WATER SERVICES
ASSOCIATION OF AUSTRALIA

MANAGING WET WEATHER OVERFLOWS

Guidelines for the Australian & New Zealand Water Industry 2023

Overview of WSAA

The Water Services Association of Australia (WSAA) is the peak body that supports the Australian urban water industry.

Our members provide water and sewerage services to over 24 million customers in Australia and New Zealand and many of Australia's largest industrial and commercial enterprises.

WSAA facilitates collaboration, knowledge sharing, networking and cooperation within the urban water industry. The collegiate approach of its members has led to industry-wide advances to national water issues.

WSAA can demonstrate success in standardising industry performance monitoring and benchmarking, as well as many research outcomes of national significance. The Executive of the Association retains strong links with policy makers and legislative bodies and their influencers, to monitor emerging issues of importance. WSAA is regularly consulted and its advice sought by decision makers when developing strategic directions for the water industry.

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For more information. please contact info@wsaa.asn.au

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Acknowledgement of Country

We acknowledge and pay respect to the past, present and future Traditional Custodians and Elders of this nation. We recognise their continuing connection to land and waters and thank them for protecting our waterways and environment since time immemorial.

EXECUTIVE SUMMARY

In Australia and New Zealand (ANZ), most cities and towns are serviced by wastewater systems that manage the wastewater flows. The wastewater systems typically operate separately to the stormwater systems, with two dedicated piped systems. In other parts of the world the two systems can be intentionally integrated into a combined system.

Stormwater and groundwater can enter separate wastewater systems unintentionally. These flows can result in the wastewater system capacity being exceeded and spilling to the environment. To manage this risk, emergency relief structures (wastewater overflow structures) are built into wastewater systems. These generally direct wastewater overflows into designated locations. The wet weather overflows (WWO) which occur across the wastewater system have the potential to cause harm to the receiving environment, endanger public health and adversely impact cultural values.

This guideline provides water utilities with a framework to develop a WWO strategy to manage their systems in relation to WWO. Wastewater system complexity varies considerably across ANZ, from small systems with minimal wet weather flows, to large complex systems, and systems with substantial wet weather flows. This guideline enables water utilities to develop a WWO strategy that will be specific to their unique needs and local context through a flexible approach.

Development of a WWO strategy requires two key considerations: the impact to the receiving environment and the management of this impact. This guideline provides a range of potential considerations for both.

Receiving environment

The WWO strategy must define the desired outcomes that the WWO strategy will strive to achieve and measure success against. These outcomes need to be defined in relation to the receiving environment. The receiving environment can be generally categorised into the following five principles (or values) which are externally focused:

- **Ecosystem –** Considers water-dependent ecosystems and terrestrial ecosystems that may be affected by WWO.
- **Community –** Considers the impacts WWO could have on the health and wellbeing of the community and protecting the use of the waterways and lands.
- **Property –** Considers the impacts WWO could have on properties. This typically refers to residential customer properties, however, could also include commercial, industrial, public or government owned properties.
- **Cultural –** Considers the impact that WWO can have on the First Nations values of Country where the WWO are discharging.
- **Economic –** Considers the impacts WWO could have on the economic value of waterways and their surrounds.

The water utility should consider which of the above are to be incorporated into the WWO strategy. Not all have to be selected and they can be tailored to the needs of the specific catchment or area.

Management approaches

The management approaches provide water utilities with a suite of tools to define performance expectations and inform decision making. The approaches vary to compliment the scale of WWO issues, local environmental conditions, complexity of the system and the scale of investment. These include:

- **Asset –** A systematic approach to construct, operate and maintain wastewater infrastructure to an agreed capacity.
- **Containment –** Uses a containment measure to manage system performance.
- **Outcomes –** Sets measurable goals or outcomes aligned with a strategic vision at a macro or micro level.
- **Risk-based –** Assesses the likelihood and potential consequences of WWO to identify the potential impact on the receiving environment principles.
- **Effects-based –** A data driven decision making approach for the management of activities and their actual impact on the receiving environment principles.

A single management approach could be adopted for the WWO strategy, however multiple approaches can also be adopted and combined to form a hybrid approach.

Water utilities may also need to bring in other factors into the WWO strategy. The guideline provides discussion around some of the most common elements that may influence the development of the strategy, such as:

- **Integrated water management (IWM) –** Is a whole-of-system, multi-disciplinary approach that aims to manage the entire urban water cycle. This is done by integrating the delivery of water, wastewater and stormwater services to contribute to the full suite of water security, public health, environmental and urban amenity outcomes.
- **Integrated catchment management (ICM) –** Is a cooperative approach to solving waterways problems. It involves the coordinated management of land, water and biodiversity resources based on catchment areas. It considers the complex relationships which exist within ecosystems.
- **Solutions –** WWO are a consequence of problems elsewhere (upstream or downstream) in the wastewater system and the cause of the WWO can be varied. Therefore, there are many interventions or solutions that can be implemented to improve the performance of WWO.
- **Data –** Becomes more critical as the need for decision making based on the quality of data increases.
- **Climate change –** Adaptation to the impacts of climate change should be considered when developing a WWO management approach to build resilience and manage the impacts of climate change.
- **Contaminants of concern –** Are contaminants that can be both natural and synthetic, that may cause ecological or human health effects and are not widely regulated. Thousands of contaminants are found in wastewater, and WWO increase the likelihood of these entering the environment.

The development of the WWO strategy will require stakeholder input and alignment. It will be important for the water utility to understand and engage with the key stakeholders, these could be internal or external e.g. community groups or the regulator. The WWO strategy may be integrated into broader wastewater system management plans and tools and does not need to be a stand-alone document. The WWO strategy does need to be a living document that is regularly updated, and decisions revisited as new information becomes available and stakeholder (internal and external), community and regulatory needs change.

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1 INTRODUCTION

In Australia and New Zealand (ANZ), most cities and towns are serviced by wastewater systems. Typically, wastewater is conveyed from domestic and commercial users to treatment plants via a system of pipelines and pumping stations. The wastewater is treated and effluent is discharged into the receiving environment or re-used when treated to a standard required for the beneficial reuse adopted. The primary environmental management focus has historically been on the appropriate management of discharges from wastewater treatment plants. Wastewater systems can also affect the environment in other ways, such as overflows of untreated wastewater entering waterways.

The wastewater system can consist of property drains, wastewater pipes (private, reticulation, branch and trunk), maintenance holes (or access chambers), emergency relief structures (ERS), wastewater pumping stations, odour management systems and vent shafts. Local councils, water authorities or private wastewater system operators have ownership of wastewater systems and are responsible for their operation and maintenance. These groups are collectively referred to in this document as water utilities.

In ANZ, wastewater systems and stormwater systems typically operate as separate systems, where there are two dedicated piped systems. In other parts of the world, the two systems can be intentionally integrated into a combined system. This guideline is therefore aimed at developing strategies for separate systems but could potentially be tailored for a combined system.

Stormwater and groundwater can enter separate wastewater systems unintentionally, including new systems. Emergency relief structures (ERS) are built into wastewater systems that generally direct wastewater overflows into designated locations in the environment to minimise the risk of impact on human health. The objective of an ERS is to prevent, where practical, wastewater from backing up through the wastewater system and discharging within private properties or high consequence locations. A wet weather overflow (WWO) occurs when stormwater enters the wastewater system during heavy rainfall and during saturated catchment conditions. This significantly increases the flows in the system, which can cause wastewater to overflow to the environment. WWO refers to spills which occur across the wastewater system and does not refer to discharge from treatment plants. A WWO has the potential to cause harm to the receiving environment, endanger public health, adversely impact cultural values, increase operational costs and cause reputational damage.

Overflows from wastewater systems should be avoided, apart from those caused by exceptional circumstances such as extreme wet weather events outside the intended design capacity of the system . Balancing the investment required to manage WWO against the types and their potential risk is a key topic of this guideline. Typical locations where a WWO can occur include:

- an emergency relief structure (ERS), which is a wastewater overflow structure designed to allow controlled release of wastewater
- maintenance holes or access chambers
- properties (inside and outside buildings)

The primary cause of WWO is stormwater entering the system during wet weather events through a variety of sources e.g. failing assets, reduced pipe capacity, localised flooding or illegally connected properties. An additional indirect cause of WWO can be a communications or control systems failure which leads to a decreased wastewater system capacity.

WWO have been identified as an area of concern for many water utilities, who are typically responsible for mitigating (as reasonably practical) the impacts of WWO to the receiving environment. For further information on the different receiving environments refer to Chapter 3. Developing an effective management approach (refer to Chapter 4) is important to mitigating the potential harm of WWO.

1.1 Guideline purpose

Management approaches for WWO vary across ANZ and a prescriptive approach is not appropriate. The purpose of this guideline is to provide a flexible framework for water utilities to develop a WWO strategy. This guideline assumes that a WWO strategy is the plan that defines the WWO outcomes a water utility needs to achieve. Where required water utilities can also define the short and long-term outcomes and detail the approach required to achieve those outcomes. The WWO strategy may be integrated into broader wastewater system management plans and tools and does not need to be a stand-alone document.

This guideline has been designed to help water utilities frame their WWO strategy. It is intended to be adaptable to local needs and conditions. As well as enabling informed discussions around the impacts of WWO to the receiving environment and the outcomes that WWO management approaches can achieve. It is not intended for use as a regulatory instrument and should be used along with existing wastewater codes, standards, and guidelines.

This guideline is intended to be used by ANZ water utilities who are developing a WWO strategy for managing WWO to minimise the impacts on the receiving environment principles. Secondary users of this guideline are those who need to understand the basis for the WWO strategy, the potential impacts and outcomes that WWO can have on the receiving environment or how they can contribute to achieving these outcomes. Secondary users may include:

- regulatory authorities e.g. environmental, health, financial
- water utility executives
- waterway managers and catchment groups
- community groups
- universities

1.2 Guideline use

This guideline has been designed using the structure shown in Figure 1-1.

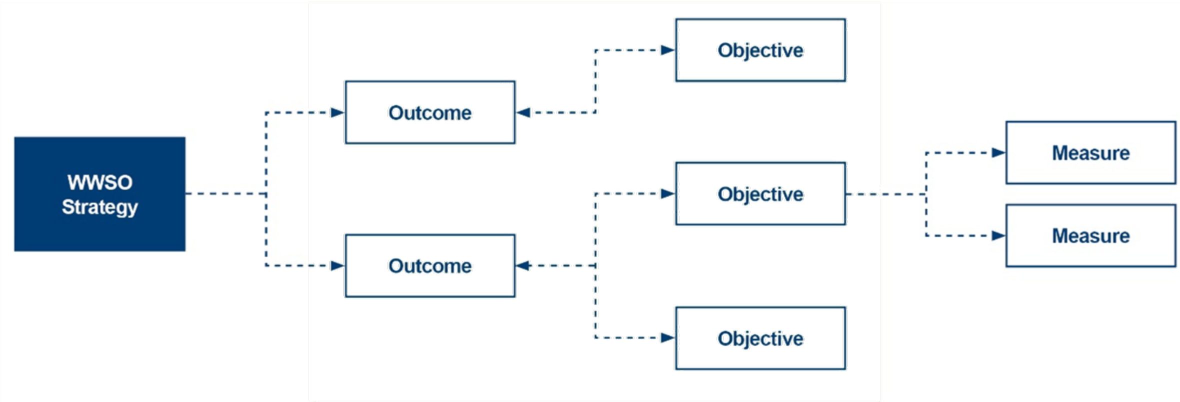


Figure 1-1 | Typical WWO strategy structure

The key elements to developing a WWO strategy are:

- how to develop an understanding of desired **outcomes** around five receiving environment principles: ecosystem, community, property, cultural and economic (Chapter 2)
- how to establish **objectives** and **measures** that progress towards achieving these outcomes (Chapter 2 and 3)
- how to identify and discuss the potential impacts of WWO and align them to the receiving environment principles (Chapter 3)
- a range of management approaches that can be used to achieve the outcomes and objectives and to make consistent and transparent decisions (Chapter 4)
- the data and tools required to implement the management approaches and inform the time and cost requirements (Chapter 4)
- an indication of the different solutions available to address WWO issues (Chapter 5)
- other considerations such as systems thinking and climate change that can be incorporated into developing a WWO strategy (Chapter 5)

Developing a WWO strategy is an iterative process and the strategy should be continually updated to reflect internal, external and regulatory needs as well as technological, scientific advances and available data.

2 Framing the context

The current management approach for WWO varies between water utilities, due to differences in the:

- cause and extent of WWO
- local environmental conditions and sensitivities
- policy and regulatory context for each water utility
- internal and external drivers
- organisational contexts and priorities and capacity and capabilities to manage WWO

Establishing the current context is important and there are five steps:

1. Define current performance objectives
2. Assess current WWO performance
3. Understand the cause of WWO
4. Understand what is being discharged
5. Explore future state

2.1 Establishing the context

Performance objectives establish the context in which WWO need to be managed. Management of WWO usually occurs in the context of managing the impacts to the receiving environment. Before water utilities can understand how they are performing they need to understand what their performance objectives are. These are typically influenced by:

- internal context
- regulatory and formal requirements
- external context

2.1.1 Internal Context

The internal context is anything within the water utility that can influence or define the objectives for WWO management. This includes overarching organisational objectives and policies that set the organisational goals, outcomes, commitments and priorities as well as the guiding principles and risk appetite that helps water utilities make decisions. Water utilities may have specific policies or strategies that outline the objectives of the wastewater system and the receiving environment. Internal requirements can include:

- corporate policies, objectives and strategies
- the organisation's values and culture
- information systems, decision making processes and management systems
- capabilities (resources and knowledge, e.g. capital, time, people, processes, systems, technologies)
- performance requirements
- standards and guidelines
- previous studies and system knowledge

Water utilities may have other specific policies or strategies that relate to WWO management such as:

- inflow and infiltration – management practices for source control, refer to Section 2.3
- private wastewater systems – ability to access for inspection and maintenance
- tree management – practices for managing the impacts from trees on the wastewater system e.g. tree root removal
- environmental management – internal management practices and requirements
- integrated water or catchment management – refer to Chapter 5

Understanding the internal context will enable the development of an internally aligned WWO strategy.

2.1.2 Regulatory and formal requirements

Water utilities are typically required to comply with regulated conditions, usually defined in:

- federal, state or territory laws or regulations
- ordinances or by-laws
- deeds or covenants
- operating licences and agreements
- environment protection licences
- contracts, including customer contracts, and agreed levels of service
- memorandums of understanding
- Australian and International standards, codes of practice and guidelines

These regulatory and formal requirements vary across ANZ, and for WWO can be set or influenced by environmental, health and economic regulators. These often form the minimum performance requirements for WWO and broadly encompass:

- local or state agreements that the water utility must comply with e.g. with local Aboriginal groups, general environmental duty and reporting obligations
- application of industry best practice codes and guidelines
- negotiated improvement programs
- enforceable licence conditions

Typical examples of regulatory requirements include:

- compliance standards mainly based on annual overflow spill frequency limits. These can be set at system, location (e.g. inland or coastal) or asset specific level
- containment of overflows in anything less than a defined annual exceedance probability (AEP)
- providsion ofa minimum defined multiple of average dry weather flow capacity, typically between 3 and 6 times average dry weather flow
- that wastewater overflows are essentially not permissible and therefore cannot be permitted under licence conditions

Regulatory and formal requirements evolve and therefore should be periodically reviewed and incorporated into the performance objectives. Understanding the drivers makes it easier to work with stakeholders and community groups to support and implement the preferred management approach.

2.1.3 External context

Beyond regulatory and formal requirements, there are many other external influences that could or should define the objectives and management of WWO. Understanding the external context helps ensure the objectives, concerns and aspirations of external stakeholders are considered. External influences could include:

- key industry drivers, trends and technological advancements (local and international)
- environmental, community and cultural values
- reputation, relationships, perceptions and values of external stakeholders and customers
- political, financial and economic considerations
- nature and sensitivity of the receiving catchment

Frameworks such as **STEEPLE** (**S**ocial, **T**echnological, **E**conomic, **E**nvironmental, **P**olitical, **L**egal and **E**thical) can be used to undertake an analysis of the external context. It is important to then understand how these external drivers will impact the WWO objectives and if there is a need to broaden or change them to embrace external expectations.

2.2 Assess current WWO performance

The current wet weather performance of the wastewater system needs to be assessed against the identified current performance objectives. It is important to understand the scale of how the system responds in wet weather so that the appropriate level of data and analysis can be undertaken. Typically, small systems that have a low response to wet weather will need less data and analysis compared to the larger more responsive systems that require more data and detailed tools to undertake the analysis. Figure 2-1 summarises the typical data and analysis needed to understand the wet weather performance of the wastewater system, noting there could be other drivers for the development of data and analysis (e.g. population growth).

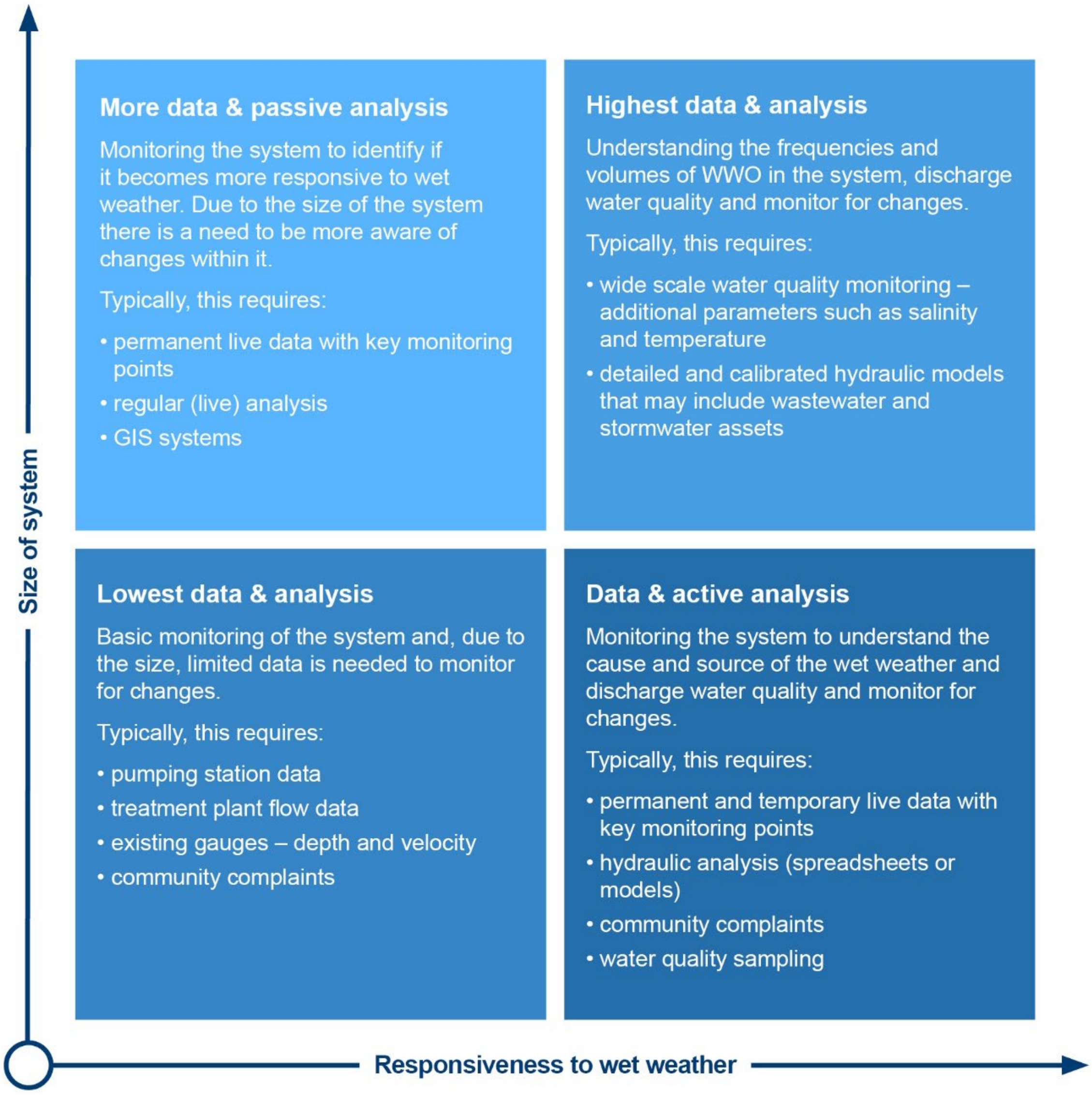


Figure 2-1 | Typical data and analysis

Characterising systems and understanding their interactions is one of the fundamentals of effective WWO management. Characterisation includes the collection and analysis of the following information:

- **Physical –** where the assets are (e.g. pipes, pumping stations, ERS, proximity to stormwater system) and any relevant system changes (e.g. upgrades, diversions and new connections)
- **Geographical –** the topography and hydrology, waterway bodies (e.g. stormwater pipes, streams, lakes, ocean)
- **Condition data –** asset conditions through operation and maintenance (O&M) records
- **Sources of flow –** key trade waste customers e.g. location and composition of discharges)
- **Customer complaint data –** records of customer complaints relating to wastewater overflows during wet weather

- **Past WWO –** typical parameters to collect are the frequency of occurrence, volume of discharge, location of overflow discharge and seasonal variations in occurrences

Understanding the system performance typically includes using a combination of observational data, monitoring and modelling. Observational data is usually available via O&M records, customer complaint data and targeted field work. Monitoring data typically comes from assets (e.g. level alarms in pumping stations), targeted wastewater flow and rainfall monitoring surveys. Monitoring data typically supports the calibration of models. For more complex systems, due to size or scale of wet weather response, hydraulic models are the best way to understand system performance. Appendix 3 contains further detail on developing appropriate models.

2.3 Understand the cause of WWO

The volume and frequency of WWO are influenced by the following key factors:

- location and topography
- climatic conditions and seasonal changes
- size, age, condition and configuration of the wastewater system
- system reliability, both internal and external factors e.g. reliability of power supply

These factors will contribute to whether the overflow volumes or frequencies are higher or lower and are typically the factors that influence the variations experienced between regions, states or countries in ANZ.

However, these factors are not the root cause of wet weather overflows. There are two broad categories, summarised in Figure 2-2, for the different causes:

- increased wet weather flows to the wastewater system
- decreased wastewater system carrying capacity in dry weather, as this compounds WWO

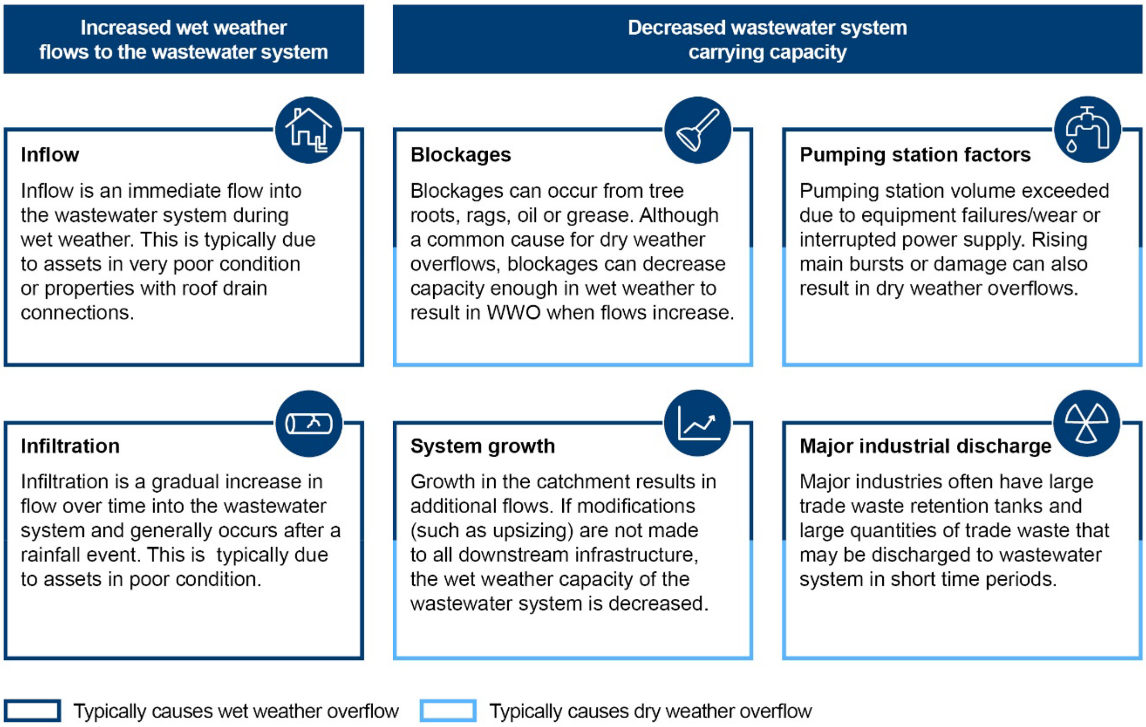


Figure 2-2 | Factors that could cause wastewater overflows

2.3.1 Inflow and infiltration

The inflow and infiltration (I&I) of stormwater into the wastewater system during a rain event can significantly increase the volume of flows in the wastewater system. These increases can be far beyond the design storm allowance made for the wastewater systems. Exceeding the capacity of the wastewater system causes overflows. These overflows typically occur from the following (as shown in Figure 2-3):

- emergency relief structures (ERS)
- maintenance holes
- overflow relief gullies (ORG)
- other private property connection points e.g. toilets, floor drains, kitchen sinks, local stormwater pits

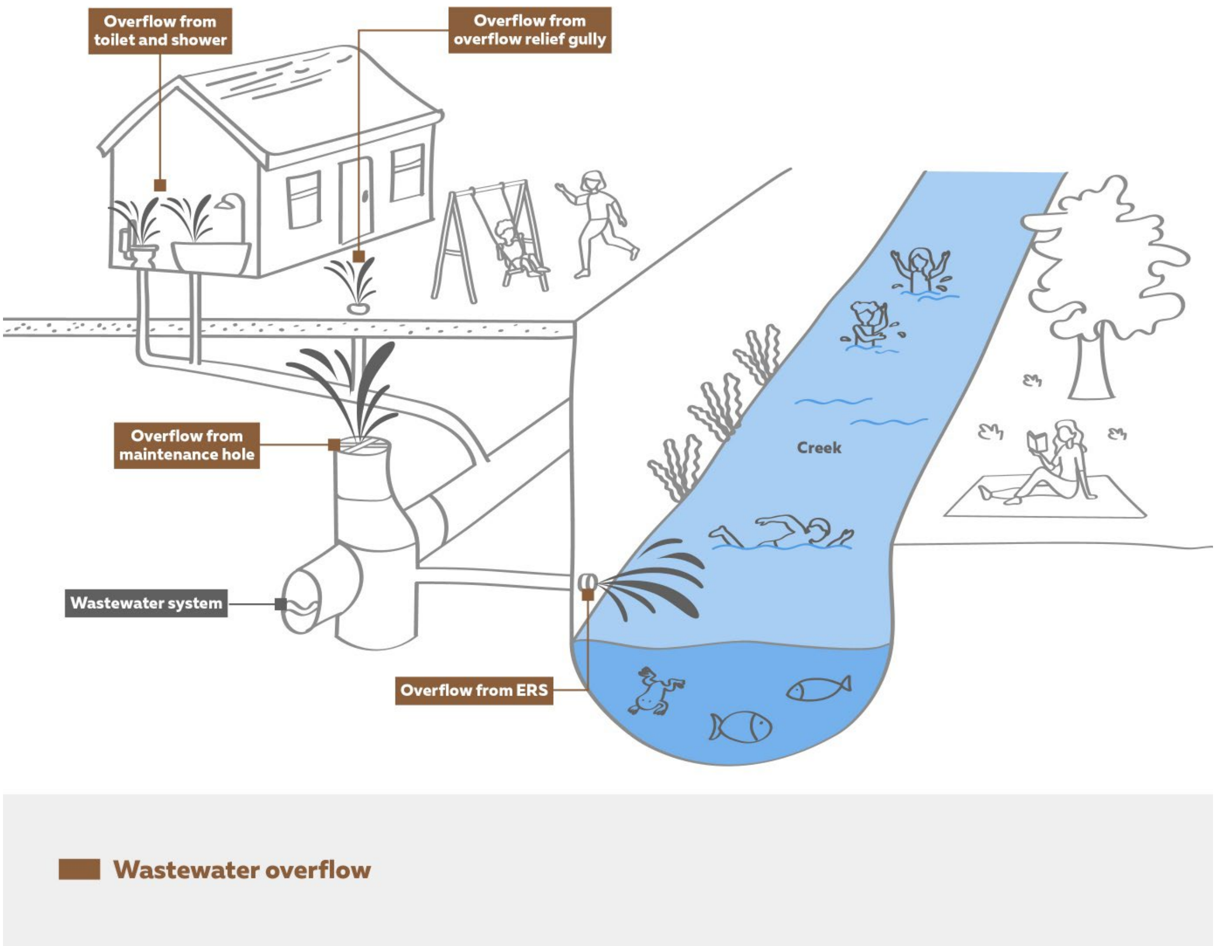


Figure 2-3 | Typical overflow locations

Inflow is an immediate flow into the wastewater system. Inflow is correlated to a fast peak in level or flow in the wastewater system directly related to rainfall event. Common sources of inflow include:

- non-compliant property roof or pool drains connecting into the wastewater system
- cross connections between stormwater and wastewater pipes
- faulty or damaged maintenance holes, in particular the covers
- faulty ERS, in particular the performance of the valve or backflow prevention device
- faulty or low gully traps
- wastewater pump station wet wells inundated by waterways during localised flooding

Infiltration is a gradual increase in flow over time into the wastewater system and typically occurs after a rainfall event. Infiltration occurs from stormwater and groundwater entering the wastewater system. Common sources of infiltration are:

- damaged wastewater pipes e.g. cracks and displaced joints
- damaged maintenance hole structures e.g. defects in the walls or covers
- damaged wastewater property pipes and fittings

Infiltration is typically due to deterioration in the wastewater system condition. System deterioration typically occurs due to the age of the assets, poor operation and maintenance, corrosion, poor installation and interference (e.g. vegetation tree root intrusion). The carrying capacity of the assets deteriorates as the condition deteriorates.

