Stormwater Quality Network Planning Report

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Synopsis:	**Technical report documenting the methodology and results for identifying trunk stormwater quality infrastructure requirements between 2021 - 2036.**	

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Executive Summary

In 2010, Moreton Bay Regional Council commenced the preparation of a Total Water Cycle Management Plan (TWCMP) in partnership with Unitywater. The TWCMP was prepared in accordance with the requirements outlined in the *Environmental Protection (Water) Policy 2009* (reprint no. 1) and in reference to the *Total Water Cycle Management Planning Guideline for South East Queensland* (Water by Design 2010). Moreton Bay Regional Council completed and endorsed the original TWCMP in 2013.

Council is currently undertaking a program of work to review and update the planning that informs the Local Government Infrastructure Plan (LGIP). The review and update of the TWCMP (this project) is being undertaken to align with this program of work, which is also being undertaken for floodplain management, transport, open space and community facilities networks.

This report forms part of Phase 5 of the TWCMP review and update. It uses the findings of Priority Infrastructure Area (PIA) modelling investigations to identify the location, size and cost of trunk stormwater quality treatment devices to meet desired standards of service, which were quantified to have a no net change (NNC) in pollutant loads over the planning period (2021-2036). Stormwater quality treatment to achieve NNC and DSS over the planning period are shown in Table 1.

Table 1 Stormwater Quality Treatment to achieve Desire Standards of Service

Catchment	Treatment to Achieve No Net Change 2021 - 2036		
	TSS (kg/yr)	TN (kg/yr)	TP (kg/yr)
Bribie	1,833	61	7.6
Brisbane Coastal	1,383	99	9.5
Burpengary	-	543	80
Caboolture	-	2,978	363
Lower Pine	-	1,230	122
Pumicestone	10,107	136	26
Sideling	1,021	11	2.4
Stanley	3,763	119	18
Upper Pine	544	7.5	1.4
Total MBRC	***18,650***	***5,185***	***631***

Table 1 shows that the key catchments requiring additional treatment beyond that required by the *State Planning Policy* (DILGP 2017) to achieve Desired Standards of Service (DSS) include:

- Caboolture River Catchment
- Lower Pine River Catchment
- Burpengary Creek Catchment.

Other catchments which require some additional treatment include Pumicestone Passage, Stanley River, Brisbane Coastal, Bribie Island, Sideling Creek and Upper Pine River catchments. Total nitrogen is the key constraining stormwater pollutant to target in each catchment.

This report identifies and assesses a number of trunk stormwater quality treatment opportunities including bioretention systems, wetlands, riparian revegetation and natural channel design to meet DSS objectives in each of the catchments, taking into consideration the trunk treatment requirements in five year cohorts over the planning period.

The methodology and results presented in this report support the schedule of works developed to satisfy LGIP requirements.

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1 Background

In 2010, Moreton Bay Regional Council commenced the preparation of a Total Water Cycle Management Plan (TWCMP) in partnership with Unitywater. The TWCMP was prepared in accordance with the requirements outlined in the *Environmental Protection (Water) Policy 2009* (reprint no. 1) and in reference to the *Total Water Cycle Management Planning Guideline for South East Queensland* (Water by Design, 2010). Moreton Bay Regional Council completed and endorsed the original TWCMP in 2013.

Council is currently undertaking a program of work to review and update the planning that informs the Local Government Infrastructure Plan (LGIP). The review and update of the TWCMP is being undertaken to align with this program of work, which is also being undertaken for floodplain management, transport, open space and community facilities networks. This program of work includes investigating a range of long-term growth scenarios to guide development within the Priority Infrastructure Area (PIA) and inform future growth decision making.

In order to review and update Council's TWCMP, while investigating future growth scenarios to guide the development of a new PIA, the current project has been divided into five phases. A summary of the project phases is outlined below:

- **Phase 1: Existing Base Case Model.** The objective of Phase 1 is to develop an existing base case model representative of current catchment conditions, and establish sustainable load targets for future development.
- **Phase 2: Future Development Scenario Models.** Phase 2 involves modelling three broad future development scenarios to understand the location, size and cost of stormwater quality infrastructure required to service the various development areas. This work was undertake to assist to inform the preparation of priority infrastructure area scenarios.
- **Phase 3: TWCMP Review and Evaluation.** The purpose of Phase 3 is to review and build upon the previous TWCMP work to recommend preferred management options that will be further assessed in Phase 4 of this project. It will summarise results of the project undertaken to date through the preparation of a revised TWCM Strategy.
- **Phase 5: Revised TWCMP / Preferred PIA Scenario.** The objective of this final phase is to prepare a revised TWCMP for the Moreton Bay region in conjunction with key stakeholders that will also satisfy LGIP requirements. This phase will use the modelling framework (developed in Phase 1) to model the preferred PIA scenario, applying the catchment management options recommended in Phase 3. It will identify the location, size and cost of trunk water quality devices required in a schedule of works that will satisfy LGIP requirements. Results will be presented as a revised TWCMP Detailed Planning Report.

This report forms part of Phase 5. It documents the findings of PIA modelling investigations to identify the location, size and the cost of trunk stormwater quality treatment devices to meet desired standards of service (DSS) for stormwater quality trunk infrastructure. The methodology and results presented in this report support the schedule of works developed to satisfy LGIP requirements.

2 Methodology

2.1 Preamble

The following section outlines the methodology applied to support the determination of trunk stormwater quality treatment infrastructure for Moreton Bay Regional Council's Local Government Infrastructure Plan (LGIP).

2.2 Desired Standards of Service and Water Quality Treatment Targets

As part of the LGIP planning process, local governments are required to define desired standards of service for trunk stormwater quality infrastructure. The purpose of DSS are to provide a summary of the key planning and design standards for a network. As part of the current study, DSS were reviewed to ensure consistency with Total Water Cycle Management Planning objectives.

The review included consultation with key internal and external stakeholders in a workshop convened on 7 November 2017 (for Phase 3 workshop 'C' and 'D'). A list of internal and external stakeholders involved in the project is included in Appendix A. The following principles were agreed on to reflect DSS for stormwater quality trunk infrastructure:

- Meet the requirements of MBRC's Total Water Cycle Management Plan (TWCMP)
- Meet "No Net Change" (NNC) target load objectives at a major catchment level (informed by the TWCMP)
- Implement planning and management of urban stormwater quality to comply with design objectives as set out in *Shaping SEQ* including *Goal 4: Sustain* (primarily Water Sensitive Communities and Biodiversity elements) and *Goal 5: Live* (primarily Working with Natural Systems.

To determine the NNC target load objects, catchment modelling was undertaken in Source Catchments. The modelling was used to assess the impact of future development on stormwater pollutant loads for planned development between 2021 – 2036, assuming a Business As Usual (BAU) Scenario.

The BAU scenario assumes that future development complies with State Planning Policy requirements for 80% removal of TSS, 60% removal of TP and 45% removal of TN. Any future predicted increases in pollutant loads as a result of development (i.e. when compared to 2021 loads) then requires treatment via trunk water quality infrastructure to achieve NNC objectives that define desired standards of service.

It is noted that the TWCM planning process will also address any predicted increases to loads between 2016 and 2021. However, as this relates to the existing pollutant loads and associated treatment measures, it is not defined as future trunk infrastructure and is subsequently omitted from this report.

In order to assist with network sequencing over planning time horizons, the catchment modelling also investigated future pollutant loads in five year cohorts for each planning time horizon to enable meeting the NNC targets determined for water quality treatment. A detailed report on the catchment modelling methodology is included in Appendix B.

2.3 Review of Existing Trunk Infrastructure

Existing trunk infrastructure was reviewed to determine whether it would also service future development, by providing additional treatment.

The information on existing trunk infrastructure was provided by Council to assess for future treatment benefits (refer to Table 2-1).

Table 2-1 Existing Trunk Infrastructure

Reference	Description
Brendale Wetland	Constructed wetland, Brendale
Glenmay Wetland	Constructed wetland, Morayfield (circa 2013)
Pine Rivers Park Lakes	Sediment basin and constructed wetland, Strathpine (circa 2016/17)
Male Road, Caboolture	Sediment basin and constructed wetland, Caboolture (circa 2018/19)
Bells Creek Bioretention	Sediment basin and bioretention basin, Redcliffe (circa 2019/20)
Humpybong Creek, Redcliffe	Sediment basin and naturalised swale, Redcliffe (circa 2019/20
Westbourne Park	Riparian vegetation works, Wights Mountain (circa 2009)
Russell Family Park	Riparian vegetation works, Highvale (circa 2009)
Sky Drive Park	Riparian vegetation works, Highvale circa (2009)

To assess whether the above assets could contribute towards treatment of future development, the following methodology was applied:

(1) Review whether the treatment asset is within a catchment that requires additional treatment to meet Desired Standards of Service (i.e. NNC targets). If not, then the site was not assessed any further.

(2) Review whether the asset will provide stormwater treatment for areas within the defined PIA. If not, then the site was not further assessed.

(3) Assess the current and future pollutant loads generated from the treated catchment of each asset. Upstream catchments were delineated for each treatment device and MUSIC modelling was undertaken for each catchment in accordance with best practice guidelines (WBD 2010) for existing and ultimate scenarios, using landuse and percentage imperviousness consistent with Source modelling functional units (refer to Appendix B). If ultimate pollutant loads were greater than existing pollutant loads (indicating potential for additional treatment), then further assessment was undertaken. If not, the site was not further assessed.

(4) Assess pollutant removal of treatment device in existing and ultimate conditions. This was undertaken in the MUSIC models developed. Where the asset facilitated additional treatment

in the ultimate scenario compared to the existing scenario, further assessment was undertaken. If not, the site was not further assessed.

(5) Assess the future development in the catchment draining to the treatment device over each time cohort. This was undertaken using information provided by MBRC on the assumed net change of land use cover as a percentage from existing (2016) to ultimate conditions for each minor catchment within the treated assets catchment.

(6) Assess the proportion of additional treatment loads likely for each time cohort, using the above assumptions on development over the cohorts in the minor catchments draining to the treatment asset. This assumes that treatment potential is proportional to development potential.

2.4 Site Identification

Potential locations for future trunk stormwater quality treatment infrastructure were primarily compiled from the following previous studies and information sources:

- MBRC's Total Water Cycle Management Plan (BMT 2013)
- Caboolture River Catchment Management Plan (BMT 2017)
- Council's current works program (LGIP2) and water sensitive urban design retrofit opportunities.

A small number of additional sites were also identified in consultation with Council.

To be classified as trunk infrastructure, sites need to treat stormwater within the Priority Infrastructure Area, as defined by MBRC. Sites identified to be treating stormwater outside of this area were therefore excluded from further assessment. A list of these excluded sites is included in Appendix C.

The suitability of sites was reviewed for key defined stormwater quality asset classes as detailed in Table 2-2.

Table 2-2 Trunk Stormwater Quality Treatment Infrastructure Categories

Trunk Infrastructure Category Description	Stormwater Quality Treatment Infrastructure Opportunity
Modified Waterways	Riparian Vegetation
	Natural Channel Design
Basins	Bioretention Basins
	Constructed Wetlands (conventional and ephemeral)

2.5 Site Prioritisation

A number of opportunities for bioretention basins and wetlands were identified from previous desktop studies. The sites were circulated within Council for review and an initial traffic light assessment was applied to help prioritise the suitability of these sites. This entailed screening the site suitability with preferential criteria in Table 2-3. A point, or 'green light' was scored for each criteria satisfied (i.e. answer yes is green light, answer no is red light), giving a score out of 7. Results of the traffic light assessment and Council comments (i.e. justifying site removal) are included in Appendix D.

Table 2-3 Traffic Light Assessment Criteria

	Criteria	Criteria Assessment
1	Open Space	Is the land in Council ownership?
2	Stormwater Infrastructure	Is the proposed asset close to existing stormwater infrastructure (within 15m of pipes / open drains)?
3	Minimum stormwater pipe or contributing catchment	For sites receiving flows from a stormwater pipe, is any pipe discharging to site greater than 450mm-diameter, or are there multiple pipes? For sites receiving overland flow, is the contributing catchment greater than 2 hectares?
4	Stream Order	Does the site receive flows from waterways with a stream order of 2 or less (or no waterways)?
5	Maximum catchment size	Is the catchment flowing through the site less than 100-hectares (for wetlands and bioretention basins)?
6	Catchment-area ratio	Does the site have an available area at least 0.5% of the size of the upstream catchment (for wetlands and bioretention basins)?
7	Protected Vegetation	Is the site clear of protected vegetation, as specified by SPP mapping layers as having matters of state environmental significance for biodiversity values.?

To help further assess the viability of these opportunities, a total of 26 sites were selected (based on results of the traffic light assessment) and inspected with Council staff in February 2019. These sites are shown in Appendix E.

The site inspections with Council were used to ground truth the suitability of sites for proposed opportunities. As a result, in some instances alternative treatment options were identified, or some opportunities were removed due to site constraints.

Desktop assessments were then undertaken, in consultation with Council, to further review the suitability of the remaining sites for treatment. Many sites were noted to have level constraints, which restricted the integration of proposed solutions into existing drainage infrastructure. Where a proposed location was considered constrained (e.g. by existing drainage infrastructure levels or by potential flooding conflicts identified by Council), alternative treatment options were considered (such as natural channel design or ephemeral wetlands) before the treatment opportunity was removed.

Each opportunity was then assessed to determine the potential treatment benefits and costs over a 20 year planning period to determine the cost effectiveness of the opportunity and assist in prioritising the works. This was determined by calculating the following:

- **Net Present Value (NPV)**: This is the total cost incurred over the planning period for establishment (i.e. design and construction capital cost) and during the operational phase (including maintenance), discounted to provide the cost in today's dollars (i.e. $2020). In determining the NPV, a nominal discount rate of 6.83% was used, and all future cash flows used an inflation rate of 1.76% based on advice provided by MBRC (C Farrant 2020, *pers. comm.*, 9 November).

- **Levelised Cost for Treatment**: The levelised cost for treatment of pollutants was calculated as the ratio of the net present value (NPV) of projected capital and operating costs of an option, to the projected pollutant load removal over the planning period (i.e. $/kg pollutant removed).

The methodology and assumptions used to determine the treatment performance and cost effectiveness of each opportunity is provided in the following sections.

It is noted that all treatment opportunities have been integrated into Council owned /managed land with zero land costs assumed.

2.6 Modified Waterways

Modified waterways are the asset category for the following trunk stormwater quality treatment opportunities:

- Riparian Vegetation
- Natural Channel Design.

A summary of these types of assets and the methodology used to assess their treatment performance and cost is provided in the following section.

2.6.1 Riparian Vegetation

2.6.1.1 Preamble

The riparian zone for waterways is the interface between the waterway and adjacent land, and provides several functions critical to the health of waterways. These functions include water quality improvement (e.g. through filtration), reducing erosion through bank stabilisation, habitat provision and flow attenuation. Anthropogenic pressures (e.g. development) can encroach into riparian areas and significantly reduce their benefits.

The condition of riparian vegetation along the banks of waterways has an important role in the stability of these banks. In areas where riparian vegetation is fully intact, waterway banks are stabilised by the root systems which provides some protection against erosive forces from the flow of water in the waterways.

The waterway riparian vegetation solution involves revegetating stretches of the waterway where mapping has identified the riparian corridor is degraded. Riparian revegetation also has the potential to provide other benefits in addition to those stated above including urban cooling, carbon sequestration and improved amenity. An example of a riparian vegetation project is shown in Figure 2-1.

Figure 2-1 Riparian Vegetation, Westbourne Park, Highvale

2.6.1.2 Treatment Performance

To quantify the reduction in sediment and nutrient loads from riparian revegetation opportunities identified, a methodology based on a study in South East Queensland by Olley *et al.* (2015) was used. Olley *et al*. (2015) found that sediment loads from catchments decrease proportionally with the increasing proportion of the stream length draining remnant vegetation[1].

Olley *et al*. (2015) extrapolated from the findings that reforested areas of the channel network will behave in a similar way to channels in areas of remnant woody vegetation. The methodology to assess pollutant reductions was based on Olley *et. al.* 2015 study findings as follows:

(1) The current condition of riparian vegetation was assessed to calculate the existing percentage of riparian cover within the catchment. The existing condition was based on the presence or absence of remnant woody vegetation.

(2) The percentage of riparian cover as a result of the revegetation strategies was calculated.

(3) The total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN) loads for both the existing riparian cover and the proposed riparian cover was calculated with the following equation:

$$Qs = 10a+b.P-3c\ (Qc\ )(A1-c\ )$$

Where Qs is the load in tonnes, Qc is discharge in m^3, A is catchment area in m^2, P is the proportion of the stream network draining remnant vegetation, and a, b and c are regression coefficients determined by multiple linear regression, which are:

TSS: a = -0.387, b = -2.038, c = 1.273

TP: a = -3.016, b = -1.576, c = 1.112

TN: a = -2.774, b = -0.41, c = 1.112

The width of riparian vegetation required to stabilise the creek bank is approximately equivalent to the height of the bank (Jon Olley, *pers comm*. 2015). The required width of

[1] Woody vegetation is mapped as remnant where the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and canopy of that stratum and is dominated by species characteristics of an undisturbed canopy (Department of Environment and Heritage Protection 2015)

vegetation was estimated based on the stream order of each creek, with the following estimated widths from top of bank assumed:

- First order streams: 5 m on either side
- Second order streams: 7 m on either side
- Third order streams: 10 m on either side
- Fourth and fifth order streams: 15 m on either side

(4) The percentage reduction between existing and proposed riparian cover was calculated and applied to the existing source model results for TSS, TN and TP.

(5) The methodology used to assess the pollutant load reduction developed by Olley *et al*. (2015) is typically applied to rural streams. Therefore, to quantify the water quality benefit to urban areas, a reduction factor of 60% was applied to the values calculated in step 4. This reduction factor accounts for the nature of urban streams, noting that flows are delivered directly to the waterway via stormwater pipes and there is no filtering of flows as they are delivered to the waterway via the vegetated buffers as would occur within rural waterways. A reduction factor of 60% was selected because research in south-east Queensland has indicated that streambank erosion contributes to approximately 40% of the end of catchment loads (Wilkinson *et al*., 2015, Hateley *et al*., 2014, Caitcheon *et al*. 2012).

When assessing the total treatment performance of riparian vegetation over the planning period, it was assumed that effective treatment would only commence after the establishment period, assumed to be approximately 5 years.

2.6.1.3 Cost

A capital cost of $15/m^2 for riparian revegetation has been adopted as recommended in MBRC's 2012 report *Capital Works Program Opportunities, Water Quality Network: Riparian Corridor Protection, Rehabilitation and Revegetation.* Using a cost escalation tool provided by MBRC, the 2020 cost for riparian revegetation was assumed to be $17.67/m^2.

When assessing the cost effectiveness of this solution, this cost was then proportioned into the various lifecycle components, as follows:

- Project site design and planning: 5% of total cost
- Year 1 on-ground works: 40% of total cost
- Year 2 on-ground works: 30% of total cost
- Year 3 on-ground works: 10% of total cost
- Year 4 on-ground works: 10% of total cost
- Project completion, assessment, and handover: 5% of total cost.

No ongoing costs were assumed after the project completion.

2.6.2 Natural Channel Design

2.6.2.1 Preamble

Natural Channel Design (NCD) involves the rehabilitation of piped or concrete-lined waterways. These projects typically involve modifications to the bed and banks, as well as channel and riparian revegetation programs to naturalise urban drainage. These projects often provide multiple benefits including water quality treatment and improved waterway health, carbon sequestration, improved habitat and connectivity, improved aesthetics and opportunities for active community involvement. Examples of NCD are shown in Figure 2-2.

Figure 2-2 Natural Channel Design Examples

2.6.2.2 Treatment Performance

For each of the sites the upstream catchment area was determined along with the proportion of each land use and the length of the NCD. To estimate the treatment performance each NCD was modelled as a swale in MUSIC, in accordance with best practice modelling guidelines (WBD 2010). Key assumptions for modelling the treatment performance in MUSIC were as follows.

- Base width: 2m
- Top width: 10m
- Depth: 1m
- Vegetation height: 1m
- Stream slope: 1%.

2.6.2.3 Cost

Cost estimates for natural channel design were based on professional experience and recommendations from Catchments and Creeks (G Witheridge, *pers. comm.*, 2015). An annualised renewal cost of 2% of the construction cost was assumed, as derived from Taylor (2005). These cost assumptions are detailed in Table 2-4 and have been escalated to present day costs using advice provided by MBRC (C Farrant 2020, *pers. comm.,* 16 October).

Table 2-4 Natural Channel Design Cost Assumptions

Natural Channel Design Cost				Escalated Natural Channel Design Cost			
Construction $/m	Maintenance $/m²/yr	Establishment[1] $/m²/yr	Renewal $/m	Construction $/m	Maintenance $/m²/yr	Establishment[1] $/m²/yr	Renewal $/m
$5,000	$1	$3	$100	$5,577.50	$1.12	$3.36	$112

[1] Maintenance during the establishment period (two years) is assumed three times the long-term annual maintenance cost (WBD 2010a)

2.7 Basins

Basins are the asset category for the following trunk stormwater quality treatment opportunities:

- Bioretention Basins
- Raingardens
- Constructed Wetlands (including conventional wetlands and ephemeral wetlands).

A summary of these types of assets and the methodology used to assess their treatment performance and cost is provided in the following section.

2.7.1 Bioretention Basin

2.7.1.1 Preamble

Bioretention systems are plant and soil-based stormwater treatment devices in which stormwater is directed into the system and infiltrates through the plant and soil environment. Stormwater is treated via a combination of physical, chemical and biological processes. Bioretention systems are flexible in size, shape and appearance, and can be readily integrated into a range of landscapes. Bioretention basins as described in this section refer to larger end of pipe treatment devices, integrated into Council owned parklands. An example of a bioretention basin is shown in Figure 2-3.

Figure 2-3 Bioretention Basin, North Lakes

2.7.1.2 Treatment Performance

The MUSIC software package was used to determine the optimal area of bioretention basin (filter area) required to achieve best practice State Planning Policy (SPP) (DLGIP 2017) reduction targets of 80% TSS, 60% TP and 45% TN. Modelling was undertaken in accordance with MUSIC Modelling Guidelines (Water by Design 2010).

For medium density residential land use in MBRC, it was determined that a typical bioretention filter area of approximately 1.0% of the upstream catchment area is required to achieve best practice treatment targets. The typical bioretention basin properties assumed for modelling purposes in a 1 ha medium density residential development are outlined in Table 2-5 below.

Each bioretention basin identified as a trunk water quality treatment asset was therefore sized to be 1.0% of the upstream catchment area to achieve optimal treatment.

Using MUSIC, the typical treatment effectiveness of bioretention systems could then be estimated per square meter of filter area, assuming optimal treatment performance in medium density residential development. This effectiveness was then used to estimate the total pollutant load removal rates expected for each bioretention basin proposed, with a 20% contingency / uncertainty factor applied. A summary of typical bioretention basin treatment performance as modelled in MUSIC is presented in Table 2-6 below.

Table 2-5 Bioretention Basin Properties for Treating 1ha of Urban Development[1]

Bioretention Property	Value Adopted / Comments
Extended Detention Depth (m)	0.3
Surface Area (m^2)	Equal to Filter Area
Filter Area (m^2)	100 Sized to achieve SPP pollutant load removal targets
Unlined Filter Media Perimeter (m)	0.01
Saturated Hydraulic Conductivity (mm/hr)	200
Filter Depth	0.5
TN Content of Filter Media (mg/kg)	400
Orthophosphate Content of Filter Media (mg/kg)	30
Exfiltration Rate (mm/hr)	0
Is the base lined?	Yes
Vegetation Properties	Vegetated with Effective Nutrient Removal Plants
Overflow Weir Width (m)	10
Underdrain Present?	Yes
Submerged Zone with Carbon Present?	No

[1] Assumes medium density residential development with 80% impervious area

Table 2-6 Bioretention Basin Treatment Performance ($kg/m^2/yr$)

Parameter	Removal ($kg/m^2/yr$)[1]	Removal with 20% contingency ($kg/m^2/yr$)
Total Suspended Solids	18.47	14.78
Total Nitrogen	0.097	0.078
Total Phosphorus	0.033	0.026

[1] Assumes filter area is 1.0% of the upstream catchment, within medium density residential development

2.7.1.3 Cost

Cost estimates were derived from Water by Design (2010a), which were based on actual project costs and data from related research. The costs assumed that maintenance during the establishment period (two years) is three times the long-term annual maintenance cost. Renewal costs were estimated to be 40% of construction costs. Costs were escalated to present day using advice provided by MBRC (C Farrant 2020, *pers. comm.*, 16 October). A summary of the bioretention basin cost assumptions are detailed in Table 2-7.

Table 2-7 Bioretention Basin Cost Assumptions

Bioretention Basin Cost (WBD 2010a)				Escalated Bioretention Basin Cost ($2020)			
Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2	Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal $/m^2
270	5	15	108	322	6	18	129

2.7.2 Raingardens

2.7.2.1 Preamble

As described in Section 2.7.1.1, bioretention systems can be integrated into a range of landscapes. Raingardens are small bioretention systems that are integrated into the streetscape. They provide benefits relative to large 'end-of-pipe' basins as follows:

- treating stormwater 'at the source'
- providing improved integration (e.g. self-watered landscaped areas within streetscapes).

Raingardens also have the potential to provide other benefits including urban cooling (particularly when planted with trees), enhanced street appeal, and improved local biodiversity.

In most catchments, existing constraints made it difficult to identify enough suitable sites to retrofit end of pipe treatment devices to achieve the target catchment pollutant loads. In these instances, it is recommended that additional treatment be achieved through integrating raingardens into streetscapes at suitable locations throughout the catchment. An example is shown in Figure 2-4.

The specific locations for these raingardens have not been identified, however the best and most cost-effective opportunities for integration would be to align with other infrastructure works programs through the catchment (e.g. road upgrades, urban renewal projects).

Figure 2-4 Raingarden, Bray Park

2.7.2.2 Treatment Performance

Raingarden treatment performance was estimated using the same approach described in Section 2.7.1.2. MUSIC modelling was undertaken in accordance with the *MUSIC Modelling Guidelines* (Water by Design 2010) to estimate the typical treatment effectiveness of raingardens for treating stormwater in a 1 ha medium density urban residential catchment in MBRC.

The key difference in the assessment of raingardens (in comparison to bioretention basins) was the use of a smaller extended detention depth and the assumption that the filter media depth would also be less, to help easily integrate into the existing drainage infrastructure. The typical raingarden properties assumed for modelling purposes are outlined in Table 2-8 below. The modelling identified that raingardens should typically be sized at 1.45% of the upstream catchment area in order to achieve optimal treatment. It is noted that, where possible, opportunities to increase the filter media depth should be undertaken to allow for the incorporation of street trees and associated benefits (e.g. urban cooling). A filter depth of 0.4m has been assumed to allow for potential depth constraints in retrofit projects. Increasing the filter depth where possible would also provide additional treatment, allowing a reduced surface area to meet the same objectives.

Modelling results were used to determine the bioretention filter area typically required to treat one kilogram of pollutant load generated from a medium density residential area within the Moreton Bay region. A 20% contingency / uncertainty factor was then applied (assuming 20% less treatment achieved). Results are provided in Table 2-9 below. These results were used to identify the area of raingardens needed to meet any additional pollutant treatment requirements in each catchment (to achieve 'no net change' in loads).

Table 2-8 Raingarden Properties for Treating 1ha of Urban Development[1]

Bioretention Property	Value Adopted / Comments
Extended Detention Depth (m)	0.1
Surface Area (m^2)	Equal to Filter Area
Filter Area (m^2)	145 Sized to achieve SPP pollutant load removal targets
Unlined Filter Media Perimeter (m)	0.01
Saturated Hydraulic Conductivity (mm/hr)	200
Filter Depth	0.4
TN Content of Filter Media (mg/kg)	400
Orthophosphate Content of Filter Media (mg/kg)	30
Exfiltration Rate (mm/hr)	0

Bioretention Property	Value Adopted / Comments
Is the base lined?	Yes
Vegetation Properties	Vegetated with Effective Nutrient Removal Plants
Overflow Weir Width (m)	Surface Area / 10
Underdrain Present?	Yes
Submerged Zone with Carbon Present?	No

[1] Assumes medium density residential development with 80% impervious area

Table 2-9 Raingarden Treatment Performance (pollutant/m²/yr)

Parameter	Area of bioretention to treat 1 kg pollutant (m^2/kg/yr)[1]	Area with 20% Contingency (m^2/kg/yr)[1]
Total Suspended Solids	0.074	0.093
Total Nitrogen	15.43	19.28
Total Phosphorus	47.19	59.98

[1] Assumes filter area is 1.5% of the treated catchment, within medium density residential development

2.7.2.3 Cost

Cost estimates were derived using both Melbourne Water (2013) estimates for streetscape raingardens and research by Water by Design (2010a). The costs assumed that maintenance during the establishment period (two years) is three times the long-term annual maintenance cost. Costs were escalated to present day using advice provided by MBRC (C Farrant 2020, *pers. comm*., 16October). A summary of the bioretention basin cost assumptions are detailed in Table 2-10.

Table 2-10 Raingarden Cost Assumptions

Bioretention Basin Cost (MW 2013[1], WBD 2010a[2])				Escalated Bioretention Basin Cost ($2020)			
Construction[1] $/m²	Maintenance [2] $/m²/yr	Establishment[1,2] $/m²/yr	Renewal[1] $/m²	Construction $/m²	Maintenance $/m²/yr	Establishment $/m²/yr	Renewal $/m²
1,000	5	15	100	1,137	6	18	114

2.7.3 Constructed Wetlands

2.7.3.1 Preamble

Constructed wetlands are engineered shallow vegetated water bodies that treat stormwater by enabling sedimentation, filtration and biological processes.

In addition to water quality benefits, wetlands provide important recreational and amenity values in our community, particularly when integrated well (i.e. through incorporation of walkways/bikeways/viewing platforms). They also provide ecological benefits, providing habitat and refuge for a diverse range of species in urban areas. An example of a constructed wetland is shown in Figure 2-5.

Figure 2-5 Constructed Wetland, North Lakes

2.7.3.2 Treatment Performance

The MUSIC software package was used to determine the optimal surface area of wetland required to achieve best practice SPP reduction targets of 80% TSS, 60% TP and 45% TN. Modelling was undertaken in accordance with MUSIC Modelling Guidelines (Water by Design 2010).

For the urban land uses assessed in MBRC, it was determined that a typical wetland surface area of approximately 8% of the upstream catchment area is required to achieve best practice treatment targets. The typical wetland properties assumed for modelling purposes in 1 ha urban development are outlined in below in Table 2-11. Commercial and industrial land uses were also investigated as these land uses dominated some catchments.

Using MUSIC, the typical treatment effectiveness of wetlands could then be estimated per square metre of surface area, assuming optimal treatment performance. This effectiveness was then used to estimate the total pollutant load removal rates expected for each wetland basin proposed, with a 20% contingency / uncertainty factor applied. A summary of typical wetland treatment performance as modelled in MUSIC for various land uses is presented in Table 2-12 below. It is noted that many of the upstream catchments draining to identified wetlands are very large, and therefore the high flow bypass will be an integral component of the design.

Table 2-11 Wetland Properties for Treating 1ha of Urban Development

Wetland Property / comments	Value Adopted Medium Density Residential[1]	Value Adopted Commercial[2]	Value Adopted Industrial[2]
Inlet Pond (m^3) *5% of surface area x 1.5m*	60	60	61
Surface Area (m^2) *Sized to achieve SPP pollutant load removal targets*	800	800	810
Extended Detention Depth (m)	0.5	0.5	0.5
Permanent Pool Volume (m^3) *Surface area x 1.25*	1000	1000	1012.5
Initial Volume	0	0	0
Exfiltration rate (mm/hr)	0	0	0
Evaporative Loss (% of PET)	125	125	125
Equivalent Pipe Diameter (mm)	37	37	38
Overflow Weir Width *Surface Area /10*	80	80	81
Notional Detention Time (hrs)	49.3	49.3	47.3

[1] Assumes 80% impervious area [2] Assumes 90% impervious area

Table 2-12 Wetland Treatment Performance ($kg/m^2/yr$)

Parameter	Removal ($kg/m^2/yr$)	Removal with 20% Contingency
Medium Density Residential Development (80% Impervious)		
Total Suspended Solids	2.164	1.731
Total Nitrogen	0.012	0.009
Total Phosphorus	0.004	0.003
Commercial Development (90% Impervious)		
Total Suspended Solids	2.466	1.973
Total Nitrogen	0.023	0.018
Total Phosphorus	0.006	0.004

Parameter	Removal (kg/m²/yr)	Removal with 20% Contingency
Industrial Development (90% Impervious)		
Total Suspended Solids	1.475	1.180
Total Nitrogen	0.015	0.012
Total Phosphorus	0.003	0.003

2.7.3.3 Cost

Cost estimates for wetlands were based on professional experience and recommendations from Australian Wetlands Consulting (AWC) (M Bailey, *pers. comm*., 22 January 2013). An annualised renewal cost of 0.52% of the construction cost was assumed, as derived from Taylor (2005). These cost assumptions are detailed in Table 2-13 and have been escalated to present day costs using advice provided by MBRC (C Farrant 2020, *pers. comm.,* 16 October).

Table 2-13 Wetland Cost Assumptions

Wetland Cost (AWC 2013)				Escalated Wetland Cost ($2020)			
Construction $/m²	Maintenance $/m²/yr	Establishment $/m²/yr	Renewal[1] $/m²/yr	Construction $/m²	Maintenance $/m²/yr	Establishment $/m²/yr	Renewal $/m²/yr
175	2.5	7.5	0.91	202	$2.88	8.64	1.05

[1] Source: Taylor (2005)

2.7.4 Constructed Ephemeral Wetlands

2.7.4.1 Preamble

Ephemeral wetlands are similar to constructed wetlands, however they have no permanent water bodies, consisting entirely of ephemeral zone vegetation that can be temporarily inundated. They have been identified at a few locations where constraints have not permitted conventional wetlands to be constructed. Treatment performance is less than conventional wetlands, however is still anticipated to provides effective water quality treatment at constrained locations.

