 137 council STPs contacted, information was received for 124 STPs (90%). Only two councils did not respond to the survey.

[18] https://environment.des.qld.gov.au/__data/assets/pdf_file/0033/97845/point-source-wq-offsets-policy-2019.pdf

The information obtained from the survey included, for each STP, information and data on release location, design EP capacity, average dry weather flow (ADWF), current operation level to the design capacity, past and future treatment upgrades, major treatment units for carbon and nutrient reductions, disinfection units for release and reuse water, chemical usage, reuse information (on-site and off-site) of treated effluent, bio-solids fate, biogas management, energy usage, information on monitoring, relative annual Operation Cost (OPEX) and Capital Cost (CAPEX) of treatment. An Industry Standards Knowledge Base was developed as a Power BI file to analyse and visualise the data from the survey and the monitoring data.

Table 7-1 shows the current operational level for the 119 council STPs that responded to the survey based on a percentage of the design capacity. This information was useful in evaluating the ultimate nutrient loads being generated by council STPs in each region. In general, the survey indicated that approximately 20% of the STPs are above 80% of their design capacity or conversely, approximately 80% of facilities are less than 80% of their design capacity. A number of facilities appear to be operating above their design capacity (> 100%).

**Table 7-1. Current operational level of council STPs within the Reef catchment based on the original design capacity**

| Current Operational Level to Design Capacity (%) | Number of STPs | Percentage of STPs |
|---|---|---|
| <10 | 0 | 0% |
| 10-20 | 9 | 7% |
| 20-30 | 4 | 3% |
| 30-40 | 16 | 12% |
| 40-50 | 20 | 15% |
| 50-60 | 14 | 10% |
| 60-70 | 17 | 12% |
| 70-80 | 13 | 9% |
| 80-90 | 10 | 7% |
| >90 | 16 | 12% |
| No information | 18 | 13% |

An STP treatment technology classification was developed as presented in Table 7-2 to help compare treatment technology against nutrient release quality. It is mainly focussed on carbon and nutrient reduction, two of the key functions of the STPs. The ‘advanced’ level involves both carbon and nutrient removal units and sophisticated, usually highly effective, engineered treatment units. Often they involve high energy consumption. The ‘high’ level focuses mainly on carbon removal units with some nutrient removal, also with well-engineered treatment units and significant energy consumption. The ‘medium’ level treatment focuses on a moderate level of carbon removal and typically uses less energy. The ‘low’ level treatment involves units that have low carbon reduction, and typically lower energy and cost compared to the other classifications. The ‘very low’ treatment level is mainly used in small STPs such as at the holiday or caravan parks and involves very simplistic treatment, often with minimal energy and running costs.

**Table 7-2. Criteria and examples of STP treatment technology classification for this review**

| No | Treatment Technology Classification | Criteria | Example |
|---|---|---|---|
| **1** | Advanced | Aimed to reduce carbon and nutrient (mainly nitrogen) constituents. | Sequencing Batch Reactor, Biological Nutrient Removal, Membrane Filtration/Membrane Bioreactor, and 5 Stage Bardenpho Bioreactor. |
| **2** | High | Primarily aimed at reducing carbon concentrations in the wastewater, with some nutrient removal. It usually produces a high-level degree of carbon removal (around 80-95%). Typically, high energy is consumed in this process. | Activated Sludge, Intermittent Extended Aeration, and some combination between medium treatment levels (e.g. Trickling Filter with Membrane Filtration). |
| **3** | Medium | Mainly aimed at reducing carbon concentrations to a medium degree of removal compared to the 'high' classification. This level uses less energy than the 'high' level treatment technology. | Oxidation Ditch, Trickling Filter, Rotating Biological Contactor, and Package Treatment Plant. |
| **4** | Low | Aimed at reducing carbon concentrations using low energy/cost of treatment. Usually, the treatment results are not as good as the 'medium' or 'high' level treatment technologies, but there is low or no energy usage involved in the treatment process. | Ponds/lagoons, Wetlands, and Imhoff Tank. |
| **5** | Very Low | Mostly used for a small STP with the intention to reduce the carbon concentrations. Usually very little to no energy/costs are involved in this treatment level, but the degree of pollutant reduction is small. | Trenches. |

Treatment technology information was provided for 119 council STPs, of which 80 council STPs release to water and 32 of those are located in the coastal zone. The number of council STPs with releases to water and their associated levels of treatment technologies is shown in Figure 7-2. All council STPs with a release to water, except 11, have an advanced, high or medium level of treatment. More nutrient monitoring data were available for the council STPs with advanced technology while significantly fewer nutrient monitoring data were available for the facilities with medium level of treatment and no monitoring data for the STPs with low-level of treatment. No council STPs with release to water were classified as having a very low-level treatment.

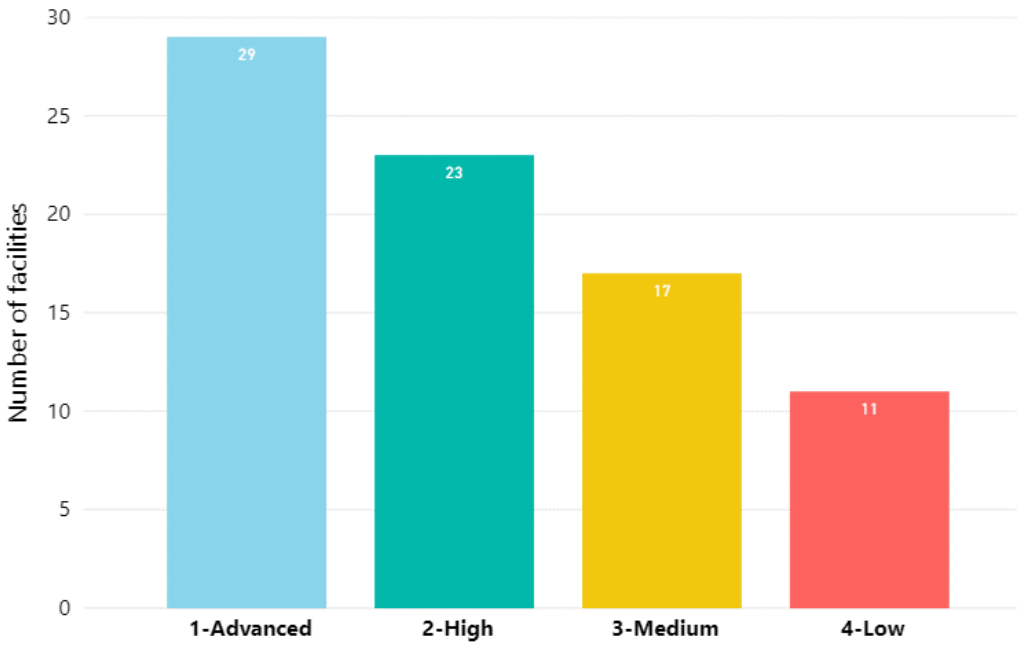



**Figure 7-2. The number of council STPs that release to water for each treatment technology classification**

Figure 7-3 shows the treatment technology classification for each council STP that release to water per activity classification. It can be seen the advanced treatment occurs mainly with larger size STPs above 1,500 EP (categories (1c) and above). All STPs above 50,000 EP (i.e. categories (1f) and (1g)) only have advanced treatment. Furthermore, low treatment is mainly found for STPs sized below 4,000 EP (categories (1c) and (1b)).

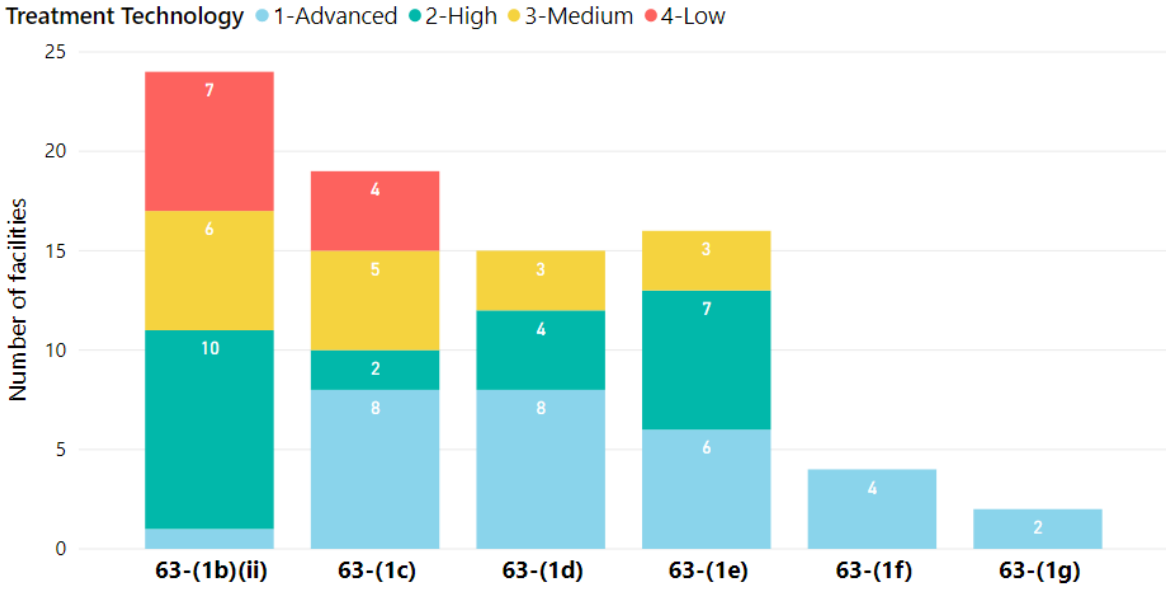



**Figure 7-3. The number of council STPs that release to water with different treatment technology for each activity classification.**

Nutrient monitoring data was available for 27 of the 32 council STPs with treatment technology information that release to water in the coastal zone. Release monitoring data for 2017 and 2018 was used to determine TN concentrations for each facility in the coastal zone that release to water and is shown in Figure 7-4 for different treatment technology classifications. As expected, it shows that lower TN concentrations are

obtained from the higher level of treatment technology, although there is a larger variability in the effluent TN for medium level treatment technology.

