QUEENSLAND OFFSETS ROADMAP EDUCATION PACKAGE

USING STORMWATER TREATMENT SOLUTIONS TO OFFSET POINT SOURCE NUTRIENTS

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Queensland Government

City of Townsville

BOHLE RIVER OFFSETS ROADMAP EDUCATION PACKAGE

USING STORMWATER TREATMENT SOLUTIONS TO OFFSET POINT SOURCE NUTRIENTS

PURPOSE OF THIS EDUCATION PACKAGE

This education package has been developed to share key learnings from the Bohle River Offsets Project. This information is provided as a guide to be used by others to develop similar offsets programs. This Education Package should be read in conjunction with the Bohle River Offset Road Map.

BOHLE RIVER PROJECT DESCRIPTION

Townsville City Council received funding from the Queensland Government to undertake the Bohle River Offsets Project - a pilot project to investigate the feasibility of offsetting point source nutrients with stormwater quality improvement. Funding was provided as part of Stage 2 of the Wastewater Stewardship Strategic Assessment Project, which is part of the Queensland Reef Water Quality Program.

The Bohle River Offsets Project has developed and tested the feasibility of using stormwater treatment solutions instead of traditional wastewater treatment upgrades to improve water quality in the Bohle River catchment, and ultimately, the Great Barrier Reef. An offsets 'Road Map' has been developed to assist Townsville City Council in the future delivery of this project. This Road Map can also be used by other Councils and utilities as a guiding framework to deliver similar projects.

PROJECT DRIVERS

- Improve water quality of the Bohle River which is currently impacted by urban land uses and associated pollutants.
- Understand if there are other options to address water quality instead of expensive wastewater treatment upgrades at the Condon Sewage Treatment Plan (STP) which will not provide other benefits for the community.
- Investigate if stormwater treatment solutions can be used instead of traditional wastewater treatment upgrades to improve waterway health as well as provide other benefits to the broader community and environment.
- Provide Council with a Road Map to guide future investment in water sensitive solutions across a Great Barrier Reef catchment which is impacted by urban pollutants and faces continued urban development pressure.
- Develop and demonstrate a suitable approach that can be used by other Councils and at different scales to support broader application of the water quality offset approach.

WHY WOULD YOU CONSIDER WATER QUALITY OFFSETS?

- You have a receiving environment which is being impacted by nutrients.
- You would like to optimize outcomes achieved by investment in water solutions (e.g. understand if blue/green infrastructure options can be used instead of traditional grey infrastructure to provide better "bang for buck" in the removal of problematic nutrients).

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STEP 1 REGULATION AND CATCHMENT UNDERSTANDING

- Desktop review of legislation, GIS, and other data
- Internal council meeting to confirm project requirements
- Catchment pollutant load modelling

OUTPUTS

- Understanding of regulatory requirements, catchment values and risks
- Quantified end of catchment loads

STEP 2 WATER QUALITY TARGETS

- Develop draft water quality targets
- Meeting with Council and State Government stakeholders to confirm targets

OUTPUTS

- Water quality targets
- Spatial equivalence requirements

STEP 3 PROJECT TYPE AND SITES

- Identify suitable offset project types
- Identify feasible offset sites
- Council workshop - input into project selection

OUTPUTS

- Suite of offset options and equivalence ratios
- Maps showing locations of suitable offset options

STEP 4 EVALUATION OF OFFSET SOLUTIONS

- Assess treatment performance of projects
- Cost effectiveness and benefit-cost assessment
- Comparison to wastewater treatment plant upgrades (not possible in this project due to lack of available data)

OUTPUTS

- Pollutant removal, cost effectiveness and benefit-cost ratios for all projects

STEP 5 DELIVERY FRAMEWORK

- Develop project implementation team
- Identify roles and responsibilities and delivery approach
- Council workshop: governance requirements

OUTPUTS

- Project implementation plan
- Governance framework including targets, suitable treatment types, governance structure, roles and responsibilities

KEY LEARNING

A broad range of stakeholders were involved throughout the Bohle River Offsets Project, including the development of targets, suitable projects, roles and responsibilities and overall governance. It is therefore important to ensure there is suitable time allocated throughout the project for this continued engagement.