2.7.4.2 Treatment Performance

Ephemeral treatment wetlands were modelled in MUSIC using the properties outlined in Table 2-14.

Table 2-14 Ephemeral Wetland Properties for MUSIC Modelling

Wetland Property / comments	BUR_WR12 Matterhorn Drive Park, Narangba	LPR_WR13 Kupidabin Park, Samford Village
Upstream catchment area (ha) *Medium density urban residential*	25.5	8.5
Inlet Pond (m^3)	0	0

Wetland Property / comments	BUR_WR12 Matterhorn Drive Park, Narangba	LPR_WR13 Kupidabin Park, Samford Village
Assumed no inlet pond		
Surface Area (m^2) *Available area*	5,400	2,400
Extended Detention Depth (m)	0.5	0.5
Permanent Pool Volume (m^3) *None*	0	0
Initial Volume	0	0
Exfiltration rate (mm/hr)	0	0
Evaporative Loss (% of PET)	125	125
Equivalent Pipe Diameter (mm)	97	65
Overflow Weir Width	100	100
Notional Detention Time (hrs)	48.4	47.9

2.7.4.3 Cost

Cost estimates for ephemeral wetlands were based on professional experience and recommendations for wetlands from Australian Wetlands Consulting (AWC) (M Bailey, *pers. comm.*, 22 January 2013). The costings were assumed to be in the lower range of typical costs assumed for constructed wetlands. An annualised renewal cost of 0.52% of the construction cost was assumed, as derived from Taylor (2005). These cost assumptions are detailed in Table 2-15 and have been escalated to present day costs using advice provided by MBRC (C Farrant 2020, *pers. comm.*, 16 October).

Table 2-15 Ephemeral Wetland Cost Assumptions

Ephemeral Wetland Cost (adapted from AWC 2013)				Escalated Ephemeral Wetland Cost ($2020)			
Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal[1] $/m^2/yr	Construction $/m^2	Maintenance $/m^2/yr	Establishment $/m^2/yr	Renewal[1] $/m^2/yr
150	2	6	0.78	173	2.31	6.92	0.9

[1] Source: Taylor (2005)

2.8 Network Sequencing Over Planning Time Horizons

2.8.1 Desired Standards of Service

Network sequencing over the planning period was undertaken to ensure that pollutant reductions required to meet desired standards of service (DSS) in each time cohort were achieved as closely as possible, to minimise costs while achieving objectives. NNC objectives to meet DSS are identified in Section 3.2 (Table 3-2 to Table 3-4). These treatment targets were limited by TN reductions in all instances, with TSS and TP reduction targets more easily achieved.

It should also be noted that the predicted treatment performance of stormwater quality assets has also allowed for some degree of uncertainty (refer to Section 2.6 and 2.7), to help ensure that DSS are achieved.

2.8.2 Selection of Stormwater Quality Treatment Assets

The stormwater quality treatment assets assessed were compiled from previous studies and information sources, as described in Section 2.4. The suitability of these sites were reviewed through a traffic light assessment of key criteria, consultation with various Council departments and site inspections with Council officers to ground truth site suitability (refer to Section 2.5). In some instances, treatment types were changed to accommodate site constraints. For example, where proposed bioretention basins could not be integrated into existing drainage infrastructure, or were identified to conflict with current uses (flooding / recreation), natural channel designs were proposed as an alternative, where appropriate.

2.8.3 Cost Effectiveness and Network Sequencing

Treatment opportunities were initially prioritised considering the cost effectiveness of TN treatment provided over the planning period (through assessment of levelised treatment costs). However, it was also recognised that opportunities for natural channel design would, in some cases, provide multiple benefits such as improved aesthetics, opportunities for recreation, improved habitat and connectivity, as well as water quality treatment, without significantly reducing the useability of the site. In a few instances, these benefits were recognised through sequencing before some other assets with more cost-effective nitrogen removal, such as wetlands in the Lower Pine River catchment.

Sequencing in some instances was also related to timing of development in a catchment. For example, while more cost effective than earlier planned works, natural channel design in Jensen Road Park (CAB_NCD2) has been delayed until the time cohort that surrounding future development is predicted to occur in. Similarly, other treatment assets to be constructed in the catchment were considered to ensure the sequencing resulted in the best outcomes. As a result, natural channel design (BURWR06b) located immediately upstream of Burpengary Greenlinks constructed wetland (BUR_CW02) is sequenced prior to the wetland, to reduce the potential for the wetland to be damaged during construction, which could result in expensive rectification works.

While the current investigation indicates that streetscape raingardens provide comparatively cost-effective TN removal, it is noted that streetscape raingardens were sequenced once other end of pipe treatment locations had been exhausted. Further detailed investigations (beyond the current scope of works) will be required to identify suitable locations throughout the catchment for streetscape raingardens.

2.8.4 Riparian Revegetation Considerations

Previous Total Water Cycle Management Planning studies have identified riparian revegetation projects as a preferred catchment solution using Multi Criteria Assessment techniques, with detailed investigations indicating they provide cost effective treatment of stormwater (BMT WBM 2010, BMT WBM 2012). Current investigations support previous findings, indicating that riparian revegetation provides cost effective treatment of TN (key target pollutant) over the planning period, even assuming no treatment during an initial five year establishment period. Network sequencing of riparian revegetation has also been undertaken to allow for this five year establishment period prior to optimal treatment being achieved.

2.8.5 Community Consultation

It is noted that no community consultation has been undertaken regarding the locations of future stormwater quality trunk infrastructure. For successful outcomes, community engagement is recommended during the conceptual design phase, particularly when implementing streetscape raingardens.

3 Results

3.1 Preamble

The following section outlines results of investigations undertaken to identify future trunk stormwater quality infrastructure requirements to ensure future development within the Moreton Bay Regional Council area meets DSS.

3.2 Water Quality Treatment Targets / Desired Standards of Service

The treatment targets needed to achieve NNC in pollutant loads between 2021 to 2036 is detailed in Table 3-1. It is noted that both Redcliffe and Hays catchments are not included, as modelling predicts pollutant loads are not expected to worsen in these catchments over this time.

Table 3-1 Treatment Target to Achieve No Net Change in Loads 2021-2036

Catchment	Treatment to Achieve No Net Change 2021 - 2036		
	TSS (kg/yr)	TN (kg/yr)	TP (kg/yr)
Bribie	1,833	61	7.6
Brisbane Coastal	1,383	99	9.5
Burpengary	-	543	80
Caboolture	-	2,978	363
Lower Pine	-	1,230	122
Pumicestone	10,107	136	26
Sideling	1,021	11	2.4
Stanley	3,763	119	18
Upper Pine	544	7.5	1.4
Total MBRC	***18,650***	***5,185***	***631***

To assist with planning when trunk infrastructure requirements will be needed over the planning horizon, treatment targets to achieve NNC have also been estimated in five year cohorts, as shown in Table 3-2 to Table 3-4.

Table 3-2 Treatment Target to Achieve No Net Change in Loads 2021-2026

Catchment	Treatment to Achieve No Net Change 2021 - 2026		
	TSS (kg/yr)	TN (kg/yr)	TP (kg/yr)
Bribie	1,080	36	4.4
Brisbane Coastal	698	42	4.2
Burpengary	-	187	25
Caboolture	-	960	120
Lower Pine	-	431	46
Pumicestone	3,836	50	9.7
Sideling	513	4.7	1.2
Stanley	543	38	5.4
Upper Pine	258	3.6	0.7
Total MBRC	**6,928**	**1,753**	**217**

Table 3-3 Treatment Target to Achieve No Net Change in Loads 2026-2031

Catchment	Treatment to Achieve No Net Change 2026 - 2031		
	TSS (kg/yr)	TN (kg/yr)	TP (kg/yr)
Bribie	556	19	2.3
Brisbane Coastal	474	28	2.8
Burpengary	-	195	30
Caboolture	-	1,314	162
Lower Pine	-	461	42
Pumicestone	4,300	58	11
Sideling	415	4.5	1.0
Stanley	1,020	37	5.4
Upper Pine	263	3.6	0.7
Total MBRC	**7,029**	**2,119**	**257**

Table 3-4 Treatment Target to Achieve No Net Change in Loads 2031-2036

Catchment	Treatment to Achieve No Net Change 2031 - 2036		
	TSS (kg/yr)	TN (kg/yr)	TP (kg/yr)
Bribie	197	6.6	0.8
Brisbane Coastal	211	28	2.5
Burpengary	-	161	25
Caboolture	-	704	81
Lower Pine	-	339	34
Pumicestone	1,971	28	5.3
Sideling	92	1.7	0.3
Stanley	2,200	44	7.0
Upper Pine	23	0.3	0.1
Total MBRC	***4,694***	***1,314***	***156***

3.3 Existing Trunk Infrastructure

Using the methodology outlined in Section 2.3, only the following assets were identified as potentially providing additional treatment to future development within the PIA:

- Brendale Wetland, Brendale
- Pine Rivers Park Wetland, Strathpine

Table 3-5 lists the results of the assessments demonstrating that other existing trunk water quality treatment infrastructure would not contribute to future trunk treatment requirements.

Table 3-5 Existing Trunk Assets Not Providing Future Trunk Treatment

Asset	Assessment Results
Glenmay Wetland, Morayfield	• Negligible additional treatment provided between 2016-Ultimate (<1kg/yr TN)
Male Road, Caboolture	• Future catchment pollutant loads < existing pollutant loads
Bells Creek Bioretention, Redcliffe	• Located in Redcliffe catchment, no additional treatment required to meet DSS
Humpybong Creek, Redcliffe	• Located in Redcliffe catchment, no additional treatment required to meet DSS
Westbourne Park, Wights Mountain	• Treats stormwater outside of PIA
Russell Family Park, Highvale	• Treats stormwater outside of PIA
Sky Drive Park, Highvale	• Treats stormwater outside of PIA

Table 3-6 lists the assumed net change in the proportion of future development/ treatment performance determined for catchments draining to Brendale Wetland and Pine Rivers Park Wetland as a result of Step 5 (refer to Section 2.3).

Table 3-6 Assumed Net Change in Treatment Performance for Existing Trunk Assets

Asset	Major Catchment	Minor Catchment	Assumed Net Change from Existing to Ultimate Conditions			
			2021	2026	2031	2036
Brendale Wetland	Lower Pine	COU_02_00000	25%	50%	75%	100%
Pine Rivers Park Wetland	Lower Pine	SPR_41_01641 SPR_41_00881 SPR_41_00746 SPR_41_00493	40%	60%	80%	100%

A summary of the predicted additional treatment facilitated from the Brendale Wetland and Pine Rivers Park Wetland in each time cohort is shown in Table 3-7. Total suspended solids are not presented as no additional treatment is required to meet NNC objectives (refer to Table 3-1).

Table 3-7 Future Additional Treatment from Existing Trunk Assets

Brendale Wetland		
Additional Treatment	**TP (kg/yr)**	**TN (kg/yr)**
Total (2016-Ultimate)	3	7
2021-2026	0.75	1.75
2026-2031	0.75	1.75
2031-2036	0.75	1.75
Total 2021-2026	2.25	5.25
Pine Rivers Park Wetland		
Additional Treatment	**TP (kg/yr)**	**TN (kg/yr)**
Total (2016-Ultimate)	3	10
2021-2026	0.6	2
2026-2031	0.6	2
2031-2036	0.6	2
Total 2021-2026	1.8	6
Total 2021-2036 (Brendale & Pine Rivers Park)	***4.05***	***11.25***

3.4 Future Trunk Water Quality Treatment Infrastructure

A summary of the trunk water quality treatment infrastructure opportunities identified for each catchment is outlined in Table 3-8. The locations are also shown in Figure 3-1.

Table 3-8 Summary of Proposed Trunk Stormwater Quality Treatment Opportunities

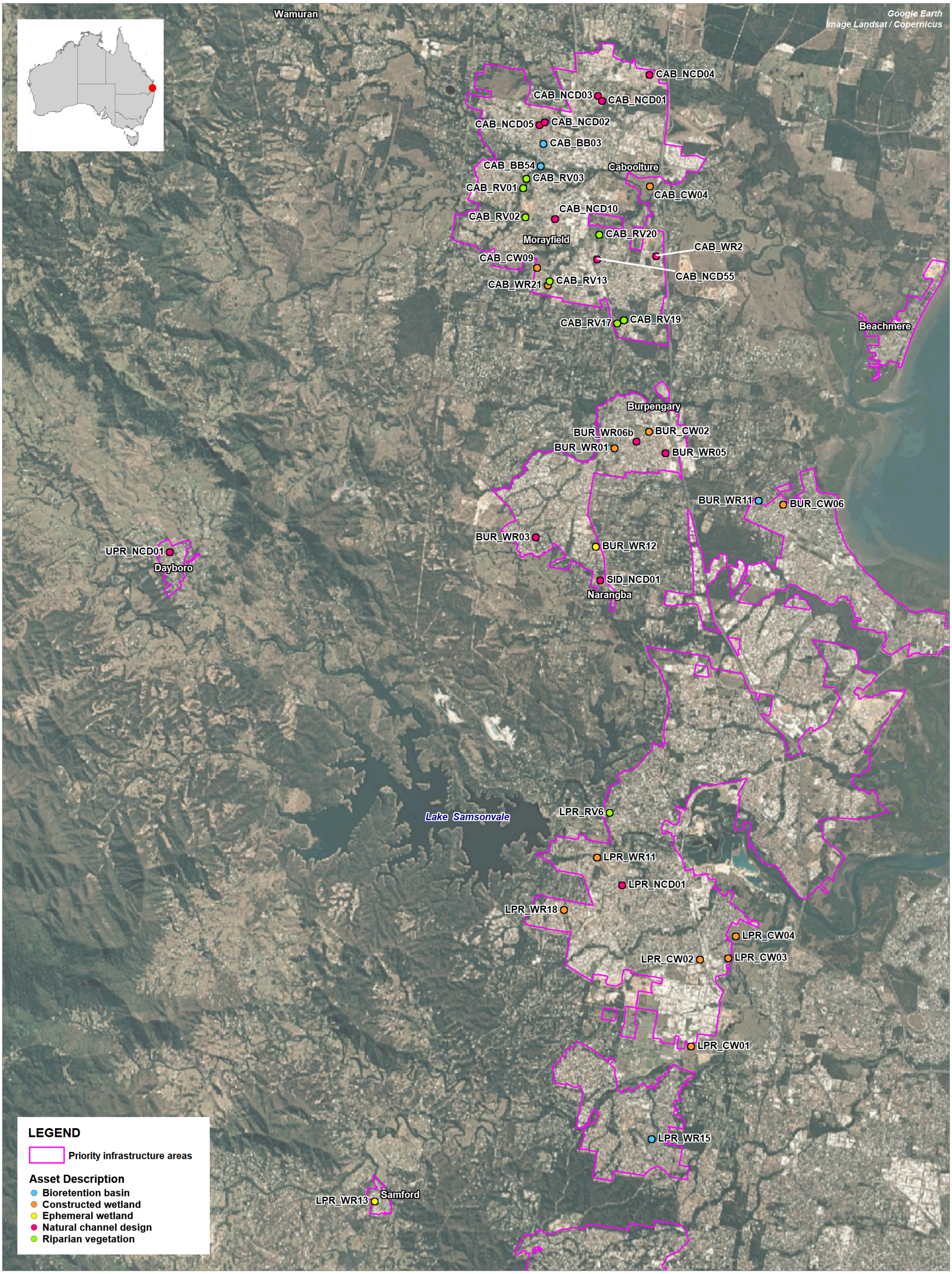
Catchment	Location	LGIP ID	Description	Treatment Area (m^2)	Treatment Length (m)
Burpengary	Burpengary Sportsgrounds, Burpengary	BUR_CW02	Constructed Wetland	13,400	
	Claverton Drive Park & Reserve, Burpengary	BUR_CW06	Constructed Wetland	3,600	
	Crendon Street Park, Burpengary	BUR_WR01	Constructed Wetland	3,733	
	Narangba Sports Centre, Narangba	BUR_WR03	Natural Channel Design	3,300	330
	Caccini Crescent Park Burpengary	BUR_WR05	Natural Channel Design	6,350	635
	Symphony Crescent Park, Burpengary	BUR_WR06b	Natural Channel Design	5,900	590
	May St Park, Deception Bay	BUR_WR11	Bioretention Basin	585	
	Matterhorn Drive Park, Narangba	BUR_WR12	Ephemeral Wetland	5,400	
Caboolture	Lynfield Drive Park, Caboolture	CAB_BB03	Bioretention Basin	3,360	
	Wararba Cres, Caboolture	CAB_BB54	Bioretention Basin	1,000	
	Lower King St Park, Caboolture	CAB_CW04	Constructed Wetland	38,800	
	Christopher Place Park Morayfield	CAB_CW09	Constructed Wetland	2,267	
	Ruby Street Park, Caboolture	CAB_NCD01	Natural Channel Design	1,750	175
	Parish Park, Caboolture	CAB_NCD02	Natural Channel Design	4,000	400
	Jensen Road Park, Caboolture	CAB_NCD03	Natural Channel Design	1,550	155
	Male Road Park, Caboolture	CAB_NCD04	Natural Channel Design	1,100	110
	Grace College, Caboolture	CAB_NCD05	Natural Channel Design	3,750	375
	Kate McGrath's Koala Park, Caboolture Sth	CAB_NCD10	Natural Channel Design	8,100	810
	The Billabongs Parkland, Morayfield	CAB_NCD55	Natural Channel Design	2,650	265
	Bel Air Estate Park, Bellmere	CAB_RV01	Riparian Vegetation	7,766	259
	Allan Road Park, Bellmere	CAB_RV02	Riparian Vegetation	21,077	703
	3 Mainsail Drive, Caboolture Sth	CAB_RV03	Riparian Vegetation	10,077	336
	Beech Drive Park, Morayfield	CAB_RV13	Riparian Vegetation	17,294	1235
	Havenwood Street Park, Burpengary	CAB_RV17	Riparian Vegetation	4,637	464
	Shangrila Street Park, Burpengary	CAB_RV19	Riparian Vegetation	17,913	1279
	Visentin Road Park, Morayfield	CAB_RV20	Riparian Vegetation	48,333	2553
	Pinegrove Rd Park, Morayfield	CAB_WR2	Natural Channel Design	1,450	145
	Beech Drive Park, Morayfield	CAB_WR21	Constructed Wetland	3,533	
Lower Pine River	Scouts Crossing Rd Park, Brendale	LPR_CW01	Constructed Wetland	14,593	

Catchment	Location	LGIP ID	Description	Treatment Area (m^2)	Treatment Length (m)
	Piggott Reserve, Strathpine	LPR_CW02	Constructed Wetland	1,467	
	Normanby Way Strathpine	LPR_CW03	Constructed Wetland	7,067	
	Learmonth Street, Strathpine	LPR_CW04	Constructed Wetland	9,733	
	Francis Road Drainage Reserve, Bray Park	LPR_NCD01	Natural Channel Design	3,500	350
	Tweedale Reserve, Petrie	LPR_RV6	Riparian Vegetation	5,771	577
	One Mile Golf Course Reserve, Joyner	LPR_WR11	Constructed Wetland	1,700	
	Kupidabin Park, Samford Village	LPR_WR13	Ephemeral Wetland	2,400	
	Bleakley Park, Albany Creek	LPR_WR15	Bioretention Basin	1,100	
	Boxwood Court Park, Warner	LPR_WR18	Constructed Wetland	3,033	
Sideling Creek	Desmond Street Park, Narangba	SID_NCD01	Natural Channel Design	1,900	190
Upper Pine River	Tullamore Park, Dayboro	UPR_NCD01	Natural Channel Design	2,250	225

In addition to the specific assets identified in Table 3-8, additional requirements for the integration of streetscape raingardens to achieved desired standard of service (NNC targets) are summarised in Table 3-9.

Table 3-9 Summary of Raingarden Trunk Infrastructure Requirements

Catchment	Estimated Timing	LGIP ID	Treatment Area (m^2)
Bribie Island	2021-2026	BRI_RG01	694
	2026-2031	BRI_RG02	366
	2031-2036	BRI_RG03	127
Brisbane Coastal	2021-2026	BC_RG01	810
	2026-2031	BC_RG02	540
	2031-2036	BC_RG03	540
Pumicestone Passage	2021-2026	PUM_RG01	964
	2026-2031	PUM_RG02	1,118
	2031-2036	PUM_RG03	540
Stanley River	2021-2026	STAN_RG01	733
	2026-2031	STAN_RG02	713
	2031-2036	STAN_RG03	848
Caboolture River	2026-2031	CAB_RG01	13,930
	2031-2036	CAB_RG02	12,819
Burpengary Creek	2031-2036	BUR_RG01	1,077
Lower Pine River	2026-2031	LPR_RG01	4,591
	2031-2036	LPR_RG02	6,527



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3.5 Trunk Water Quality Treatment Performance and Cost

A summary of the results determining the NPV and levelised treatment costs for future trunk infrastructure are shown in Table 3-10. It is noted that the levelised costs have been determined assuming each pollutant has an equal contribution towards the total NPV.

Table 3-10 Summary of Estimated NPV and Levelised Treatment Costs

LGIP ID	Description	NPV ($2020)	Annual Pollutant Removal[1] (kg/yr)			Levelised Treatment Cost[2] ($/kg)		
			TSS	TP	TN	TSS	TP	TN
BUR_WR11	Bioretention Basin	$301,259	10,805	19	57	$0.46	$259	$88
BUR_CW02	Constructed Wetland	$3,560,655	28,994	51	154	$2.05	$1,165	$385
BUR_CW06	Constructed Wetland	$956,594	7,790	14	41	$2.05	$1,165	$385
BUR_WR01	Constructed Wetland	$992,023	8,078	14	43	$2.05	$1,165	$385
BUR_WR12	Ephemeral Constructed Wetland	$985,176	22,500	36	82	$0.73	$451	$200
BUR_WR03	Natural Channel Design	$2,352,295	44,400	63	44	$0.88	$626	$891
BUR_WR05	Natural Channel Design	$4,526,387	45,300	63	52	$1.67	$1,190	$1,451
BUR_WR06b	Natural Channel Design	$4,205,619	113,300	158	110	$0.62	$444	$637
CAB_BB03	Bioretention Basin	$1,730,305	62,059	111	326	$0.46	$259	$88
CAB_BB54	Bioretention Basin	$514,972	18,470	33	97	$0.46	$259	$88
CAB_CW09	Constructed Wetland	$602,300	4,905	9	26	$2.05	$1,165	$385
CAB_CW04	Constructed Wetland	$10,309,956	83,954	147	446	$2.05	$1,165	$385
CAB_WR21	Constructed Wetland	$938,879	7,645	13	41	$2.05	$1,165	$385
CAB_NCD02	Natural Channel Design	$2,851,267	31,200	46	30	$1.52	$1,042	$1,584
CAB_NCD10	Natural Channel Design	$5,773,816	114,100	167	120	$0.84	$576	$802
CAB_NCD55	Natural Channel Design	$1,888,965	53,300	97	90	$0.59	$325	$350
CAB_NCD01	Natural Channel Design	$1,247,429	19,900	26	15	$1.04	$800	$1,386
CAB_NCD03	Natural Channel Design	$1,104,866	16,100	22	17	$1.14	$826	$1,083
CAB_NCD04	Natural Channel Design	$784,098	26,700	33	18	$0.49	$391	$726
CAB_NCD05	Natural Channel Design	$2,673,063	43,400	60	44	$1.03	$740	$1,013

LGIP ID	Description	NPV ($2020)	Annual Pollutant Removal[1] (kg/yr)			Levelised Treatment Cost[2] ($/kg)		
			TSS	TP	TN	TSS	TP	TN
CAB_WR2	Natural Channel Design	$1,033,584	40,500	54	27	$0.43	$319	$638
CAB_RV01	Riparian Vegetation	$125,037	21,578	17	30	$0.13	$159	$92
CAB_RV13	Riparian Vegetation	$278,450	8,891	21	59	$0.70	$294	$104
CAB_RV17	Riparian Vegetation	$74,658	870	2	4	$1.91	$866	$414
CAB_RV19	Riparian Vegetation	$288,415	3,359	7	15	$1.91	$866	$414
CAB_RV02	Riparian Vegetation	$339,364	38,189	34	58	$0.20	$224	$130
CAB_RV20	Riparian Vegetation	$778,226	147,600	178	318	$0.12	$97	$54
CAB_RV03	Riparian Vegetation	$162,256	22,992	19	32	$0.16	$192	$111
LPR_WR15	Bioretention Basin	$566,469	20,317	36	107	$0.46	$259	$88
LPR_CW01	Constructed Wetland	$3,914,596	21,525	50	215	$3.03	$1,305	$303
LPR_CW02	Constructed Wetland	$389,723	3,174	6	17	$2.05	$1,165	$385
LPR_CW03	Constructed Wetland	$2,074,923	16,787	36	138	$1.87	$907	$250
LPR_CW04	Constructed Wetland	$2,586,346	21,061	37	112	$2.05	$1,165	$385
LPR_WR11	Constructed Wetland	$451,725	3,678	6	20	$2.05	$1,165	$385
LPR_WR18	Constructed Wetland	$806,019	6,563	12	35	$2.05	$1,165	$385
LPR_WR13	Ephemeral Constructed Wetland	$466,176	9,400	15	34	$0.83	$508	$229
LPR_NCD01	Natural Channel Design	$2,494,859	54,800	73	41	$0.76	$569	$1,014
LPR_RV6	Riparian Vegetation	$92,918	16,323	33	75	$0.13	$28	$63
SID_NCD01	Natural Channel Design	$1,354,352	17,960	24	17	$1.26	$944	$1,328
UPR_NCD01	Natural Channel Design	$1,603,838	12,080	20	16	$2.21	$1,371	$1,671

[1] Does not include uncertainty for bioretention basin and wetland treatment performance
[2] Assumes NPV proportioned evenly between each pollutant

3.6 Trunk Water Quality Treatment Devices and Schedule of works

The following tables provide a summary of the proposed works required for each major catchment to meet desire standards of service within each development time cohort.

The location of the proposed trunk water quality treatment infrastructure is shown in Figure 3-1. The schedule of works has been provided in spreadsheet format to MBRC, and is also included in Appendix F.

Table 3-11 Caboolture River Catchment Trunk Stormwater Quality Infrastructure

Description	Asset ID	Annual Pollutant Treatment (kg/yr)[1]			Construction Cost	Establishment Cost	Annual Maintenance Cost
		TSS	TP	TN			
2021-2026							
Riparian Vegetation	CAB_RV20	147,600	178	318	$854,000		
	CAB_RV01	21,578	17	30	$137,200		
	CAB_RV13	8,891	21	59	$305,600		
	CAB_RV03	22,992	19	32	$178,100		
	CAB_RV02	38,189	34	58	$372,400		
	CAB_RV19	3,359	7	15	$316,500		
Bioretention Basin	CAB_BB03	49,647	89	261	$1,081,900	$120,960	$20,160
	CAB_BB54	14,776	26	78	$322,000	$36,000	$6,000
Natural Channel Design	CAB_NCD55	47,970	87	81	$1,478,000	$17,808	$2,968
Constructed Wetland	CAB_WR21	6,116	11	33	$713,700	$61,050	$10,175
Total		**361,118**	**490**	**965**	**$5,759,400**	**$235,818**	**$39,303**
Target for NNC		**N/A**	**120**	**960**			
2026-2031							
Riparian Vegetation	CAB_RV17	870	2	4	$81,900		
Constructed Wetland	CAB_CW04	67,163	118	357	$7,837,600	$670,464	$111,744
	CAB_CW09	3,924	7	21	$457,900	$39,174	$6,529
Natural Channel Design	CAB_WR2	36,450	49	24	$808,700	$9,744	$1,624
	CAB_NCD4	24,030	30	16	$4,517,800	$54,432	$9,072
	CAB_NCD10	102,690	150	108	$4,517,800	$54,432	$9,072
	CAB_NCD2	14,490	20	15	$4,517,800	$54,432	$9,072
	CAB_NCD1	17,910	23	14	$2,091,600	$25,200	$4,200
	CAB_NCD02	28,080	41	27	$2,231,000	$26,880	$4,480
Raingardens	CAB_RG01	2,029,985	236	722	$15,838,600	$501,487	$83,581
Total		**2,325,591**	**676**	**1,309**	**$42,900,700**	**$1,436,245**	**$239,374**
Cumulative Total		*2,686,710*	*1,166*	*2,274*			
Cumulative Target for NNC		***N/A***	***282***	***2,274***			
2031-2036							
Natural Channel Design	CAB_NCD5	39,060	54	40	$4,517,800	$54,432	$9,072
Raingardens	CAB_RG02	1,867,995	217	665	$14,574,700	$461,469	$76,912
Total		**1,907,055**	**272**	**704**	**$19,092,500**	**$515,901**	**$85,984**
Cumulative Total		4,593,765	1,438	2,978			
Cumulative Target for NNC		***N/A***	***363***	***2,978***			

[1] Includes 20% contingency for wetland and bioretention basin treatment performance, and 10% contingency for Natural Channel Design.

Table 3-12 Lower Pine River Catchment Trunk Stormwater Quality Infrastructure

Description	Asset ID	Annual Pollutant Treatment (kg/yr)[1]			Construction Cost	Establishment Cost	Annual Maintenance Cost
		TSS	TP	TN			
2021-2026							
Existing Wetlands	Brendale & Pine Rivers Park Wetlands		1.4	3.8			
Riparian Vegetation	LPR_RV6	16,323	33	75	$102,000		
Bioretention Basin	LPR_WR15	16,254	29	85	$354,200	$39,600	$6,600
Ephemeral Constructed Wetland	LPR_WR13	7,520	12	27	$415,200	$33,264	$5,544
Constructed Wetland	LPR_CW03	13,429	28	111	$1,427,500	$122,118	$20,353
	LPR_CW01		1.4	3.8	$2,947,800	$252,167	$42,028
Total		**70,746**	**144**	**474**	**$5,246,700**	**$447,149**	**$74,525**
Target for NNC		***N/A***	**46**	**431**			
2026-2031							
Existing Wetlands	Brendale & Pine Rivers Park Wetlands	-	1.4	3.8			
Constructed Wetland	LPR_WR11	2,943	5	16	$343,400	$29,376	$4,896
Constructed Wetland	LPR_WR18	5,251	9	28	$612,700	$52,410	$8,735
Natural Channel Design	LPR_NCD01	49,320	66	37	$1,952,100	$23,520	$3,920
Constructed Wetland	LPR_CW02	2,539	4	13	$296,300	$25,350	$4,225
Constructed Wetland	LPR_CW04	16,848	30	90	$1,966,100	$168,186	$28,031
Raingardens	LPR_RG01	648,013	75	231	$5,056,000	$160,085	$26,681
Total		**724,914**	**191**	**418**	**$10,226,600**	**$458,927**	**$76,488**
Cumulative Total		***795,660***	***335***	***892***			
Cumulative Target for NNC		***N/A***	***88***	***892***			
2031-2036							
Existing Wetlands	Brendale & Pine Rivers Park Wetlands	-	1.4	3.8			
Raingardens	LPR_RG02	940,603	109	335	$7,338,900	$232,366	$38,728
Total		***940,603***	***111***	***339***	***$7,338,900***	***$232,366***	***$38,728***
Cumulative Total		***1,736,263***	***446***	***1,230***			
Cumulative Target for NNC		***N/A***	***122***	***1,230***			

[1] Includes 20% contingency for wetland and bioretention basin treatment performance, and 10% contingency for Natural Channel Design.

Table 3-13 Burpengary Creek Catchment Trunk Stormwater Quality Infrastructure

Description	Asset ID	Annual Pollutant Treatment (kg/yr)[1]			Construction Cost	Establishment Cost	Annual Maintenance Cost
		TSS	TP	TN			
2021-2026							
Bioretention Basin	BUR_WR11	8,644	15	45	$188,400	$21,060	$3,510
Ephemeral Constructed Wetland	BUR_WR12	18,000	29	66	$934,200	$74,844	$12,474
Natural Channel Design	BUR_WR06b	101,970	142	99	$3,290,700	$39,648	$6,608
Total		**128,614**	**187**	**210**	**$4,413,300**	**$135,552**	**$22,592**
Target for NNC		**N/A**	**25**	**187**			
2026-2031							
Constructed Wetland	BUR_CW02	23,195	41	123	$2,706,800	$231,552	$38,592
	BUR_CW06	6,232	11	33	$727,200	$62,208	$10,368
	BUR_WR01	6,462	11	34	$754,100	$64,506	$10,751
Total		35,889	63	191	$4,188,100	$358,266	$59,711
Cumulative Total		164,503	250	401			
Cumulative Target for NNC		***N/A***	***55***	***382***			
2031-2036							
Natural Channel Design	BUR_WR03	39,960	56	40	$1,840,600	$22,176	$3,696
Natural Channel Design	BUR_WR05	40,770	57	47	$3,541,700	$42,672	$7,112
Raingardens	BUR_RG01	156,952	18	56	$1,224,600	$38,773	$6,462
Total		**237,682**	**132**	**142**	**$6,606,900**	**$103,621**	**$17,270**
Cumulative Total		***402,185***	***382***	***543***			
Cumulative Target for NNC		***N/A***	**80**	**543**			

[1] Includes 20% contingency for wetland and bioretention basin treatment performance, and 10% contingency for Natural Channel Design.

