**CLEAN OCEAN FOUNDATION**

**NATIONAL OUTFALL DATABASE**

# FINAL REPORT
## Emerging Priorities Project: National Outfall Database


John Gemmill[1], Q. A. Rohmana[1,2], Katherine Morrison[3], Ian Wright[3] and Andrew Fischer[2]

[1]Clean Ocean Foundation
[2]University of Tasmania
[3]University of Western Sydney



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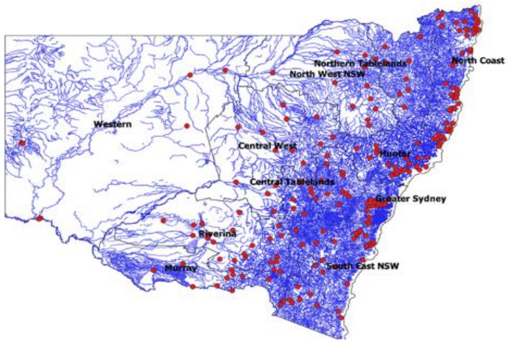


National Outfall Database

National Environmental Science Programme

Australian Government

clean ocean foundation

WESTERN SYDNEY UNIVERSITY

UNIVERSITY of TASMANIA

IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Enquiries should be addressed to:

John Gemmill
johng@cleanocean.org
0409 425 133

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Picture by:
1. Swimmers in Nepean River (top left) – Susan Wright
2. NSW inland river outfalls (top right) – Katherine Morrison
3. Water quality engagement in Warriewood with Surfrider (bottom left) – Ruby Gemmill
4. Water quality testing in a small creek (bottom right) – Ian Wright

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# EXECUTIVE SUMMARY

As a result of the success of National Outfall Database (NOD) project (Marine Biodiversity Hub, 2015), the Clean Ocean Foundation (COF) continues to engage in research regarding outfalls and their impacts on the environment and human health. Early 2021, the COF has been entrusted by the federal Department of Agriculture, Water and Environment (DAWE) to continue the NOD project under the National Environment Science Program (NESP) Emerging Priorities program (EPP). The project is fully funded by the DAWE and delivered by the COF and associates. The work of the NOD was formerly part of the NESP 1.0, commenced in 2015, whilst it is now in transition to NESP (2.0). In the current project, the NOD-EPP has six milestones which cover (1) the continuation of NOD data collection for 2019/2020 financial year; (2) microplastics, emerging contaminants and biosolids from the outfall discharge; (3) understanding the recycling of wastewater treatment plants (WWTP) effluent; (4) preliminary review on collecting inland outfalls data in New South Wales, Australia; (5) national standard for reporting outfall data; and (6) preliminary review of industrial ocean outfalls discharge.

A key finding across all sections of this paper is the value of increased transparency created by the Emerging Priorities program (and the National Outfall Database) in examining opportunities and addresses challenges posed by wastewater discharges nationally.

We note the timely release of the 2021 Australian Infrastructure Plan that identifies as one of its key themes “Customer empowerment through data – Using data to change the way infrastructure is delivered in Australia”.

We are proud of the uniquely successful innovative approach of data collection and investigation driven by community concern that has drawn on both academic and governmental support essential for this endeavour and look forward to continuing this process into the future

**(1) The continuation of NOD data collection for 2019/2020 financial year**

Driven by community need for greater understanding, the NOD has developed into an innovative program that collects data and provides an evidenced based approach to complex issue of outfall discharges.

The NOD has provided a level of transparency and accessibility not previously available in the water sector and enjoys widespread support for its continuance from both the general and scientific communities and most of the water sector.

**(2) Microplastics, emerging contaminants and biosolids from the outfall discharge**

Our research found that a developing body of knowledge exists within WTA in relation to emerging contaminants of concern such as PFAs, microplastics, biosolids and engineered nanomaterials (ENMs) and research tends to be conducted by the larger WTAs.

Emerging contaminant concerns (ECCs) represent a challenge for WTAs, decisions makers and communities that need to balance the urgent need for a greater understanding of these ECCs in water and wastewater discharges with the practical realities of current treatment processes. This is also complicated by differing perspectives on the amount of risk related to exposure these contaminants and the different values put on externalities.

It is the evolving nature of ECCs that a majority of WTAs will find it difficult to monitor or treat ECCs until required to by regulatory processes, i.e., when evidence is sufficiently overwhelming for action to be taken. However, there will always be a need to integrate the

understanding of ECCs in a transparent way so the communities, researchers and other stakeholders can participate in an informed manner in the ECCs issue. A register of such projects may be worth consideration.

**(3) Understanding the recycling of wastewater treatment plants (WWTP) effluent**

Decisions on water security are fundamentally related with water recycling infrastructure. Understanding the pressures on how WTAs approach recycling and the potential impact on pollutant discharge to the receiving environment should be seen as a critical part of an evidenced based approach to water security.

Most WTAs were able to provide a good estimate of their water recycling activities. Our research found only a relatively small fraction of water is recycled from coastal WTA's and of that only thirty five percent of recycled water resulted in a reduction of pollutant load by the outfall discharge.

Also of note was that although a circular economy approach is being considered by approximately fifty percent of WTAs (and an even higher proportion considered consider water recycling to be an increasingly high priority into the future), ninety percent of WTAs would be unable to set clear five- or ten-year goals in this area.

This suggests that despite the wishes of WTAs to prioritise large scale water recycling, there is a serious deficiency in practical measures required support commitment in this area.

Our research suggests that ongoing provision of this data would offer critical insights for policy makers. This might also benefit from future collaboration with Bureau of Meteorology that already collects some data in this area.

**(4) National standard for reporting outfall data**

Most WTA and EPAs responded constructively and supported the need for transparency and information based on evidence to be publicly accessible wherever practical and broadly supported the proposed approach outlined in the standard document.

An option to formalise this standard, along with a process for its continual evolution, now exists.

**(5) Preliminary review on collecting inland outfalls data in New South Wales, Australia**

The inland pilot study revealed large differences in the standards of effluent treatment required in the regulation of the 214 inland outfalls, owned by 94 WTAs, across NSW. This would make any attempt of comparison of discharges across NSW or nationally, without a standardised database extremely difficult.

However, the pilot study did see many opportunities for small to medium improvements in the standard of treatment at inland outfalls (in NSW). This could result in higher quality recycled water for different uses. National standards for varying grades of recycled water, perhaps based on the Victorian Recycled Water Standards (Class A+ to Class D) could help influence upgrades at inland WWTPs across Australia. This should be coupled with national standards for inland outfalls. When broad geographic comparisons of inland outfall quality are available, it will enable a more effective targeted approach for prioritising upgrades.

The NSW pilot study shows that the skills currently developed by the existing NOD team could build upon the methodology used for national ocean outfalls across to inland outfalls. Many of the WTAs are medium to small Local Governments and are less likely to have dedicated staff available to facilitate sharing data. However, collecting inland outfall data and making outfall data public will be achievable with appropriate resourcing. It is likely that Queensland will also include a very large number of medium to small WTAs, similar to NSW. The other states and territories have a centralised ownership of the WWTPs and accessing inland outfall data should be easier.

**(6) Preliminary review of industrial ocean outfalls discharge**

Each state/territory has a different classification approach for industrial outfalls. This makes any attempt to achieve a national comparison of industrial discharges into coastal or estuarine environments difficult. However, a review of these different classification approaches has indicated a number of good features, for example, the mapping overlay feature within the Land Information System of Tasmania (LIST) in Tasmania that could be integrated into a national industrial outfall database.

By using the capacity of the existing NOD team, an informal system could be rapidly developed for collecting information on a collaborative basis. Appropriately resourced, a preliminary national database could be completed in 2022 that could provide links to existing documents and make them publicly accessible. Subsequent cycles would produce refinements and help standardise reporting for classes of industry, producing comparative data. These developments when mature, could then be integrated into the NPI.

# INTRODUCTION

As a result of the success of National Outfall Database (NOD) project (Marine Biodiversity Hub, 2015), the Clean Ocean Foundation (COF) continues to engage in research regarding outfalls and their impacts on the environment and human health. Early 2021, the COF has been entrusted by the federal Department of Agriculture, Water and Environment (DAWE) to continue the NOD project under the National Environment Science Program (NESP) Emerging Priorities program (EPP). The project is fully funded by the DAWE and delivered by the COF and associates. The work of the NOD was formerly part of the NESP 1.0, commenced in 2015, whilst it is now in transition to NESP (2.0). In the current project, the NOD-EPP has six milestones which cover (1) the continuation of NOD data collection for 2019/2020 financial year; (2) microplastics, emerging contaminants and biosolids from the outfall discharge; (3) understanding the recycling of wastewater treatment plants (WWTP) effluent; (4) preliminary review on collecting inland outfalls data in New South Wales, Australia; (5) national standard for reporting outfall data; and (6) preliminary review of industrial ocean outfalls discharge.

The continuation of the NOD data collection for 2019/2020 financial year, as an ongoing research, presents a comprehensive collection of discharge monitoring data between 2019 and 2020 from outfalls across Australian coastal regions. This research also examines the outfall nutrients load to prioritise the potential degree of impact of each source to the environment and human health. In general, the results of this analysis will be able to provide stakeholders and the general community with a better understanding of the relative impacts of outfalls to their coastal waterways and provide policy makers and managers evidence to prioritise outfall infrastructure reform and wastewater recycling initiatives.

Currently, there are limited studies regarding microplastics and PFASs in Australian wastewater effluent and biosolids. Comprehensive research is needed to investigate and mitigate the impact of PFASs in the Australian environment, and across the world (Gallen et al., 2017). This research aims to evaluate the current resources and data availability for identifying microplastics and other emerging pollutants, such as PFASs, and to determine various possible options for future provision of microplastics and emerging pollutants data from a national perspective.

The purpose of wastewater recycling research is to identify the current water recycling classifications, calculation and reporting from wastewater treatment plants (WWTPs). The outcome of this study will provide a basis for developing benchmarks in future years related to the reporting of wastewater recycling.

The preliminary review on collecting inland outfalls data is to develop a comprehensive understanding of the environmental impact caused by the river inland outfalls. This intention is going to be a step towards the NOD ability to collect data on key inland river system nationally.

The national standard of reporting for outfall data research started before the extended funding agreement between the DAWE and COF. This initiative aims to promote discussion and encourage feedback from stakeholders on national scale reporting procedures for outfall discharges from the nation’s coastal wastewater treatment plants.

As the sixth milestone, a preliminary review of industrial outfalls was conducted to investigate the availability of effluent quality data out of the industrial discharge. Australian coastal areas, where the industries are, would be the first study area. The initial step would be consulting the relevant states and territories official organisations in order to identify the extent of available information.

# Chapter 1. The continuation of national outfall database: Outfall ranking 2019/2020 FY

## Introduction

Wastewater disposal into the marine environment is one of the main factors leading to the deterioration of coastal water quality. Poorly managed disposal can lead to increased concentrations of nutrients, organic and inorganic pollutants, as well as alter levels of turbidity, pH and bacteria ((Beck and Birch, 2012, Carey and Migliaccio, 2009, Cheung et al., 2015). An increase in the level of pollutants can have an impact on coastal ecology and biodiversity and affect the health of recreational users (Schwarzenbach et al., 2010, Boehm et al., 2017, Burd et al., 2012, Becherucci et al., 2016).

In order to manage and safeguard aquatic and marine environments around Australia from the impacts of wastewater effluent, state/territory governments have each established Environment Protection Authorities (EPA). Each EPA acts as an independent environmental protection regulator to prevent and control pollutant impacts to human health and the environments. For example, in Victoria the EPA was established under section 5(1) of the Environmental Protection Act of 1970. In New South Wales, the Protection of the Environment Administration Act (1991) (POEA Act) served as the mechanisms to establish the environmental protection regulator. With regards to wastewater effluent each state or territory EPA has a role in regulating wastewater treatment plant (WWTP) discharges. For example, in New South Wales, the EPA regulates water pollution through the establishment of conditions in environmental protection licenses. These licenses take into account several factors, such as the community value of a waterway, the community's uses of a waterway and practical measures to prevent deterioration of waterway values and uses. (EPA NSW, 2013). Any activity that may produce a discharge of waste that by reason of volume, location or composition adversely affects the quality of any segment of the environment will require a licence from the Authority (DECC NSW, 2009). The basic requirement of the licence consists of an explanation of the activity, pollutant loads, and discharge limits. The actual load of a pollutant is the mass (in kilograms) of the pollutant (e.g., nitrogen, phosphorous, total suspended solids, oil and grease) released into the environment from the potential emission sources. Throughout each state and territory, emission sources are required to monitor their discharges and to be in compliance with the conditions set out in their licenses. Each WWTP is required to conduct monitoring within the vicinity of their outfalls, analyse the samples and report the results to the EPA (DECC NSW, 2009, EPA VIC, 2009).

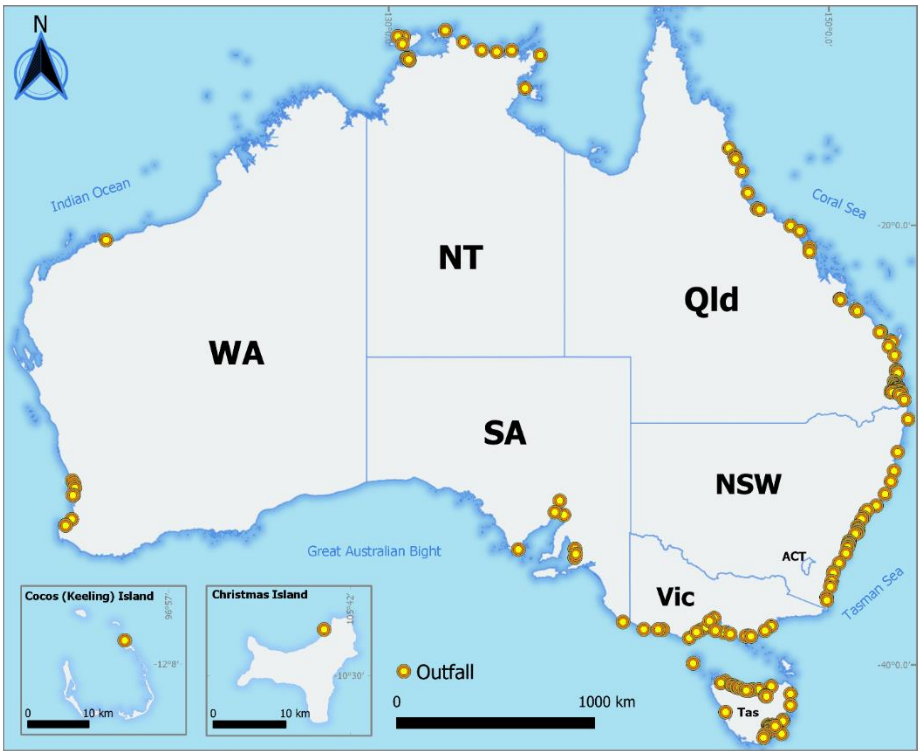
The NOD, developed by the COF in collaboration with State and Territory Governments, provides policy makers with a guide to help prioritise outfall reform and identify public and private sector opportunities for wastewater recycling (Marine Biodiversity Hub, 2015). In collaboration with the NESP, the NOD also provides Australian water authorities and the public an accessible database to help identify pollutant loads and assess any potential health and environmental impact risks of sewerage outfalls on the marine environment and surrounding communities. The NOD provides an unprecedented national collection of water quality data, collected by water authorities and Local Governments according to guidelines set out in Environmental Protection Authority (EPA) licenses. Given the NOD's centralised collection of national scale water quality data the opportunity to examine the comprehensive impacts of sewerage outfalls at regional scales becomes possible.

The aim of this report is to present a comprehensive collection of discharge monitoring data between 2019 and 2020 from outfalls across Australian coastal regions. This report also ranks each outfall according to the total flow volume and nutrients load to prioritise the potential degree of impact of each source to the environment and human health. In general, the results of this analysis will be able to provide stakeholders and the general community with a better understanding of the relative impacts of outfalls to their coastal waterways and provide policy makers and managers evidence to prioritise outfall infrastructure reform and wastewater recycling initiatives.

## Data collection

Water quality data were collected from 43 Water Treatment Authorities (WTAs) around Australia (Figure 1) by either downloading the water quality data reports directly from WTA websites or by formally requesting the data through email. To standardise data collection, the NOD prepared a document outlining a predefined format in which the data was to be delivered. Through this process, the NOD collected, verified, and published data from 42 WTAs up until 2019/2020 financial year. This report analysed 2019/2020 financial year data, which is equal to 12 months in terms of calendar year. WTA monitoring requirements varied depending on EPA license requirements. Therefore, the type of pollutant data monitored varied across all outfall locations. In this report, we assess only nitrogen, phosphorus and flow volume (Table 1), as these three indicators were commonly measured across all WTAs.

Figure 1. The location of 185 wastewater discharge points managed by 43 water treatment authorities around Australia.




## Data Analysis

The pollutant contribution index, based on nitrogen and phosphorous loads, was calculated for each outfall (Figure 1). Outfalls were ordered from lowest to highest index value to rank them according to their relative pollutant contribution to the coastal and marine environment. The index is based on a total nutrient load discharge (see below) using the variables of flow, and nitrogen and phosphorous concentrations.

Nitrogen and phosphorous (nutrient) load was calculated based on the Load Calculation Protocol (DECC NSW, 2009) using

$$N_l = \sum_{n,p} \frac{Tf * N_a}{1000} . (1)$$

where, $N_l$ is the total nutrient load in tonnes, calculated for nitrogen and phosphorous individually, $Tf$ is the total annual flow from each outfall in megalitres (ML) and $N_a$ is the annual average nutrient concentration in mg/L. Nitrogen and phosphorous loads were summed to provide the total nutrient load. Values were sorted and ranked for each outfall location for 150 outfall locations and grouped into quartiles. Those sites with incomplete data for 2019/2020 financial year were not considered in the final ranking.

## Results

The NOD has been consistently collecting data from the WTAs since 2015. As for current data collection, water quality data collected were from 38 out of 43 WTAs. Across these several years, Queensland, South Australia, Tasmania, Western Australia were able to maintain consistency in providing water quality data (Table 1). Despite having various WTAs, Victoria has been successfully maintaining the data submission to the NOD. Due to various circumstances, some WTAs in New South Wales and the Northern Territory were experiencing difficulties to supply the requested information as previous years (Gemmill et al., 2019).

Table 1. Outfalls water quality data collected for 2019/2020 financial year.

| States/Territory | Number of outfalls | Outfalls collected | Data repository (%) |
|---|---|---|---|
| New South Wales | 34 | 20 | 60% |
| Northern Territory | 14* | 0 | 0% |
| Queensland | 55 | 55 | 100% |
| South Australia | 10 | 10 | 100% |
| Tasmania | 47 | 47 | 100% |
| Victoria | 19 | 19 | 100% |
| Western Australia | 12 | 12 | 100% |

Asterix (*) indicates that only four outfalls are provided for the NOD.

Top and bottom quartiles of the outfall rankings are presented in Table 2. Total nutrient load from individual outfalls sites ranged from 12 to 5,103,568 kg, with a mean of 115,489 kg. Tasmania had 16 outfall sites in the top quartile (lowest nutrient load). Queensland and Victoria each had five outfalls in the top quartile. New South Wales and Western Australia each had four outfalls. Only one South Australian outfall recorded in the top quartile. The bottom quartile (highest nutrient load) was represented by nine outfalls each from Queensland and Victoria. Tasmania, Western Australia and South Australia each had seven, five and four, respectively. Compared to previous ranking (Rohmana et al., 2020), New South Wales managed to have only one outfall recorded in the bottom quartile. There is almost no difference between previous (Rohmana et al., 2020) and current results. The top and bottom quartile were dominated by the same outfalls.

Table 2. Top (green) and bottom (red) quartiles of outfall ranking for 2019/2020 financial year data.