WHO NEEDS TO BE INVOLVED?

All stakeholders who may be involved in the future delivery of the offset framework. This may include:

- Regulator of the offset program
- Responsible party to deliver and report on the offset program / licence holder
- Departments involved in the delivery of the offsets program, including planning, design, construction and ongoing maintenance.

STEP 1 - UNDERSTAND THE CATCHMENT CONDITION AND REGULATORY CONTEXT

CATCHMENT CONDITION

A review of the catchment is required to understand the key pollutants of concern and their sources. Pollutant sources can include:

1. Diffuse catchment stormwater pollutants
2. Point source pollutants (such as STPs)

Modelling is a useful way to determine the pollutant loads across the catchment. This should consider the existing and future condition in terms of location and coverage of land uses (which will influence catchment diffuse loads) as well as point source pollution volumes and concentrations (such as from STPs).

The review of the catchment condition will highlight the main pollutant of concern and where the best opportunities to address it are located. For the Bohle catchment, the main pollutant of concern is Total Phosphorus (TP) and most of it is discharged from the urban land uses across the catchment

REGULATORY REQUIREMENTS

It is important to understand the regulatory requirements for the offset project early. The following are key pieces of legislation and policy that are relevant to the operation of the Condon STP and any subsequent offsets in the Bohle catchment:

- The Environmental Protection Act 1994 and ERA 63 – This sets out the licence requirements for the STP which informed water quality targets for the offset program. The Condon STP within the Bohle catchment has an existing flow-based licence agreement rather than a nutrient discharge limit.
- Point Source Water Quality Offsets Policy 2019 – This is generally applied to point source polluters that have pollutant concentration limits imposed on their licensed conditions of discharge.
- Reef 2050 Water Quality Improvement Plan (WQIP) - This plan outlines targets for all 35 reporting regions across the reef, providing the load reduction values needed to achieve ecologically relevant outcomes in the Barrier Reef lagoon. The only target which has been set for the Bohle catchment area is a 60% load reduction for dissolved inorganic nitrogen for the Ross River sub-catchment. There is no TP load reduction target for the Bohle River in the WQIP.

BOHLE OFFSETS PROJECT KEY OUTCOMES

- The focus of an offset option is the Condon STP and in particular managing TP loads.
- Catchment flows from the urban areas is the focus for the removal of TP.

USEFUL CATCHMENT MODELLING TOOLS

The Bohle catchment already had a Source model which was able to be used for this project. This may not always be the case.

There are other ways to determine the pollutant loads across catchments including:

- Simple unit loading rates (i.e. tonnes per ha per year for specific land uses)
- MUSIC modelling
- Previous modelling across the region (e.g. Paddock to Reef model outputs)

BOHLE RIVER KEY LEARNINGS

Models are only as good as the data they use. There is some uncertainty regarding the pollutant concentrations used in the Bohle catchment modelling for urban land uses. Previous catchment work (BMT WBM, 2015) relied on some stormwater monitoring results for a small number of samples in Townsville and that was used in the existing Source model to define the urban loads. It was noted at the time that these deviated somewhat from standard MUSIC concentrations adopted across Queensland and therefore modelling results from these 2 different models differ. To overcome this uncertainty in this study, results are presented as a range to be refined once further work on the final stormwater treatment designs are completed and updates to the modelling are undertaken. This is a useful learning from this project and demonstrates the need for consistency in the evaluation approaches used and also the need to have better data on the urban stormwater nutrient concentrations used in these models. There is a paucity of this data except in the South East Queensland region.

STEP 2 - IDENTIFY SUITABLE WATER QUALITY TARGETS

The key outcomes of the regulatory and catchment condition assessment (Step 1) can then be used to develop suitable water quality targets. For the Bohle catchment, an absence of existing nutrient water quality targets required a target to be developed. This was done by calculating the equivalent nutrient load of the Condon STP discharging effluent at current practice treatment concentrations.