Table 3-14 Sideling Creek and Upper Pine River Catchment Stormwater Quality Trunk Infrastructure

Description	Asset ID	Annual Pollutant Treatment (kg/yr)[1]			Construction Cost	Establishment Cost	Annual Maintenance Cost
		TSS	TP	TN			
Sideling Creek 2030							
Natural Channel Design	SID_NCD01	16,164	22	15	$1,059,700	$12,768	$2,128
Target for NNC		**1,021**	**2.4**	**11**			
Upper Pine River 2026							
Natural Channel Design	UPR_NCD01	10,872	18	14	$1,254,900	$15,120	$2,520
Target for NNC		**544**	**1.4**	**7.5**			

[1] Includes 10% contingency for treatment performance

Table 3-15 Bribie Island, Brisbane Coastal, Pumicestone Passage and Stanley River Catchment Stormwater Quality Trunk Infrastructure

Asset ID	Catchment Serviced	Time Cohort	Annual Pollutant Treatment (kg/yr)[1]			Construction Cost	Establishment Cost	Annual Maintenance Cost
			TSS	TP	TN			
BRI_RG01	Bribie Island	2021-2026	7,495	12	36	$789,200	$24,989	$4,165
BRI_RG02	Bribie Island	2026-2031	3,956	6	19	$416,500	$13,189	$2,198
BRI_RG03	Bribie Island	2031-2036	1,374	2	7	$144,700	$4,581	$764
BC_RG01	Brisbane Coastal	2021-2026	8,744	14	42	$920,800	$29,154	$4,859
BC_RG02	Brisbane Coastal	2026-2031	5,829	9	28	$613,900	$19,436	$3,239
BC_RG03	Brisbane Coastal	2031-2036	5,829	9	28	$613,900	$19,436	$3,239
PUM_RG01	Pumicestone Passage	2021-2026	10,410	16	50	$1,096,200	$34,707	$5,785
PUM_RG02	Pumicestone Passage	2026-2031	12,075	19	58	$1,271,600	$40,261	$6,710
PUM_RG03	Pumicestone Passage	2031-2036	5,829	9	28	$613,900	$19,436	$3,239
STAN_RG01	Stanley River	2021-2026	7,911	12	38	$833,100	$26,378	$4,396
STAN_RG02	Stanley River	2026-2031	7,703	12	37	$811,200	$25,684	$4,281
STAN_RG03	Stanley River	2031-2036	9,160	14	44	$964,600	$30,543	$5,090

[1] Includes 20% contingency for treatment performance

4 Conclusion

This report documents findings of investigations undertaken to identify the location, size and cost of trunk stormwater quality infrastructure to meet desired standards of service for future development in MBRC’s priority infrastructure area between 2021 and 2036. The methodology and results presented in this report support the schedule of works developed to satisfy LGIP requirements.

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Appendix A TWCMP Stakeholders

Internal Stakeholders	External Stakeholders
Moreton Bay Regional Council • Strategic Planning • Environmental Services • Regulatory Services • Waterways & Coastal	DES: Department of Environment and Science
Unitywater (in partnership with Council)	Seqwater
	DLGRMA: Department of Local Government, Racing and Multicultural Affairs
	DNRME: Department of Natural Resources, Mines and Energy
	DAF: Department of Agriculture and Fisheries
	BCC: Brisbane City Council
	SCC: Sunshine Coast Council
	HLW: Healthy Land and Water

Appendix B Source Modelling Report

DRAFT REPORT:

MBRC TWCMP Review: Existing case and scenario catchment modelling

November 2020

Document history

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Checked	Tony Weber
Approved	Tony Weber
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1 Introduction

1.1 Project background

In 2010, Moreton Bay Regional Council (MBRC) commenced the preparation of a Total Water Cycle Management Plan (TWCMP) in partnership with Unitywater. The TWCMP was prepared in accordance with the requirements outlined in the *Environmental Protection (Water) Policy 2009* (reprint no.1) and with reference to the *Total Water Cycle Management Planning Guideline for South East Queensland* (Water by Design, 2010). MBRC completed and endorsed its TWCMP in 2013.

Council recently embarked on a program of work to review and update the planning that informs the Local Government Infrastructure Plan (LGIP). As part of this work, the review and update of the TWCMP has been brought forward to align with the other components of the LGIP including floodplain management, transport, open space and community facility networks. This program of work includes investigating a range of long term growth scenarios to guide the development of a new Priority Infrastructure Area and inform future growth decision making.

This report outlines the methodology and results from the catchment modelling sections to inform Phase 5 (see Figure 1). The works undertaken build upon results as presented in the *MBRC TWCMP Review: Existing Base Case Catchment Model (Phase 1 Report)* (Alluvium 2017). Changes to modelling methodology (namely land use typologies) have dictated the need for an updated existing case representative model.

Phase 5 works (undertaken and presented throughout this report) include creation of several catchment models to represent:

- the most likely ultimate case scenario
- four incremental scenarios as the catchment changes from the existing to ultimate cases. These are referred to as the cohort scenarios.

This work will aim to inform the potential location, size, and implementation timing of water quality infrastructure, which is required to service the various development areas, in turn informing the priority infrastructure areas. A more detailed description of the scenarios modelled is presented in the subsequent section. A summary of the sections presented throughout this report are outlined in Table 1.

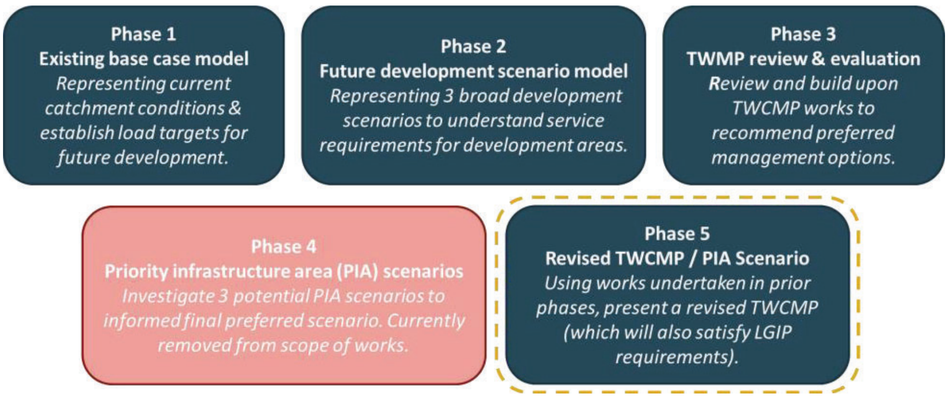

Figure 1. *Project phases*

Table 1. Report outline

Section	Description
1	Introduction
2	Catchment model development
3	Calibration and validation
4	Modelling results
5	Discussion and conclusions

2 Catchment model development

Construction of a Source catchment model requires transforming the physical catchment information into a mathematical form that is used to convert rainfall to runoff and calculate subsequent pollutant loads. The outcome is a numerical representation of the physical features that represent the land-based framework, hydrological processes, and pollutant load generation aspects of the catchment. Following the model construction phase, calibration and verification is required to ensure the constructed numerical model adequately represents the study area.

2.1 Model construction

The underlying data used to construct the updated MBRC catchment model included:

- Catchment and sub-catchment boundaries from the previously developed MBRC Source catchment model used in the previous TWCMP
- A land use map (combination of that provided by MBRC (updated to 2018) and QLUMP (2012)
- Climate data (daily rainfall and evaporation data from SILO gridded dataset)
- Observed streamflow, storages and water quality data for model calibration (Obtained from DNRME and Seqwater).

Step 1 – The catchment and sub catchment boundaries were replicated from the previous MBRC Source catchment model. Initially the catchment and streams were described spatially using a DEM (see Figure 2).

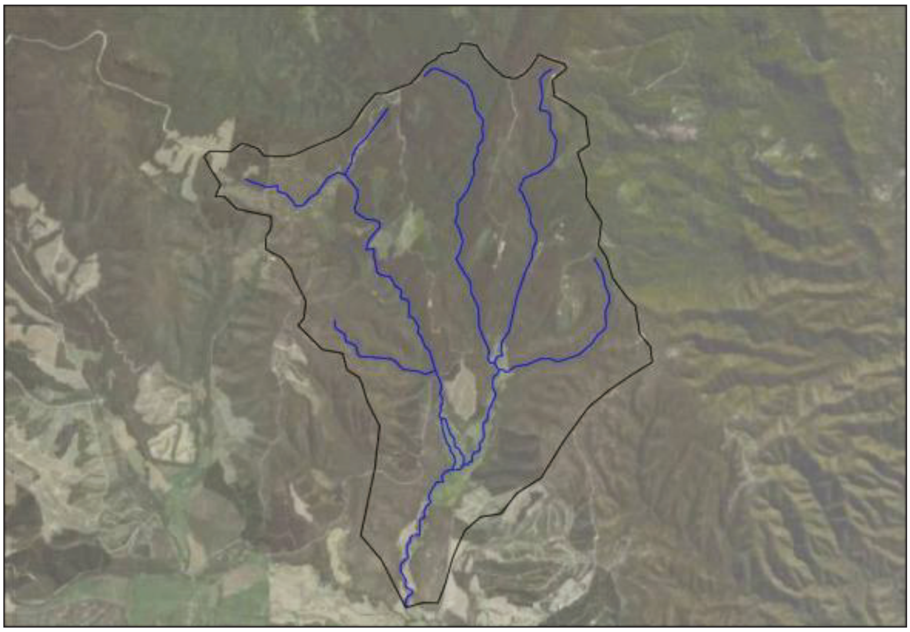

Figure 2. *A spatial description of the catchment (using an example catchment)*

Step 2 – A node-link network is built either automatically from the digital elevation model or manually from the data obtained in Step 1 (refer to Figure 3).

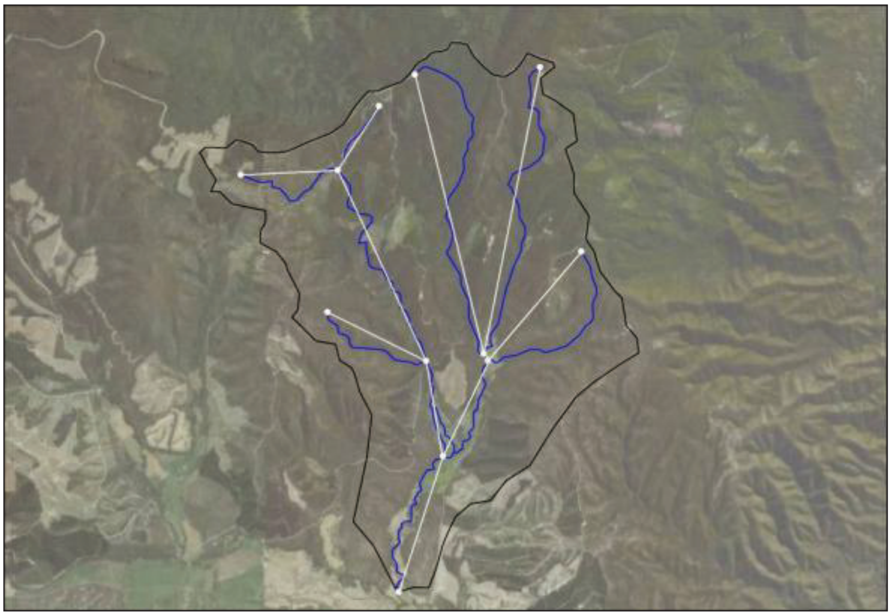

Figure 3. *Construction of a Node-Link Network (using an example catchment)*

Step 3 – Information about each subcatchment is described and within this step, land use data is used to describe the "Functional Units" (FUs) within each subcatchment where each one has a particular runoff and constituent generation characteristics. There are typically a common set of FUs for the entire catchment, though the extent differs within each subcatchment (see Figure 4).

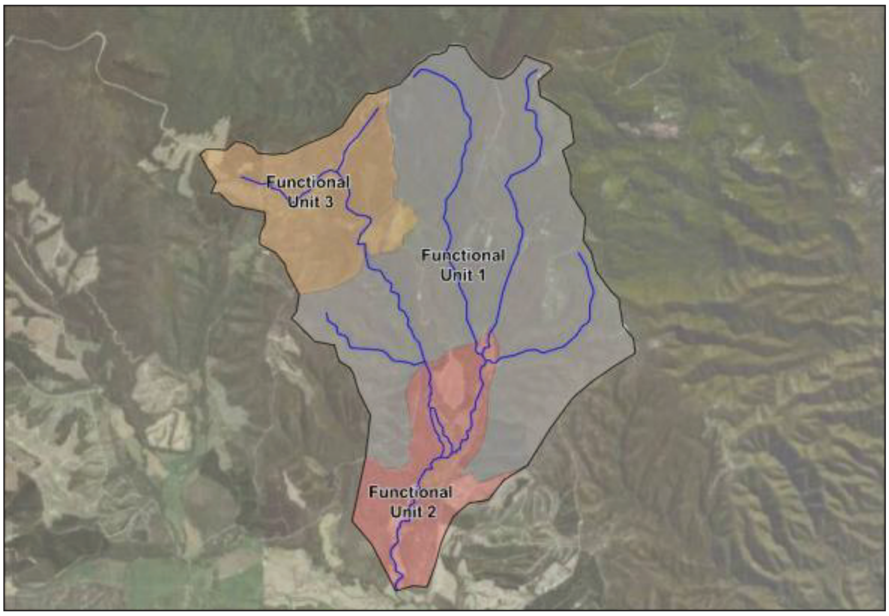

Figure 4. *Definition of Functional Units (using an example catchment)*

Step 4 – Particular models are selected which are best suited to the subcatchment/node and these then describe (through different parameters) how each functional unit responds to climatic and pollutant inputs (Figure 5).

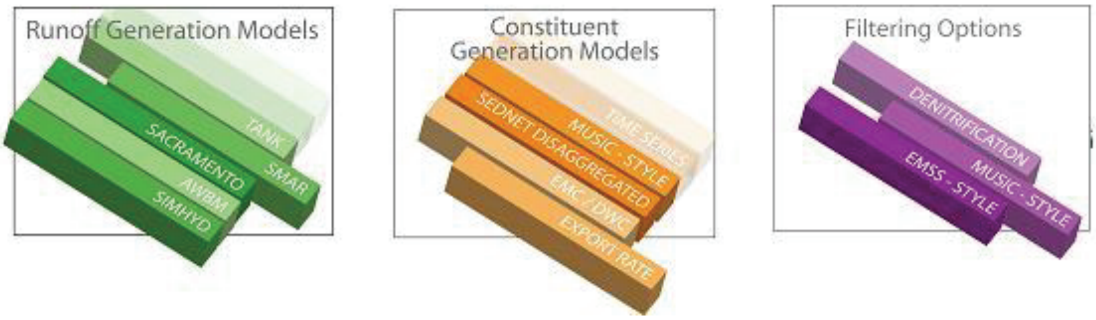

Figure 5. *Selection of Node Models*

Step 5 – Each link in the stream network is defined using an appropriate model in a similar way to the subcatchments in Step 4 inputs (Figure 6).

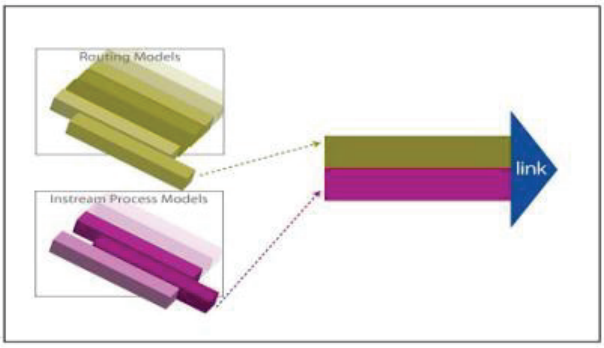

Figure 6. *Selection of Link Models*

These link models are combined with the subcatchment/node models so that groups of models are linked together to describe the catchment as shown in Figure 7.

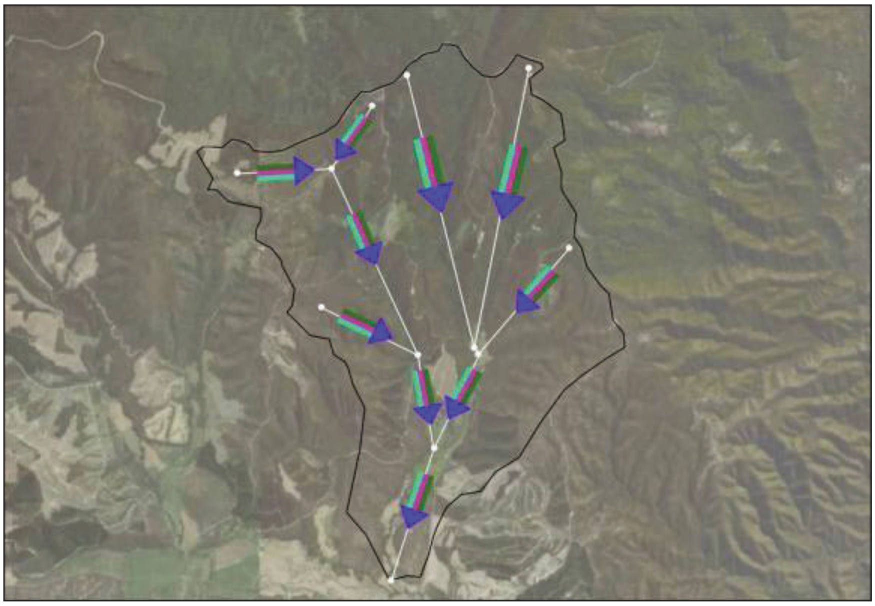

Figure 7. *Node and Link Models Describe the Catchment (using an example catchment)*

Step 6 – Climatic data is selected. This can be either from individual stations, or interpolated gridded data (e.g. SILO, PET Atlas). The Source framework then interrogates this data for each model run performed. In the MRBC model SILO rainfall and PET data was used.

2.2 Catchment delineation

The catchment and subcatchment boundaries have been adopted from earlier iterations of the MBRC Source model (BMT WBM, 2012), which originally have been delineated based on a digital elevation model (DEM). The model consists of 14 major subcatchment, which are identified in Figure 8. These major subcatchments consist of 217 modelled subcatchments, each of which represent individual areas within the model that generate runoff and constituent loads.

There are several main watercourses which flow through the catchment area, including the Caboolture River, North and South Pile River, and the Stanley River. The catchment in its entirety spans an area of approximately 2290 km^2.

Figure 8. *Map of the region showing the Moreton Bay Regional Council catchment boundary and locations of interest.*

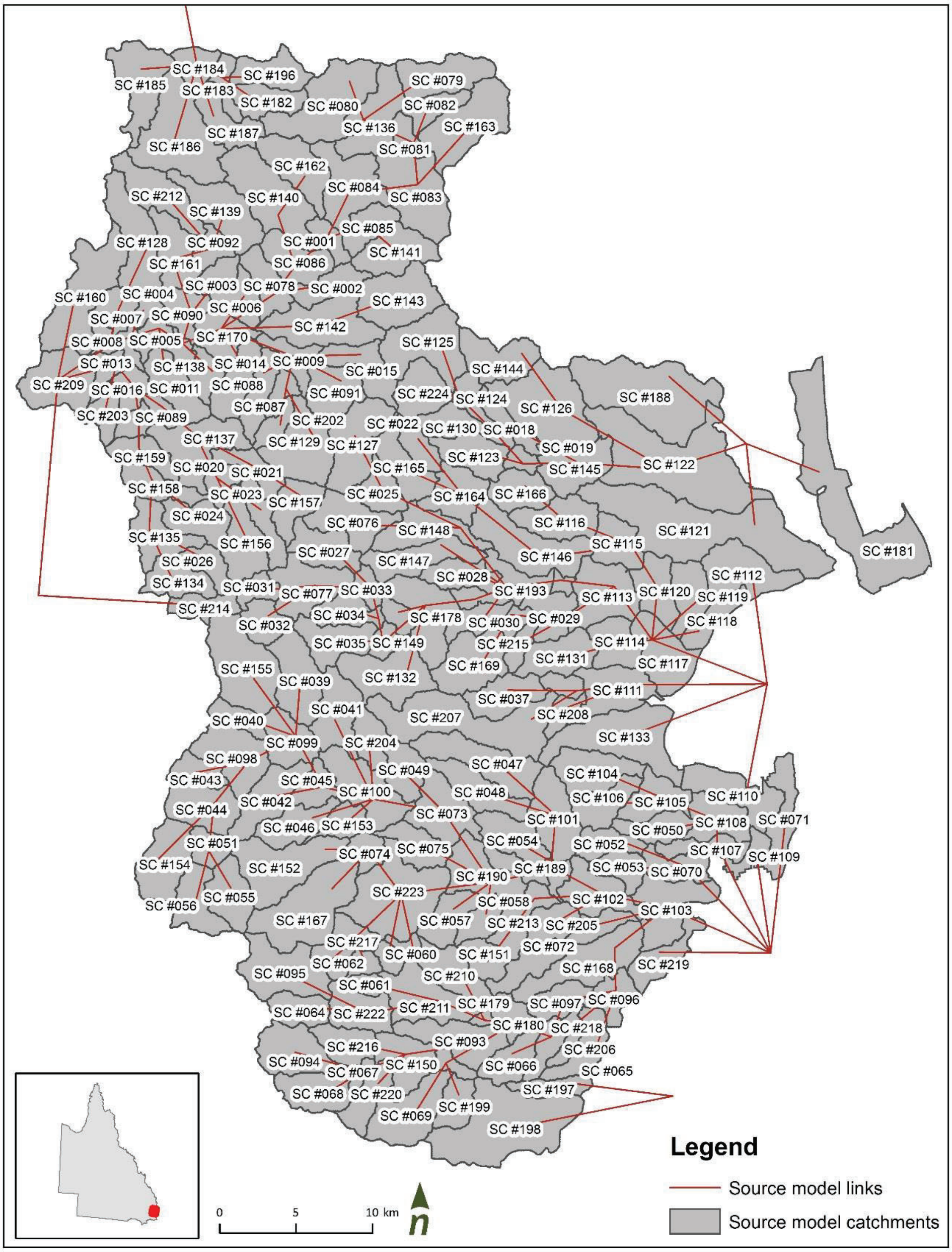

Figure 9. *MBRC catchment model sub catchment delineation and links*

2.3 Functional units

Existing case

The land use for the existing case scenario has been based on both MBRC land use layers (updated to November 2018) and the Queensland Land Use Mapping Program (QLUMP) 2012. It should be noted that the QLUMP dataset was only used to infill the subcatchment areas outside of the MBRC boundary, which has mainly occurred in the north-west and south-east sections of the model.

The individual land use classes were lumped together to form 26 functional units, based on similar hydrological and pollutant characteristics. Further, these functional units are congruent with those adopted in flood modelling for the area, allowing for a consistent approach across different modelling platforms. The land use typologies and functional units created present the main difference between this current iteration of modelling and that presented in the Alluvium (2017) report.

The functional units incorporated in the catchment modelling are listed below (Table 2). A full list of the functional unit mapping is provided in Attachment A. A spatial representation of the existing land use in the MBRC catchment is shown in Figure 10, with a breakdown of distribution presented in Figure 11.

Table 2. Functional Units in the MBRC catchment

Functional Unit Number	Functional Unit
1	Building Commercial
2	Building Community
3	Building Education
4	Building Health
5	Building Industry
6	Building non private res
7	Building office
8	Building open space
9	Building rec env
10	Building residential
11	Building retail
12	Building rural res
13	Building rural use
14	Concrete surface
y15	Cropping
16	Dirt
17	Extractive
18	Gravel Sand
19	Grazing
20	Plantation forest
21	Road surface
22	Rural other
23	Rural Residential
24	Tree canopy
25	Urban other
26	Urban Residential
27	Water
28	Wetlands

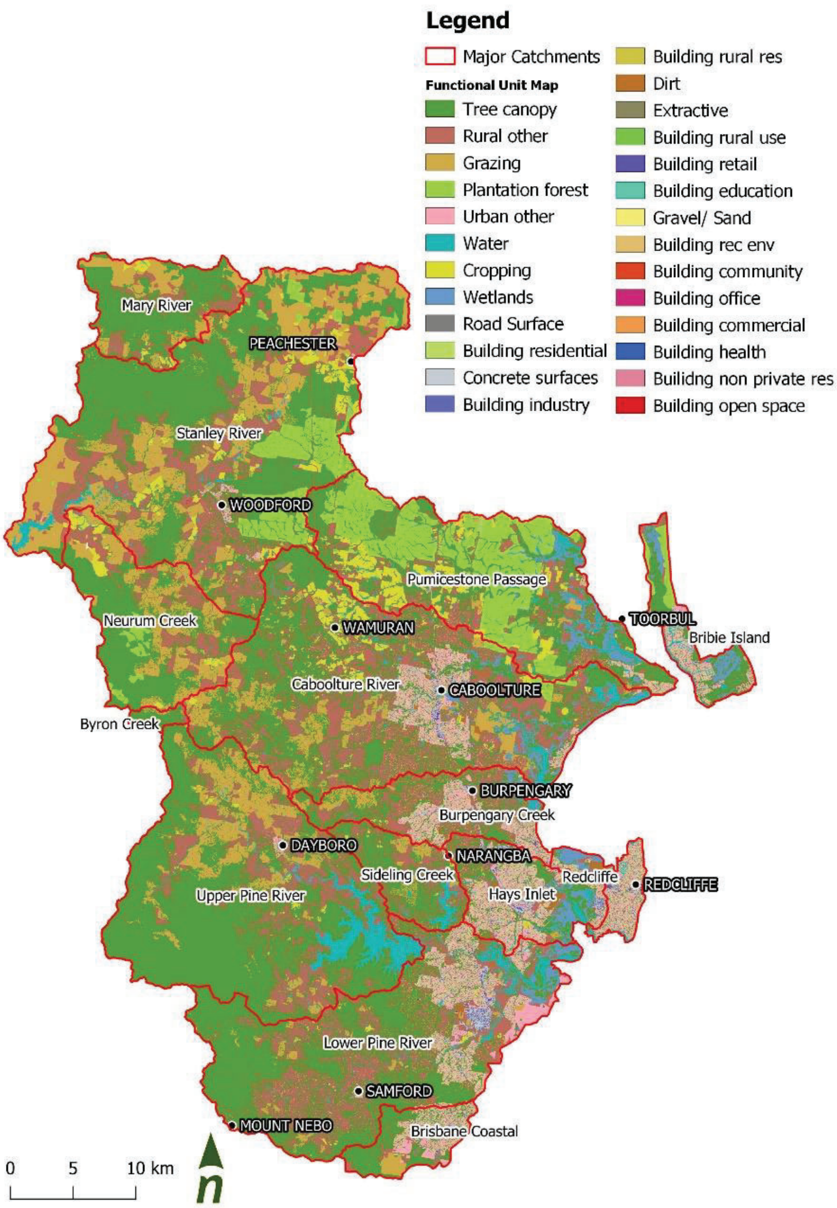

Figure 10. *Existing land use in the MBRC catchment*

Ultimate case
The land use utilised for the ultimate case scenario is again a combination of layers supplied by MBRC (based on council's Planning Scheme and Strategic Framework Place Types) and obtained from QLUMP (used only for infill and remaining as existing land use in these areas).

The land use classes for the ultimate case have adopted those specified for the existing case scenario, however with 2 additional functional units. These units have been included to account for future areas of Rural Residential and Urban Residential. A breakdown of the ultimate case scenario functional units across the MBRC catchment is shown in Figure 12 and Table 3.

Cohort cases
The land uses adopted for each of the 2021, 2026, 2031 and 2036 cohort case scenarios are based on a percentage change between the existing case to ultimate case scenario for that cohort. The amount of change for each area, and for each cohort, has been provided by Council. A breakdown of the cohort case scenarios functional units across the MBRC catchment is shown in Table 3.

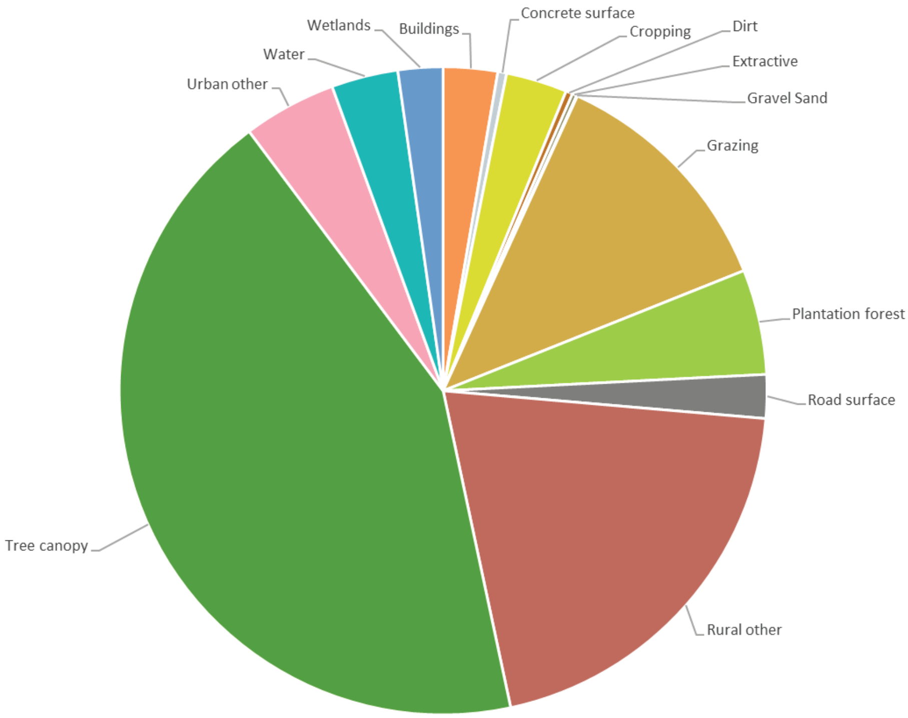

Figure 11. *Existing case land use distribution comparison*

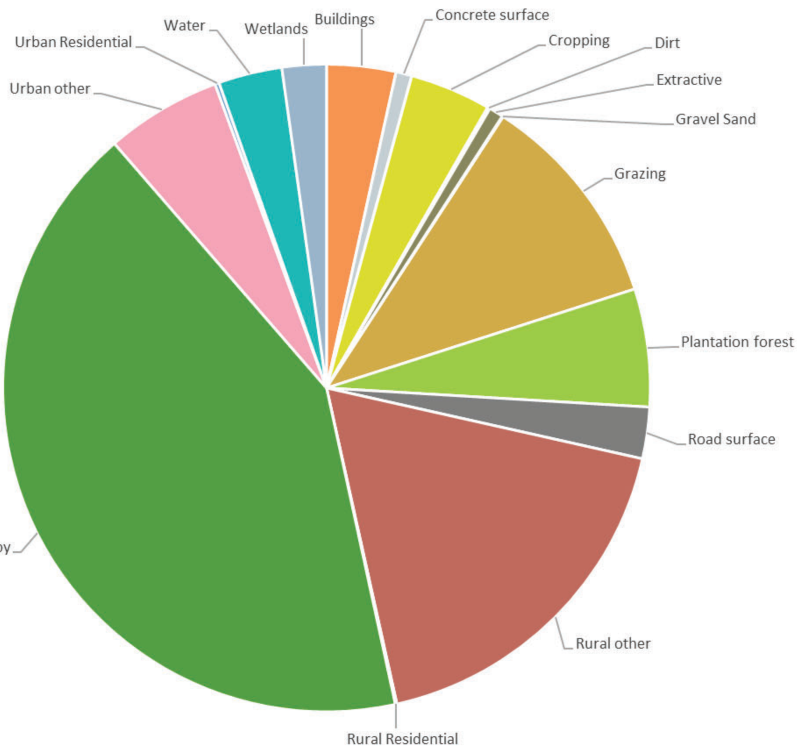

Figure 12. *Ultimate case land use distribution comparison*

Table 3. Functional unit area distribution for all modelled scenarios

Functional Unit	Area (ha)					
	Existing Case	2021 Cohort	2026 Cohort	2031 Cohort	2036 Cohort	Ultimate Case
Building Commercial	18	31	35	40	43	51
Building Community	22	22	22	22	22	22
Building Education	119	122	124	126	128	134
Building Health	15	16	16	16	16	17
Building Industry	926	912	925	940	952	936
Building non private res	11	11	11	11	11	11
Building office	18	23	25	28	30	42
Building open space	7	7	7	7	7	7
Building rec env	51	51	51	51	51	51
Building residential	3709	3689	3888	4121	4266	5049
Building retail	152	169	176	185	192	232
Building rural res	842	913	932	954	970	1042
Building rural use	306	304	303	301	300	294
Concrete surface	1005	1268	1364	1469	1549	1834
Cropping	6993	7404	7723	8032	8300	9275
Dirt	780	589	516	455	417	290
Extractive	500	911	1030	1163	1240	1639
Gravel Sand	106	106	106	106	106	106
Grazing	27810	26756	26496	26225	26028	24883
Plantation forest	12000	13293	13355	13418	13426	13476
Road surface	4976	5064	5197	5342	5432	5889
Rural other	46454	45189	44552	43900	43452	41218
Rural Residential	0	121	133	144	149	181
Tree canopy	98742	97667	97431	97160	97009	96237
Urban other	10650	11404	11642	11870	12004	13224
Urban Residential	0	394	405	414	419	478
Water	7618	7409	7391	7370	7359	7285
Wetlands	5135	5121	5109	5096	5087	5060

2.4 Climate data

Daily rainfall and potential evapotranspiration data for the catchment was obtained from the gridded SILO data set from available through the Long Paddock website (https://www.longpaddock.qld.gov.au/). SILO (Scientific Information for Land Owners) is a database of historical climate records for Australia.

2.5 Pollutant data

The pollutant load generation capacity of the catchment is critical in understanding future treatment measures required; their treatment capacity, location and time of availability. For the MBRC catchment area, event mean concentrations (EMC) and dry weather concentrations (DWC) of total nitrogen (TN), total phosphorous (TP) and total suspended solids (TSS) for each of the land uses identified in Section 2.3.