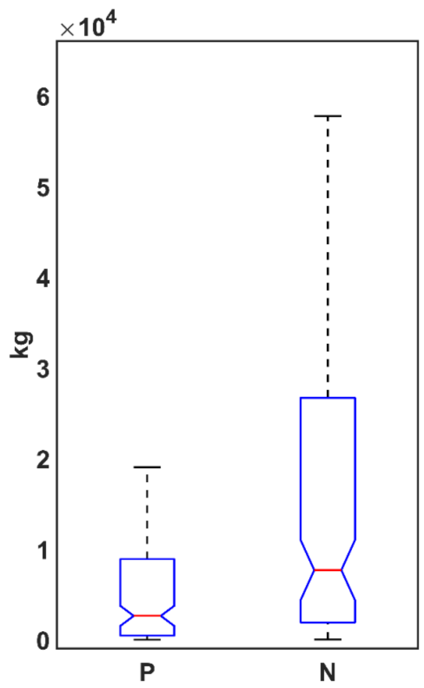
| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 1 | South Australia | Christies Beach-Southern | 12 |
| 2 | New South Wales | Iluka | 15 |
| 3 | Tasmania | Beaconsfield | 32 |
| 4 | New South Wales | Crescent Head | 42 |
| 5 | Tasmania | Swansea | 51 |
| 6 | Tasmania | Cambridge | 151 |
| 7 | Tasmania | Bicheno | 164 |
| 8 | Queensland | Bundaberg North | 185 |
| 9 | Tasmania | Rokeby | 287 |

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 10 | Western Australia | Cocos (Keeling) Island | 291 |
| 11 | Tasmania | Sisters Beach | 391 |
| 12 | Tasmania | Triabunna | 403 |
| 13 | Western Australia | Wickham | 419 |
| 14 | Western Australia | Christmas Island | 436 |
| 15 | Western Australia | Busselton (North) | 508 |
| 16 | Tasmania | Boat Harbour | 522 |
| 17 | Tasmania | St Helens | 543 |
| 18 | Victoria | Toora | 561 |
| 19 | Victoria | Port Welshpool | 626 |
| 20 | Tasmania | Port Arthur | 631 |
| 21 | New South Wales | Bermagui | 1,010 |
| 22 | Tasmania | Beauty Point | 1,016 |
| 23 | Queensland | Karana Downs | 1,080 |
| 24 | Queensland | Port Douglas | 1,121 |
| 25 | Tasmania | Dover | 1,210 |
| 26 | Victoria | Apollo Bay | 1,531 |
| 27 | Queensland | Bowen | 1,620 |
| 28 | Victoria | Lorne | 1,717 |
| 29 | Tasmania | Stanley | 1,824 |
| 30 | Tasmania | Orford | 1,936 |
| 31 | Victoria | Anglesea | 2,243 |
| 32 | New South Wales | Camden Head | 2,423 |
| 33 | Tasmania | Cygnet | 2,513 |
| 34 | Tasmania | Risdon | 2,588 |
| 35 | Queensland | Cannonvale | 2,657 |
| 106 | Victoria | Delray Beach | 34,315 |
| 107 | Queensland | Merrimac | 36,592 |
| 108 | Victoria | Baxter's Beach | 36,655 |
| 109 | Victoria | Altona | 38,354 |
| 110 | Tasmania | Cameron Bay | 46,220 |
| 111 | Tasmania | Newnham | 51,912 |
| 112 | Queensland | Elanora | 52,066 |
| 113 | Queensland | Rockhampton North | 52,316 |
| 114 | Western Australia | Bunbury | 54,120 |
| 115 | Victoria | Port Fairy | 57,729 |
| 116 | South Australia | Christies Beach-Northern | 63,023 |
| 117 | South Australia | Bolivar High Salinity | 65,998 |
| 118 | Queensland | Gibson Island | 67,840 |
| 119 | Tasmania | Smithton | 68,620 |
| 120 | Queensland | Loganholme | 101,003 |
| 121 | Tasmania | Prince of Wales | 101,969 |
| 122 | Queensland | Coombabah | 102,068 |
| 123 | Tasmania | Ti-tree Bend | 152,605 |
| 124 | Victoria | Boags Rock (Boneo, Mt Martha, Somers) | 156,658 |

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 125 | Tasmania | Macquarie Point | 160,696 |
| 126 | Queensland | Oxley | 207,249 |
| 127 | Tasmania | Pardoe | 210,031 |
| 128 | Victoria | Black Rock | 227,317 |
| 129 | New South Wales | Winney Bay (Kincumber) | 239,581 |
| 130 | Queensland | Kawana | 243,404 |
| 131 | South Australia | Glenelg | 260,974 |
| 132 | Victoria | Warrnambool | 285,982 |
| 133 | South Australia | Bolivar WWTP | 366,621 |
| 134 | Western Australia | Subiaco | 421,021 |
| 135 | Western Australia | Point Peron | 448,070 |
| 136 | Queensland | Luggage Point | 517,419 |
| 137 | Western Australia | Beenyup | 681,269 |
| 138 | Western Australia | Woodman Point | 1,011,506 |
| 139 | Victoria | Boags Rock (Eastern Treatment Plant) | 3,479,639 |
| 140 | Victoria | Werribee (Western Treatment Plant) | 5,103,568 |

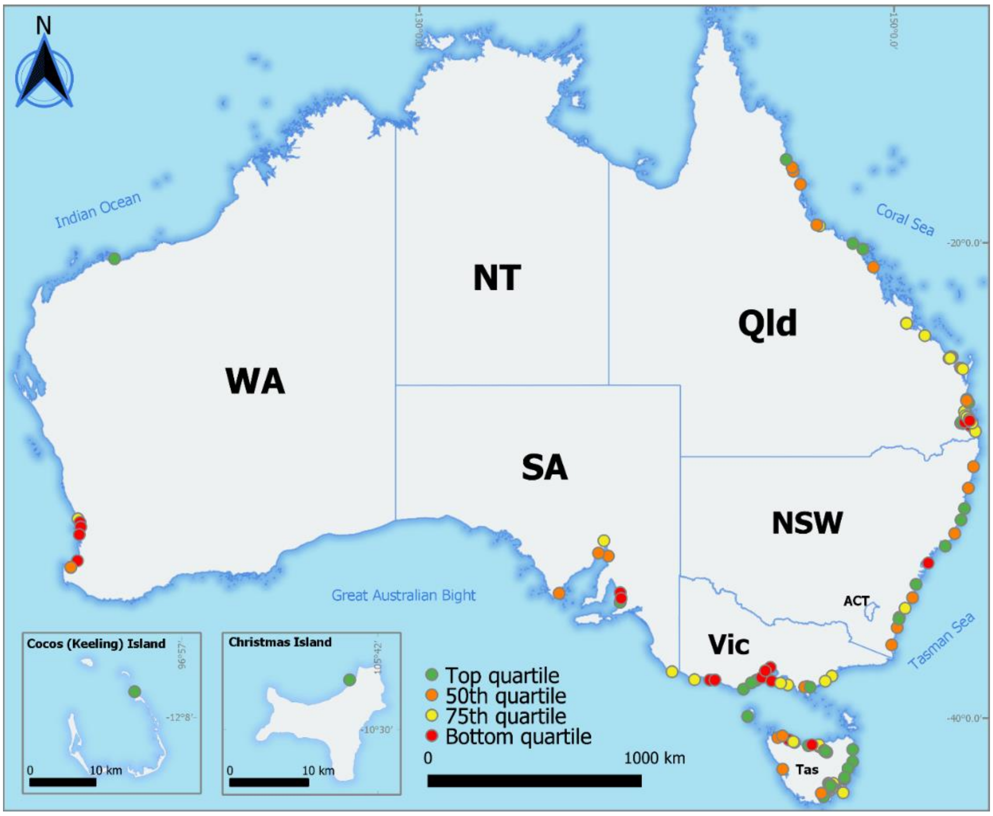
The boxplot (Figure 2), with outliers removed, shows the difference between the median contributions of nitrogen and phosphorous in the total nutrient load. Phosphorous concentrations contribute less to the overall outfall nutrient load and vary less between outfall sites. Nitrogen, on the other hand, has a higher median contribution and high variability across the sites. The outfalls contributing higher nitrogen and phosphorous loads vary more than those delivering lower loads.

Figure 2. A boxplot of nitrogen (N) and phosphorous (P) loads (kg) for each outfall's reported data (n=140).



The map in Figure 3 shows the distribution ranked outfalls throughout Australia grouped by quartiles. The top quartile (lowest nutrient load) of outfalls seems to be more prevalent in regional areas and discharge less nitrogen and phosphorus loads into the coastal and marine environment. Discharges in the top quartile ranged between 12 to 2,657 kg (Table 1). The bottom quartile, on the other hand, with higher nutrient loads appear to occur around the major cities. The total load discharged by this quartile ranged between 34,315 to 5,103,568 kg. Each quartile consisted of 35 outfalls. The rankings for all the outfalls appear in Appendix A.

Figure 3. Australian coastal and river/estuary outfalls ranked by quartiles for 2019/2020 financial year data.



# Chapter 2. Microplastics, emerging contaminants and biosolids from outfall discharge

## Microplastics in effluent

Microplastics are one of the most challenging issues around the world. Many studies and reviews of microplastics including their distribution and trends have increased public awareness to reduce entry of microplastics into the environment (Auta et al., 2017, Alimba and Faggio, 2019, Ogunola et al., 2018). Wastewater disposal is one of the main sources of contaminants into the marine environment, and poorly managed disposal can lead to increased microplastics introduction (UNEP, 2020).

There are various types of microplastics, including fibers, nurdles, films, microbeads, plus the fragmentation/breakdown of these products. Their sizes vary between 1.6μm to 5mm. In the aquatic environment there are two sources of microplastics, primary and secondary. Primary microplastics are plastics which were intentionally added as enhancement materials for certain products and are released directly into the environment (Boucher and Friot, 2017, Komyakova et al., 2020). For instance, scrubbing agents (microbeads) from cosmetic products, tyre fragments, and polyester fragments from clothing. Secondary microplastics are the result of fragmentation of plastic products, such as textiles, fishing line, clothespin pieces, and paint chips. The fragmentation may be caused by oxidation, weather (UV radiation), and biofouling (GESAMP, 2015). Due to its various sizes, microplastics can be perceived as food and ingested by the marine organisms across trophic levels, including zooplankton, shellfish (Goldstein and Goodwin, 2013), fish and megafauna (Cole et al., 2019). With the assistance of atmospheric fallout these microplastics can travel long distances (Chen et al., 2020, Dris et al., 2016). The potential of human health risks may also increase due to the presence of microplastics in the food chain (Smith et al., 2018, Schwabl et al., 2019, Gasperi et al., 2018).

Wastewater treatment plants (WWTPs) have various levels of wastewater treatment (and pre-treatment) and technological approaches that impact on removal of various pollutants and ultimately the quality of wastewater. Non-tertiary treatment will remove up to 66% of microplastics while tertiary treatment removes 98% (Conley et al., 2019, Cristaldi et al., 2020, Sol et al., 2020). However, other studies detected the opposite results, where primary treatment is able to remove 98% of microplastics, while secondary and tertiary reduce (7-20%) of microplastics by a small amount (Carr et al., 2016, Murphy et al., 2016, Prata, 2018, Talvitie et al., 2017). Albeit, given the WWTP's capability to remove microplastics, there is potential to release microplastics into the waterways (Ziajahromi et al., 2017). Knowing the technology processes operating at each WWTP allows systematic research into mitigation measures to reduce microplastics and emerging contaminants.

## Emerging contaminants in effluent

Numerous studies claim that WWTPs are the main source of per- and polyfluoroalkyl substances (PFASs) present in the surface water (Gonzalez et al., 2021, Muir and Miaz, 2021). There is also evidence that the presence of PFAS in agriculture soils is from biosolids produced by WWTPs (Gallen et al., 2016). PFASs are widely used for industrial processes and consumer products due to their heat resistance, and their use as dispersion, wetting or surface-treatment agents (Department of Defence, 2021). For instance, PFAS have been used in fire retardants foams for firefighting as well as in chromium plating for protecting workers from toxic hexavalent chromium fumes. PFASs can also be found in common consumer goods, such as carpets, coated fabrics, paper and packaging. PFASs are a group of manufactured chemicals which include perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) (Department of Defence, 2021, Gallen et al., 2016, 3M, 2021). Although these substances are no longer manufactured in the United States, other countries still produce them today. PFOS and PFOA are currently the most concerning in Australia and internationally. Since the PFOS and PFOA are persistent, bioaccumulative and toxic, they pose potential concerns for the ecosystem (Bossi et al., 2015, Buck et al., 2011, Department of Health, 2016). These pollutants can be as well harmful to humans if accumulated overtime (Department of Health, 2016). The threat does not only come from present deposition, but also the accumulation of past deposition, which may still linger in the environment and human body (Armitage et al., 2009).

Under the Stockholm Convention on Persistent Organic Pollutants, Australia is obliged to protect human health and the environment from persistent organic pollutants (Stockholm Convention, 2004). The Department of the Environment and Energy published a draft of Commonwealth Environmental Management Guidance on PFOS and PFOA in 2016 (CEMG) (Department of the Environment and Energy, 2016). It focuses on PFOS and PFOA persistent characteristics and pathways to ecosystems and management. The objectives are to investigate and identify PFASs contamination, diagnose the potential risks to the receiving environment, respond by establishing management plans where appropriate and undertaking targeted actions.

Recently, The Heads of EPAs Australia and New Zealand (HEPA) released the PFASs National Environmental Management Plan version 2.0 (PFAS NEMP) to provide a national guideline on PFASs contamination, addressing the wide range of issues associated with PFASs contamination (HEPA, 2020). Similar to CEMG, the PFAS NEMP covers the general issues, such as monitoring, assessment, environmental levels and management responses. Both guidelines (CEMG and PFAS NEMP) classify freshwater and marine environmental guideline values, which are used to assess and investigate any potential risks to aquatic ecosystems (Table 3). The guideline values were developed based on Australian Water Quality Guideline Framework (WQGF) (HEPA, 2020). These values are not applicable to recycled water quality (subject to policy process under the national water quality guidelines), contaminant levels in industrial effluent, mixing zones, or stormwater run-off. The wastewater effluent guideline values have yet to be included in the guidelines, as further study is needed. Although PFAS NEMP will be utilized throughout Australian states, there is still a possibility to develop jurisdictional guideline values, as well as site-specific guideline values for specific catchments. Currently, each state and territory has adopted the NEMP management responses for responding to PFASs contamination (DAWE, 2021).

Table 3. Ecological water quality guideline values for PFOS and PFOA based on ecosystem type and exposure scenario.

| Ecosystem type | PFOS (μg/L) | PFOA (μg/L) | Exposure scenario |
|---|---|---|---|
| Freshwater | 0.00023 | 19 | 99% species protection – high conservation value systems |
| | 0.13 | 220 | 95% species protection – slightly to moderately disturbed systems |
| | 2 | 632 | 90% species protection – highly disturbed systems |
| | 31 | 1,824 | 80% species protection – highly disturbed systems |
| Marine | 0.29 | 3,000 | 99% species protection – high conservation value systems |
| | 7.8 | 8,500 | 95% species protection – slightly to moderately disturbed systems |

| Ecosystem type | PFOS (µg/L) | PFOA (µg/L) | Exposure scenario |
|---|---|---|---|
| | 32 | 14,000 | 90% species protection – highly disturbed systems |
| | 130 | 22,000 | 80% species protection – highly disturbed systems |

According to the National Health and Medical Research Council (NHMRC), the recommended health-based guideline values for PFASs in recreational water (does not include aquatic facilities) must not be over 2 µg/L (PFOS and PFHxS) and 10 µg/L (PFOA) (NHMRC, 2019). Both values indicate the safest amount of PFAs if a person is exposed on regular basis without any significant risk to health. The exposure may be from ingestion, skin contact and inhalation.

In parallel with PFASs, there has also been concern regarding engineered nanomaterials (ENMs), which are categorised as industrial chemicals (Law and Davison, 2018). ENMs are nanoparticles and nanotubes, and nanostructured materials which have sizes ranging between 1nm and 100nm. These materials could have been used in advanced water treatment for improving the efficiency of the treatment process (Nnaji et al., 2018), antimicrobial applications (Ogunsona et al., 2020), and applications for improving agronomic production (Liu and Lal, 2015). However, they may have the potential to accumulate over time in the environment (Hochella et al., 2019). There are growing concerns regarding potential human health and environmental impacts with only limited studies guiding industry (Law and Davison, 2018). Nanoscale particles ≤3.5nm can also clog the microfiltration membranes which increases the operational costs for the WWTP processes (Smeraldi et al., 2011).

## Microplastics and PFAS in Biosolids

Biosolids are a product of sewage sludge from wastewater treatment processing (ANZBP, 2020b). Biosolids can only be non-hazardous if they undergo proper treatment according to approved management guidelines. Normally, biosolids are used for fertilizer to improve soil to stimulate plant growth, and some may be used in manufacturing processes and biofuels. Notwithstanding, even if it has been treated, biosolids still contain nutrients (e.g., nitrogen, phosphorus, magnesium) and traces of heavy metals, such as lead, mercury and nickel. On average, Australia produces 328,000 tonnes per year of dry biosolids (ANZBP, 2020a). Approximately 70% of Australian biosolids were used for agriculture purposes in 2019 and as little as 5% was discharged from landfills into the marine environment. Compared to other developed countries, Australia is the strictest in terms of biosolids regulation. The Natural Resource Management Ministerial Council (NRMMC, 2005) released the guidelines for sewerage system biosolids management which covers ecological, health and economic impacts associated with biosolids, provides a national framework, and regulates control and transfers procedures. As with water quality guidelines, each state and territory are encouraged to adopt the NRMMC guidelines and adjust the guidelines to local conditions.

In order to reduce contaminant and pathogen levels in biosolids, NRMMC created a classification system, which depends on the contaminants (C) and stabilization (P) grading (NRMMC, 2005). The grading has several criteria, such as contaminant concentration (C1, C2), process, microbial level and other conditions, with P3-C2 as the lowest and P1-C1 as the highest grade. The lowest grade can only be used in forestry and land rehabilitation, while the highest grade can be used on all lands including residential, excluding sensitive areas. However, this guideline has yet to include levels of PFASs contamination, albeit polychlorinated biphenyls (PCBs) were monitored. There have been many studies examining PFASs concentration in biosolids. A latest study confirmed that PFASs may be present in biosolids from Australian WWTPs (Moodie et al., 2021). Similarly, ENMs are likely to present in biosolids as well. Latest studies corroborated that metallic ENMs have been one of the sources of plants growth damage, due to phytotoxicity which intervenes with the photosynthetic process (Poustie et al., 2020, Velicogna et al., 2020). Given the wide-range usage of biosolids, this does not rule out that these substances may have been spread around and possibly impacted biodiversity and human health.

In addition, microplastics and their interaction with the environment and biosolids is becoming of increasing concern. It is likely that biosolids may contain microplastics (Edo et al., 2020, Raju et al., 2018). Ziajahromi et al. (2016) also stated that approximately 95% of microplastics stayed in biosolids during the treatment processes. Studies confirm that, annually, up to 1000 microplastics particles were found in the agricultural soils after biosolids application (Edo et al., 2020). It is estimated that 44,000 to 430,000 tonnes of microplastics managed to enter the agroecosystem via biosolids (Nizzetto et al., 2016). Referring to the Australian guidelines, it was also reported that between 2,800 to 19,000 tonnes microplastics were found in soils which is recently treated with biosolids (Ng et al., 2018).

Currently, there are limited studies regarding microplastics and PFASs in Australian wastewater effluent and biosolids. Comprehensive research is needed to investigate and mitigate the impact of PFASs in the Australian environment, and across the world (Gallen et al., 2017). This research aims to evaluate the current resources and data availability for identifying microplastics and other emerging pollutants, such as PFASs, and to determine various possible options for future provision of microplastics and emerging pollutants data from a national perspective.

## Methods

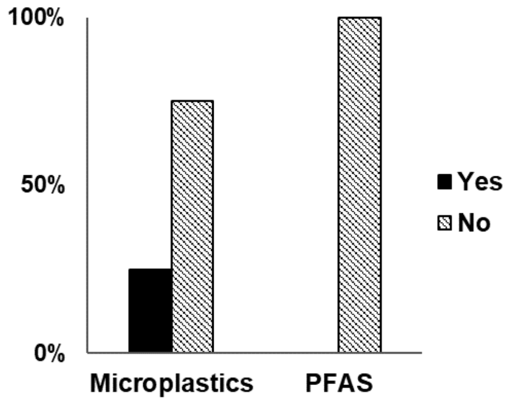
This study was conducted nationwide, across Australian states and a territory. The survey targeted 25 key stakeholders of 43 water treatment authorities (WTAs), who liaised with the NOD project. Key stakeholders were sent an email invitation requesting participation. The survey was administered primarily through an online survey tool (SurveyMonkey). The survey itself took approximately 20-40 minutes to complete. A survey instrument was developed to address the aims of the project (Appendix B). There were two sections covered in the survey, microplastics and emerging contaminants, and wastewater recycling. The microplastics and emerging contaminants section consisted of 26 questions with three sub-questions including yes-no, two multiple answers and nine open-ended style questions. This section covered topics regarding microplastics and PFAS treatment, monitoring, reporting, and data availability. The information sheet was sent along with the direct online survey access describing the aims of the project and information that will be used for the participants' reference.