Figure 2-4 shows the potential sources of I&I. Inflow and infiltration affects the operation of every wastewater system in Australia to some extent. The extent of inflow and infiltration and the problems it causes varies within and between systems. I&I is influenced by factors such as rainfall intensity, ground water level, sea level, soil condition and infrastructure condition. When WWO occur, the events that caused them should be documented and, where possible, the cause of the event identified. Hydraulic modelling of the systems can assist in understanding the implications of wet weather flows.

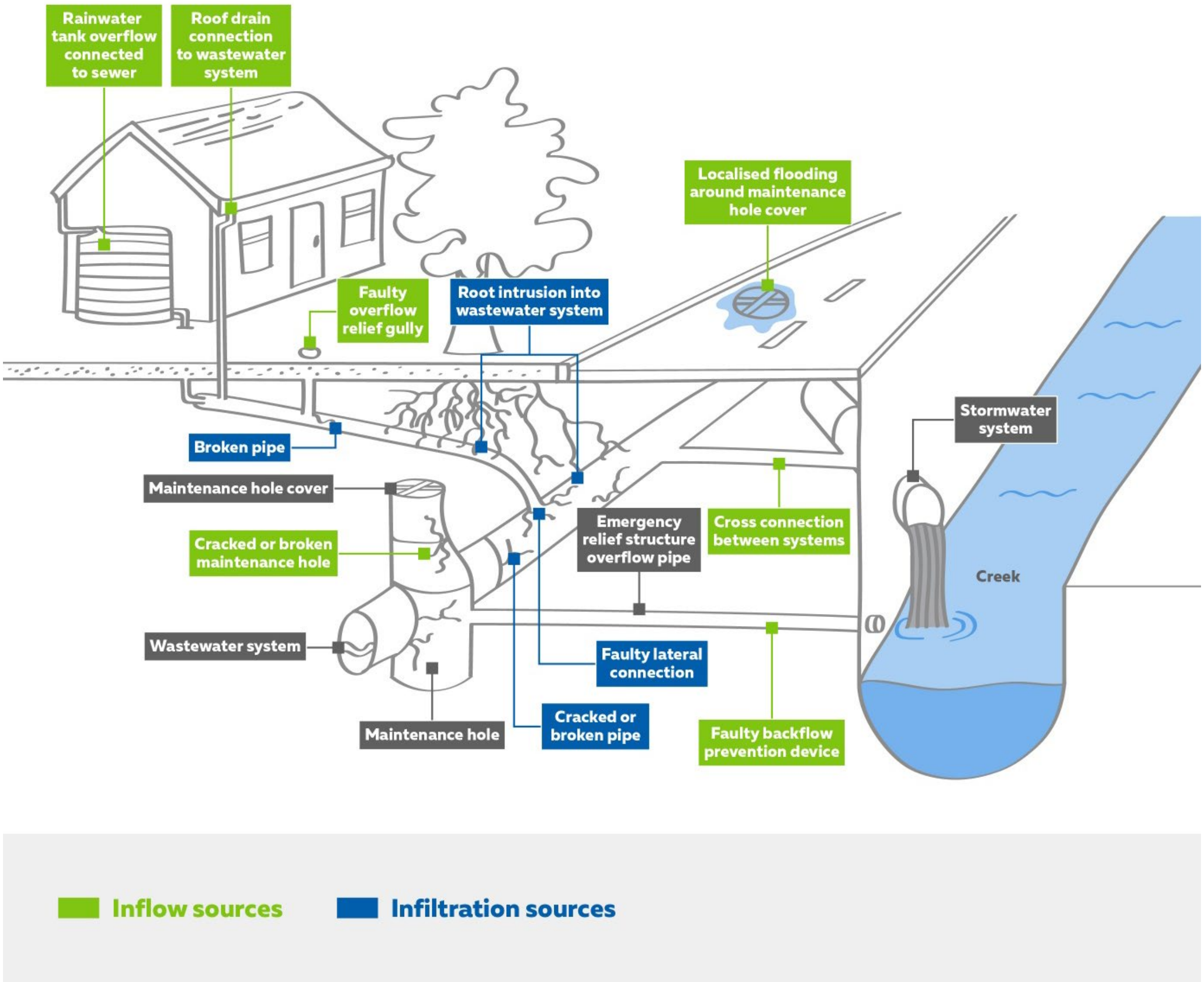


Figure 2-4 | Typical sources of I&I

2.4 Understand what is being discharged

To understand what (e.g. volume, frequency, composition) is being discharged from the wastewater system, it is common for water utilities to use modelling tools to simulate performance. These tools vary considerably in complexity and functionality. The simulation from these tools is ultimately driven by the quality of the data input. It is important when establishing the tools for the strategy that the following are understood and defined:

- **Purpose** – to inform the strategy, what information is required? Beyond defining the study boundary, the scale of information required needs to be defined. A simple model can simulate frequency and volume of overflows from each ERS. A more complex model may be required that simulates more aspects including the water quality from the wastewater system and the dynamic hydraulic relationship with the receiving environment. This could also involve using the receiving environment water quality model to assist in understanding the risk or effect of the discharges.
- **Confidence** – how the model results are used to inform the strategy will determine the level of confidence required in the simulation. It is an important part of the decision making to understand the limitation of the tools being used. The model may initially be used at a strategic level to help inform the strategy. However, it may need further refinement in the future when used for more detailed planning.
- **Data and time** – gathering data for calibration of models can take time and be costly. It is important that these aspects are considered because it can take years for some data sets to be collected, particularly if large, infrequent, storm events are required. Data could include wastewater flow and level at strategic points within the wastewater system over a fixed time period through to continual monitoring at more critical locations. Data gathering could also include water quality sampling (wastewater and waterway). If this is undertaken it is important to establish which parameters need to be sampled.

The Chartered Institution of Water and Environmental Management (CIWEM), Integrated Urban Drainage Modelling Guide (free to access) provides a reference for developing wastewater system models. When the wastewater system and stormwater system models are combined, this is often referred to as integrated modelling or integrated catchment modelling.

2.5 Understand the impact of discharge

To understand the potential impact and effect of WWO on the receiving environment, it is important to identify what is being discharged. The pollutants within WWO can be influenced by other factors beyond domestic flows that can affect the composition and concentration of the pollutants. These can include chemical dosing units, trade waste connections. The location of the overflow within the wastewater system can also influence the concentration of the pollutants e.g. reticulation overflows and major carrier overflows/industrial or residential catchments.

To understand the composition of WWO and understand the concentrations of the pollutants of concern, the following tools and processes can be used:

- GIS mapping including overlays such as the upstream system, location of key assets, customers and receiving environments.
- modelling of the wastewater, stormwater or water quality in a combined model or separate models.
- sampling of the wastewater and/or the receiving environment, in dry and wet weather. Sampling provides more detailed information which can be incorporated into models as required.

The actual effects of WWO vary substantially depending on the specific site conditions, time of year, receiving water characteristics and the size of the wet weather event. Sometimes overflows have little or no impact and sometimes the impacts are significant. The amount of evidence informing the effect on the receiving environment principles, in particular human health, ecology and aesthetics, is continually growing. It is important to stay up to date with the latest developments in scientific understanding. This can require extensive research and the engagement of relevant experts.

There are significant financial risks due to misunderstanding the actual effects of overflows, with the main financial risk being that capital expenditure does not lead to true benefits. This is often due to misunderstanding:

- the desired outcomes
- the sources of the pollutant affecting the outcome
- the composition of the WWO and the effect it may (or may not) be having

It is important to clearly identify the outcomes that water utilities want to achieve, best framed within receiving environment principles, as well as understand the cause of the WWO and the problems or effects it could be having. Correctly defining the problem will help the utility to set objectives and develop a cost-effective program of activities to resolve and achieve the agreed outcomes.

2.6 Desired future

Water utilities should systematically and methodically identify and analyse emerging issues to identify potential changes and then explore the implications and impacts of the change. This will help navigate and anticipate future operating environments and identify alternative options to address those futures and make better decisions today. To do this, foresight tools and techniques can be used, such as:

- **Horizon scanning:** A systematic process to scan for, identify and monitor trends of emerging issues and weak signals in the current external operating environment and understand potential future environments.
- **Horizon mapping:** Understanding the short, medium and long-term impacts of change to generate innovations, make sense of trends and identify uncertainty.
- **Trend analysis:** Analysing existing trends to understand the trajectories and patterns of change to identify causes, drivers and potential impacts.
- **Technology mapping:** Using a systematic approach to categorise and assess the evolution of technologies.
- **Scenario mapping:** Prepare for the future and test possibilities by understanding the range of plausible future operating environments.

To set the direction for the WWO strategy, water utilities need to establish the future context for the WWO management. This requires an understanding of the current expectations for WWO performance, the outcomes that need to be achieved and an understanding of the trends and emerging issues. Water utilities need to determine:

- the timeframe (short, medium or long-term) to which the issues apply. Is there a stakeholder expectation that the outcomes will be realised immediately or can they be achieved over time?

- what may drive a change in expectations or requirements
- the impact of external influences such as growth, technological and scientific advancement
- what receiving environment principles may become more or less important over time

A robust assessment of the desired future state will ensure that activities carried out to improve WWO performance in the short to medium term will contribute towards achieving the desired future.

3 RECEIVING ENVIRONMENT PRINCIPLES

The water utility must define the desired outcomes that the WWO strategy will strive to achieve and measure success against. These outcomes need to be defined in relation to the receiving environment. The receiving environment can be categorised into the following five principles (or values) which are externally focused:

Ecosystem
Considers water dependent ecosystems and terrestrial ecosystems that may be affected by WWO

Community
Considers the impacts WWO could have on the health and wellbeing of the community and protecting the use of the waterways and lands

Property
Considers the impacts WWO could have on properties. This typically refers to residential customer properties, however, could also include commercial, industrial, public or government owned properties

Economic
Considers the impacts WWO could have on the economic value of waterways and their surrounds

Cultural
Considers the impact that WWO can have on the First Nations values of Country where the WWOs are discharging

Figure 3-1 | Receiving environment principles

It is important for water utilities to determine the receiving environment principles that are important to their organisation, regulators and community, and set desired outcomes to reflect this. The outcomes define what needs to be achieved, therefore providing the context and basis for setting the objectives. Objectives, sometimes referred to as targets or goals, are the way to measure progress towards achieving outcomes. For simplicity, this guideline will refer to them as objectives. Management approaches are often based on the objectives as they are a measurable way to achieve the desired outcomes.

> An example of an outcome is “to improve swimmability at a beach”, and the associated objective could be “to reduce the enterococci entering the waterway to an acceptable standard”.

When establishing the desired outcomes, water utilities should understand and consider the following:

- **Existing receiving environment:** What is the health of the receiving environment and how is the current receiving environment being used and valued? What is important to maintain and improve this? Information may be available in reports, from stakeholder documents and websites or may require stakeholder consultation and field observations.
- **Future receiving environment:** Are there plans to enhance or change the use of the receiving environment? For example, there could be plans to transform the waterway into a swimming site, or rehabilitate and naturalise a waterway. Consider internal, customer, community and regulatory aspirations for the receiving environment and how these could change over time. This could include growth, liveability, integrated water management, technological change, scientific advancement and aging infrastructure.

When setting the objectives for each outcome, water utilities should consider the following:

- **Current objective:** Is there a current objective that has been used to achieve this outcome? What is the basis and background to this objective? Is this the correct objective or could a better one be used to achieve the desired outcome?
- **Legislation and regulation:** Are there objectives in legislation, policies or guidelines that have been defined for this outcome? What is the basis and background to these objectives? Refer to Appendix 2 for some key ANZ documents.
- **Scientific knowledge:** What scientific knowledge and evidence is there that can be used to set the objective? Is the science still evolving in this space and could this change the objective in the medium to long-term?
- **Measures or proxies:** Determine if specific measures or proxies will be used. Proxies are indirect measures or indicators that represent what is being studied, and they are used when a direct measure is not available. If a proxy is used, water utilities must understand why. Is it because the science has not established a direct measure, or is it because the data or information is not available, cannot be collected or would be too costly to collect? The accuracy and confidence of the proxy needs to be understood when used.
- **Issues or barriers:** What could inhibit or make the objective impractical to achieve? Typically, this is due to site specific issues, costs to implement or measure the objective or other sources that may not be within the Water utilities control contributing more than WWO.

Objectives need to be regularly reviewed and updated so that they reflect the changes in the above and progressively move water utilities to achieving their receiving environment aspirations.

When the outcome and objective are set, measures can be developed as shown in Figure **3-2**. The measures need to be specific to the objective and define the value and impact.

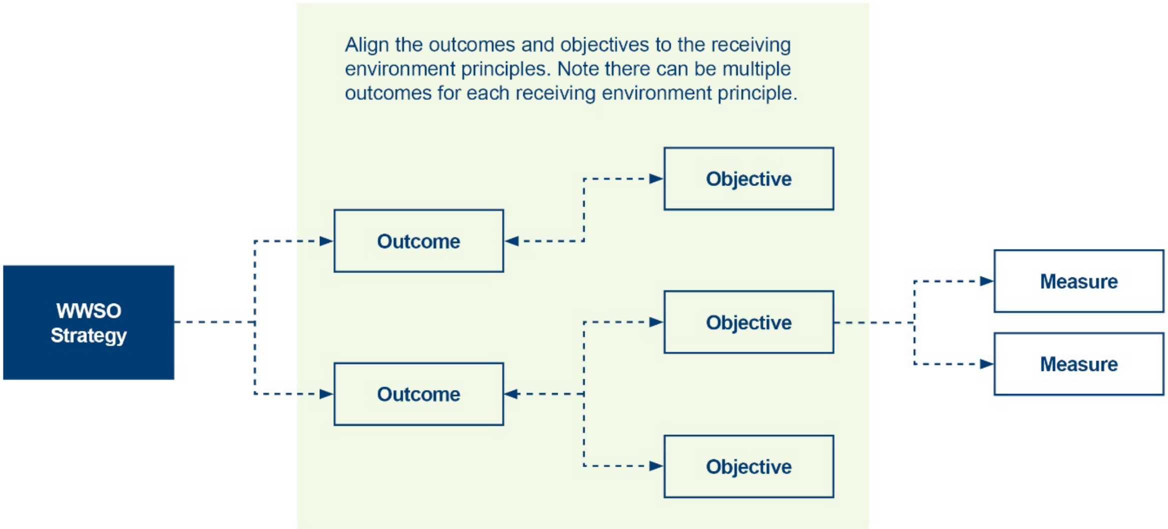


Figure 3-2 | Outcomes – objectives – measures

These receiving environmental principles will account for most of the receiving environments that can be impacted by WWO. However, water utilities should tailor them by selecting the ones that apply or adding additional ones to suit their needs. This could also include considering other outcomes that need to be achieved and including them as part of the WWO strategy e.g. broader business strategic outcomes such as IWM and circular economy.

The remainder of this chapter explores each of the receiving environment principles and provides the following:

- definition of the principle
- typical outcomes that are achieved within this principle
- typical objectives that can be used to measure the outcome
- typical data sources that can be used to inform the outcome and objectives
- key regulation and guidelines that can be referenced

Ecosystem

Considers water-dependent ecosystems and terrestrial ecosystems that may be affected by WWO. **Water-dependent ecosystems** are defined as the ecosystems for which the composition of species and natural ecological processes are determined by the permanent or temporary presence of flowing or standing surface water or groundwater. Waterways should also be considered and their connectivity understood. This could include considering the potential accumulation and attenuation based on factors such as dilution and distance. **Terrestrial ecosystems** are defined as ecosystems found on land e.g. national parks	
Typical outcomes	Waterway health and environmental values are typically used to define the outcomes for this principle. These can consider: • water quality of the receiving waters • community expectations • protection of aquatic ecosystems, habitats and ecosystem health • objectives for water flows and sharing • integrated catchment management and integrated water management approaches • Ecologically Sustainable Development (ESD) principles and outcomes
Typical objectives	Ecosystem use and health is complex as there are many variables which can impact water dependent ecosystems. Objectives can include the following: • fauna, flora, biodiversity, macroinvertebrates and endangered species • vegetation (riparian extent, condition and instream) • physical and chemical property of waterway • growth of algae (e.g. monitored directly by species identification and quantification, or indirectly by chlorophyll-a concentration) and harmful aquatic plants and animals • pollutant loads which can include organic carbon (e.g. measured indirectly by biochemical oxygen demand [BOD]), nutrients (e.g. ammonium nitrogen, total nitrogen and phosphorous), gross and suspended solids, heavy metals, pharmaceuticals, halogenated organic compounds and microplastics
Measure	For each potential objective there is a number of measures that could be used to define value and impact. These will need to be determined relative to the specific objective, data and approach adopted.
Typical data sources	• assessing dry and wet weather hydraulic conditions on aquatic habitats • sediment and water sampling for pollutants (recommend multiple sampling points) • chronic and acute toxicity assessment assays • monitoring of key baseline parameters e.g. dissolved oxygen (DO), temperature, pH, turbidity, conductivity (e.g. WaterWatch) • surveys to confirm presence or absence of aquatic organisms (benthic and water column) • sensitive receptor mapping – of endangered ecological communities, populations & species, aquatic reserves, etc.
Key regulation and guidelines	• The National Water Quality Management Strategy (NWQMS): provides the framework to protect local water quality • ANZ Guidelines for Fresh and Marine Water Quality (ANZG) • WSAA Australian Wastewater Quality Management Guidelines

Community

Considers the impacts WWO could have on the health and wellbeing of the community and protecting the use of the waterways and lands. The study area can be broken into two types of uses: **Waterway uses** considers primary, secondary and tertiary contact recreation as well as source water for treatment and consumption. **Land based uses** considers active public spaces (e.g. playgrounds and sporting facilities) and passive open spaces (e.g. walking paths and parklands).	
Typical outcomes	The value of the waterway and land is typically used to develop the outcomes and can consider: • primary (e.g. swimming), secondary (e.g. boating) and tertiary (e.g. walking) contact recreation • consumption - drinking water source or aquatic food (e.g. shellfish) • aesthetics (e.g. toilet paper, personal care products, wet wipes, odour)

Typical objectives	Generally, impacts on health and wellbeing are dependent on contact with contaminated lands or waterways and therefore can include:
	• water quality:
	  ○ pathogen and viral loads and faecal indicators (e.g. enterococci and E. coli)
	  ○ other pollutants such as heavy metals
	  ○ water colour/appearance (e.g. turbidity)
	• the number of no swim days
	• odour and wastewater debris (e.g. ragging)
	• hydraulic conditions (e.g. modified conditions making swimming dangerous)
	• frequency and volume of overflows

Measure	For each potential objective there are a number of measures that could be used to define value and impact. The impacts to health and wellbeing of the community due to WWO are difficult to determine. Popularity and usage statistics of the waterway or land could be measures relating to the value to the community.
Typical data sources	• assessing hydraulic conditions • water quality surveys • surveys to assess the presence of wastewater debris, such as ragging • microbial source tracking (MST) markers • usage surveys or swim data (e.g. Beachwatch or Safeswim) • customer complaints – typically for odours and aesthetics • environmental monitoring program • community notification of pollution events and waterway closures
Key regulation and guidelines	• National Health and Medical Research Council (NHMRC): Managing Risks in Recreational Water • State public health acts and regulations • ANZ Guidelines for Fresh and Marine Water Quality (ANZG)

Property

Considers the impacts WWO could have on properties. This typically refers to residential customer properties, however, could also include public or government owned properties. WWO which occur on properties can be internal through property fixtures such as toilets, and external through gully traps, maintenance holes or sometimes from overland flow from the neighbouring property.

This could impact the customer of the property through the inability to use facilities, property damage, impact to health and wellbeing due to contact with wastewater and stress associated with the potential of WWO on property during rain.

Acceptable level of risk of impact to properties may be dependent on a range of considerations including plumbing codes and location of properties relative to flood zones.

It should be noted that when considering property as a receiving environment principle, not all impacts to properties are of equal value, and elements such as type of property, size of property, number of people impacted from the property could be considered. For example, very high risk properties could include medical, hospitality and education facilities.

Typical outcomes	Outcomes for property could include: • determining acceptable, defendable and manageable level of risks at an organisational level • acceptability of internal and external property wastewater surcharges • defining the level of acceptable customer complaints
Typical objectives	Generally, impacts on properties can include: • frequency and scale (e.g. volume) of impact on property and customer • complaint standards e.g. no more than 2 complaints per year from a property owner • health and wellbeing of property occupants • property type/sensitivity • response time from the water utility including contact with the customer, clean up of the incident and rectification • cost of property rectification and compensation of owner
Measure	Popularity, usage statistics or classification of the property could be indicators for the value to the community.
Typical data sources	• assessing hydraulic conditions • asset information such as site inspection data and photos • surveys to assess the presence of wastewater debris, such as ragging and weed infestations • flood mapping data
Key regulation and guidelines	• state public health acts and regulations • refer to existing customer contracts or policies • customer service codes • general environmental duty • plumbing codes • design standards for wastewater systems

Cultural

Considers the impact that WWO can have on the First Nations values of Country where the WWO are discharging. At the core of this principle is engaging with First Nations communities to listen, observe and understand their priorities in terms of wastewater infrastructure provision, installation and maintenance. When engaging with First Nations communities the following principles should be considered:

Recognition:

- Understand who the First Nations people are within the water utility's service area, the formal organisations, and the boundaries of their traditional land and waters.
- Take a Country-centred approach.
- Consider the impact of WWO downstream outside of the utility's service area.
- Acknowledge and work to ameliorate past injustices and ongoing structural inequality within the water utility's areas of responsibility and influence.
- Understand that the cultural values, principles and practices for sharing knowledge can considerably vary between groups.
- Understand that First Nations groups set their own priorities that may not align with project timing.

Partnerships:

- Develop lasting relationships with First Nations organisations to encourage a partnership and stewardship approach that goes beyond the needs of the WWO strategy.

Participation:

- Invest in First Nations people's capability to be actively engaged in water and wastewater system planning decision-making process and remunerate fairly for cultural knowledge where it is not freely given.

Protection:

- Be clear on how the WWO approach will create positive steps for protecting the rights, interests and self-determination of First Nations people within the water utility's service area.
- Consider Indigenous Data Sovereignty principles when gathering and utilising cultural knowledge.

Whole of organisation:

- Engage as a whole organisation to ensure a coordinated approach that gives respect for the time needed to communicate cultural values and not just for one aspect such as WWO.
- Build cultural safety and competency across the organisation – all staff can be champions for this.

<table>
<tr><td>Typical outcomes</td><td>The WWO strategy requires understanding the impact of WWO on local cultural values which could include but are not limited to:
• spiritual
• economic
• social
• ecological
These can only be determined by the local First Nations groups themselves and are likely to grow and evolve as the partnership develops and more information is uncovered. However, the primary outcome from the utility's perspective is developing a lasting relationship and trust</td></tr>
</table>

	between the water utility and their local First Nations organisations, which supports their self-determination. This should deliver mutual benefits and across multiple utility programs.
Typical objectives	The objectives are specific to each cultural value identified, as well as to the particular Country where the project is located and need to be developed with the local First Nations organisation. Examples include improving opportunities for: • fishing • hunting • ceremony • harvesting medicinal plants
Measures	The engagement with local First Nations communities should identify and co-develop indicators to measure impacts to Country and culture.
Typical data sources	• Walking Country with representatives of local First Nations organisations such as Registered Aboriginal Parties, Aboriginal Land Councils, Native Title holders, Traditional Custodians, elders, Māori iwi and other groups with similar formal agreements • The water utility’s own organisation – historical records of engagement and learnings from other programs • National and State data sources e.g. NSW Aboriginal Heritage Information Management System (AHIMS) and VIC ACHRIS (Aboriginal Cultural heritage Register and Information System) • Indigenous Data Network
Key regulation and guidelines	Australia and New Zealand have very different legislative and regulatory requirements therefore the local requirements need to be understood and followed. The following are some key reference documents: • National Cultural Flows Research Project • The Three Waters Reform Programme (NZ) • Commonwealth State of the Environment report • Connecting with Country – Government architect NSW • DELWP (Vic) – Traditional Owner and Aboriginal Community Engagement Framework

Economic

Considers the impacts WWO could have on the economic value of waterways and their surrounds. The economic impact of WWO could be direct or indirect. For example, a direct economic impact of a WWO could be an oyster farm losing revenue due to a WWO. An indirect economic impact could be waterfront businesses losing revenue due to media coverage of a WWO spill in a nearby area. The economic impact could occur at a micro or macro level.