Observed water quality data collected at the Caboolture gauge (142001A) between June 2007 and May 2010 provided an indication of the average event mean and dry weather concentrations upstream of the Caboolture gauge (Table 4). Over this period, a total of 18 wet weather events and 9 dry weather days were sampled. It should be noted that the dominant land uses upstream of the Caboolture gauge are 'tree canopy' (44%) and 'rural other' (32%). The EMC and DWC applied in the model are presented in Table 5. Further information on water quality validation is provided in Section 3.3.

For both the cohort and ultimate cases, the same values have been applied, with new urban development areas incorporating a 'business as usual' approach to pollutant load reduction (i.e. application of the *State Planning Policy* (2017) guidelines for reduction in TSS, TP and TN of 80%, 60% and 45% respectively).

Table 4. Average observed concentration data during wet and dry weather events for Caboolture gauge

	TSS	TN	TP
Event Mean Concentration	140	1.4	0.2
Dry Weather Concentration	10	0.3	0.02

Table 5. EMC/DWC parameters applied in the model

	TN		TP		TSS	
Land use group	**EMC**	**DWC**	**EMC**	**DWC**	**EMC**	**DWC**
Buildings (all types)	0.700	0.400	0.060	0.030	10	7
Concrete surface	1.820	1.580	0.501	0.107	269	10
Cropping	5.200	0.700	0.449	0.070	550	10
Dirt	6.100	0.400	1.100	0.030	5341	7
Extractive	6.100	0.400	1.100	0.030	5341	7
Urban other	1.820	1.580	0.339	0.107	151	10
Rural other	1.600	0.300	0.280	0.020	230	5
Gravel or Sand	6.100	0.400	1.100	0.030	5341	7
Grazing	1.700	0.300	0.300	0.020	260	5
Plantation Forest	1.950	0.700	0.321	0.070	300	10
Road Surface	1.820	1.580	0.501	0.107	269	10
Rural Residential	1.600	0.300	0.280	0.020	230	5
Tree Canopy	1.500	0.300	0.060	0.020	20	5
Urban Residential	1.820	1.580	0.339	0.107	151	10
Water	0.000	0.000	0.000	0.000	0	0
Wetlands	1.500	0.400	0.060	0.030	20	7

3 Calibration and validation

The SIMHYD rainfall runoff model was used to simulate the runoff responses across the catchment (Figure 13). The flow calibration tool within Source was used to obtain initial reasonable calibrations then further manipulation of the routing parameters were used to provide an optimal calibration result wherever possible.

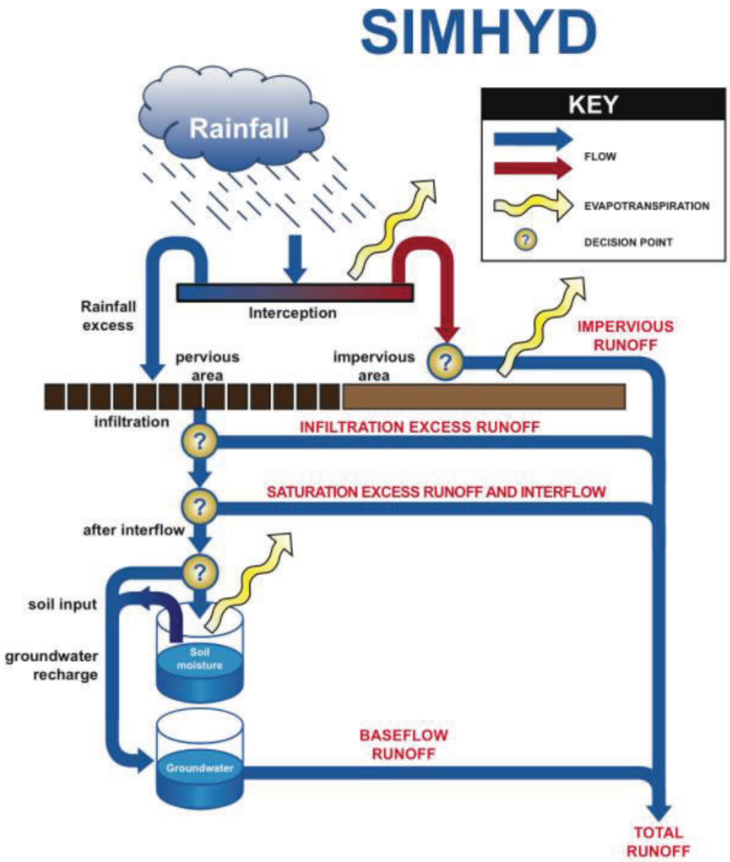

Figure 13. *Structure of SIMHYD model (eWater Source, 2020)*

3.1 Statistical performance

The statistical performance of the hydrological parameterisation process has been measured using the criteria as set out by Moriasi et. al. (2015). This sets out specific ranges for several hydrologic calibration criteria as discussed further below. As per Moriasi et. al. (2015) the model performance is determined by the poorest performing of these criteria.

Nash-Sutcliffe efficiency (NSE) coefficient

The NSE coefficient is used to assess the predictive power of hydrological models. An efficiency of 1 corresponds to a perfect match of modelled discharge to the observed data. An efficiency of 0 indicates that the model predictions are only as accurate as the mean of the observed data. An efficiency of less than 0 occurs when the observed mean is a better predictor than the model. The NSE coefficient is calculated using the following equation (from Moriasi et. al., 2015):

$$\text{NSE} \qquad 1-\frac{\sum_{i=1}^{n}(O_i-P_i)^2}{\sum_{i=1}^{n}(O_i-\bar{O})^2}$$

Percent bias (PBIAS)

The average tendency of modelled data to be greater or less than the corresponding observed data. PBIAS is calculated using the following equation (from Moriasi et. al., 2015):

$$\text{PBIAS} \qquad \frac{\sum_{i=1}^{n}O_i-P_i}{\sum_{i=1}^{n}O_i}\times 100$$

Root Mean Squared Error (RMSE) to observed data standard deviation ratio (RSR)
Standard Regression (R^2)

A goodness-of-fit measure for the collinearity between the modelled and observed data. The closer the R^2 value is to 1, the more closely correlated the two sets of data. R^2 is calculated using the following equation (from Moriasi et. al., 2015):

$$R^2 \qquad \left[\frac{\sum_{i=1}^{n}(O_i-\bar{O})(P_i-\bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i-\bar{P})^2}}\right]^2$$

Table 6. General performance ratings for model statistics for a monthly time step –stream flow (adapted from Moriasi et. al., 2015)

Performance Indicator	PBIAS (Stream flow)	NSE	R^2
Very good	PBIAS < ±5	0.80 < NSE ≤ 1	$0.85 < R^2 \leq 1$
Good	±5 ≤ PBIAS < ±10	0.70 < NSE ≤ 0.80	$0.75 < R^2 \leq 0.85$
Satisfactory	±10 ≤ PBIAS < ±15	0.5 < NSE ≤ 0.70	$0.60 < R^2 \leq 0.75$
Unsatisfactory	PBIAS ≥ ±15	NSE ≤ 0.5	$R^2 \leq 0.60$

3.2 Hydrologic calibration and validation

The existing case model was calibrated to two regions consistent with the available flow gauges in the catchment (Figure 14). The flow gauges used in the calibration were the Caboolture River at Caboolture (142001A) and South Pine River at Drapers Crossing (142202A). Validation was able to be applied to the model using the Stanley River at Peachester (143303A) and Stanley River at Woodford (143901A) (see Figure 14). No additional gauges were available to validate the South Pine zone.

The flow calibration tools within Source and Rainfall Runoff library were used to obtain the initial rainfall runoff parameters. The gauges were calibrated as per the general performance ratings developed by Moriasi et. al. 2015 (as per Section 3.1 above).

The data for calibration at these sites has been obtained from the Department of Natural resources, Mines and Energy's (DNRME) Water Monitoring Information Portal (WMIP). For each site, a rating table has been developed, to present the flow anticipated at incremental heights. To quantity the reliability of the flow at each gauge height, a rating has been applied of either 'Reliable', 'Fair', 'Poor' or 'Estimate', with 'Reliable' being the most accurate and 'Estimate' the worst. These value ranges have been considered in analysis of the calibration of these gauges.

Over the entire modelled period (1990-2019) both gauges represent an "very good" calibration (with reference to the Moriasi et. al. 2015 performance ratings). Tabulated results for both calibration gauges are presented in Table 7, with a graphical representation presented from Figure 15 to Figure 17.

Table 7. Hydrological calibration performance for the total modelled period (1/1/1990 – 31/12/2018)

Calibrated Gauges	PBIAS	NSE	R^2	Acceptance
Caboolture River at Upper Caboolture (142001A)	-4.7	0.892	0.929	Very Good
South Pine River at Drapers Crossing (142202A)	1.7	0.889	0.908	Very Good

The performance of the model against the validation gauges is presented in Table 8. Both validation gauges meet at least a 'satisfactory' acceptance (as per the Moriasi et. al. 2015 performance ratings). For the purposes of representing the change in flow between the existing (2016) and future development scenarios, this model is considered to be fit for purpose.

Table 8. Hydrological validation performance for the total modelled period (1/1/1990 – 31/12/2018)

Calibrated Gauges	PBIAS	NSE	R^2	Acceptance
Stanley River at Woodford (143901A)[1]	14.6	0.938	0.952	Satisfactory
Stanley River at Peachester (143303A)	13.2	0.917	0.923	Satisfactory

[1] Validated for 1/3/2002 – 31/12/2018 due to lack of observed data.

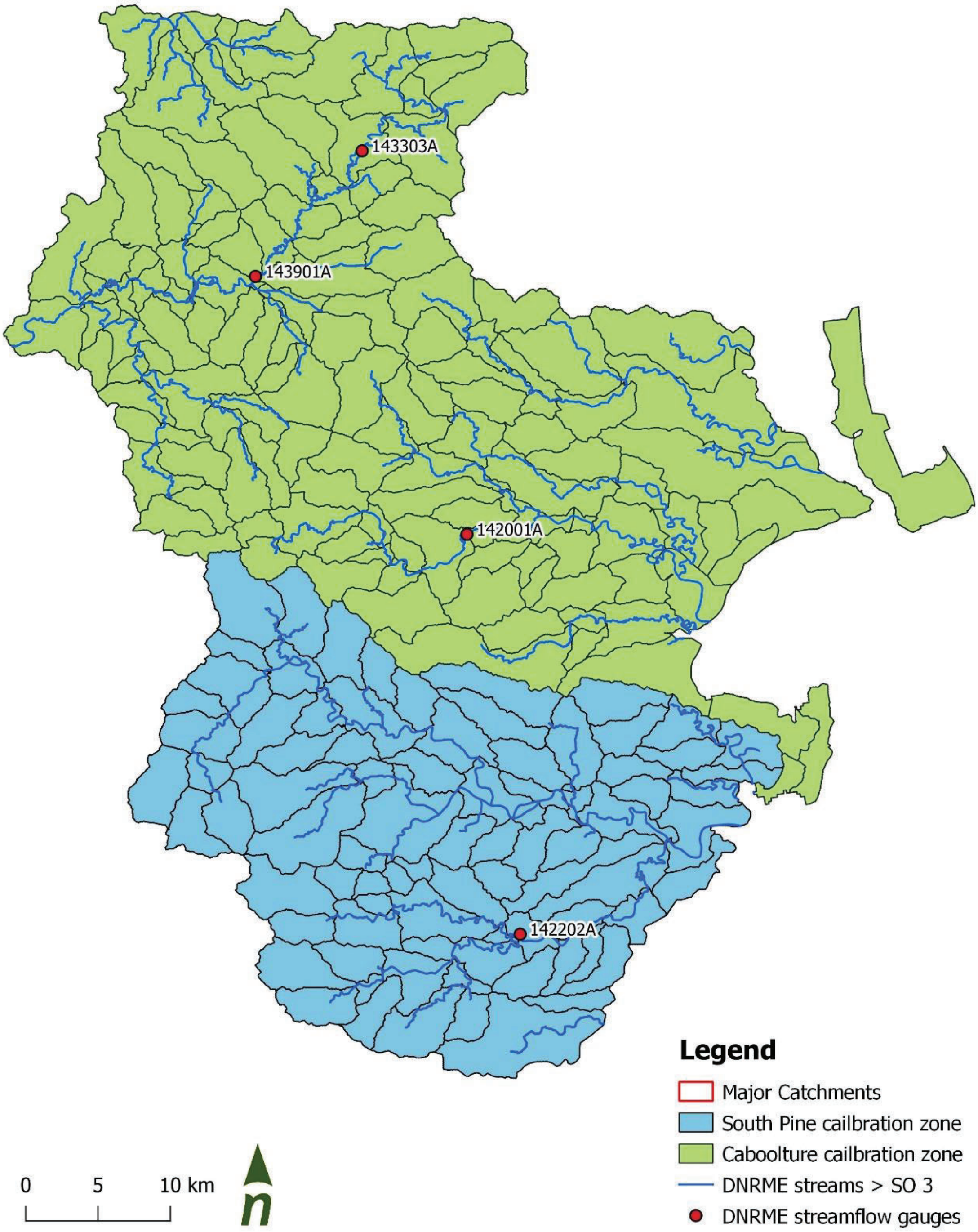

Figure 14. *Calibration zones used in MBRC catchment model*

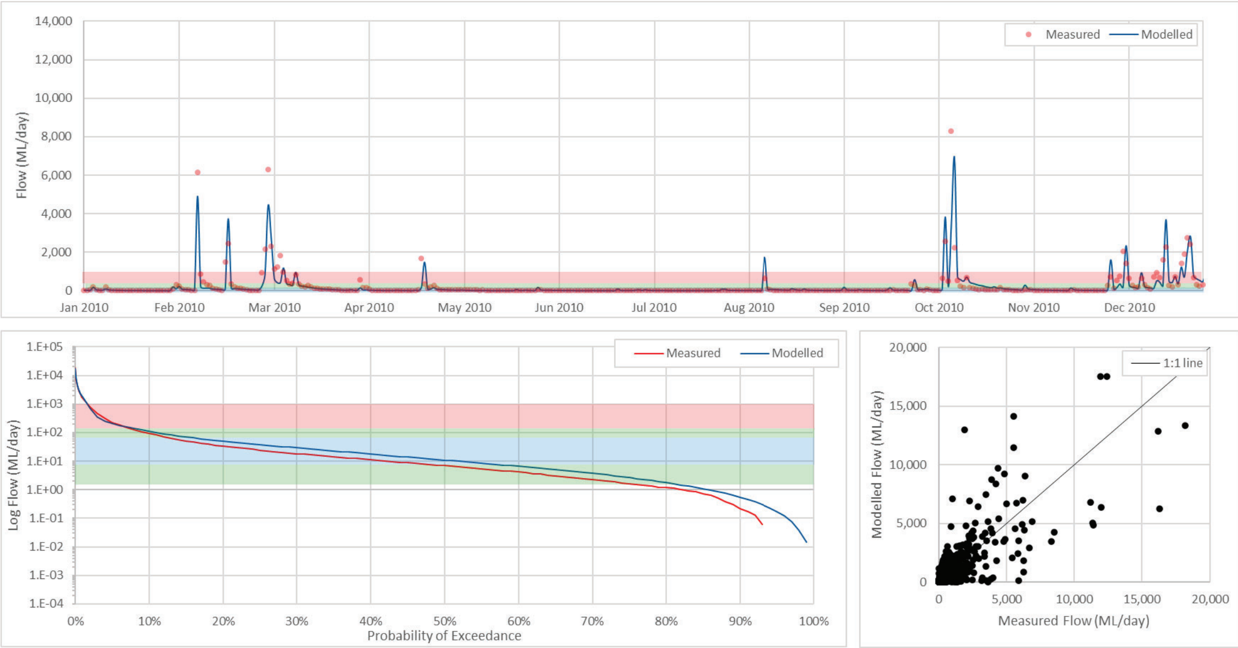

Figure 15. *Caboolture River at Caboolture (142001A) timeseries[2], exceedance curve and scatter plot graph: 01/01/1990 – 31/12/2018*

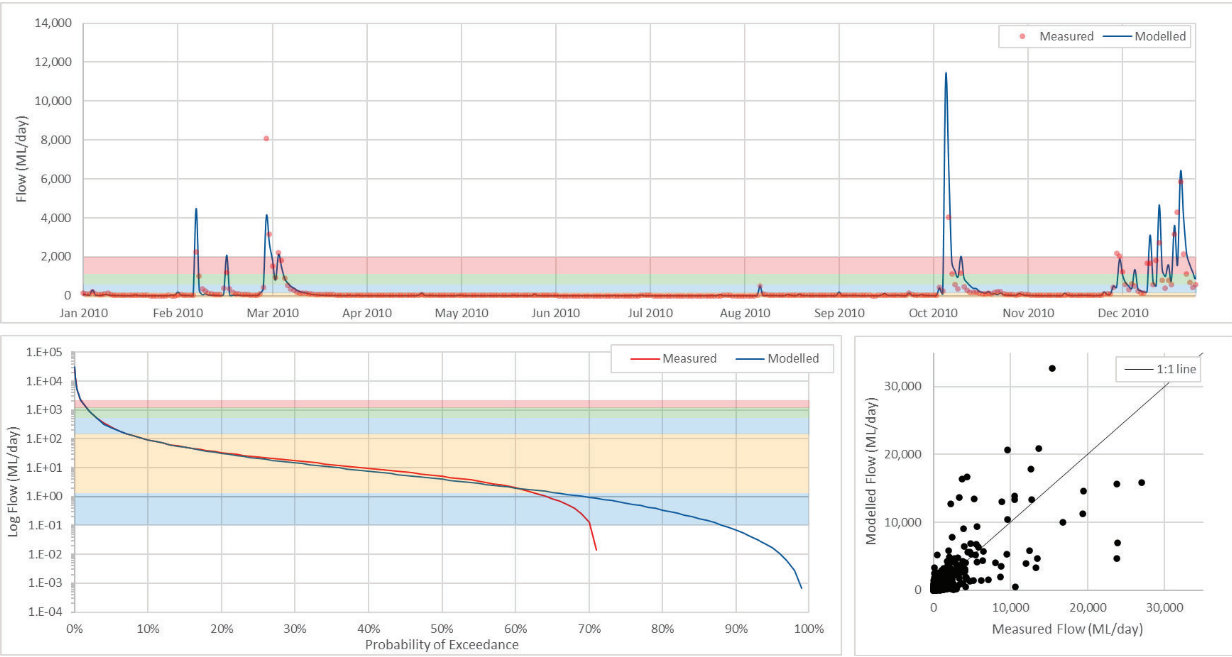

Figure 16. *South Pine River at Drapers Crossing (142202A) timeseries[1], exceedance curve and scatter plot graph: 01/01/1990 – 31/12/2018*

Gauge Rating Reliability	Lower Bound (Flow)	Upper Bound (Flow)
Fair	1.58	6.43
Reliable	8	60
Fair	62.4	140
Estimate	144	1000

Gauge Rating Reliability	Lower Bound (Flow)	Upper Bound (Flow)
Reliable	0.01	0.522
Poor	1.35	149
Reliable	160	520
Fair	543	1050
Estimate	1082	2000

Figure 17. *DNRME gauge rating reliability for Caboolture River at Caboolture (left) and South Pine River at Drapers Crossing (right)*

[2] A representative year has been presented (2010) out of the modelled period to represent modelled fit to measured data.

3.3 Water quality validation

Water quality was validated using the Ecosystem Health Monitoring Program (EHMP) data. The most upstream estuarine sites in Caboolture (1008) and South Pine (812) were compared to the corresponding link in the catchment (Figure 18) over the estuary modelling period. During this period, eight samples were collected at the Caboolture site, while only one sample was collected at the South Pine site as monitoring was ceased in July 2014. Comparison plots for TN and TP are presented in Figure 19 to Figure 22. Total suspended solids were not compared as only turbidity data is collected by EHMP.

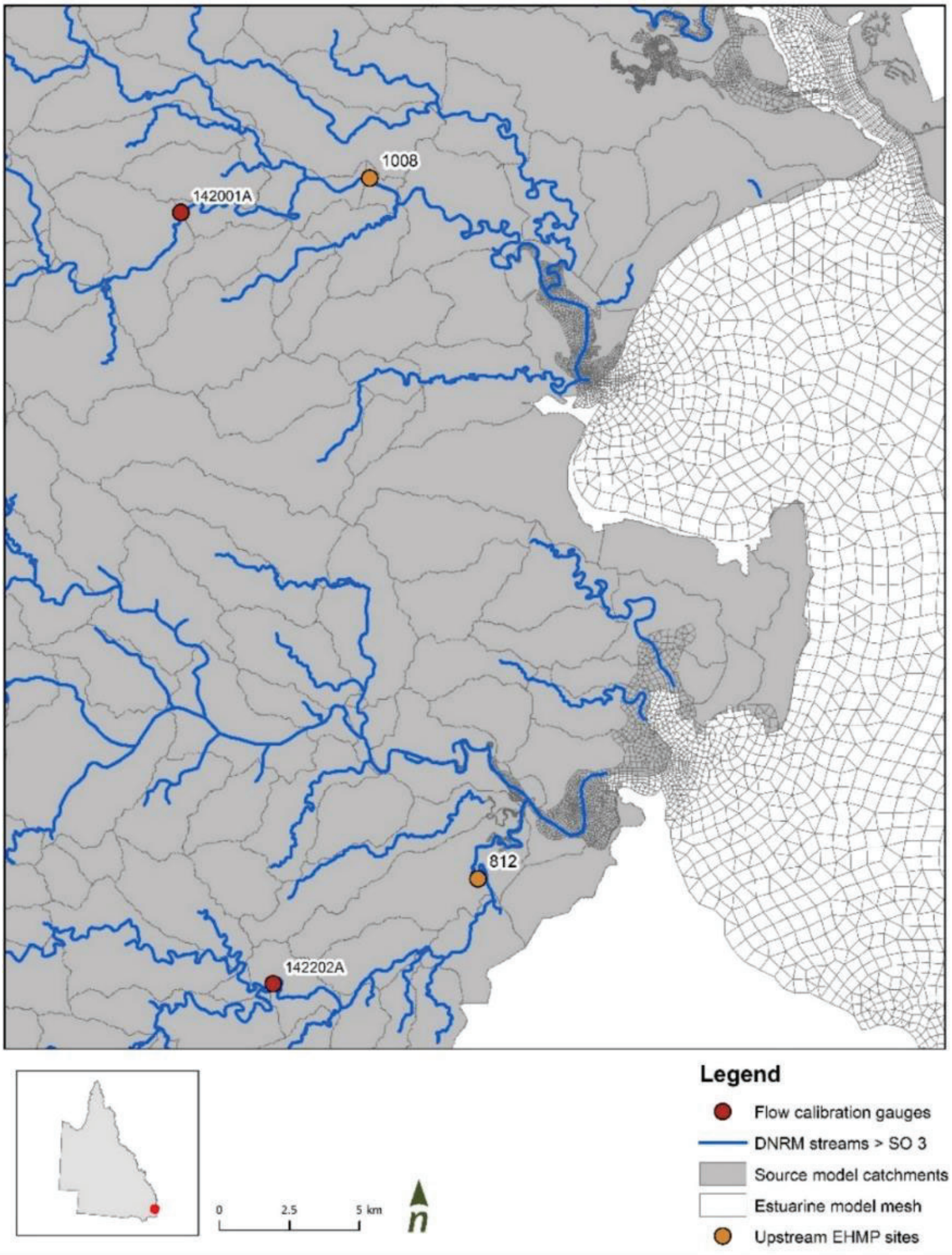

Figure 18. *Water Quality validation sites*

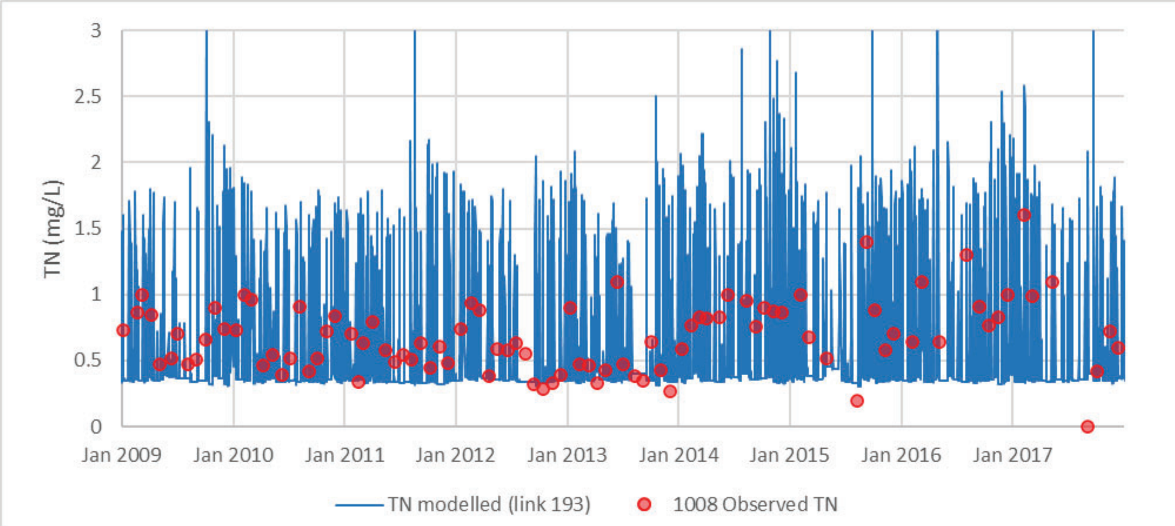

Figure 19. *Caboolture Total Nitrogen concentration comparison plot between observed (EHMP) and catchment model*

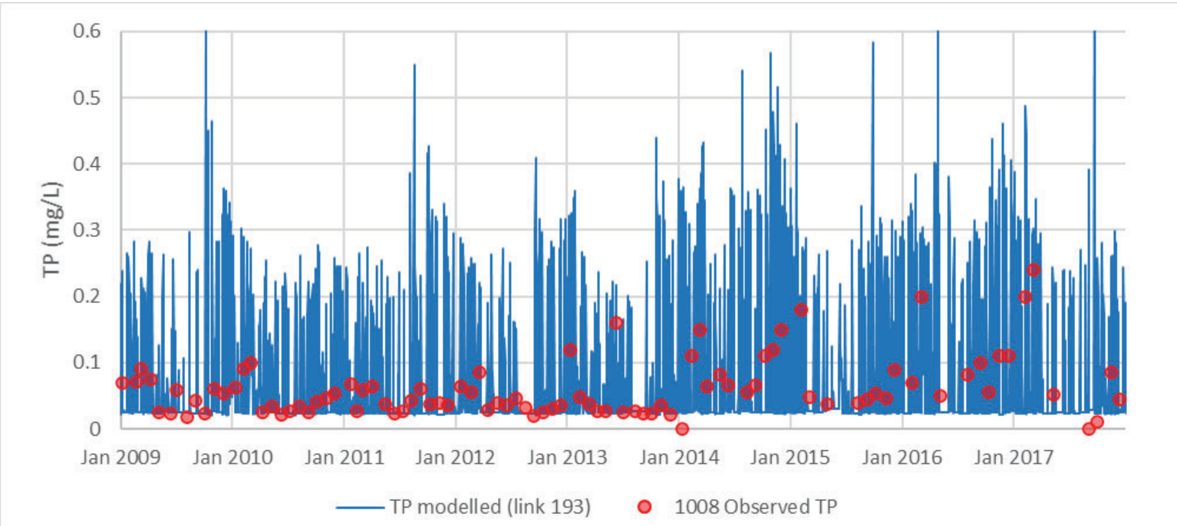

Figure 20. *Caboolture Total Phosphorous concentration comparison plot between observed (EHMP) and catchment model*

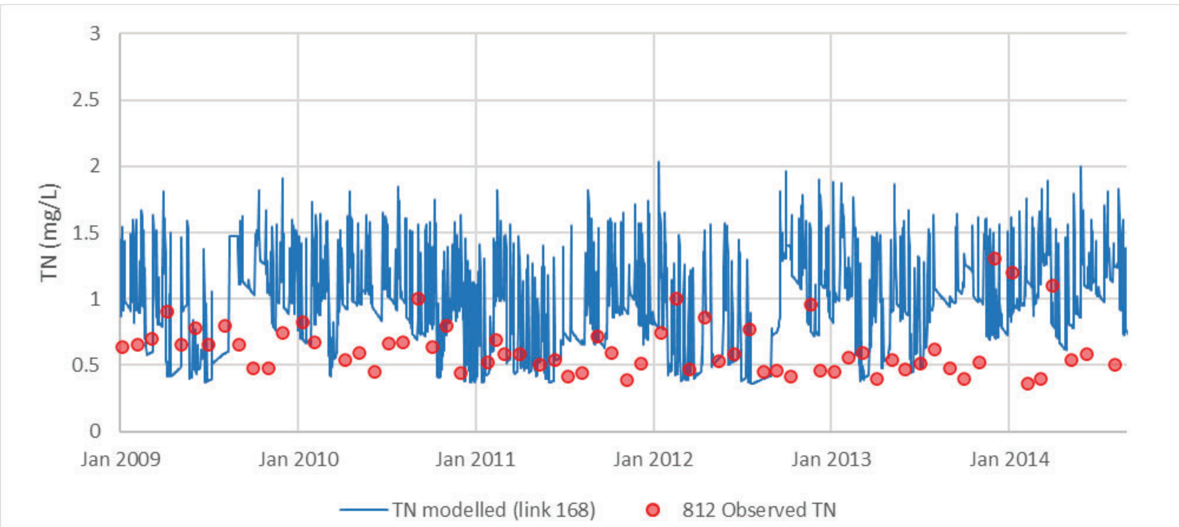

Figure 21. *South Pine Total Nitrogen concentration comparison plot between observed (EHMP) and catchment model*

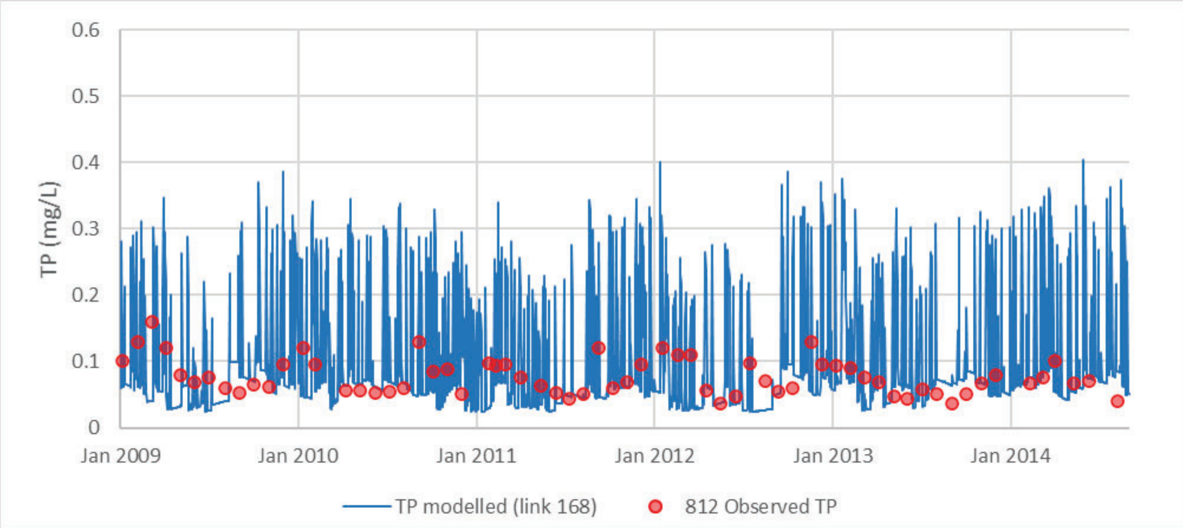

Figure 22. *South Pine Total Phosphorous concentration comparison plot between observed (EHMP) and catchment model*

An assessment of the modelled TN and TP concentration against the EHMP observed data at the upstream estuarine site for the Caboolture River show that the model predicted concentrations represent the monthly observed concentrations well.

The modelled concentration within the South Pine River is generally within the bounds of the observed monthly EMHP data, albeit more often at the upper bound (most notable in the TN comparison between 06/09 – 06/10, 06/11 – 01/12, 06/12 – 01/13 and 06/13 – 08/14). Given the EHMP site is monitored monthly, it is feasible that the monitored concentration may not be fully representative of sub-monthly concentrations at this site.

Consequently, it is considered that the model is performing well at predicting nutrient concentrations from the catchment. For the purposes of representing the change in pollutant load generation between the existing (2016) and future development scenarios, this model is considered to be fit for purpose.

4 Modelling results

4.1 Scenario modelling

After calibration of the existing case Source model, several scenarios were required to be configured to aid in informing potential location, size, and implementation timing of water quality infrastructure to service development areas to achieve a no worsening in pollutant runoff conditions from base case (i.e. 2016 'existing' conditions).

The scenarios analysed (for both the total MBRC catchment area and the priority infrastructure area (PIAs) (see Figure 23)), are:

- Current development (existing conditions as of 2016 for calibration)
- Future (ultimate) development with 'business as usual' BAU stormwater management
- Interim (cohort) development with 'business as usual' BAU stormwater management for:
  - 5 years from existing to 2021
  - 5 years from 2021 to 2026
  - 5 years from 2026 to 2031
  - 5 years from 2031 to 2036

The results from each of the scenarios modelled are discussed below.