Spatial equivalence requirements should also be considered as part of this step based on the main environmental outcomes to be achieved by the project. For the Bohle, this was to improve the overall quality of the Bohle catchment to protect important downstream environments (such as the Bohle fish habitat area at the mouth of the river and the Great Barrier Reef).

BOHLE OFFSETS PROJECT KEY OUTCOMES

- The water quality target is to reduce 2.8 tonnes of TP (mean annual load) from entering the Bohle River in the current state, and 4.3 tonnes of TP under ultimate development conditions.
- A 1:1 spatial equivalence was proposed for projects delivered within the Bohle catchment area.

KEY LEARNINGS

A meeting with the regulator was important during this step to ensure that this water quality target was suitable. This early agreement is important as the remaining steps are looking at assessing options against this target.

EXISTING WATER QUALITY TARGETS

A derived target was required for the Bohle offsets project as there were no set water quality targets in place. Typical best practice nutrient-based limits were used as a guide to develop these. In other settings, this water quality target may already be set through license requirements etc.

Bohle Catchment (Source: T. Weber)

STEP 3 - IDENTIFY SUITABLE OFFSET TYPES AND SITES

SUITABLE OFFSET PROJECT TYPES

The focus for this offset project is the use of stormwater treatment solutions which provide water quality improvements (TP, TN and TSS reduction) as well as other additional benefits to the broader community such as cooling, amenity, habitat and alternative water use. To assist in identifying potential solutions, it is important to understand the potential pollutant removal and the additional benefits that they might provide.

There are many stormwater treatment solutions which have been researched and applied over the past 15 years and are well documented in technical design and pollutant modelling guidelines. There are also some solutions which are not as commonly applied in urban settings and therefore lack some of the design and treatment performance knowledge. Equivalence ratios can be applied to account for this uncertainty in treatment performance. Table 1 presents the stormwater treatment systems considered and their recommended environmental equivalence ratios for the Bohle project.

Table 1 – Stormwater treatment solutions considered and environmental equivalence ratios for the Bohle River Offsets Project

Treatment type	Risk			Equivalence ratio
	Complexity	Design uncertainty	Actual treatment performance	
Bioretention basin	Low	Low	High	1.0
Constructed wetland / sediment ponds	Low	Low	Moderate - High	1.0
Floodplain wetland	Low	Moderate-High	Moderate	1.25
Channel naturalisation	Moderate	High	Moderate	1.25
Rainwater tanks	Low	Low	Low	1.0
Streetscape bioretention	Low	Low	High	1.0
Passively irrigated street trees – Type 1	Very Low	Low	Very Low	1.0
Passively irrigated street trees – Type 2	Low	Moderate	Low	1.0
Swales	Low	Low	Low-Moderate	1.0
Buffer Strips	Low	Moderate	Low	1.0
Bank Stabilisation	Moderate	Moderate	Moderate	1.5

SUITABLE PROJECT SITES

The following criteria can be used to select project sites:

- Land tenure – Identify land parcels which are owned or managed by the project owner. Additional sites can also be considered for future acquisition or partnerships if they could provide high quality outcomes.
- Connection to urban stormwater flows – Identify if and where stormwater could be intercepted from the network at the surface. This could be from opportunities to daylight existing pipes, or intercept overland flow from drainage channels.
- Depth to stormwater – Often stormwater infrastructure is very deep, making it challenging to get water to the surface without running pumps.
- Slope – Steep slopes are generally not conducive to water quality improvement infrastructure, owing to the large flat area generally required for these systems. Where extensive cut and/or fill is required, this does not enable good site integration and can be a very costly exercise.
- Existing utilities – Retrofitting water quality improvement infrastructure into existing urban areas can be very problematic owing to the extensive infrastructure already underground. Knowledge of location of services such as sewer, water, electrical and telecommunications can assist in the selection of potential sites.
- Existing vegetation – Where possible existing vegetation should be avoided, unless it was expected to be largely weedy.