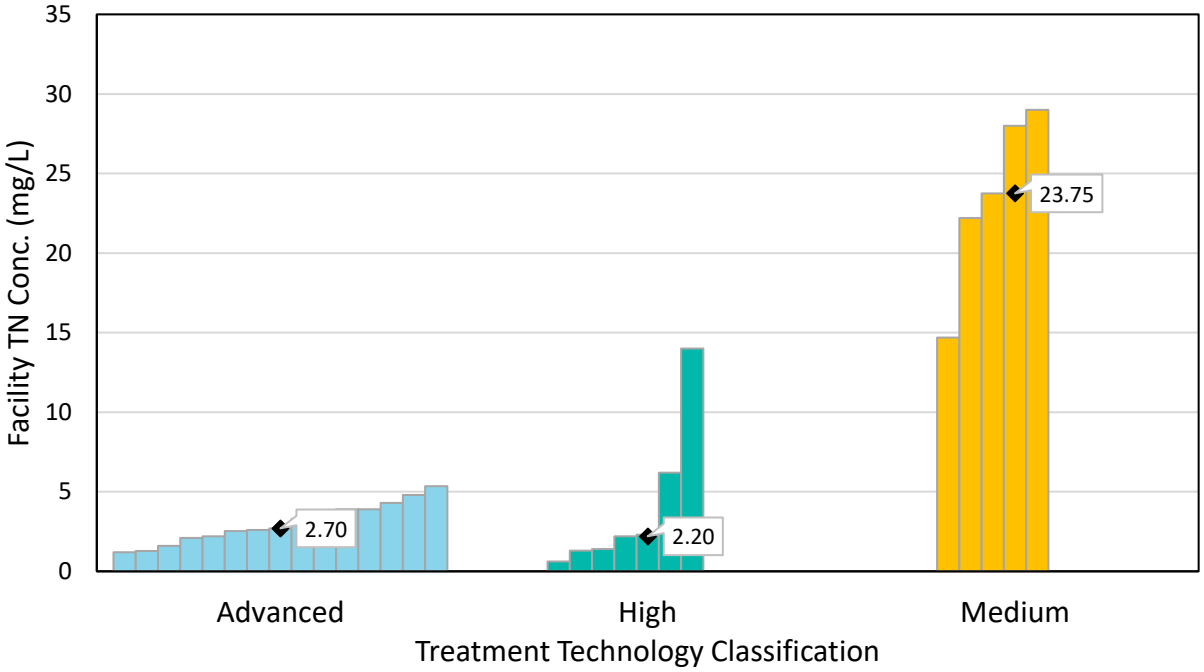



**Figure 7-4. TN concentrations for council STPs located in the coastal zone, grouped per treatment classification. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. Black dots show the middle value for each category.**

Overall, there is not much information available in relation to enhanced biological phosphorus removal. Nonetheless, release monitoring data for 2017 and 2018 was used for council STPs that release water to the coastal zone to determine TP concentrations for each facility and grouped based on different treatment technology classifications. The relationship between the treatment classification and phosphorus removal is not as clear as with nitrogen removal, and consideration of chemicals used for phosphorus was needed.

Substantial information was provided in the survey on the types and amounts of chemicals used to remove phosphorus and it appears chemical phosphorus removal is very common within the industry. The chemicals most commonly used were alum and polymer/polyelectrolytes. TP release concentrations for each facility in the coastal zone that release to water are shown in Figure 7-5 considering both treatment classification and chemical usage. Firstly, chemical phosphorus removal did not appear to be used in smaller STPs. In general, for council STPs that used chemical phosphorus removal, TP release concentrations were generally around or below 1 mg/L. The use of alum appeared to be needed to achieve these low levels. A further observation was that the TP release concentrations for council STPs in the very high and high classification was around 5 mg/L without the use of alum. For STPs in the medium treatment classification, the TP release concentrations were around 8 mg/L without the use of alum. It is assumed that these concentrations are achieved as a result of biological treatment.

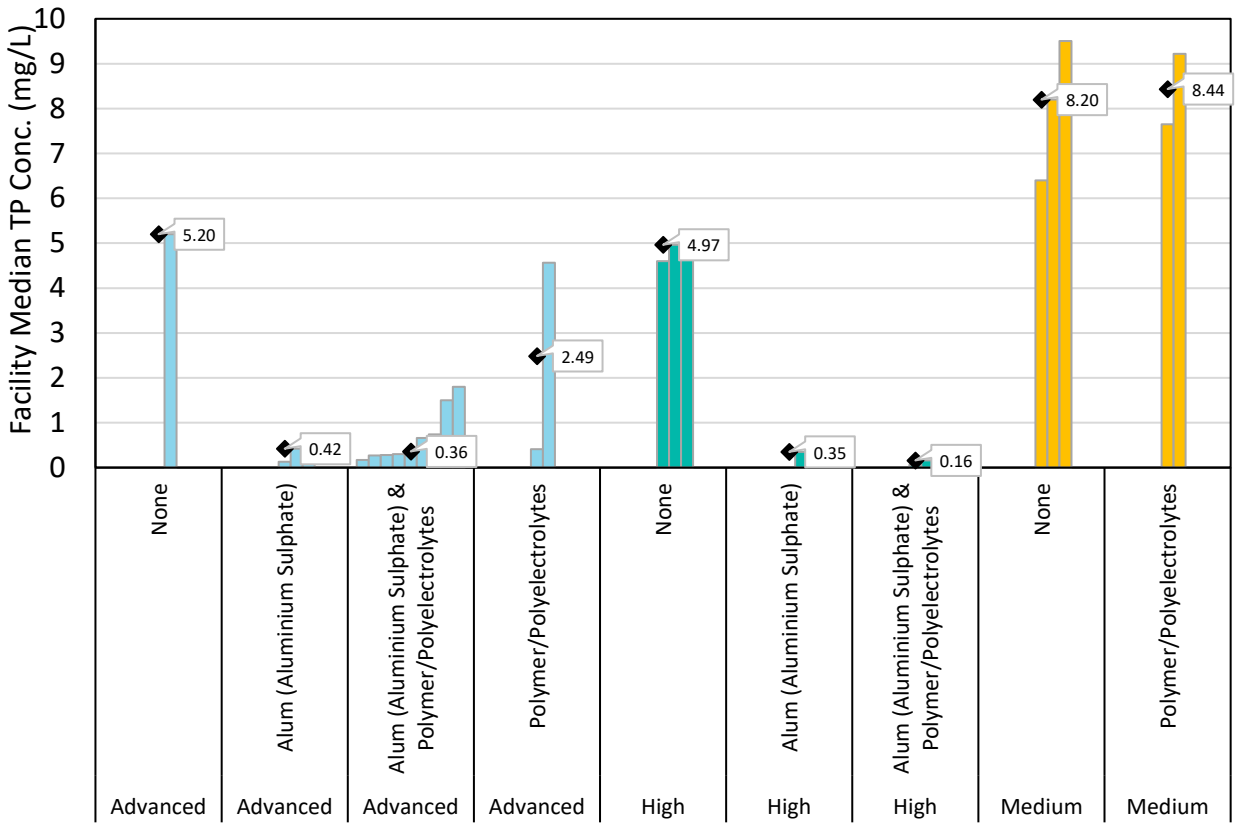



**Figure 7-5. TP concentrations for council STPs located in the coastal zone, grouped per treatment classification and chemical addition. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. Black dots show the middle value for each category.**

Release monitoring data for 2017 and 2018 was used to determine ammonia concentrations for each facility in the coastal zone that release to water and is shown in Figure 7-6 for different treatment technology classifications. As discussed in Section 6, the release of high levels of ammonia concentrations from an STP can be of potential concern due to toxicity to aquatic ecosystem and are also a potential indicator of a low level of treatment or poor treatment. The median ammonia concentrations for facilities with very high and high level treatment classification was very low, less than 0.75 mg/L. However, two of the facilities classified with medium level treatment had ammonia concentrations of approximately 12 and 17 mg/L, while the third STP in this treatment classification had release ammonia concentration of 1 mg/L.

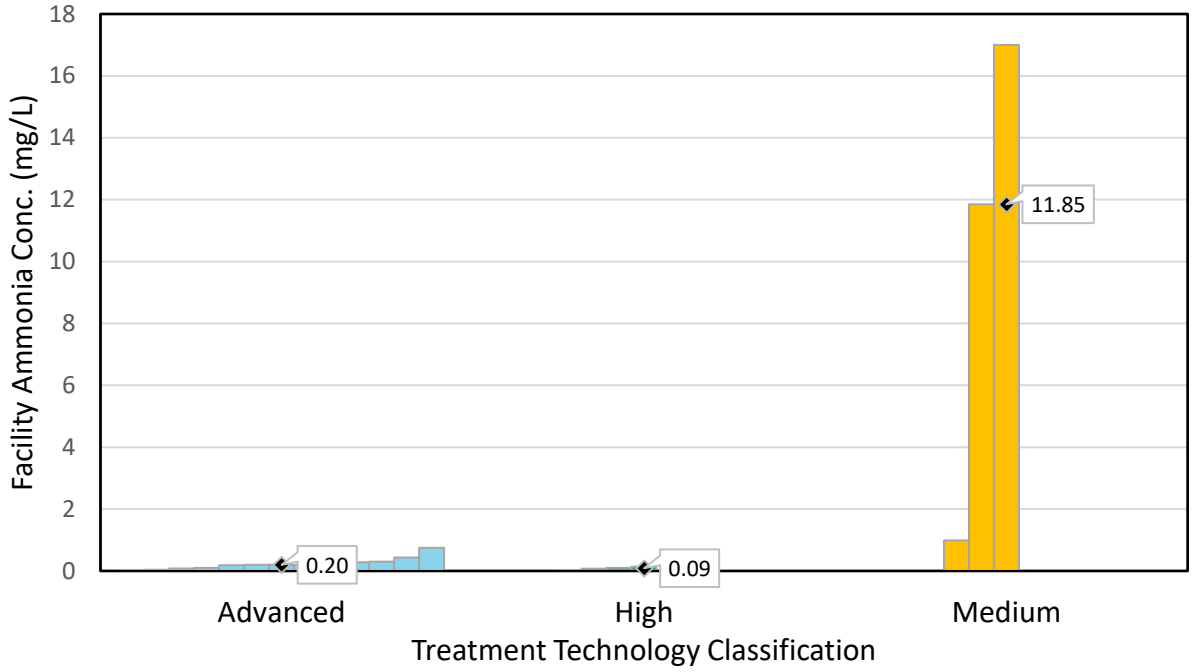



**Figure 7-6. Ammonia concentrations for council STPs located in the coastal zone, grouped per treatment classification. Values are the median of all release monitoring data collected for that facility from 2017 and 2018. Black dots show the middle value for each category.**

## 7.3 Sustainability review

This section will present the review of the sustainability aspects of environmental management for council STPs that release to water. The key areas that will be discussed include alternatives to release to water, including reuse and disposal to land, management of bio-solids, energy usage, capital and operating costs, and environmental monitoring. The information presented in this section is largely based on the facility questionnaires that were completed by the councils who operate these STPs. It is acknowledged that each of these areas will have additional considerations, and potentially legislation, compared to release to water. A key one is potential human health risks for reuse, often assessed using microbial indicators. Also in Queensland, biosolids are managed under the *Waste Reduction and Recycling Act 2011*, and specifically through the End of Waste Code Biosolids (ENEW07359617). These considerations were not covered as part of the questionnaire or this review.