In order to measures the extent of relationships between pairs of variables, chi-square tests were conducted. The chi-squared statistic is a measure of how similar two categorical probability distributions are. If the two distributions are identical, the chi-squared statistic is 0, if the distributions are very different, some higher number will result.

## Results

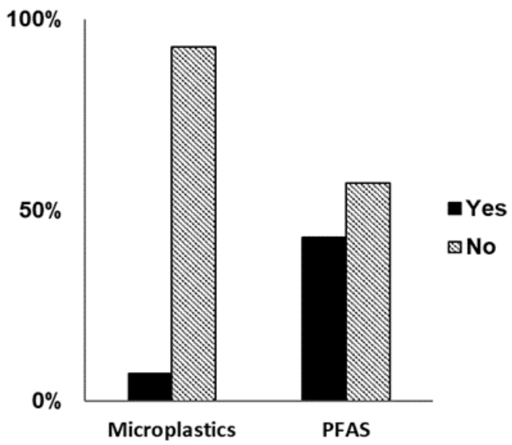
The key stakeholders were asked if their facilities currently treat and/or filter microplastics fragment as well as emerging pollutants (e.g., PFAS) from their effluent. Approximately 75% participants answered no and 25% yes for treating microplastics, while 100% participants answered no for treating PFAS from the WWTP effluent (Figure 4). The treatments used for screening microplastics varied. For instance, membrane ultrafiltration, tertiary filtration up to 5 microns, as well as relying on the sand filtration. Most WTAs rely on conventional treatment, such as primary, secondary and tertiary, in order to screen and remove microplastics from the effluent.

Figure 4. Microplastics and PFAS treatment.




The WTAs tend to monitor the amount of PFAS concentration (43%) compared to microplastics (7%) from the effluent (Figure 5). However, several chose not to monitor both pollutants, microplastics (93%) and PFAS (57%).

Figure 5. Microplastics and PFAS monitor from the WWTP effluent.




Further questions were asked to investigate microplastics and PFAS within the biosolids. Only 38% of WTAs sample biosolids for microplastics and/or emerging pollutants. However, almost 72% of the WTAs monitor the composition of biosolids prior to general use or disposal to landfill (Table 4). Annually, WTAs produce biosolids ranging between 200 and 180,000 tonnes for dry, and 2,400 to 9,000 tonnes per annum for wet biosolid products (Table 5). Generally, the biosolids are used for agriculture purposes, including composting, land revitalisation and forest plantation, while the rest are disposed of into the landfill.

Table 4. Biosolids monitoring on microplastics, emerging pollutants and its composition.

| Monitor | Yes | No |
|---|---|---|
| Microplastics / emerging pollutants | 29% | 71% |
| Biosolids composition | 54% | 46% |

Table 5. Annual biosolids production from WWTPs.

| | Biosolid (T/annum) |
|---|---|
| Dry | 200 – 180,000 |
| Wet | 2,400 – 9,000 |

Chi-square tests were performed to examine the association between microplastics and PFAS treatment, microplastics and PFAS monitoring, general treatment and monitoring, and data reporting and public availability. Table 6 presents the results of the tests. The pollutant treatment process was not associated with pollutant monitoring. However, the public availability of effluent data was significantly dependent on the data reporting.

Table 6. Chi-square test results ($\alpha < 0.05$).

| Variables | Null - Hypothesis | Results |
|---|---|---|
| Microplastics (Q1) vs. PFAS (Q8) treatments. | The treatment of microplastics and PFAS are not related. | $X^2 = 8.00$, df = 1, p = 0.0047, n = 56 |
| Microplastics (Q3) vs. PFAS (Q9) monitoring. | Microplastics and PFAS monitoring are not related | $X^2 = 2.074$, df = 1, p = 0.1498, n = 56 |
| Treatment (Q1, Q8) vs. monitoring (Q3, Q9). | The WWTP effluent treatment is not related to effluent monitoring. | $X^2 = 2.667$, df = 1, p = 0.1025, n = 56 |
| Data reporting (Q4, Q10, Q17, Q39) vs. availability (Q5, Q11, Q18, Q40). | Data reporting is not related to its availability for public. | $X^2 = 10.252$, df = 1, p = 0.0014, n = 112 |

In terms of data reporting, the WTAs prefer to report their monitoring dataset to the EPA or relevant authority, as well as having keeping records within their organisation. Data availability may be made public by several methods, such as direct request, freedom of information (FOI), or through the WTAs website. This depends on state and territory regulation regarding data publication.

# Chapter 3. Understanding the recycling of WWTP effluent

## What is wastewater recycling, benefits and risks?

Rainfall deficiencies and drought in large parts of Australia have made water a more valuable resource (SoE, 2016, BoM, 2021). In order to achieve the water sustainability, each Australian state and territory supports the notion of water recycling. Water recycling is a process of reusing the treated effluent from wastewater treatment plants (WWTPs), to obtain a higher satisfactory standard of water for non-potable purposes. The first proposal for recycled water uses in Australia was prepared in a report released in 1977 (Gutteridge et al., 1977). Overall, the report recommended the opportunity of using recycled water as an additional source of water. From this point forward, the government continues to develop guidelines, policy and principles to improve the management of water recycling (Radcliffe and Page, 2020).

By recycling WWTPs effluent, the amount of wastewater discharged into the environment will be reduced, which means less nutrients and pollutants flowing into the waterways. With regards to water security, water recycling obviously helps to secure water storage over long time periods, especially during periods of dry climate. A study showed that numerous towns and cities in regional areas across Australia have limited water storage, ranging between 3-12 months or less (Page and Marinoni, 2020). As a solution to these shortages, recycled water tends to be cheaper, and can be utilized for multiple purposes including agricultural, municipal, residential, and commercial applications (Ballina Shire Council, 2017, SEW, 2021, Water Unit, 2011).

Despite having various benefits, recycled water may conceivably have potential risks which can affect human health and the environment, if not treated correctly. Recycled water can contain harmful pathogens, which can cause gastroenteritis when exposed to humans (NRMMC et al., 2006). When recycled water is used for irrigation, it may still contain higher concentration of certain parameter(s) after treatment, which can affect the plant growth, and possibly contaminate groundwater or surface water (NRMMC et al., 2006).

## Water recycling classification

Generally, there are four classifications of recycled water (A-D) (Table 7). However, certain states, such as Victoria and Queensland, are capable of producing higher standards of recycled water (A+) with as little as 1 or less pathogen per 100 millilitres in the final product.

Table 7. Recycled water classification (DEWS, 2013, EPA VIC, 2003, SADHA, 2012).

| Purpose | Class | Details | Treatment | Parameter |
|---|---|---|---|---|
| Potable | | Stringent testing and process control. | Requires higher level of filtration and other treatment dependant on source water. | Chlorine: 0 mg/L<br>Pathogens: nil cfu/100mL<br>Fluoride: 1.5mg/L/y |

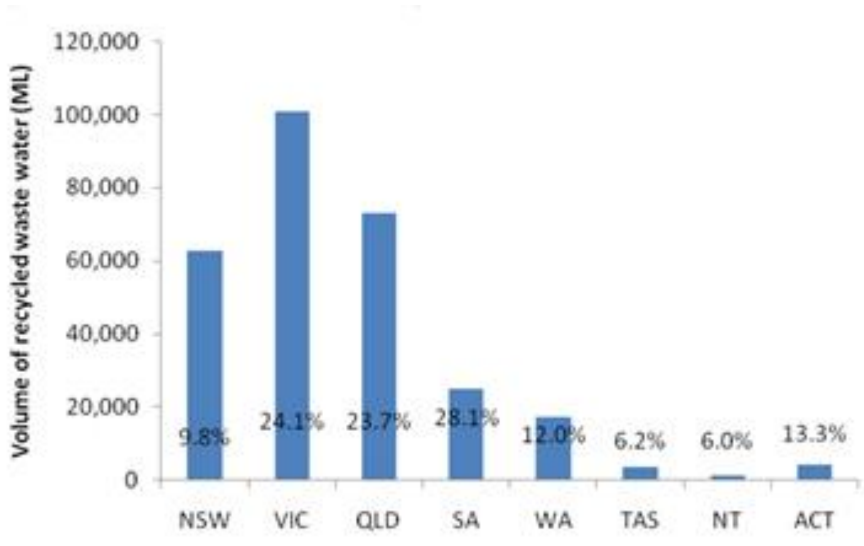
| Purpose | Class | Details | Treatment | Parameter |
|---|---|---|---|---|
| Non-Potable | A + | Class A+ is only produced at Eastern Treatment Plant (Melbourne).<br>It is suitable for all non-potable uses. | Tertiary reduces pathogens | Nitrogen: <5 mg/L<br>Pathogens: <1 cfu/100 mL<br>pH: 6 – 9<br>BOD/SS: <5 - 10 mg/L<br>Chlorine: 0.2-1 mg/L<br>Turbidity: <2 NTU |
| | A | Class A has the widest range of uses including those which involve direct human contact. These include clothes washing, closed system toilet flushing, garden watering and firefighting. It can be used to irrigate food crops that consumed raw or sold to consumers uncooked or processed as well as for all the uses allowed for Classes B, C and D. | Tertiary and pathogen reduction | Nitrogen: <5 mg/L<br>Pathogens: <10 cfu/100 mL<br>pH: 6 – 9<br>BOD/SS: <5 - 10 mg/L<br>Chlorine: 1 mg/L<br>Turbidity: 2 NTU |
| | B | Class B recycled water may be used to irrigate sports fields, golf courses and dairy cattle grazing land. It can also be used for industrial wash down as well as for the uses listed for classes C and D but has restrictions around human contact. | Secondary and pathogen reduction | Nitrogen: <10-30 mg/L<br>Pathogens: <100 cfu/100 mL<br>pH: 6 – 9<br>BOD/SS: <20-30 mg/L |
| | C | Class C may be used for a number of uses including for cooked or processed human food crops including wine grapes and olives. It can also be used for livestock grazing and fodder and for human food crops grown over a meter above the ground and eaten raw such as apples, pears, table grapes and cherries. It can be used by councils for specific purposes but | Secondary and pathogen reduction | Nitrogen: <10 - 30 mg/L<br>Pathogens: <1,000 cfu/100 mL<br>pH: 6 – 9<br>BOD/SS: <20 - 30 mg/L |

| Purpose | Class | Details | Treatment | Parameter |
| --- | --- | --- | --- | --- |
| | | there are restrictions around human contact. | | |
| | D | Class D has received the least amount of treatment of all four classes and may be only used for non-food crops such as instant turf, woodlots and flowers. | Secondary | Nitrogen: <10 - 30 mg/L<br>Pathogens: <10,000 cfu/100 mL<br>pH: 6 – 9<br>BOD/SS: <20 - 30 mg/L |

## Wastewater recycling percentages

Currently, neither federal nor state/territory governments set how much water should be recycled from WWTPs. In order to preserve drinking water, some states have started wastewater recycling. A report shows that, volumetrically, the largest volumes recycled are in the states with the largest populations – Victoria, New South Wales and Queensland (Figure 6) (Whiteoak et al., 2012). However, by proportion of wastewater flows, South Australia reuses the most wastewater at 28%, followed by Victoria (24%) and Queensland (24%). Tasmania and the Northern Territory recycled the least by both volume and proportion, facing the lowest demand and abundant potable supplies in their major centres (Whiteoak et al., 2012).

Figure 6. Australian wastewater recycling 2009/2010 by jurisdiction (ML/y).




## Monitoring and reporting

In order to reduce the risk for both end-users and the receiving environment, the state and territory EPAs specified a set of requirements including monitored parameters and minimum treatment levels (Table 7). The parameters vary depending on the class and reuse options, such as residential or agricultural purposes. Common water quality parameters that must be monitored are pathogens (all harmful bacteria and viruses), suspended solids (SS), biochemical oxygen demand (BOD), nitrogen and pH. The parameter monitoring period and frequency must be in accordance with the EPA requirements depicted in WWTPs licenses. Monitoring frequency varies across states and territories and can occur as often as daily or on a monthly basis. As for flow volume, the EPA requires WTAs to measure daily influent and effluent (recycled/discharge to environment). Class A requires daily monitoring of pathogens and weekly monitoring for other parameters. Class B and C require weekly monitoring of all parameters, while class D requires only monthly monitoring.

The reporting procedures in every state and territory are comparable. In Tasmania, for example, WTAs are required to supply a formal monthly report to the EPA Director and are responsible for maintaining monthly monitoring reports, including laboratory analysis reports, for a minimum period of three years. In Victoria, the water authorities must submit an annual summary to the EPA and keep all monitoring results and analyses for at least ten years. Meanwhile, in Queensland, South Australia and Western Australia, WTAs have to provide annual copies of all relevant data and there is no limit to what time the WTAs should keep the records. The purpose of wastewater recycling research is to identify the current water recycling classifications, calculation and reporting from wastewater treatment plants (WWTPs). The outcome of this study will provide a basis for developing benchmarks in future years related to the reporting of wastewater recycling.

## Methods

This study was conducted nationwide, across Australian states and a territory. The survey targeted 25 key stakeholders of 43 water treatment authorities (WTAs), who liaised with the NOD project. Key stakeholders were sent an email invitation requesting participation. The survey was administered primarily through an online survey tool (SurveyMonkey). The survey itself took approximately 20-40 minutes to complete. A survey instrument was developed to address the aims of the project (Appendix B). There were two sections covered in the survey, microplastics and emerging contaminants, and wastewater recycling. The microplastics and emerging contaminants section consisted of 26 questions with three sub-questions including yes-no, two multiple answers and nine open-ended style questions. This section covered topics regarding microplastics and PFAS treatment, monitoring, reporting, and data availability. The information sheet was sent along with the direct online survey access describing the aims of the project and information that will be used for the participants' reference.

The second survey section, wastewater recycling, comprised 14 questions with three sub-questions including matrix of dropdown menus, two multiple choices, three likert scales, five open-ended and seven yes-no questions. This section covered topics regarding recycling priority, percentage, calculation, classification, reporting and data availability.

A Wilcoxon Signed-Rank test was chosen to analyse two likert scale questions regarding the wastewater recycling prioritisation. WSR measured the mean rank between two categories from the same samples (Wilcoxon, 1945). This analysis was applied for question 27 and 28 (Appendix B).

## Results

Survey questions 22-23 investigate the commitment of WTAs in prioritising water recycling in general and the next ten years. The Wilcoxon Signed-Rank's test indicated that, among the WTAs, the wastewater recycling priority in ten-years' time (mean rank = 4.00) would be more viable compared to the general and current prioritization wastewater (mean rank = 0.00). The difference was statistically significant ($Z = -2.46$, $p = 0.016$) (Table 8 and 9). Although 90% WTA indicated water recycling as a priority (Q 22, 23) 40% of respondents indicated it would be difficult to set and/or achieve five- or ten-year goals in this area (Q 40).

Table 8. Wilcoxon Signed Ranks test.

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Ten years - General | Negative Ranks | 0[a] | .00 | .00 |
| | Positive Ranks | 7[b] | 4.00 | 28.00 |
| | Ties | 13[c] | | |
| | Total | 20 | | |

a. Tenyears < General

b. Tenyears > General

c. Tenyears = General

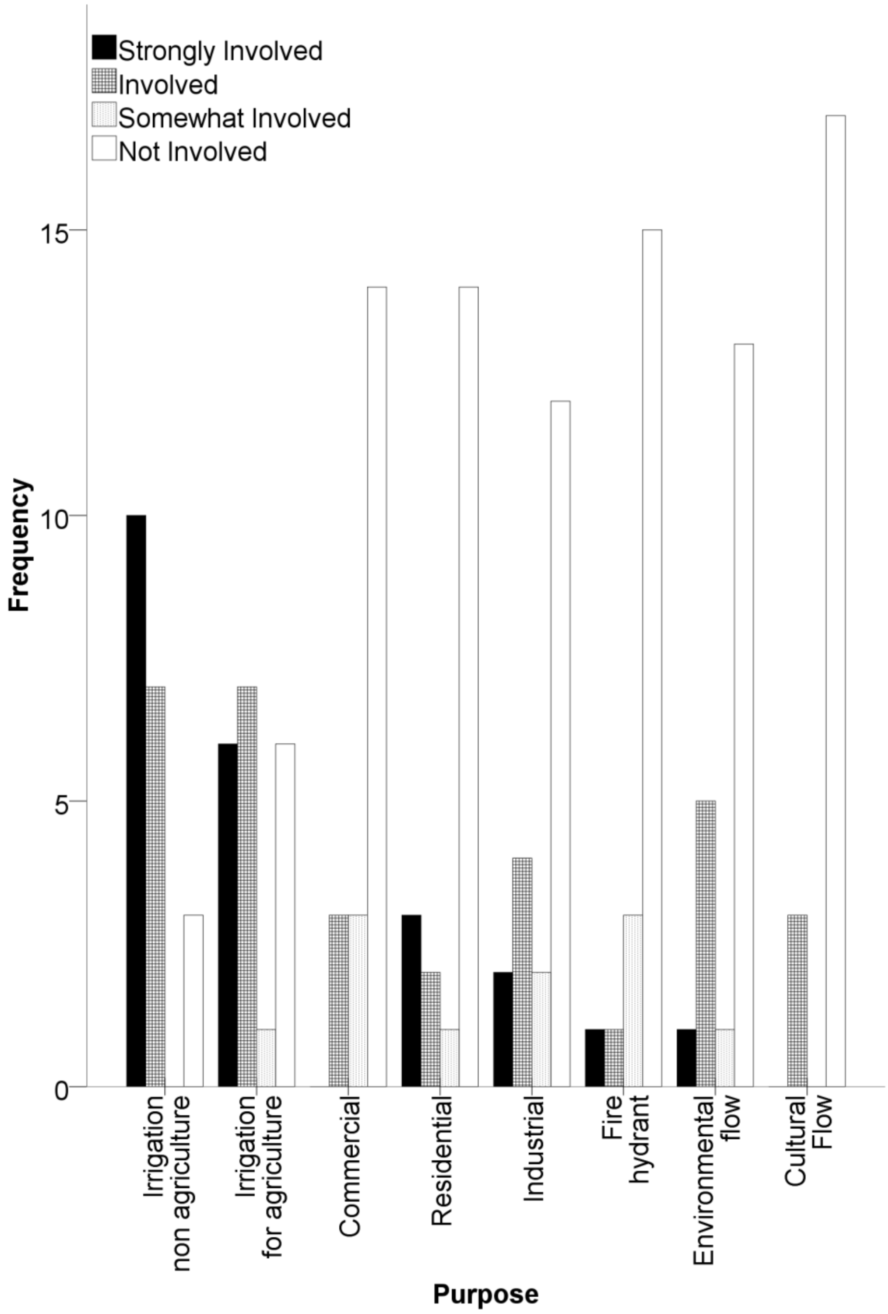
Table 9. Wilcoxon Signed Ranks statistics test ($\alpha < 0.05$).

| | Tenyears - General |
|---|---|
| Z | -2.460[a] |
| Asymp. Sig. (2-tailed) | .014 |
| Exact Sig. (2-tailed) | .016 |
| Exact Sig. (1-tailed) | .008 |
| Point Probability | .008 |

a. Based on negative ranks.

Figure 7 shows the rating of WTAs involvement on wastewater recycling based on certain purposes. It can be seen that irrigation for both non-agriculture and agriculture purposes are the most engaged activity for utilising the recycled wastewater. Although, there are small numbers of strong involvement on the residential and industrial, it is not as high as irrigation uses. The majority of key stakeholders also did not get involved in using recycled wastewater for commercial, residential, industrial, fire hydrant and other flows.