BOHLE OFFSETS PROJECT KEY OUTCOMES

30 potential stormwater treatment projects have currently been identified for this project. These include bioretention systems, constructed wetlands, floodplain wetlands, channel naturalisation and passively irrigated street trees.

USEFUL TOOLS

The following tools are useful for reference when considering suitable urban stormwater treatment options:

- Townsville City Council (2011) WSUD Technical Design Guidelines for the Dry Tropics
- Water by Design (2018) Water Wise Street Tree – Sizing Guide
- Water by Design (2019) Passively Watered Street Trees
- Water by Design (2019) Bioretention Technical Design Guidelines
- Water by Design (2017) Wetland Technical Design Guidelines
- CRCWSC (2020) Designing for a cool city: guidelines for passively irrigated landscapes

Ideally any guidelines which have been developed specifically for the local climate should be used in preference of other South East Queensland focused guidelines.

KEY LEARNINGS

The identification of project sites for the Bohle project was based on a desktop assessment by the project consultant team. Engagement with Council stakeholders during this phase was therefore important to ensure the selected sites were appropriate based on local knowledge. This engagement also allowed for prioritisation of the sites as well as confirmation that Council were comfortable with the treatment types proposed.

TREATMENT PERFORMANCE

The treatment performance of the proposed stormwater treatment solutions needs to be assessed to understand how effective they are at meeting the water quality targets. For the Bohle River Offsets Project, two modelling approaches have been used to assess treatment performance:

- Treatment system performance – MUSIC modelling was used to determine the treatment performance of the individual treatment systems. This considered catchment flows and pollutant concentrations entering the system (using the MUSIC modelling guideline recommendations for the local area). The TP reduction was then modified using the relevant environmental equivalence ratio for the treatment type (Figure 2).
- Catchment scale performance – Source modelling was then undertaken to understand the role of the treatment measures in the context of the overall catchment loads and water quality processes. To undertake this assessment, the percentage reductions of loads from the MUSIC modelling were taken and applied to the relevant urban catchments within the Source catchment model.