Alternatives to release to water are wastewater reuse or disposal to land via irrigation. Typically, wastewater is either provided to third parties for reuse, such as for irrigation of public spaces, golf courses, or reused on-site around the STP for garden watering, grit washing, and dust control. One or a combination of these options may be used for one facility.

The average amounts of off-site reuse, on-site reuse and disposal to land are shown in Figure 7-7. Overall, off-site reuse via third parties is the most significant alternative used to release to water. Conversely, disposal to land is the least significant option, although is most common for the smaller facilities for activity classifications (1c) and (1d), i.e. size >1,500 to <10,000 EP. The distribution of reuse, including land disposal, for facilities over different activity classifications is shown in Figure 7-8. Some facilities in all activity classifications, except (1g) (>100,000 EP), have 100% of reuse/disposal to land. However, categories (1c) and (1f) have the greatest proportion of facilities with high reuse. Approximately half of the (1c) category STPs have more than 60% reuse/land disposal while half of the (1f) category STPs have more than 90% reuse/land disposal (not shown below). STPs in categories (1g) and (1b), and to a lesser extent category

(1d), have the greatest proportion of facilities with low levels of reuse/land disposal. These facilities, therefore, have the greatest potential to increase the level of reuse/land disposal where suitable options are available.

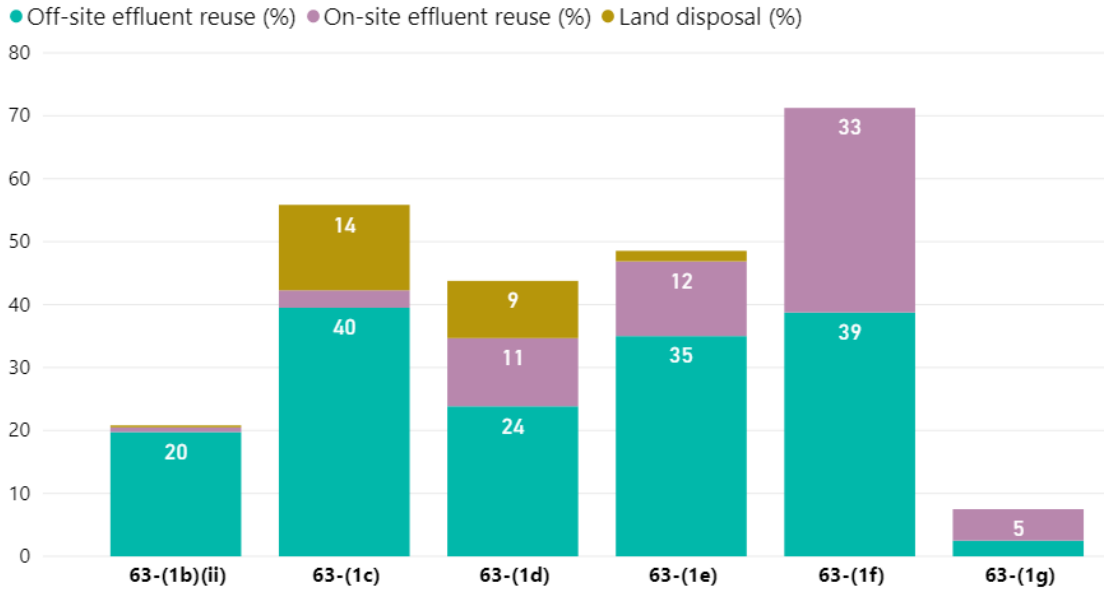



**Figure 7-7. Effluent reuse performed by council STPs within the Reef catchment. Values show average percentage of effluent for facilities within each activity classification.**

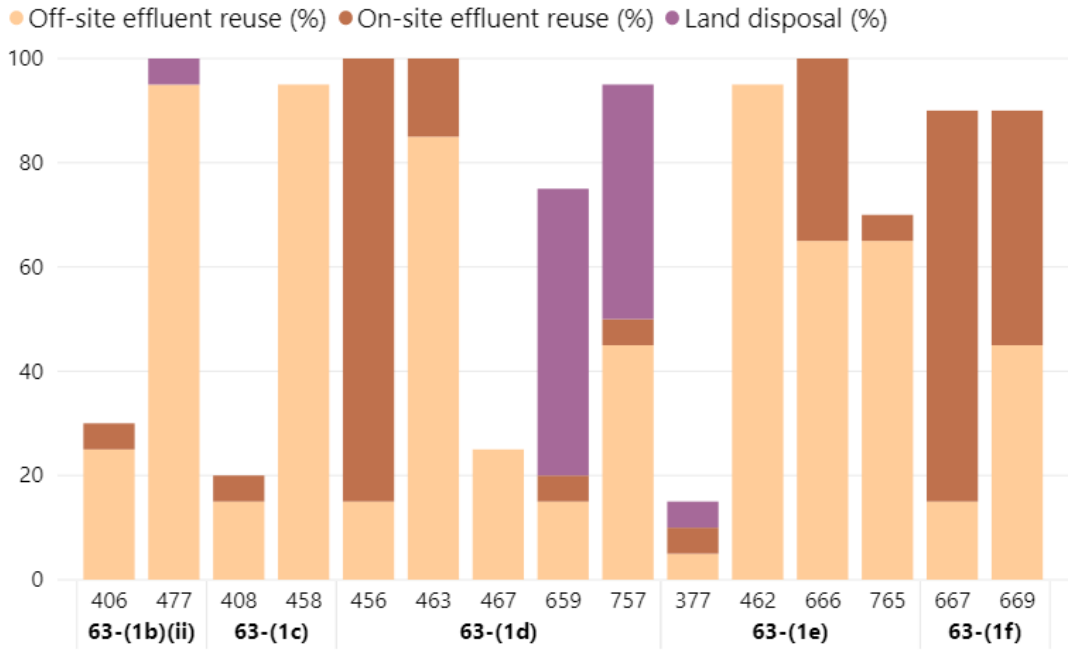



**Figure 7-8. Effluent reuse (including land disposal) for council STPs within the Reef catchment. Values are percentages of effluent reuse (off-site or on-site) or land disposal for a facility within each activity classification. Numbers on x-axis are facility ID.**

Off-site reuse of bio-solids is the most common practice performed by council STPs within the Reef catchment for managing bio-solids. Off-site applications include composting/fertilizer, agriculture, mine

rehabilitation, commercial landscaping, and forestry. On-site purposes include gardening, composting/fertilizer, or on-site land rehabilitation. On-site reuse is generally lower than off-site reuse, particularly for larger STP facilities. Figure 7-9 shows the distribution of overall bio-solids reuse for each activity classification. This shows that council STPs of sizes greater than 4,000 EP (category (1d) or higher) predominantly have 100% bio-solid reuse. For council STPs less than 4,000 EP (categories (1b) and (1c)), 100% bio-solid disposal to landfill is much more common.

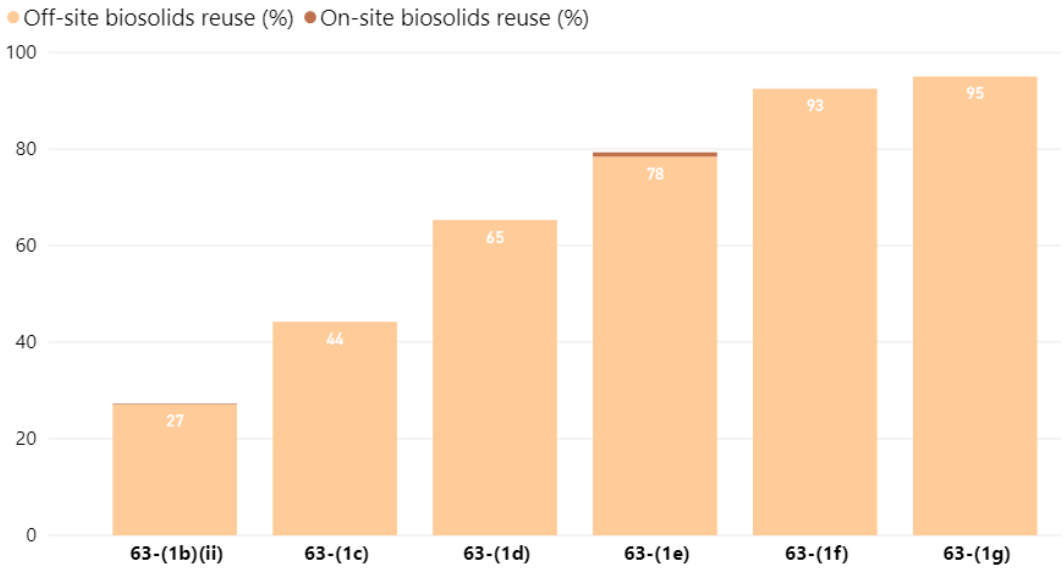



**Figure 7-9. Overall bio-solids reuse for council STPs within the Reef catchment. Bar and values shows averages percentage for facilities within each activity classification.**

Information on average energy usage for each council STP was obtained and standardised based on current size (EP) for each facility. It should be noted that these costs are not just for nutrient treatment but would also cover energy used across the entire facility such as pumping, physical treatment, dissinfection, office space etc. The average energy usage for each activity classification is shown in Figure 7-10. The median annual energy usage was 116 kWhrs per EP. Other than the larger (1g) category, average energy costs per EP increased with smaller activity classifications. High energy usage will increase overall costs and, if sourced from fossil fuels, will increase carbon emmisions and, through this, result in potential harm to the Great Barrier Reef.