This receiving environment principle considers any businesses that are economically impacted by WWO, including:

- non-potable usage of water such as irrigation
- water for domestic raw water supply
- water used for commercial land (stock and crops) and water (shellfish) farms
- water that adds value to recreational or tourism locations e.g. waterfront dining, accommodation
- national and international impact of WWO
- recreational business e.g. kayaks, inflatable jumping castle, sailing, picnic boating
- global events, industries or attractions e.g. the Olympics, public celebrations, fun runs

Typical outcomes	Economic values and uses of water are typically used to define the outcomes for this principle and includes immediate and long-term impacts. These can consider: • business reputation outcomes • cost to the community due to loss of business, e.g. communities that are dependent on the impacted economic streams • economic impacts to business e.g. impact to revenue
Typical objectives	Water utilities can work with government and business owners to measure and quantify the economic impact of WWO, which can include: • waterway type/sensitivity • receiving environment type • water availability for farming (e.g. irrigation of crops, drinking water for livestock) • water quality e.g. nutrients and pathogens • the number of no swim days • odour and wastewater debris (e.g. ragging) • hydraulic conditions (e.g. modified conditions make swimming dangerous) • frequency and volume of overflows
Measure	The economic value of the receiving environment can typically be determined by considering the value of the waterway and land which the WWO are impacting.
Typical data sources	• economic value assessments of waterways • business data e.g. financial loss • customer complaints and negative media coverage • surveys to assess the presence and composition of wastewater • swim data (e.g. Beachwatch or Safeswim)
Key regulation and guidelines	• National Health and Medical Research Council (NHMRC): Managing Risks in Recreational Water • customer service codes

4 MANAGEMENT APPROACHES

Management approaches provide water utilities with a suite of tools to define performance expectations and inform decision making. They are the approaches to achieve the receiving environment principles and outcomes of the WWO strategy. These can be achieved by applying one or more of the following management approaches:

- **Asset:** A systematic approach to operate and maintain wastewater infrastructure to meet the performance requirements
- **Containment:** Uses a containment measure to manage system performance
- **Outcomes:** Sets measurable goals or outcomes aligned with a strategic vision at a macro or micro level
- **Risk-based:** Assesses the likelihood and potential consequences of WWO to identify the potential impact on the receiving environment principles
- **Effects-based:** A data driven decision making approach for the management of activities and their actual impact on the receiving environment principles

> When selecting the appropriate management approach for each receiving environment principle and outcome, water utilities should consider the balance between the benefit and the scale of the WWO performance, complexity and cost.

Each management approach is discussed in this section and has a one-page summary with key considerations (complexity, data, time, consultation and strategy cost). These are defined as follows:

- **Complexity:** The complexity to develop and apply the approach includes consideration of organisational requirements, the level of data analysis required, external influences such as growth, technology and working with extensive and varied data from a variety of sources.
- **Data:** The quality, quantity and source of data required. This includes the types of additional information and tools necessary to apply the approach.
- **Time:** The time that is needed to develop and implement the management approach, which can be influenced by the complexity, data requirements and additional consultation needed.
- **Consultation:** The level of consultation needed to develop and apply the approach, which considers the level of alignment required around the receiving environment principles, other projects and initiatives, and community, government and regulator engagement.
- **Approach cost:** The cost to develop the approach, which includes the consideration of data gaps and resources required for developing complex approaches or extensive stakeholder consultation and customer willingness to pay.

> Different management approaches can be combined to form a hybrid approach, which can allow the limitations of an approach to be overcome and achieve additional benefits, such as increasing the flexibility of implementation.

WWO issues can be considered at a micro or macro scale:

- A **macro scale** refers to a whole of wastewater system or receiving environment catchment.
- A **micro scale** refers to specific asset or receptor and allows the water utility to be more specific about what is targeted.

Management approaches can be applied at both macro and micro scales to achieve relevant outcomes for specific WWO issues. A WWO strategy typically considers both scales, relevant to the desired outcomes.

When determining the measures relating to the receiving environment principles, it is beneficial to establish early whether those measures will be qualitative or quantitative as this may influence the management approach selection. The management approach may end up being staged whereby initially it could be qualitative. As the data quality and quantity improve, the management approach will shift to a more quantitative approach.

The management approach will be iterative during its development while short and long-term visions are established. It is common for water utilities to regularly review and revise their management approaches after completion of the WWO strategy.

The management approaches in this chapter are to provide a framework for water utilities to manage WWO. Each of the approaches should be developed in accordance with the current versions of AS ISO 55000 *Asset Management – Overview, principles and terminology* and AS/NZS ISO 31000 *Risk Management – Guidelines.*

4.1 Asset

4.1.1 Overview

An asset approach is a systematic approach to construct, operate and maintain wastewater infrastructure to an agreed capacity. The asset approach does not consider performance of the system in relation to WWO or any impact of sensitive receivers in the receiving environment. Therefore, this approach may not reduce the WWO risk to the receiving environment.

An asset approach is one of the more traditional approaches to manage WWO and is based on prescriptive design measures to drive asset performance. The measures used can be coarse and are typically arbitrary standards e.g. designing wastewater systems for five times average dry weather flow (ADWF). Asset design requirements can be set relevant to local, state, or federal guidelines or policy.

The approach does not allow for prioritisation of assets for investment, and the assets will either pass or fail meeting the design measures. This makes it relatively simple to assess and regulate.

4.1.2 Why choose this approach?

An asset approach can be applied to systems with:

- low complexity
- low levels of WWO performance issues
- minimal regulatory requirements
- minimal impacts to the receiving environment

Advantages of this approach include:

- it can be adopted with limited resources and budget
- it is a well understood and transparent approach, which allows water utilities to communicate with regulators and demonstrate compliance
- can be applied in conjunction with other approaches to form a hybrid approach

4.1.3 Typical requirements

The data needs can vary depending on the application of the measures adopted and can include the following:

- basic wastewater hydraulic models (this can be either spreadsheets, uncalibrated or calibrated models)
- population data
- operational data such as asset performance
- historical performance and asset data
- general asset data (construction drawings, survey information)

4.1.4 Other considerations

The asset approach is common and well understood among water utilities. However, it has the following limitations:

- The approach is not easily adapted where regulatory requirements require consideration of risk to the receiving environment principles.
- The approach can potentially lead to over engineered solutions with high capital cost.
- The approach is not easily adapted to community and organisational needs e.g. to improve water quality at a swimming site.

How is an asset approach developed?

The below summarises the typical steps in developing an asset approach.

1 Define design measures

Using relevant local, state, or federal guidelines, policy or regulator requirements establish the system performance design measures.

This could include:

- minimum conveyance capacity or containment standards usually expressed as a multiplier of ADWF
- weir levels of ERS relative to ADWF
- pumping station flow rates and storage relative to ADWF

2 Establish current performance

Using available data calculate the systems capacity relative to the design measures defined in step 1. Identify the performance gaps and develop solutions to achieve the design measures.

3 Apply and assess ability to achieve design measures

Before finalising the asset approach the Water Utility should assess the design measures set are practical and achievable within the required:

- time frames
- regulation
- stakeholder expectations (internal and external)
- available funding

The assessment could include sensitivity analysis to achieve design measures and consideration of the different solution strategies.

4 Approval of approach

When the approach has been determined to be practical and achievable the Water Utility should obtain required approvals to implement this approach. These may include:

- internal e.g. board approval
- regulatory approval e.g. licence

Asset

An asset approach is a systematic approach to operate and maintain wastewater infrastructure to meet planning and design criteria. Asset performance requirements can be set relevant to local, state, or federal guidelines or policy. The asset approach does not consider performance of the system in relation to WWO or any impact of sensitive receivers in the receiving environment.

Typical application

Underpinning the asset approach is a clear understanding of the performance level of the assets.
An asset approach is typically applied to low complex systems and/or systems that have low levels of WWO performance issues. It is typically applied where the system has low regulation requirements and low impacts to the receiving waterways.

Complexity	The asset approach is typically one of the least complex to adopt. It can be applied to most levels of systems and does not typically require a high level of data analysis. Complexity may increase if other factors are considered e.g., level of model calibration, deteriorating assets, growth etc.
Data	The asset approach requires a clear understanding of the asset performance levels. Standard data inputs could include basic wastewater hydraulic calculations (models or spreadsheets), operational data and general asset data.
Time	The typical time required to develop an asset approach can be minimal depending on the current management approach, available data, and number of assets.
Consultation	The performance level of the assets can be influenced by statutory and regulatory requirements and the water utility's strategic vision and objectives.
Approach cost	The cost of developing this approach can vary depending on the base case scenario. It can be applied with minimal budget, with the cost increasing as the level of detail of the approach increases. It can be low cost to implement, manage and maintain the framework, however, can result in significant expenditure with oversized infrastructure, especially for larger systems due to it being a conservative approach.

Key advantages

- Can be approached with limited resources/budget
- Staged implementation to allow for catchment prioritisation
- Can be applied in conjunction with other management approaches

Key disadvantages

- Not easily adapted where regulatory requirements require consideration of receiving waterway risks and values
- No guarantee of community benefits and value for money
- Difficult to adapt and remain flexible for growth

4.2 Containment

4.2.1 Overview

The containment approach is generally well understood among water utilities and has been applied throughout Australia and globally. A containment approach manages WWO by adopting a containment measure which could be applied to set the performance of:

- an asset (micro)
- a system (macro)

Typical containment measures adopted for WWO are:

- annual spill frequency e.g. 5 % AEP
- annual spill volumes
- conveyance capacity

The containment measures can be nominal or defined through consideration of receiving environment principles and desired outcomes. A containment measure that considers the receiving environment principles may require more data and consultation and could result in different containment measures for each objective.

This approach can be cost effective to develop. However, the water utility must consider the cost to implement and funding availability. The implementation cost could be influenced by:

- the containment measure chosen
- the solution adopted (e.g. source control, amplification, storage)
- the timing and staging of the solution

4.2.2 Why choose this approach?

A containment approach is typically adopted when a quick implementation strategy is required. The advantages include:

- the containment measures applied are transparent and measurable therefore, making them easy to understand and regulate
- easy to apply to one or more receiving environment principles
- shorter timeframes to implement compared to other more complex approaches
- ability to implement as part of a hybrid or staged solution
- application to systems of different complexity
- providing additional system resilience if relevant drivers are incorporated into the desired outcomes

4.2.3 Typical requirements

The data needs can vary considerably depending on the complexity of the approach adopted and can include the following:

- wastewater hydraulic models - calibrated models are usually required
- operational data such as flow gauges or asset performance

- asset condition and performance reports
- general asset data (construction drawings, survey information)
- historical performance and asset data
- receiving environment data
- customer feedback and complaints

4.2.4 Other considerations

While some of the benefits of the containment approach have led to this approach becoming the industry standard, its limitations have resulted in some regulators and water utilities searching for alternative frameworks.

Limitations of the approach include:

- if containment is applied via storage strategies, it can result in the planning and implementation of large capital solutions
- the nominal level of containment adopted may not align with the community and stakeholder expectations
- over time, containment may be difficult to maintain due to other factors such as system deterioration, growth and climate change
- containment measures typically focus on asset performance and do not direct improvements to areas with the greatest impact on the receiving environment principles

Containment strategies are simple to apply and can remain a cost-effective strategy in low complexity environments, in terms of both the wastewater system and the receiving environment principles. However, as these become more complex, containment strategies require greater consideration of many factors and alternative management approaches provide a more suitable framework.

How is a containment approach developed?

The below summarises the typical steps in developing a containment approach.

1 Define outcomes and objectives

The desired outcomes and objectives may be nominal or set by considering the receiving environment principles that are prioritised by the Water Utility.

These may be defined internally or in consultation with the regulator and other external stakeholders (e.g. community, councils etc.)

2 Establish current wastewater system performance

Understand the baseline system and WWO performance. This typically includes:

- mapping the wastewater assets
- calibrated sewer system models
- key asset condition and performance verification (field data)
- existing and future conditions e.g. growth

3 Set containment measures to achieve the outcomes and objectives

The containment measures can be nominal or defined through consideration of receiving environment principles and desired outcomes. These can be set using latest technology, tools and scientific knowledge.

Containment measures can include:

- annual spill frequency e.g. 5 % AEP
- annual spill volumes
- conveyance capacity

4 Apply and assess ability to achieve containment measures

Before finalising the containment measures the Water Utility should assess the measures set are practical and achievable within the required:

- time frames
- regulation
- stakeholder expectations (internal and external)
- available funding

The assessment could include sensitivity analysis to achieve containment measures and consideration of the different solution strategies.

5 Approval of approach

When the approach has been determined to be practical and achievable the Water Utility should obtain required approvals to implement this approach. These may include:

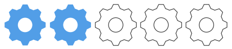
- internal e.g. board approval
- regulatory approval e.g. licence

Containment

A containment approach uses a benchmark performance to manage systems. For WWO, containment approaches are often focussed on the performance of an asset, but it can be managed at a system level.
Examples of a containment approach include a requirement to contain wastewater flows associated within a defined rainfall event, or requirement to maintain an average frequency of overflows over a defined period of time.

Typical application

This approach has typically been used by regulators and water utilities as the objectives are easily defined and the performance is transparent and measurable. It is usually applied to systems which have a medium to high complexity and medium to high levels of performance issues. Containment standards simplistically consider community values or environmental effects associated with overflows and therefore abatement options may not always deliver the best social or environmental outcomes. Typical performance standards may include a rainfall event-based approach such as a 5% annual probability of exceedance (AEP) event or a frequency approach such as 40 overflows in 10 years.

Complexity		This approach is common in the industry and can be of low complexity to develop and implement. Complexity increases when considering how to future-proof the approach. The containment standard targets, while they may consider environmental or social indicators, are often nominal targets for example on average a nominal frequency per year.
Data		The containment approach requires an understanding of the asset performance levels. Data inputs could be basic wastewater hydraulic calculations (models or spreadsheets), however a calibrated wastewater hydraulic model is ideal.
Time		The typical time required to develop a containment management approach can be minimal depending on the current management approach, available data, and number of assets.
Consultation		The performance level of the assets can be influenced by statutory and regulatory requirements and the water utility's strategic vision and objectives. External stakeholder requirements could significantly influence the containment targets.
Approach cost		The cost of developing this approach can vary depending on the base case scenario. It can be applied with minimal budget, with the cost increasing as the level of detail of the approach increases. It can be low cost to manage the framework, however can result in significant expenditure.

Key advantages	• Objectives are easily defined • Performance is transparent and measurable • Relatively easy to implement
Key disadvantages	• Typically, does not consider community values or environmental effects associated with overflows or is able quantify benefits to customers, community, or environment. • Can result in large capital solutions with long lead times and big footprints • Difficult or costly to future-proof

4.3 Outcomes

4.3.1 Overview

An outcomes management approach sets measurable goals or outcomes aligned with a strategic vision at a macro or micro level. The project objectives can be qualitative or quantitative in nature and are often focused on achieving the desired receiving environment principles. The outcomes, such as improved water quality of a specific water body, can be the result of a range of different factors which can be internal or external. The success of the approach is measured by whether the water utility is achieving the set outcomes. Typically, the outcomes set are aspirational, and therefore may take considerable time to achieve measurable change. The approach is flexible in application, and the rigidity and specificity of the results is largely determined by the water utility and regulator.

It is typical for the outcomes to be determined or strongly influenced by external factors. Therefore, the approach must be highly collaborative and requires community and stakeholder engagement to gain alignment on the desired outcomes. For example, to improve the waterways of a State protected area to increase platypus population may be a State Government initiative, however management of WWO in relation to that waterbody will be required by the water utility.

Endorsement from the community and stakeholders on the desired outcomes also allows for a more collaborative approach, greater transparency and shared efforts and resources. For example, the desired outcome may be relating to the health of a waterway, which could require contribution from water utilities, councils and governments.

4.3.2 Why choose this approach?

The outcomes approach is typically applied by water utilities who are aiming to integrate catchment objectives when determining investment solutions. The flexible nature of the approach provides a simple way to consider aspirational goals aligned with the receiving environment principles.

The project could result in broader outcomes (beyond the wastewater system) such as receiving environment improvement. These broader catchment initiatives are often directly or indirectly influenced by different entities, from a local level through to national strategies. For example, in the Dandenong Creek case study in Appendix 1, the project set an outcome of improving the health of waterways and an approach was developed based on deferring augmentation and adopting environmental improvement works.

Additional advantages of this approach include:

- It can be used for benchmarking safety for swimming at swimming sites. For example, Auckland Safeswim (Nau mai ki Safeswim) enables people to make informed decisions about where and when to swim.
- The approach can be applied to meet broad catchment wide performance objectives. For example, the Healthy Waterways Strategy (HWS) in Melbourne sets a long-term vision for managing the health of rivers, wetlands and estuaries, to protect and improve their value to the community.

- It can be combined with other management approaches, for example, applied in conjunction with an effects-based approach to determine whether the outcomes are being achieved.
- Applying this management approach could result in broader outcomes such as environmental offsets, including nutrient offsets, land practice offsets and sediment offsets.

4.3.3 Typical requirements

The outcomes approach considers outcomes generally related to the receiving environment. Therefore, the data and information requirements are more related to the receiving environment and the receiving environment principles, rather than primarily at an asset level.

The success of the approach depends on having enough information on the receiving environment to be able to effectively measure performance and outcomes.

The following are typical data and information inputs:

- organisational goals and strategies
- details from external stakeholders including government initiatives and community consultation findings
- wastewater hydraulic models - calibrated models may be required depending on the outcomes required
- water quality models and guidelines
- operational data such as flow gauges or actual asset performance
- asset condition and/or performance reports
- general asset data (construction drawings, survey information)
- historical performance data
- key receiving environment indicators, such as water quality and ecosystem health data
- qualitative data such as amenity and liveability
- literature searches for current and historical approaches to data collection and application of information

4.3.4 Other considerations

While the outcomes management approach can be flexible in its application, it does have certain limitations which must be considered.

For an outcomes management approach, activities or programs are assessed by whether they achieve a particular outcome, such as water quality improvement. As a result, they can often be costly to understand and measure the desired outcomes as this could be the result of a large range of internal and external factors.

A key limitation with this management approach is that the water utility implementing the framework may not be able to influence the change required to achieve the desired outcome. For example, stormwater pollution sources that are managed by other entities.

Additional limitations of the outcomes approach include:

- The data needed to measure the effectiveness of the approach is often difficult to obtain and varying in quality and quantity, due to the many unknown and dynamic variables of the receiving environment.
- The application of the approach can vary significantly.
- The approach can become very complex and costly due to the systems and monitoring required.
- The approach does not allow for prioritisation of measures to achieve the set outcomes.
- As the outcomes are typically aspirational, it may take a long time to achieve measurable change.
- Agreeing to realistic expectations e.g. returning a waterway to reference conditions may not be achievable.
- The water utility would need to engage with the regulator to determine the appropriate regulatory measures during development of the WWO strategy.
- If the outcomes are not effectively measurable, it may lead to uncertainty around whether the outcome is delivering the community objectives.

How is an outcomes approach developed?

The below summarises the typical steps in developing an outcomes approach.

4 Approval of approach

When the approach has been determined to be practical and achievable the Water Utility should obtain required approvals to implement this approach. These may include:

- internal e.g. board approval
- regulatory approval e.g. licence
- stakeholder acceptance and alignment

3 Apply and assess ability to achieve the outcomes

Before finalising the outcomes measures the Water Utility should assess the measures set are practical and achievable within the required:

- time frames
- regulation
- stakeholder expectations (internal and external)
- available funding

As the outcomes and application of the approach is typically unique to each WWO strategy the Water Utility will need to determine the appropriate implementation strategy.

1 Define outcomes and objectives

The Water Utility should consider which receiving environment principles are best achieved through an outcomes approach. The outcomes should be set by considering:

- short, medium or long term components
- best available data and science, typically includes a broader data system e.g. data from external stakeholders
- considering external factors such as government regulation, stakeholder goals and values

2 Set measures

Expected outcomes should align to what best available science indicates can be achieved in a set timeframe. This could include:

- significant literature review
- field testing and data analysis
- models e.g. wastewater and receiving water
- scale – macro or micro

Typically this is a collaborative approach with external stakeholders and therefore extensive engagement and co-development is required.

Outcomes

An outcomes management approach sets measurable goals or outcomes aligned with a strategic vision at a macro or micro level. The project objectives can be qualitative or quantitative and are often focused on achieving the desired receiving environment principles. This approach often requires community and stakeholder engagement.

Typical application

The outcomes approach is typically applied by water utilities who aim to integrate catchment objectives when determining investment solutions. The approach can be applied on macro or micro level. The project could result in broader outcomes (beyond the wastewater system) such as environmental offsets e.g. nutrient offsets. These broader catchment initiatives are often directly or indirectly influenced by different entities, from a local level through to national strategies. A key limitation with this framework type is that the water utility may not be able to influence the change required to achieve the desired outcome.

Complexity		The complexity of the approach stems from the multitude of factors that influence the desire outcome, including the extensive consultation required and the varying quantity and quality of data.
Data		Data required for the outcomes approach is typically part of a much broader data system, including utilising data from external stakeholders. Data is often difficult to obtain due to the many unknown variables of the receiving environment. Significant literature review, field testing and data analysis must be undertaken, in addition to calibrated wastewater and receiving water models and stakeholder consultation.
Time		This approach can become timely due to the coordination and consultation of a wide range stakeholders.
Consultation		The desired outcomes can be influenced by statutory and regulatory requirements and the water utility's strategic vision and objectives. The outcomes are typically influenced by other stakeholder groups e.g. community, council and regulators. Success is strongly influenced by stakeholder alignment on outcome goals and regulator acceptance.
Approach cost		This approach typically requires more data and analysis of the receiving environment, as well as consultation with the community and stakeholders to determine the desired outcomes, which can lead to increase cost.

Key advantages

- The implementation of management measures or actions can be flexible in approach
- Outcomes can be aligned to changing community and environmental values
- Can deliver cost effective solutions and long-term positive outcomes

Key disadvantages

- Does not allow for prioritisation of measures to achieve outcomes.
- Can be costly to understand and measure the desired outcomes.
- Can have long lead times to achieve measurable change and is difficult to quantify and track effectiveness.

4.4 Risk-based

4.4.1 Overview

A risk-based approach (RBA) assesses the likelihood and potential consequences of WWO to identify the potential risk of impact on the receiving environment principles. This provides a structured method for identifying WWO that have the greatest risk of impact, enabling water utilities to understand the potential risk and develop appropriate mitigation strategies.

The risk is determined by the "likelihood" and "consequence" of WWO, which are defined in the AS/ANZ ISO 31000 *Risk Management – Guidelines* as:

- **likelihood:** chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively.
- **consequence:** outcome of an event affecting receiving environment outcomes or objectives. Consequences can be expressed qualitatively or quantitatively and can be certain or uncertain and can have positive, negative or indirect effects.

For likelihood and consequence a risk measure needs to be established for each to determine the risk of impact on the objective. A risk-based approach can either be comparative or discrete across a system or systems.

A **comparative risk approach** compares the risk of impact of WWO relative to other assets in the system to identify the scale of risk from lowest to highest

A **discrete risk approach** considers the risk of impact of WWO at a discrete asset to identify the level of risk.

Risk-based approaches are used internationally and are generally in accordance with the international standards relating to risk such as AS/NZS ISO 31000 *Risk Management - Guidelines*, which provides principles and guidelines for effective risk management.

4.4.2 Why choose this approach?

A risk-based approach is useful for water utilities who seek to prioritise the management of assets that have a potential or known risk to the receiving environment principles. The approach also allows WWO to be assessed across multiple outcomes and objectives.

This approach is a more comprehensive approach than the asset or containment approaches. It is therefore suited for larger systems with WWO issues or where multiple outcomes or objectives need to be considered.

Advantages of this approach include:

- investment can be prioritised to areas at greatest risk of impact
- flexible and adaptable to community and organisational needs e.g. to improve water quality at a swimming site
- adaptable different regulatory requirements e.g. regulation that prioritises improvement strategies around assets with greatest risks
- adaptable to different types and quantities of data

- enables a water utility to make better decisions with available information and industry practices
- can be qualitative or quantitative

4.4.3 Typical requirements

A risk-based approach is largely data driven and the outcomes are dependent on the quality of the data used. Water utilities should understand the:

- quality of the data used, including how the data was collected, auditing practices, when the data was collected and the source of the data
- limitations of the data including the original purpose for which the data was collected
- quantity and consistency of the data and how this can be used at a macro or micro scale, including the use of proxies

The data requirements for a risk-based approach must be determined early as data collection needs may take substantially longer than asset or containment-based approaches. The following are typical data and information inputs:

- models e.g. wastewater system, stormwater and water quality
- water quality data, e.g. enterococci, nutrients
- operational data such as flow gauges or asset performance
- asset condition and performance reports
- general asset data (construction drawings, survey information)
- historical performance data and asset data
- key receiving environment indicators e.g. flora and fauna, sensitive areas, areas of cultural significance
- customer feedback and complaints
- council, community groups and key stakeholder input on receiving environment

In addition to the data needs, there must be a strong focus around defining objectives and consideration of the regulatory requirements.

4.4.4 Other considerations

A risk-based approach is tailored to different needs and developed with varying data and can have unique limitations. Typical limitations can include:

- can be difficult to implement particularly if there is uncertainty related to assessment of risk
- data gaps or poor-quality data can lead to uncertainty
- a comprehensive risk assessment for a complex system can be resource, data and cost intensive

This is based on the potential risk only and therefore does not define the actual effect or potential benefits (which is achieved by the effects-based approach)

How is a risk-based approach developed?

The below summarises the typical steps in developing a risk-based approach.

1 Define outcomes and objectives

The outcomes and objectives should be established by considering the following:

- establish which receiving environment principles and outcomes are to be used for the risk-based approach
- define the objectives for each outcome which may align with regulation, legislation, policies and literature

2 Establish current wastewater system performance

Understand the baseline system and WWO performance. This typically includes:

- mapping the wastewater assets
- calibrated wastewater system models
- key asset condition and performance verification (field data)
- existing and future conditions e.g. growth

3 Assess the risk

Determine the risk by considering:

- how the risk will be calculated e.g. this can typically be calculated using the risk equation: likelihood x consequence
- if multiple risk measures are adopted for likelihood or consequence, the application of this equation needs to be open and transparent
- if a risk matrix or a different approach will be used e.g. geospatial (where multiple data sets are used in a spatial environment)

4 Apply and assess ability to achieve outcomes

Before finalising the risk assessment the Water Utility should identify if and how the risk will be prioritised and addressed. This includes:

- sense checking the outcome of the risk assessment e.g. does it align with expectations?
- a sensitivity analysis e.g. how does the risk assessment change in different scenarios
- understanding the limitations of the data and how it may impact the risk assessment
- the different solution strategies
- the time frames to implement
- the available funding

5 Approval of approach

When the approach has been determined to be practical and achievable the Water Utility should obtain required approvals to implement this approach. These may include:

- internal e.g. board approval
- regulatory approval e.g. licence
- stakeholder acceptance e.g. community

Risk-based

A risk-based approach assesses the likelihood and potential consequences of WWO to identify the potential impact on the receiving environment principles. This provides a structured method for identifying those WWO that have the greatest risk of impact. This therefore enables water utilities to prioritise investment based on potential risk.