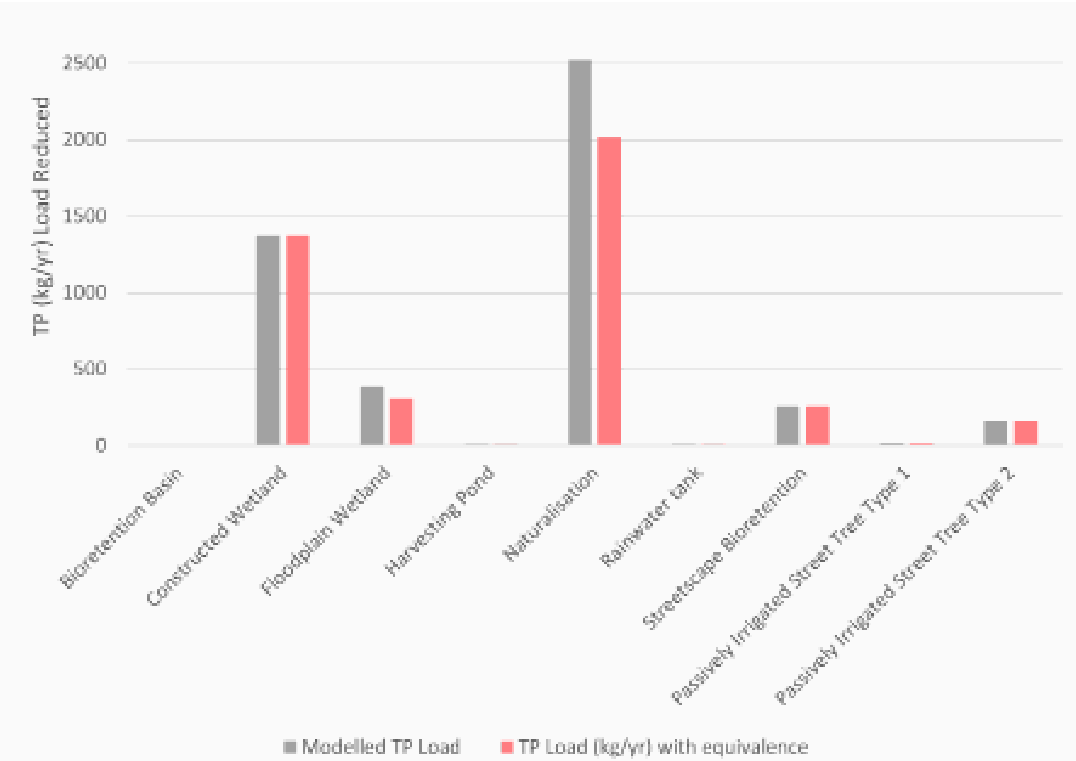

Figure 2 - Total pollutant removal (TP kg/yr) by the different stormwater treatment asset types, as modelled in MUSIC (grey) and with environmental equivalence applied (red) for the Bohle River Offsets Project

BOHLE OFFSETS PROJECT KEY OUTCOMES

- MUSIC modelling showed that the proposed stormwater treatment systems could remove a combined total of 4.3 tonnes of TP. The majority of this treatment is from channel naturalisation and wetland projects.
- The Source model showed that at least 2.6 tonnes of TP reduction at the outlet of the Bohle catchment. This factors in all pollutant generation and removal processes occurring throughout the catchment, including the proposed stormwater treatment offset measures.

USEFUL TOOLS AND RESOURCES

The following tools can be used to model stormwater treatment performance:

- Water by Design (2018) MUSIC Guideline – to provide guidance on suitable modelling parameters for different treatment types.
- MUSIC models – to model treatment performance of stormwater treatment assets.
- Source model – to model catchment outcomes evaluating all pollutant sources and transformations.
- Existing modelling completed previously such as the Paddock to Reef (P2R) catchment model results.

KEY LEARNINGS

The discrepancy between the MUSIC and Source models is due to a number of factors:

- Differences in modelling results when evaluating performance on a treatment by treatment basis (higher number) and across whole catchments (lower number)
- Differences in concentrations used in the models (Source catchment model parameters are using a mean concentration approach rather than the stochastic (variable) approach used in the MUSIC model to assess the treatment system performance)

At this stage, we are considering the higher values within our analysis as it reflects treatment system performance which is not overshadowed by catchment processes. It also reflects the end of treatment pollutant reductions which aligns with wastewater treatment plant performance assessment (measured at the treatment plant outlet rather than end of catchment).

ECONOMIC ASSESSMENT

An economic assessment which considers both the costs and the benefits ensures that the decision-making process is based on a solid understanding of the outcomes achieved from the investment. This assessment should compare the stormwater treatment solutions against the alternative wastewater treatment upgrades. The economic evaluation undertaken for the Bohle River Offsets Project used two related approaches:

1. Cost effectiveness analysis (CEA) – This is used to estimate the ratio of lifecycle costs to annual reduction in pollution, providing a comparable measure of how much TP can be removed relative to the current value cost of the treatment solution. The costs will depend on size and type of the asset which influence the treatment effectiveness (Figure 3).
2. Benefit-cost analysis (BCA) – This is used to estimate relative benefit of the project compared to its cost over its project life. A BCR over 1.0 represents projects where the benefits outweigh the costs. Costs are based on both the capital as well as the ongoing operational costs. While there are many benefits that can be provided by these stormwater treatment assets, only some of these can have a monetary value assigned and therefore be considered in the BCR assessment (Table 2).