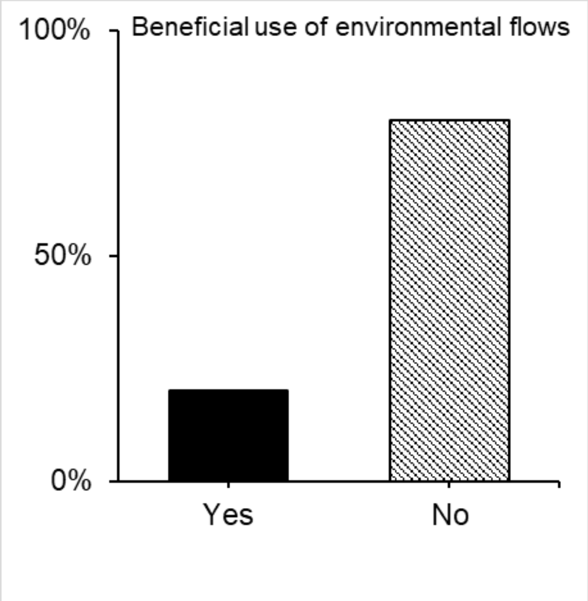
Figure 7. Water authorities' involvement on wastewater recycling based on purposes.




Of interest was that of those respondents where water recycling occurred, only 35% noted a reduction in pollutant load discharged to the environment (Q24). It can be concluded that water recycling cannot be directly equated with benefit to the receiving coastal environment in majority of instances.

Beneficial use of environmental flows varies depending on conditions (e.g., drought/flood) in the receiving environment (Q8, Figure 8). Only 20% of respondents take this into account when reporting amount of recycled water. Thus, at this stage actual practical adoption of water recycling requires more rigorous reporting.

Figure 8. Percentage of environmental flows for beneficial uses.




Also, although respondents were working to adopt circular economy principles (Q38, 39), these existed mainly at a “discussion level.” Only 50% thought a circular economy approach could be used as potential tool for recycling.

The respondents indicated that most protocols for calculating recycling were using flow balances/metered results (Q30). One authority referenced the Essential Services Commission Definitions (Victoria) that bases its definitions on National Performing Reporting Framework and Bureau of Meteorology standards. It is mainly used for urban utilities which would provide useful basis for regional reporting of recycling standards as well as the environmental flows and beneficial use in times of high rainfall.

Our research suggests that ongoing provision of this data would offer critical insights for policy makers. This might also benefit in the future from collaboration with Bureau of Meteorology that already collects some data in this area. We recommend development of an informal of a preliminary National Water Recycling Database to be completed by end of 2022.

# Chapter 4. National standard for reporting outfall data

## Introduction

Monitoring requirements vary across states, ranging from Environmental Protection Authority (EPA), water treatment authority (WTA's), and in some cases individual outfalls. Individual monitoring arrangements are made in each case between EPAs and WTAs. Monitoring requirements ultimately depend on EPA requirements, WWTP treatment level, and the condition of the marine environment (EPA NSW, 2003, EPA VIC, 2017). A balance needs to be met between WWTP operators, largely interested in minimising expense and staying within their license conditions, and the EPA, which has an interest in regulating impacts on environmental quality. This system of WWTP effluent monitoring and reporting varies across states, jurisdictions, regions and ultimately individual outfalls.

Inconsistency in monitoring requirements and a lack of national-level standards for data collection, transmission and sharing results in a lack of transparency and a reduced ability to comprehensively assess regional and national scale water quality impacts and health risks. Existing monitoring arrangements make it difficult to get a clear picture of how individual wastewater treatment plants compare with others around the country. For example, it is difficult to compare technology, cost of disposal, recycling efficiencies, evaluating risk of emerging contaminants, quantities and qualities of effluent streams if the available data is sparse and lacks detail.

The current system for water quality management is guided by the National Water Quality Management Strategy (NWQMS). The NWQMS was designed to protect water resources by maintaining and improving water quality, while supporting dependent aquatic and terrestrial ecosystems, agricultural and urban communities, and industry (ANZECC, 1992, ANZECC and ARMCANZ, 2000). The NWQMS is guided by both the Water Quality Management Framework (WQMF) and the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) water quality guidelines.

Both the WQMF and the ANZECC guidelines provide managers with steps and technical details for planning and managing water quality on an individual catchment/water body basis. The WQMF outlines 10 steps that logically encompass key requirements for long-term management strategies. The initial steps are to examine the current understanding of how a waterway system works, the issues they face and how to manage them. The second step suggests to "establish or refine community values and more specific management goals (including level of protection) for the relevant waterways at stakeholder involvement workshops." The first two steps of the WQMF are key elements with respect to national reporting standards. With regards to the National Outfall Reporting Standards, they can be viewed as the first steps toward achieving consistent reporting of outfall parameters to support community water quality monitoring efforts and the inclusion of community stakeholders in management process.

The ANZECC guidelines form the central technical reference of the NWQMS. The ANZECC guidelines provide detailed approaches and advice on identifying appropriate guideline values for water quality indicators. These guideline values were developed to help ensure that agreed community values and their management goals are protected. According to the ANZECC guidelines, for protection of aquatic ecosystems, locally derived guideline values are most appropriate. Consistently and effectively reported outfall monitoring data could be further integrated into the detailed approaches and for setting guideline values for water quality indicators as carried out in the ANZECC guidelines. Furthermore, standardised datasets could be integrated into risk-based management frameworks such as the New South Wales, "Risk-based Framework for Considering Waterway Health Outcomes in

Strategic Land-use Planning Decisions," to assist with management of the impacts of land-use activities on the health of waterways.

Overall, this research does five things.

1) Identifies the needs, benefits, and challenges of establishing national reporting standard.

2) Identifies the successes and lessons learned from a pilot reporting project, the National Outfall Database.

3) Identifies and considers the key elements of a proposed national approach to reporting, such as the process used to gather data, data storage arrangements, data access, reporting outputs and frequency and reporting costs.

4) This version lists the key research questions for stakeholders to address.

5) Lastly, the fifth section will propose a way forward.

As it currently stands, given the level of variability in reporting requirements and varying levels of data accessibility, it is difficult to comprehensively manage and assess effluent impacts on biodiversity, human health, water security and possibly the economic sector from a national perspective. The State of Environment 2016 has highlighted a deterioration in the quality of coastal waters around Australia (Clark and Johnston, 2017). A national approach to identify, assess and mitigate the impacts causing this deterioration will require accurate, standardised data from the wastewater sector. Decision makers at regional, state, and federal levels need greater clarity when allocating resources for water quality management and the opportunity to develop a clear set of standards will be essential. These standards can provide both a set of:

Baseline national standards – minimum acceptable standards in reporting expected that most responsible agencies already supply to the NOD

Aspirational standards – more comprehensive standards that agencies should strive for over a reasonable time period or required very quickly if additional national funding for infrastructure upgrades was to be made available.

## Method

Australian WTAs were invited for participating in a survey to promote discussion and encourage feedback from stakeholders on national scale reporting procedures for outfall discharges from the nation's coastal wastewater treatment plants. There were four proposed recommendations, which each at least had one dichotomous, a multiple choice and open-ended response type questions. First recommendation asked about the transparency and accountability of the NOD in collating and publishing outfall data on a national scale. Secondly, the recommendation on expanding the required monitoring pollutants which includes emerging pollutants, such as PFAS, microplastics, fire retardants and pharmaceuticals. The third recommendation questioned the WTAs regarding the comprehensive data access and reporting format to address the needs of relevant stakeholders (e.g., researchers, decision makers and general public). Last recommendation was related to the modification of reporting frequency to address needs of environmental protection and human health outcomes. In total, the survey contained 13 questions which spread over four recommendation. All survey questions for this chapter are provided in Appendix C.

## Results

Twenty-six WTAs and outfall data providers were asked their willingness to complete the survey. Of the 26, only 21 participants agreed to participate in the next discussion and 15 participants completed the survey (a 58% response rate). Participant responses to the survey questions are summarised below.

**Recommendation (R1):** To improve transparency and accountability within the community by continuing to build on the National Ocean Database which collates and publishes outfall data on a national scale from WTA, councils and WWTPs.

*R1-Q2: What are the key benefits from a centralised database/data repository for WWTP pollutant information?*

Participants were asked to choose the key benefits of a centralised database/data repository. They were allowed to choose more than one.

Figure 9. The percentages of centralised database key benefits. N is number of samples.

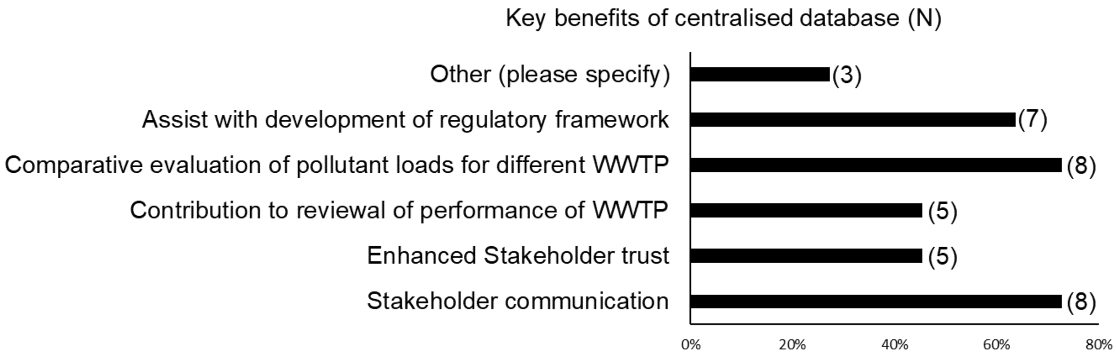



Figure 9 shows that the majority of WTAs believed that a centralised database will benefit the stakeholder communication with the general public (73%), allow them to compare pollutant loads between WWTPs (73%), and assist regulatory framework development (64%). Some WTAs also consider the centralised database to enhance the community's trust and may contribute the performance review and accountability of WWTPs.

*R1-Q3: What elements of the current data collection process would you improve upon in order to make the data exchange/collection process more effective?*

WTAs believed that data formatting (36%) for the NOD submission should be improved (Table 10). Currently, COF has a uniform spreadsheet form which it collects only monthly data. Respondents indicated that this is insufficient. The authorities also stated that longer timeframe (18%) to collate the data will be needed.

Table 10. Elements which need improvements for data exchange process.

| Element | N | Results |
|---|---|---|
| Communication (e.g., email) | 2 | 18.18% |
| Timeframe | 2 | 18.18% |
| Data formatting | 4 | 36.36% |
| Spreadsheet form | 1 | 9.09% |
| Other | 6 | 54.55% |

Under the “others” category, participants identified the following key themes:

To improve data exchange process: Continuity of the NOD will provide WTA with justification to allocate resources for systematic data preparation.

Data collected should:

1. Align with regulatory reporting requirements to ease administration burden.
2. Add value to the decision-making process rather than be collected for punitive purposes.
3. Provide context with respect to site specifics i.e., receiving dynamics, measurable impacts, or disturbance.

**Recommendation (R2)**: To expand the scope of monitoring to include a comprehensive list of required pollutants to be monitored across all WTPs and expand the list to include emerging pollutants.

*R2-Q1a: Based on the list of pollutants in appendix E, Table 23, can you indicate a percentage of those that are currently monitored at the recommended frequency?*

Table 11. Indicated percentage or current monitored pollutant.

| Percentage of monitored pollutants | N | Response |
|---|---|---|
| 100% | 0 | 0.0% |
| 80% | 6 | 66.67% |
| 60% | 2 | 22.22% |
| 40% | 1 | 11.11% |
| 20% or less | 0 | 0.0% |

The majority of WTAs have monitored at least 80% of the pollutants in appendix E (Table 23), while the rest monitored only 60% and 40% (Table 11). There are no authorities which monitor all (100%) of the pollutants, or 20% or less.

*R2-Q1b: Can you list those that would be most difficult to monitor?*

Views largely reflected the lack of evidence related to the risk of emerging contaminants and a concurrent lack of resources to consistently provide data on high profile contaminants such as Per- and polyfluoroalkyl substances (PFAS)/perfluoro octane sulfonic acid (PFOS).

One large WTA indicated,

> *“We currently sample for contaminants of emerging concern as part of discrete research projects with Universities, CSIRO, WaterRA or WSAA etc to understand the risk to the environment…... to understand if they pose a risk”*

whilst another indicated that

> *“All sewerage treatment plants are at the end of the waste hierarchy with their main focus to improve public health outcomes. Where does monitoring and*

*regulation of microplastics add value for the community, environment and public health?"*

Several respondents cited that many of the parameters (influent and effluent) are not monitored and not required to be reported to regulatory authorities. They also cited that the cost against perceived benefit was a key impediment to monitoring and reporting pollutants listed in the draft framework. Also noted was that smaller and remote WWTPs are unlikely to have resources to analyze and supply data. One larger WTA indicated that it most likely will have ability to collect this data.

*R2-Q1c: Are there any other pollutants that could be added to the list?*

Table 12. Other pollutants to be added to the list?

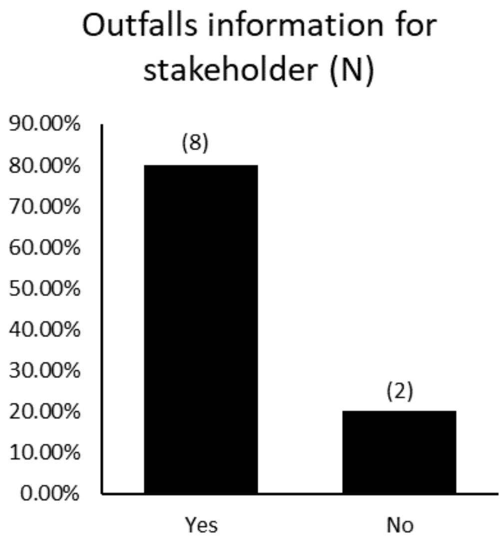
| Answer choices | Response |
|---|---|
| No | 80.0% |
| Yes (please specify) | 20.0% |

Those that responded stated that other pollutants could be added but what is to be added should be based on site specific characteristics and legislation (Table 12). One respondent indicated that toxic metals (e.g., copper, zinc, aluminium, cadmium, chromium, mercury, copper, lead, selenium), cyanide, nonyl phenol ethoxylates, pesticides are being measured by their organisation, but these measurements were not required by the EPA.

**Recommendation (R3):** To provide a more comprehensive data access and reporting format to address the needs of stakeholders.

*R3-Q1a: Does the current outfalls information website currently meet the needs of your stakeholder group in terms of data storage requirements and data access*?

Figure 10. The needs of current outfalls information for stakeholders.

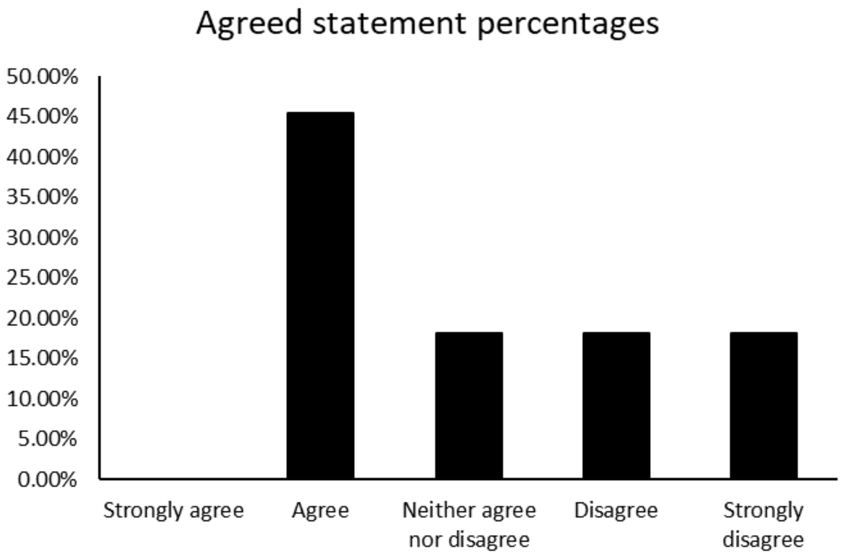



Most WTA felt the data access and reporting provided by the NOD was appropriate, although it was suggested by one respondent that a reference to guideline values might add perspective (Figure 10).

*R3-Q2a: Please review the proposed elements for the "report-card" reporting format presented in appendix E (Table 24). Do you agree on the following statement?*

*"The proposed elements will provide valuable information and can be supplied relatively easily."*

Figure 11. The percentages of the report card reporting format statement.




A key concern was that report card that included representations of "Olympic swimming pools or toxic containers" might give the wrong impression about the impact of effluent discharges on the receiving environment. Another respondent recommended keeping to simple pictorial representation of the types, location, and sizes of WWTPs to avoid "people trying to read more into it than they should be." They also expressed concern that some pictorial representations such as toxic containers can be misleading, especially when there is "no avenue for observed location and/or ecological disturbance in what has been put forward." The same respondent also was critical of including "contaminants of emerging concern" as there is "still scientific uncertainty about them and they don't have guidelines" and that the concept of a general "load" category was vague. Another respondent urged a collaborative approach during a report card development process.

*R3-Q2b: Are there additional components you feel should be added to make the report-card format more useful?*

One WTA thought an emerging pollutant list might also need to consider "toxicity, metals (e.g., copper, zinc, aluminium, cadmium, chromium, mercury, copper, lead, selenium), cyanide, nonyl phenol ethoxylates, pesticides."

**Recommendation (R4):** To modify reporting frequency to address needs of environmental protection and human health outcomes.

*R4-Q1: Based on the reporting frequencies recommended in the table in appendix A, what frequency of information is possible.*

Table 13. Possibility of monitoring frequency.

| Monitoring frequency | Response |
|---|---|
| Daily | 9.09% |
| Weekly | 9.09% |
| Fortnightly | 0.0% |
| Monthly | 18.18% |
| Other (please specify) | 63.64% |

Most of the respondents suggested annual reporting was sufficient. More frequent reporting was not possible due to the remoteness of some of the sites where there are “legacy designs and inadequate infrastructure and services” (Table 13.)

*R4-Q2: What sort of resources/infrastructure are needed to for you to comply to the desired reporting frequencies in appendix E (Table 23)?*

**Key themes**
Only a small minority of WTAs (10%) would find it possible to deliver parameters daily assuming extra resources were made available for this to happen. For all other WTA’s, cost of integration, especially with older legacy projects, was a major impediment. Once again, a common thread included demonstrating benefit to stakeholders to justify an increased frequency of reporting to that level. The majority (63%) of respondents indicated a twelve-month reporting period was suitable.

# Chapter 5. Preliminary review on collecting inland outfalls data in New South Wales

*Develop the process of understanding how inland outfalls impact on the environment. The project will continue to collect data on a trial river system; the Nepean - Hawkesbury as well as identify and survey relevant NSW water treatment authorities discharging into rivers on their capacity to supply similar data in future years. This is intended as a step towards developing the ability to collect data on key inland river system nationally.*

The project has enabled an important collaboration with Western Sydney University (WSU: PhD candidate Katherine Morrison and Dr Ian Wright) who are investigating the governance of inland sewage wastewater (WWTP) outfalls across NSW. Katherine Morrison's PhD research is focussed on the NSW Southern Highlands and is investigating the contribution of WWTP outfalls on water and sediment quality, river invertebrates, riparian vegetation and river platypus.

## Survey of NSW inland outfalls (June-September 2021)

WSU identified and contacted all 94 inland water treatment authorities (WTAs) across NSW. An initial survey was drafted and sent to all WTAs seeking information on WWTP effluent (treated sewage). It was sent out by the of end June (2021) and it explained the importance of the project and sought their cooperation to supply outfall effluent data that each WTA routinely collected. As this survey was conducted in NSW the legislation (*Protection of the Environment Operations* Act NSW) requires that each waste outfall in NSW is licenced to operate by the NSW EPA. As part of the EPA licence outfall performance data is required to be monitored and provided to the EPA, and also to any person that requests the information.

The outfall data requested from NSW WTAs was very similar to data previously collected for coastal outfalls established in the NOD. This has been adapted for riverine environments. It will also consider the variation from city-based authorities to regional authorities in terms of resources and challenges.

The survey also included few questions related to the cost of improving testing to include emerging contaminants and microplastics to gauge their commitments and ability to implement changes. The survey questions asked about their aims in improving water treatment effluent, reductions in traditional and emerging contaminants, as well as finding better uses for recycled water to support community needs, as these aims vary from local Government area (LGA) to LGA. For example, the budget and funding available for the very large water authorities such as Hunter Water Corporation and Sydney Water Corporation will be significantly different to the much smaller budgets of a single rural Council, such as Warrumbungle Shire Council.