Typical application

This approach recognises the variety of values within each of the receiving environment principles, allowing utilities to tailor it to their own priorities and objectives. It has flexibility in how it can be applied, how much data is required and how relativity is considered, which allows it to be applied to various local areas. Risk-based approaches are internationally adopted and are generally in accordance with the international standards relating to risk, AS/NZS ISO 31000. A risk-based approach can either be comparative or discrete across a system or systems.

Complexity		A risk-based approach ranges in its complexity and becomes more complex with the more data and assets that need to be considered. Complexity may also increase depending on the availability and quality of data e.g. if the data is inconsistent, it can be difficult to accurately prioritise risk.
Data		The data requirements for a risk-based approach must be determined early. To assess likelihood, hydraulic models are required to effectively understand frequency and volume. To understand the consequence, data and information about the receiving environment principles is needed. This data and information may be sourced internally or externally which can result in varying quality, quantity and age of data.
Time		Detailed, robust risk frameworks may be costly and time consuming to develop. To effectively consider the receiving environment principles, the time (in consultation, undergoing detailed modelling and assessments etc) increases.
Consultation		The criteria and the extent of the consultation will be dependent on the current objectives and approach. Depending on how much of a change it is from the current framework, early engagement with the regulator may be prudent.
Approach cost		This approach can vary in complexity which directly impacts the cost. The level of assessment required to develop a robust approach can require extensive data, modelling, consultation, which would therefore increase the cost and could require considerable time and resources to gather.

Key advantages

- Allows for assessment across multiple receiving environment principles which enables targeted investment (effort and cost) in areas at greatest risk of impact.
- Flexible and adaptable and can therefore account for changing drivers and uncertain or inaccurate input data.
- Applicable at both a macro and micro level and can be used in conjunction with other management approaches.

Key disadvantages

- Risk assessments that consider multiple objectives, use extensive data over large systems may be costly and time consuming to develop.
- Difficult to implement, particularly when there is uncertainty related to a risk, and challenging to demonstrate robustness to stakeholders.
- Potential to be overly complicated or onerous for small, well performing systems.

4.5 Effects-based

4.5.1 Overview

An effects-based assessment (EBA) is a scientific approach used to quantify the effectiveness of an activity (pressure or response) on the health (state) of the waterway. An effects-based approach can test and compare the effectiveness of a wide range of management responses to protect, maintain and/or improve the receiving environment principles of a waterway. The approach focusses on the receiving environment principles and takes a more rigorous approach to the WWO strategy.

An effects-based assessment could be developed by a water utility or form part of a broader waterways plan from external stakeholders, which could include catchment managers, stormwater asset owners or governing bodies. An effects-based assessment tests effectiveness of managing WWO in different ways to achieve an outcome in the downstream waterway. Management, investment priorities and actions can then be based on the level of risk to the water quality objectives.

The ultimate value of an effects-based assessment is being able to understand if the measures and controls being implemented are going to achieve what is desired. An effects-based assessment should help to understand how a waterway will respond to multiple stressors.

The approach is very data driven and looks to rely less on judgement calls by using reliable datasets. Due to the quantity and quality of data required, it is an incredibly rigorous approach.

The type of effects-based assessment chosen will depend on the waterway type, the level of risk to the waterway, the complexity of the issues and the data and information available for the assessment. Effects-based assessments are increasingly being implemented using numerical models. They can be implemented more simply by using desktop assessments of readily available datasets however outcomes may not be as reliable.

4.5.2 Why choose this approach?

The key benefit of an effects-based approach is being able to direct resources based on evidence to achieve the greatest improvement for waterways, aligned with the water utility's desired receiving environment principles. This may lead to more cost-effective solutions for internal and external stakeholders.

An effects-based approach assists to provide clarity on what proportion of impact is related to WWO. Waterways are highly dynamic systems and different reaches of a waterway can respond very differently to the same type of stressor. For example, a well flushed tidal estuary will respond very differently to the same WWO in a freshwater reach in the upper catchment.

The approach is useful when managing complex waterways where there are multiple factors influencing the receiving environment principles concurrently. The approach can assist in understanding when the contributions from WWO would push water quality issues beyond the threshold that would cause harm and is typically applied at a macro level.

The key difference between a risk-based and effects-based approach is that an effects-based approach draws a direct link between the activity, in this case WWO, and the impact on the receiving environment principles. Detailed data sets would reduce the uncertainty around how the environment would respond to WWO and the effectiveness of measures.

An effects-based approach should leverage existing data sets, models and knowledge held by water utilities and external stakeholders and should produce powerful answers to questions such as:

- What is the actual vs perceived impact of our operations on waterways?
- How can we most efficiently optimise the available budgets?
- Is there a business case for collaborating with non-water utilities on works out of jurisdiction, and if so, what does it look like?

Due to the complex nature of natural systems, there may be a level of uncertainty in applying an effects-based approach. Any data gaps can be managed as a hybrid risk-based framework. Also, risk-based frameworks may transition towards effects-based assessment by continually improving processes, models and understanding risk of impact of WWO and waterway dynamics.

Where data gaps or uncertainties are significant, an alternate approach should be adopted e.g. risk-based approach, until sufficient data is available to quantify the contributions and direct impacts of WWO on receiving environment principles.

In areas where new wastewater infrastructure is being installed e.g. growth areas, utilities can adopt an effects-based approach to inform design standards or a level of service that is based on preserving the ecosystem health and beneficial uses of receiving waterways. The approach could also identify a sustainable load of WWO on different reaches of a waterway. This information could therefore influence the design standard from the water utility in terms of how much the waterway can receive before impacting the receiving environment principles.

Other opportunities include:

- useful for setting point and distributed targets, and variable targets for different receiving environment sensitivities
- provides valuable evidence base for water utilities
- can be applied to inform or underpin a business case for works on ground or maintenance budgets (e.g. nutrient trading)

4.5.3 Typical requirements

The effects-based approach seeks to reduce the uncertainty around how WWO affects the receiving environment through high quality data and models. Data requirements therefore match the complexity of waterways themselves and interaction of WWO.

Effects-based assessments can be done in stages, with an initial assessment conducted using simplistic analysis with existing data sets to determine what data gaps exist and if a more detailed quantitative, conceptual model is warranted.

Typically, an effects-based approach requires the following:

- understanding of the uses and receiving environment principles of the waterway (e.g. swimming, fishing, aquaculture, stocking and grazing)
- specific flows, environmental health or water quality objectives, triggers or thresholds (e.g. NHRMC, ANZG, environmental flows) that support or sustain the uses and values of the waterway
- numerical conceptual models and monitoring data (e.g. calibrated hydrodynamic and receiving water quality models) that accurately describe baseline flow and water quality conditions in the waterway
- details on the scale and magnitude of distributed or point source loads (e.g. catchment loads and WWO models) to the waterways that can be used to test a range of scenarios WWO management approaches
- details on how to affect and implement measures (e.g. strategically or works on-ground) and may require iterative honing-in on a solution

To improve the approach, the following could also be incorporated to test the cost effectiveness of the WWO scenarios tested:

- CAPEX and OPEX for measures
- economic valuation of waterway uses and values

4.5.4 Other considerations

The direct application of this approach has several challenges. The greatest challenge is producing accurate, reliable and timely conceptual models that provide certainty on how the environment would respond to catchment and WWO inputs. Models are very data, labour and time intensive. Advances in modelling and monitoring techniques contribute to a better understanding of the outcomes of effects-based approaches. A process of continual refinement and improvement may also be needed.

Another challenge is in estimating the proportion of flow contribution from all pollutant sources in the catchment and requires close collaboration and data sharing with stormwater system, land use and waterway managers.

The utility implementing the framework may not initially be able to influence external catchment and land use-based stressors which may be more significant than the impacts of WWO.

An effects-based approach is a rigorous, data intensive approach. The data is often difficult to obtain due to the many unknown variables of the receiving environment. It can also be complex to analyse due to multiple sources, data hierarchy and interrelations. If the data is of varying quality and quantity, the data gaps may make it difficult to accurately measure the effectiveness of the approach. This is particularly important to consider when utilising data from external stakeholders. This is beneficial to consider at the early stages of developing the approach, to mitigate where possible.

It may be worthwhile to invest in staged refinement of models through studies that reduce uncertainty (and often reduce the risk rating) around the “higher” priority principles and WWO. This ensures that the more detailed, expensive and time-consuming investigations are targeted at locations where the risks may be high and the benefits likely to be significant.

These aspects also make an effects-based approach an expensive and lengthy framework to implement, due to the substantial monitoring required. If suitable data is not available for immediate utilisation, monitoring and modelling to understand the current health of the waterway and the linking of stressors to impacts can sometimes take years.

Additionally, the water utility implementing the framework may need to work with external stakeholders and regulators to implement all the changes required to achieve the desired level of protection or improvement.

How is an effects-based approach (EBA) developed?

The below summarises the typical steps in developing a effects-based approach.

1 Define outcomes and objectives

Define the receiving environment principle that will be addressed through the effects-based approach and consider:

- each receiving environment principle could have a different EBA to achieve the Water Utilities strategic outcomes.
- determine what flows and water quality conditions support the specific receiving environment principle, this could include specific flows or water quality triggers.

2 Establish current wastewater system performance

Identify a range of measures that will influence the receiving environment e.g. flow or water quality conditions. Consider:

- internal and external influences on the receiving environment
- the scale - macro or micro
- how the WWO may impact the receiving environment e.g. for public health, measures like enterococci load for swimming can be adopted
- the data needs and time frames
- how the data will be analysed e.g. models

The list of measures may be extensive, and can be reduced by considering factors such as data requirements, complexity and feasibility.

3 Test effectiveness of measures

Test how effectively those measures protect, maintain or improve the state of the receiving environment.

Simulate the management measures in the conceptual model to determine the resulting state of the receiving environment.

Compare the resulting state of the receiving environment against specific flows or water quality objectives, triggers or thresholds relevant to the defined receiving environment principle (e.g. NHRMC, ANZG, environmental flows). Steps 2 and 3 may be iterative.

4 Apply and assess ability to achieve outcomes

Before finalising the effects-based approach the Water Utility should consider:

- the cost effectiveness of each measure, which may range significantly between options due to the varying degree of data requirements and consultation required for the different measures e.g. utilising past project CAPEX and OPEX
- if in the short to medium term another approach needs to be adopted while working towards the effects-based approach
- the different solution strategies
- the available funding

5 Approval of approach

When the approach has been determined to be practical and achievable the Water Utility should obtain required approvals to implement this approach. These may include:

- internal e.g. board approval
- regulatory approval e.g. licence
- stakeholder acceptance e.g. community

Effects-based

An effects-based approach is a data driven decision making approach for the management of activities and their actual impact on the receiving environment principles. An effects-based approach is used to quantify the effectiveness an activity (pressure or response) on the health (state) of the waterway or specific environmental principle. An effects-based approach can be used test and compare the cost effectiveness of a wide range of management responses to protect, maintain and/or improve the health of waterway or a community values/use.

Typical application

An effects-based approach is typically applied as part of a larger waterway management strategy to inform or underpin a business case for works on ground or maintenance budgets. The approach allows water utilities to establish performance targets, develop system management strategies, size discrete management works or explore measures to offset the decision to embark on an effects-based approach will depend on the complexity of the waterway, the level of risk to the waterway, the complexity of catchment inputs the issues and the data and information available for the assessment.

Complexity		The complexity of the approach stems from the multitude of factors that influence the desire outcome. This can include the organisation implementing the framework potentially not being able to influence the change required to achieve the desired outcome, the extensive consultation required and the varying quantity and quality of data.
Data		A tailored effects-based approach should leverage existing models, data sets and knowledge held by water utilities and stakeholders. Data requirements should match the complexity interaction of WWO with the receiving environment. An effects-based approach uses robust conceptual and numerical modelling, but also requires a strong understanding of community values, uses and ecological values of waterways, specific flows or water quality objectives, triggers or thresholds, numerical conceptual models and monitoring.
Time		This approach can become time consuming due to the coordination and consultation of a wide range stakeholders and the time consuming nature of numerical modelling.
Consultation		The desired outcomes can be influenced by statutory and regulatory requirements and the water utility's strategic vision and objectives. The outcomes are typically influenced by other stakeholder groups e.g. community, council etc. Where the WWO contribute a small amount to the state of the waterway compared to other land uses, success is strongly influenced by the utility taking a leadership role with stakeholders and alignment on customer/community values, objectives and aspirations.
Approach cost		This approach requires more data and analysis of the receiving environment, as well as consultation with the community and stakeholders to determine the desired outcomes, which can lead to increase cost.

Key advantages

- Reduced uncertainty on the relative contribution of WWO and where investment should be prioritised
- Potentially can be used to identify and prove cost effective offsets to WWO impacts
- Can assist in identifying where additional protection measures are needed that are outside of the utilities control
- Assists in answering complex questions about the cumulative impacts of WWO in the context of other catchment pressures and processes

Key disadvantages

- Data and consultation requirements can be time intensive which can increase the cost of developing the approach
- Data is often difficult to obtain due to the many unknown variables of the receiving environment.
- Long-term maintenance needs (e.g. resources, investment) must be considered if it is to remain accurate or reliable and this could be considerable for a complex system

4.6 Hybrid

A hybrid approach is a combination of multiple management approaches, which can be staged in their application. A hybrid approach often allows for the limitations of a lone framework to be overcome and to achieve additional benefits, such as increasing the flexibility of implementation. For example, a hybrid staged approach could be adopting an RBA and containment management approach and progressing to an effects-based approach in the future.

It should also be noted that for each receiving environment principle, water utilities may choose a different management approach. Different management approaches can also be applied at different levels, for example, a risk-based approach may be selected at a catchment level and effects-based at micro level within the same catchment.

The hybrid approach is non-prescriptive and allows water utilities flexibility on how they move forward with their WWO management approaches.

Advantages:

- allows for increased flexibility in implementation
- typically allows for more cost-effective solutions
- it can potentially lead to better community and environmental outcome

Disadvantages:

- if the goals, outcomes and key metrics are not defined clearly, a hybrid approach may make it difficult to assess the impact of the approach
- if applied ineffectively, it could result in an inefficient use of resources (time, personnel and budget)

5 ADDITIONAL CONSIDERATIONS

This chapter provides discussion on other factors that may be considered in the development of the WWO strategy and application of the receiving environment principles and management approaches.

5.1 Systems thinking

A complex system, such as a catchment, is made up of multiple smaller systems. These systems can be environmental, social, economic or infrastructure systems each with systems within them. For example, WWO are one component of the wastewater system (an infrastructure system) and they have the potential to impact on other systems (e.g. a waterway) and to be impacted by other systems (e.g. the stormwater system).

Each system is unique in its initial and boundary conditions, configuration, capacity, operation and behaviour over time. The dynamic interactions between systems results in complexity and uncertainty. Fundamentally, applying a systems approach involves making decisions that consider the interconnections and interdependencies between the systems. This informs an integrated approach to investment and opens up different options such as:

- policy and regulation
- incentives and penalties
- joint operations
- integrated solutions
- pollution offsets

This has the potential to realise efficiencies and deliver greater receiving environment outcomes and broader social and economic outcomes. A systems approach requires strong collaboration between stakeholders of all the systems being considered.

For example, applying a systems approach to WWO management could require all stakeholders to identify the different pollutant sources in a catchment, their contributions to the impact and the possible solutions for reducing the impact. This approach may allow water utilities to cost-effectively offset pollution load from WWO with other, higher benefit, catchment remediation activities.

Systems thinking is not a new approach for the wastewater industry and there are two established frameworks that can be adopted:

- Integrated water management (IWM)
- Integrated catchment management (ICM)

Water utilities need to determine what perspective to take based on the problems experienced and the scale of outcomes that need to be achieved.

5.1.1 Integrated water management (IWM)

The Australian Productivity Commission defines integrated water management (IWM) as, "a whole-of-system, multi-disciplinary approach that aims to manage the entire urban water cycle by integrating the delivery of water, wastewater and stormwater services to contribute to the full suite of water security, public health, environmental and urban amenity outcomes that the community is seeking".

IWM is the concept of bringing together all stakeholders involved in the planning, management and delivery of the water cycle (water supply, storm water and wastewater). There is the opportunity as well as the need to coordinate and develop improvements towards water security, liveability and the health of waterways. These improvements can be achieved through aligning the goals of stakeholders who have authority over the development and management of the water cycle.

Stormwater capture, habitat restoration and water reuse/recycling are elements of the water management cycle which can be used to yield benefits to water quality, water reliability, health of humans and the environment.

Traditional water management operated under the practise of extracting, treating, using and discharging water supplies. This traditional approach does not maximise the full utility of water.

IWM seeks to utilise better water management strategies. For example, large scale water recycling can provide reliable local drinking water, reducing reliance on energy intensive processes such as desalination, and reduces pressure on water security during droughts, which may be becoming more frequent with climate change. Additionally, proper wastewater management ensures the health of waterway users, protect water quality and enables safer consumption of seafood, all of which ultimately improve the quality of life for the community.

IWM is an evolving process towards best practise of water cycle management. WWO are part of the urban water cycle and therefore need to be considered within the development of the IWM. A successful IWM approach will have a clear vision and objective of what needs to be solved and the desired outcomes to be achieved. The following are key factors of an IWM approach:

- a collaborative process that is owned by all stakeholders involved in the water cycle, from planning to ongoing management
- is driven by the needs of customers and the community
- considers all options related to water, wastewater and drainage services
- supports a circular economy through maximising efficiency and working towards regenerative outcomes
- considers the environmental, cultural, social and economic dimensions

The IWM objectives can inform the WWO strategy by identifying:

- key receiving environment objectives
- key pollution sources e.g. stormwater, wastewater, agricultural runoff
- stakeholder groups and their values and goals
- waterway variations (e.g. seasonal)
- waterway uses
- potential solutions to manage impacts to the waterway

5.1.2 Integrated catchment management (ICM)

Integrated catchment management (ICM) is a cooperative approach to solving waterways problems. It involves the coordinated management of land, water and biodiversity resources based on catchment areas. The catchment area is considered a complete system. It considers the complex relationships which exist within ecosystems. These might be relationships between flora and fauna, geology and hydrology, soil and the biosphere, and between the biosphere and the atmosphere. In some states, ICM is also known as Total Catchment Management or Integrated Natural Resource Management.

Cooperation means that individual members of the community, landowners, industry and the government work together to develop common objectives. Everyone is involved in planning and managing the catchment. It recognises that water utilities should be guided by their customers, and the communities in which they operate, when determining what aspects of liveability, resilience and economic prosperity they should focus on.

The following are the key traits of an ICM approach:

- ICM is a **systems approach.** This means recognising that landforms, soils, water, vegetation and other natural resources in a catchment are interdependent. Management of one issue must be done with consideration of the whole system. It integrates social, financial and environmental issues.
- ICM develops **partnerships**. State and local government agencies work alongside farmers, industrialists, conservationists and the community to solve problems and sustainably manage natural resources. Everyone is kept informed and resources are pooled and used more efficiently.
- ICM identifies **stakeholders** by recognising that everyone lives in the catchment and everyone has the right to, and is able to, participate in decision making.
- ICM provides a **process** for dealing with complex environmental issues relating to natural resources. This process of information gathering, meeting and discussion keeps everyone informed. It uses spatial representations of regional priorities and values to align with land use planning.

Some of the key relationships within catchments that relate to WWO are:

- point source pollutant sources
- diffuse pollutant sources, such as urban stormwater, streambank/gully erosion and agricultural or horticultural runoff, exfiltration of septic tanks
- waterway variations (e.g. seasonal)
- waterway uses
- biodiversity

IWM and ICM are established approaches and there are likely region-specific regulations, policies, catchment management authorities, regional catchment strategies and frameworks that need to be considered when managing WWO.

5.1.3 United Nations Sustainable Development Goals (SDGs)

The United Nations Sustainable Development Goals (SDGs) articulate the economic, societal, and environmental challenges that Australian society and the rest of the world is facing. They provide a blueprint for achieving sustainable development through articulation of goals, targets and indicators. They are also a platform for water utilities, governments, regulators and the community to talk about current and future priorities.

SDG 6: Clean water and sanitation captures the water industry's fundamental role, however there are interlinks between the 17 goals. Depending on the local context and if a systems thinking approach is adopted different SDGs may be applicable, in particular the following:

- SDG 3: Good health and well being
- SDG 11: Sustainable cities and communities
- SDG 14: Life below water
- SDG 15: Life on land

When considering the receiving environment outcomes, the WWO strategy should strive to achieve the SDGs and provide a framework for thinking about the different outcomes, indicators and benchmarks. WSAA's report *Global Goals for Local Communities: Urban water advancing the UN Sustainable Development Goals*, outlines the contribution water utilities are already making and the opportunity to do more.

5.2 Solutions

WWO are the consequences of problems elsewhere (upstream or downstream) in the wastewater system and the cause of the WWO can be varied, as explored in Chapter 2. Therefore, there are many interventions or solutions that can be implemented to improve the performance of WWO. These can be broadly categorised into the following:

- **Source control** - the reduction of stormwater entering the wastewater system at the source. Source control can be an effective solution provided that the source is property identified. Once the source of the I&I is known, source control solutions can be relatively quickly implemented and can be cost effective, especially compared to most end of pipe solutions.
- **End of pipe** – a range of solutions that typically require new infrastructure to be built to contain the stormwater after it has entered the wastewater system due to I&I.
- **Policy** – future thinking, where policies are adopted to prevent future I&I issues.
- **System operation and maintenance** – improvements in operational or maintenance practices to avoid issues that cause I&I.
- **Whole of catchment** – these solutions consider the catchment outcomes or impacts and may not always be directly associated to the wastewater system.

Selecting the appropriate solution requires considering the sources and scale of I&I, the site conditions and catchment characteristics. It also requires understanding of the outcomes that need to be achieved, the time frame for when they need to be achieved and the cost associated with implementing the solution.

Table 5-1 provides typical solutions. This list is not exhaustive and is only included in this guideline to identify potential solutions that could be considered. *The WSAA Management of Wastewater System Infiltration* and *Inflow Good Practice Guideline* (as amended) can be referred to for guidance on I&I management solutions.

Table 5-1 | Typical solutions to manage WWO

Solution	Description
Source control	
ERS remediation	The installation of backflow prevention devices to prevent stormwater entering the wastewater system through the ERS discharge point.
Maintenance hole rehabilitation	Rehabilitation of the maintenance hole structures which may include remediating sections, lining the maintenance hole or installing anti-infiltration devices ("rain stoppers") to prevent stormwater entering the wastewater system through the cover.
Pipe lining	Lining of wastewater pipes to repair cracks, breaks or displaced joints, that could be targeted based on the location of the wastewater pipe.
Property defects rectification	Rectification of property defects (e.g. roof drain connection, broken property connection, uncapped cleanout) to reduce inflow of stormwater into the wastewater system. Property defects are typically identified through smoke testing or visual inspection of properties.
End of pipe	
Store and return	Temporarily store excess flows during wet weather and provide a delayed and controlled return to the wastewater system once flows have reduced and the downstream capacity of the wastewater system is restored. These solutions reduce the volume and frequency of overflows into the environment.
Treat and discharge	Treat and discharge facilities that capture wet weather flows, treat the pollutants and release the treated water into the environment. This solution can be applied through small scale treatment directly at the discharge point of the WWO to a large scale wet weather treatment plant that treats a larger portion of wet weather flows. The treatment type applied must be clearly linked to the required outcomes and objectives.
Emergency relief structure (ERS)	Installation of an ERS that provides controlled discharges to the environment and minimises overflows in sensitive locations such as private properties. Screens (mechanical or gravity) can be added to an ERS to reduce the rags and other larger pollutants from being discharged into the environment. Additionally, the discharge of the ERS can be relocated away from receiving environments that have higher impacts or values (e.g. bathing waters, shellfish waters, sensitive aquatic environments etc.).
Flow diversion	Piped solutions such as bifurcations or relief mains that divert some of the flow to another area downstream that has more capacity. These are typically gravity options.
Wet weather pumping stations	Wastewater pumping stations that only operate during wet weather events. They divert flows from the system where the capacity has been exceeded in wet weather to another part of the system where there is capacity or discharge directly to the environment.
Flow control	Structures such as vortex flow control devices, orifice plates or weirs that control wet weather flows.

Solution	Description
Removal of trade or commercial discharges	On site treatment or diversion of high concentration wastewater (e.g. a hospital or an abattoir) to downstream of an overflow location. This will only remove or reduce certain pathogens/toxic chemicals e.g. removal of heavy metals (zinc/copper).
Outfall mixing or increased dilution	Locating the outfall or providing diffusers such that the discharge plume is sufficiently mixed and therefore diluted prior to reaching sensitive receiving environments. Other options may include mixing the wastewater discharge with other stormwater discharges to increase the overall dilution.
Aeration	Aeration of water bodies to improve dissolved oxygen content and reduce the impact of wastewater overflow discharges.
System operation and maintenance	
System maintenance	Undertake activities to recover capacity, these can include: removing blockages (typically tree roots), repairing collapses or breaks in the wastewater pipe, desilting, de-gritting and control of fats, oils and grease.
System operation	This can include: direct operational control, real time control and spill monitoring and intervention.
Spill response plan	Develop monitoring systems and management plans to respond to spills to reduce their impact and clean-up when they occur.
Policy	
Pressure or vacuum systems	These are alternatives to gravity systems and reduce the risk of I&I into the wastewater system. However, this does not prevent I&I entering the system through private property connections. They can be a good alternative for new developments which are in areas prone to flooding or high ground water.
Low I&I systems for growth	For new growth areas, adopt policy where pipes and maintenance holes installed are low I&I products. This policy could also be extended to include the private property connections.
Other approaches	
Nutrient offsets	This solution involves offsetting the impacts of WWO by improving the receiving environment by other means in equal measure. It weighs the benefits and costs of addressing other contaminant sources against those of direct wastewater overflows to achieve the best outcome for the receiving environment. Offsetting options, e.g. wetlands or riparian revegetation, require significant buy-in of a wide range of stakeholders to be considered appropriate and may create secondary or residual risks that may need to be shared or accepted.
Green infrastructure	Solving urban design challenges by building with nature. It is an important catchment-based risk treatment option that can be used to offset pollutants from WWO whilst building catchment resilience. It can improve waterway health and enhance ecology and social values.
Stormwater management	To reduce stormwater contaminant load from urban areas which can include stormwater runoff detention, treatment devices and

Solution	Description
	additional gross pollutant traps for stormwater and wastewater overflows. Flood management schemes should also consider the impact on the performance of the wastewater system, either positive impacts e.g. through reduction in water levels or negative impact e.g. ERS unable to discharge during storm events.
Surface nutrient/contaminant source control	Control through bylaws or other legislation of certain nutrients (e.g. nitrogen/phosphorus) or other contaminants (e.g. zinc/metals/pesticides) that may be used within watersheds that contribute to stormwater contaminants reaching the receiving environment.
Minimise runoff pollution	Local management and the design of sustainable intercepting and treatment environments between the site and receiving waters.