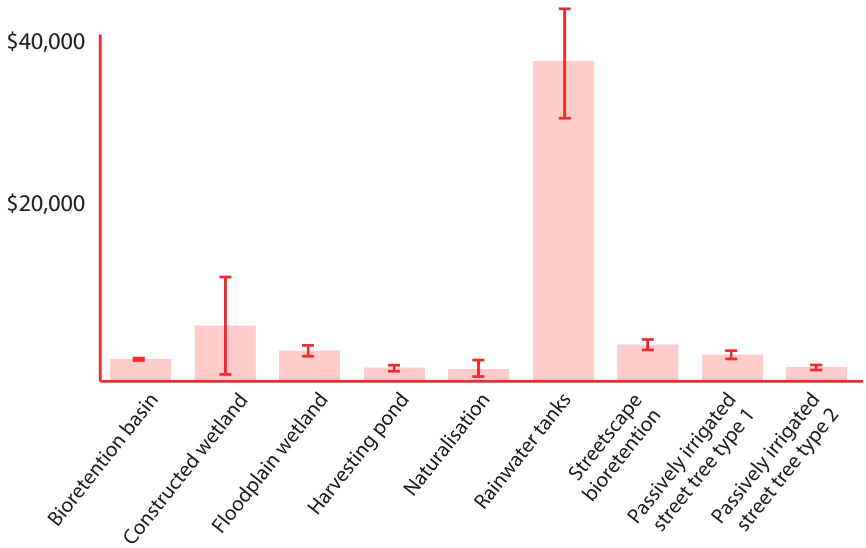

Figure 3 – Summary of estimated cost-effectiveness range for TP removal for the different stormwater treatment types identified for the Bohle River Offsets Project [1]

MISSING DATA

- The information available for the Condon STP upgrade was not reliable enough to allow a direct comparison with the stormwater treatment projects and therefore this was not included in the current assessment. This is valuable information which should be included when available to inform future decision-making processes.

Table 2 - Summary of benefits that can be provided (identifying which of these can be valued) for each stormwater treatment type. While the Condon STP has not been included in the current cost assessment due to limited available data, this table shows that there are limited benefits associated with this option.

Asset Type	Water quality improvement (N abatement value)	Enhancement amenity / property value increase (dependant on location)	Enhanced recreation and physical activity stimulation	Urban cooling (dependant on location)	Enhanced habitats and biodiversity	Carbon pollution mitigation associated with trees	Other vegetation carbon abatement	Reduced tree replacement	Avoided cost of water	Social licence to operate	Reduced peak flows
Naturalisation	✓	✓	✓	✓	✓		✓			✓	✓
Constructed Wetland	✓	✓		✓	✓		✓			✓	✓
Harvesting Pond	✓			✓					✓	✓	✓
Bioretention Basin	✓			✓	✓		✓			✓	✓
Floodplain Wetland	✓			✓	✓		✓			✓	✓
Passively Irrigated Tree (Type 1)	✓	✓	✓	✓	✓	✓		✓		✓	✓
Passively Irrigated Tree (Type 2)	✓	✓	✓	✓	✓	✓		✓		✓	✓
Streetscape Bioretention	✓		✓	✓	✓	✓				✓	✓
Rainwater Tank (Standard Residential)	✓								✓	✓	✓
Condon STP Upgrade (not included in assessment)	✓										
Monetary value available for this study to include in BCR	Yes	Yes	No	No	No	Yes	No	Yes	Yes	No	No

1 The assessments used 2020-dollar values, assumed a 30-year period and a 7% discount rate.

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BOHLE OFFSETS PROJECT KEY OUTCOMES

The current target of 2.8 tonnes could be achieved by delivering 8 of the 30 identified stormwater treatment projects. These projects are estimated to remove over 3 tonnes of TP/ year at an estimated CAPEX cost of $56M, establishment cost of $3.9M / year and ongoing OPEX cost of $1.3M / year. The BCRs of the stormwater treatment systems ranged from 0.11 to 2.7, with an average of 0.60.

Ideally this cost assessment will include a comparison with the proposed Condon STP upgrades when the TP reduction and cost data is available.