There was a disappointing response to the survey. Of the 94 WTAs, only six responded to the survey. Five of the six supported the concept of the national outfall database and would be willing to upload monitoring data from their WWTPs. When asked about their need for infrastructure support and planning for water services in regional NSW, five of the six WTAs agreed that the NSW State Government had fallen short of understanding the needs of regional communities and providing funding, direction and access to resources to support improved water services.

Riverine environments in regional NSW are vital for communities in many ways, particularly as many rivers stopped flowing after several years of drought. Survey responses stated these river environments were used by their community for swimming/recreation, drinking water supply, essential environmental flows and irrigation (both urban and agriculture). The survey respondents showed a general interest in the topic of using effluent for recycled water uses. Two of the six WTAs that responded to the survey explained that they were already recycling treated effluent. One was utilising more than 85% of treated effluent and another more than 10%. None of the six responses monitored microplastics or emerging contaminants and one stated at the cost and resources involved to undertake this testing would far outweigh the benefits of the program.

## Assessment of inland NSW WWTP discharge licences

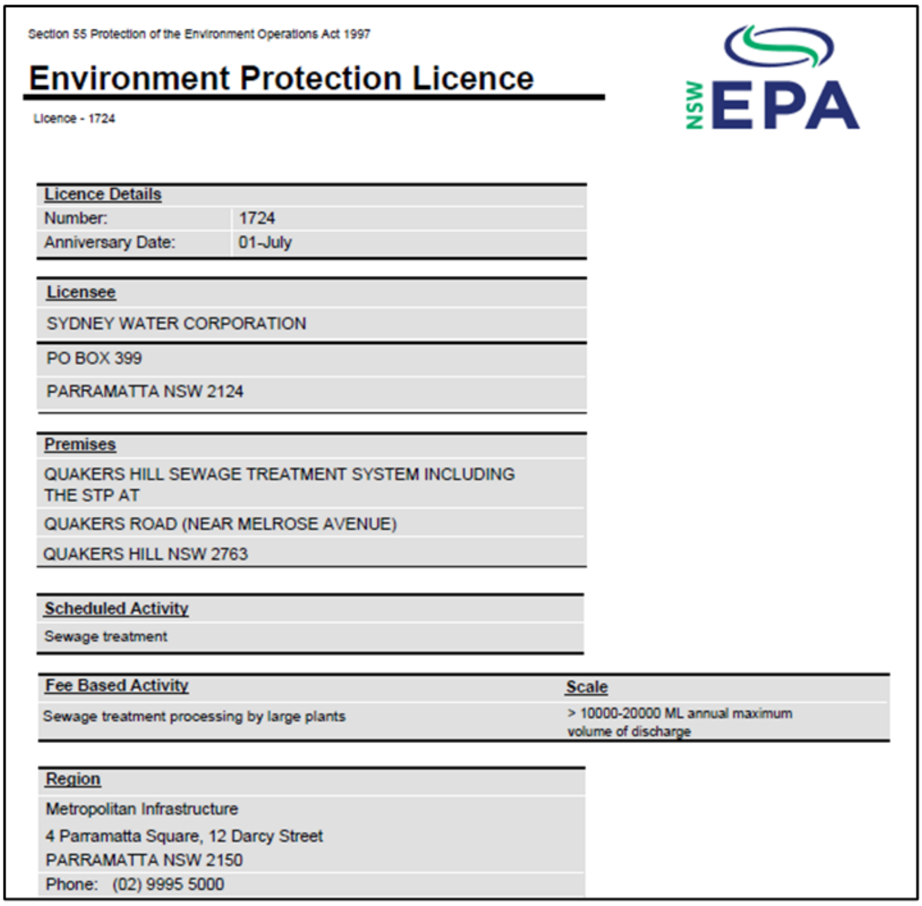
In addition to surveying all NSW WTAs, WSU also investigated governance of inland WWTP discharges. All inland WWTPs within NSW are operated by their owners, usually Local Governments, according to detailed requirements of the NSW EPA. Each WWTP has an individual site-specific licence that contains details of the operation and environmental performance of the facility. The licence enforced by the NSW EPA is termed an '*Environmental Protection Licence'* (EPL). Each has a unique EPL identification number and contains detailed specifications of the level of treatment of the wastewater that is authorised to be discharged to the environment (or for recycled water uses). Although not always clearly explained in the EPL most WWTPs dispose of their effluent to a nearby waterway, such as an estuary, creek, river or wetland.

The smallest inland WWTPs in NSW are two small settlements in the Manning River catchment on the lower NSW north coast, Coopernook (EPL 12583) and Landsdowne (EPL 12586). Each was classed as annually processing <3 ML of sewage. At the other end of the scale were the three largest (Figure 1 and 2: Quakers Hill EPL 1724) and Penrith EPL 1409 and St Marys EPL 1729). Each is located in the western suburbs of Sydney, in the Hawkesbury River catchment and each annually processes 10000 to 20000 ML of sewage.

Each EPL specifies the required quality of wastewater effluent. This is stated as the concentration of a suite of four to twelve (or more) pollutants in the effluent. The number, type and permitted concentration differs considerably from site to site. The EPL also specifies the required monitoring of wastewater. This includes the frequency that pollutants need to be sampled in the WWTP effluent. It is commonly required that samples are collected at monthly intervals and are required to be reported to the EPA. The EPL may require that certain discharge limits are never exceeded. This is classified in the EPL as a '100 percentile' limit meaning that it cannot be exceeded. Other discharge limits are allowed to be exceeded periodically, for example a '50 percentile' discharge limits means that half of all samples collected over the period (generally a year) must be less than that specified discharge limit. Other common classes are '90 percentile' that allow 10% of samples to exceed the limit.

Figure 12. Quakers Hill WWTP (EPL 1724; Western Sydney) discharging treated effluent to Breakfast Creek, a tributary flowing within the Hawkesbury-Nepean catchment.

Figure 13. Cover page of 42-page Environment Protection Licence (EPL 1724) for Quakers Hill WWTP (Western Sydney).



Section 55 Protection of the Environment Operations Act 1997

**Environment Protection Licence**

Licence - 1724

| Licence Details | |
|---|---|
| Number: | 1724 |
| Anniversary Date: | 01-July |

**Licensee**

SYDNEY WATER CORPORATION

PO BOX 399

PARRAMATTA NSW 2124

**Premises**

QUAKERS HILL SEWAGE TREATMENT SYSTEM INCLUDING THE STP AT

QUAKERS ROAD (NEAR MELROSE AVENUE)

QUAKERS HILL NSW 2763

**Scheduled Activity**

Sewage treatment

| Fee Based Activity | Scale |
|---|---|
| Sewage treatment processing by large plants | > 10000-20000 ML annual maximum volume of discharge |

**Region**

Metropolitan Infrastructure

4 Parramatta Square, 12 Darcy Street

PARRAMATTA NSW 2150

Phone: (02) 9995 5000

Each of the 214 individual inland WWTPs in NSW has an EPL that displays the required quality of effluent that is available on a publicly accessible register (https://apps.epa.nsw.gov.au/prpoeoapp/). The 214 inland NSW WWTP licences were examined for this project to investigate whether effluent was regulated to a standard where it could be potentially used for a range of recycled water uses. It is not known exactly what proportion of NSW inland WWTP effluent is recycled as the majority is disposed into nearby waterways. In order to encourage potential use of treated effluent for beneficial uses this investigation sought to determine if inland NSW wastewater could match any of the recycled water classifications specified in Victoria (Class A+, Class A, Class B, Class C, Class D).

There are seven key pollutants (Table 14) that are used to classify recycled water into one of the five categories. The Victorian recycled water categories require higher levels of treatment to achieve the highest quality (A+ and A grade) recycled water that can be safely used for the widest variety of potential uses, compared to the lower Class B and Class C recycled water. The lowest standard of treatment is needed to achieve Class D. For this investigation four of the most important pollutants (nitrogen, oxygen demand, total suspended sediment, faecal bacteria) were examined using the EPLs for each of the inland NSW WWTPs. These four pollutants are frequently used to regulated treated sewage discharges (in EPLs) and they are key water quality indicators used to assess the suitability of treated effluent for recycling.

Table 14. Treated sewage effluent wastewater conditions and suitability for recycling using the Victorian Government's recycled water categories.

| Classes | Total Nitrogen (mg/L) | Biochemical Oxygen Demand (mg/L) | Faecal Coliforms (cfu/100 mL) | Suspended Sediment (mg/L) | Chlorine (mg/L) | Turbidity (NTU) | pH (pH units) |
|---|---|---|---|---|---|---|---|
| Class A+ | <5 | <10 | <1 | <10 | <1 | <2 | 6-9 |
| Class A | <5 | <10 | <10 | <10 | <1 | <2 | 6-9 |
| Class B | <30 | <30 | <100 | <30 | - | - | 6-9 |
| Class C | <30 | <30 | <1000 | <30 | - | - | 6-9 |
| Class D | <30 | <30 | <10000 | <30 | - | - | 6-9 |

The inland WWTP were grouped according to one of 29 NSW river catchment divisions (Figure 14, Figure 15). Some catchments had only 1 WWTP, such as Tweed River catchment (far north-east corner of NSW). In contrast, two larger catchments (Hawkesbury-Nepean River and Murrumbidgee both had the equal most (26) WWTPs (Figure 15).

Figure 14. Map identifying locations of 214 inland WWTPs in NSW (red dots) examined in this study. The inland NSW river systems (blue) and broad regional areas of NSW (black lines).

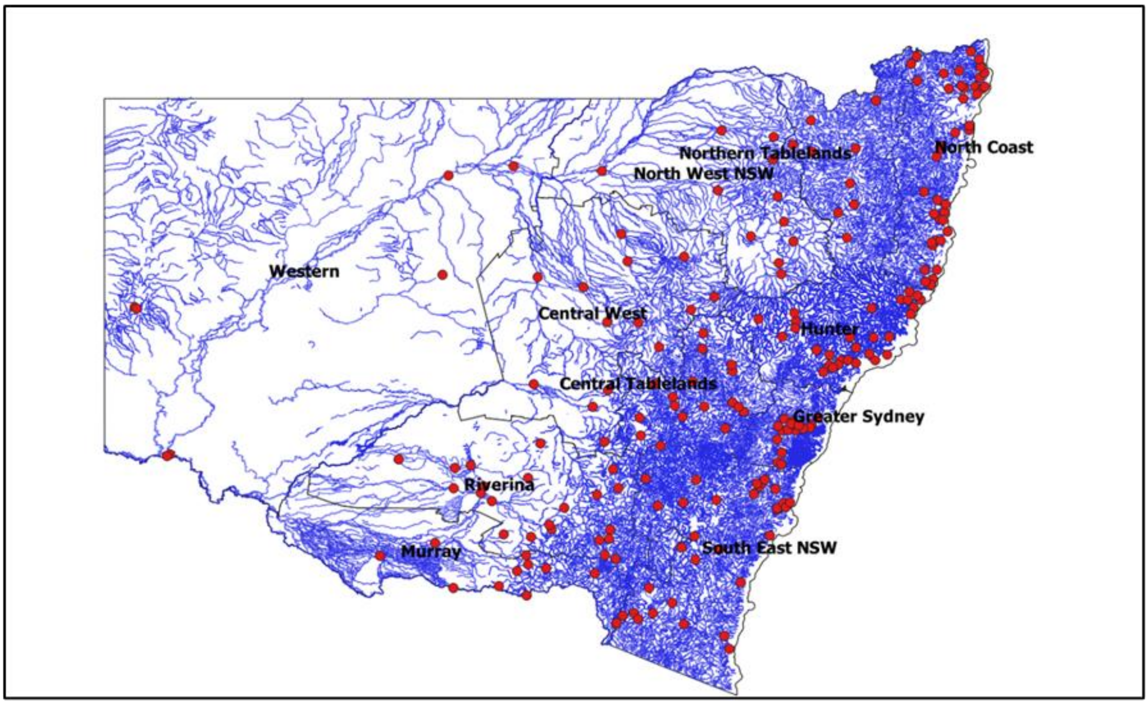
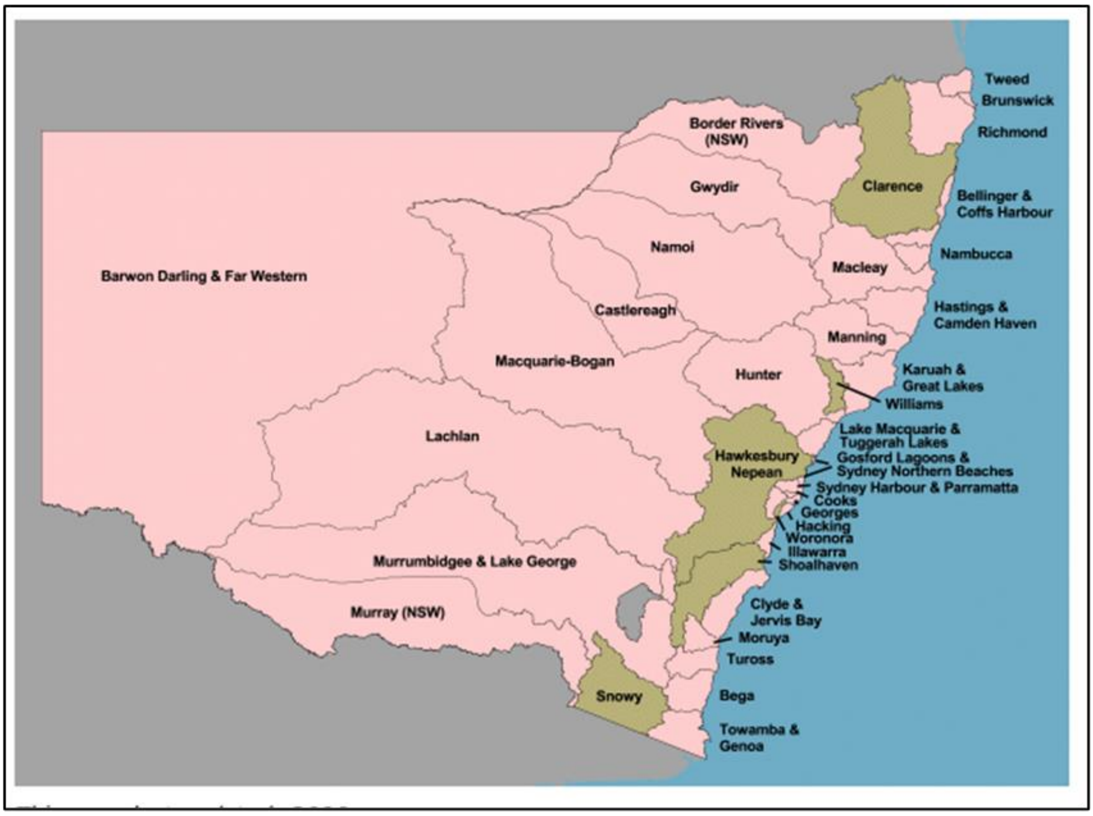



Figure 15. Map of NSW river catchments.



## Total Nitrogen in NSW inland treated sewage outfall discharges

Nitrogen is an essential plant nutrient and is generally present in relatively low amounts in undisturbed waterways in south-eastern Australia. When elevated concentrations of nitrogen occur in inland waters (streams, rivers, lakes and wetlands). It is often associated with problematic blooms of blue-green algae that be harmful to people, to animals (livestock and wildlife; Figure 16). It is one of the four key pollutants used to classify treated sewage effluent for recycled uses, in the Victorian recycled water guidelines. Nitrogen is also very commonly used in NSW discharge licences for WWTPs.

Figure 16. A small wetland with elevated nitrogen, phosphorus and a bloom of blue-green algae.

NSW inland waterways often suffer from hazardous levels of blue-green algae (also called cyanobacteria) and public warnings are regularly made advising people to take precautions to avoid contact with contaminated water. Elevated nitrogen is one of the key pollutants that can allow blue-green algae to bloom in inland waterways. Elevated nitrogen can also impair inland waterways and adjoining land through encouraging over-stimulation of invasive aquatic weeds within waterways, and along adjoining riparian lands (Figure 17).

The highest quality treated WWTP effluent recommended for the widest variety of recycled water uses (Class A and Class A+) according to the Victorian standards require less than 5 mg/L of total nitrogen. Class B, C and D allow up to 6 times more nitrogen (<30 mg/L). Of the 217 STP outfalls to NSW inland waterways (or to nearby land) 73 (33.6 %) have no discharge limit for total nitrogen in the treated effluent (Table 2). The other 142 that do specify nitrogen discharge limits ranging from 0.4 mg/L (90$^{th}$ percentile) to a maximum of 45 mg/L (100$^{th}$ percentile; Table 15).

Figure 17. Invasive aquatic plants being removed from an urban wetland with elevated nutrients (nitrogen and phosphorus) Photo from Bankstown City Council.

The Quakers Hill WWTP (see Figure 13) is one of the three largest inland STPs that also has the largest 100 percentile discharge limits in NSW for Total Nitrogen in effluent of 45 mg/L (Table 15). Such a highly elevated level would not be appropriate for any of the five classes of recycled water (Victorian Government). However, the EPL 1724 for Quakers Hill advises that much lower concentrations of Total Nitrogen (50 % percentile of 6 mg/L) will be required from 2024 onwards (NSW EPA, EPL 1724). From then it is expected that the nitrogen would conform with Class B, C and D recycled water (for nitrogen) requirements.

Blackheath STP operated from the 1930s until its closure in 2009 and discharged very high concentrations of nitrogen into Hat Hill Creek, that flowed into high conservation-value lands covered by the Greater Blue Mountains World Heritage Area (Figure 18). The sewage flows from Blackheath and other small Blue Mountains townships are now transferred to a much larger STP (Winmalee EPL 1963) in the lower Blue Mountains that releases effluent away from the World Heritage Area and discharges waste via a small tributary to the Nepean River and it has a $90^{th}$ percentile total nitrogen limit of 15 mg/L.

Table 15. Number of NSW Inland WWTP licenced to meet various total nitrogen discharge limits and compliance with Victorian recycled water standards (for total nitrogen).

| Total Nitrogen discharge limit | Recycled water grade (Victoria) | Number (percentage) |
|---|---|---|
| 35-45 mg/L (100 percentile) | Does not comply | 13 (6.1 %) |
| 10-30 mg/L (100 percentile) | Grade B, C, D | 45 (21%) |

| Total Nitrogen discharge limit | Recycled water grade (Victoria) | Number (percentage) |
|---|---|---|
| <10 mg/L (100 percentile) | Grade A/A+ | 0 |
| 0.4 – 30 mg/L (50 or 90 percentile) | Uncertain | 83 (38.8%) |
| No nitrogen discharge limits | Does not comply | 73 (34.1%) |

Figure 18. Treated sewage containing elevated concentrations of nitrogen and phosphorus from the now closed Blackheath sewage treatment plant entering Hat Hill Creek (NSW Blue Mountains). Photo Ian Wright.

## BOD in treated sewage outfall discharges

Elevated levels of BOD in inland waters (streams, rivers, lakes and wetlands), along with nutrients (nitrogen and phosphorus) are together associated with water pollution due to untreated or poorly treated sewage wastewater. BOD is directly related to the amount of organic material in wastewater and reflects the degree of sewage treatment. The measurement of BOD is a laboratory test that measures the amount of oxygen demanded by a sample of the effluent to break down all of the organic matter contained within a sample. Effluent with an elevated BOD concentration that enters a waterway can remove dissolved oxygen from large areas of estuary, stream, river or wetland resulting in the death of fish (termed a 'fish-kill') and causing wider damage to river ecosystems.

The highest quality treated sewage effluent recommended for the widest variety of recycled water uses (Class A and Class A+) according to the Victorian standards recommend treated effluent has less than 10mg/L of BOD. The other three lesser categories (Classes B, C and D) allow a much higher BOD (10 mg/L- 30 mg/L).

BOD is one of the most widely used pollutants in NSW inland WWTPs (Table 16). Of the 214 WWTPs, 92.5% (198) included BOD as an assessable pollutant in their discharge licence. 16 (7.5 %) of WWTP did not include BOD in their discharge licence. The other 198 have a wide variety of BOD discharge limits, with limits based on permitted discharges at the 50 percentile, 90 percentile and/or 100 percentiles. The 198 EPLs that specify BOD concentration discharge limits ranged the lowest levels of 4 mg/L (90 percentile).