5.3 Data

Data becomes more critical as the complexity and sensitivity of decision making increases. In particular, the risk-based approach and effects-based approach require good data management practices.

In the development of the data management process, water utilities should consider:

- what data is required and for what context, e.g. is it required in large storm events, is it just level data or does water quality need to be collected at the same time?
- how is the data going to be used, is it for calibrating models or informing risk analysis?
- who needs to access the data?

Big data can be difficult to comprehend if purely managed through spreadsheets. Visualising the data through systems such as GIS tools or graphical dashboards can significantly improve the ability to understand the data and allow a broader group of people to access and use the data.

The ISO19650.1: *Organization and digitization of information*, can provide guidance on good practice for data management.

The development of risk-based and effects-based approaches will often result in a multitude of data from different sources, which will have differing levels of quality and validity. A data hierarchy may also therefore need to be considered. A data hierarchy refers to the organisation of data into hierarchical order based on the appropriateness, resolution and detail of the data. The assessment should use the data hierarchy to select the best available data at each location in the study area regardless of the extent of coverage of that data to improve the accuracy of the assessment at that location.

The following factors affect the data hierarchy:

- data completeness, data precision, data accuracy and data consistency
- the extent and spread of field verification
- quality of data and information collected

- scale of the data collected
- data age and temporal resolution
- purpose of data collection

5.4 Cost benefit assessment

Water utilities need to justify the investment required for WWO management, this is typically done through business cases which, depending on the size of the investment and the organisations requirements, can be both internal and external. A business case typically includes a cost benefit assessment as a way of comparing the different investment levels and assisting decision makers. This enables them to optimise the level of investment which may require adjusting the desired outcomes, approach or solutions to deliver the highest net return, while balancing the internal, external and regulatory requirements.

The budgetary, regulatory and pricing implications will influence the detail and rigour of the cost benefit assessment and whether detailed economic evaluations are required. Economic evaluations for understanding the benefits to the WWO receiving environment principles can include:

- financial analysis
- multicriteria assessment
- triple bottom line analysis
- total value of ownership
- choice modelling
- benefit transfer
- hedonic pricing
- direct and indirect economic loss
- property valuation
- valuing amenity (includes contact recreation)

Cost benefit assessment can be used to justify the investment but they can also be used to help set the desired outcomes and objectives for the WWO strategy.

With the advancement of technology, tools and scientific knowledge, water utilities are undertaking studies to help better understand the relative contribution of wet weather overflow impacts on the receiving environment principles and if further wastewater system investment will deliver measurable benefits and lead to the desired outcomes.

5.5 Stakeholders

Stakeholder engagement is vital to the success of a water utility's WWO strategy as they influence the receiving environment outcomes. Consultation and collaboration with a diverse group of stakeholders should be undertaken. The IAP2 (International Association for Public Participation) Public Participation Spectrum is frequently used framework for stakeholder consultation.

Key stakeholders will vary for each water utility however the following categories should be considered:

- regulators (environmental, financial, health)
- Internal stakeholders? Board, executive, operational and maintenance teams
- government stakeholders (government departments and councils)
- industry bodies
- customer and community
- local Aboriginal, Torres Strait Islander and iwi (Māori) groups

5.5.1 Regulators

Water utilities should engage with regulators when developing the WWO strategy. This will facilitate alignment on regulation to achieve the WWO outcomes. The regulators may be responsible for:

- health
- economics or pricing
- environmental protection
- primary industries e.g. fisheries
- technical design standards

5.5.2 Customer and community

Effective communication with customers and community increases awareness of WWO management approaches and responsibilities. It helps them understand that the services of a water utility are to help protect the health and amenity of communities and waterways. It should let them know how they can help. It should also be noted that discussions around customer willingness to pay may be required relating to managing WWO and this should be an ongoing discussion.

Customer and community stakeholders could include:

- customers (residents and businesses)
- local Aboriginal, Torres Strait Islander and iwi (Māori) groups
- land, waterway or catchment managers
- the broader community
- retailers and third party proponents
- developers and landowners
- community and public interest groups

5.6 Climate change

Adaptation to the impacts of climate change should be considered when developing a WWO management approach to build resilience & manage the impacts of climate change.

Climatic records show that the historical climate has already changed and will continue to do so in future. This change is predicted to increase the impacts of WWO in terms of frequency and magnitude.

When considering the impacts of climate change on WWO, certain climate variables that could impact the wastewater system performance could include:

- maximum 1-day precipitation projected to increase as the climate warms
- sea level rise and coastal extremes inundating overflow structures
- projected increase in droughts

The consequence of climate change on WWO frequency and volume could include:

- increased groundwater infiltration with rising sea levels
- increased discharges result in failure to meet customer or regulator expectations and service standards
- wastewater systems with connections to stormwater or in flood prone areas may be more vulnerable
- maintenance cost increases due to saltwater exposure and increased expansion or contraction of soils
- increased tree roots infiltrating into wastewater system during droughts

High resolution tools exist to predict climate change in different locations. Up to date, locally relevant projection tools should be used to identify impacts at specific locations, as projections continue to develop and become more refined.

Potential strategies to manage impacts of climate change on WWO include:

- inclusion of climate change scenarios and projections in development of management approaches
- increased community engagement and water quality sampling programs
- increased effort for programs to mitigate cross connections of stormwater into the wastewater system
- build redundancy/resilience into system design to augment capacity to accommodate increased wet weather flows and reduce impacts of individual component failures
- emergency storages and overflows at wastewater pump stations for wet weather flows
- liaising with communities in low lying areas to build resilience in smaller events
- avoid new combined wastewater/stormwater systems

The DELWP Guidelines for the *Adaptive Management of Wastewater Systems Under Climate Change* in Victoria is a useful document to refer to when considering the effects of climate change on WWO.

5.7 Contaminants of concern

Contaminants of concern are contaminants that can be both natural and synthetic, that may cause ecological or human health effects and are not widely regulated. Thousands of contaminants of concern are found in wastewater, and WWO increase the likelihood of contaminants of concern entering the environment. Examples include:

- caffeine
- Endocrine-disrupting chemicals (EDCs)
- flame retardants

- food additives
- illicit drugs
- microplastics
- Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Contaminants of concern enter the wastewater system through:

- human excretion e.g. medication
- trade waste e.g. hospital waste, industrial processes
- cleaning activities e.g. washing clothes, bathing
- storm water and agriculture
- recreational activities
- legacy contamination infiltration or mitigation e.g. plumes in groundwater

More work is needed to understand the impact of contaminants of concern loadings and their effects on human health and aquatic life. The impact can be better understood by considering the sources, occurrence, prevalence and distribution of contaminants of concern from WWO.

5.8 Research, Development and Innovation

It is beneficial for water utilities to participate in research and development about WWO management and continuous improvement.

Research, development and innovation can help water utilities assess:

- new ways of operating
- whether new equipment and infrastructure is appropriate and reliable
- design changes for improved plant performance and control systems

New management approaches and solutions need pilot scale research and evaluation before being implemented full scale.

Most water utilities access industry wide research and development through collaboration with organisations and research bodies such as cooperative research centres, universities, water research bodies and industry associations.

Collaboration could occur across service delivery, supply optimisation, customers, workforce, liveability and the circular economy.

Continuous improvement is part of everyone’s role that is associated with wastewater quality management. A critical component is the constant review of monitoring data, which helps to better understand the wastewater system and how different inputs affect key objectives. Further details on this can be found in the *WSAA Australian Wastewater Quality Management Guidelines*.

5.9 Monitoring, evaluation and audit

A water utility must evaluate the WWO management plan over its duration to ensure the management strategies and their translation into policies, processes and actions are effective, and are being appropriately carried out. These reviews allow water utilities to measure performance against the receiving environment and identify ways to improve.

5.9.1 Operational monitoring and control points

Operational monitoring is vital to understand system performance and to adjust the management approach as efficiently and effectively as possible. The data which ongoing monitoring produces is a valuable resource in event analysis and the formation of longer term responses.

Control points follow a framework which is designed to give consistency to a management approach. These enable prevention (or reduction) of WWO which otherwise would not have been possible. For further details of the operational monitoring steps which can be used for the management approaches, refer to the *WSAA Australian Wastewater Quality Management Guidelines* or relevant State or Territory guidelines.

5.9.2 Environmental monitoring

When a management approach considers the impacts of WWO on the receiving environment, the environmental monitoring of that environment is important. Monitoring may be used to establish the level of risk or to verify that the risk rating for the source of risk was valid.

Environmental monitoring should assess how the quality management system is performing by monitoring impacts on the receiving environment. Targeted monitoring can validate operational decisions that are based on a risk assessment.

Environmental monitoring may:

- vary depending on the risks associated with pollutant sources and how risk scores were established
- be routine or non-routine
- target short to long-term impacts
- assess local to regional impacts
- be required regardless of risk due to regulatory conditions

Typically, environmental monitoring consists of the following:

- objectives and data needs
- data evaluation (representative and reliable)
- reporting mechanisms
- corrective and preventative actions
- collaboration with academia

5.9.3 Long-term evaluation of data

This typically involves collecting and evaluating long-term results to assess performance and identify trends, and reporting results. For information about the steps involved in the long-term evaluation of the management approaches, refer to the *WSAA Australian Wastewater Quality Management Guidelines*.

5.9.4 Validation processes

Process validation aims to ensure control measures are effective and will control hazards. Measures should be checked before water utilities implement them, and processes revalidated regularly or when variations occur. For information about the triggers for revalidation which can be used for the management approaches, refer to the *WSAA Australian Wastewater Quality Management Guidelines*.

5.9.5 Audit

An audit systematically evaluates activities and processes to confirm that objectives are being met. It checks that systems are being implemented correctly and are working well. It identifies effective aspects as well as ways to improve policy and operations.

Internal audits are undertaken by trained staff who review the WWO strategy and its operational procedures, monitoring programs, and records. This is essential to maintaining a functional system. The frequency and schedule, responsibilities, requirements, procedures and reporting should be defined by the water utility.

External auditing is done by a third party or by peer review. This can help maintain credibility and confidence with customers, regulators and other stakeholders. Auditors should deliver a written report for staff and management.

6 IMPLEMENTATION

The development of the WWO strategy is an iterative process and is influenced by many varied factors. This chapter provides guidance on how the elements from the previous chapters are used to form the WWO strategy that is tailored to the water utility's internal, external and regulatory context. Figure 6-1 summarises the staged approach to developing a WWO strategy. This approach is a flexible framework that can be adapted to local needs.

Define current state	Establish desired future state	Gap analysis	Selecting the approach	Develop WWO strategy	Additional steps for implementation
Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	**Stage 5**	**Stage 6**
The stage establishes the existing context. • Define current performance objectives, considering internal, external and regulatory needs. • Understand the outcome the performance objectives are trying to achieve and what receiving environment principle they relate to. • Understand current WWO performance. • Identify what management approaches are being used to manage and achieve the current performance objectives.	**This stage establishes the desired future.** • Identify desired future outcomes. • Consider internal community and regulatory requirements and aspirations. • Consider how external influences such as growth, technological and scientific advancement influence the outcomes. • Align outcomes with the receiving environment principles. • Consider expectations on timeframes.	**This stage identifies whether the WWO performance meets the current and future outcomes.** • Identify if there are WWO performance shortfalls. • Understand what else is missing to achieve the receiving environment outcomes e.g. data, knowledge, stakeholder engagement.	**This stage selects the right management approaches to achieve the short term and long term outcomes.** • Set objective(s) for each outcome. • Identify the preferred management approach for each objective. • Identify the measures required to implement the management approach. • Resolve data and information gaps. • This stage is iterative and may require going back and refining stage 2 and 3.	**This stage develops the strategy to improve WWO performance to achieve the desired outcomes.** • Understand the cause of WWO. • Identify the potential solutions to achieve each outcome. • Understand the high level cost and time to develop and implement the management approach(es) for each outcome. • Understand the high level cost and timeframe to implement the activities to achieve the outcome. • This stage is iterative and may require going back and refining stages 2, 3 and 4. • Identify the key internal and external processes and the key milestones.	**This next steps will vary for each organisation and is not the focus of this guideline. However, they could include:** • Development of supporting items such as policies, business cases, funding applications and detailed planning. • Gaining internal stakeholder endorsement. • Engaging with regulators (financial, health, economic) for endorsement and approvals. • Engaging with customers to understand willingness and ability to pay.
The output from this stage identifies the minimum requirements and obligations.	The output from this stage sets the required outcomes of the strategy.	The output of this stage identifies whether there is a need for further investment in WWO management.	The output from this stage aligns all the outcomes and objectives and determines how they will be managed and what information is required so that the WWO strategy can be developed.	The output of this stage is the WWO strategy.	N/A

Iteration between theses stages as required

Figure 6-1 | Staged approach to developing a WWO strategy

Stage 1: Define current state

This stage establishes the existing context. This is a vital step to understand where water utilities are on their WWO journey and their existing minimum requirements and obligations. Defining the current state should consider:

- Existing or current internal, external or regulatory requirements. These requirements should also be aligned to the receiving environment principles.
- The current WWO performance should be assessed. Determining how the system performs and what performance data and information is available and limitations of this data.
- Identify any immediate emerging concerns, e.g. growth, that could impact WWO performance and impact.
- Identify what management approaches are currently being used and their benefits and potential limitations.

Establishing the current state is critical to the development of the WWO strategy as it is the baseline the strategy is built from.

Stage 2: Establish desired future state

This stage requires the water utility to consider the outcomes that may be required or desirable to the organisation, customers, community or regulators. The outcomes maybe considered in terms of short-term (within 5 years) through to long-term (e.g. 30 years +). Understanding potential long-term outcomes. This stage establishes the outcomes, which includes defining:

- The required outcomes for the WWO strategy by considering internal, external and regulatory requirements and aspirations and aligning them to the receiving environment principles.
- The timeframe (short, medium or long-term) for achieving the outcomes. This should consider the internal, external and regulatory expectations as well as what is required for this to be practicably achievable.
- The management approach to be adopted, for each receiving environment principle, recognising this may change over time.

At this stage, water utilities should also consider what systems perspective to adopt based on the desired outcomes. The WWO strategy will need to identify when the management of WWO changes from just focusing on the wastewater system to expanding to incorporate the wider systems. This will influence the:

- timing of the desired outcomes
- management approaches e.g. containment to effects-based
- activities required, e.g. establishment of partnerships or aligned outcomes
- solutions, e.g. wider waterway catchment solutions that may not be applied to the wastewater system

Stage 3: Gap analysis

This stage identifies the gap between current WWO performance and achieving the current and future WWO outcomes. There are two key aspects to the gap analysis:

- gap in knowledge to define outcomes and set objectives
- gap in WWO performance to achieve the outcomes

Defining the knowledge gap can be challenging, as it can be difficult to define what is not known. However, it is important these gaps are recognised and defined to enable the objectives to be determined. Depending on the knowledge (data) required it may take many years for the gaps to be resolved and this needs to be factored into the strategy.

This stage is key in establishing if there is a current need for investment in WWO management and if investment may be required in the future. For example, water utilities may identify that the current investment and management approaches to achieve the desired outcomes in the short to medium term are successful and investment may only be required in the medium to long-term.

Stage 4: Selecting the approach

This stage selects the management approach to achieve each objective and the required measures. During this stage the water utility needs to establish the timeframe for each objective based on external stakeholder expectations and availability of people, finance, knowledge and resources. The outcomes must be realistic and have achievable timeframes.

Knowledge gaps may exist for some or all of the outcomes. The water utility needs to identify what knowledge gaps are necessary to be closed. However, it may not be necessary or possible to close all the gaps in the short-term. Therefore, the water utility should consider the knowledge available to achieve:

- the outcomes with objectives for the short-term management approach
- the outcomes with objectives for the long-term management approach (if applicable)

It is highly likely that this stage will be iterative and may require revisiting Stages 2 and 3.

Knowledge and data changes over time can lead to continuous improvement in managing WWO. As additional knowledge and data is obtained the outcomes and objectives may need to be revised. These revisions may also be relative to the timeframes associated with implementing different management approaches to achieve the desired outcomes.

In addition to knowledge of performance and impact, knowledge also includes cost to implement an effective solution and it is important that this is considered by the water utility. If there are knowledge gaps in the ability to implement solutions, this should be recognised and if necessary, resolved in this stage.

Figure **6-2** provides an example of how the strategy, outcomes, objectives, measures and time are structured.

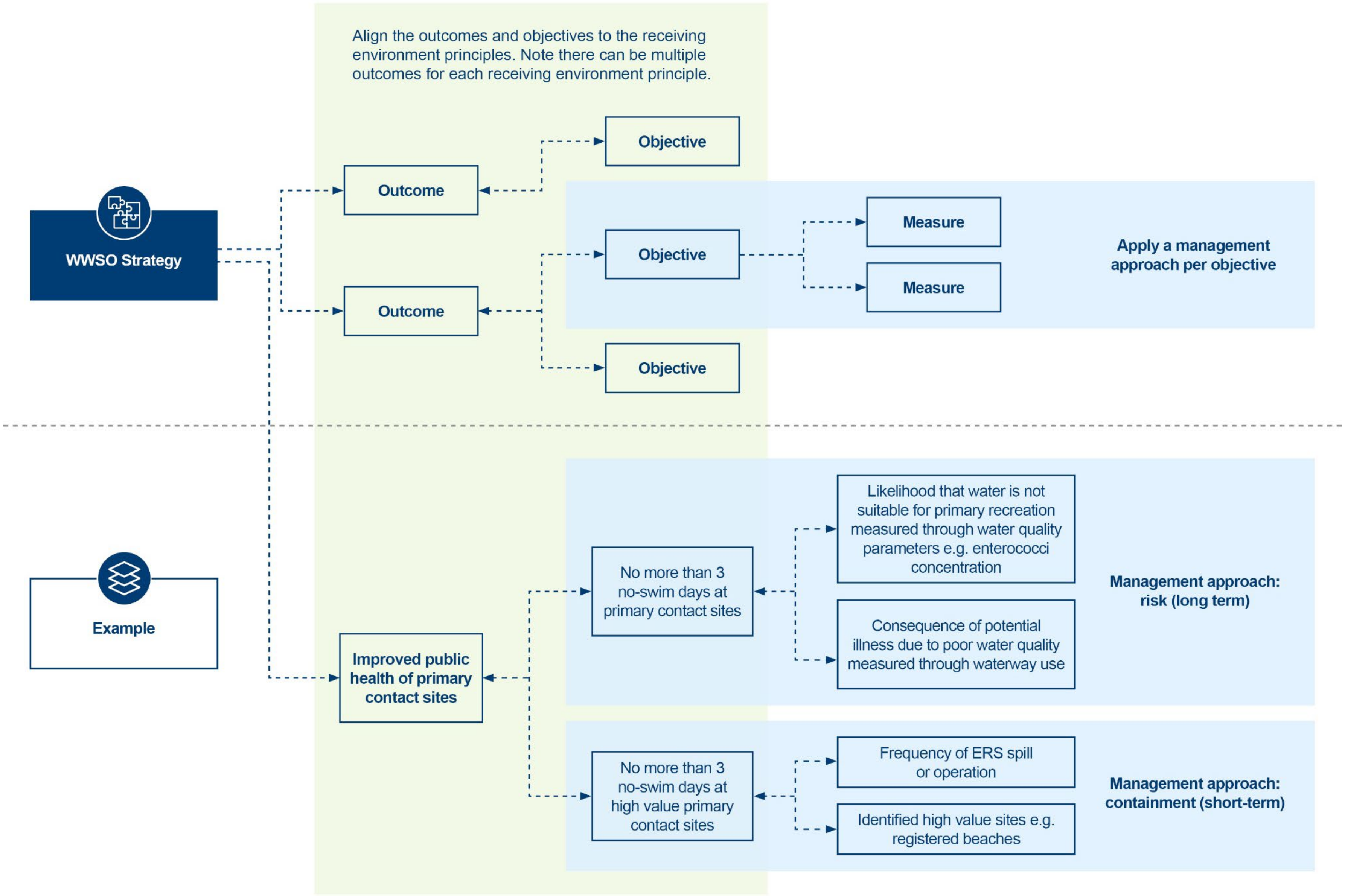


Figure 6-2 | Typical structure of a WWO strategy

Stage 5: Develop WWO strategy

The final stage consolidates all the findings from the previous stages and documents the WWO strategy. The WWO strategy needs to clearly:

- align outcomes with receiving environmental principles
- align objectives with outcomes
- set the required measures for each objective
- the data and knowledge needs for the measures
- explore and document the reason for the management approach(es) adopted
- identify the solutions to achieve the required objectives
- capture the key timeframes and milestones for implementation

A key aspect of this stage is development of the cost estimates for implementation. Whilst these cost estimates will be strategic in nature, it is important that they consider the range of solutions available to the water utility.

The WWO strategy should also consider:

- **Challenges and risks** in the implementation of the WWO strategy
- **Finance and funding** sources
- **Cost benefit** evaluation
- **Technology** and how this may change future outcomes or enable future measures
- **Regulation** and the mechanism for regulating the outcomes
- **Implementation** and how this will be undertaken

Stage 6: Additional steps for implementation

This stage will vary for each water utility and will need to be considered for each WWO strategy. The WWO strategy may be a change to the current practices and to achieve successful implementation the following may be required:

- development of policies and business cases
- internal and external engagement and endorsement
- changes to internal processes
- internal upskilling
- regulatory alignment

7 Glossary

Term	Definition
Asset management	An asset management system provides a structured, best practice approach to managing the lifecycle of assets.
Asset management approach	A systematic approach to operate and maintain wastewater infrastructure to meet the performance requirements.
Average dry weather flow (ADWF)	The combined average daily flow into a wastewater system from domestic, commercial and industrial sources.
Beachwatch	Beachwatch is a NSW Government-led program that monitors and reports on recreational water quality at ocean beaches and estuaries in NSW
Chlorophyll-a	A green pigment found in plants. Chlorophyll-a concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters and are a useful indicator of degraded water quality condition.
Community (receiving environment principle)	Considers the impacts WWO could have on the health and wellbeing of the community and protecting the use of the waterways and lands.
Consequence	The outcome of an event that has an impact, either positive or negative, on objectives.
Containment management approach	A containment approach uses a benchmark performance to manage systems.
Criteria	The specific measure used to assess the likelihood and consequence of an event occurring.
Cultural (receiving environment principle)	Considers the impact that WWO can have on the First Nations values of Country where the WWO are discharging.
Data hierarchy	The organisation of data into hierarchical order based on the appropriateness, resolution and detail of the data. The model will use the data hierarchy to select the best available data at each location in the study area regardless of the extent of coverage of that data to improve the accuracy of the assessment at that location.
Economic (receiving environment principle)	Considers the impacts WWO could have on the economic value of waterways and their surrounds.
Ecosystem (receiving environment principle)	Considers water-dependent ecosystems that may be affected by WWO.
Ecosystem health	The health of aquatic ecosystems and riparian vegetation in and around waterways.
Effects-based approach	An effects-based approach (EBA) is a scientific approach used to quantify the effectiveness an activity on the health of the waterway.

Emergency relief structure (ERS)	A designed wet weather overflow structure that is used to prevent wastewater overflows through maintenance holes or internal surcharges into customer connections and to protect the wastewater system from damage, particularly during extreme rain events.
End of pipe	A term used for construction of infrastructure, typically near to where the ERS is located for WWO projects.
Enterococci	Enterococci are bacteria that live in the intestinal tracts of warm-blooded animals, including humans, and therefore indicate possible contamination of streams and rivers by faecal waste.
Environment Protection Authority (EPA)	A NSW government statuary authority that administers the Protection of the Environment Operations Act 1997 (POEO) and issues environment protection licences under this Act.
Geographic information system (GIS)	A geographic information system (GIS) is a system that creates, manages, analyses, and maps all types of data.
Infiltration	Infiltration will also cause an increase, although it typically appears as a gradual response over time and can occur after a rainfall event. Infiltration occurs from, stormwater and groundwater entering the wastewater system.
Inflow	Inflow of stormwater and ground water typically due to assets in poor condition or with defects, property roof drainage connections and stormwater connections.
Integrated catchment management (ICM)	A system-based approach, which attempts to blend the objectives of environmental protection, sustainable agriculture, and natural resource management within catchments, together with the principles of ecologically sustainable development.
Integrated water management (IWM)	A collaborative approach to the way we plan for and manage all elements of the water cycle. IWM considers how the delivery of water, wastewater and stormwater services can contribute to water security, public and environmental health and urban amenity.
Likelihood	The chance of something happening.
Macro scale	Refers to a whole of wastewater system or receiving environment catchment. It considers a bigger picture overview.
Management approach	Management approaches provide water utilities a suite of tools to define performance expectations and inform decision making. They are the approaches to achieve the receiving environment principles and outcomes of the WWO strategy.
Measures	The measures need to be specific to the objective and define the value and impact.
Micro scale	Refers to specific asset or receptor and allows the water utility to be more specific about what is needing to be targeted.
Objective	Objectives, sometimes referred to as targets or goals, are the way to measure progress towards achieving outcomes.
Outcomes	The outcomes that the WWO strategy will strive to achieve and measure success against.

Outcomes management approach	An outcomes management approach sets measurable goals or outcomes aligned with a strategic vision at a macro or micro level. The project objectives can be qualitative or quantitative and are often focused on achieving the desired receiving environment principles.
Overflow points	See ERS.
Overflow volume	Average annual volume of wet weather overflows from a particular overflow point over a set period, for example, 10 years (usually shown as ML per year).
Overflows	See WWO.
Performance objectives	See objective.
Primary contact recreation	An activity where the whole body, face or trunk are frequently immersed, or the face is frequently wet by spray and where it is likely that water will be swallowed or encounter the ears, eyes, nasal passages or cuts in the skin. Examples are swimming, diving, surfing and white-water canoeing.
Property (receiving environment principle)	Considers the impacts WWO could have on properties. This typically refers to customer properties, however, could also include public or government owned properties.
Proxy	Indirect measures or indicators that represent what is being studied and they are used when a direct measure is not available
Public health	The health and wellbeing of the community.
Receiving environment principle	Broad categories which are externally focused. These can be used to guide the development of outcomes that the WWO strategy will strive to achieve and measure success against.
Risk assessment	A process to identify hazards and evaluate the risk associated with those hazards.
Risk-based approach	A risk-based approach assesses the likelihood and potential consequences of WWO to identify the potential impact on the receiving environment principles.
Risk score	The absolute risk score allocated to an overflow point based on the potential risk of impact that overflow point poses to the receiving environment principles.
Secondary contact recreation	An activity where only the limbs are regularly wet and greater contact, including swallowing water, is unusual, includes activities where occasional and inadvertent immersion through slipping or wave action. Examples are boating, fishing and wading.
Sewage	See wastewater.
Sewer	See wastewater pipe.
Sewerage	See wastewater system.
Source control	The prevention of stormwater entering the wastewater system.