USEFUL TOOLS TO DETERMINE COSTS AND BENEFITS

- CRC for Water Sensitive Cities INFFEWS (Investment Framework For Economics of Water Sensitive Cities) tools including a BCA tool and value tool
- Queensland Government (2015) Project Assessment Framework: Cost-benefit analysis

KEY LEARNINGS

The cost values determined during a project identification phase can only be high level estimates based on typical /m2 rates. The treatment areas identified at this high level are not refined and are not yet informed by more detailed site understanding and hydraulic assessments. Therefore costs are indicative only and would be refined during design.

The estimated BCRs should also be cautiously interpreted by acknowledging that some of the important community benefits are not able to be quantified and thus the BCR would represent a lower end estimation of the economic outcomes.

It is also beneficial to have the costs and benefits data available for both the stormwater treatment and wastewater treatment options to allow direct comparison.

STEP 5 - DEVELOP A DELIVERY APPROACH

There are a number of key steps required for the delivery of the stormwater treatment solutions: planning, design, construction, establishment and ongoing maintenance. These tasks are likely to be delivered by different departments across the Council or water utility.

It is important that the stormwater treatment systems are designed and delivered successfully to ensure they continue to deliver the assumed pollutant reductions into the future. Best practice guidelines, such as the Water by Design guidelines, should be used to inform this process. The assumed pollutant reductions are likely to be refined through the design and delivery process. This needs to be recorded in a tracking spreadsheet to keep an up-to-date account of pollutant loads delivered and planned against the required water quality target.

Figure 3 provides a summary of the key steps and supporting tools required for the delivery of projects such as the Bohle River Offsets Project. It also identifies the role of the Council (or water utility) and the regulator.

There will need to be a clear governance framework between the Council or utility and the regulator. This should identify the key responsibilities of the parties as well as agreement of the following in a Memorandum of Understanding (MoU):

- Water quality targets
- Types of acceptable solutions and the treatment assessment approach (this will allow additional projects to be added in the future)
- Monitoring and reporting requirements

While there is no current mechanism for the Bohle River Offsets Road Map to be used in Townsville to offset nutrients from the Condon STP, this sets up a solid framework which can be used for this purpose in the future once the offset trading system is in place. It also provides the option of expanding the program to support additional targets (such as the Reef 2020 targets), funding opportunities (stormwater offsets) and project types. Further development of the State Government reporting guidelines for point source offsetting will also further clarify the future regulatory requirements for participating Councils/utilities.