One WWTP (EPL 2391 Old Bar Sewerage Treatment Works, MidCoast Council) had the lowest BOD discharge limit of 5 mg/L. This was one of ten (10) NSW WWTP that had BOD discharge limits (of <10 mg/L) that conform the Victorian Class A/A+ recycled water BOD standards. 134 (62.6%) of the EPLs of the 214 inland NSW treated sewage have a 100% discharge limit with a BOD of 15-30 mg/L (or less). This would be an appropriate BOD standard to produce recycled water of Class B, Class C or Class D, which all require < 30 mg/L BOD.

Table 16. Number of NSW Inland WWTPs licenced to meet various BOD discharge limits and compliance with Victorian recycled water standards (for BOD).

| BOD discharge limit | Recycled water grade (Victoria) | Number (percentage) |
|---|---|---|
| >30 mg/L (100 percentile) | Does not comply | 15 (7 %) |
| 15-30 mg/L (100 percentile) | Grade B, C, D | 134 (62.6%) |
| <10 mg/L (100 percentile) | Grade A/A+ | 10 (4.7 %) |
| 4 – 90 mg/L (50 or 90 percentile) | Uncertain | 39 (18.2%) |
| No BOD discharge limits | Does not comply | 16 (7.5%) |

Figure 19. Aged trickling filter technology at the Blackheath sewage treatment that closed in 2009. Photo Ian Wright.

## Faecal bacteria (coliforms) in treated sewage outfall discharges

Faecal bacteria are routinely tested in water and wastewater to measure the likely presence of potentially harmful disease-causing microorganisms. These might include water-borne disease-causing organisms such as viruses, bacteria, protozoans. This is particularly important where rivers, streams and estuaries are used for swimming and other forms of aquatic recreation (Figure 20). Many rivers are also used as town and domestic water supplies. As many of the NSW rivers are also used to dispose of treated sewage effluent and the conflicts with water supply and recreational uses have obvious health risks. The highest quality treated sewage effluent recommended for the widest variety of recycled water uses (Class A <10 and Class A+ <1 cfu/100 mL) has very low to low levels of faecal bacteria. According to the Victorian standards recommend treated effluent with than <1 to 10 Faecal Coliforms cfu/100 mL. The survey revealed that no NSW WWTP has faecal coliform discharge limits that comply with either Class A/A+ recycled water.

Of the 214 STP outfalls to NSW inland waterways (or to nearby land), 102 (47.7 %) have no discharge limits for faecal bacteria in the treated effluent (Table 8). The other 112 have a wide variety of discharge limits, based on permitted discharges at the 50 percentile, 90 percentile and/or 100 percentiles. The most common tests are faecal coliforms. Discharge limits range from 2 cfu/100 mL to 10000 cfu/100 mL. The WWTP in NSW with the lowest 100 percentile discharge limit for faecal coliforms is EPL 456 (Berridale sewage treatment plant in the Snowy catchment) with a limit of 100 cfu/100 mL (REF). There are no EPLs that conform with the Victorian class A recycled water categories requires faecal bacteria of 10 cfu/100 mL (or less for Class A+). 89 WWTPs in NSW have faecal coliform discharge limits that comply with Class C recycled water. These have discharge limits ranging from 100 to 100 cfu/100 mL (Table 17).

Table 17. Number of NSW Inland WWTP licenced to meet various Faecal Coliform discharge limits and compliance with Victorian recycled water standards (for faecal coliforms).

| Faecal coliforms discharge limit | Recycled water grade (Victoria) | Number (percentage) |
|---|---|---|
| >10000 cfu/100 mL (100 percentile) | Does not comply | 0 (0 %) |
| 1000< – <10000 cfu/100 mL (100 percentile) | Grade D | 1 (0.5%) |
| 100< – <1000 cfu/100 mL (100 percentile) | Grade C | 89 (41.6 %) |
| 10< - <100 cfu/100 mL (100 percentile) | Grade B | 1 (0.5%) |
| 1<-<10 cfu/100 mL (100 percentile) | Grade A | 0 (0 %) |
| <1 cfu/100 mL (100 percentile) | Grade A+ | 0 (0 %) |
| 2 – 200 cfu/100 mL (50 or 90 percentile) | Uncertain | 22 (10.3%) |
| No faecal coliforms discharge limits | Does not comply | 102 (47.7%) |

Figure 20. Swimmers entering the Nepean River (Penrith NSW) for an annual 3 km swimming race in 2008. Photo Susan Wright.

## Suspended solids in treated sewage outfall discharges

Elevated concentrations of suspended solids in inland waters (streams, rivers, lakes and wetlands), along with nutrients (nitrogen and phosphorus) are often associated with sewage effluent pollution. Raw sewage contains about 100-600 mg/L of suspended solids (Figure 21). Total suspended solids (TSS) are very small particles that are larger than 2 microns and remain suspended in water. Larger particles are too heavy to be suspended and fall to the bottom of waters. Particles smaller than 2 microns (which is the average filter size) is considered a dissolved solid. Most suspended solids are made up of inorganic materials, such as clay particles and very small silt particles. Organic materials such as bacteria and algae can also contribute to the total suspended solids concentration. Elevated levels of suspended solids can be a physical pollutant that can impair natural waterway ecological processes, such as reducing light penetration and clogging gills. They can also discolour waterways and contribute to poor recreational water quality of natural waters (Figure 22).

Figure 21. Sewage being treated at St Marys Sewage Treatment Plant. Photo Ian Wright.

The highest quality treated sewage effluent recommended for the widest variety of recycled water uses (Class A and Class A+) according to the Victorian standards recommend treated effluent with than < 10mg/L of TSS.

Of the 214 STP outfalls to NSW inland waterways, (or to nearby land) 24 provide no EPL discharge limit for suspended solids in the treated effluent (Table 18). The other 193 have a wide variety of discharge limits, based on permitted discharges at the 50 percentile, 90 percentile and/or 100 percentiles. The discharge limits vary from 5 to 480 mg/L. Overall, the 151 EPLs that specify one or more 100 percentile TSS concentration discharge limits, the smallest is 15 mg/L. Consequently, no inland STP in NSW has an EPL licence appropriate for production of effluent of 10 mg/L (or less) as required under SS criteria for class A and A+ recycled water.

Figure 22. Sediment polluted water in South Creek, near the confluence with Hawkesbury River (Windsor, NSW). Photo Ian Wright.


Table 18 shows that 121 (56.5%) of the EPLs of the 214 inland NSW treated sewage have a 100% discharge limit with a TSS limit of 30 mg/L (or less). This would be sufficient to satisfy the SS requirements for recycled water of Class B, Class C or Class D, which all require < 30 mg/L SS.

Table 18. Number of NSW Inland WWTP licenced to meet various Total Suspended Solids (TSS) discharge limits and compliance with Victorian recycled water standards (for TSS).

| TSS discharge limit | Recycled water grade (Victoria) | Number (percentage) |
|---|---|---|
| Above 30 mg/L (100 percentile) | Does not comply | 30 (14 %) |
| 10<-<30 mg/L (100 percentile) | Grade B, C, D | 121 (56.5%) |
| <10 mg/L (100 percentile) | Grade A/A+ | 0 (0 %) |
| 5 – 480 mg/L (50 or 90 percentile) | Uncertain | 37 (17.3%) |
| No TSS discharge limits | Does not comply | 26 (12.1%) |

## Environmental Monitoring of WWTP discharges to NSW rivers

A surprising finding from the review of the 214 NSW EPLs was that only 42 (19.6%) required the WWTP owner to monitor the river water quality above and below the outfall. This allows an ongoing assessment of the water quality environmental impact monitoring on the river or stream that receives the effluent. The majority (80.4%) only requiring monitoring of the outfall 'end of pipe'. This suggests that the many WWTP may not be aware of the impact of their outfalls on the surrounding environment. The upstream / outfall and downstream triangulation allows a more detailed understanding of how dilution of river flow may be softening the adverse effects of effluent.

## Conclusions from investigation of NSW inland and regional WWTP outfalls

1. NSW WWTP outfalls are regulated by the NSW EPA using a diverse range of pollutant discharge limits, contained in 'Environmental Protection Licences'.
2. None are regulated to a standard that would appear likely to reliably produce a highly treated wastewater that would conform to Victorian Class A (or Class A+) recycled water standard.
3. It is possible that some WWTPs may be producing a much higher quality effluent that their EPA licence requires, and comparison of raw effluent with Victorian recycled water standards may yield more positive results.
4. The survey of the 94 WTAs showed a very poor response rate and gathering outfall effluent data is likely to be very slow and require more time and resources than was earlier anticipated.
5. Although there was limited participation in the initial survey, those that did respond showed a distinctive positive consensus surrounding interest in the use of recycled water particularly in regional communities often at risk of drought and water shortages.
6. Obtaining monitoring data should be a simple process in NSW under the Protection of the Environment Operations Act (NSW) (POEO) that requires public access to EPL data on request.
7. However, the survey was hampered by websites not being updated or updated with condensed summary data. Slow response from WWTP involved long wait times to obtain any response. Accessing data can take up to a month. In all cases the three WTAs required reminder and follow up emails with one Local Government water authority requiring EPA intervention to 'encourage' the request for data.
8. This information is required to be accessible to the public under the POEO Act. Any of the above information that is not accessible to the public can be requested under Section 66 (6):
   "Licensees who undertake monitoring as a result of a licence condition must publish or make available pollution monitoring data within 14 days of obtaining the data and/or receiving a specific request for a copy of the data"
9. An unanticipated difficultly was obtaining the exact location of inland WWTP outfalls. The location is often vague or missing from EPLs. This may prevent people from knowing where sewage effluent is released in a waterway. In some cases, this could pose a human health risk for local waterway users, such as for swimming and other recreational activities.

   Example:
   a. EPL 350 – Gulargambone Sewerage Treatment Works*: Outlet of Tertiary Pond as shown on map titled "Point 1 - Outlet of Tertiary Pond" dated 14 November 2018 (EPA reference DOC18/755051)*

   b. EPL 363 – Frederickton Sewage Treatment System: *The effluent outlet point discharging to the Macleay River as marked "363" on drawing titled "Frederickton*

*Sewerage Scheme" submitted with Licence Information From dated 27 July 1999.*

10. The address of the WWTP often lacked a street address which makes it difficult for members of the public to find these locations on a map. This investigation used 'Google Maps' or other EPL documents (see Figure 12 and 13) to obtain aerial images of WWTPs to confirm location. These images did not show discharge pipe to the river which made it impossible to accurately confirm the coordinates of discharge points. Some WWTPs discharge several kilometres away from the plant.

## Pilot Study collecting WWTP performance data in three Local Government Areas

A pilot study was conducted on three Local Government Areas (LGAs) in NSW to determine the accessibility of up-to-date monitoring data. It also was done to assess the responsiveness of WWTP owners and EPA in providing data requested under the NSW POEO Act. The intention behind this project was to identify the ease of access to information for members of the public with regards to seeking information on outfalls in their local river. The WWTP are coded as WTA 1, WTA 2 and WTA 3. These WWTPs were chosen as they discharge treated effluent into important rivers that have multiple uses and values in NSW. It is a legislated requirement in NSW that outfall monitoring data is published on the water authority websites. In all three cases it appeared that the data available was not up to date.

It is important to note this study was conducted during the COVID-19 lockdown period when all businesses, particularly local government, were responding to a higher volume of inquiries under difficult circumstances. Under the POEO Act, monitoring data is required to be kept up to date and published on the WTAs website or made available within a reasonable timeframe (two weeks) following a written request. An initial email was sent to the respective LGA General Managers to explain the nature of the request and also to introduce the project. A follow up email was then sent to all three WTAs 13 days after the initial request if no effective response to our request was received.

WTA 1 had a prompt same day response with a link to the location of their outfall data on their website. They had not realised that the outfall data was incomplete and not up to date. However, following a second reminder email the data was provided just over two weeks after the initial request.

WTA 2 did not respond to the initial email but did quickly respond to the follow up email and the data was made available just under two weeks follow the initial request. The General Manager of WTA 2 did apologise for the delay as they had forwarded on the request to the appropriate personnel and was "disappointed" in the delay.

WTA 3 did not respond to either the initial request for up-to-date monitoring data or to the follow up reminder email. At this time a request was submitted to the NSW EPA for assistance. It took two weeks for the EPA to confirm if the data could be released after some debate surrounding the need for a formal NSW Government Information Access Request (GIPA) request. However, the EPA was able to get in contact with WTA 3 and the required information was consequently updated on their website. This resulted in access to the requested data more than 4 weeks after the original request was made.

This pilot study demonstrates how difficult and slow it can be to obtain complete, up-to-date outfall monitoring data. In one instance, the conflicting advice from the EPA would have made it very confusing for members of the public to understand what information they are legally entitled to access under the POEO Act. It appeared that the EPA do not monitor WTAs to ensure that monitoring data is published and kept up to data, as required by law. Residents of regional and metropolitan NSW often use local rivers for recreation and as a heat refuge during the summer months. This pilot study of three of 217 outfalls in NSW revealed how access to recent outfall monitoring data can be slow and difficult to receive. This could have many implications for many uses and values of rivers that are subject to outfalls. The ability to assess the impact of outfalls on quality of their river is vital for human health and for river ecological health.

# Chapter 6. Preliminary review of Industrial ocean outfalls discharge

## Research Gap

Changes to marine environment health in the coastal zone are becoming more complex, pervasive and are occurring at a much faster rate, primarily due to human-related activities (Cloern et al., 2016). Wastewater disposal into the marine environment is a key factor leading to the deterioration of coastal water quality. Disposals from coastal industries, such as dairies, mining, meat works, manufacturing plants and aquaculture contribute to the problem. Compared to normal household, industrial sourced wastewater tends to contain more pollutants including traces of toxic chemicals and heavy metals (Jahan and Strezov, 2019, de Morais et al., 2018, El Zrelli et al., 2018). These pollutants may cause serious and possibly lethal impact on the marine ecosystem (El Zrelli et al., 2018) and human health (Chen et al., 2019).

The National Pollution Inventory (NPI) is an internet database providing a list of information related to emission and toxic substances in Australia (DAWE, 2020). This pollution inventory is managed by the DAWE. The NPI has identified over 90 substances which may have possible impacts on the environment and human health. However, this database is exclusively for recording only chemical and heavy metals. While dairies and meat industries may release bacteria and pathogens into the environment, these measurements are not included in the NPI.

To address this need, the COF conducted a preliminary review of industrial outfalls for investigating the data availability and possibility for future collection. Each state and territory EPAs were contacted for further assistance in order to gain initial information. The results are explained below.

## Results

It was found that each state/territory has its own licensing system with no standardisation in terms of accessibility and parameters readily available. This in part is confounded by industries specific key pollutants. Availability is listed in Table 19.

Table 19. Licensing and annual report availability within Australian state and territory. Asterix (*) indicates that license number available on map. The link contains a unique token for downloading purposes.

| State/Territory | License Online | | | Annual Report Online | | |
|---|---|---|---|---|---|---|
| | Availability | Pollutants | Example | Availability | Pollutant Loads | Example |
| Queensland | Yes | Yes | Here | No | No | No |
| Northern Territory | Yes | Yes | Here | No | No | No |
| Western Australia | Yes | Yes | Here | No | No | No |
| South Australia | Yes | Yes | Here | Yes | No | No |
| Victoria | Annual | Annual | Annual | Yes | Yes | Here |
| Tasmania | Yes (mapped) | ID # only* | No | No | No | No |
| New South Wales | Yes | Yes | Here | N/A | N/A | N/A |

Tasmania has industrial locations recorded in the LIST, which makes identification of coastal discharges easier. With the exception of Tasmania, other states and Northern Territory have a directory with an online search function and types of waste discharges which can be identified using the search functions (e.g.: process or industry) and cross referencing with licenses.

Annual pollutant load limits appear in most licenses. Victoria's EPA is the only authority publishing "Annual Performance Statements" in which average values of pollutants and volumes along with compliance/noncompliance issues are included.

Regulatory authorities in all jurisdictions were contacted for further assistance. Tasmania EPA responded that approximately over 20 industrial discharges could be identified, with data available upon request. Victoria EPA's website is still in transition; information of parameters can be sourced from licences where accessible but at this stage they are not linked to any mapping. A New South Wales EPA representative stated that there are only small number of sites identified, which are mainly located in the Hunter Valley. Cross referencing with the National Pollutant Inventory was also suggested to identify sites.

A preliminary search of industries, which possibly discharge effluent into the waterways, yielded the following sites of industrial discharges (Table 20). Currently, the COF has recorded approximately 130 sites including 49 sites below.

Table 20. An initial list of industries that discharged their effluent into the coastal waterways.

| Industry name | Industry activity | Licence No. | Authority |
|---|---|---|---|
| Power Generation Corporation | Gas | WDL212-02 | NT EPA |
| Power Generation Corporation | Gas | WDL212-02 | NT EPA |
| INPEX Operations Australia Pth Ltd | Dredging | WDL240 | NT EPA |
| INPEX Operations Australia Pth Ltd | Dredging | WDL240 | NT EPA |
| INPEX Operations Australia Pth Ltd | Dredging | WDL240 | NT EPA |
| INPEX Operations Australia Pth Ltd | Dredging | WDL240 | NT EPA |
| Project Sea Dragon Pty Ltd | Aquaculture | WDL242 | NT EPA |
| Vista Gold Australia Pty Ltd | Mining | WDL178 | NT EPA |
| Territory Iron Pty Ltd | Mining | WDL191-07 | NT EPA |
| Territory Iron Pty Ltd | Mining | WDL191-07 | NT EPA |
| Territory Iron Pty Ltd | Mining | WDL191-07 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL166-06 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL180 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL180 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL180 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL180 | NT EPA |
| NRR Mining Pty Ltd | Mining | WDL246 | NT EPA |
| NRR Mining Pty Ltd | Mining | WDL246 | NT EPA |
| Northern Territories Resources Pty Ltd | Mining | WDL177 | NT EPA |
| McArthur River Mining Pty Ltd | Mining | WDL174 | NT EPA |

| Industry name | Industry activity | Licence No. | Authority |
|---|---|---|---|
| McArthur River Mining Pty Ltd | Mining | WDL175 | NT EPA |
| Broadwater Cogeneration Power Plant | Power station | 20425 | NSW EPA |
| Rocla Pty Limited | Concrete works | 4786 | NSW EPA |
| Hanson Construction Materials Pty Ltd | Mining | 5289 | NSW EPA |
| Hurd Haulage Pty Ltd | Mining | 4040 | NSW EPA |
| Sydney Metropolitan Pipeline | Chemical storage | 1969 | NSW EPA |
| Blue Ridge Hardwoods | Sawmill | 11124 | NSW EPA |
| Pentarch Logistics Pty Ltd | | 1482 | NSW EPA |
| Seymour Whyte Constructions Pty Ltd | Construction | 21127 | NSW EPA |
| John Holland Pty Ltd | Construction | 21182 | NSW EPA |
| Ina Operations Pty Limited | | 5888 | NSW EPA |
| Supagas Pty Limited | Chemical storage | 21178 | NSW EPA |
| Shoalhaven Starches Pty Ltd | Processing | 883 | NSW EPA |
| DPI Nsw | Miscellaneous | 2309 | NSW EPA |
| BOC Limited | Chemical | 11164 | NSW EPA |
| SCE Transport and Logistics Pty Limited | Shipping | 20984 | NSW EPA |
| Port Kembla Copper Pty Ltd | Mining | 1753 | NSW EPA |
| Park Pty Ltd | Chemical and shipping | 654 | NSW EPA |
| Metal Manufactures Pty Limited | Metallurgical | 6158 | NSW EPA |
| Ixom Operations Pty Ltd | Chemical | 549 | NSW EPA |
| Hanson Construction Materials Pty Ltd | Mining | 2193 | NSW EPA |
| Graincorp Operations Limited | Chemical and shipping | 3693 | NSW EPA |
| Dunmore Sand & Soil Pty Limited | Mining | 11147 | NSW EPA |

# DISCUSSION

## (1) The continuation of NOD: outfall ranking 2019/2020 FY

Due to significant changes caused by COVID-19, some WTAs have to reduce the capacity of human resources in their organisations. This has impacted the NOD data collection for 2019/2020 financial year. Under normal circumstances, the data collection timeframe is between one to two months and receives almost all water quality data. Currently, a quite large number of outfalls were not included in the data analysis, hence the incompleteness compared to last year (Rohmana et al., 2020).