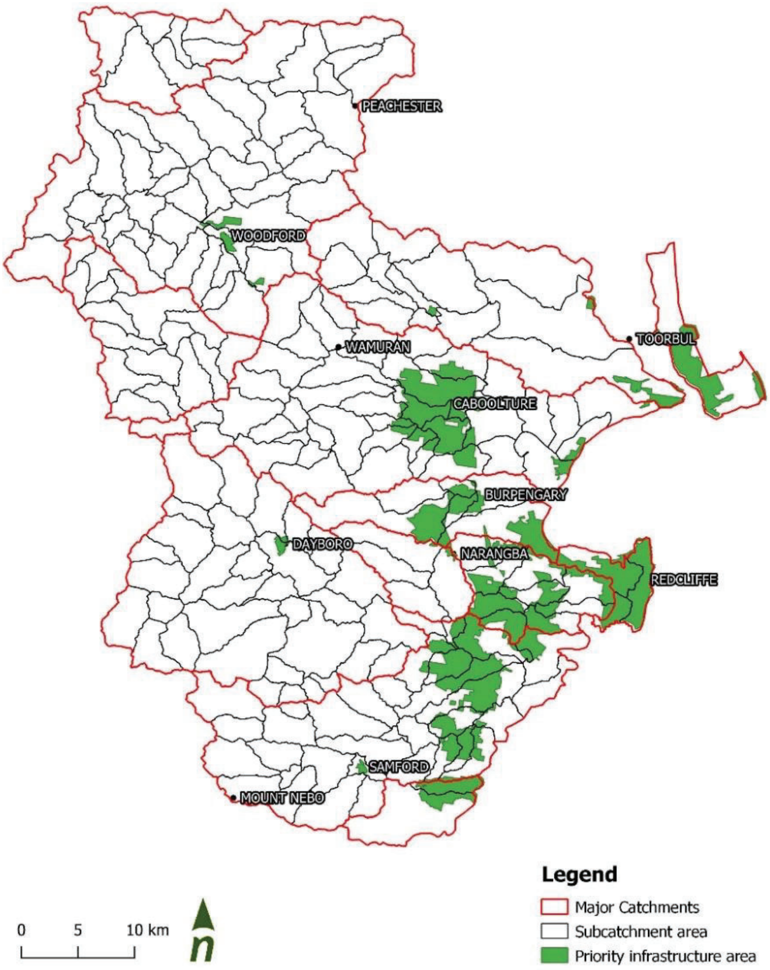

Figure 23. *Priority Infrastructure Area within the MBRC catchment*

Existing Case Scenario
To determine flow and pollutant load conditions under the existing case scenario for the total MBRC catchment area (as per 2016), modelling was simulated using the calibrated model (as described in Section 2 and Section 3). To simulate the existing conditions from the priority infrastructure areas (as provided by Council and represented in Figure 23) the model outputs were apportioned based on the PIA within each subcatchment.

Tabulated results (at a major subcatchment scale) for the flow and loads in the existing case scenario for both the entire MBRC catchment area, and the PIA excerpt, have been provided in Table 9.

Thematic maps showing the existing flows and pollutant loads from each sub-catchment are presented in the associated drawing addendum *MBRC TWCMP Review: Existing case and scenario catchment modelling – DRAWING ADDENDUM* (Alluvium, 2020). All results are presented as annual average areal loads per calendar year (January – December).

Table 9. Annual average flow and load results – existing case scenario

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,324	14	2	1,102	5,754	7	2	575
Brisbane Coastal	11,350	17	2	3,921	3,903	5	1	319
Burpengary Creek	27,212	36	6	6,607	9,517	13	2	2,107
Byron Creek	1,808	1	0	97	-	-	-	-
Caboolture River	121,644	172	25	32,745	19,026	77	36	4,413
Hays Inlet	29,168	45	7	9,266	16,471	39	5	5,767
Lower Pine	83,223	111	17	19,975	22,915	31	5	2,875
Mary River	24,215	26	3	2,558	-	-	-	-
Neurum Creek	31,555	37	5	4,013	-	-	-	-
Pumicestone Passage	68,871	103	12	12,360	1,885	2	3	164
Redcliffe	11,774	20	3	5,911	10,550	18	3	5,250
Sideling Creek	11,180	17	3	4,508	-	-	-	-
Stanley River	144,017	180	24	21,232	987	1	0	92
Upper Pine River	73,624	86	12	10,280	498	1	0	34
TOTAL	651,964	864	122	134,575	91,737	194	58	21,609

Ultimate Case Scenario

The ultimate case scenario presents what the catchment is anticipated to 'look like' in a fully developed scenario. To determine the flow and pollutant loads from this scenario, the calibrated model was adopted and adapted with the following changes:

- ultimate land use (as per Table 3) was applied to the model
- a pollutant generation filter was applied to account for the 'business as usual' BAU approach to new urban development (i.e. application of the *State Planning Policy* (2017) guidelines for reduction in TSS, TP and TN of 80%, 60% and 45% respectively)

As with the existing case scenario, the flows and loads from the ultimate scenario PIAs have been based on relevant area (i.e. PIA area to total subcatchment area) apportioning. Tabulated results (at a major subcatchment scale) for the flow and loads in the ultimate case scenario for both the entire MBRC catchment area, and the PIAs, have been provided in Table 10.

Thematic maps showing the existing flows and pollutant loads from each sub-catchment are presented in the associated drawing addendum *MBRC TWCMP Review: Existing case and scenario catchment modelling – DRAWING ADDENDUM* (Alluvium, 2020). All results are presented as annual average areal loads per calendar year (January – December).

Table 10. Annual average flow and load results – ultimate case scenario

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,859	14	2	1,144	6,395	8	1	589
Brisbane Coastal	13,258	17	2	1,213	4,667	6	1	343
Burpengary Creek	31,509	46	8	14,038	12,923	15	3	1,240
Byron Creek	1,808	1	0	112	-	-	-	-
Caboolture River	141,266	209	30	55,539	32,110	35	6	3,149
Hays Inlet	33,521	43	7	4,953	19,822	25	4	2,384
Lower Pine	87,530	112	17	19,199	27,306	34	5	2,509
Mary River	24,216	26	3	2,865	-	-	-	-
Neurum Creek	31,501	36	5	4,321	-	-	-	-
Pumicestone Passage	71,320	114	13	15,729	2,531	3	0	218
Redcliffe	12,159	16	3	1,748	10,968	14	2	1,099
Sideling Creek	12,284	23	4	10,123	-	-	-	-
Stanley River	145,064	191	25	22,975	1,503	2	0	103
Upper Pine River	73,911	85	12	11,308	610	1	0	38
TOTAL	692,206	934	131	165,268	119,138	141	23	11,689

Cohort Scenarios

The cohort scenarios have been identified to present the catchment development at several interim periods of 5 years, to 2021, 2026, 2031 and 2036. These scenarios have been based on the calibrated model, with the following adaptations:

- the percent of progression in development from the existing to ultimate cases (for each cohort) has been supplied by Council. The progression percentage (the amount of change there is in each subcatchment per cohort) is the product of the change in land use in each subcatchment (between existing and ultimate) and the progression percent (as provided by Council). The resulting functional unit area distribution throughout the catchment for each functional unit is per Table 3. .
- a pollutant generation filter was applied to account for the 'business as usual' BAU approach to new urban development (i.e. application of the *State Planning Policy* (2017) guidelines for reduction in TSS, TP and TN of 80%, 60% and 45% respectively)

It is important to note that the extent of the changes up to 2036 do not necessarily represent the ultimate case scenario, with future works to occur beyond these timeframes to reach the ultimate case scenario.

As with the above case scenarios, the flows and loads from the ultimate scenario PIAs have been based on relevant area (i.e. PIA area to total subcatchment area) apportioning. Tabulated results (at a major subcatchment scale) for the flow and loads in each of the cohort scenarios for both the entire MBRC catchment area, and the PIAs, have been provided in Table 11 to Table 14.

Thematic maps showing the existing flows and pollutant loads from each sub-catchment are presented in the associated drawing addendum *MBRC TWCMP Review: Existing case and scenario catchment modelling – DRAWING ADDENDUM* (Alluvium, 2020). All results are presented as annual average areal loads per calendar year (January – December).

Table 11. Annual average flow and load results – cohort 1 scenario (2016-2021)

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,701	14	2	1,132	6,206	7	1	585
Brisbane Coastal	12,681	17	2	1,873	4,369	6	1	339
Burpengary Creek	28,679	40	7	9,597	10,620	14	2	1,832
Byron Creek	1,808	1	0	110	-	-	-	-
Caboolture River	125,626	184	27	40,331	21,067	28	5	4,192
Hays Inlet	30,979	44	7	7,343	17,809	25	4	4,238
Lower Pine	85,163	112	17	20,053	24,544	32	5	2,672
Mary River	24,215	26	3	2,852	-	-	-	-
Neurum Creek	31,536	36	5	4,264	-	-	-	-
Pumicestone Passage	70,072	107	13	14,035	2,246	3	0	201
Redcliffe	11,831	19	3	4,751	10,616	16	3	4,093
Sideling Creek	11,678	19	3	7,053	-	-	-	-
Stanley River	144,539	184	25	22,095	1,223	1	0	96
Upper Pine River	73,843	85	12	11,217	589	1	0	37
TOTAL	665,352	889	126	146,703	99,554	134	22	18,300

Table 12. Annual average flow and load results – cohort 2 scenario (2021-2026)

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,747	14	2	1,135	6,261	8	1	586
Brisbane Coastal	12,781	17	2	1,771	4,426	6	1	339
Burpengary Creek	29,117	41	7	10,171	10,978	14	2	1,733
Byron Creek	1,808	1	0	110	-	-	-	-
Caboolture River	127,518	188	28	42,691	22,489	29	5	4,015
Hays Inlet	31,517	43	7	6,460	18,153	25	4	3,464
Lower Pine	85,715	112	17	19,895	25,177	33	5	2,631
Mary River	24,216	26	3	2,852	-	-	-	-
Neurum Creek	31,532	36	5	4,275	-	-	-	-
Pumicestone Passage	70,302	109	13	14,460	2,300	3	0	204
Redcliffe	11,861	18	3	4,125	10,650	16	3	3,470
Sideling Creek	11,805	20	3	7,672	-	-	-	-
Stanley River	144,632	185	25	22,192	1,282	1	0	97
Upper Pine River	73,871	85	12	11,252	596	1	0	38
TOTAL	669,422	897	127	149,061	102,585	135	22	16,594

Table 13. Annual average flow and load results – cohort 3 scenario (2026-2031)

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,771	14	2	1,137	6,289	8	1	587
Brisbane Coastal	12,849	17	2	1,700	4,464	6	1	340
Burpengary Creek	29,578	42	7	10,979	11,347	14	2	1,635
Byron Creek	1,808	1	0	111	-	-	-	-
Caboolture River	129,723	193	29	45,444	24,381	30	5	3,826
Hays Inlet	32,213	43	7	5,768	18,604	24	4	2,905
Lower Pine	86,311	112	17	19,726	25,871	33	5	2,592
Mary River	24,216	26	3	2,853	-	-	-	-
Neurum Creek	31,529	36	5	4,286	-	-	-	-
Pumicestone Passage	70,551	110	13	14,880	2,364	3	0	209
Redcliffe	11,906	18	3	3,771	10,699	15	3	3,116
Sideling Creek	11,941	21	3	8,347	-	-	-	-
Stanley River	144,741	186	25	22,303	1,336	2	0	98
Upper Pine River	73,898	85	12	11,286	603	1	0	38
TOTAL	674,034	905	128	152,591	106,241	136	22	15,362

Table 14. Annual average flow and load results – cohort 4 scenario (2031-2036)

	Total MBRC catchment area				MBRC PIA			
Subcatchment	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**	**Flow (ML/yr)**	**TN (t/yr)**	**TP (t/yr)**	**TSS (t/yr)**
Bribie Island	12,779	14	2	1,138	6,300	8	1	587
Brisbane Coastal	12,915	17	2	1,649	4,508	6	1	340
Burpengary Creek	29,964	43	7	11,507	11,674	14	2	1,538
Byron Creek	1,808	1	0	111	-	-	-	-
Caboolture River	131,276	196	29	47,052	25,599	31	5	3,633
Hays Inlet	32,519	43	7	5,537	18,849	24	4	2,729
Lower Pine	86,701	112	17	19,379	26,380	33	5	2,561
Mary River	24,216	26	3	2,853	-	-	-	-
Neurum Creek	31,525	36	5	4,291	-	-	-	-
Pumicestone Passage	70,710	111	13	15,096	2,396	3	0	211
Redcliffe	11,961	17	3	3,585	10,755	15	3	2,931
Sideling Creek	11,990	21	3	8,590	-	-	-	-
Stanley River	144,845	186	25	22,405	1,397	2	0	100
Upper Pine River	73,899	85	12	11,287	604	1	0	38
TOTAL	677,109	911	128	154,479	108,746	137	22	14,684

4.2 Comparison of scenario modelling

The above discussed scenarios have been configured and run to indicate treatment requirements to achieve no worsening from the adopted existing case scenario. Graphical representation of this (i.e. annual average loads to indicate treatment requirements to achieve no worsening) have been presented in Figure 24 to Figure 26. Additionally, the percentage of change to the existing condition flow and loads for each of the modelled scenarios are presented in Table 15 to Table 18. These results only consider the total catchment area modelled, not the PIA area modelled.

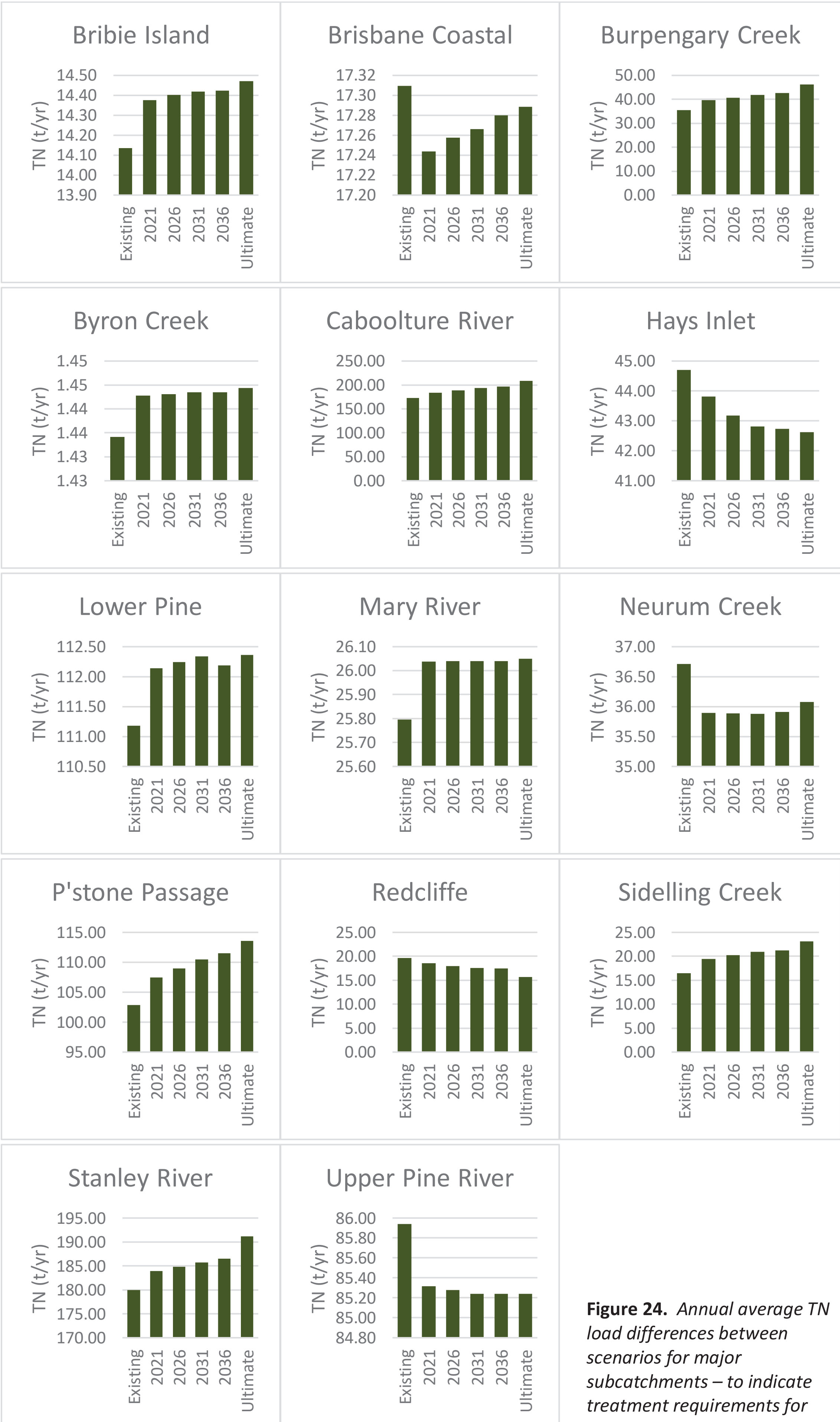

Figure 24. *Annual average TN load differences between scenarios for major subcatchments – to indicate treatment requirements for no worsening.*

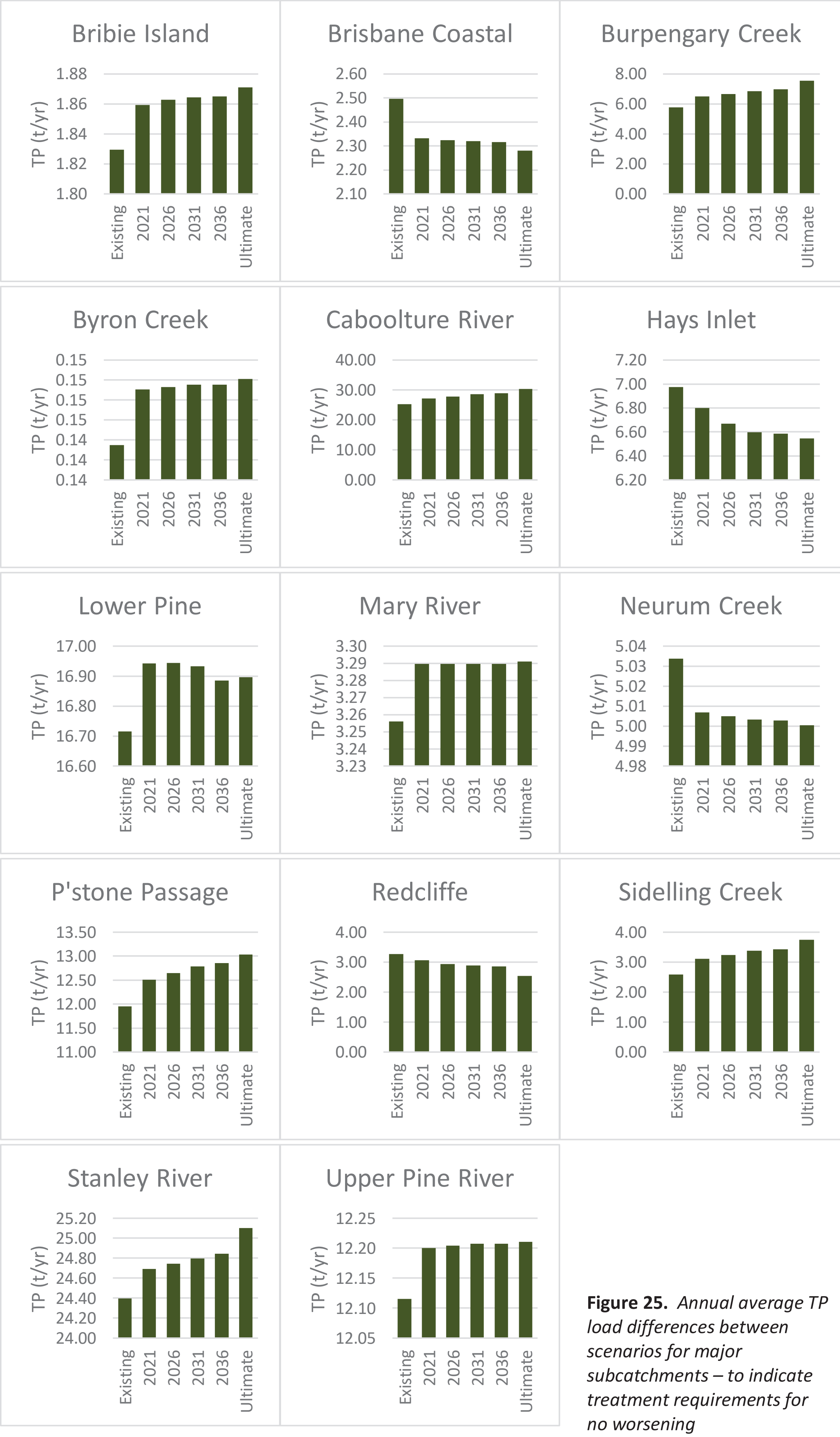

Figure 25. *Annual average TP load differences between scenarios for major subcatchments – to indicate treatment requirements for no worsening*

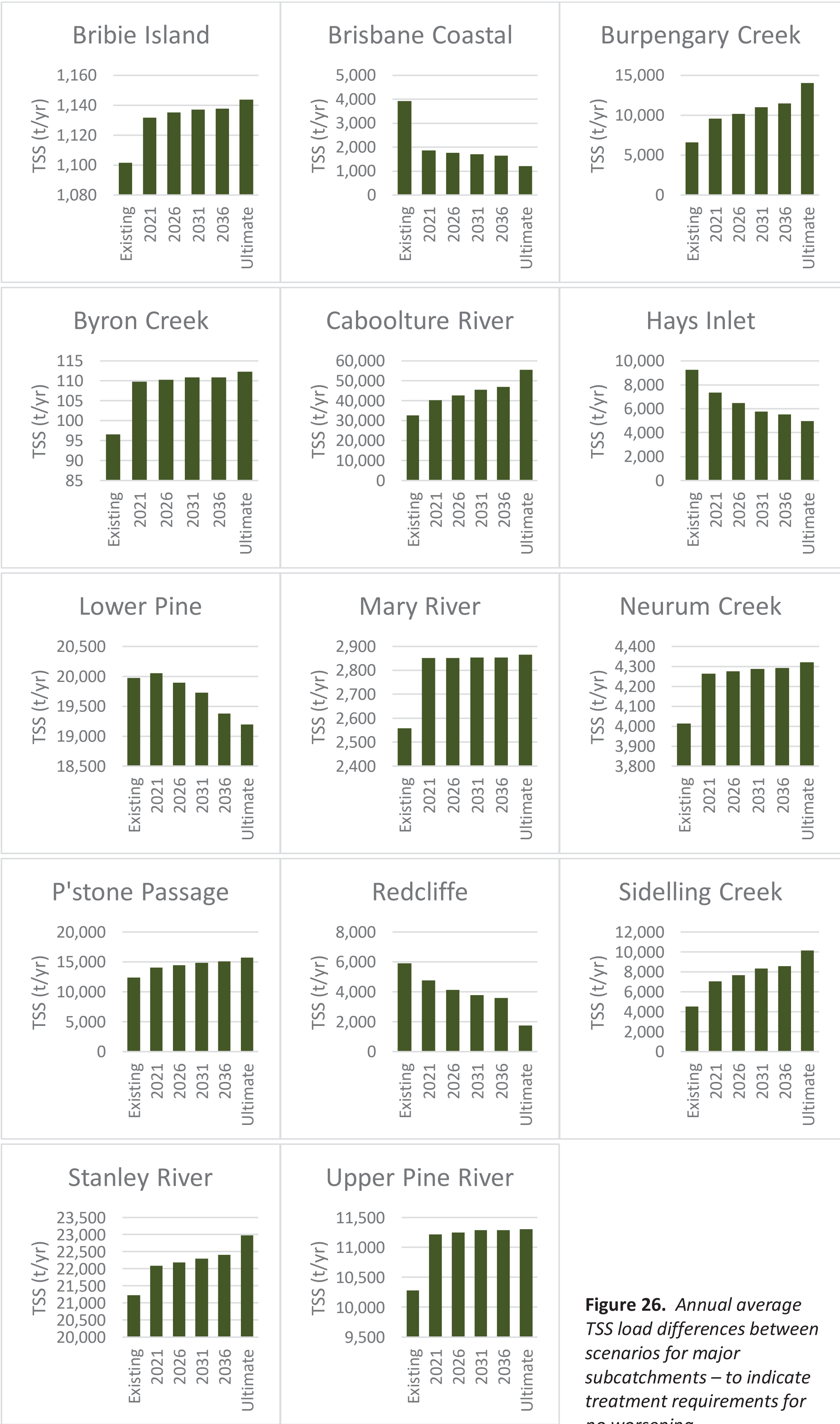

Figure 26. *Annual average TSS load differences between scenarios for major subcatchments – to indicate treatment requirements for no worsening*

Table 15. Percentage increase in annual average flow (ML/yr) from existing case scenario

Major subcatchment	Existing	2021	2026	2031	2036	Ultimate
Bribie Island	12,324	3%	3%	4%	4%	4%
Brisbane Coastal	11,350	12%	13%	13%	14%	17%
Burpengary Creek	27,212	5%	7%	9%	10%	16%
Byron Creek	1,808	0%	0%	0%	0%	0%
Caboolture River	121,644	3%	5%	7%	8%	16%
Hays Inlet	29,168	6%	8%	10%	11%	15%
Lower Pine	83,223	2%	3%	4%	4%	5%
Mary River	24,215	0%	0%	0%	0%	0%
Neurum Creek	31,555	0%	0%	0%	0%	0%
Pumicestone Passage	68,871	2%	2%	2%	3%	4%
Redcliffe	11,774	0%	1%	1%	2%	3%
Sidelling Creek	11,180	4%	6%	7%	7%	10%
Stanley River	144,017	0%	0%	1%	1%	1%
Upper Pine River	73,624	0%	0%	0%	0%	0%
TOTAL	651,964	2%	3%	3%	4%	6%

Table 16. Percentage increase in annual average TN load (t/yr) from existing case scenario

Major subcatchment	Existing	2021	2026	2031	2036	Ultimate
Bribie Island	14	2%	2%	2%	2%	2%
Brisbane Coastal	17	0%	0%	0%	0%	0%
Burpengary Creek	36	12%	14%	18%	20%	30%
Byron Creek	1	1%	1%	1%	1%	1%
Caboolture River	172	7%	9%	12%	14%	21%
Hays Inlet	45	-2%	-3%	-4%	-4%	-5%
Lower Pine	111	1%	1%	1%	1%	1%
Mary River	26	1%	1%	1%	1%	1%
Neurum Creek	37	-2%	-2%	-2%	-2%	-2%
Pumicestone Passage	103	4%	6%	7%	8%	10%
Redcliffe	20	-6%	-9%	-11%	-11%	-20%
Sidelling Creek	17	18%	22%	27%	29%	40%
Stanley River	180	2%	3%	3%	4%	6%
Upper Pine River	86	-0.7%	-0.8%	-0.8%	-0.8%	-0.8%
TOTAL	864	3%	4%	5%	5%	8%

Table 17. Percentage increase in annual average TP (t/yr) load from existing case scenario

Major subcatchment	Existing	2021	2026	2031	2036	Ultimate
Bribie Island	1.83	2%	2%	2%	2%	2%
Brisbane Coastal	2.50	-7%	-7%	-7%	-7%	-9%
Burpengary Creek	5.78	13%	15%	19%	21%	31%
Byron Creek	0.14	1%	1%	1%	1%	1%
Caboolture River	25.35	7%	10%	13%	14%	20%
Hays Inlet	6.98	-2%	-4%	-5%	-6%	-6%
Lower Pine	16.72	1%	1%	1%	1%	1%
Mary River	3.26	1%	1%	1%	1%	1%
Neurum Creek	5.03	-1%	-1%	-1%	-1%	-1%
Pumicestone Passage	11.95	5%	6%	7%	8%	9%
Redcliffe	3.27	-6%	-10%	-12%	-13%	-23%
Sidelling Creek	2.59	20%	25%	31%	33%	45%
Stanley River	24.40	1%	1%	2%	2%	3%
Upper Pine River	12.12	1%	1%	1%	1%	1%
TOTAL	121.90	3%	4%	5%	5%	7%

Table 18. Percentage increase in annual average TSS (t/yr) load from existing case scenario

Major subcatchment	Existing	2021	2026	2031	2036	Ultimate
Bribie Island	1,102	3%	3%	3%	3%	4%
Brisbane Coastal	3,921	-52%	-55%	-57%	-58%	-69%
Burpengary Creek	6,607	45%	54%	66%	74%	112%
Byron Creek	97	14%	14%	15%	15%	16%
Caboolture River	32,745	23%	30%	39%	44%	70%
Hays Inlet	9,266	-21%	-30%	-38%	-40%	-47%
Lower Pine	19,975	0%	0%	-1%	-3%	-4%
Mary River	2,558	11%	11%	12%	12%	12%
Neurum Creek	4,013	6%	7%	7%	7%	8%
Pumicestone Passage	12,360	14%	17%	20%	22%	27%
Redcliffe	5,911	-20%	-30%	-36%	-39%	-70%
Sidelling Creek	4,508	56%	70%	85%	91%	125%
Stanley River	21,232	4%	5%	5%	6%	8%
Upper Pine River	10,280	9%	9%	10%	10%	10%
TOTAL	134,575	9%	11%	13%	15%	23%

The results presented in the above Figure 24 to Figure 26, and Table 15 to Table 18 indicate there is likely to be an increase in at least one modelled pollutant load (TN, TP or TSS) for all major subcatchments with the exception of Brisbane Coastal, Hays Inlet and Redcliffe. The magnitude of change from existing is anticipated to be greatest within the Sideling Creek subcatchment, followed by the Burpengary Creek and Caboolture River subcatchments.

It is anticipated that with urbanisation, the pollutant load generated from a subcatchment is likely to increase, due to increases in pollutant concentration (see Table 5) and effective impervious area. What is not as often anticipated is a decrease in pollutant loads (with business as usual stormwater treatment employed). Consequently, investigation has been undertaken into the reason for pollutant load decrease for the major subcatchments identified above. The anticipated reasonings for the decreases are presented below:

- **Brisbane Coastal**: subcatchment SC #198 (within this major subcatchment area) experiences approximately 700 ha of land use change between the existing and ultimate case scenarios. Generally, there is a (slight) increase in pollutant EMC & DWC pollutant concentrations. However, there is a significant decrease in effective impervious area, resulting in less surface runoff. It is anticipated that the reduced runoff (although with higher pollutant concentrations) is responsible for the decrease in pollutant loads in this major subcatchment.
- **Hays Inlet**: this major subcatchment exhibits a decrease in all annual average pollutant loads between the existing and ultimate case scenarios. It is anticipated that this primarily due to the reduction of the dirt functional unit (which has the highest EMC value of all functional units) in subcatchments SC #050 and SC #108.
- **Neurum Creek**: this major subcatchment experiences an overall decrease in TN and TP, but an increase in TSS. It is anticipated that the decrease in total nutrient loads can be primarily attributed to the change of functional unit from cropping to grazing (with cropping having higher EMC & DWC values than grazing) and increase in TSS resulting from the addition of dirt.
- **Redcliffe**: all of TN, TP and TSS annual average pollutant loads decrease in this major subcatchment, anticipated primarily to be driven by the reduction of the dirt functional unit (a reduction of 111 ha in subcatchment SC #110).
- **Lower Pine**: this subcatchments exhibits a decrease in annual average TSS loads only, with an increase in annual average TN and TP loads. It is anticipated that the decrease in TSS is primarily driven by the decrease in dirt and extractive land uses in subcatchments SC #102 and SC #168, whist the increase in nutrients is due to change in functional units from tree canopy and rural other, to urban other, road and concrete surfaces (all of which have greater nutrient EMC & DWC values).
- **Upper Pine**: this major subcatchment exhibits a very slight decrease in annual average TN load only (less than 1% in all scenarios). Considering the slight change, investigation of this subcatchment has not been undertaken, however it is considered the change is due to similar reasons as identified in the other major subcatchments.

5 Discussion and Conclusion

Alluvium was engaged by Moreton Bay Regional Council (sub-consulting to BMT) to develop a Source model of the Moreton Bay Regional Council (MBRC) catchment to allow for assessment of future development impacts and aid the implementation of water quality infrastructure.

The model was calibrated at two gauges, with ‘very good’ acceptance achieved as per the Moriasi et.al. (2015) acceptance criteria. These calibrated areas were applied to the remainder of the model, and validated to two gauges within the Caboolture zone (see Figure 14), both of which achieved at least a ‘satisfactory’ acceptance.

The nutrient concentration modelled within the catchment generally represents the trends in concentration as observed at the most upstream site in the EHMP datasets for the Caboolture and South Pine rivers. For the purposes of representing the difference between the current (2016) and future development scenario flow and pollutant load generation, this model is considered to be fit for purpose.

Six scenarios have been modelled, representing the current development (as per land use conditions as of 2016), future (ultimate) development with BAU stormwater management and four interim (cohort) scenarios with BAU stormwater management.

The existing has been represented by the calibrated model, which has been used to determine the baseline flows and loads from the catchments, and to which the future case scenarios have been assessed. The ultimate case scenario represents the catchment fully developed as per council’s Planning Scheme and Strategic Framework Place Types. The cohort scenarios represent predicted flows and loads by the end of 2021, 2026, 2031, and 2036, through incremental land use change. The extent of the changes in 2036 does not necessarily represent the ultimate case scenario.

The modelling results have identified that there is anticipated to be an increase in at least one of the modelled pollutants (TN, TP or TSS) for all the major subcatchments, with the exception of Brisbane Coastal, Hays Inlet and Redcliffe. As anticipated, the changes (either increase or decrease in pollutant loads) are incremental from the existing case to the ultimate case scenario. Consequently, to ensure future loads match or are below existing loads, incremental water quality infrastructure will be required.

6 References

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eWater Source, 2020, *Scientific Reference Guide*, eWater, Canberra.

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State of Queensland, 2017, *July 2017 State Planning Policy,* Department of Infrastructure, Local Government and Planning, Brisbane.