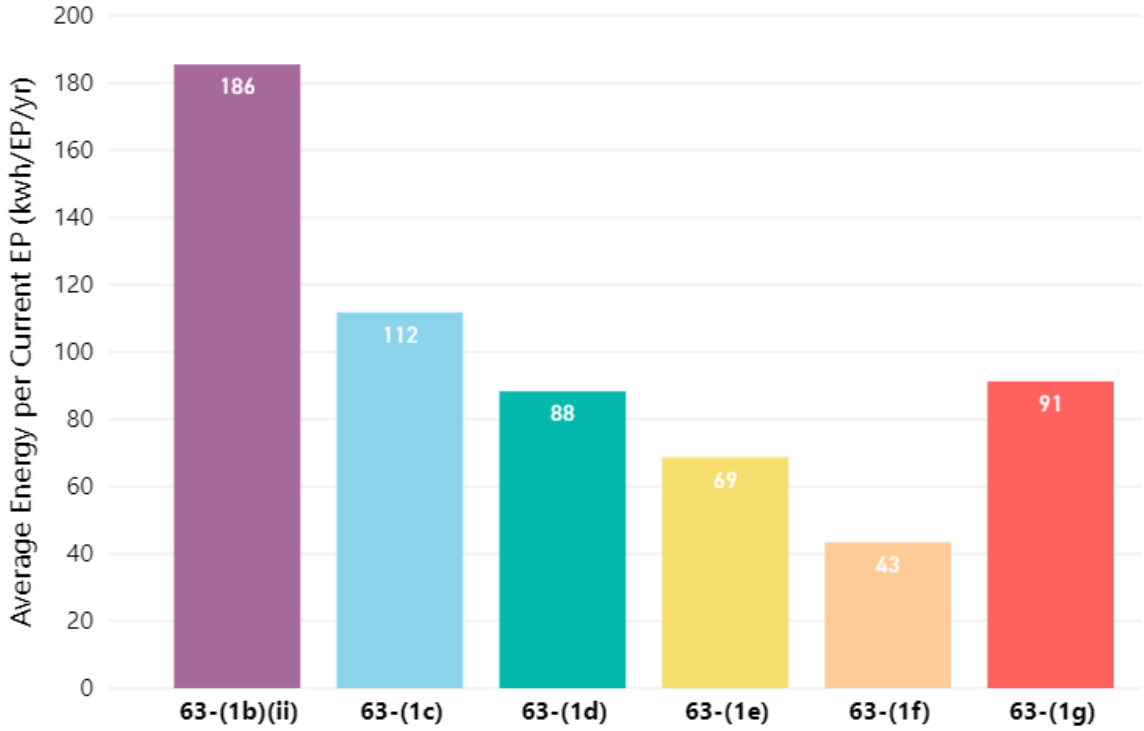



**Figure 7-10. Average electrical energy usage for council STPs within the Reef catchment for each activity classification.**

The relative Operating Cost and relative Capital Cost for each council STP was gathered as part of the facility questionnaire. Limited guidance was provided as to how this was calculated, other than it should be based on present day costs, and in terms of capital, based on replacement costs. Operating costs was to include all operating costs for the facility, including dissinfection. Operating costs were standardised based on current EP levels. Two facilities with data that appeared to be outliers were removed. The results are plotted for each activity classification in Figure 7-11. Overall, the operating costs increased with the smaller facility size classificaiton, as did the average energy cost. The average operating cost ranged from approximately $50 per EP per year for larger faciltiies (i.e. categrories (1f) and (1g)) to around $500 per EP per year for the smallest facilities (1b(ii)). Capital costs were also standardised but using design EP levels. These are shown in Figure 7-12 for different activity classifications. There was a substantial difference between very small (1b(ii)) and very large (1g) STPs, however, the capital cost for STPs in the catagories (1d) to (1f) in the order of $700 to $900 per EP. Category (1c) STPs had an average capital cost of around $1,900 per EP.

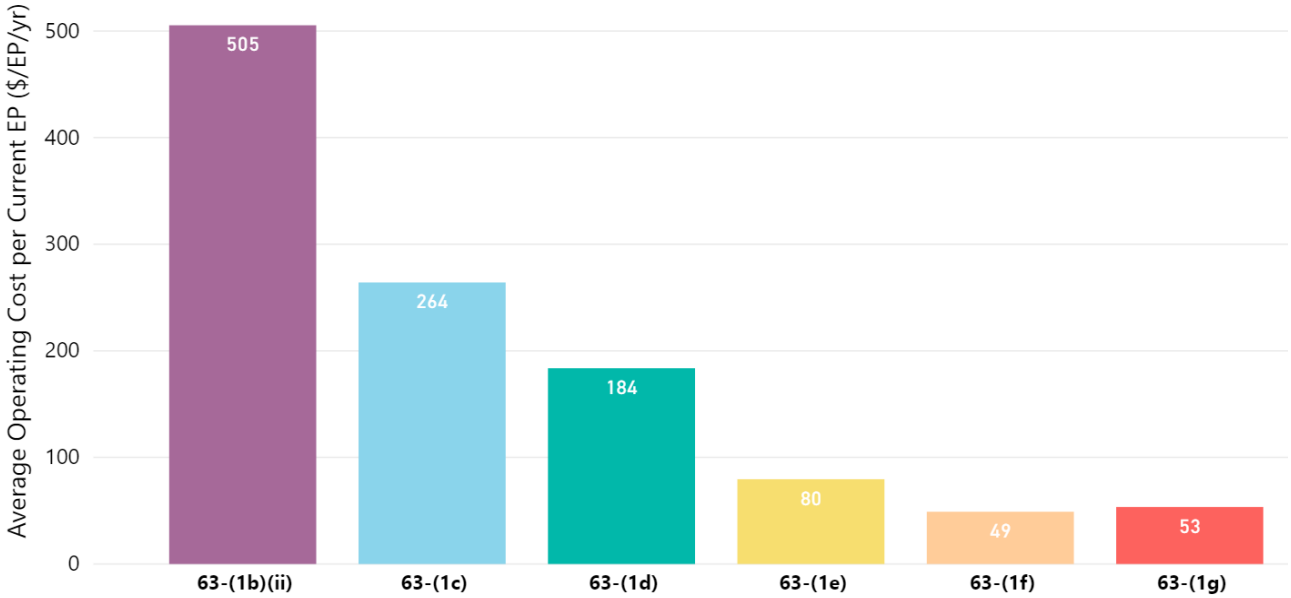



**Figure 7-11. Relative Operation Cost (OPEX) per current EP per year for council STPs within the Reef catchment for each activity classification.**

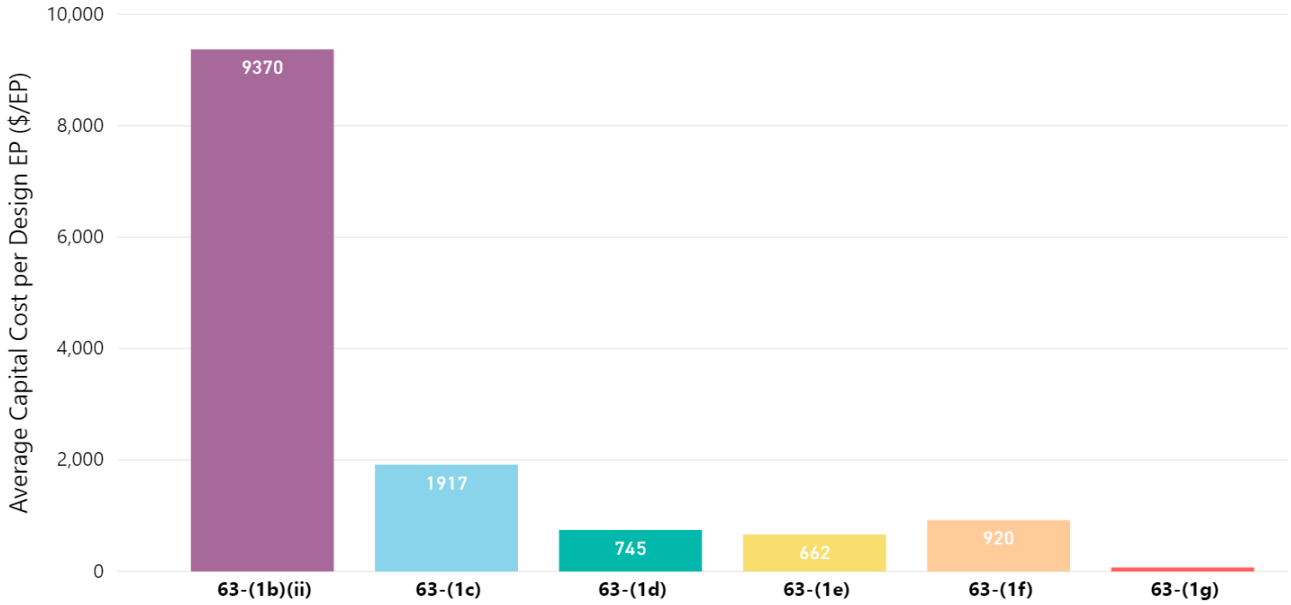



**Figure 7-12. Relative capital cost (CAPEX) per design EP for council STPs within the Reef catchment for each activity classification.**

In addition to release monitoring, STP operators may undertake monitoring of receiving waters. This monitoring is often referred in the approval as Receiving Environment Monitoring Programs (REMPs). The results of the questionnaires in regard to REMPs is shown in Figure 7-13 across Reef catchment regions and STP activity classifications. Of the 66 council STPs that were used in Section 6 to estimate nutrient loads, a total of 48 REMPs are undertaken across the Reef catchment and the largest number of REMPs occur in the Wet Tropics and Burnett-Mary regions. The highest number of REMPs relate to STPs in the (1c), (1d) and (1e) activity classifications but these also represent the activity classifications that have the most STPs that release to water (as shown in Table 4-6). In reality, the majority of STPs that have a continuous release to water also undertake a REMP or similar monitoring program, except for activity classification (1b(ii)). The

survey indicated that a total of 35 REMPs were undertaken as part of a broader regional monitoring programs, which is undertaken in collaboration with other parties such a regional bodies or state or local government.