Nutrient concentrations and discharge flow data was collected from 140 outfalls around Australia. These outfalls were ranked according to their combined nutrient load (nitrogen and phosphorous). General patterns show that the highest nutrient loads tend to occur through those outfalls serving metropolitan and surrounding areas. Outfalls with lower nutrient loads seem to occur in regional areas, however the loads varied across individual outfalls. The nitrogen and phosphorous loads seemed to vary more across sites with higher nutrient loads. This may simply be related to the high population levels in urban areas and the resulting increase in general discharge at metropolitan and outfall sites. There are some exceptions to this pattern, with rural/regional sites contributing higher nutrient loads than urban areas. These include places such as Smithton in Tasmania, Rockhampton in Queensland and Warrnambool, Victoria. The reasons for them may vary, however, and they may primarily be due to the condition set out in the licenses. License conditions are determined by a variety of factors, including the conditions of the waterway being discharged to, and the communities uses of the waterway (EPA NSW, 2013, EPA VIC, 2017). For example, Warrnambool has a nitrogen concentrations limit of 30 mg/L, compared to the combined Melbourne Eastern Treatment Plant (ETP) and Boneo (Table 2) outfalls that each has the same concentration limit of 25 mg/L. In addition to existing conditions and the uses of waterways, available resources for treatment plant upgrades and community pressure may also contribute to WWTP load. Boag's Rock outfall, which is run by the Melbourne ETP, have come under significant community pressure in the past and upgraded to tertiary treatment in 2012 (Melbourne Water, 2017). Therefore, Warrnambool, which is a secondary treatment plant, ranks in the bottom quartile with the outfalls that service the Melbourne metropolitan area.

Several sites that ranked toward the bottom of the highest quartile were sites that do not have nitrogen and phosphorous concentration limits as conditions in their licenses. This essentially means that they will not be in breach of their license regardless of the amount of nitrogen and phosphorous discharged. Werribee treatment plant in Victoria has no nitrogen concentration limit restrictions in its license. This, however, is a tertiary treatment plant, which tends to be more efficient at the removal of bacteria and the further reduction of organics, turbidity, nitrogen and phosphorous.

As illustrated here, this ranking and the identification of nutrient loads by site can therefore be useful in prioritising treatment upgrade resources. In addition, these discrepancies in treatment level and license conditions warrant further examination of water quality guidelines at a national scale, as well as wastewater reuse policies. The top quartile (lowest nutrient load) of wastewater treatment plants contributes only 0.2% of the overall nutrient load to the coastal and marine environment, while the bottom quartile contributes about 94%. Perhaps, treatment plants in the bottom quartile should be the target of an upgrade feasibility assessment in order to achieve the greatest benefit per cost in upgrade investment (Blackwell and Gemmill, 2019). In addition, some sites (e.g., Richmond and Rokeby in Tasmania) reported zero discharge. These sites are already fully recycling and diverting their wastewater to agricultural use, highlighting the success of a program that could be implemented in other areas.

## (2) Microplastics, emerging contaminants and biosolids from the outfall discharge

Our research found that there exists a developing body of knowledge within WTA in relation to emerging contaminants of concern PFAs, microplastics, biosolids and ENMs and research tends to be conducted by the larger WTAs.

Emerging contaminant concerns (ECCs) represent a challenge for WTA, decisions makers and the community that need to balance the urgent need for a greater understanding of these ECCs in water and wastewater discharges with the practical realities of current treatment processes. This is also complicated by differing perspectives on the amount of risk related to exposure these contaminants and the different values put on externalities.

It is the evolving nature of ECCs that a majority of WTA will find it difficult to monitor or treat ECCs until required to by regulatory processes i.e.: when evidence is sufficiently overwhelming for action to be taken. However, there will always be a need to integrate the understanding of ECCs in a transparent way so the community, researchers etc. can participate in an informed manner in the ECCs issue.

It is worthwhile to consider the development of a public register of involvement of WTA in either research projects, internal/voluntary monitoring or regulatory authorities related to ECCs.

## (3) Understanding the recycling of wastewater treatment plants (WWTP) effluent

Decisions on water security are fundamentally related with water recycling infrastructure. Understanding the pressures on how WTAs approach recycling and the potential impact on pollutant discharge to the receiving environment should be seen as a critical part on an evidenced based approach to water security.

Most WTAs were able to provide a good estimate of their water recycling activities. Our research found only a relatively small fraction of water is recycled from coastal WTAs and of that only thirty five percent of water recycled resulted in a reduction of pollutant load to the outfall discharge.

Also of note was that although a circular economy approach is being considered by approximately fifty percent of WTAs (and an even higher proportion considered consider water recycling to be an increasingly high priority into the future), ninety percent of WTAs would be unable to set clear five- or ten-year goals in this area.

This suggests that, despite the wish by WTAs to prioritise large scale water recycling, there is a serious deficiency in practical measures required support to commitment in this area.

Our research suggests that ongoing provision of this data would offer critical insights for policy makers. This might also benefit in future from collaboration with Bureau of Meteorology that already collects some data in this area.

## (4) National standard for reporting outfall data

Most WTA and EPAs responded constructively and supported the need for transparency and information based on evidence to be publicly accessible wherever practical, and broadly supported the proposed approach outlined in the standard document.

National standards can provide further legal directive to reduce WWTP effluent impacts to the marine environment. It can also improve health outcomes for recreational users and enhance business output (European Commission, 2017, European Commission, 2019, World Bank, 2018). National standards can redefine parameters, monitoring methods and reporting requirements in an effort to expand Australia's efforts in enhancing biodiversity protection and achieving Sustainable Development Goal 14.

Many countries have already implemented national wastewater standards in order to protect their aquatic and marine environments. The European Commission (EC) has developed the Urban Wastewater Treatment Directive (UWWTD) 91/271/EEC in 1991 (European Commission, 1991; 2019). The Directive is related to Marine Strategy Framework Directive (MSFD) 2008/56/EC, Water Framework Directive (WFD) 2000/60/EC and Environmental Quality Standards Directive (EQSD) 2013/39/EU, for setting up the water quality parameter concentration limits. It lays down four main obligations, planning, regulation, monitoring and information and reporting. The UWWTD plays a main role to deal with wastewater collection, treatment level and designated discharge location, which includes estuaries and coastal waters. The EC invested approximately EUR 25 million each year for the UWWTD framework development, implementation, wastewater infrastructures, drinking water supply and water conservation (European Commission, 2017).

In order to fulfill the UWWTD obligations, specifically monitoring, information and reporting, the EC has created Water Information System for Europe (WISE) which is divided into two areas, freshwater and marine (European Environment Agency, 2017). Under the MSFD, WISE Marine provides access to information and data on the state of European seas, including the pressures and actions being taken to protect and conserve the marine environment. The WISE Marine also prepares built-in visualisation tools for its users, such as the urban wastewater treatment viewer map. All data reported in the WISE Marine database must be in accordance with the approved formatting before it finally can be published for general usage (European Environment Agency, 2017). This website has successfully improved quality and consistency of assessment within European national level. It also harmonises the technical and organisational processes which create a streamlined high quality data reporting.

The United States has developed a water portal as a single window for reporting standard purposes (NWQMC, 2016, Read et al., 2017). The main objectives of the water portal development between these countries were similar, reducing administrative cost and paperwork of regulatory compliance. The portal also helps to streamline and simplify environmental reporting requirements. This portal provides a centralised data repository for WTP monitoring data allowing for the centralised analysis, reporting and display of water quality data across the United States. Similar to the NOD, the portal has a standardised format data upload, presentation, analysis and mapping.

Having gained a degree of ongoing support from key stakeholders the option of formalising a baseline standard of reporting in the near future, along with a process for its continual evolution as needs change, now exists.

## (5) Preliminary review on collecting inland outfalls data in New South Wales, Australia

The inland pilot study revealed large differences in the standards of effluent treatment required in the regulation of the 214 inland outfalls, owned by 94 WTAs, across NSW. This would make any attempt of comparison of discharges across NSW or nationally, without a standardised database, extremely difficult.

However, the pilot study did see many opportunities for small to medium improvements in the standard of treatment at inland outfalls (in NSW). This could result in higher quality recycled water for different uses. National standards for varying grades of recycled water, perhaps based on the Victorian Recycled water standards (Class A+ to Class D) could help influence upgrades at inland WWTPs across Australia. This should be coupled with national standards for inland outfalls. When broad geographic comparisons of inland outfall quality are available, it will enable a more effective targeted approach for prioritising upgrades.

The NSW pilot study shows that the skills currently developed by the existing NOD team could build upon the methodology used for national ocean outfalls across to inland outfalls. Many of the WTAs are medium to small Local Governments and are less likely to have dedicated staff available to facilitate sharing data. However, collecting inland outfall data and making outfall data public will be achievable with appropriate resourcing. It is likely that Queensland will also include a very large number of medium to small WTAs, similar to NSW. The other states and territories have a centralised ownership of the WWTPs and accessing inland outfall data should be easier.

### (6) Preliminary review of industrial ocean outfalls discharge

Each state/territory has significantly different format, presentation, and details for industrial outfalls. This makes any current attempt for a national perspective involving comparison of coastal or estuarine discharges between similar industries for instance very difficult. However, a review these different reporting formats has indicated a number of good features e.g., the mapping overlay feature in existence in Tasmania that could be integrated into a national industrial outfall database.

By using the skills developed by the existing NOD team, an informal system could be rapidly developed for collecting information on a collaborative basis. Appropriately resourced, a preliminary national database could be completed in 2022 that could provide links to existing documents publicly accessible. Subsequent cycles would produce refinements and help standardise reporting for classes of industry which would produce comparative data. These developments when mature, could then integrated as part of the NPI as part of it longer institutional cycle.

# CONCLUSION

The EPP has produced a foundational understanding for further research in critical areas of emerging priorities involving the complex interaction of the marine and/or riverine environment and effluent discharges from land-based activities of water authorities and continued the work of the National Outfall Database, including further refinement of a set of national standards for outfall development.

The research approach adopted of combining community interest in collaboration with other stakeholders has once again proven to be a useful approach to complex areas that will continue to challenge decision makers as they make critical decisions relating to water security and environmental impacts into the future.

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# APPENDIX A OUTFALLS RANKING 2019/2020 FY

Table 21. Australian coastal outfalls ranking by quartiles.

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 1 | South Australia | Christies Beach-Southern | 12 |
| 2 | New South Wales | Iluka | 15 |
| 3 | Tasmania | Beaconsfield | 32 |
| 4 | New South Wales | Crescent Head | 42 |
| 5 | Tasmania | Swansea | 51 |
| 6 | Tasmania | Cambridge | 151 |
| 7 | Tasmania | Bicheno | 164 |
| 8 | Queensland | Bundaberg North | 185 |
| 9 | Tasmania | Rokeby | 287 |
| 10 | Western Australia | Cocos (Keeling) Island | 291 |
| 11 | Tasmania | Sisters Beach | 391 |
| 12 | Tasmania | Triabunna | 403 |
| 13 | Western Australia | Wickham | 419 |
| 14 | Western Australia | Christmas Island | 436 |
| 15 | Western Australia | Busselton (North) | 508 |
| 16 | Tasmania | Boat Harbour | 522 |
| 17 | Tasmania | St Helens | 543 |
| 18 | Victoria | Toora | 561 |
| 19 | Victoria | Port Welshpool | 626 |
| 20 | Tasmania | Port Arthur | 631 |
| 21 | New South Wales | Bermagui | 1,010 |
| 22 | Tasmania | Beauty Point | 1,016 |
| 23 | Queensland | Karana Downs | 1,080 |
| 24 | Queensland | Port Douglas | 1,121 |
| 25 | Tasmania | Dover | 1,210 |
| 26 | Victoria | Apollo Bay | 1,531 |
| 27 | Queensland | Bowen | 1,620 |
| 28 | Victoria | Lorne | 1,717 |
| 29 | Tasmania | Stanley | 1,824 |
| 30 | Tasmania | Orford | 1,936 |
| 31 | Victoria | Anglesea | 2,243 |
| 32 | New South Wales | Camden Head | 2,423 |
| 33 | Tasmania | Cygnet | 2,513 |
| 34 | Tasmania | Risdon | 2,588 |
| 35 | Queensland | Cannonvale | 2,657 |
| 36 | Tasmania | Bridgewater | 2,740 |
| 37 | Queensland | Landsborough | 2,907 |
| 38 | Tasmania | Currie | 2,929 |
| 39 | New South Wales | Merimbula | 2,938 |
| 40 | Tasmania | Geeveston | 3,081 |
| 41 | Queensland | Bargara | 3,251 |

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 42 | Western Australia | Busselton (South) | 3,298 |
| 43 | Queensland | Innisfail | 3,941 |
| 44 | Tasmania | Strahan | 4,082 |
| 45 | Queensland | Edmonton | 4,277 |
| 46 | New South Wales | Yamba | 4,423 |
| 47 | New South Wales | Long Nose (Tomakin) | 4,654 |
| 48 | Queensland | Capalaba | 4,982 |
| 49 | Queensland | Nambour | 5,077 |
| 50 | Queensland | Rubyanna | 5,153 |
| 51 | Victoria | Foster | 5,401 |
| 52 | Queensland | Victoria Point | 5,432 |
| 53 | Queensland | Thorneside | 5,630 |
| 54 | Tasmania | Bridport | 5,708 |
| 55 | New South Wales | Penguin Heads (REMS) | 5,812 |
| 56 | Tasmania | Somerset | 5,983 |
| 57 | Queensland | Marlin Coast | 6,025 |
| 58 | New South Wales | Narooma | 6,063 |
| 59 | Queensland | Fairfield | 6,455 |
| 60 | New South Wales | Coffs Harbour | 6,957 |
| 61 | Queensland | Millbank | 7,137 |
| 62 | South Australia | Whyalla | 7,464 |
| 63 | South Australia | Port Lincoln | 8,321 |
| 64 | New South Wales | Batemans Bay | 8,450 |
| 65 | Queensland | Coolum | 8,465 |
| 66 | Queensland | Luggage Point Advanced | 8,771 |
| 67 | Tasmania | Legana | 9,736 |
| 68 | Queensland | Mackay North | 10,062 |
| 69 | South Australia | Port Pirie | 10,420 |
| 70 | New South Wales | Forster | 10,727 |
| 71 | Tasmania | George Town | 10,987 |
| 72 | Queensland | Mt St John | 13,009 |
| 73 | New South Wales | Ulladulla | 13,144 |
| 74 | Queensland | Beenleigh | 13,334 |
| 75 | Queensland | Carole Park | 13,438 |
| 76 | Western Australia | East Rockingham | 13,685 |
| 77 | South Australia | Port Augusta East | 14,081 |
| 78 | Queensland | Wynnum | 14,314 |
| 79 | Western Australia | Alkimos | 14,854 |
| 80 | Queensland | Sandgate | 15,510 |
| 81 | Queensland | Wacol | 15,798 |
| 82 | Tasmania | Round Hill | 16,370 |
| 83 | Queensland | Murrumba Downs | 17,316 |
| 84 | Tasmania | Blackmans Bay | 18,027 |
| 85 | Tasmania | Hoblers Bridge | 18,089 |
| 86 | Queensland | Caboolture South | 18,456 |

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 87 | Queensland | Maroochydore | 19,866 |
| 88 | Queensland | Woree (Southern WWTP) | 19,908 |
| 89 | Tasmania | Port Sorell | 20,777 |
| 90 | Tasmania | Selfs Point | 20,869 |
| 91 | Queensland | Goodna | 21,654 |
| 92 | Queensland | Redcliffe | 22,540 |
| 93 | Tasmania | Turners Beach | 22,628 |
| 94 | Queensland | Burpengary East | 23,993 |
| 95 | Victoria | McGaurans Beach | 24,358 |
| 96 | Tasmania | Ulverstone | 24,651 |
| 97 | Queensland | Bundamba | 25,711 |
| 98 | South Australia | Finger Point | 25,828 |
| 99 | Tasmania | Wynyard | 26,312 |
| 100 | Tasmania | Rosny | 26,844 |
| 101 | Queensland | Rockhampton South | 27,186 |
| 102 | Queensland | Cleveland Bay | 30,969 |
| 103 | Tasmania | Riverside | 32,440 |
| 104 | Victoria | Portland | 33,477 |
| 105 | Victoria | Phillip Island | 34,174 |
| 106 | Victoria | Delray Beach | 34,315 |
| 107 | Queensland | Merrimac | 36,592 |
| 108 | Victoria | Baxter's Beach | 36,655 |
| 109 | Victoria | Altona | 38,354 |
| 110 | Tasmania | Cameron Bay | 46,220 |
| 111 | Tasmania | Newnham | 51,912 |
| 112 | Queensland | Elanora | 52,066 |
| 113 | Queensland | Rockhampton North | 52,316 |
| 114 | Western Australia | Bunbury | 54,120 |
| 115 | Victoria | Port Fairy | 57,729 |
| 116 | South Australia | Christies Beach-Northern | 63,023 |
| 117 | South Australia | Bolivar High Salinity | 65,998 |
| 118 | Queensland | Gibson Island | 67,840 |
| 119 | Tasmania | Smithton | 68,620 |
| 120 | Queensland | Loganholme | 101,003 |
| 121 | Tasmania | Prince of Wales | 101,969 |
| 122 | Queensland | Coombabah | 102,068 |
| 123 | Tasmania | Ti-tree Bend | 152,605 |
| 124 | Victoria | Boags Rock (Boneo, Mt Martha, Somers) | 156,658 |
| 125 | Tasmania | Macquarie Point | 160,696 |
| 126 | Queensland | Oxley | 207,249 |
| 127 | Tasmania | Pardoe | 210,031 |
| 128 | Victoria | Black Rock | 227,317 |
| 129 | New South Wales | Winney Bay (Kincumber) | 239,581 |
| 130 | Queensland | Kawana | 243,404 |
| 131 | South Australia | Glenelg | 260,974 |

| Rank | State | Outfall | Total Nutrient Load (kg) |
|---|---|---|---|
| 132 | Victoria | Warrnambool | 285,982 |
| 133 | South Australia | Bolivar WWTP | 366,621 |
| 134 | Western Australia | Subiaco | 421,021 |
| 135 | Western Australia | Point Peron | 448,070 |
| 136 | Queensland | Luggage Point | 517,419 |
| 137 | Western Australia | Beenyup | 681,269 |
| 138 | Western Australia | Woodman Point | 1,011,506 |
| 139 | Victoria | Boags Rock (Eastern Treatment Plant) | 3,479,639 |
| 140 | Victoria | Werribee (Western Treatment Plant) | 5,103,568 |
| **Total Load** | | | **16,168,516** |

**Note:**

- = Top quartile
- = $50^{th}$ quartile
- = $75^{th}$ quartile
- = Bottom quartile

# APPENDIX B SURVEY QUESTIONS FOR CHAPTER 2 AND 3

**Part 1 Microplastics and emerging pollutants in wastewater effluent and biosolids**

Microplastics and emerging pollutants are some of the most challenging issues around the world. Many studies and reviews of microplastics, including its distribution and trends have increased public awareness to reduce the entry of microplastics into the environment. Numerous studies claim that WWTPs are the main source of per- and polyfluoroalkyl substances (PFASs) present in the surface water. The aim of this survey is to develop a greater understanding of the potential impacts of emerging pollutants (e.g. PFAS) and microplastics in the marine environment in order to forge a better understanding of current resources and data availability for identifying microplastics and other emerging pollutants, such as PFASs, and (2) to determine various possible options for future provision of microplastics and emerging pollutants data from a national perspective.

Microplastics

1. Do your facilities currently treat/filter for microplastics?
   A. Yes
   B. No

2. If yes, what technology do you use?

3. Do you monitor for the amount of microplastics in effluent?
   A. Yes
   B. No

4. Do you record or report data on microplastics?
   A. Yes
   B. No

5. Is this data available?
   A. Yes
   B. No

6. If yes, where?

7. If no, what options exist for future provision off data from a national perspective?

Emerging Pollutants

8. Do your facilities currently treat for PFAS?
   A. Yes
   B. No

9. Do you monitor for the amount of PFAS in effluent?
   A. Yes

B. No

10. Do you record or report data on PFAS?
    A. Yes
    B. No

11. Is this data available?
    A. Yes
    B. No

12. If yes, where?

13. If no, what options exist for future provision off data from a national perspective?

<u>Biosolids</u>

14. Do you record or report data on biosolids?
    A. Yes
    B. No

15. Is this data available?
    A. Yes
    B. No

16. If yes, where?

17. If no, what options exist for future provision off data from a national perspective?

18. Do you sample your biosolids for microplastics or emerging pollutants?
    A. Yes
    B. No

19. Do you monitor the composition of biosolids?
    A. Yes
    B. No

20. Approximately, how much biosolid material do you produce?

21. Where is the use of biosolids and/or where are they biosolids disposed of?

**Part II – Australian wastewater recycling: classification, calculation, and reporting.**

Rainfall deficiencies and drought in large parts of Australia have made water become a more valuable resource. In order to achieve the water sustainability, each Australian state and territory must support the notion of water recycling. In order to achieve a better understanding of the current state of water recycling throughout Australia, the Clean Ocean Foundation has been funded to conduct some foundational research into the topic. The aim of the research is to gain a wholistic understanding of

1) How each WTA measures and records its water recycling
2) How much is this a priority into the future?
3) Do WTAs have measurable targets for recycling into the future (e.g. in terms of volume or % against time)?
4) Do WTAs see a need to adopt a circular economy approach to WWTP as a potential tool of water recycling initiatives?