Attachment A
Land Use Mapping

Appendix A – Land use mapping

Table 19. MBRC Land Use mapping to Functional Units

LU_DESC	Functional Unit
Marina, Reservoir / Dam / Bores, Waterbodies, Rivers and Creeks	Water
Bed & Breakfasts, Child Care excl K/garten, Community Protection Centre, Drive in Shopping Centre (all areas), Educational Including K/garten, Guest House/Private Hotel, Hospitals, Hotel/Tavern, Library, Licenced Clubs (excluding bowling greens and golf courses), mega store retailer, motel, other clubs (non business), professional offices, public hospital, religious, restaurant, restaurant with drive through facility, retail warehouse, shops, sports clubs/sports facilities (excluding sport fields), Advertising - Hoarding (only FID 1595 in existing LU layer)	Building commercial, Building community, Building education, Building health
Builders Yard, Contractors, Extractive, Funeral Parlours, General Industry, Large Industrial/Commercial, Light Industry, Noxious/Offensive Industry (Incl Abattoir), Oil Depot & Refinery, Sales Area Outdoors (Dealers, boats, cars etc), Service Station (all sizes), Telco/Transformer sites, Transport Terminal, Warehouse & Bulk Stores	Building industry
Bed & Breakfasts, Child Care excl K/garten, Community Protection Centre, Drive in Shopping Centre (all areas), Educational Including K/garten, Guest House/Private Hotel, Hospitals, Hotel/Tavern, Library, Licenced Clubs (excluding bowling greens and golf courses), mega store retailer, motel, other clubs (non business), professional offices, public hospital, religious, restaurant, restaurant with drive through facility, retail warehouse, shops, sports clubs/sports facilities (excluding sport fields), Advertising - Hoarding (only FID 1595 in existing LU layer)	Building non private res, Building office
Advertising - Hoarding (excluding FID 1595 in existing LU layer), Caravan Parks, Cemeteries (incl Crematoria), Parks/Gardens, Show Ground/Race Course/Airfield, Sports Clubs/Facilities, Vacant Land	Building open space, Building rec env
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Building residential
Bed & Breakfasts, Child Care excl K/garten, Community Protection Centre, Drive in Shopping Centre (all areas), Educational Including K/garten, Guest House/Private Hotel, Hospitals, Hotel/Tavern, Library, Licenced Clubs (excluding bowling greens and golf courses), mega store retailer, motel, other clubs (non business), professional offices, public hospital, religious, restaurant, restaurant with drive through facility, retail warehouse, shops, sports clubs/sports facilities (excluding sport fields), Advertising - Hoarding (only FID 1595 in existing LU layer)	Building retail
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Building rural res
Animal Special, Cattle Breeding, Cattle Breeding & Fattening, Cattle Fattening, Horses, Milk - No Quota, Milk - Quota, Pigs, Poultry (all), Sheep Breeding, Turf Farms	Building rural use
Car Parks, Footpaths, Road	Concrete surface
Grains, Small Crops & Fodder No Irrigation, Sugar Cane, Tobacco	Cropping
Builders Yard, Contractors, Extractive, Funeral Parlours, General Industry, Large Industrial/Commercial, Light Industry, Noxious/Offensive Industry (Incl Abattoir), Oil Depot & Refinery, Sales Area Outdoors (Dealers, boats, cars etc), Service Station (all sizes), Telco/Transformer sites, Transport Terminal, Warehouse & Bulk Stores	Dirt, Extractive
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Urban other

LU_DESC	Functional Unit
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Rural other
Builders Yard, Contractors, Extractive, Funeral Parlours, General Industry, Large Industrial/Commercial, Light Industry, Noxious/Offensive Industry (Incl Abattoir), Oil Depot & Refinery, Sales Area Outdoors (Dealers, boats, cars etc), Service Station (all sizes), Telco/Transformer sites, Transport Terminal, Warehouse & Bulk Stores	Gravel/ Sand
Low Grass Grazing, Sheep Grazing Dry	Grazing
Not separated in MBRC layer (FU included in QLUMP surrounding MBRC)	Plantation forest
Car Parks, Footpaths, Road	Road surface
Forestry & Logs, State Forest, National Park, Dense Vegetation, Medium Dense Vegetation, Reeds	Tree canopy
Marina, Reservoir / Dam / Bores, Waterbodies, Rivers and Creeks	Wetlands
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Urban residential
Outbuildings, Residential CTS Properties, Residential CTS Properties in a Retirement, Residential CTS Properties in a Retirement Village, Residential Institution (Non Medical Care), Retirement Village, Single Dwelling Unit, Single Unit Dwelling, Single Unit Dwelling, Special Tourist Attraction, Welfare Home / Institution, Multi Residential (Relocatable Home Parks), Multi Unit Dwelling (flats)	Rural residential

DRAFT REPORT:

MBRC TWCMP Review: Existing case and scenario catchment modelling – DRAWING ADDENDUM

November 2020

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Contents

Figures

MBRC Catchment – FLOW
Existing Scenario (2016)

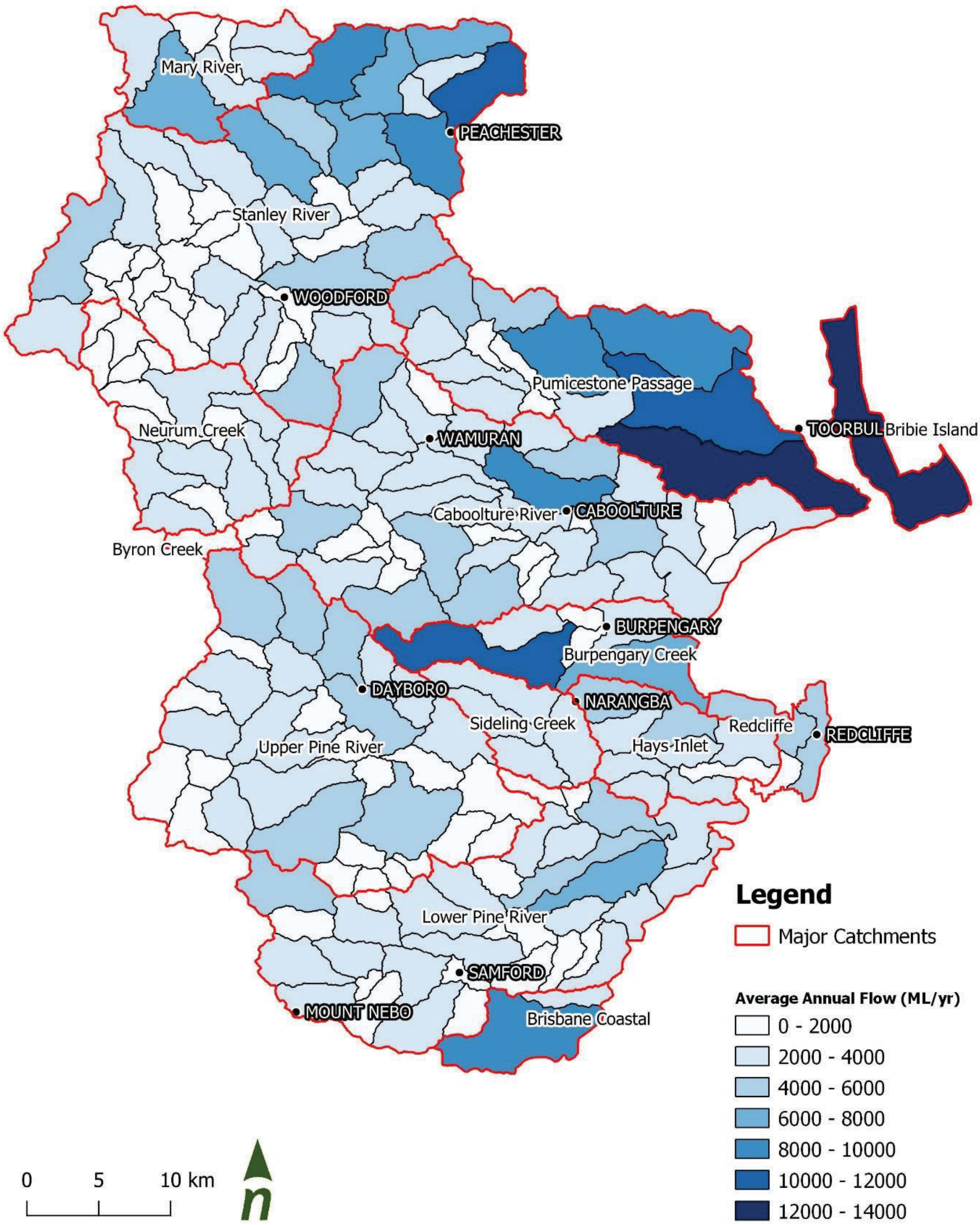


Figure 1. *Existing scenario - average annual flow*

MBRC Catchment – FLOW
Cohort 1 Scenario (2021)

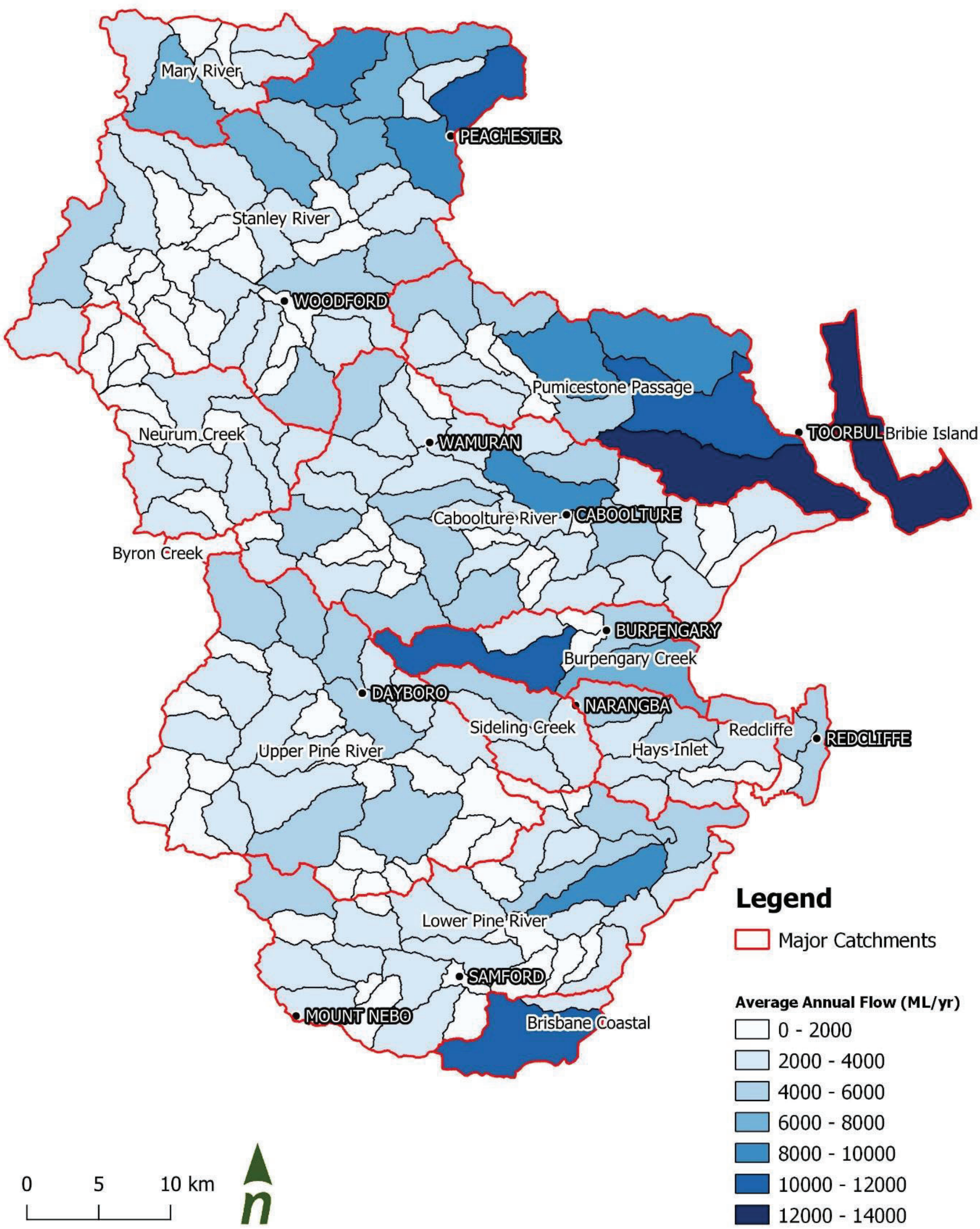


Figure 2. *Cohort 1 scenario - average annual flow*

MBRC Catchment – FLOW
Cohort 2 Scenario (2026)

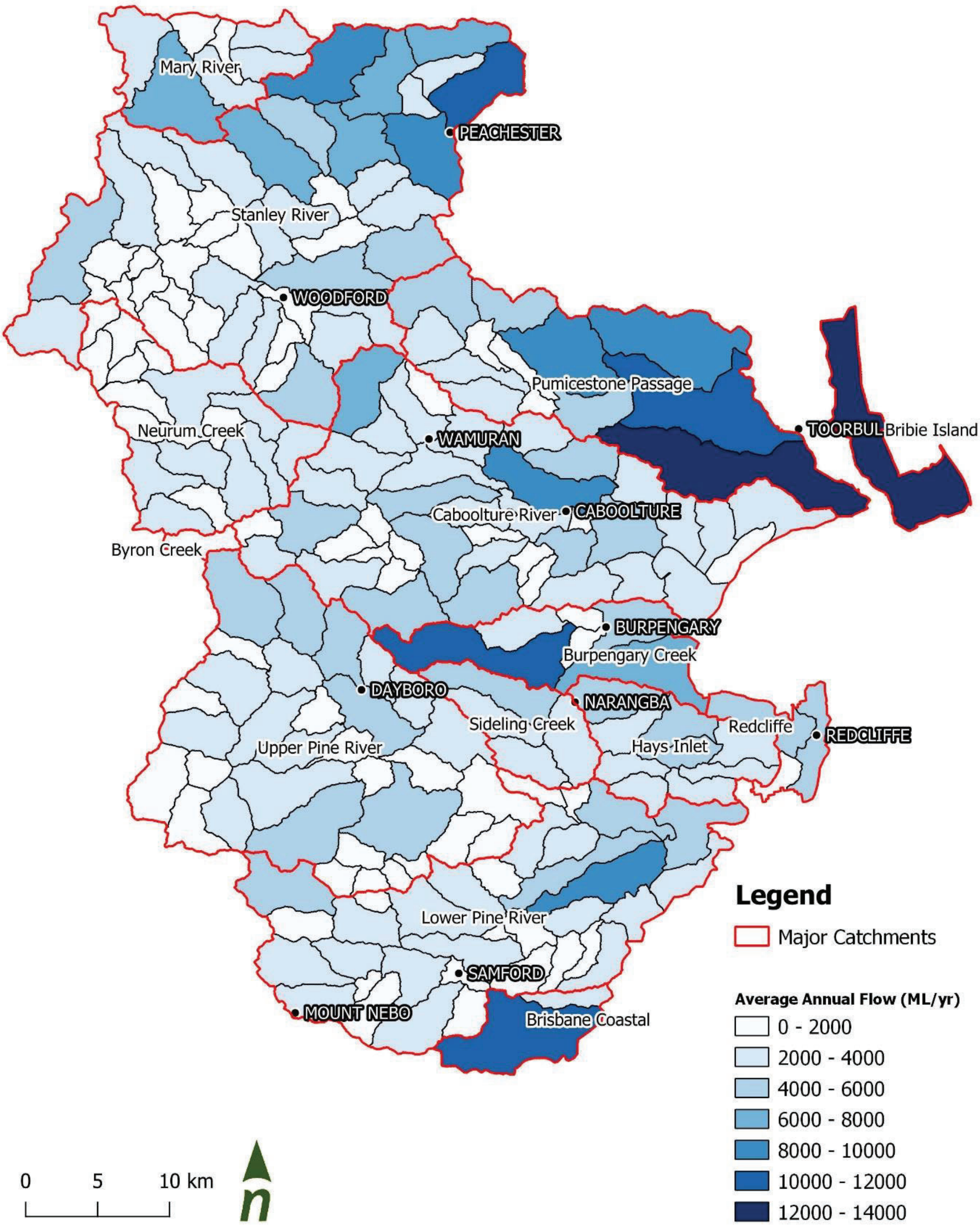


Figure 3. *Cohort 2 scenario - average annual flow*

MBRC Catchment – FLOW
Cohort 3 Scenario (2031)

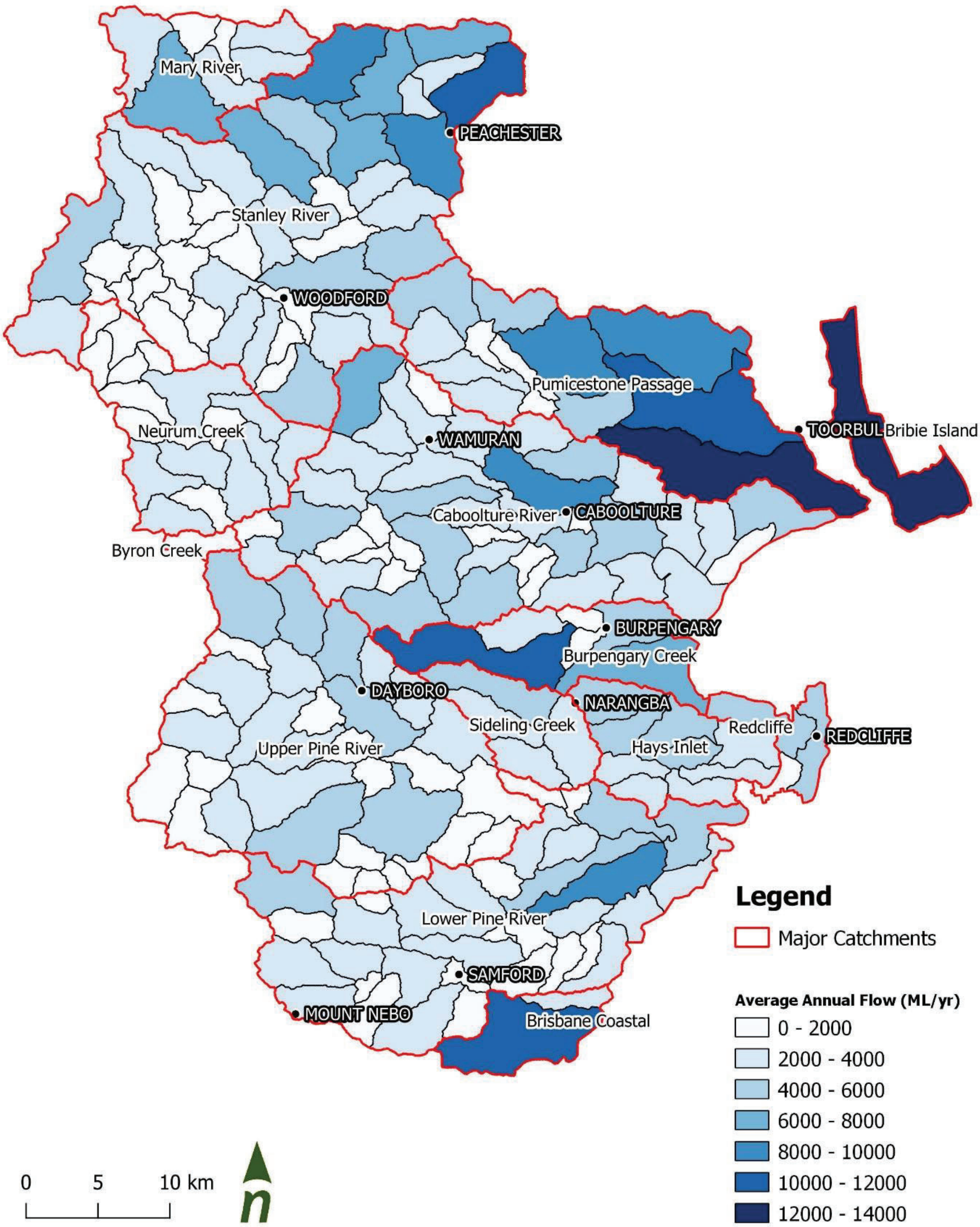


Figure 4. *Cohort 3 scenario - average annual flow*

MBRC Catchment – FLOW
Cohort 4 Scenario (2036)

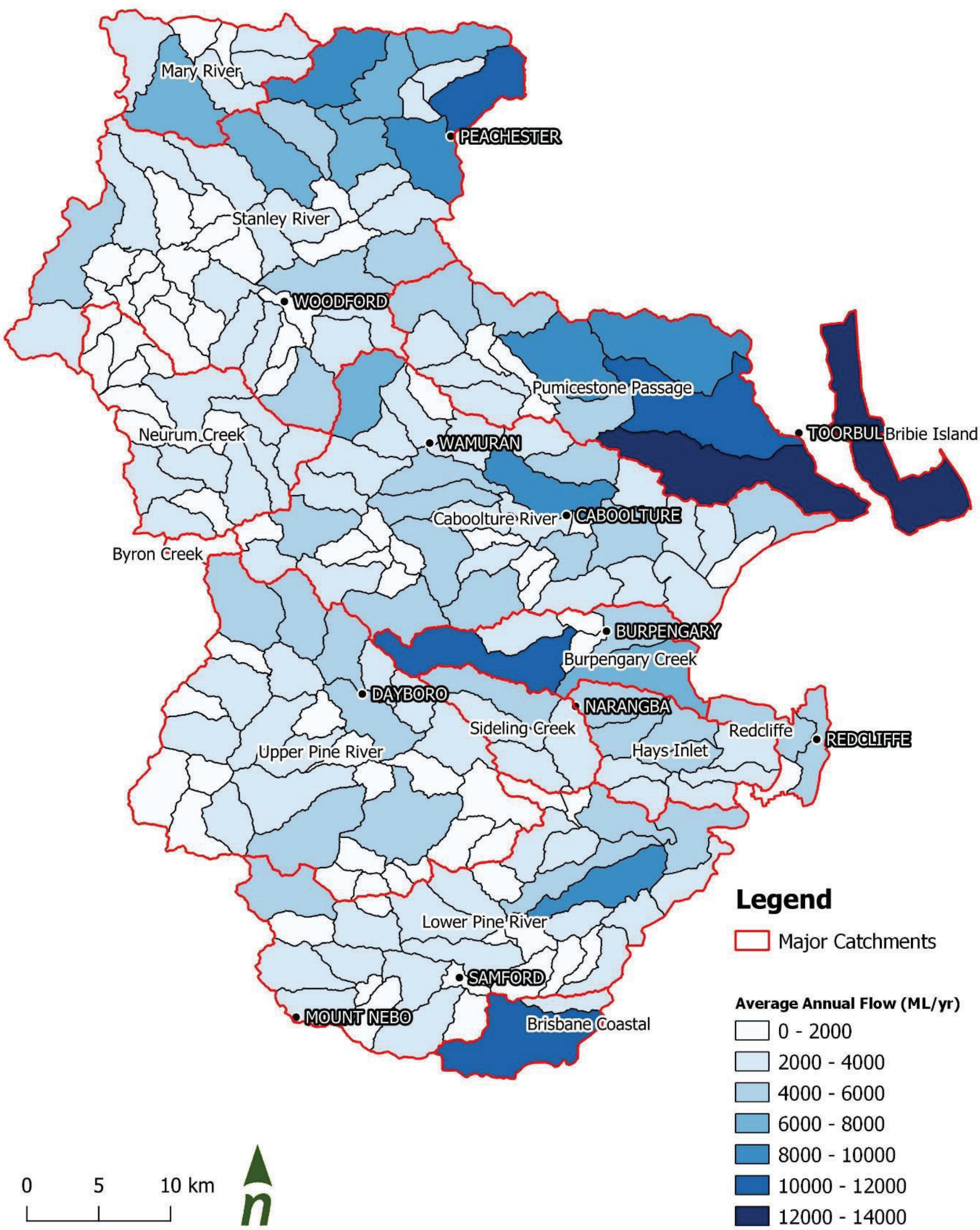


Figure 5. *Cohort 4 scenario - average annual flow*

MBRC Catchment – FLOW
Ultimate Scenario (>2036)

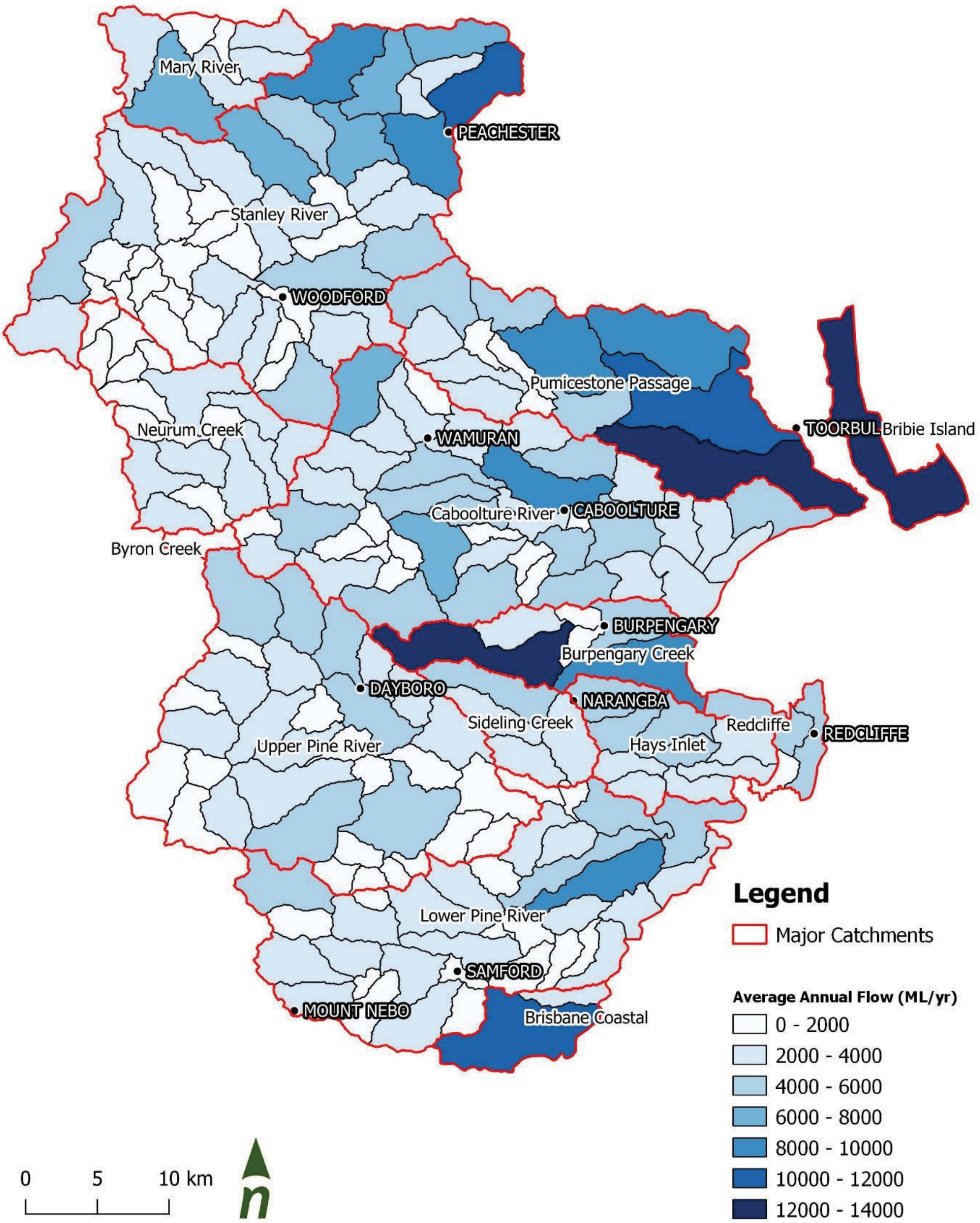


Figure 6. *Ultimate scenario - average annual flow*

MBRC Catchment – TN
Existing Scenario (2016)

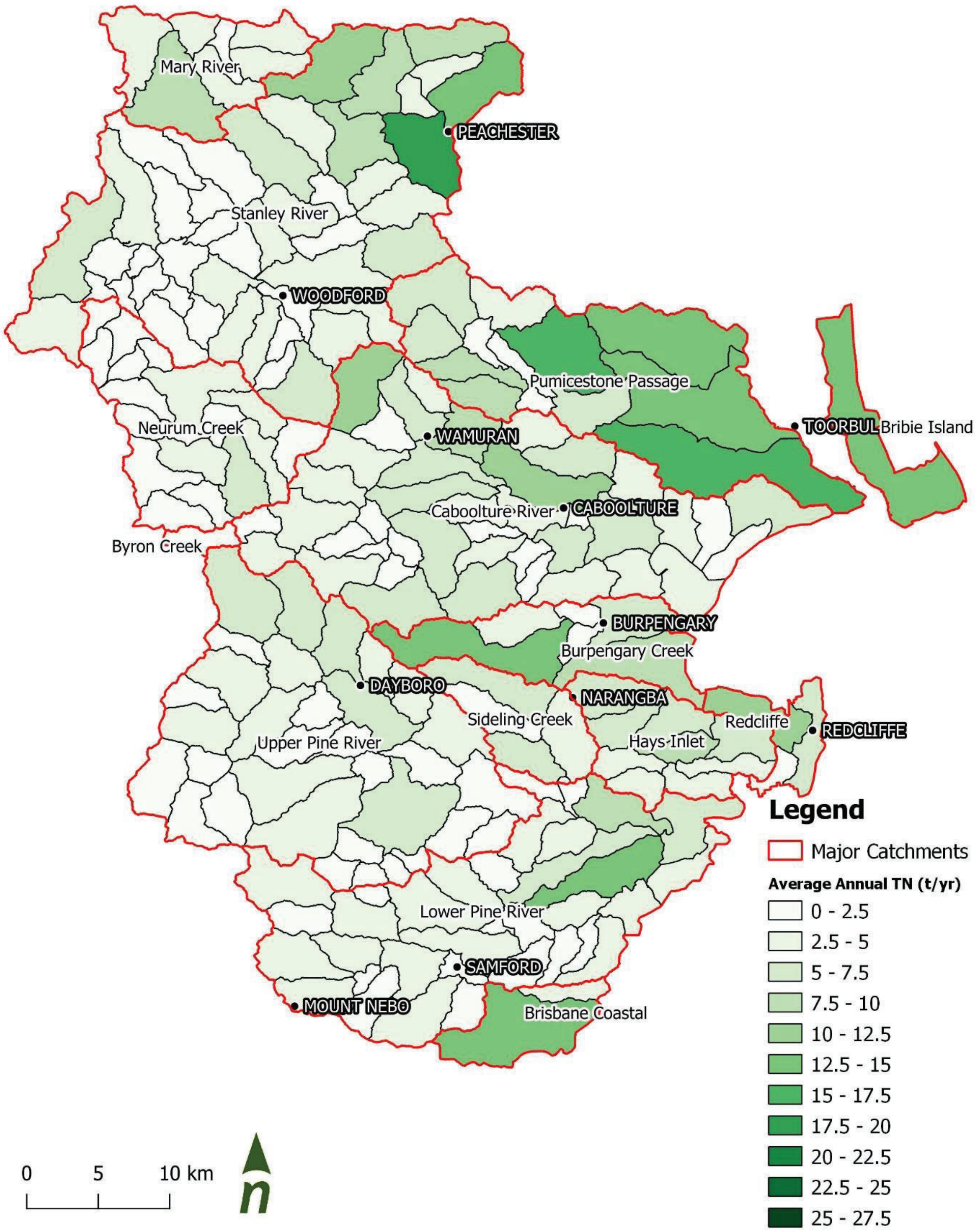


Figure 7. *Existing scenario - average annual total nitrogen (TN)*

MBRC Catchment – TN
Cohort 1 Scenario (2021)

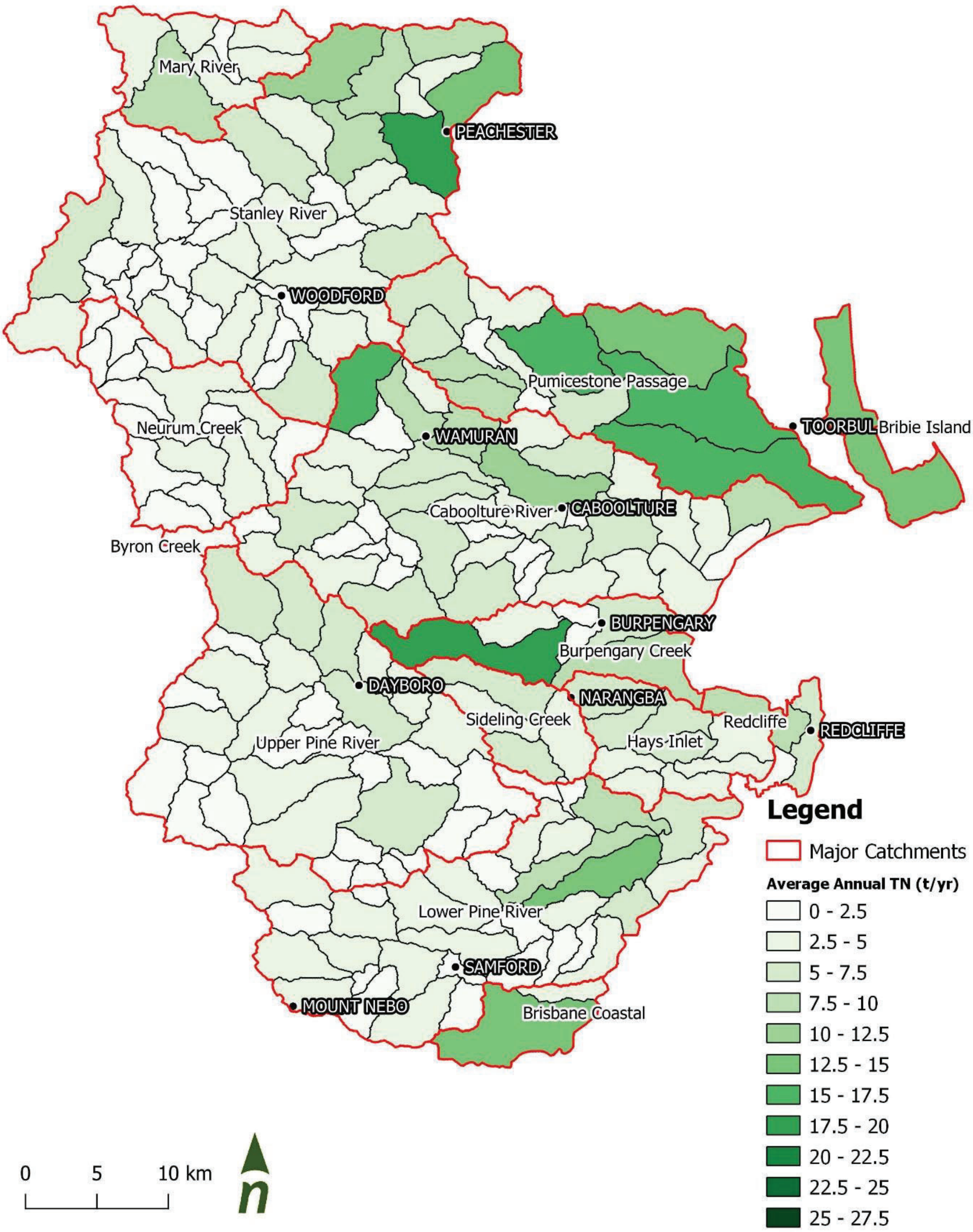


Figure 8. *Cohort 1 scenario - average annual total nitrogen (TN)*

MBRC Catchment – TN
Cohort 2 Scenario (2026)