Stormwater	Stormwater is a generic term used to refer to surface flows generated during wet weather events or flows in the stormwater system.
Sustainable development goals (SDGs)	A collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all". They were set up in 2015 by the United Nations General Assembly and are intended to be achieved by 2030.
Wastewater	The contents of the wastewater system, including discharges from domestic, industrial and commercial uses.
Wastewater pipe	The pipes that transport wastewater.
Wastewater system	The system of the pipes and other infrastructure that transports wastewater.
Water quality modelling	Systematic and planned series of water quality measurements or observations that are analysed and reported to understand the real-world health of waterways.
Water quality monitoring	Systematic and planned series of water quality measurements or observations that are analysed and reported to understand the real-world health of waterways.
Water utility	Refers to the groups responsible for managing the wastewater system.
Wet weather overflow (WWO)	An overflow discharge in the reticulation system caused by wet weather.

8 Acronyms

Term	Definition
ACHRIS	Aboriginal Cultural Heritage Register and Information System
ADWF	Average Dry Weather Flow
AEP	Annual Exceedance Probability
AHIMS	Aboriginal Heritage Information Management System
ANZG	ANZ Guidelines for Fresh and Marine Water Quality
ANZ	Australia New Zealand
BOD	Biological Oxygen Demand
CAPEX	Capital Expenditure
CIWEM	Chartered Institution of Water and Environmental Management
DELWP	Department of Environment, Land, Water and Planning (Victoria)
DO	Dissolved oxygen
EBA	Effects-Based Approach
EDC	Endocrine-Disrupting Chemicals
ERS	Emergency Relief Structure
ESD	Ecologically Sustainable Development
GIS	Geographic Information System
HWS	Healthy Waterways Strategy
IAP2	International Association for Public Participation
ICM	Integrated Catchment Management
ISO	International Organisation for Standardisation
IWM	Integrated Water Management
I&I	Inflow and Infiltration
NCFRP	National Cultural Flows Research Project
NHMRC	National Health & Medical Research Council
NWQMS	National water quality management strategy
MST	Microbial Source Tracking
NZ	New Zealand
O&M	Operation and Maintenance
OPEX	Operational Expenditure
ORG	Overflow Relief Gully

PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
POEO	Protection of the Environment Operations Act 1997
RBA	Risk-Based Approach
REP	Receiving Environment Principle
SDG	Sustainable Development Goal
STEEPLE	Social, Technological, Economic, Environmental, Political, Legal and Ethical
UN	United Nations
WSAA	Water Services Association of Australia
WWO	Wet Weather Overflow

Appendix 1
Case studies

Australia
International

Case study name	Utility	Asset	Containment	Outcomes	Risk	Effects	Ecosystem	Community	Property	Cultural	Economic
Enhancing Our Dandenong Creek	Melbourne Water			◎	◎		◎	◎	◎		◎
Launceston Combined Sewerage System Investigation Interim Options and Strategy Development	TasWater					◎	◎	◎			
Lake Macquarie effects-based assessment study	Hunter Water					◎	◎	◎			
Merri Creek Waterways Investment Prioritisation Project	Yarra Valley Water			◎			◎	◎			◎
Proposal for licensing to improve wet weather overflow management	Sydney Water					◎	◎	◎			
Private Plumbing Inspection program	Unity Water	◎					◎	◎	◎		◎
Exercising the general environmental duty in the ACT	Icon Water				◎		◎	◎			
Central Interceptor	Watercare		◎				◎	◎	◎	◎	◎
Elster Creek Sewer Capacity Upgrade Stage 1	South East Water		◎				◎	◎	◎		

CASE STUDY 1:
MELBOURNE WATER – ENHANCING OUR DANDENONG CREEK

Melbourne Water's alternative approach to meeting the Victorian 1 in 5 sewage containment policy by deferring traditional sewer augmentation.

The Dandenong Creek project addresses uncontrolled spills, preventing catchment pollution, natural amenity and threatened species habitat.

Management approach
Outcomes, Risk-based

Receiving environment principles considered/met/achieved
Ecosystem, Community, Property, Economic

Background
Melbourne Water has used a standard of "five year frequency wet weather additive flow" when designing sewers since the 1980s. This standard for sewage containment connected to 1 in 5 storm events was embedded through an initial Memorandum of Understanding (MOU) with EPA Victoria in 1994 and has been an objective in State environment protection policy since the Yarra schedule was gazetted in 1999.

Melbourne Water implemented its Wet Weather Sewage Spill Reduction Program to achieve the 1 in 5 policy objective through a risked based approach using data collected to understand sewage flows, rainfall impacts and receiving environments. Spills from emergency relief structures (ERS) were ranked and a program of works was developed to achieve compliance over time.Augmentation to reduce spills progressed until lower priority sites remained, including a Yarra Valley Water ERS that spilled more frequently (than 1 in 5) into Dandenong Creek (the spills being caused by hydraulic limitations in a Melbourne Water sewer).

Project assessment showed that augmenting the Melbourne Water sewer was not the best solution and an alternative approach was developed based on adopting environmental improvement works, with the sewer augmentation still planned but deferred. A Memorandum of Understanding (MOU), agreed with EPA Victoria, was implemented in July 2012 through to 2018 which enabled this alternative approach to be piloted.

Investigations and Program Objectives
Whilst this project was required arising from policy objective to contain sewage, sewage spills to Dandenong Creek were found to not a priority issue for the waterway: a study of primary factors influencing the Creek's aquatic ecosystem health found pollution caused by heavy metals, petroleum hydrocarbons, organic and synthetic chemicals were significant stressors to aquatic ecosystem health. Wet weather sewage spillage was not a significant cause of poor waterway health outcomes, and furthermore, an augmentation to the sewerage system was unlikely to have a measurable benefit to ecosystem health.

The middle section of the Creek, the focus of this project, has been heavily modified over the last century due to significant changes in land use and subsequent flood mitigation works. These changes, coupled with the legacy issues of industrial pollution in the catchment has resulted in degraded ecological value of the creek, however the primary value is local amenity, which is still supported by Melbourne Water's waterway management.

CASE STUDY 1: MELBOURNE WATER – ENHANCING OUR DANDENONG CREEK

The options developed needed to achieve the policy intent and be able to demonstrate a measurable impact on the endpoints identified through the scientific investigations. All alternative measures were compared to the sewer augmentation, and should achieve the best for community cost . The options included do nothing, augmentation of sewer hydraulics, defer augmentation for five years and/or prepare a program of works that focus on waterway improvement. Over sixty potential improvement projects were developed, assessed and shortlisted to three project areas using a triple-bottom-line approach considering the impact or benefit in addressing issues of water quality, aquatic and riparian ecosystems, access and recreation as well as financial impacts.

Stakeholder Involvement

In 2011 the EPA/Victorian Water Industry Strategic Project No.1 - "Risk-Based Management of Wet Weather Sewage overflows", included the project as a case study to prepare a method for a risk based approach to determine investment priorities for the sewerage system.

Establishing authentic partnership between the regulator, sewerage and waterway managers was a fundamental step in the initiation of the Enhancing Our Dandenong Creek program. In 2012 a project MOU was established with key deliverables and actions that were considered by EPA Victoria to assess compliance.

Stakeholders, including Councils, EPA and community groups, were engaged in concept development and in detailed project planning to ensure community and regulator satisfaction. This included developing generic educational media about ERSs and the role they play. Project evaluation also included community satisfaction with outcomes.

Outcomes

This project achieves waterway health and amenity improvements to the community and waterways, as well and provides a financial saving to Melbourne Water and its sewerage customers. Augmenting the sewer has not been abandoned, simply deferred, and the need for this will be reviewed at regular intervals. The project shows that a risk based, flexible approach to achieving sewage containment for marginal overflows can be developed with community and regulator support. It is important to understand that project support was enhanced by the long term investment by Melbourne Water through its Wet Weather Sewage Spill Reduction Program addressing significant overflow locations.

Cost / Benefits

The NPV of traditional augmentation (as revised for a preliminary business case) was $99 million compared to the NPV of $84 million for a five year augmentation deferral including the improvement works program (at the time of the project inception in 2013). The cost of the improvement program was $15.5 million for both opex and capex. Concurrently, Melbourne Water was able to save its customers $15M through the deferral of the augmentation.

A review conducted at the end of five years determined that the program was effective in achieving the desired outcomes, and a second round of the program should be considered.

Project timing

The pilot project has been competed, with the Enhancing Our Dandenong Creek program running from 2013-2018. Since this time, a second phase of the project has been established, with new projects and measures. This has been established in the context of Melbourne Water pricing submissions and will be assessed in five yearly blocks. Importantly, the capital upgrade of the sewer is still scheduled within Melbourne Water's capital program, with the timing of these works dependent on the outcomes of this project and further monitoring.

CASE STUDY 2:
TASWATER - LAUNCESTON COMBINED SEWERAGE SYSTEM INVESTIGATION INTERIM OPTIONS & STRATEGY DEVELOPMENT

TasWater operates a combined sewerage system that services the city of Launceston; it is the last significant combined system within Australia. The operation of the combined system is of concern to the local community and there is a perception that the combined system has a highly deleterious impact on the environment during combined sewage overflow events.

Management approach
Effects-based

Receiving environment principles considered/met/achieved
Ecosystem, Community

Background
During wet weather periods the combined system is designed to overflow to the Tamar and North Esk rivers to prevent localised flooding of the city. The combined system has approximately 60 overflow locations into the Tamar and North Esk rivers. There are many smaller gravity overflows and several pumped overflows in and around the city's levee system.

TasWater received federal funding as part of the Tamar River Recovery Plan (TRRP) to investigate the impact that the combined sewerage system was having on the Tamar River. There is significant concern amongst the local community and interest groups that the combined system is causing environmental harm during overflow periods. The purpose of the study was to understand the frequency, volume and pollutant loading associated with combined sewage overflows (CSO). The Launceston Combined Sewerage System drains an area of approximately 11 square kilometres and provides stormwater and sewerage services to more than 15,000 Equivalent Tenements (ET).

It was considered that the use of an effects-based analysis would be the most appropriate method to quantify the impact that the combined system was having on the receiving environment and the completion of a mass balance model would provide numerical indicators of pollutant loads. The project made use of a modified approach to assess the risk and impact of CSO events based on overarching principles of the UK Urban Pollution Management (UPM) Manual. TasWater has now progressed beyond this assessment to a strategic business case assessing relevant options for the LSIP project.

Project Objectives
The following required project outcomes have been developed to provide clear 'line-of-sight' and ensure solutions address the problem whilst also achieving alignment with key TasWater strategic and corporate objectives:

- Environmental compliance (EPA Licence) at all STPs
- Compliance with EPA 2019 Sewer Pump Station Guidelines
- Odour management - achieve EPN licence compliance and EPA Pump Station Guidelines compliance with respect to odour (based on Environment Protection Policy (Air Quality) 2004).
- System growth - the project will ensure that all STPs and new network structures have sufficient existing or planned capacity to service growth within the thirty-year planning horizon
- System resilience the project will ensure infrastructure resilience is planned for, designed and built into assets, networks and systems.

CASE STUDY 2: TASWATER - LAUNCESTON COMBINED SEWERAGE SYSTEM INVESTIGATION INTERIM OPTIONS & STRATEGY DEVELOPMENT

- Economic sustainability (value for money)- the project will provide economically sustainable solutions that ensure value for money for the level of investment required.
- Alignment with TasWater strategic directions.

Stakeholders

The project has had a strong emphasis on stakeholder engagement as it was identified that educating and engaging with the key stakeholders would be essential to delivering the project successfully. One on one interviews were conducted with the other committee members of the TRRP to understand the key drivers for them in terms of what role the rivers played for the community, the values associated with the river and what impact they thought the combined system had on the community's use of the river. This engagement process outlined some of the knowledge gaps to be addressed and revealed that although all of the stakeholders had a key interest in the health of the river there was generally low understanding of how pollutants entered the river and the impact that CSO events had on river health.

The stakeholders were heavily involved throughout the project and were asked to nominate upgrade and improvement ideas at the solutions workshop and to contribute to the development of the MCA that was used to score the four major upgrade options investigated.

Cost and Valuation

The development of the strategy and associated strategic business case has included developing costs for each option considered.The current preferred option costing a total CAPEX value of $435M based on a P50 confidence level; and based on the indicative staging strategy based on strategic business case costings.

Outcomes

One of the most successful aspects of the project was that the stakeholders and to a lesser extent TasWater staff went through an education process to learn more about combined systems, the risks associated with CSO events but also a greater awareness that river health is a complex area and that sewage overflows are just one of the contributing factors to the overall amenity and health of a watercourse. The initial outcomes of this work has been used to inform future capital works strategies in the combined system as well as provide community education and engagement pieces. The use of an effects-based analysis type assessment has provided tangible outcomes in terms of solution identification and project costing, and it is proposed that this method be used by TasWater for future projects across a number of sewerage systems.

Through development of a strategic business case, TasWater has completed site-specific assessments for Legana, Riverside and Newnham to identify whether local treatment or transfer to Ti Tree Bend STP was the preferred compliant option. Each catchment was considered individually and independently of other STPs across a range of cost and non-cost criteria. Based on the site-specific assessments of each catchment's servicing strategy, the preferred outcomes for satisfying the project drivers were:

- Legana: decommission Legana STP and transfer Legana's catchment to Ti Tree Bend STP for treatment via 6x ADWF transferred flows (option L2b) (refer Section 13.3)
- Riverside: decommission Riverside STP and transfer Riverside's catchment to Ti Tree Bend STP for treatment via 6x ADWF transferred flows (option R2b) (refer Section 14.3)
- Newnham: decommission Newnham STP and transfer Newnham's catchment to Ti Tree Bend STP for treatment via 6x ADWF transferred flows (option N2b) (refer Section 15.3).

The outcomes of the site-specific assessment were agreed with the Stakeholder Group during the Options Assessment and Selection Workshop held on 23 and 24 February 2022.
Therefore, the overall preferred LSIP Strategic Option for investment is for Full Consolidation of the three LSIP STPs to Ti Tree Bend STP via 6x ADWF transfer rate.

Project Timing

The key deliverable from the Project Development phase will be a Detailed Business Case (DBC). Current program timing from the strategic business case is execution in January 2023 with a staged approach with final completion in March 2038

CASE STUDY 3:
HUNTER WATER – LAKE MACQUARIE EFFECTS-BASED STUDY MODELLING APPROACH

Hunter Water undertook an effects-based study of the impacts of sewage overflows and stormwater flows on Lake Macquarie. Ecological health risks of WWSO were modelled to be negligible compared to the impact of diffuse stormwater flows. Potential human health risks associated with WWSOs were modelled to be spatially and temporally complex. Further investigation is required to understand the source of pathogen loads.

Management approach
Effects-based

Receiving environment principles considered/met/achieved
Ecosystem, Community

Background
Hunter Water has traditionally adopted a containment strategy for the management of wet weather sewage overflows (WWSO) through a process of assessing sewage system performance followed by upgrades in areas where the largest and most frequent overflows occur. Starting in 2001, Hunter Water prepared Upgrade Management Plans (UMPs) for its sewerage systems that identified system upgrades to improve the performance of the sewerage systems in wet weather. The containment objective targets were based on perceived 'best value for money' by comparing the cost to reduce overflow frequency and volume of various modelled scenarios. Implementation of high priority elements of the UMPs has resulted in a reduction in overflow frequency and volume. However the direct benefits to the receiving environment, public health and amenity of these works have not been assessed and therefore it is uncertain if the most cost effective upgrades, for benefits gains, have been targeted.

Modelling approach
Hunter Water commenced a study of Lake Macquarie in 2012 to assess the impacts of WWSO on the receiving environment and public health risks. Initial strategic planning at the time was focused on adopting a risk-based study, whereby sewerage assets would be categorised based on the distance from sensitive receptors and the frequency and volume of overflows. Through discussions with stakeholders it was discovered that ecological modelling had already been completed of Lake Macquarie that would align with an effects-based study.
Hunter Water partnered with the NSW Department of Planning and Environment (DPE) to enhance a pre-existing ecological response model (ERM) of Lake Macquarie and develop a pathogen model. The pre-existing ERM treated all pollution sources as equal, with no consideration of the contribution of wastewater overflows versus diffuse stormwater pollution sources.

The key steps undertaken were:

- Data Collection – This involved the collation of existing data, models and a gap analysis. This led to an environmental monitoring and a WWSO event-based sampling program to collect data for the calibration of models and to ascertain the relative contribution of stormwater and sewage pollution loads to the receiving environment.
- Modelling – This consisted of developing multiple complex interconnected models as shown in Figure 1, which also shows the key data inputs required for each model.

CASE STUDY 3: HUNTER WATER – LAKE MACQUARIE EFFECTS-BASED STUDY MODELLING APPROACH

- Ecological Impact Assessment – The model outputs identified areas of ecological impact within the lake, with seagrass used as an indicator of ecological heath. It included quantification of the contribution of sub-catchment pollutant loads and a comparison of WWSO and stormwater contributions.
- Community Values – This identified recreational areas around the lake that have the greatest value. This was achieved through the utilisation of community surveys, mobile phone data and active recreational areas identified by Lake Macquarie City Council.
- Human health risk assessment – Mapped the results of community values in GIS and correlated it with the modelled enterococci throughout the lake to assess human health risks.

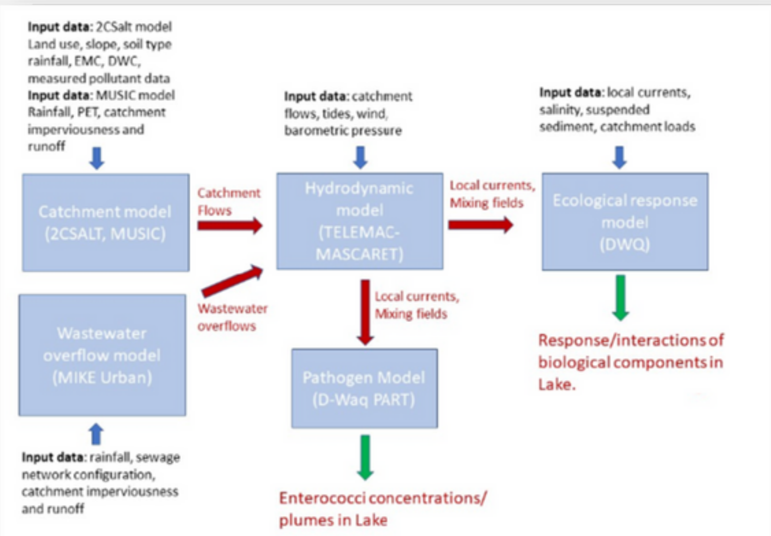
Stakeholder Involvement

This trial project was established with the support of the environmental regulator, the NSW Environment Protection Authority, as Hunter Water sought new science-based methods for understanding the impacts of WWSO.

The pre-existing water quality / ERM developed by DPE predicts the impacts of catchment inputs on water quality and flow-on effects on aquatic plants within the Lake, where seagrass is an indicator of ecological health. Utilisation of this model, originally developed on behalf of Lake Macquarie City Council (LMCC) to aid stormwater management decision making for new development, saved Hunter Water from undertaking several years of data gathering and modelling.

Hunter Water provided assistance to DPE when undertaking WWSO event-based sampling as multiple teams were required at various locations of the wastewater network. Significant collaboration went into planning the sampling program, which included a pilot study to better define the sampling effort and logistics of the final sampling campaign. The sampling program was dependent on sufficiently large rain events to trigger overflows and mobilise DPIE and Hunter Water staff. However the program occurred over a period of below average rainfall which proved problematic when sampling over a narrow timeframe and only resulted in 2 of the 3 planned sampling events taking place.

FIGURE 1
Schematic diagram of effects-based modelling (DPIE, 2021)



CASE STUDY 3:
HUNTER WATER – LAKE MACQUARIE EFFECTS-BASED STUDY MODELLING APPROACH

Outcomes

The model outputs indicate that the ecological health risks of WWSO are negligible compared to the overwhelming impact of diffuse (stormwater) flows and their constituent nutrient and sediment loads. This can be largely attributed to the small volume of WWSO relative to the stormwater runoff volume that enters Lake Macquarie. The study also indicated that there are some potential human health risks due to wastewater overflows however these are spatially and temporally complex, requiring nuanced qualification.

- Sampling data indicates that enterococci densities provide a robust indicator of human faecal contamination in sewage and diffuse flows.
- Comparisons of Beachwatch data and model outputs suggest that enterococci densities in the lake for most of the year cannot be predicted by WWSO alone which implicates significant impacts due to a large background of pathogen loads in diffuse catchment runoff.
- Further investigation is required to determine the temporal and spatial dynamics of the pathogen profiles, and sources, of these diffuse loads in order to better assess human health risk in the lake.

Work is ongoing to relate the results of modelling to WWSO sources and prioritise a reduction in WWSO in accordance with Hunter Water's strategic objectives and risk appetite.

Costs/benefits

The traditional containment strategy approach involves undertaking sewer flow gauging and hydraulic model calibration to understand sewerage system performance. There are 4 catchments around Lake Macquarie and the cost to undertake flow gauging and build 4 calibrated models would be in excess of $1.5m.

An effects-based approach requires the addition of developing catchment, hydrodynamic, ecological response and pathogen models. The update of existing models and the development of a new pathogen model cost in the order of $600k, which is on the top of the cost of developing the original ERM. The overall financial benefits to the water authority, or the overall economic benefits to the community, through an effects-based approach have not been quantified.

Project Timing

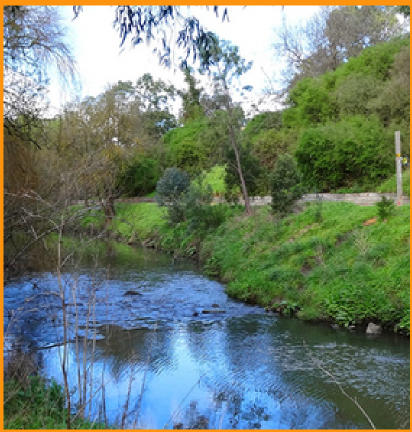
The modelling project took 5 years to complete, which was in addition to the development of the sewer hydraulic models and the original ERM developed for LMCC. The original ERM would have taken several years to build, suggesting that the effects-based approach takes considerably more time to develop when compared to a containment approach.

A repeat of this study with no prior data or models could potentially be undertaken in 4 years if it was highly focused with parallel model development and favourable event-based data collection. In comparison sewer hydraulic models used for a containment approach can be built within 18 months, at considerably less cost and less onerous requirements for event-based data collection.

References

- NSW DPIE, 2021; Effects-based assessment of wastewater overflows in the Lake Macquarie catchment
- NSW OEH, 2016; Conceptual Model of the Lake Macquarie Ecosystem
- NSW OEH, 2016; Lake Macquarie Effects Based Assessment – Modelling Approach Report
- Rutledge F, Silk J, Ferguson A, Floyd J, Wright A, Adams M, 2018; Effects based assessment framework for management of wet weather sewer overflows.

CASE STUDY 4:
YARRA VALLEY WATER – MERRI CREEK WATERWAYS INVESTMENT PRIORITISATION PROJECT



The collaborative Waterways Investment Prioritisation (WIP) project sought to pilot in the Merri Creek urbanised catchment, utilisation of an "Outcomes-based approach" to garner greater community and environmental value at the lowest community cost. Focussed on the existing northern suburbs of Melbourne, it sought to determine if we can deliver greater community and environmental benefits by integrating water management programs and services of Water Authorities (Yarra Valley Water and Melbourne Water) and local Councils.

Management approach

An Outcomes Based Approach was taken to align stakeholders' investments within the Merri Creek catchment that are most likely to achieve the agreed outcomes sought for the waterway. The approach provides a basis for both prioritising solution implementation schemes and ensuring that any scheme is appropriate in terms of the applied technical solution, the level of control and the benefits realised for the customers and the environment.

Receiving environment principles considered

The practical outcomes to be achieved in the Merri Creek were largely based on a previously completed community consultation, the current legislation State Environmental Protection Policy Waters of Victoria[1] (SEPP WoV) and Melbourne Water's Healthy Waterways Strategy and the Merri Creek Management Committees views. The practical outcomes were split into three main categories (See Table 1)

1. Public Health
2. Environment
3. Aesthetics

[1] With implementation of current Victorian Environment Protection Act from July 2021, SEPP does not continue as subordinate instruments under the EP Act, and its formal statutory role except in some limited circumstances however, some clauses of SEPP continue to provide a useful source of information to aid duty holders. SEPP's clause 27: "Management of Sewerage Systems" will be used as guidance for the General Environmental Duty until further notice. Please refer to EPA's publication: 1994: Using SEPPs and WMPs in the new environment protection framework guide.

Background

The catchment of Merri Creek is located in the established suburbs of Melbourne. To improve the water quality of Merri Creek, Yarra Valley Water and other major stakeholders planned to invest approximately $25M. The planned investments were designed to meet the obligations and drivers of individual organisations rather than as a whole. Most of the planned expenditure (~$19M) was related to sewage infrastructure upgrades for compliance with the SEPP clause 27 to contain flows associated with a 1-in-5-year rainfall event. The rest of the investment (~$6M) was planned for stormwater, vegetation management, WSUD and waterway maintenance programs.

Yarra Valley Water (YVW), Melbourne Water (MWC), the Department of Environment, Land, Water and Planning (DELWP) and the relevant councils have partnered to develop a case study on waterway investment prioritisation for the existing developed areas in Merri Creek catchment to test whether their waterway investments can deliver greater value to the community and the waterway health as well as provision of amenity.

Investigations and Program Objectives

The objective of this case study was to integrate water agencies and local councils' waterway investments, to provide greater values to the community in terms of:

1. Improved waterway health
2. Provision of amenity

CASE STUDY 4: YARRA VALLEY WATER – MERRI CREEK WATERWAYS INVESTMENT PRIORITISATION PROJECT

Table 1 shows an agreed practical outcome used for this project.

TABLE 1
Perceptions, agreed practical outcomes of WIP

	Community perception study	Current legislation	Key stakeholder	Agreed practical outcome
Public health				
Primary contact recreation	N	Y	N	N
Secondary contract recreation	N	Y	Not clearly defined	N
Passive recreation-liveability	Y	Y	Y	Y
Environment				Maintain and/or enhance biodiversity
Native fish	Y	Y	Y	
Frogs	Y	Y	Y	
Macroinvertebrates	Y	Y	Y	
Vegetation	Y	Y	Y	
Aesthetics				
Vegetation	Y	Y	Y	Y
Odours	Y	Y	Y	Y
Water colour/appearance	Y	Y	Y	Y
Water turbidity/murky	Y	Y	Y	N
Accessibility	Y	N	Y	Y
Absence of litter	Y	Y	Y	Litter load reduced

An assessment of the key threats or inhibitors to achieving these outcomes was then completed. These were derived from diffuse and point source stormwater and wet and dry weather sewage analysis. Extensive data provided by the Centre of Aquatic Pollution Identification and Management (CAPIM) was used to inform stormwater pollution concentrations and locations within the catchment, whereas sewage data was collected from YVW sewage overflow history and hydraulic model analysis.