We seek your input in guiding this research.

22. In general, how high a priority is water recycling within your organisation?
    1- Low
    2- Medium
    3- High
    4- Very High
    5- Essential

23. In ten years' time how high a priority would you expect water recycling to be in your organisation?
    1- Low
    2- Medium
    3- High
    4- Very High
    5- Essential

24. How much are you involved with the use of recycled wastewater for each of the following?

| Purposes | Not involved | Somewhat involved | Involved | Very well involved |
|---|---|---|---|---|
| Irrigate golf courses | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in business parks | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in public parks | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in school ground | ☐ | ☐ | ☐ | ☐ |
| Irrigate non-edible crops | ☐ | ☐ | ☐ | ☐ |
| Irrigate crops for human consumption | ☐ | ☐ | ☐ | ☐ |
| Use in industrial processes | ☐ | ☐ | ☐ | ☐ |
| Use to cool buildings | ☐ | ☐ | ☐ | ☐ |
| Flush toilets in public buildings | ☐ | ☐ | ☐ | ☐ |

| Purposes | Not involved | Somewhat involved | Involved | Very well involved |
|---|---|---|---|---|
| Supply fire hydrants | ☐ | ☐ | ☐ | ☐ |
| Supply car wash businesses | ☐ | ☐ | ☐ | ☐ |
| Environmental Flows | ☐ | ☐ | ☐ | ☐ |
| Cultural Flows | ☐ | ☐ | ☐ | ☐ |
| Other - Please Describe | ☐ | ☐ | ☐ | ☐ |

25. How much water do you recycle for each of the following? (Estimates ok.)
    0-100%

| Purposes | 0% | 25% | 50% | 100% |
|---|---|---|---|---|
| Irrigate golf courses | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in business parks | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in public parks | ☐ | ☐ | ☐ | ☐ |
| Irrigate landscaping in school ground | ☐ | ☐ | ☐ | ☐ |
| Irrigate non-edible crops | ☐ | ☐ | ☐ | ☐ |
| Irrigate crops for human consumption | ☐ | ☐ | ☐ | ☐ |
| Use in industrial processes | ☐ | ☐ | ☐ | ☐ |
| Use to cool buildings | ☐ | ☐ | ☐ | ☐ |
| Flush toilets in public buildings | ☐ | ☐ | ☐ | ☐ |
| Supply fire hydrants | ☐ | ☐ | ☐ | ☐ |
| Supply car wash businesses | ☐ | ☐ | ☐ | ☐ |
| Environmental Flows | ☐ | ☐ | ☐ | ☐ |
| Cultural Flows | ☐ | ☐ | ☐ | ☐ |
| Other - Please Describe | ☐ | ☐ | ☐ | ☐ |

26. Does any of the effluent reuse identified in question 25 apply to usage onsite (i.e.: internal treatment process) as opposed to reuse external to the site?
    A) Yes
    B) No

27. If so, roughly what percentage is used for internal processes?
    _________________________________ (0-100%)

28. Environmental Flows.
    Beneficial use of environmental flows can vary depending on the conditions of the receiving environment (e.g., drought or flooding).

    Are these variations factored into estimates of environmental flows/beneficial use?
    A) Yes, please describe___________________________
    B) No

Classification

29. Classification of water quality for reuse varies across jurisdictions.
What type of classification system do you use to grade recycled water?

1) Class type (e.g. A, B, C, D).
2) Pathogen reduction (e.g. log removal values)
3) Fit for purpose (see questions 24 and 25).
4) Other Key Parameters – Please describe.

Calculation

30. Please provide a sample calculation of effluent reuse to help illustrate your methodology of estimating amount recycled for question 24 and 25

31. If Yes to Question 26, please provide a sample calculation of effluent reuse for internal use to help illustrate your methodology for estimating this amount.

32. What proportion of the pollutant mass loads ($BOD_5$, Total Nitrogen, Total Phosphorus) are diverted from discharge to the receiving environment through the recycling scheme on an annual basis?

Reporting

33. Which water quality parameters do you monitor in the recycled water?
List of parameters

34. Do you publish your monitoring data?
A. Yes
B. No

35. If Yes Q2, where are these data available?

36. Would you be able to provide them every 12-months?

37. Have you encountered any challenges to reporting?
A. Yes, please discuss______________________
B. No

38. As an organisation, do you discuss circular economy approaches as a potential tool of water recycling initiatives.
A. Yes
B. No

39. If Yes Q38, please elaborate.

40. Would it be possible for your organisation to set and report on five- and ten-year targets for water recycling?
A. Yes
B. No

# APPENDIX C SURVEY QUESTION FOR CHAPTER 4

**Survey questions - Recommendations (and high-level questions posed to stakeholders)**

Toward that end, the following recommendations and related questions have been posed to stakeholders to further develop national standard and guidelines for reporting wastewater treatment plant outfall data. Each of the questions are related to a recommendation that has been developed to improve outfall monitoring and ultimately marine environmental protection. https://www.surveymonkey.com/r/outfall-standard

| | |
|---|---|
| **Recommendation (R1): To improve transparency and accountability within the community by continuing to build on the National Ocean Database which collates and publishes outfall data on a national scale from WTA, councils and WWTPs.** | |
| **Questions** | **Answers** |
| | Yes or No |
| R1-Q1: Do you support a centralised and standardised data repository for WWTP pollutant information? | |
| | Select relevant benefits |
| R1-Q2: What are the key benefits from a centralised database data repository for WWTP pollutant information? | ☐ Stakeholder communication<br>☐ Enhanced Stakeholder trust<br>☐ Contribution to reviewal of performance of WWTP<br>☐ Comparative evaluation of pollutant loads for different WWTP<br>☐ Assist with development of regulatory framework<br>☐ Other? ______________________ |
| | Select relevant elements |
| R1-Q3: What elements of the current data collection process would you improve upon on order to make the data exchange/collection process more effective? | ☐ Communication (e.g., email)<br>☐ Timeframe<br>☐ Data formatting<br>☐ Spreadsheet form |
| | |
| **Recommendation (R2): To expand the scope of monitoring to include a comprehensive list of required pollutants to be monitored across all WTPs and expand the list to include emerging pollutants** | |
| R2-Q1a: Based on the list of pollutants in appendix A, can you indicate a percentage of those that are currently monitored at the recommended frequency? | ☐ 100%<br>☐ 80%<br>☐ 60%<br>☐ 40%<br>☐ 20% or less |
| R2-Q1b: Can you list those that would be most difficult to monitor? | |
| R2-Q1c: Are there any other pollutants that could be added to the list? | ☐ No<br>☐ Yes (please specify…) |
| | |
| R2-Q2: What is the current capacity and resource requirements to monitor microplastics and emerging pollutants? | |
| | |

| **Recommendation (R3): To provide a more comprehensive data access and reporting format to address the needs of stakeholders.** | |
|---|---|
| | Yes or No (including additional elements) |
| R3-Q1a: Does the current outfalls information website currently met the needs of your stakeholder group in terms of data storage requirements and data access? | |
| R3-Q1b: If no, what additional elements would you like to see? | |
| | Identify additional components |
| R3-Q2a: Please review the proposed elements for the "report-card" reporting format presented in appendix B.<br>Do you agree on the following statement?<br>"The proposed elements will provide valuable information and can be supplied relatively easily." | ☐ Strongly agree<br>☐ Agree<br>☐ Neither agree nor disagree<br>☐ Disagree<br>☐ Strongly disagree |
| R3-Q2b: Are there additional components you feel should be added to make the report-card format more useful? | |
| **Recommendation (R4): To modify reporting frequency to address needs of environmental protection and human health outcomes.** | |
| | Select reporting frequency |
| R4-Q1: Based on the reporting frequencies recommended in the table in appendix A, what frequency of information is possible. | ☐ Daily<br>☐ Weekly<br>☐ Fortnightly<br>☐ Monthly<br>☐ Other |
| | Identify resources |
| R4-Q2: What sort of resources/infrastructure are needed to for you to comply to the desired reporting frequencies in appendix A? | |

# APPENDIX D INITIAL LIST OF INDUSTRIAL OUTFALLS

Table 22. Initial list of industries that discharged their effluent into the coastal waterways.

| Industry_name | Industry_activity | Licence | Authority |
|---|---|---|---|
| Power Generation Corporation | Gas | WDL212-02 | NT EPA |
| INPEX Operations Australia Pth Ltd | Dredging | WDL240 | NT EPA |
| Project Sea Dragon Pty Ltd | Aquaculture | WDL242 | NT EPA |
| Vista Gold Australia Pty Ltd | Mining | WDL178 | NT EPA |
| Territory Iron Pty Ltd | Mining | WDL191-07 | NT EPA |
| RTA Gove Pty Ltd | Mining | WDL171-10 | NT EPA |
| NT Mining Operations Pty Ltd | Mining | WDL166-06 | NT EPA |
| NRR Mining Pty Ltd | Mining | WDL246 | NT EPA |
| Northern Territories Resources Pty Ltd | Mining | WDL177 | NT EPA |
| McArthur River Mining Pty Ltd | Mining | WDL174 | NT EPA |
| McArthur River Mining Pty Ltd | Mining | WDL175 | NT EPA |
| Broadwater Cogeneration Power Plant | Power station | 20425 | NSW EPA |
| Rocla Pty Ltd | Concrete works | 4786 | NSW EPA |
| Hanson Construction Materials Pty Ltd | Mining | 5289 | NSW EPA |
| Hurd Haulage Pty Ltd | Mining | 4040 | NSW EPA |
| Sydney Metropolitan Pipeline | Chemical storage | 1969 | NSW EPA |
| Blue Ridge Hardwoods | Sawmill | 11124 | NSW EPA |
| Pentarch Logistics Pty Ltd | | 1482 | NSW EPA |
| Seymour Whyte Constructions Pty Ltd | Construction | 21127 | NSW EPA |
| John Holland Pty Ltd | Construction | 21182 | NSW EPA |
| Ina Operations Pty Ltd | | 5888 | NSW EPA |
| Supagas Pty Ltd | Chemical storage | 21178 | NSW EPA |
| Shoalhaven Starches Pty Ltd | Processing | 883 | NSW EPA |
| DPI NSW | Miscellaneous | 2309 | NSW EPA |
| BOC Ltd | Chemical | 11164 | NSW EPA |
| SCE Transport and Logistics Pty Ltd | Shipping | 20984 | NSW EPA |
| Port Kembla Copper Pty Ltd | Mining | 1753 | NSW EPA |
| Park Pty Ltd | Chemical and shipping | 654 | NSW EPA |
| Metal Manufactures Pty Ltd | Metallurgical | 6158 | NSW EPA |
| Ixom Operations Pty Ltd | Chemical | 549 | NSW EPA |
| Hanson Construction Materials Pty Ltd | Mining | 2193 | NSW EPA |
| Graincorp Operations Ltd | Chemical and shipping | 3693 | NSW EPA |
| Dunmore Sand & Soil Pty Ltd | Mining | 11147 | NSW EPA |
| Dunmore Resources and Recycling Pty Ltd | Recycling | 20096 | NSW EPA |
| Coastwide Civil Pty Ltd | Boat mooring | 12426 | NSW EPA |
| Cleanaway Operations Pty Ltd | Waste | 10251 | NSW EPA |
| Boral Resources (NSW) Pty Ltd | Mining | 77 | NSW EPA |
| Bluescope Steel (Ais) Pty. Ltd. | Manufacturing | 6092 | NSW EPA |
| Australian Industrial Energy Pty Ltd | Oil and gas | 21529 | NSW EPA |

| Industry_name | Industry_activity | Licence | Authority |
|---|---|---|---|
| Vopak Terminals Sydney Pty Ltd | Chemical storage | 6007 | NSW EPA |
| VIVA Energy Australia Pty Ltd | Chemical storage | 570 | NSW EPA |
| Veolia Water Operations Pty Ltd | Sydney desalination plant | 12904 | NSW EPA |
| Terminals Pty Ltd | Chemical and shipping | 1048 | NSW EPA |
| Zoological Parks Board of NSW | Sewage treatment plant | 1677 | NSW EPA |
| Lubrizol International Inc | Chemical | 134 | NSW EPA |
| Cleanaway Operations Pty Ltd | Waste | 4560 | NSW EPA |
| Ampol Refineries (NSW) Pty Ltd | Oil and gas | 837 | NSW EPA |
| Ampol Australia Petroleum Pty Ltd | Chemical and shipping | 6950 | NSW EPA |
| Allnex Resins Australia Pty Ltd | Chemical | 993 | NSW EPA |
| Sunset Power International Pty Ltd | Energy and coal | 761 | NSW EPA |
| Hunter & Central Coast Development Corp. | Urban development | 5042 | NSW EPA |
| Great Southern Energy Pty Ltd | Mining | 1770 | NSW EPA |
| Generator Property Management Pty Ltd | Power station | 759 | NSW EPA |
| Centennial Newstan Pty Ltd | Mining | 395 | NSW EPA |
| Centennial Myuna Pty Ltd | Mining | 366 | NSW EPA |
| Bettergrow Pty. Ltd | Mining | 1246 | NSW EPA |
| Suez Water Pty Ltd | Water treatment plant | 20757 | NSW EPA |
| Tomago Aluminium Company Pty Ltd | Metallurgical | 6163 | NSW EPA |
| Stolthaven Australia Pty Ltd | Chemical and shipping | 20193 | NSW EPA |
| Port Waratah Coal Services Ltd | Waste | 5022 | NSW EPA |
| Pwcs Carrington Coal Terminal | Mining | 601 | NSW EPA |
| Newcastle Bulk Terminal | Shipping | 1967 | NSW EPA |
| Mayfield No. 4 Berth | Shipping | 13181 | NSW EPA |
| Orica Kooragang Island | Chemical and shipping | 828 | NSW EPA |
| Mcdonald's Hexham | Sewage treatment plant | 329 | NSW EPA |
| Mayfield Industrial Estate WWTP | Miscellaneous | 11549 | NSW EPA |
| Infrabuild Wire - Mayfield Campus | Metallurgical | 11149 | NSW EPA |
| Incitec Pivot | Chemical and shipping | 11781 | NSW EPA |
| Hexham Bowling Club Co-Op Ltd | Miscellaneous | 1586 | NSW EPA |
| Donaldson Coal Pty Ltd | Mining | 11080 | NSW EPA |
| Hydromet (Northern) | Chemical | 5986 | NSW EPA |
| Crei Industrial Nominees No 2 Pty Ltd | Miscellaneous | 20151 | NSW EPA |
| Mondelez Australia | Milk processing | | TAS EPA |
| Ta Ann | Wood processing | | TAS EPA |
| One Stop Recycling | Waste depot | | TAS EPA |
| Forico | Wood processing | | TAS EPA |
| Forico | Wood processing | | TAS EPA |
| Impact Fertlilizers | Chemical Works | | TAS EPA |
| Zeehan Landfill wetlands | Landfill and wetlands | | TAS EPA |
| Intercontinental Metals Pty Ltd | Waste Depot – metals recycler | | TAS EPA |
| Burnie City Council | WWTP – leachate treatment wetland | | TAS EPA |
| The King Island Company Pty Ltd | Milk Processing Works | | TAS EPA |

| Industry_name | Industry_activity | Licence | Authority |
|---|---|---|---|
| Huon Aquaculture Whale Point | Hatchery | | TAS EPA |
| Tasmanian Eel Exporters | Eel Farm/Hatchery | | TAS EPA |
| Norske Skog Paper Mills (Australia) Ltd | Pulp and Paper Mill | | TAS EPA |
| Nyrstar Hobart Pty Ltd | Metallurgical works | | TAS EPA |
| Tasmanian Seafoods Pty Ltd | Fish processer | | TAS EPA |
| Tassal Operation Pty Ltd | Fish processer | | TAS EPA |
| Forcett House Quarry | Materials Handling | | TAS EPA |
| Boral Construction Materials Group Ltd | Materials Handling | | TAS EPA |
| Circular Head Dolomite and Trading Company Pty Ltd | Materials Handling | | TAS EPA |

# APPENDIX E BASELINE STANDARD AND REPORT CARD

Table 23. Baseline standard for outfall reporting.

| **Outfall Details (As per outfall.info)** | | | | | |
|---|---|---|---|---|---|
| Water Manager/Authority | | | | | |
| License no. | | | | | |
| Outfall location | | | | | |
| Plant capacity/scale | | | | | |
| Connected population | | | | | |
| Treatment level | | | | | |
| Outfall type | | | | | |
| Mixing zone | | | | | |
| **Parameters (As per what we collect now)** | | | | | |
| Priority (A = Essential, B = Important, C = High value) | Water quality parameter | Unit | Annual | Monthly | Daily Flow |
| A | Outfall flow volume | ML | | | |
| C | Influent flow volume | ML | | | |
| B | pH | pH | | | |
| C | Total dissolved solids | mg/L | | | |
| C | Total suspended solids | mg/L | | | |
| A | Total phosphorus | mg/L | | | |
| A | Total nitrogen | mg/L | | | |
| A | Oil and grease | mg/L | | | |
| B | Surfactants (MBAS) | mg/L | | | |
| B | *E. coli* | org/100mL | | | |
| C | Enterococci | org/100mL | | | |
| C | Faecal coliforms | org/100mL | | | |
| B | Turbidity | NTU | | | |
| B | Colour | Pt. Co. Units | | | |
| **Incidents** | | | | | |
| Description | Further infromation (links etc.) | | | | |
| Out of license events | | | | | |
| Community interactions | | | | | |
| Algal blooms | | | | | |
| Blue green algal bloom | | | | | |
| **Future Changes and Key Dates Governance** | | | | | |
| Capital works- planning stage | | | | | |
| Works approval - pending | | | | | |
| Works approval - in process | | | | | |
| Proposed variation to license | | | | | |
| License history (variations etc.) | | | | | |
| Community notification policy | | | | | |
| **Emerging Contaminants** | | | | | |
| Results (if measured) | | | | | |
| Participating in research | | | | | |
| Links to papers | | | | | |
| **Recycling** | | | | | |
| Details and methodology | | | | | |

Table 24. Report card for outfall reporting

| Feature to Display | Information Listed | Pictorial Representation |
|---|---|---|
| Outfall location | GPS coordinates | Point |
| Treatment level/process | Primary, Secondary, Tertiary, Advanced Tertiary | |
| Water quality compared to class A+ recyclable | | 4 Shaded drops |
| Outfall type | Deep ocean | Symbol |
| | Coastal/estuary | Symbol |
| | River | Symbol |
| Treatment plant capacity | % Influent capacity (influent volume/capacity) | Visual % representation. |
| Influent received | Actual flow received per day | Olympic swimming pools or other relatable volume |
| Population serviced | | People |
| Effluent discharged | | Olympic swimming pools or other relatable volume |
| Nutrient load | As calculated with NOD | Containers of Food/Protein??? |
| Key pollutants/issues related to specific to outfall | e.g., Warriewood heavy rain events, Warrnambool: cotton buds phosphorus etc. | List eg e-coli, phosphorus, pH. |
| Emerging contaminant load | Are these being addressed or monitored? If so how and link to data. | Question Mark |
| Water Recycling | Percentage of Water Recycled | Recycled symbol |
| Size of mixing zone (Compromised Beneficial Use) | Description | Shaded area of mixing zone on map |
| Future changes or proposals that may affect discharge e.g., Capital works, License changes or anything else that might change pollutant load | Key dates and description of change and regulatory requirements | A suitable symbol for change |

----End of Report----

Australian Government

National Environmental Science Programme

National Outfall Database

clean ocean foundation

UNIVERSITY of TASMANIA

IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

WESTERN SYDNEY UNIVERSITY