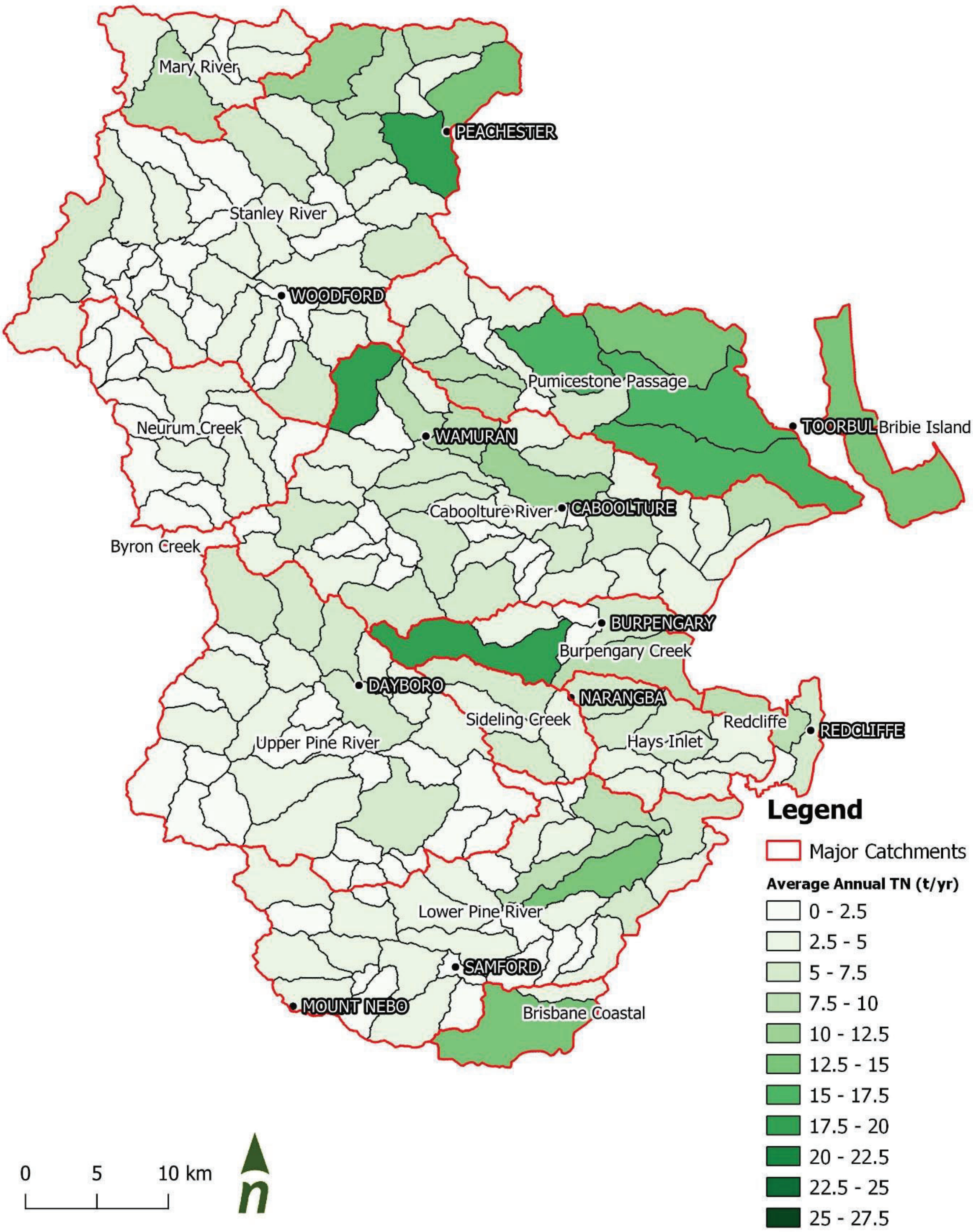


Figure 9. *Cohort 2 scenario - average annual total nitrogen (TN)*

MBRC Catchment – TN
Cohort 3 Scenario (2031)

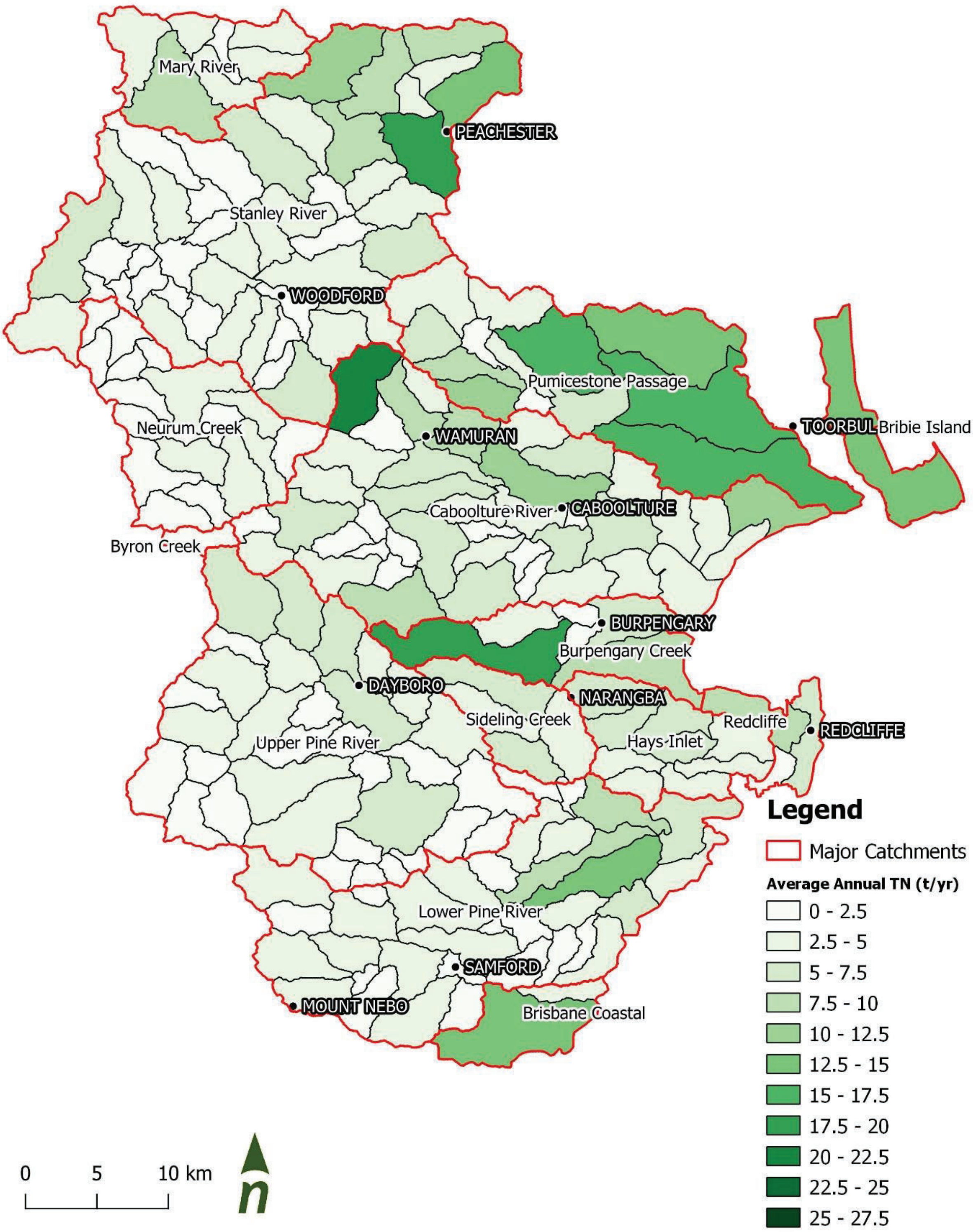


Figure 10. *Cohort 3 scenario - average annual total nitrogen (TN)*

MBRC Catchment – TN
Cohort 4 Scenario (2036)

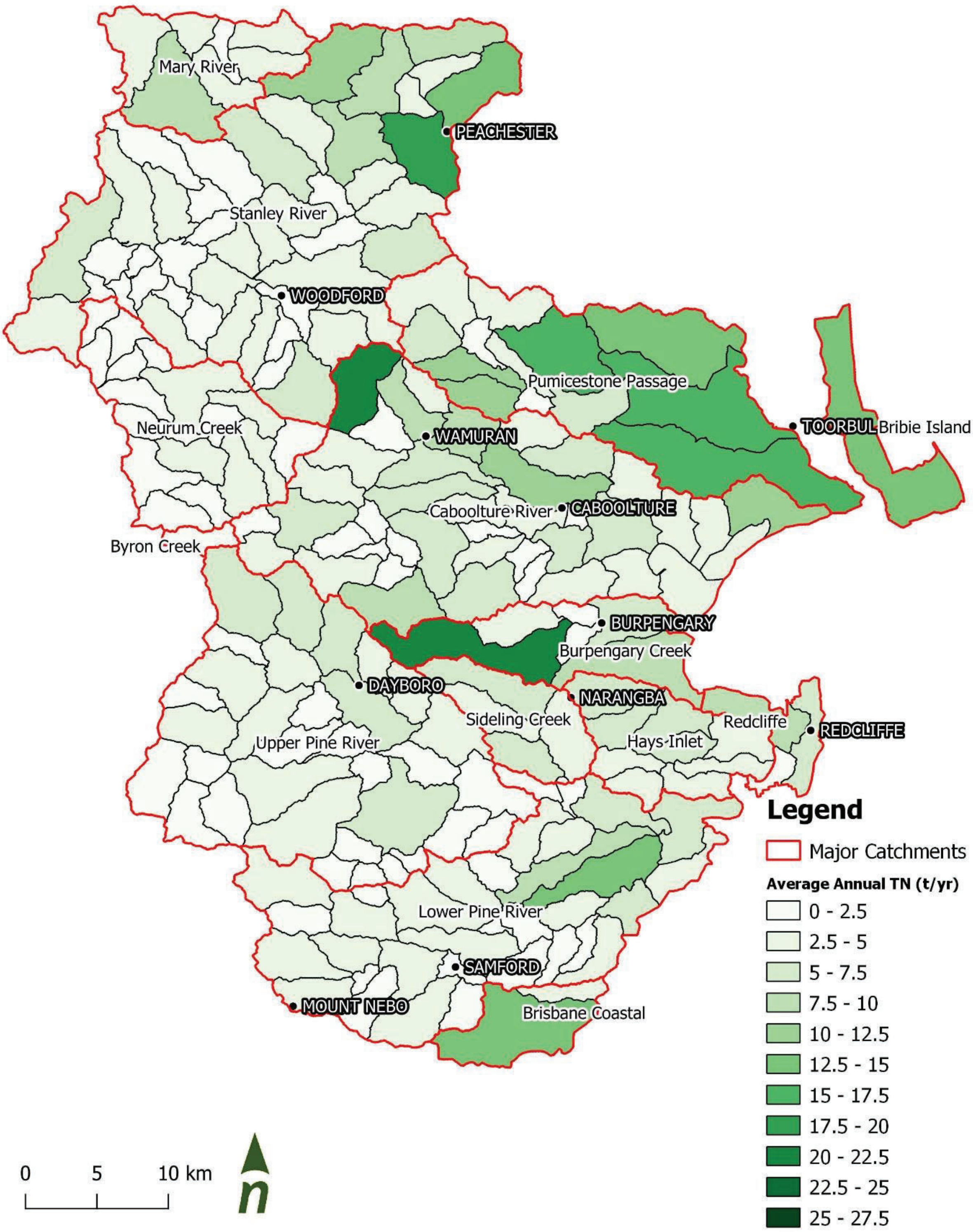


Figure 11. *Cohort 4 scenario - average annual total nitrogen (TN)*

MBRC Catchment – TN
Ultimate Scenario (>2036)

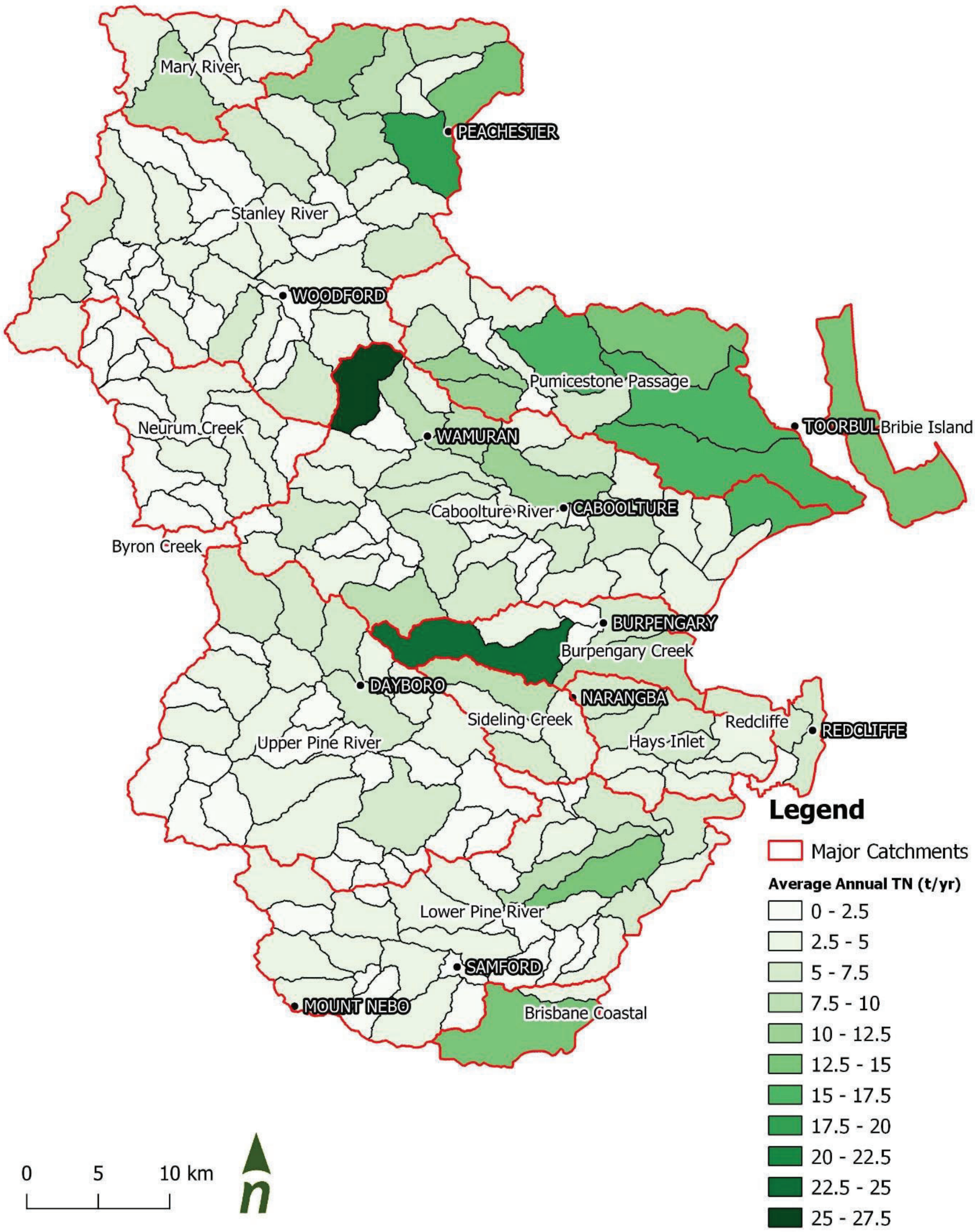


Figure 12. *Ultimate scenario - average annual total nitrogen (TN)*

MBRC Catchment – TP
Existing Scenario (2016)

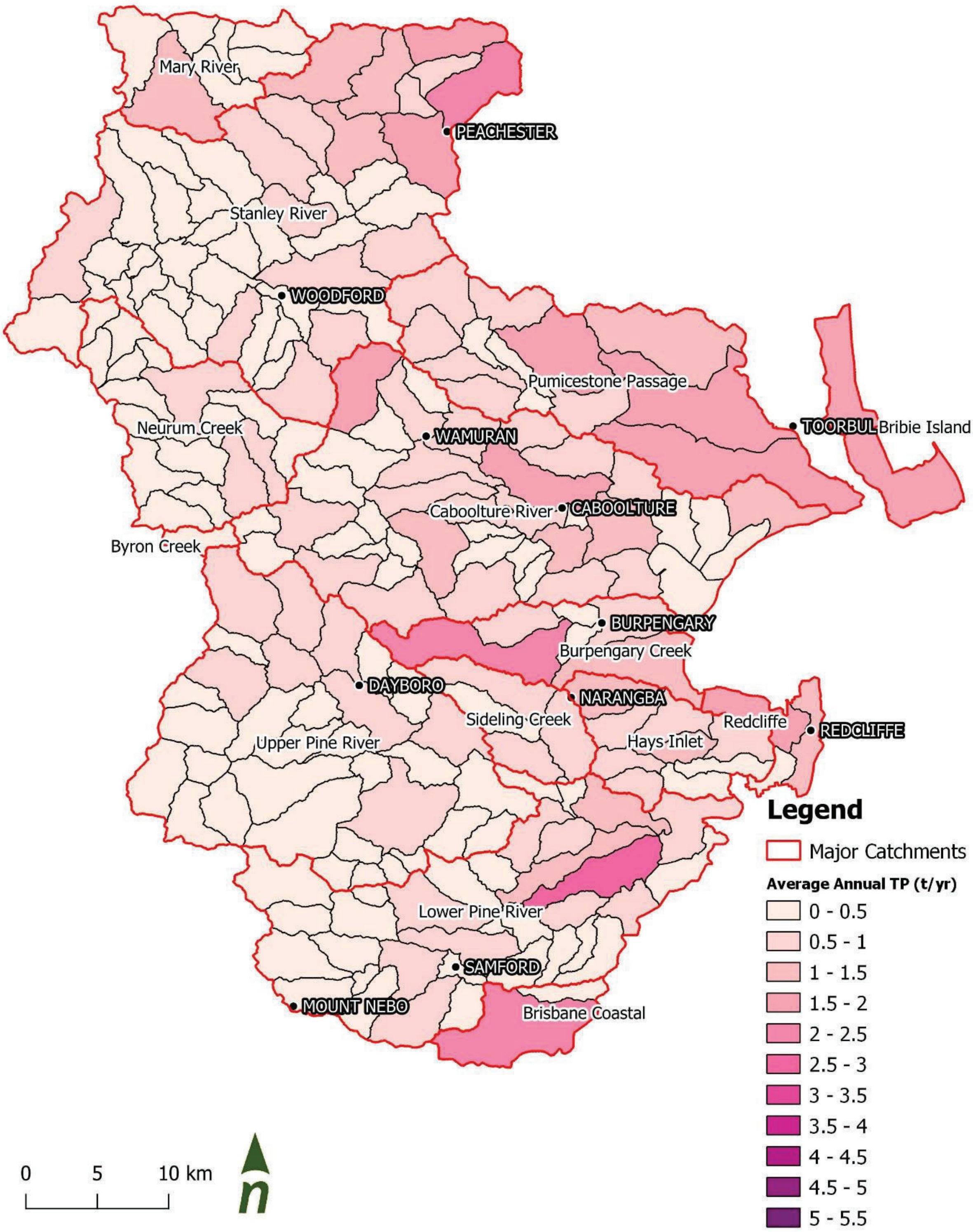


Figure 13. *Existing scenario - average annual total phosphorus (TP)*

MBRC Catchment – TP
Cohort 1 Scenario (2021)

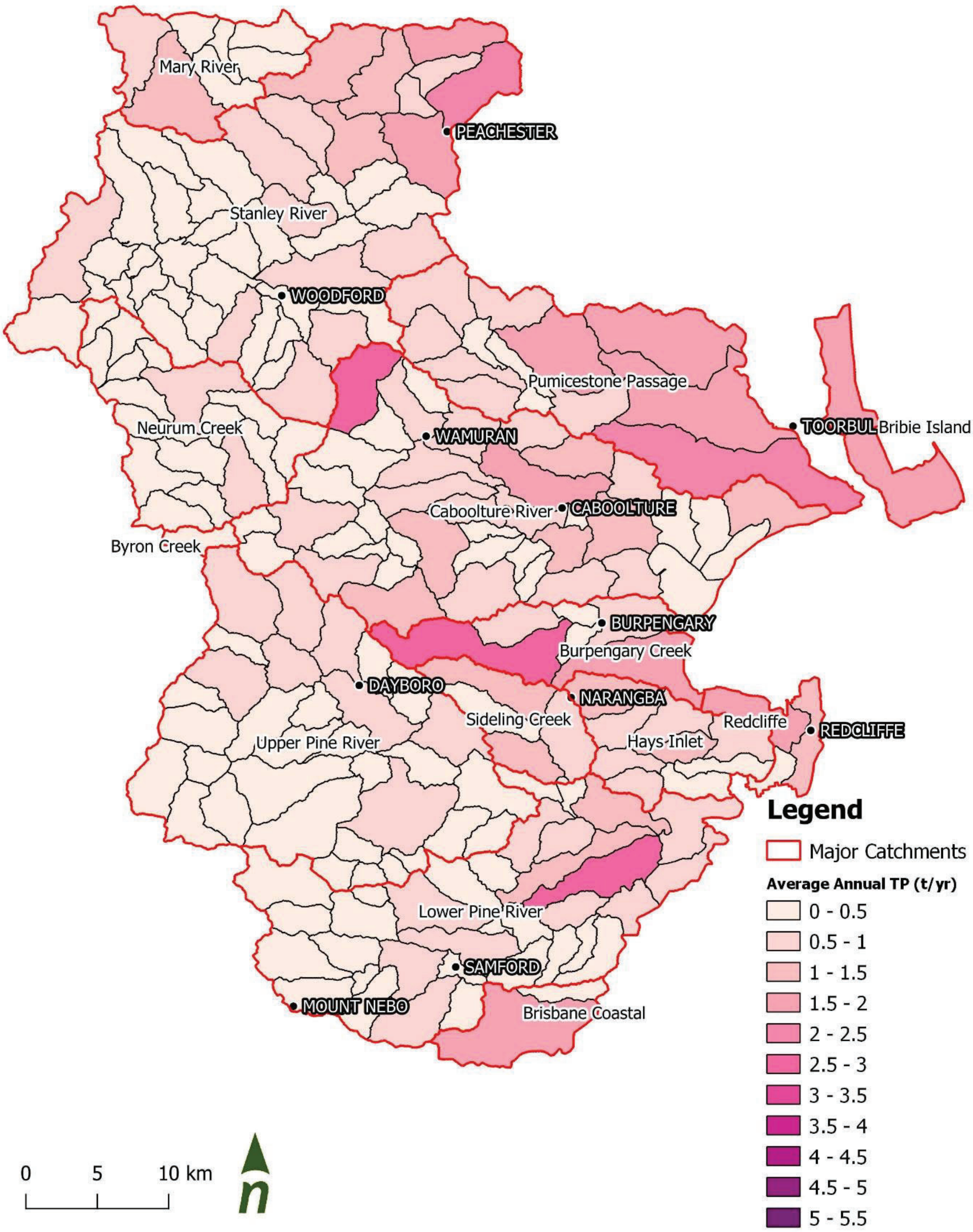


Figure 14. *Cohort 1 scenario - average annual total phosphorus (TP)*

MBRC Catchment – TP
Cohort 2 Scenario (2026)

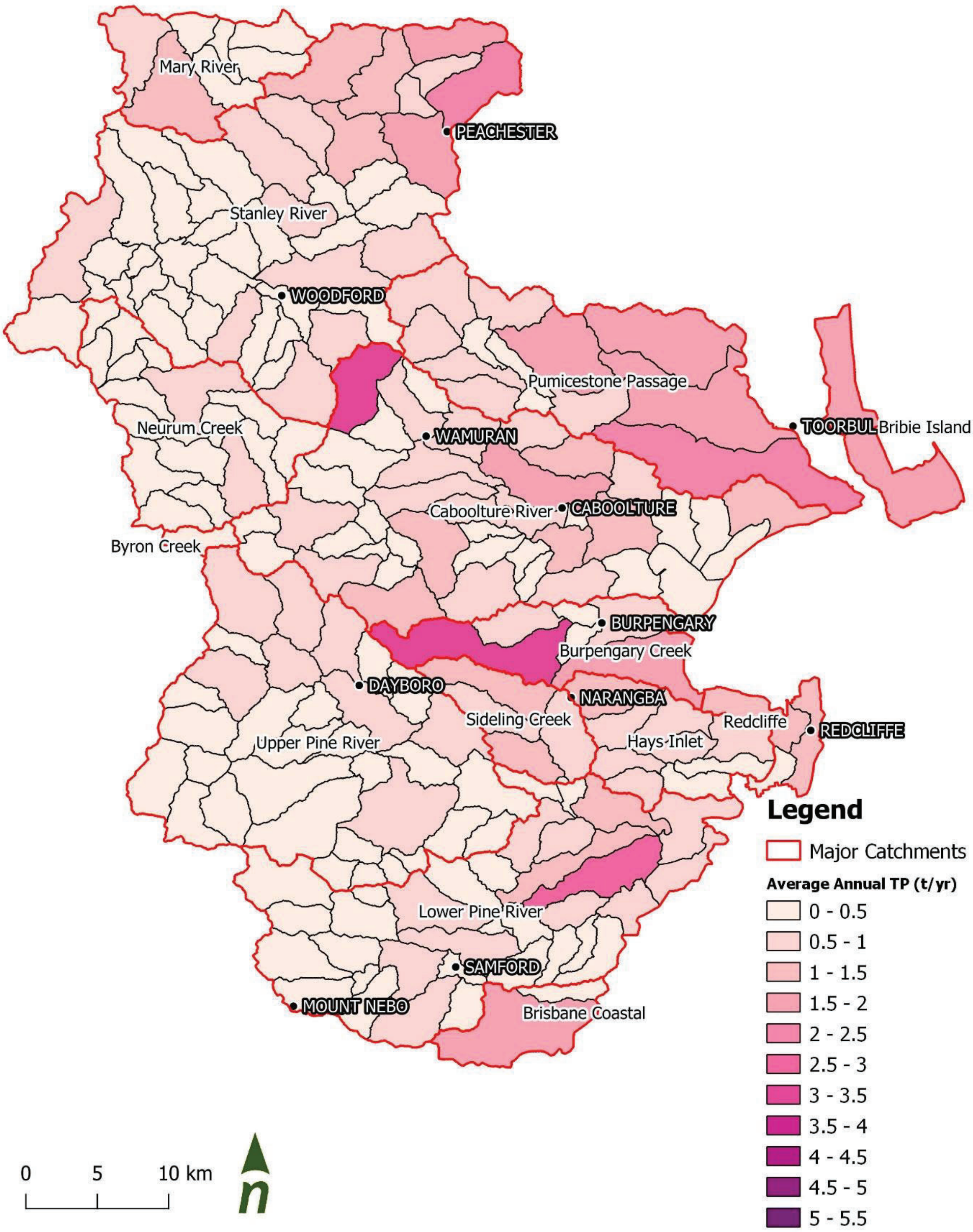


Figure 15. *Cohort 2 scenario - average annual total phosphorus (TP)*

MBRC Catchment – TP
Cohort 3 Scenario (2031)

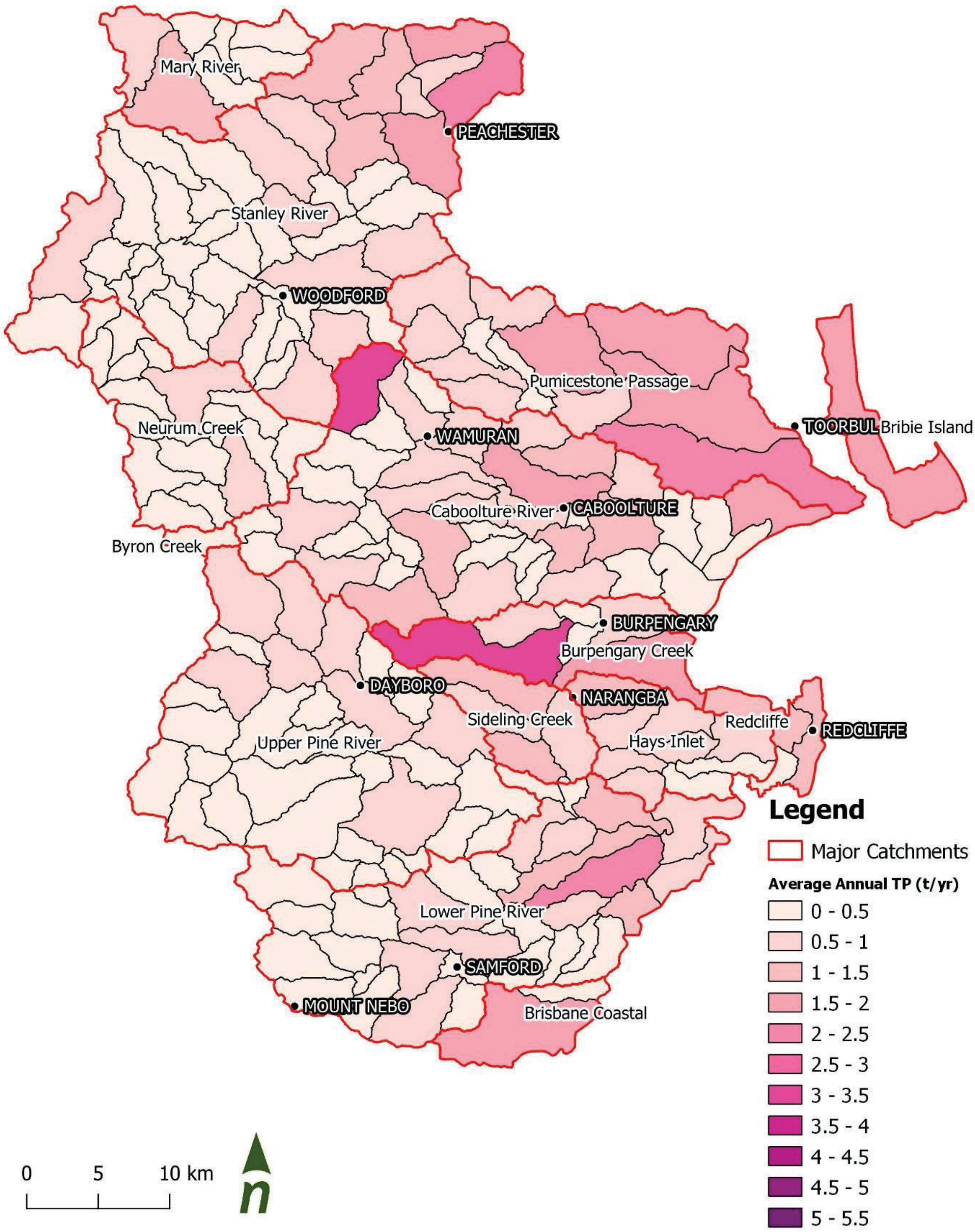


Figure 16. *Cohort 3 scenario - average annual total phosphorus (TP)*

MBRC Catchment – TP
Cohort 4 Scenario (2036)