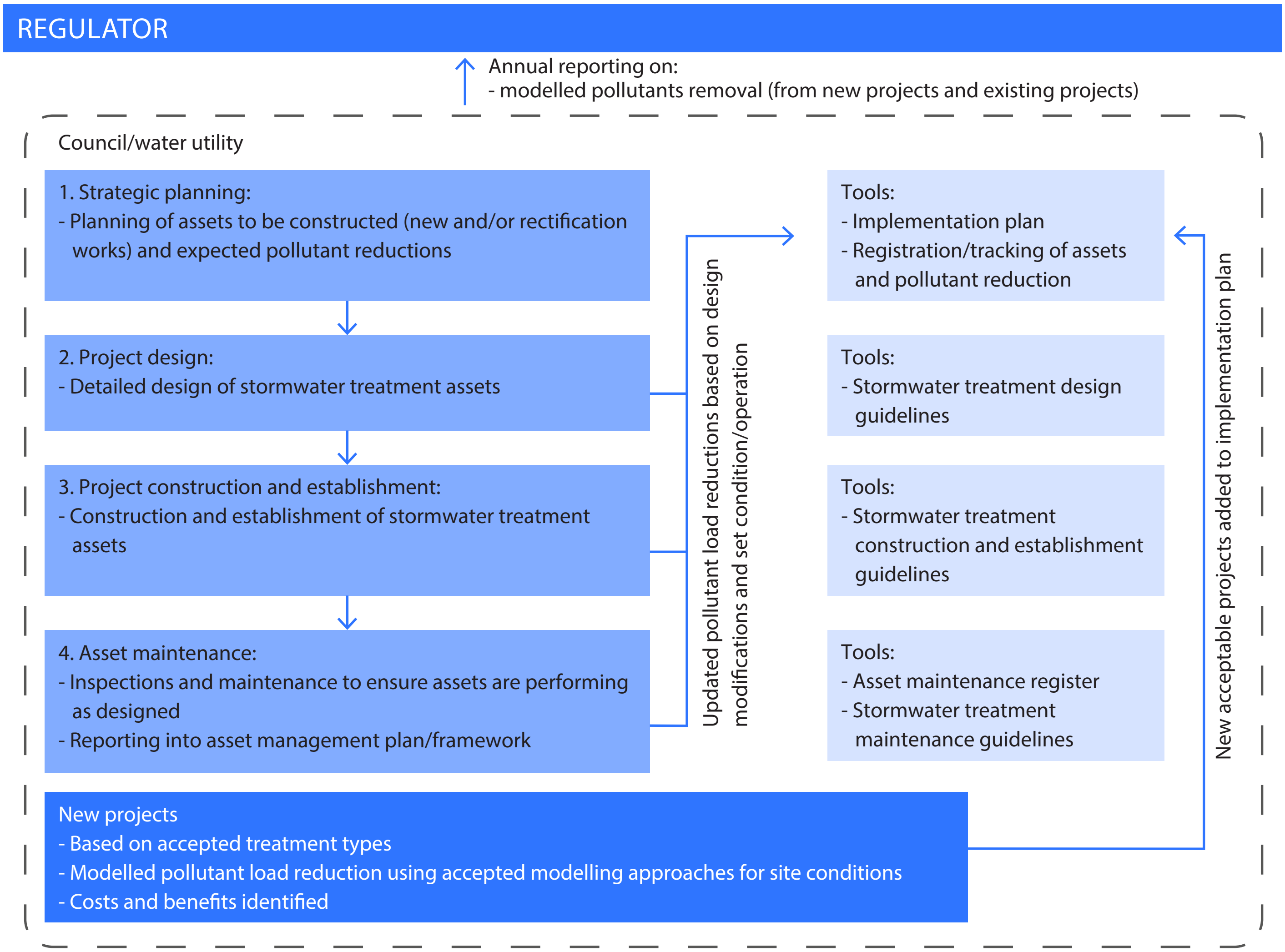

Figure 3 – Summary of a delivery framework for offset projects such as the Bohle River Offsets Project

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BOHLE OFFSETS PROJECT KEY OUTCOMES

Agreed governance framework outlining delivery requirements, roles and responsibilities.

KEY LEARNINGS

It is important to engage with all stakeholders who are likely to be involved in the future delivery of the road map to help inform the development of an agreed delivery approach and governance framework. This is critical as it is likely there will be different stakeholders involved throughout the different stages of the road map delivery and therefore there may need to be MoUs developed between parties to agree on roles, responsibilities, budget allocations, additional resource requirements etc.

CONCLUSIONS

The Bohle River Offsets Project has developed a robust framework which can be used by other Councils and utilities to undertake a similar process.

While the comparison of the identified stormwater treatment projects with the Condon STP upgrades is not currently possible due to a lack of data, this project has provided Council with a Road Map which is based on sound science to guide future investment in stormwater treatment options across the Bohle River catchment.

Recommended next steps for this project include:

- To continue this project the following next steps are recommended:
- Confirm pollutant reduction and costs for Condon STP upgrade to allow comparison with stormwater treatment projects.
- Confirm governance and legal requirements for how to deliver road map into the future.
- Include assessment of likely nutrient assimilation processes within the Bohle River downstream of Condon STP to understand if the equivalence ratios may need to be altered/reduced.
- Collaborate with the State Government to confirm processes with which to “bank” project nutrient reductions as offsets for future inclusion in an updated licensing regime for Condon STP.