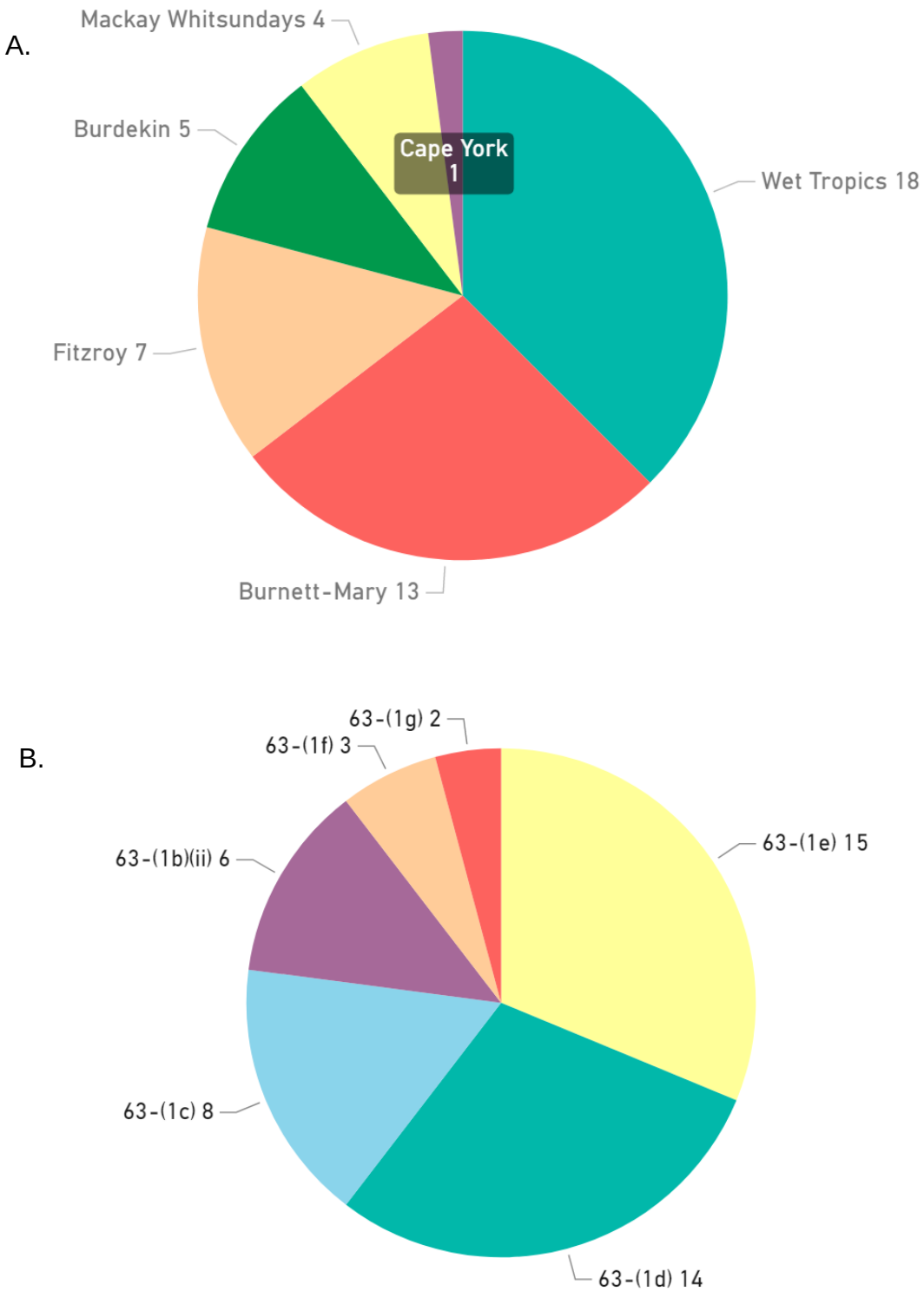



**Figure 7-13. The proportion and number of REMPs undertaken for council STPs within A) Region and B) Activity classification.**

# 8. Key recommendations and further work

From the work done in this project, it is recommended that all facilities that involve nutrient activities should monitor nutrients and daily volumes of release water, and intake water if applicable. As a minimum, nutrient monitoring should include TN and TP concentrations on a weekly basis (current industry standard) and for continuous releases should ideally involve routine monitoring of dissolved nutrients such as ammonia and nitrate/nitrite (oxidised nitrogen) and filterable reactive phosphorus.

To assist with obtaining monitoring data and reporting on this data, it is recommended that all facilities involving release to water in the Reef catchment provide their monitoring data to the Department in a digital format and on a regular basis (minimum annually). Some approval conditions may require changes to support this recommendation. Ideally WaTERS should be used as the portal to submit such monitoring data to the Department.

Given approval information is continually changing, ongoing maintenance and updating of the current nutrient metadata database and spatial layer is required. This could also include sourcing missing information identified in this stage of the project, in particular the spatial location of release and monitoring points and the indicators monitored. Ideally, further work should be undertaken to ensure approval conditions are digitally available and clearly identify facilities, location information and release conditions.

It is also recommended that a communication portal be developed to convey information to industry, other government and the public on point source activities in the Reef catchment. The portal could capture information and products from this project and provide the latest up-to-date monitoring data and information.

Monitoring of the local receiving environment appears to be the standard for point source activities of all sizes that are authorised to release to water, particularly for continuous releases to coastal waters. However, receiving environment monitoring is not undertaken in all cases. Further work is required to develop guidance to ensure that receiving water monitoring can be done efficiently and cost-effectively, while still allowing for potential environmental impacts to be identified. For STPs, the monitoring programs are also linked to a range of partnership monitoring that is done collaboratively with other parties such as state government or regional organisations. To assist with a review of these monitoring programs and providing better linkages with waterway reporting and assessment, we recommend that this receiving environment monitoring data is collated and reviewed. Ideally, this monitoring data should be regularly submitted to WaTERS.

Although the nutrient removal of many STPs in each activity classification was good, some higher release concentrations were observed. For example, some facilities in ERA category 63-(1e) and 63-(1c) had higher release nutrient concentrations and could be investigated further to determine the potential for improved nutrient removal and nutrient load reduction at these facilities. Additional information on release nutrient concentrations is also required for some STPs.

Substantial information was collected in this project on STP environmental management, including chemical usage for TP removal but further work is required to analyse these data and benchmark practices and standards. For those privately owned STPs that were identified to involve a release to water, future work could be undertaken to collect relevant information and data about these releases.

Although preliminary information was obtained on aquaculture facilities, significantly more information is needed, particularly given the complexity and nature of these activities and releases. This information would need to be obtained in close collaboration with the industry and relevant industry associations. Also, WaTERS should be implemented to the aquaculture industry to assist with data management and analysis for both release and intake water. Further work is also required, similar to that undertaken for STPs, to

understand the specific processes involved in the industry for both prawn and barramundi farming, and to benchmark leading practice environmental management for the industry.

Further investigation into phosphorus released to water from meat processing plants should also be considered. Other areas of further work include nutrient activities identified as having a release (disposal) to land in the Reef catchment. In coastal areas, these could be a potential contributor to nutrient loads, particularly where they are not managed well or occur on sandy soils.

# Appendix A - Products

## Power BI Metadata Tool

The Power BI Metadata Tool can be used to determine the number of facilities with nutrient activities and the number of nutrient activities in the Reef catchment. The most frequent nutrient activities were sewage treatment, followed by waste disposal and then mining/mineral process. The number of those nutrient activities that are authorised to release to water and land, as well as those with a requirement to undertake receiving environment monitoring as part of REMP or Site Base Management Programs (SBM) can be determined.

Using the Power BI Metadata Tool, it is also possible to interrogate the spatial locations of facilities or activities in the Reef catchment and the number of activities in each sub-catchment.

For any facility or activity, it is then possible to interrogate the limits for the authorised releases to water. This information can help assess the consistency of standards that are applied for different industries and in different Reef catchment regions or sub-catchments. The majority of these releases were for sewage treatment, aquaculture and meat processing facilities.

## Spatial layer

One of the main challenges in reviewing the approvals was that information describing the exact location of the facility was typically limited. Site information provided in approval is often given as a reference to lot and plan and not the physical address, or geographical coordinates (latitude and longitude) of the facility.

In Stage 1 a polygon and point spatial layer for each facility with a nutrient activity was determined by using publicly available spatial layers and the process outlined in Appendix B. The polygon represented the boundary of the lot and plan or the lease for each facility. The facility location was determined as the centroid of the polygon. This meant that the spatial information may not accurately represent the location of the facility within the spatial boundary of the polygon.

In Stage 2 the spatial location of the facility was refined and the actual release point and the receiving environment monitoring points were included at a finer spatial resolution, where available. Therefore, the location of the release is now able to be more accurately attributed to a region and sub catchment.

A number of abbreviations were used in the online ArcGIS map to describe the metadata, including:

| Abbreviation | Description |
|---|---|
| **ID** | Facility unique identification number |
| **Name** | Facility name |
| **Activity_I** | Nutrient activity identification code |
| **EA_No_** | Environmental Authority (Approval) number |
| **Date** | Date from which the approval came into effect |
| **Link** | Hyperlink to the online Environmental Authority |
| **Client** | EA holder |
| **Operator_N** | Operator (client) number |
| **Owner** | Whether the facility is private, council or government owned |
| **Operationa** | Whether the facility is operational |
| **WaTERS_Cod** | WaTERS unique code |

| Abbreviation | Description |
|---|---|
| **Address** | Facility street address |
| **Catchment** | Natural resource management regions |
| **Sub_catchm** | Sub-catchments based on the Scientific Consensus Statement management units |
| **Latitude** | Latitude |
| **Longitude** | Longitude |
| **Location** | Lot and Plan, Mining lease and Petroleum lease (See Appendix A for full list) |
| **Activity** | Environmental Relevant Activity (ERA) |
| **RtW** | Release to water authorised |
| **RtW_Monito** | Release to Water Monitoring Specified in EA |
| **RE_Monitor** | Receiving Environment Monitoring Specified in EA |
| **REMP_Condi** | REMP/IMP Condition in the EA |
| **RtL** | Release to Land Authorised |
| **RtL_Monito** | Release to Land Monitoring Specified in EA |
| **MP** | Monitoring Point Code |
| **MP_Descrip** | Monitoring Point description |
| **MP_Type** | Type of monitoring point (release point (RP), reference monitoring point (ref), downstream receiving environment monitoring point (ds), upstream receiving environment monitoring point (us), other monitoring points (MP)) |
| **Stream** | Waterway that is monitored |
| **Indicators** | List of indicators that are monitored |
| **Monitor_Fr** | Frequency at which site is monitored |

# Appendix B – GIS method

Steps that were used by the project team to create the January 2017 Reef catchment approval list and Stage 1 project spatial layers.

1. Created a Reef catchment GIS layer based on Drainage Basins GIS layer and the Scientific Consensus Statement management units figure. GBR catchments.shp

2. Using GIS software intersected the following GIS layers with the Reef catchment GIS layer to create new GIS layers containing only polygons that occurred in the Reef catchment.

1. Property boundaries Queensland (Lot and Plan) – GBR Lot Plan.shp

1. Exploration permit coal (EPC) - GBR EPC.shp
2. Exploration permit petroleum (ATP) – GBR ATP.shp
3. Exploration permit mineral (EPM) - GBR EPM.shp
4. Mineral development licence (MDL) - GBR MDL.shp
5. Mining claim (MC) - GBR MC.shp
6. Mining leases (ML) - GBR ML.shp
7. Petroleum facility licence (PFL) - GBR PFL.shp
8. Petroleum lease (PL) - GBR PL.shp
9. Petroleum pipeline licence (PPL) - GBR PPL.shp
10. Petroleum survey licence (PSL) - GBR PSL.shp

1. Dead mineral development licence - GBR_dead_MDL.shp
2. Dead mining claim – GBR_dead_MC.shp
3. Dead mining lease - GBR_dead_ML.shp
4. Historic exploration permits for coal - GBR_historic_EPC.shp
5. Historic exploration permits for mineral - GBR_historic_EPM.shp
6. Historic mining leases - GBR_historic_ML.shp
7. Historic petroleum leases - GBR_historic_PL.shp

3. Created a combined polygon layer of current and historic mining and petroleum licence areas in the Reef catchment.

4. Created a point file using the centroids of the polygons. (Vector/Geometry Tools/Polygon centroids)

1. GBR Lot Plan centroids.shp
2. GBR licence areas centroids.shp
3. GBR historic licence areas centroids.shp
4. GBR historic EPC centroid.shp

5. GBR historic EPM centroid.shp

5. Created two new column (latitude and longitude) in the point GIS layers. (In attributes table use the field calculator. Geometry - $x and $y).