An assessment of the current planned expenditure relating to the outcomes sought was then undertaken and potential actions were identified to target the best community and environmental values.

CASE STUDY 4:
YARRA VALLEY WATER – MERRI CREEK WATERWAYS INVESTMENT PRIORITISATION PROJECT

Stakeholder Involvement

YVW, MWC, DELWP and the relevant councils have collaborated to develop this pilot study. CAPIM and YVW provided data and information about stormwater pollution and wastewater overflows.

Outcomes

The study demonstrated that the key threats to achieving the desired outcomes in Merri Creek and the downstream Yarra River and Port Phillip Bay derived from stormwater pollution, which contributed over 99% of the pollutant loads. Therefore, the planned expenditure for Merri Creek does not align well with the expected practical outcomes[2].

The industrial area towards the top end of the study area was a particularly high contributor of heavy metal pollution, impacting the ecological habitat in the waterway. The main impact to aesthetics was from stormwater sediments and gross pollutants whereas less frequent sewage overflows was also an impact.

The study demonstrated the primary areas of focus for the incoming years should be:

- Public health – Prevent dry weather spills and rectify any illegal sewer to stormwater connections
- Environment – Reduce heavy metal loads, enhance riparian vegetation, further monitoring and stormwater characterisation targeting load reductions from priority sources
- Aesthetics – litter load reduction and passive recreation enhancements

Several alternate engineering solutions were identified including tactical stormwater to sewer diversion, stormwater treatment tanks and additional gross pollutant traps (stormwater and sewage overflows). These approaches coupled with the current vegetation management and enhancement programs will deliver a far greater benefit at a lower community cost.

[2] A comparison of E.coli loads found in dry and wet weather showed that E.coli from stormwater sources pose a far higher risk to recreational uses of waterway than wet weather wastewater overflows.

Costs

The potential actions identified in Table 2 shift investments from low or no-risk areas (wastewater overflows) to high-risk areas (stormwater discharges). In doing so, the overall investment could potentially be reduced from $25M to $13M, and the overall outcomes could be improved. This demonstrates that an outcomes management approach can yield better results for less expenditure than that achieved by the singular containment standard, which focuses on the sewerage system as the pollution source.

Table 2
Outcome management approach for Merri Creek: Actions and outcomes

Description	Estimated Investment	Outcome	Benefit
Reduction of heavy metal pollution loads and associated toxicants from industrial areas	$1M	Environment	High
Stormwater monitoring and characterisation. Program to identify key sites for stormwater treatment/diversion to sewer (first flush)	$2M $3M	Environment, aesthetics	High
Identification and rectification of illegal sewer and stormwater connections	$1M	Public health	High
Continue targeted vegetation management/ enhancement programs	$3.5M	Environment, Aesthetics	High
Mitigate aesthetic impacts from stormwater	$2M	Aesthetics	High
Mitigate aesthetic impacts from WWOs	$0.5M	Aesthetics	Low/Medium
TOTAL	$13M		

Project Timing

This pilot study has been completed in 2016. In 2018 YVW and MWC jointly supported a research project by Monash University to quantify the wastewater and stormwater contributions to human health risks in the Merri Creek by using a Quantitative Microbial Risk Assessment (QMRA) model. The findings of this research in 2020 confirms that stormwater might be of a greater concern for the public health risks that wastewater.

CASE STUDY 5:
SYDNEY WATER CORPORATION – RISK-BASED APPROACH FOR LICENSING TO IMPROVE WET WEATHER OVERFLOW MANAGEMENT

Sydney Water and the NSW Environment Protection Authority (EPA) have co-created a refined approach to managing and regulating wet weather overflows, using a risk-based prioritisation methodology for Sydney's four major coastal sewage systems.

Management approach
Risk-based

Receiving environment principles considered/met/achieved
Ecosystem, Community

Background
In 1998, Sydney Water proposed frequency targets for wet weather overflows from its wastewater system. A key driver of this measure was to reduce the number of lost swimming days due to wet weather. Since then, the business has invested over $1.5 billion to reduce the frequency of wet weather overflows. More than $5.5 billion of investment would have been required to continue achieving the original frequency targets (2012), by building large storage tanks, tunnels and bigger pipes and pumps, resulting in a potential increase in customers' sewage bills with limited environmental or community benefit.

Sydney Water's area of operations has over 3,000 emergency relief structures (ERS) in highly urbanised areas. The geological features and topography in these areas limit the available options to store excess wastewater during wet weather, posing significant impact to the environment and community.

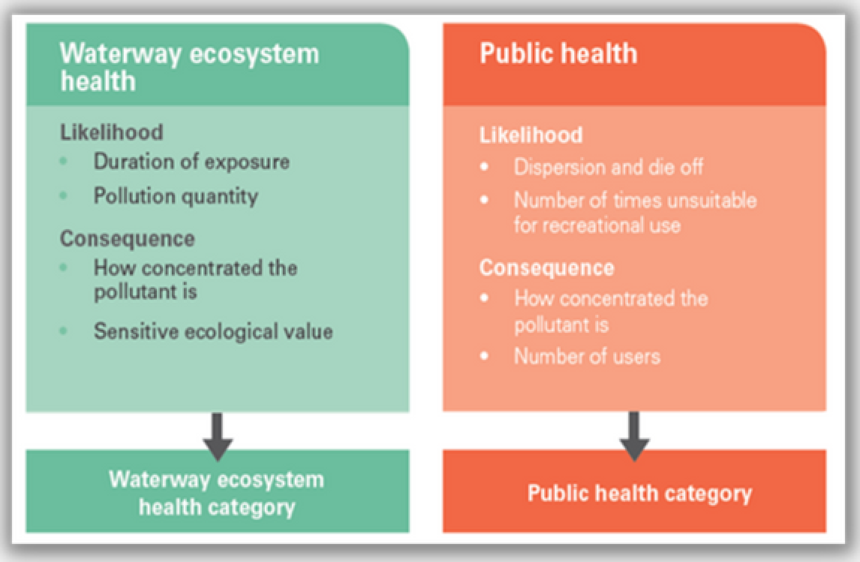
Since 2012, Sydney Water and the NSW Environment Protection Authority (NSW EPA) have been working on a risk-based approach in four major coastal wastewater systems to abating wet weather overflows (Northern and Western suburbs – North Head EPL 378; Eastern suburbs – Bondi EPL 1688; Southern and Western suburbs – Malabar EPL 372; and Southern suburbs – Cronulla EPL 1728). This has been an iterative approach, with an initial simple prioritisation methodology to direct cost-effective investment in areas with known environmental and/or public health value during the 2020-24 Independent Pricing and Regulatory Tribunal (IPART) period.
Further improvements since March 2020 have revised our methodology from a spreadsheet risk assessment to a data centric spatial prioritisation tool. The regulatory measure has also been changed to reflect a stronger focus on protecting the receiving environment.

Investigations and program objectives
The risk-based prioritisation methodology incorporates community expectations regarding public health and the environment, the EPA's expectations on a new regulatory approach and Sydney Water's principal business objectives. It has been designed to be transparent, repeatable and allow for a focus on abating wet weather overflows in locations with the highest potential for impact.

The prioritisation uses a manual spreadsheet assessment which incorporates the best information available (at the time) to a system-wide reduction of volume and frequency, while considering the sensitivity and use of receiving waters (waterway ecosystem health, public health).

CASE STUDY 5: SYDNEY WATER CORPORATION – RISK-BASED APPROACH FOR LICENSING TO IMPROVE WET WEATHER OVERFLOW MANAGEMENT

FIGURE 1



Experts and stakeholders were consulted to develop the risk criteria and associated measures for each of the waterway values. Sydney Water assessed the current risk of overflow points using data from geographic information system layers and modelled wastewater system performance. The risk assessment results were then combined into a risk profile. This method was used to identify higher risk overflow points across the systems within the priority areas, and to inform the improvements compared to a baseline.

For the 2020-24 IPART period, the EPA is implementing a flexible regulatory point system (Pollution Reduction Program 307) to replace the previous frequency targets in the four major coastal wastewater systems (North Head, Bondi, Malabar & Cronulla). Abatement works are required on category 1 sites firstly (highest risk) and the majority of regulatory points must be achieved through this means. Some regulatory points can then also be achieved through abatement of category 2 and 3 sites under a sliding scale set of point ratios and rules. At the end of the improvement period, it must be demonstrated that volume and/or frequency of overflow points has been reduced from the baseline risk profile. Each subsequent improvement period would incorporate an updated baseline risk profile. Through this process of adaptive management, we will reduce risks from wet weather overflows over time.

A recent revision of the prioritisation methodology will be applied to the next price period (2025-30). The revised prioritisation methodology relies on a data centric spatial model, (gathered from sources such as Sydney Water, NSW Government departments, councils and mobile phone usage) to improve the risk assessment allocation by using updated data and software to create a sophisticated and robust tool (Figure 2, Figure 3).

CASE STUDY 5:
SYDNEY WATER CORPORATION – RISK-BASED APPROACH FOR LICENSING TO IMPROVE WET WEATHER OVERFLOW MANAGEMENT

FIGURE 2. Principles of the spatial prioritisation tool.

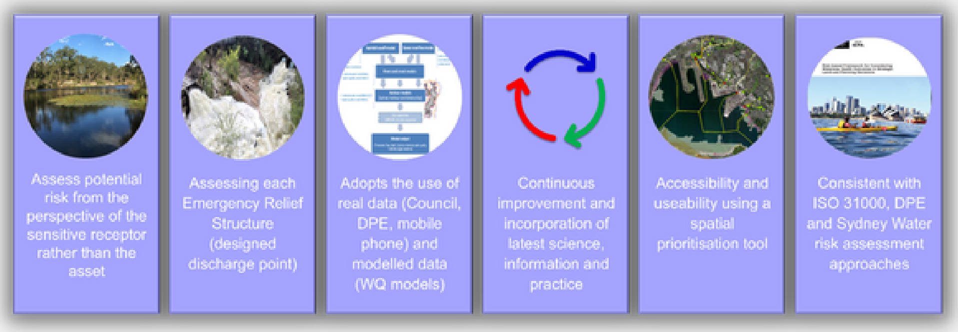
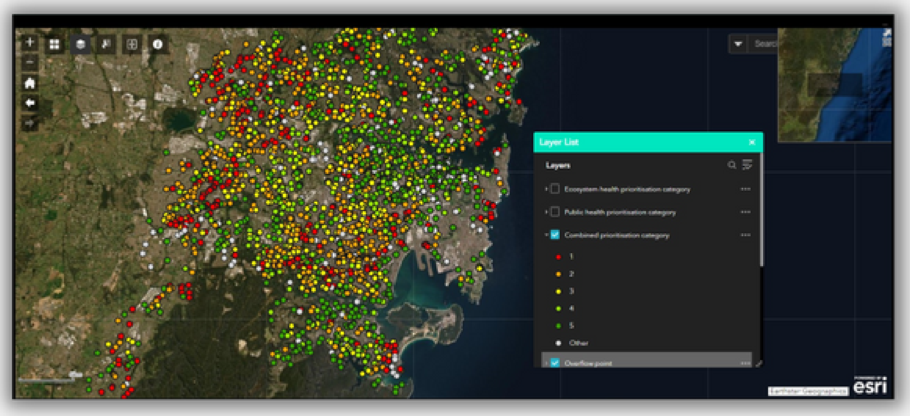


FIGURE 3. Preliminary risk-based prioritisation results from the spatial tool.



Sydney Water and the EPA agreed to an interim regulatory measure for 2024-25 of 1% total volume reduction of Category 1 ERS, from the four large coastal systems.

Stakeholder involvement

Sydney Water consulted customers, councils, community, industry partners and environmental groups on how they want to use waterways now and in the future. Guided by the IAP2 Public Participation Spectrum on Engagement, the community and stakeholder engagement strategy for the first iteration of the prioritisation methodology (2020-24) reflected the stakeholder feedback and their expectations on maintaining a healthy waterway.

As part of the engagement process, a range of workshops, site tours and online discussion forums were hosted to gauge community and stakeholder views on the proposal. Participants generally saw a benefit by using the risk-based approach to inform a new regulation and as a mechanism to reduce wastewater overflow. This valuable feedback has been used to test the thinking behind the proposal, identify gaps as the process develops, and refine how information is presented so stakeholders can understand the proposed approach.

The recent revision to the prioritisation methodology was developed in consultation with the EPA and the NSW Department of Planning and Environment (DPE).

CASE STUDY 5:
SYDNEY WATER CORPORATION – RISK-BASED APPROACH FOR LICENSING TO IMPROVE WET WEATHER OVERFLOW MANAGEMENT

Outcomes

The risk-based prioritisation methodology to address wet weather overflows:

- better represents potential for impact on sensitive receptors
- can adapt to changing environments and community values
- provides a holistic approach that is fair and equitably applied across all areas
- effectively targets improvement where it is most needed
- allows integration and use of better data, tools and solutions to deliver environment and community benefits cost effectively
- is easy to access and use
- is capable of informing other projects by providing a framework that could be developed to assess risk for other assets and activities

Each ERS in Sydney's four large coastal wastewater systems was analysed as part of this project. The results prioritised the ERS with the highest potential for risk to the environment and community and highlighted where abatement work would deliver greater environment and community benefit. The regulation-based approach enables targeted and effective source control solutions to reduce the risk of overflows.

Costs/benefits

The Sydney Water risk-based prioritisation methodology and new regulatory measure was developed in two phases:

· $4.9 million for the 2020-24 IPART period manual spreadsheet risk-based prioritisation and interim regulatory measure, which included:

- a wet weather overflow strategy
- the proposal to the EPA for a licence variation
- the development of the prioritisation methodology, including the water quality models as an input into the prioritisation methodology
- community and stakeholder engagement cost benefit valuation and analysis
- costings for implementation

· $1.1 million to revise risk-based prioritisation to a data centric spatial prioritisation tool applied to the 2024-30 IPART period. This included:

- sourcing suitable and relevant data as inputs
- building a spatial prioritisation tool
- engagement workshops with the EPA and DPE
- costing for implementation

The implementation of wet weather overflow abatement solutions is in addition to these costs.

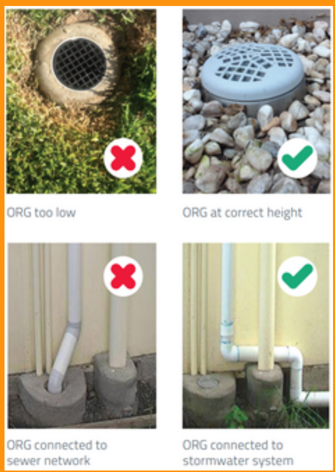
Project timing

Development of a risk-based prioritisation methodology for wet weather regulation is an iterative process. Continuous improvement is key to ensure that the most relevant data is used to assess potential for risk. The Sydney Water's multi-disciplinary team undertook for the:

- 2020-24 IPART price period - approximately 6 months to develop the initial risk-based prioritisation model
- 2025-30 IPART price period - an additional 6 months to upgrade to a data centric spatial tool
- negotiations on the inputs and application of the revised prioritisation methodology and resultant regulatory measure - 12 to 18 months (for each iteration) of workshops with the EPA and DPE

The length of time may change and will depend on the resourcing, level of data accuracy/extent and regulator requirements.

CASE STUDY 6:
UNITYWATER – PRIVATE PLUMBING INSPECTION PROGRAM



ORG too low
ORG at correct height
ORG connected to sewer network
ORG connected to stormwater system

Over the last 10 years, Unitywater has implemented an extensive inflow and infiltration (I-I) investigation program of 70,000+ properties. A comprehensive defects rectification program (on private drainage and Unitywater assets) followed to reduce the risks associated with uncontrolled sewer network overflows to properties during wet weather events. With help from the community, the number of overflows has been controlled with public health and environmental risks being mitigated.

Management approach
Asset (Flow Reduction- I/I Removal)

Receiving environment principles considered/met/achieved
Ecosystem, Community, Property, Economic

Background
Unitywater provides essential water supply and sewage treatment services to residents and businesses in the Moreton Bay, Sunshine Coast and Noosa regions in South-East Queensland.

It manages approximately 6,100 km of sewer mains, 800 Sewage Pump Stations (SPS) and 17 Sewage Treatment Plants (STP).

During recent La-Nina event and during higher rainfall events in 2010-2012 some of the sewerage catchments have recorded overflows during moderate wet weather events (50-100mm of rain), impacting private properties and, in some instances, temporarily closing Caloundra beaches. Unitywater needed to mitigate overflows to help avoid customer complaints, adverse media attention and environmental impacts.

The main cause of the sewage overflows is the rainfall dependent Inflow and Infiltration (I/I). The rainfall enters the sewerage network from many minor defects contributing small amounts of ingress dispersed widely throughout the network. According to Management of Wastewater

Modelling approach
System Infiltration and Inflow (I/I), Good Practice Guideline, Volume1 (Background and Theory) and Volume 2 (the "How to ") (Nov-2011), up to half of the rainfall dependent I/I can be from the private property plumbing.

Unitywater adopted its first Sewage Overflow Abatement Plan (SOAP) in 2011, which led to the successful reduction of 90 hot spot overflow locations, and hydraulic model calibration for four catchments for controlled overflow location identification. One of the key initiatives of the SOAP was to undertake private plumbing inspection using smoke testing for approximately 65,000 properties in the following five years. The private plumbing inspection program was kick-started again in 2021, after the revision of the SOAP. Approximately 4,200 properties have been smoke tested and inspected in 2021-22 and another 12,000 are planned for inspection in 22-23. Sewerage manhole condition assessments and corresponding sealing of manholes are also part of this inspection program.

Investigations and Program Objectives
Unitywater's main goal is to actively manage sewer overflow abatement within its regions to minimise overflow frequency and impact. The related goals for the plan are summarised below:

- reduce the impact on the sewerage system during wet weather events and minimise uncontrolled overflows
- mitigate risks to the environment, public health and community amenities

CASE STUDY 6:
UNITYWATER – PRIVATE PLUMBING INSPECTION PROGRAM

- decrease the number of illegal or inappropriate connections throughout the region
- reduce sewage pumping and treatment costs in wet weather
- optimise the capacity of the sewer network and defer the need for expensive upgrades.

Unitywater developed screening KPIs for prioritising inspections at STPs and SPSs that indicated stormwater inflow issues. These KPIs are based on data that is already being collected as opposed to further investment in the collection of additional data. This aligns with WSAA guidelines that SOAP should be based on simple measures relating to the sources of I/I rather than more sophisticated approaches which would require additional data and resources. Figure 1 shows the priority matrix developed for the SPS catchments based on Unitywater's data available in Maximo, SCADA, GIS, rainfall and hydraulic models.

An I/I community education and awareness program was also developed in parallel to achieve optimum results. The objectives were as follows:

- Educate the community and key stakeholders on the effects of stormwater I/I on the sewerage system.
- Engage and partner with various external stakeholders to ensure we are all working towards a common goal i.e. working with local councils, environmental regulator, plumbing associations and community groups.
- Ensure communications with customers regarding I/I are strategic and considered to avoid potential backlash when requesting rectification works.

The I/I community education and awareness program included information on the identification of private stormwater inflow sources (defects) to sewer systems and how they contribute to wet weather sewage overflows and the consequent impacts on neighbours and the environment. The educational initiatives included notices in local newspapers, pamphlets, social media posts, educational segments on Unitywater's website and presentations to the interested stakeholders and community groups.

Following the identification of defects, rectification programs were implemented for private plumbing issues, sewer mains and manhole repairs.

FIGURE 1
Screening KPIs for Prioritising the sewerage pump stations for inspection

SPS	SPS1* – No. SCADA Overflow Triggers	No. Overflow Complaints	SPS2* – No. Overflow Complaints/ 100 km	SPS3[1] – Average Daily Run Hrs Per Pump (Hrs/d)	SPS4[2] – Wet Weather Pump Run Hrs Per Pump (Hrs/d)	GWI[3] (L/EP/d)	SWI[4] (PWWF/ADWF)	RDII[5] (%)	Overall Score	Priority Ranking
SPS-CAL010	0	1	125.4	1.9	3.9	540.3	8.8	17.5%	37	1
SPS-CAL011	13	1	23.3	2.5	10.5	286.9	7.2	8.5%	35	3
SPS-CAL008	0	4	59.6	6.8	15.0	296.0	4.2	3.7%	35	3
SPS-LMT006	0	0	0.0	0.3	0.7	443.6	171.9	7.0%	33	5
SPS-LMT001	0	4	8.2	8.0	23.1	192.3	3.4	10.2%	32	6
SPS-GLD002	0	2	69.0	4.0	14.1	164.8	5.2	22.6%	31	7
SPS-GLD005	0	1	56.2	5.7	14.0	346.4	5.5	1.7%	31	7
SPS-CPK003	0	0	0.0	3.2	7.6	440.1	26.9	10.4%	31	7
SPS-CAL001	8	2	4.3	3.1	11.9	211.1	7.5	7.0%	30	10
SPS-LMT005	0	0	0.0	6.1	18.7	486.1	3.6	1.4%	30	10
SPS-CKS030	7	2	9.9	3.5	8.8	134.1	7.8	5.2%	29	12
SPS-CAL004	2	5	44.4	2.8	10.5	85.3	24.3	3.2%	29	12
SPS-PWS014	1	1	62.9	3.4	5.2	466.0	8.2	0.0%	29	12
SPS-CPK007	14	4	33.3	3.3	8.2	348.1	5.9	3.3%	27	16

CASE STUDY 6:
UNITYWATER – PRIVATE PLUMBING INSPECTION PROGRAM

Stakeholder Involvement

Throughout the program, officers from the environmental regulator were very interested in the I/I program and its planned outcomes to reduce sewer system overflows and mitigate risks to the environment and were kept up-to-date with quarterly meetings. Unitywater management was also kept up-to-date with progress with papers to the Infrastructure Strategy Committee.

Table 1 details the extent of the smoke testing program and the success of private property rectifications.

TABLE 1
Screening KPIs for Prioritising the sewerage pump stations for inspection

Timeframe	Inspection Program		Private property defects identified	Private property defects currently referred to Council	Private property defects rectified
	Properties	Manholes			
2011 to 2016	66,775	26,525	2,926	181	2,745
2021 onwards	4,547	2,508	415*	94	204

*about 100 property owners are still in the process of responding to Unitywater notice

In the first phase of the inspection program, the majority (87%) of private property defect rectifications were resolved by the property owners (at their expense) through a three-notice process by Unitywater. In the second phase of the inspection program, only a single notice for rectification is sent with a success rate of 60% of defects rectified by the owner. The notices also include information on educating the customer about the cost and effects of wet weather sewage overflows and the importance of keeping stormwater out of the sewer system.

If the defect(s) is not rectified by the property owner, it is referred to the Local Council which has regulatory power (under *Plumbing and Drainage Act 2018 - Qld*) to enforce rectification at their discretion. Unitywater has recently signed a Memorandum of Understanding (MoU) with Sunshine Coast Regional Council to streamline the process of communicating the defect handovers and the status of the rectification work.

Outcomes

In the second phase of this program the percentage of properties with plumbing defects has increased to 9.1% compared with 4.4% in the first phase. Ignoring the sample size, it can be attributed that a refined KPI screening process (refer Figure 1) has been adopted in the second phase to target the poor performing catchments.

As shown in Table 2, the predominant private property drainage defect type found throughout the investigations was low Overflow Relief Gullies (ORG) at 61%. During wet weather, a low ORG can drain large areas (paved and unpaved) and contribute to wet weather sewer system overflows.

TABLE 2
Screening KPIs for Prioritising the sewerage pump stations for inspection

Defect Type	Number per Type	Percentage of Total
Overflow Relief Gullies – low.	1,785	61%
Inspection Openings - cap removed, damaged etc.	478	16%
House drainage pipes - displaced joints, cracked, etc.	341	12%
Roof-water pipes connected to sewer	247	8%
Rainwater tank overflows connected to sewer	37	1%
Wash-down bay draining to sewer	20	1%
Private Service Pit	18	1%
Uncovered sink or shower	12	<1%
TOTALS	3,341	

CASE STUDY 6: UNITYWATER – PRIVATE PLUMBING INSPECTION PROGRAM

Table 3 shows the types of defects found during manhole inspections. It is concerning that approximately 10% of the manholes displayed on GIS either could not be located or could not be opened by the contractor in the field. These account for 54% of total defects observed. All these manholes have been added to the maintenance schedule for rectification work.Approximately 25% of the manhole lids were sealed during the inspection program, if signs of the pounding of water were evident.

TABLE 3
Summary of Manhole Defect Types

Defect Type	Percentage of Total
Manhole to be accessed/raised	54%
Signs of gas attack	4%
Defective copping rings	2%
Signs of infiltration	18%
Tree roots	22%

A reduction in the number of sewer network overflows and internal sewage surcharges was noted after the first phase of the inspection program. Two significant wet weather events impacted the Unitywater region in early 2015. Both events severely affected the sewerage network due to the volume of rainwater in the sewer network. The first event saw a prolonged period of continuous rainfall, while the second had a more intense short period of high-volume rainfall:

- Between 19 and 23 February 2015 as a result of two weather fronts, former tropical cyclone Marcia and a tropical low, 451mm of rainfall fell in 56 hrs, 253mm in 24 hrs.
- Between 30 April and 02 May 2015, a more extreme wet weather event occurred, predominantly affecting the Moreton Bay region, with over 433mm of rainfall in 46 hrs, 312mm of which fell in just 4 hrs from 2pm 1 May 2015, a 1 in 50 year ARI.

The ability of the sewer network to cope with the extreme wet weather events in early 2015, and the reduction of internal sewage surcharges in comparison to similar rain events in 2012 (from 42 down to 17) highlights its success.
Unitywater is developing an automated process as part of its Intelligent Customer and Network Operation project to calculate screening KPIs (refer Figure 1) for all pump stations. This will help in measuring ongoing monitoring of the effectiveness of the inspection program.