6. Created excel files from the .dbf GIS files.

6. GBR Lot Plan centroids.xlsx

7. GBR licence areas centroids. xlsx

8. GBR historic licence areas centroids. xlsx

9. GBR historic EPC centroid. xlsx

10. GBR historic EPM centroid. xlsx

7. In Power BI unpivot the location and activity columns of the Environmental Approval Public Register file.

8. In Power BI using the Environmental Approval Register file and the centroid files link the location columns.

## Spatial layers used

The publicly available spatial layers used to create the project spatial layers are listed below.

**Drainage basins Queensland**

http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Drainage basins Queensland%22
Publish date – 20 Jan 2009

**Property boundaries Queensland (Lot and Plan)**

http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Property boundaries Queensland%22
Download date – 28 Aug 2017

**Mining leases (DP_QLD_MINES_TEN_EXP_ML)**

11. Exploration permit coal (EPC)
12. Exploration permit petroleum (ATP)
13. Exploration permit mineral (EPM)
14. Mineral development licence (MDL)
15. Mining claim (MC)
16. Mining leases (ML)
17. Petroleum facility licence (PFL)
18. Petroleum lease (PL)
19. Petroleum pipeline licence (PPL)

20. Petroleum survey licence (PSL)

http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Mining lease surface areas - Queensland%22
Publish date – 17 Aug 2017, Download date – 31 Aug 2017

**Historic mining leases (DP_QLD_MINES_TEN_HISEXP)**

21. Dead mineral development licence
22. Dead mining claim
23. Dead mining lease
24. Historic exploration permits for coal
25. Historic exploration permits for geothermal
26. Historic exploration permits for mineral
27. Historic exploration permits for petroleum
28. Historic mining leases
29. Historic petroleum leases
30. Historic petroleum pipeline leases

http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=%22Historic exploration and production permits - Queensland%22
Download date – 15 Sept 2017

# Appendix C – Monitoring data sources

## Wastewater Tracking and Electronic Reporting System Data

Approval holders provide water monitoring data to the Department as part of their annual return, often as pdf reports, as part of requests from the Department, or by submitting monitoring data electronically to the Wastewater Tracking and Electronic Reporting System (WaTERS). Monitoring data submitted to the Department as part of a pdf or other hard copy report is difficult to use because raw data may not be presented specifically or easily extracted or the data often only covers a small distinct time period. Monitoring data submitted to WaTERS is in a raw electronic format that is stored in a database and can easily be extracted and used for data analysis and reporting.

Data is submitted by approval holders to WaTERS either quarterly or annually depending on whether releases are continuous or periodic (i.e. event-based). Approval holders upload raw monitoring data and WaTERS provides an automated check of the ranges of data. Other anomalies or missing data are checked by the WaTERS administrators. The data includes any monitoring results of the quality or quantity of the releases or associated receiving environment.

WaTERS is progressively being implemented to activities across Queensland following departmental priorities. WaTERS receives monitoring data from medium to large STPs across Queensland, major industries in South East Queensland and the Gladstone area, coal mines, coal seam gas activities, and some mineral mines, abattoirs and power plants. Most large STPs have been submitting monitoring data to WaTERS since 2006, and as far back as 2000 in some cases.

## Additional monitoring data collection

The facilities identified in this project as nutrient activities with releases to water, which were not currently submitting to WaTERS, were prioritised for a potential monitoring data request. The priority was based on the approval limit details, such as whether they include nutrients load, maximum TN concentration or peak flow limits. Facilities decommissioned, not commissioned or not operational were excluded. For STPs, the selection included facilities with nutrients monitoring requirements. A total of 81 facilities were identified, including 46 STPs, 33 aquaculture facilities and two meat processing facilities. Table C-1 lists the facilities that were targeted for the monitoring data request and includes for each the Facility ID, Activity ID, Reef catchment and operational status.

In April 2019, correspondence was sent to each of the approval holders requesting monitoring data on water quality and quantity collected under their approval between 2013 and 2018. Contact details stored in the Department's licensing system were used for the correspondence. Once monitoring data was received, a general quality check of the data received was undertaken (for example, of units, limit of reporting, missing data) and the data was then uploaded into WaTERS.

**Table C-1. Facilities from which monitoring data was requested for this project**

| Activity | Facility ID | Activity Classification | Region | Operational Status |
|---|---|---|---|---|
| Aquaculture | 208 | 1.1(a) | Wet Tropics | Yes |
| Aquaculture | 224 | 1.1(a) | Wet Tropics | No |
| Aquaculture | 225 | 1.1(a) | Wet Tropics | Yes |
| Aquaculture | 234 | 1.1(a) | Wet Tropics | Yes |

| Activity | Facility ID | Activity Classification | Region | Operational Status |
|---|---|---|---|---|
| Aquaculture | 236 | 1.1(a) | Wet Tropics | Yes |
| Aquaculture | 270 | 1.1(a) | Wet Tropics | Unknown |
| Aquaculture | 278 | 1.1(a) | Burnett-Mary | No |
| Aquaculture | 282 | 1.1(a) | Wet Tropics | No |
| Aquaculture | 307 | 1.1(a) | Mackay Whitsundays | No |
| Aquaculture | 520 | 1.1(a) | Wet Tropics | No (Suspended) |
| Aquaculture | 552 | 1.1(a) | Wet Tropics | No |
| Aquaculture | 498 | 1.1(a), 1.2(a) | Burdekin | No |
| Aquaculture | 521 | 1.1(a), 1.2(a) | Wet Tropics | Yes |
| Aquaculture | 163 | 1.1(b) | Burnett-Mary | Yes |
| Aquaculture | 194 | 1.1(b) | Mackay Whitsundays | Unknown |
| Aquaculture | 235 | 1.1(b) | Wet Tropics | Yes |
| Aquaculture | 246 | 1.1(b) | Burnett-Mary | Unknown |
| Aquaculture | 247 | 1.1(b) | Mackay Whitsundays | Yes |
| Aquaculture | 259 | 1.1(b) | Wet Tropics | Yes |
| Aquaculture | 262 | 1.1(b) | Wet Tropics | No |
| Aquaculture | 285 | 1.1(b) | Mackay Whitsundays | Yes |
| Aquaculture | 308 | 1.1(b) | Mackay Whitsundays | No |
| Aquaculture | 309 | 1.1(b) | Wet Tropics | Unknown |
| Aquaculture | 206 | 1.1(c) | Wet Tropics | Yes |
| Aquaculture | 237 | 1.2(b) | Wet Tropics | Yes |
| Aquaculture | 254 | 1.2(b) | Wet Tropics | Unknown |
| Aquaculture | 180 | 1.2(c) | Wet Tropics | No |
| Aquaculture/Seafood | 209 | 1.1(b), 1.2(b), 27 | Wet Tropics | Yes |
| Aquaculture/Seafood | 275 | 1.1(b), 1.2(b), 27 | Burdekin | Yes |
| Aquaculture/Seafood | 656 | 1.1(b), 1.2(b), 27 | Burdekin | Yes |
| Aquaculture/Seafood | 695 | 1.1(b), 27 | Wet Tropics | Yes |
| Aquaculture/Seafood | 2001 | 1.1(b), 27 | Burdekin | No (Suspended) |
| Meat processing | 276 | 25.2(c) | Fitzroy | Yes |
| Meat processing | 311 | 25.2(c) | Mackay Whitsundays | Yes |
| Seafood | 380 | 27 | Burnett-Mary | No |
| Sewage Treatment | 386 | 63-(1a)(i) | Wet Tropics | Yes |
| Sewage Treatment | 283 | 63-(1b)(i) | Wet Tropics | Yes |
| Sewage Treatment | 515 | 63-(1b)(i) | Fitzroy | Yes |
| Sewage Treatment | 167 | 63-(1b)(ii) | Cape York | Yes |
| Sewage Treatment | 398 | 63-(1b)(ii) | Fitzroy | Yes |
| Sewage Treatment | 403 | 63-(1b)(ii) | Burnett-Mary | Yes |
| Sewage Treatment | 406 | 63-(1b)(ii) | Burnett-Mary | Yes |
| Sewage Treatment | 446 | 63-(1b)(ii) | Cape York | Yes |
| Sewage Treatment | 534 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 535 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 536 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 537 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 538 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 539 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 540 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 541 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 542 | 63-(1b)(ii) | Island | Yes |

| Activity | Facility ID | Activity Classification | Region | Operational Status |
|---|---|---|---|---|
| Sewage Treatment | 577 | 63-(1b)(ii) | Mackay Whitsundays | Yes |
| Sewage Treatment | 578 | 63-(1b)(ii) | Fitzroy | Yes |
| Sewage Treatment | 606 | 63-(1b)(ii) | Burnett-Mary | Yes |
| Sewage Treatment | 658 | 63-(1b)(ii) | Burnett-Mary | Yes |
| Sewage Treatment | 675 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 2053 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 2054 | 63-(1b)(ii) | Island | Yes |
| Sewage Treatment | 168 | 63-(1c) | Island | Yes |
| Sewage Treatment | 390 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 407 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 408 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 409 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 457 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 458 | 63-(1c) | Burnett-Mary | Yes |
| Sewage Treatment | 495 | 63-(1c) | Island | Yes |
| Sewage Treatment | 661 | 63-(1c) | Fitzroy | Yes |
| Sewage Treatment | 726 | 63-(1c) | Island | Yes |
| Sewage Treatment | 170 | 63-(1d) | Island | Yes |
| Sewage Treatment | 189 | 63-(1d) | Burdekin | Yes |
| Sewage Treatment | 456 | 63-(1d) | Burnett-Mary | Yes |
| Sewage Treatment | 463 | 63-(1d) | Burnett-Mary | Yes |
| Sewage Treatment | 564 | 63-(1d) | Cape York | Yes |
| Sewage Treatment | 763 | 63-(1d) | Fitzroy | Yes |
| Sewage Treatment | 543 | 63-(1e) | Island | Yes |
| Sewage Treatment | 605 | 63-(1e) | Burnett-Mary | Yes |
| Sewage Treatment | 607 | 63-(1e) | Burnett-Mary | Yes |
| Sewage Treatment | 609 | 63-(1e) | Burnett-Mary | Yes |
| Sewage Treatment | 880 | 63-(1e) | Burnett-Mary | Yes |
| Sewage Treatment, Bulk mineral Handling | 310 | 63-(1b)(ii), 50.2 | Mackay Whitsundays | Yes |

## Responses

Overall, monitoring data was received from 85% of the facilities that were contacted. Table C-2 summarises the number of monitoring data sets received by activity.

Despite an active approval, a third of the aquaculture facilities were not currently operational. For many of these, this had been the case for several years. Contact details were not always up-to-date in the licensing system and it was not possible to source the details during the project. Consequently, the operational status of five aquaculture facilities remains unknown. For STPs and meat processing facilities, contact details were mostly up-to-date or readily available. All STPs targeted were currently operational, although four facilities did not provide monitoring data for this project.