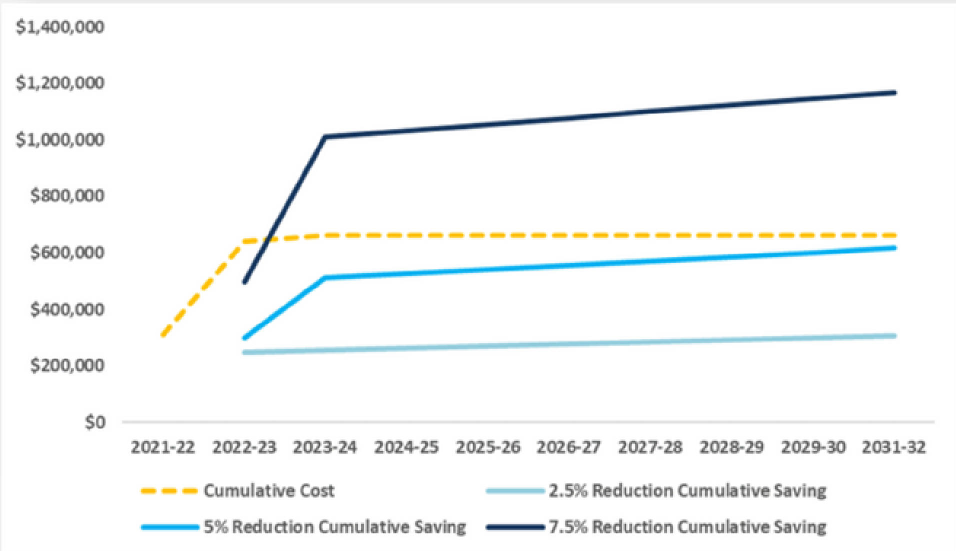
Costs/benefits

A cost/benefit analysis for the Nambour STP catchment is presented here. Nambour STP catchment comprises a large fragmented geographical area surrounding Nambour, Palmwood, Yandina and Eumundi townships. A 10km long 150mm diameter duplication of the pressure main is planned from Eumundi to the STP in the year 2023 with an estimated cost of $6.5M. A smoke testing and manhole inspection program was carried out in the Eumundi catchment involving approximately 2,500 properties. Every 7th property was identified with a plumbing defect and 80% of which were rectified by the owner. The assessment of the actual reduction in the rainfall dependent flow has not yet been carried out. This cost-benefit analysis is based on the assumption of three scenarios: 2.5% reduction, 5% reduction and 7.5% reduction in the I/I. A delay in the construction of the pressure main for six-month, one year and two years is calculated respectively with the above reduction scenarios.

The total cost of the project includes project management, smoke testing and manhole rectification. The economical benefits are achieved with a reduction in cost for; STP consumables, power and overflow management. The major benefit is achieved by saving the interest payment by delaying the construction of the pressure main. Figure 2, shows that a 7.5% reduction in I/I can achieve cost-benefit within a year.

CASE STUDY 6: UNITYWATER – PRIVATE PLUMBING INSPECTION PROGRAM

FIGURE 1
Screening KPIs for Prioritising the sewerage pump stations for inspection



It is to note that, the above cost-benefit does not include environmental and social non-economical benefits.

Project Timing

The first phase of the project was carried out during 2011 to 2016. The private plumbing inspection program was kick-started again in 202. Approximately 4,200 properties have been smoke tested and inspected in 2021-22 and another 12,000 are planned for inspection in 22-23.

CASE STUDY 7:
ICON WATER – EXERCISING GENERAL ENVIRONMENTAL DUTY IN THE ACT

Icon Water has applied risk-based decision-making tools during liaison with environmental regulators to identify appropriate, feasible and prudent approaches to managing wet weather overflows.

Management approach
Risk-based

Receiving environment principles considered/met/achieved
Ecosystem, Community

Background
Icon Water has a general environmental duty to take reasonable and practicable steps to minimise environmental harm or nuisance from activities under Part 3 Section 22 of the ACT Environment Protection Act 1997 (EP Act). Compliance with the duty allows for consideration of the environment and planning context, current technical knowledge, financial implications, the likelihood and degree of success of harm minimisation and any other relevant circumstances.

Investigations and Program Objectives
The Canberra Sewer Network is designed to contain sewage flows associated with up to a 1 in 10 year ARI event standard consistent with the approved Environment Management Plan for the Canberra Sewer Network. There are ~60 designed overflow points. Performance may not always adhere to design standards due to incremental growth in the sewage catchment beyond pipe/pump capacity, failures in power supply to sewer pump stations or climate change with more extreme weather events.

Icon Water developed a risk-based approach to compare potential options using decision-making criteria based on the provisions of the EP Act to demonstrate compliance with the general environmental duty and to support optimal liaison with the environmental regulator. A spreadsheet was developed at asset level outlining baseline information for a defined wet weather overflow event, including:

- infrastructure performance – design standard requirement, average dry weather flow, peak wet weather flow, retention volumes
- site environment and planning context – land use, sensitive receivers, planning layers, water catchment code, protected matters

Stakeholder Involvement
A series of options were identified through workshops with asset managers, operators and environmental scientists as potential solutions to address the event risk. These options ranged from 'do nothing' (which may already include monitoring, alarms and operational controls), through to reduction in inflow and infiltration, screens, new valves, upsizing of pipes/pumps, overflow storage containment and new or renewed sewer mains. Preferred options were then identified using multi-criteria evaluation based on:

- the nature and sensitivity of the receiving environment – description and spatial imagery

CASE STUDY 7:
ICON WATER – EXERCISING GENERAL ENVIRONMENTAL DUTY IN THE ACT

- the regulatory compliance, reputation and environmental risks of the event (with the option controls in place)
- current technical knowledge – asset condition, configuration, feasibility, performance
- financial implications – both capital and operational cost including for incident response
- the extent to which the option is likely to minimise the environmental harm (measured by assessing the likelihood and degree of success of the option) – subject to technical feasibility of option, typically the inverse of risk of the event with option controls in place
- any other relevant circumstances – growth modelling, geotechnical uncertainty, manual versus automated control, construction disruption, land management constraints, implicit benefits/costs

Outcomes

The process to apply an environmental risk-based assessment of options was demonstrated to the environmental regulator. The environmental regulator provided feedback that they were confident in the risk based decision-making framework as it clearly applies the tests required by the EP Act. Solutions were identified, discussed and agreed with the environmental regulator at individual asset level only.
Both internal and external stakeholders found the risk-based approach useful in identifying, evaluating and selecting appropriate, feasible and prudent options for managing wet weather overflows. The method has facilitated consistent synthesis of both qualitative and quantitative information and demonstrated compliance with the general environmental duty.

Costs/benefits

The use of this risk based decision-making framework for one capital works program resulted in savings of ~$173m by defining the benefits of a combined operational and capital solution at a cost of ~$33m as opposed to the previously preferred option of upsizing the existing sewer main to for wet weather overflow design standard at a cost of ~$200m (with a margin of error of +/- 70%).

The value of overall savings at a program level has not been quantified. The approach has justified the benefits of applying a risk-based approach to determine investment requirements on a case by case basis, as opposed to applying standard major capital improvements across a program scale (to manage wet weather overflows).

Project Timing

Environmental duty risk assessments continue to be undertaken for specific assets and locations as part of asset planning and for the capital expenditure program.

CASE STUDY 7:
ICON WATER – EXERCISING GENERAL ENVIRONMENTAL DUTY IN THE ACT

CASE STUDY 8:
WATERCARE SERVICES LTD – CENTRAL INTERCEPTOR

The Central Interceptor is the largest wastewater project in Watercare's history, a 14.7 kilometres long and 4.5 metre-wide bored tunnel running between 15 and 110 metres beneath central Auckland, from Grey Lynn and Watercare's Māngere Wastewater Treatment Plant. It will also have two link sewers and a number of shafts along the route for collecting and transferring wastewater into the tunnel. The consent (licensing) process ran throughout 2012-14 after which design commenced and a main contractor, Ghella Abergeldie, an Italian-Australian joint venture, was appointed in 2019. The first construction started at a site alongside the wastewater plant in 2019. The project will build occupy some 16 sites, sinking 18 shafts in total.

Management approach

Pick one: Asset, Containment, Outcomes, Risk-based, Effects-based

Receiving environment principles considered/met/achieved

Pick all appropriate: Ecosystem, Community, Property, Cultural, Economic

Background

The Central Interceptor (CI) is a key part of Watercare's region-wide wastewater strategy. It will ensure there is enough sufficient capacity in the central Auckland wastewater network to cater for both more homes and more people. It will also provide resilience for critical and ageing assets, some of which are 100 years old.

CI is part of a larger programme of projects in the western isthmus, such as separating the stormwater and wastewater pipes. Together, the Central Interceptor and our western isthmus strategy will significantly reduce wastewater overflows in the region.

Program Objectives

The Central Interceptor project has three key objectives:

1. Cleaning up central Auckland's waterways and open spaces by significantly reducing wastewater overflows
2. Managing population growth and urban infill
3. Managing ageing assets

Wastewater overflows occur in heavy rain events, when stormwater flows into our sewer pipes and tunnels, overwhelming the network and forcing polluted water out into waterways.

Older suburbs with one home on a quarter-acre plot are now accommodating two-four houses, a dozen townhouses or even a four-five storey apartment block. CI will provide additional capacity, some 226,000 m2, for transporting the increased wastewater flows to our treatment plant for purification.

In addition, the existing wastewater network is ageing and could be in increasing danger of failing. In fact, when commissioned, CI will enable Watercare to take the neighbouring Western Interceptor off-line to investigate and institute a major repair and maintenance programme, to increase its life-span. The CI tunnel itself is projected to operate for a century.

Stakeholder Involvement

The project passes through some of the longest established and most densely populated suburbs in the city: there is a huge range of partners and stakeholders with an interest in CI. Mana whenua[1], consisting of 19 iwi[2], is a vital partner and provides advice and guidance to the project through representatives on the 'Kaitiaki[3] Managers Forum'.

[1] Māori people
[2] Tribe
[3]Guardian (of the sky, the sea and the land)

CASE STUDY 8:
WATERCARE SERVICES LTD – CENTRAL INTERCEPTOR

The project runs through five Auckland local board areas and four wards, represented by 40 elected members in total, as well as interest from the Auckland Mayor's office. Four of the local boards have a statutory interest as land owners of public parks and reserves where we have construction sites – each has reviewed and approved the plans for CI to occupy that land in their area.

As four inland waterways run through the CI catchment area, there are environmental groups interested in how CI will help clean up these creeks and streams. We also have several well-organised residents' associations who give us feedback from their members.

We also work closely with businesses, neighbouring residents and schools – for the latter we deliver an education course on wastewater systems for years 5-8. From day one, we have actively engaged with our communities, holding open days as site works commence and developing a state-of-the-art mobile visitor centre which we take to community events and schools.

Outcomes

The project's expected outcomes are to significantly reduce wastewater overflows in heavy rain events, when stormwater can overwhelm pipes and tunnels, forcing polluted water out into those waterways. Linked to this outcome to have appropriate sewerage capacity for population growth that is already occurring across the tunnel catchment area, and as back up for ageing infrastructure such as the Western Interceptor.

The CI tunnel is being built to last 100 years, in itself creating an environmental legacy for the people of central Auckland. However, our ambition for the project extends well beyond this, with a set of practical social, cultural, environmental and sustainability initiatives. We aim to deliver social outcomes that improve the well-being of both the communities along the tunnel route and of our own project staff.

Examples of our work are:

- paying a local social enterprise organisation for hand-knitted socks for students at a local lower-decile school
- committed to recruiting more Māori and Pasifika graduates through an internship programme of three tertiary students each summer
- initiating a literacy and numeracy programme for staff, enabling many to then apply for promotion and pay increases
- planting twice as many trees as we remove from public parks and reserves
- reducing our carbon footprint with a pilot programme of three fully-electric haulage trucks

Costs/benefits

The broad project budget is $1.2 billion. Our aim is a significant reduction in wastewater overflows into inland waterways during heavy rain events. At present, these overflows occur at 219 locations along the tunnel route and we aim to reduce that to just 10 locations.

Project Timing

The consenting process began in 2012 and progressed alongside design and selection of a main contractor, which was appointed in 2019. That year the two main sites opened (with two shafts each), five opened in 2020, two in 2021 and a further six in 2022. The final site, of 16, is on track to open in 2023.

The original completion date was late 2025 but with Covid and its attendant worldwide supply-chain problems the completion date has moved to mid-2026.

CASE STUDY 9:
SOUTH EAST WATER – ELSTER CREEK SEWER CAPACITY UPGRADE STAGE 1

Figure 1 – Tucker Rd Sewage Pump Station (SPS804)

Management approach
Containment

Receiving environment principles considered/met/achieved
Ecosystem, Community and Property

Background
The Elster Creek sewerage catchment serves over 26,000 customer connections across the south-eastern Melbourne suburbs of Bentleigh, Bentleigh East, Brighton East, McKinnon, as well as parts of Hampton East, Highett, Moorabbin, and Ormond.

Hydraulic modelling completed prior to the 2018-2023 Regulatory Period identified that sewers within four sub-catchments (Murray Road, Tucker Road, Higgins Road, and Mortimore Street) experience significant surcharging and predict spills in the current network during wet weather events. Without upgrade, the network is at risk of uncontrolled spills during wet weather events from various manholes. The level of risk will increase over time, as customer connections are expected to grow to approximately 49,000 by 2056.

Field observations supported the conclusions of the hydraulic modelling that the system was nearing capacity. Consequently, a capacity upgrade of the Elster Creek sewer network was deemed to be required.

Investigations and Program Objectives
Hydraulic Modelling & Flow Monitoring
Due to the extent of deficiencies and to reconfirm loading rates and usage profiles across the catchment, a decision was made to collect flow data to enable the recalibration of the Elster Creek hydraulic model.

Field monitoring completed over the FY2017/18 captured a wide range of wet weather events providing improved confidence in the model's wet weather calibration. The subsequent system performance incorporated the revised Australian Rainfall & Runoff (ARR) 2016-19 data, including climate change scenarios.

Analysis of the updated model showed a significant reduction of deficiencies across the sewer network, when compared to analysis of the earlier model which incorporated ARR1987.

Program Objective
Consequently, a staged augmentation of the Elster Creek Sewer Network was proposed. This scope of work would meet SEW's objective by ensuring the containment of sewage within the Elster Creek sewer network for an 18.13 per cent AEP rainfall event, as required in the State Environment Protection Policy (Waters) (SEPP). Whilst the SEPP has recently been revoked, clauses relating to sewerage management such as the containment standard can be used as guidance on meeting the General Environmental Duty in Victoria's new environment protection framework.

A 'do nothing' option was explored, however due to many of the predicted spills being uncontrolled, this option was discounted because of the direct impact to the community.

CASE STUDY 9:
SOUTH EAST WATER – ELSTER CREEK SEWER CAPACITY UPGRADE STAGE 1

Project Timing

The capacity upgrades are to be delivered in stages.

Stage 1 Works (2022-2024):
Tucker Rd PS Sub-Catchment & Higgins Rd PS Sub-Catchment Upgrade
- 1.4km DN300 gravity sewer
- 320 kL detention storage

Stage 2 Works (2028 - beyond):
Murray Road Pump Station Sub-Catchment Upgrade
- 0.5km DN450 gravity sewer

Stage 3 (2035 – beyond):
The Mortimore Street Pump Station Sub-Catchment
- 0.2km of DN300 gravity.

The scope of work detailed in stage 2 and stage 3 is indicative only and further work refinement will be completed in due course. The performance of the network will continue to be monitored using SEW's BlokAids and funding will be sought at the appropriate time in the future.

Stakeholder Involvement

South East Water considers the input of both internal and external stakeholders as integral to achieving optimal project results.

· External stakeholders included:
- Glen Eira City Council
- Melbourne Water
- Department of Transport

· Internal stakeholders included members from the following teams:
- Operations
- Pipes & Structures (Delivery)
- Design
- Environment & Approvals
- Engagement
- Reliability

Both groups of stakeholders were engaged early in the planning phase, with all parties attending a Multi-Criteria Assessment (MCA) workshop in which the preferred option was determined. This engagement continued through to the finalization of the detail design.

Outcomes

In recent years, the Elster Creek sewerage catchment has experienced controlled and uncontrolled spills during wet weather. Uncontrolled spills are overflows that occur through low lying manholes and other points within the network which in some instances can result in spills within dwellings with unacceptable direct impacts to the community. The proposed works at the Tucker Road Pump Station and upstream gravity network will eliminate these spills and any resulting impacts on the environment and customers in the area.

Costs/benefits

The indicative cost to deliver Stage 1 of the Elster Creek Sewer Capacity Upgrade project is $14.1 million.

This upgrade to the Elster Creek sewerage catchment will ensure a more reliable sewerage network free from spills. The works align with outcomes of the Price Submission 5 customer engagement and what our customers value and expect, protecting the environment, maintaining customers service levels, and ensuring we have reliable services across the whole network which minimise disruptions to our customer.

Appendix 2
Reference information

Reference to key national and international documents that are useful for WWO management

Policy, regulation or guideline	About the guideline
National	
Author: National Health and Medical Research Council (NHMRC) **Title:** NHMRC 2008: Managing Risks in Recreational Water	The primary aim of these guidelines is to protect the health of humans from threats posed by the recreational use of waterways. The Guidelines provide a nationally consistent best practice approach for managing recreational water quality. ***Link:*** *https://www.nhmrc.gov.au/about-us/publications/guidelines-managing-risks-recreational-water*
Author: Australian Government **Title:** National Water Quality Management Strategy (NWQMS)	The National Water Quality Management Strategy (NWQMS) is an Australian Government initiative in partnership with state and territory governments. The purpose of the NWQMS is to protect the nation's water resources by assisting water resource managers to understand and protect (maintain or improve) water quality. A range of tools and guiding documents to assist in improving water quality and reducing pollution are available under the NWQMS ***Link:*** *https://www.waterquality.gov.au/about*
Author: Australian Government **Title:** ANZ Guidelines for Fresh and Marine Water Quality (ANZG) 2018	The objective of the ANZG 2018 is to provide authoritative guidance on the management of water quality in Australia and New Zealand. They provide a platform for consistent water quality management and planning, technical support for the NWQMS and tools that can be used to assess and manage ambient water and sediment quality. ***Link:*** https://www.waterquality.gov.au/anz-guidelines
Author: Water Services Association of Australia **Title:** Australian Wastewater Quality Management Guidelines (2022)	The Australian Wastewater Quality Management Guidelines are a framework for effectively managing the wastewater product from its source, through its collection and transfer to a wastewater treatment plant (WWTP). By adopting the approach detailed in these guidelines, utilities will have a systematic mechanism to better manage wastewater quality and the associated inputs. ***Link:*** *https://www.wsaa.asn.au/publication/australian-wastewater-quality-management-guidelines-2022*
Author: National Health and Medical Research Council (NHMRC) **Title:** The Australian Drinking Water Guidelines	The Australian Drinking Water Guidelines provide guidance to water regulators and suppliers on monitoring and managing drinking water quality. ***Link:*** *https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines*
Author: Australian Government **Title:** PFAS National Environment Management Plan 2.0 (2020)	The PFAS National Environmental Management Plan (NEMP) provides nationally agreed guidance on the management of PFAS contamination in the environment, including prevention of the spread of contamination. ***Link:*** *https://www.dcceew.gov.au/environment/protection/publications/pfas-nemp-2*
Author: Murray Lower Darling Rivers Indigenous Nations	The National Cultural Flows Research Project was a collaborative research effort driven by and for Aboriginal people. It was established to provide rigorous and defendable knowledge on

Policy, regulation or guideline	About the guideline
(MLDRIN), Northern Basin Aboriginal Nations (NBAN) & North Australian Indigenous Land and Sea Management Alliance (NAILSMA) **Title:** National Cultural Flows Research Project (NCFRP)	Aboriginal water interests, with the aim of securing a future where Aboriginal water allocations are embedded within Australia's water planning and management regimes, delivering cultural, spiritual, social, environmental and economic benefit to communities in the Murray-Darling Basin and beyond ***Link:*** http://www.culturalflows.com.au/
Author: Australian Government **Title:** Australia State of the Environment report (2021)	Australia state of the environment 2021 assesses the changing condition of our natural environment across 12 themes. The 2021 report combines scientific, traditional and local knowledge to provide a rigorous, peer-reviewed assessment. ***Link:*** *https://soe.dcceew.gov.au/*
Author: Water Services Association of Australia **Title:** Management of Wastewater System Infiltration and Inflow – Good Practice Guidelines	A comparative review and report on the infiltration and inflow management practices. The good practice guideline aims to develop a common understanding of inflow and infiltration practices, determine how inflow and infiltration can be realistically reduced and identify how other wastewater system improvements can be integrated with inflow and infiltration management solutions.
ACT	
Author: ACT Government **Title:** Environment Protection Act 1997 (ACT)	Environmental harm risk assessment and test against Part 3 Section 22 (General environmental duty) of the Act, to determine reasonably practicable approach balancing environmental sensitivity, technical feasibility, financial implications, likelihood of success, and any other circumstances relevant to the conduct of the activity.
New South Wales	
Author: Office of Environment and Heritage and the Environment Protection Authority **Title:** Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (2017)	This framework brings together existing principles and guidelines recommended in the National Water Quality Management Strategy, which the federal and all state and territory governments have adopted for managing water quality. It allows decision-makers to determine management responses that meet waterway health outcomes and reflect the community's environmental values and uses of waterways. ***Link:*** *https://www.environment.nsw.gov.au/research-and-publications/publications-search/risk-based-framework-for-considering-waterway-health-outcomes-in-strategic-land-use-planning*
Author: Government Architect NSW **Title:** Connecting with Country	A framework for understanding the value of Aboriginal knowledge in the design and planning of places ***Link:*** *https://www.governmentarchitect.nsw.gov.au/projects/designing-with-country*

Policy, regulation or guideline	About the guideline
New Zealand	
Author: Water New Zealand **Title:** Water New Zealand Good Practice Guide: Addressing Wet Weather Wastewater Network Overflow Performance	A Good Practice Guide for the management of wastewater overflows in New Zealand. The primary purpose of this Guide is to provide a common framework for wastewater network service providers. ***Link:*** *https://www.waternz.org.nz/Resources/Article?Action=View&Article_id=2303*
Queensland	
Author: Queensland Government **Title:** Receiving Environment Monitoring Program Guidelines	The Queensland Water Quality Guidelines (QWQG) are intended to address the need identified in the ANZECC 2000 Guidelines by providing guideline values (numbers) that are tailored to Queensland regions and water types and providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland. ***Link:*** *https://environment.des.qld.gov.au/management/activities/prescribed/guidelines*
Victoria	
Author: Melbourne Water (lead role, co-delivery with partners) **Title:** Healthy Waterways Strategy	The Healthy Waterways Strategy 2018-28 sets a long-term vision for managing the health of rivers, wetlands and estuaries in the Port Phillip and Westernport region, in order to protect and improve their value to the community. This Strategy provides detailed, catchment-specific visions, goals, long-term targets (10 to 50 years), and 10-year performance objectives. ***Link:*** *https://healthywaterways.com.au/*
Author: Environment Protection Authority Victoria **Title:** 1707.1: Sewerage management guidelines (2020)	These guidelines provide information to water corporations to support the effective management of the risk of wastewater overflows and leakages to the beneficial uses of receiving waters, consistent with the obligations established by SEPP (Waters). The focus of the guidelines is to describe suitable approaches to managing the risk of wastewater spills or leakage from a wastewater system. ***Link:*** *https://www.epa.vic.gov.au/about-epa/publications/1707-1*
Author: Department of Environment, Land, Water and Planning **Title:** Guidelines for the Adaptive Management of Wastewater Systems Under Climate Change in Victoria	These Guidelines support wastewater practitioners assessing the potential effects of climate change on wastewater systems, primarily the direct impacts, those that are likely to impact the systems, as well as the functions and services delivered by wastewater systems. ***Link:*** *https://www.water.vic.gov.au/__data/assets/pdf_file/0036/591579/Guidelines-for-the-Adaptive-Management-of-Wastewater-Systems-Under-Climate-Change-in-Victoria-Final-2022.pdf*
Author: Department of Environment, Land, Water and Planning	The Traditional Owner and Aboriginal Community Engagement Framework enables meaningful engagement between DELWP staff and Traditional Owners

Policy, regulation or guideline	About the guideline
Title: Traditional Owner and Aboriginal Community Engagement Framework	by creating the necessary mechanisms, opportunities and protocols for participation and collaboration. ***Link:*** *https://www.delwp.vic.gov.au/aboriginalselfdetermination/how-we-engage-with-traditional-owners*
International	
Author: Chartered Institution of Water and Environmental Management (CIWEM) **Title:** Integrated Urban Drainage Modelling Guide (United Kingdom)	A reference guide on good practice in relation to hydraulic modelling of the different components of urban drainage systems. ***Link:*** *https://www.ciwem.org/assets/uploads/IUD_1.pdf*
Author: ISO (International Organization for Standardization) **Title:** ISO 55000:2014 *Asset management – Overview, principles and terminology*	ISO 55000:2014 provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management. ISO 55000:2014 can be applied to all types of assets and by all types and sizes of organizations. ***Link:*** *https://www.iso.org/standard/55088.html*
Author: ISO (International Organization for Standardization) **Title: ISO 31000:2018 Risk management - Guidelines**	ISO 31000:2018 provides guidelines on managing risk faced by organizations. The application of these guidelines can be customized to any organization and its context. ISO 31000:2018 provides a common approach to managing any type of risk and is not industry or sector specific. ISO 31000:2018 can be used throughout the life of the organization and can be applied to any activity, including decision-making at all levels. ***Link:*** *https://www.iso.org/standard/65694.html*

Appendix 3
Modelling catchment and wet weather performance

The following are recommendations for the use of models to assess the catchment water quality during wet weather events:

- ***Ensure that models provide an appropriate level of detail for the study catchments.*** Often referred to as the "model extents", models need to include enough of the catchment's assets to ensure an appropriate level of accuracy. For some studies it may be necessary to expand the level of detail of the land-use, stormwater generation and wastewater system overflow generation included in the modelling. At a minimum the model should include all known major pollutant load contributors to the catchment.
- ***Targeted monitoring of wastewater and/or stormwater systems to calibrate models.*** Monitoring needs to be well planned and executed. The number of flow monitors, level sensors, rain gauges, etc. depends on the extents of the model and level of accuracy needed. At a minimum, monitor all known discharge locations during the calibration surveys. Often the use of models is constrained by a lack of monitoring data for a good level of accuracy and understanding. Recently monitoring costs have dropped significantly. Costs fell particularly for level sensors which can send data remotely with cellular connections. Consider the benefits of more monitoring data on overall system management decisions.
- ***Models need to be appropriate calibrated to current conditions.*** Re-calibration might be needed if there was significant growth or changes to catchment assets and land-use. As a general standard, models should be calibrated to a minimum of three wet weather events. The events should represent a range of wet weather conditions, and then verified to an event not used in the calibration set.
- ***Conduct a "gut check" for model accuracy against field observations and customer complaint records.*** This is particularly important in assessing uncontrolled and unmonitored pollutant sources. If the model predicts very high pollutant loads, then field observations and water quality testing can confirm if this is occurring.
- ***When using models to assess catchment pollutant loads consider existing and future scenarios.*** The simplest form of wet weather performance assessment is use of single event design storms. But the performance is better assessed by continuous simulation of long-term rainfall data series. Many pollution events occur due to a combination of existing conditions and specific storm events. Assessment of future performance requires an appropriate understanding of planned development and timings. As with any modelling exercise, there will be uncertainties in some of the key parameters. If uncertainty is high a sensitivity assessment can help to understand the impact on predictions of overflows.