Across all industries, there were some incomplete monitoring data sets because of change of staff, lost records, or monitoring was not being undertaken as required in the approval. Data quality was also an issue due to unit errors or data not being checked by approval holders prior to providing the data. The most recent monitoring data provided, such as for 2017 and 2018, were the most complete, and as a result, were the major focus of this review.

**Table C-2. Number of datasets received from approval holders per activity**

| Activity | Number of Data Requests | Number of Unanswered Requests | Number of Non-Operational Facilities | Number of Data Sets from Operational Facilities |
|---|---|---|---|---|
| Aquaculture | 33 | 5 | 11 | 14 (64%) |
| Sewage Treatment Plants | 46 | 4 | 0 | 42 (91%) |
| Meat processing | 2 | 0 | 0 | 1* (100%) |
| **Total** | **81** | **9** | **11** | **51 (63%)** |

**The second site is operational but does not release to water*.

# Appendix D – Nutrient load calculations

## Estimate of nutrient loads from approvals

Approvals vary significantly in regard to the range and type of conditions that may be placed on the activity. These also often vary significantly between activities. As a result, a range of methods were used to estimate the “authorised” nutrient release loads permitted from point source activities in the Reef catchment based on the availability of different types of approval limits. The following equations describe the methods used, in preferred order. The equations were used to estimate the annual nutrient load in kilograms per year using “average” authorised conditions. This required the use of rules of thumb often adopted to derive maximum approval concentration and peak flow limits within approvals. The estimates of authorised annual nutrient release load of either TN or TP is possible for any approval that has a limit for nutrient load or a combination of nutrient concentration and flow limit for a release. In general, this applies to activities that are authorised to release continuously. For releases that occur only during events, in most cases it was not possible to estimate authorised annual nutrient release load. The authorised annual nutrient release load will in most cases be an overestimate of the actual load assuming that activity is operating in compliance with the approval. Therefore, load estimates based on monitored release data is preferred in all cases where monitoring data is available.

1. Annual Nutrient Load Limit (kg/year)

   This method is based on the actual annual load limit for TN or TP that is specified in the approval. The annual load limit is typically compared to the annual median of the nutrient concentration (mg/L) multiplied by the average of the daily dry weather flow (ML/day) times 365 days per year.

2. Average Nutrient Concentration and Average Daily Flow

   This method uses average, median or 80$^{th}$ percentile limits for TN or TP, typically applied over 12 months. For flow, the average or daily dry weather flow is adopted. The equation for the annual load is as follows:

   Nutrient Load (kg/year) = Average Nutrient Concentration (mg/L) x Average Daily Flow (ML/day) x 365

3. Average Nutrient Concentrations and Peak/Wet Weather Daily Flow

   This method uses average, median or 80$^{th}$ percentile limits for TN or TP, typically applies over 12 months. For flow, the peak or wet weather daily flow is adopted. The equation for the annual load is as follows:

   Nutrient Load (kg/year) = Average Nutrient Concentration (mg/L) x Peak Daily Flow (ML/day) / 3 x 365

4. Maximum Nutrient Concentration and Average Daily Flow

   This method uses short term or maximum concentration limits for TN or TP. For flow, the average or daily dry weather flow is adopted. The equation for the annual load is as follows:

   Nutrient Load (kg/year) = Maximum Nutrient Concentration (mg/L) /3 x Average Daily Flow (ML/day) x 365

5. Maximum Nutrient Concentration and Peak/Wet Weather Daily Flow

   This method uses short term or maximum concentration limits for TN or TP. For flow, the peak or wet weather daily flow is adopted. The equation for the annual load is as follows:

   Nutrient Load (kg/year) = Maximum Concentration (mg/L) /3 x Peak Daily Flow (ML/day) /3 x 365

6. Max Ammonia Concentration and Average Daily Flow

   In some cases, no TN limits are used but limits are applied to ammonia concentrations. This method uses short term or maximum concentration limits for ammonia. For flow, the average or daily dry weather flow is adopted. The equation for the annual load is as follows:

   Nutrient Load (kg/year) = Maximum $NH_3$ Concentration (mg/L) /3 x Average Daily Flow (ML/day) x 365

7. Max Ammonia Concentration and Peak Daily Flow

In some cases, no TN limits are used but limits are applied to ammonia concentrations. This method uses short term or maximum concentration limits for ammonia. For flow, the peak or wet weather daily flow is adopted. The equation for the annual load is as follows:

Nutrient Load (kg/year) = Maximum $NH_3$ Concentration (mg/L) /3 x Peak Daily Flow (ML/day) /3 x 365

# Nutrient load calculations from release monitoring data

## Sewage Treatment Plants

Nutrient loads were determined for STPs using monitoring data of releases undertaken by councils (and one water utility). The monitoring data typically included daily volume and weekly nutrient concentration measurements. Nutrient loads were determined for each year by summing the daily load calculated from a daily volume measurement multiplied by the most recent nutrient concentration measurement for each day of the calendar year.

The following tables (Table D-1 and Table D-2) provide the TN and TP loads for each council STP. Nutrient loads determined from monitoring data are marked as “M” and was the case for the majority of facilities. A small number of facilities had a gap in either flow or concentration data for a year and in this case, nutrient loads were estimated using measurements taken from other years. These are marked as “E” in the following tables. A small number of facilities had no monitoring data and in these cases the nutrient loads were estimated using approval information and the STP capacity recorded in the survey for 2018. For example, an STP at 50% capacity was allocated 50% of the approval nutrient load. These are marked as “A” in the following table. For ultimate capacity, the 2018 nutrient loads were divided by the STP capacity used, in other words estimating the nutrient load with 100% capacity assuming all wastewater is released to water.

**Table D-1. Total nitrogen (TN) release loads for council STPs in Reef catchment**

| Facility ID | Catchment | TN load 2017 (kg/yr) | | TN load 2018 (kg/yr) | | TN Ultimate (kg/yr) |
|---|---|---|---|---|---|---|
| 685 | Burdekin | 32069 | M | 49559 | M | 71825 |
| 399 | Fitzroy | 56860 | M | 44724 | M | 53885 |
| 689 | Burdekin | 14626 | M | 22692 | M | 34382 |
| 667.1 | Wet Tropics | 26400 | M | 26341 | M | 32926 |
| 400 | Fitzroy | 19936 | M | 21272 | M | 32725 |
| 669.1 | Wet Tropics | 15308 | M | 16564 | M | 21794 |
| 607 | Burnett-Mary | 2291 | M | 9023 | M | 12708 |
| 177 | Burdekin | 7106 | M | 11317 | M | 12077 |
| 437 | Mackay Whitsunday | 6270 | M | 7379 | M | 10851 |
| 438 | Mackay Whitsunday | 22385 | M | 6925 | M | 10183 |
| 377 | Burnett-Mary | 3110 | M | 3615 | M | 9270 |
| 178 | Burdekin | 5482 | M | 7092 | M | 9053 |
| 763 | Fitzroy | 5880 | A | 5880 | A | 8400 |
| 666 | Wet Tropics | 4785 | M | 6548 | M | 8395 |
| 609 | Burnett-Mary | 7300 | A | 7300 | A | 7300 |
| 738 | Wet Tropics | 4487 | M | 3736 | M | 7049 |
| 664 | Wet Tropics | 3741 | M | 4283 | M | 5948 |
| 746 | Burnett-Mary | 3486 | E | 3486 | M | 5908 |
| 709 | Fitzroy | 3422 | M | 3708 | E | 5374 |
| 321 | Mackay Whitsunday | 2333 | M | 2805 | M | 5194 |
| 711 | Fitzroy | 7025 | M | 4867 | M | 4867 |
| 761 | Wet Tropics | 1124 | M | 3801 | M | 4751 |
| 323 | Mackay Whitsunday | 2004 | M | 2291 | M | 4242 |
| 757 | Wet Tropics | 2487 | M | 2437 | M | 4202 |
| 665 | Wet Tropics | 2103 | M | 2421 | M | 3905 |
| 250 | Burdekin | 3577 | M | 2855 | M | 3569 |
| 605 | Burnett-Mary | 393 | M | 1897 | E | 3514 |
| 456 | Burnett-Mary | 1543 | M | 2728 | M | 3100 |
| 663 | Wet Tropics | 2360 | M | 1689 | M | 2639 |
| 880 | Burnett-Mary | 1212 | M | 2539 | M | 2539 |
| 467 | Wet Tropics | 3388 | M | 2146 | M | 2525 |
| 462 | Burnett-Mary | 3049 | M | 2169 | M | 2494 |
| 379 | Burnett-Mary | 280 | E | 280 | M | 2154 |
| 657 | Burnett-Mary | 301 | M | 742 | M | 2121 |
| 541 | Island | 654 | A | 654 | A | 2044 |
| 543 | Island | 123 | A | 864 | M | 1963 |
| 535 | Island | 734 | A | 1243 | M | 1855 |
| 458 | Burnett-Mary | 1318 | M | 1352 | M | 1733 |
| 443 | Mackay Whitsunday | 784 | M | 591 | M | 1689 |
| 537 | Island | 361 | A | 361 | A | 1387 |
| 743 | Wet Tropics | 1762 | M | 865 | M | 1374 |
| 755 | Wet Tropics | 863 | M | 1272 | M | 1368 |
| 539 | Island | 618 | A | 618 | A | 1314 |
| 495 | Island | 1034 | A | 1034 | A | 1217 |
| 536 | Island | 434 | A | 434 | A | 1205 |
| 540 | Island | 537 | A | 537 | A | 1095 |
| 463 | Burnett-Mary | 428 | M | 453 | M | 1079 |
| 606 | Burnett-Mary | 3 | M | 743 | E | 885 |
| 439 | Mackay Whitsunday | 176 | M | 870 | M | 870 |
| 457 | Burnett-Mary | 477 | M | 790 | M | 790 |
| 659 | Burnett-Mary | 354 | A | 354 | A | 786 |
| 758 | Wet Tropics | 122 | M | 301 | M | 753 |
| 478 | Wet Tropics | 304 | A | 304 | A | 608 |
| 692 | Burdekin | 13 | M | 234 | M | 586 |

| Facility ID | Catchment | TN load 2017 (kg/yr) | | TN load 2018 (kg/yr) | | TN Ultimate (kg/yr) |
|---|---|---|---|---|---|---|
| 710 | Fitzroy | 374 | A | 374 | A | 543 |
| 538 | Island | 233 | A | 233 | A | 465 |
| 474 | Wet Tropics | 2125 | M | 207 | M | 413 |
| 542 | Island | 201 | A | 201 | A | 411 |
| 564 | Cape York | 153 | M | 133 | M | 402 |
| 476 | Wet Tropics | 66 | M | 81 | M | 116 |
| 170 | Island | 61 | M | 84 | M | 93 |
| 691 | Island | 19 | M | 33 | M | 48 |
| 661 | Fitzroy | 17 | M | 18 | M | 41 |
| 168 | Island | 6 | M | 11 | M | 11 |
| 460 | Burnett-Mary | 44313 | M | 8617 | M | 0 |
| 401 | Fitzroy | 9909 | M | 7659 | M | 0 |
| **Total** | | **346699** | | **328636** | | **439013** |

**Table D-2. Total phosphorus (TP) release loads for council STPs in Reef catchment**

| Facility ID | Catchment | TP load (kg) 2017 | | TP load (kg) 2018 | | TP Ultimate (kg/yr) |
|---|---|---|---|---|---|---|
| 399 | Fitzroy | 21115 | M | 13547 | M | 16322 |
| 400 | Fitzroy | 8340 | M | 8731 | M | 13433 |
| 685 | Burdekin | 4961 | M | 8349 | M | 12100 |
| 177 | Burdekin | 11510 | M | 8449 | M | 9016 |
| 462 | Burnett-Mary | 5098 | M | 5235 | M | 6017 |
| 689 | Burdekin | 2213 | M | 3588 | M | 5436 |
| 609 | Burnett-Mary | 5110 | A | 5110 | A | 5110 |
| 669.1 | Wet Tropics | 2940 | M | 3424 | M | 4505 |
| 456 | Burnett-Mary | 346 | M | 351 | M | 604 |
| 665 | Wet Tropics | 2255 | M | 2280 | M | 3678 |
| 607 | Burnett-Mary | 565 | M | 2402 | M | 3383 |
| 377 | Burnett-Mary | 953 | M | 1094 | M | 2805 |
| 438 | Mackay Whitsunday | 6691 | M | 1253 | M | 1843 |
| 178 | Burdekin | 1023 | M | 1337 | M | 1707 |
| 763 | Fitzroy | 1176 | A | 1176 | A | 1680 |
| 710 | Fitzroy | 1123 | A | 1123 | A | 1628 |
| 321 | Mackay Whitsunday | 691 | M | 798 | M | 1478 |
| 457 | Burnett-Mary | 571 | M | 575 | M | 575 |
| 463 | Burnett-Mary | 613 | A | 613 | A | 1460 |
| 880 | Burnett-Mary | 359 | M | 1418 | M | 1418 |
| 709 | Fitzroy | 1032 | M | 1714 | E | 1225 |
| 738 | Wet Tropics | 776 | M | 581 | M | 1095 |
| 458 | Burnett-Mary | 972 | M | 834 | M | 1070 |
| 437 | Mackay Whitsunday | 317 | M | 716 | M | 1053 |
| 666 | Wet Tropics | 1275 | M | 804 | M | 1030 |
| 541 | Island | 327 | A | 327 | A | 1022 |
| 667.1 | Wet Tropics | 2307 | M | 812 | M | 1015 |
| 746 | Burnett-Mary | 576 | E | 576 | M | 976 |
| 605 | Burnett-Mary | 134 | M | 503 | E | 932 |
| 711 | Fitzroy | 1516 | M | 795 | M | 795 |
| 664 | Wet Tropics | 506 | M | 559 | M | 777 |
| 537 | Island | 180 | A | 180 | A | 694 |
| 755 | Wet Tropics | 733 | M | 624 | M | 671 |
| 663 | Wet Tropics | 475 | M | 427 | M | 667 |
| 539 | Island | 309 | A | 309 | A | 657 |
| 761 | Wet Tropics | 201 | M | 498 | M | 623 |

| Facility ID | Catchment | TP load (kg) 2017 | | TP load (kg) 2018 | | TP Ultimate (kg/yr) |
|---|---|---|---|---|---|---|
| 536 | Island | 217 | A | 217 | A | 602 |
| 379 | Burnett-Mary | 73 | E | 73 | M | 562 |
| 250 | Burdekin | 784 | M | 440 | M | 549 |
| 540 | Island | 268 | A | 268 | A | 548 |
| 467 | Wet Tropics | 504 | M | 434 | M | 511 |
| 323 | Mackay Whitsunday | 410 | M | 237 | M | 438 |
| 495 | Island | 310 | A | 310 | A | 365 |
| 535 | Island | 244 | E | 244 | M | 364 |
| 743 | Wet Tropics | 344 | M | 204 | M | 324 |
| 439 | Mackay Whitsunday | 137 | M | 281 | M | 281 |
| 538 | Island | 124 | A | 124 | A | 248 |
| 443 | Mackay Whitsunday | 124 | M | 80 | M | 228 |
| 657 | Burnett-Mary | 21 | M | 78 | M | 223 |
| 542 | Island | 107 | A | 107 | A | 219 |
| 606 | Burnett-Mary | 1 | M | 167 | E | 199 |
| 659 | Burnett-Mary | 80 | A | 80 | A | 178 |
| 692 | Burdekin | 44 | M | 51 | M | 128 |
| 757 | Wet Tropics | 152 | M | 62 | M | 107 |
| 758 | Wet Tropics | 28 | M | 32 | M | 80 |
| 474 | Wet Tropics | 393 | M | 32 | M | 65 |
| 478 | Wet Tropics | 30 | A | 30 | A | 61 |
| 564 | Cape York | 26 | M | 12 | M | 35 |
| 661 | Fitzroy | 16 | M | 13 | M | 30 |
| 170 | Island | 21 | M | 24 | M | 27 |
| 476 | Wet Tropics | 18 | M | 10 | M | 14 |
| 543 | Island | 5 | E | 5 | M | 12 |
| 168 | Island | 3 | M | 4 | M | 4 |
| 691 | Island | 1 | M | 2 | M | 3 |
| 460 | Burnett-Mary | 11077 | M | 2188 | M | 0 |
| 401 | Fitzroy | 2257 | M | 2359 | M | 0 |
| **Total** | | **107108** | | **89280** | | **114905** |

## Aquaculture and Meat Processing facilities

Annual nutrient loads for other activities including aquaculture and meat process were determine for each facility using the same approach for STPs (Table D-3 and Table D-4). That is, the annual nutrient loads was calculated by summing the daily nutrient load, which was calculated by multiplying the daily release volume measurement by the most recent nutrient release concentration measurement for each day of the calendar year. For aquaculture facilities, please note that the loads are gross release loads and do not consider any intake load. Also, note that monitoring data was not available for all facilities and there was insufficient information to estimate these loads.

**Table D-3. Total nitrogen (TN) and phosphorus (TP) release loads for aquaculture facilities in the Reef catchment**

| Facility ID | Annual TN Load 2017 (kg/yr) | Annual TN Load 2018 (kg/yr) | Annual TP Load 2017 (kg/yr) | Annual TP Load 2018 (kg/yr) |
|---|---|---|---|---|
| **206** | 14533 | 12963 | 1117 | 896 |
| **209** | 1875 | 5510 | 134 | 390 |
| **236** | | 371 | | 19 |
| **237** | | 637 | | 21 |
| **275** | 25859 | 39439 | 3354 | 4633 |
| **285** | 8209 | 7287 | 525 | 468 |
| **656** | 17881 | 12388 | 1936 | 1002 |
| **695** | 2670 | 7905 | 21 | 74 |
| **Total** | **71026** | **86499** | **7088** | **7502** |

**Table D-4. Total nitrogen (TN) and phosphorus (TP) release loads for meat processing facilities in the Reef catchment**

| Facility ID | Annual TN Load 2017 (kg/yr) | Annual TN Load 2018 (kg/yr) | Annual TP Load 2017 (kg/yr) | Annual TP Load 2018 (kg/yr) |
|---|---|---|---|---|
| **751** | 12242 | 8588 | 17239 | 17021 |

## Anthropogenic diffuse nutrient loads

As discussed in Section 6, the point source nutrient load estimates were compared to modelled anthropogenic diffuse loads for the Reef catchment. Anthropogenic diffused nutrient loads were estimated based on the Department's catchment modelling data used for the Reef Water Quality Report Card for 2018/2019 (see Table D-5). This modelling is done each year and includes runoff from land uses for the weather condition of that period in addition to some STP wastewater releases. The model outputs for the 2018/19 period were used to estimate the anthropogenic nutrient load for the 2018 calendar year. Although this is an approximation, both 2018 and 2019 were considered dry years, with 2019 having slightly less rainfall in Queensland. Regardless, anthropogenic diffuse nutrient loads would be expected to be higher in average or wet years.

The process to estimate the diffuse nutrient loads involved firstly identifying the anthropogenic load for DIN, DIP, DON and DOP for each region for the year (see Table D-5). The point source load component used in the model was then excluded as this is only a subset of the STPs considered in this review. The anthropogenic TN and TP load for each region was then estimated by combining the inorganic and organic dissolved component. In other words, the modelled anthropogenic particulate component of nitrogen and phosphorus was excluded from the calculation.

**Table D-5. Estimation of anthropogenic diffuse nutrient loads for the Reef catchment**

**A. Modelled anthropogenic diffuse nutrient load**

| Region | DIP (t/y) | DOP (t/y) | DIN (t/y) | DON (t/y) |
|---|---|---|---|---|
| Wet Tropics | 153 | 112 | 2352 | 1768 |
| Burdekin | 31 | 9 | 876 | 263 |
| Mackay Whitsunday | 169 | 43 | 966 | 841 |
| Fitzroy | 423 | 106 | 194 | 1390 |
| Burnett-Mary | 85 | 43 | 929 | 1229 |
| **Total** | **861** | **313** | **5316** | **5491** |

**B. Modelled STP nutrient load**

| Region | DIP (t/y) | DOP (t/y) | DIN (t/y) | DON (t/y) |
|---|---|---|---|---|
| Wet Tropics | 12 | 3 | 42 | 11 |
| Burdekin | 13 | 4 | 41 | 11 |
| Mackay Whitsunday | 5 | 2 | 21 | 5 |
| Fitzroy | 28 | 8 | 67 | 18 |
| Burnett-Mary | 16 | 5 | 43 | 12 |
| **Total** | **74** | **22** | **213** | **57** |

**C. Modelled anthropogenic diffuse load without STPs**

| Region | DIP (t/y) | DOP (t/y) | DIN (t/y) | DON (t/y) | **TN (DIN+ DON) (t/y)** | **TP (DIP+ DOP) (t/y)** |
|---|---|---|---|---|---|---|
| Wet Tropics | 141 | 109 | 2310 | 1757 | **4067** | **250** |
| Burdekin | 18 | 5 | 835 | 252 | **1087** | **23** |
| Mackay Whitsunday | 164 | 41 | 945 | 836 | **1781** | **205** |
| Fitzroy | 395 | 98 | 127 | 1372 | **1499** | **493** |
| Burnett-Mary | 69 | 38 | 886 | 1217 | **2103** | **107** |
| **Total** | **787** | **291** | **5103** | **5434** | **10537** | **1078** |

Source: DES Catchment Modelling Results, Reef Water Quality Report Card for 2018/2019