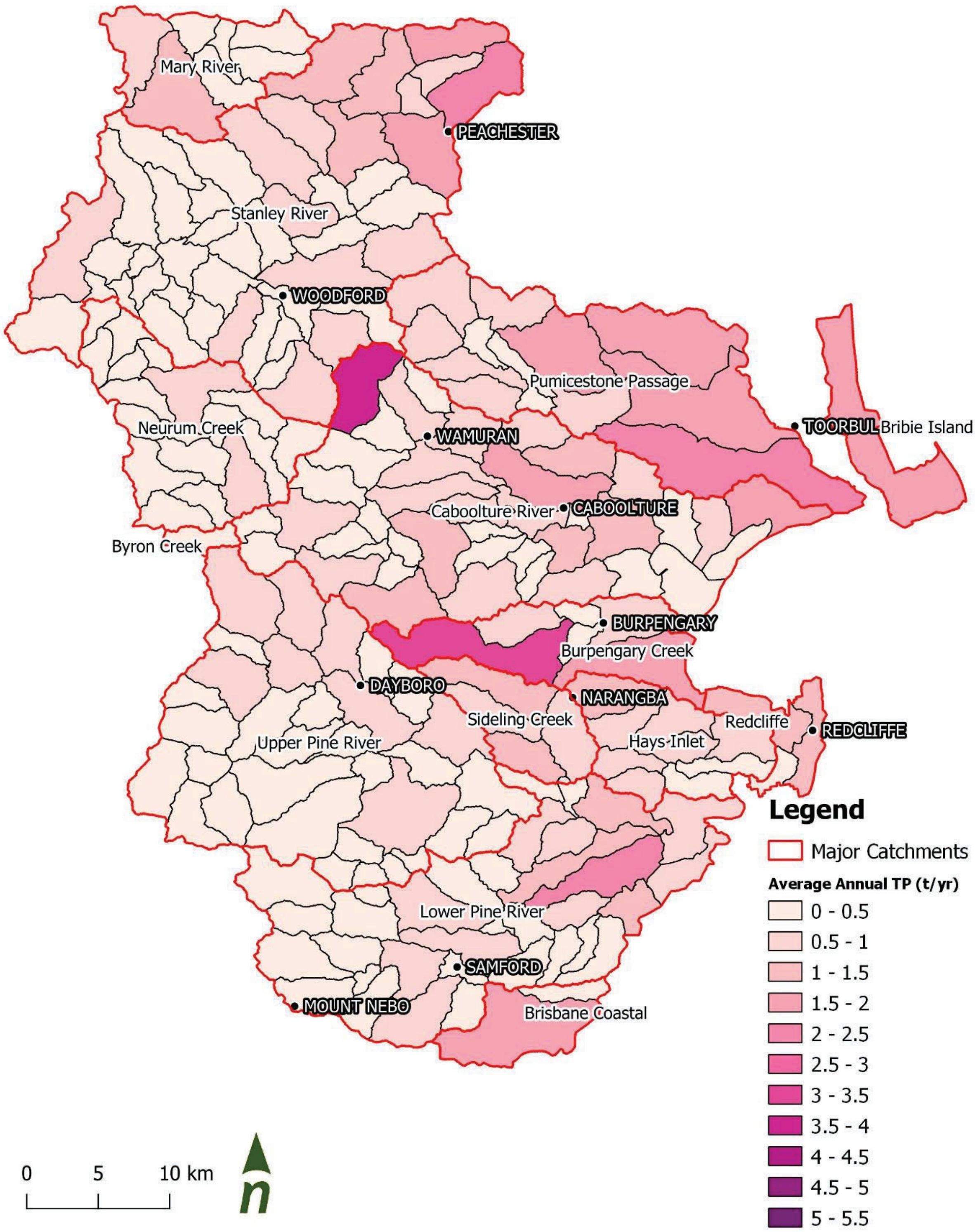


Figure 17. *Cohort 4 scenario - average annual total phosphorus (TP)*

MBRC Catchment – TP
Ultimate Scenario (>2036)

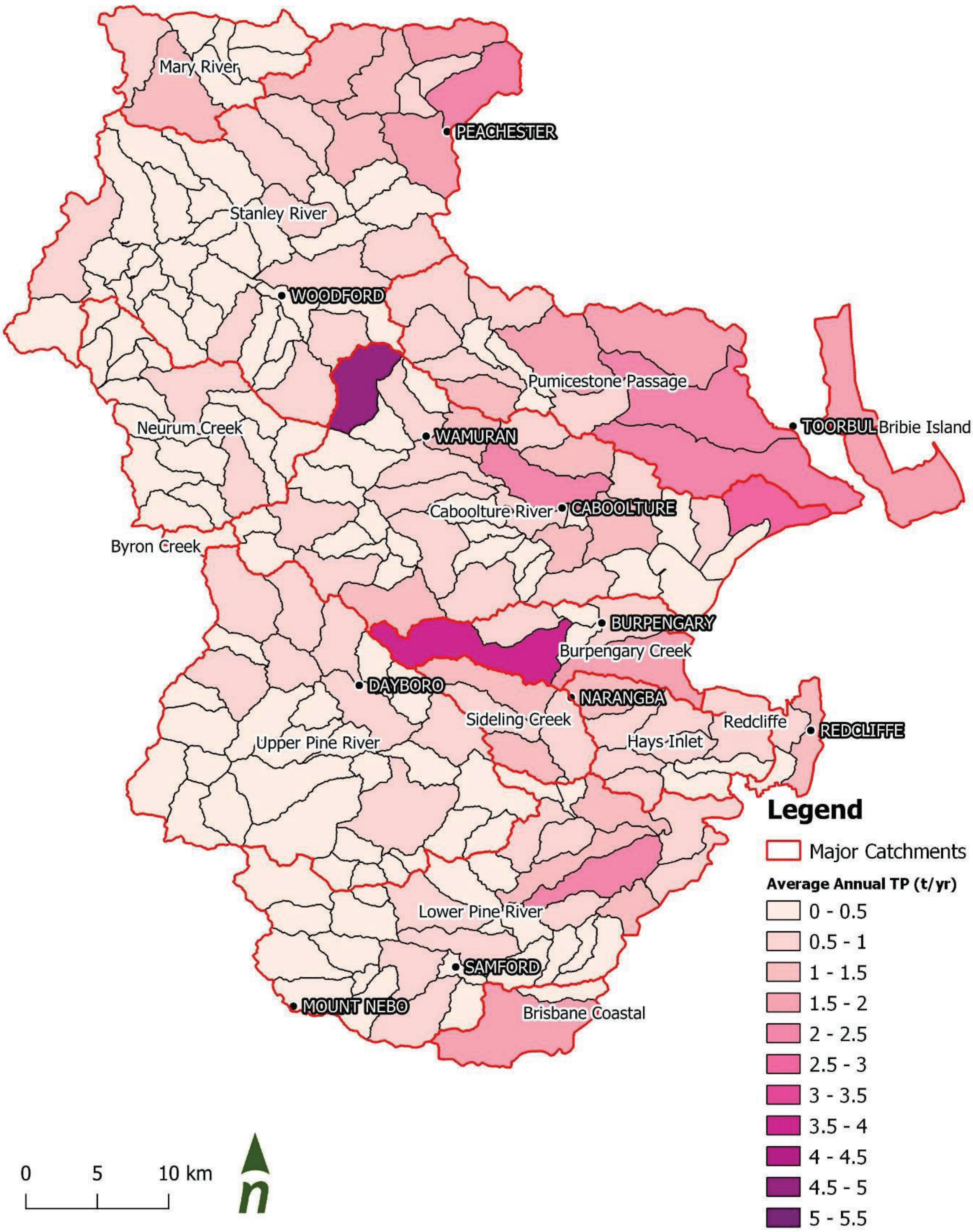


Figure 18. *Ultimate scenario - average annual total phosphorus (TP)*

MBRC Catchment – TSS
Existing Scenario (2016)

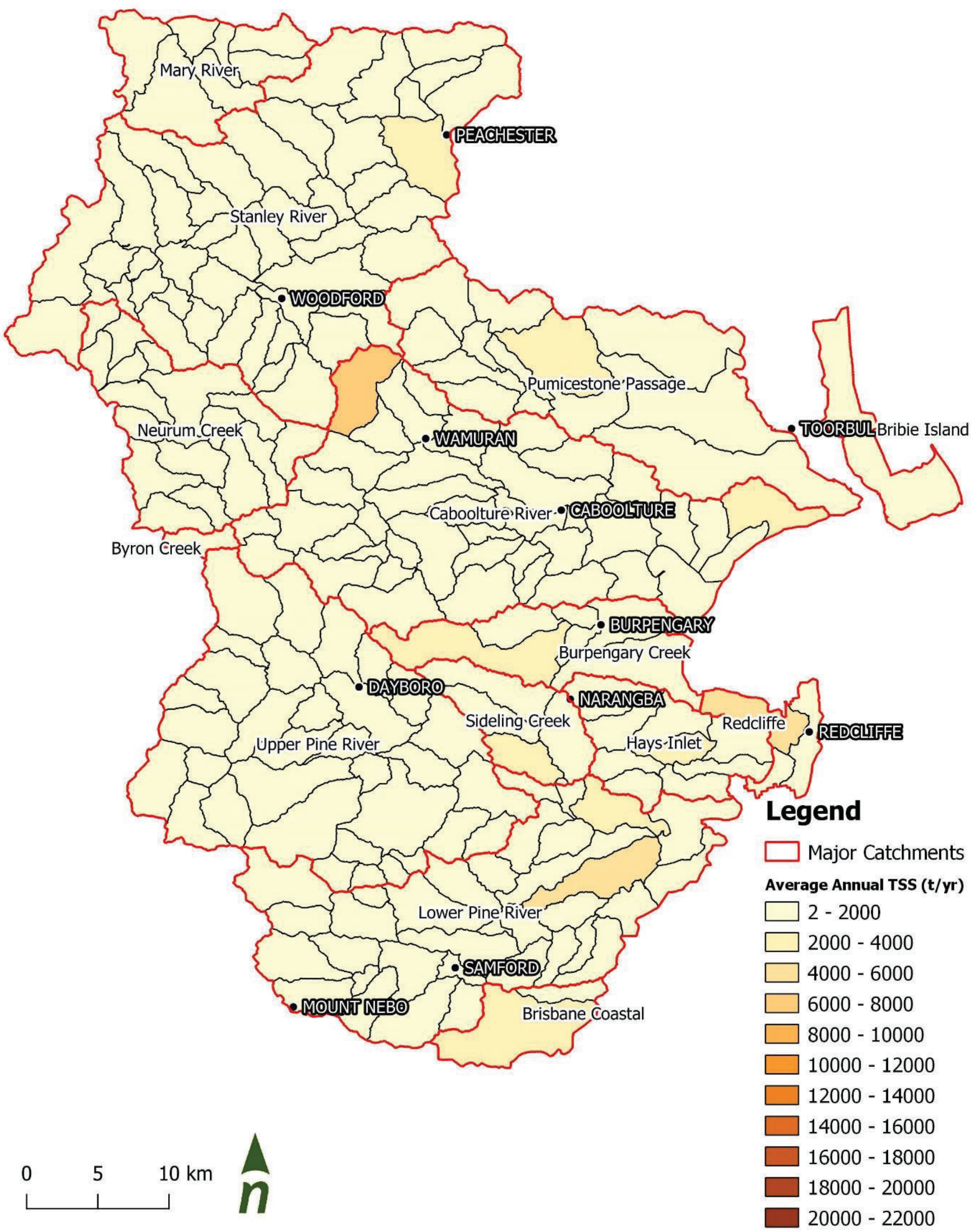


Figure 19. *Existing scenario - average annual total suspended solids (TSS)*

MBRC Catchment – TSS
Cohort 1 Scenario (2021)

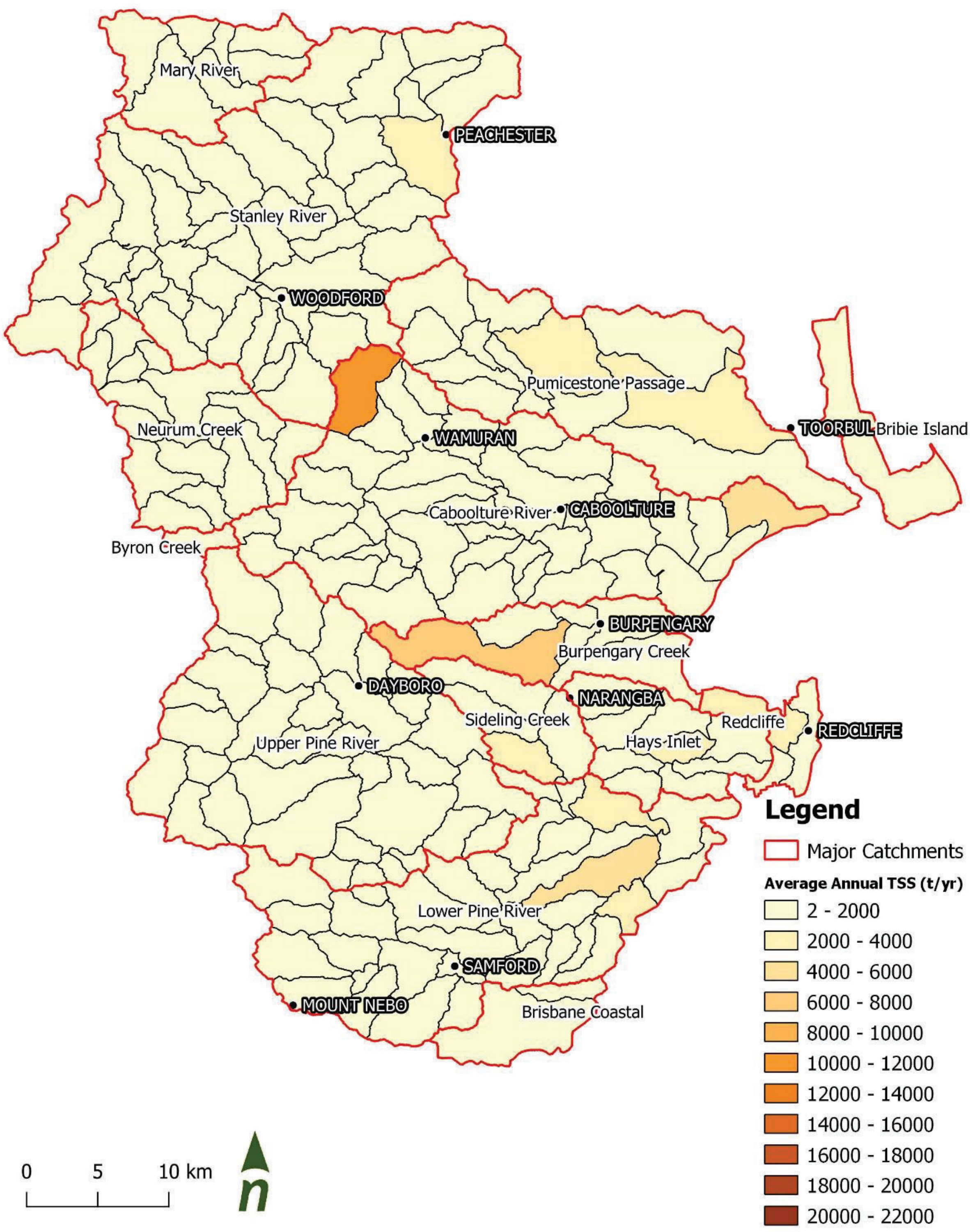


Figure 20. *Cohort 1 scenario - average annual total suspended solids (TSS)*

MBRC Catchment – TSS
Cohort 2 Scenario (2026)

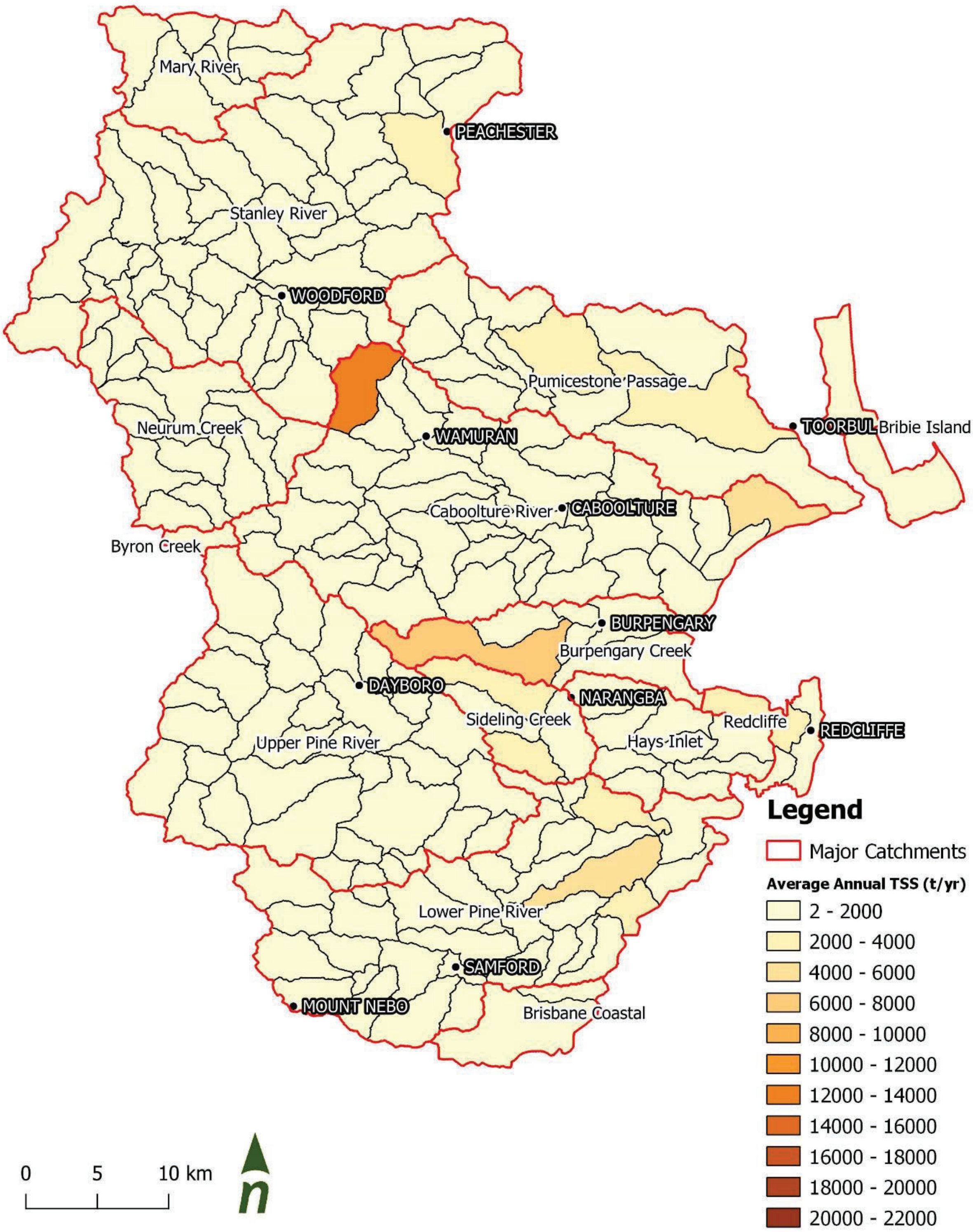


Figure 21. *Cohort 2 scenario - average annual total suspended solids (TSS)*

MBRC Catchment – TSS
Cohort 3 Scenario (2031)

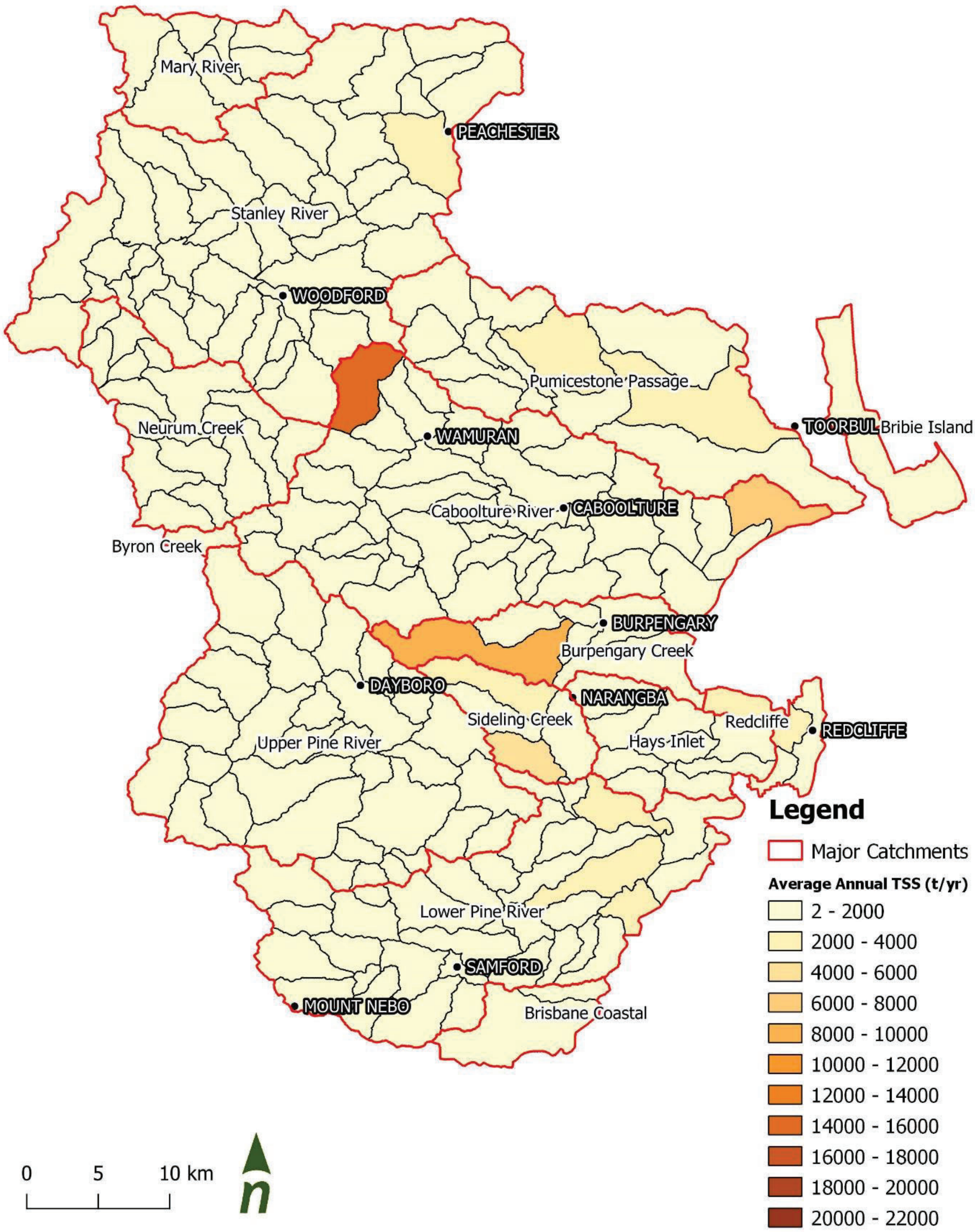


Figure 22. *Cohort 3 scenario - average annual total suspended solids (TSS)*

MBRC Catchment – TSS
Cohort 4 Scenario (2036)

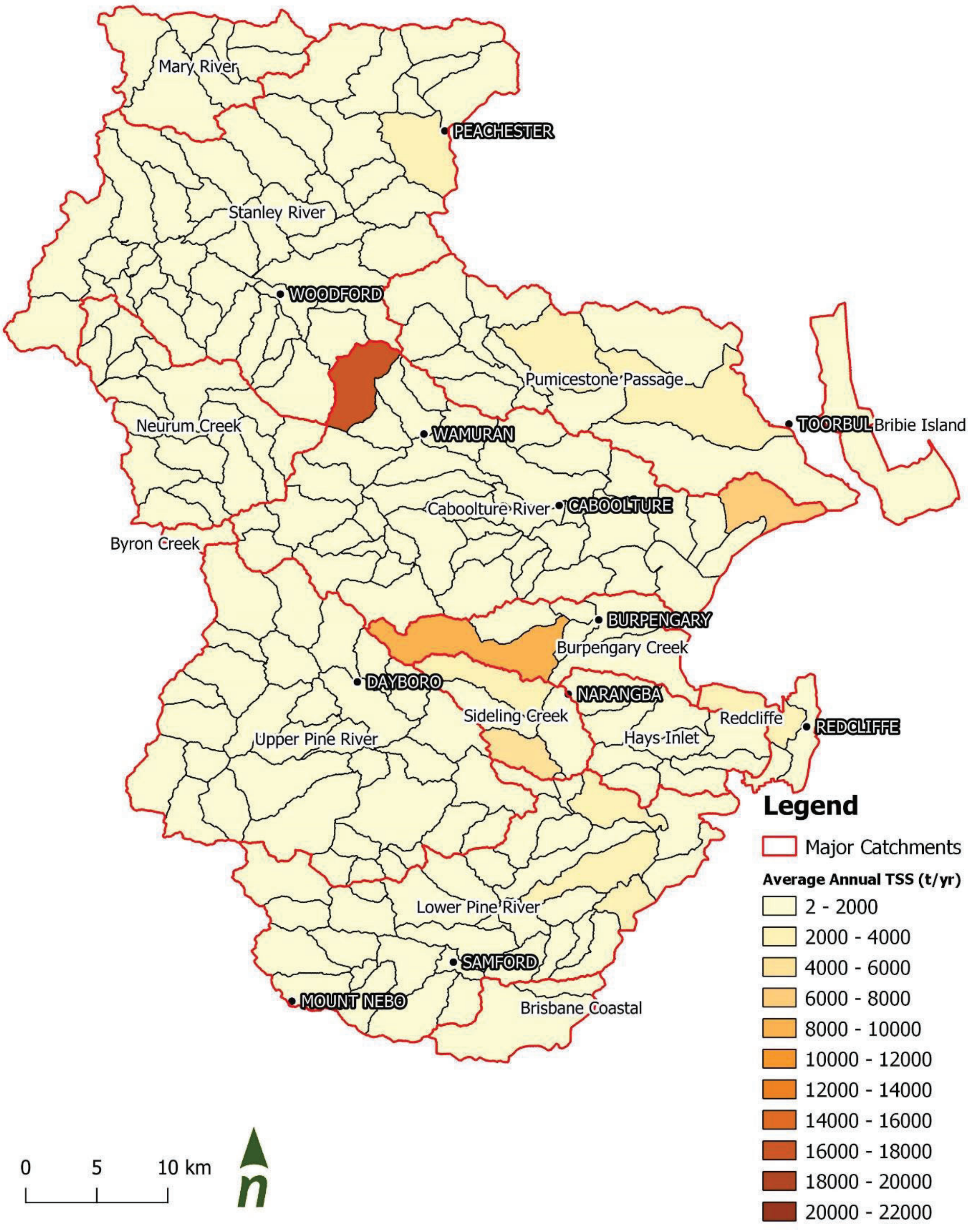


Figure 23. *Cohort 4 scenario - average annual total suspended solids (TSS)*

MBRC Catchment – TSS
Ultimate Scenario (>2036)

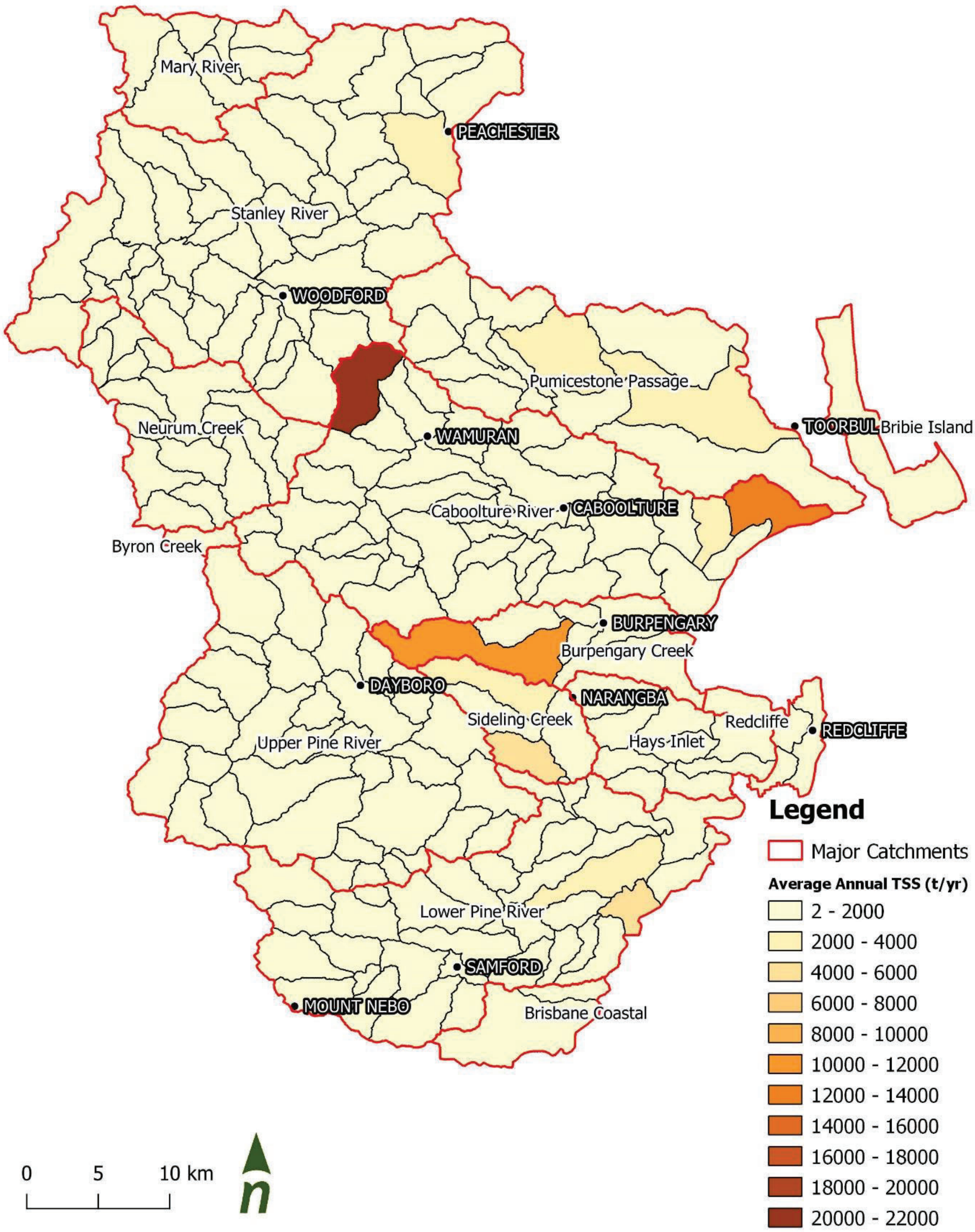


Figure 24. *Ultimate scenario - average annual total suspended solids (TSS)*

Appendix C Sites Excluded from Assessment

Table C-1 lists the sites excluded from further assessment, as they treat stormwater outside of the Priority Infrastructure Area.

Table C-1 Sites Excluded Outside of PIA

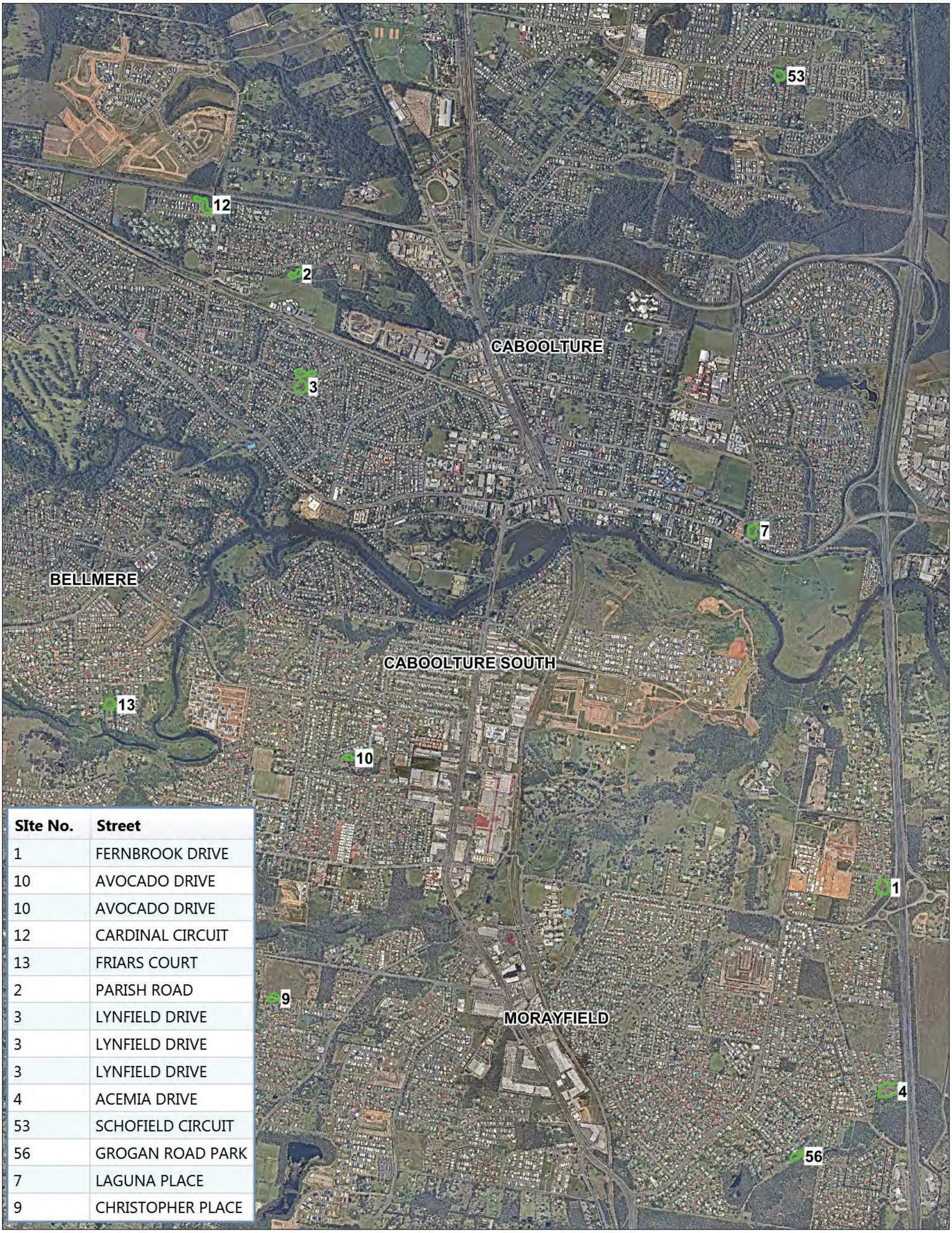
Reference	Description
PUM_CW01	Constructed wetland on private property, Pumicestone
PUM_CW02	Constructed wetland on private property, Pumicestone
CAB_CW01	Constructed Wetland, Childs Road Caboolture
CAB_CW02	Constructed Wetland, Limburg Avenue Caboolture
CAB_CW03	Constructed Wetland, Beerburrum Road Caboolture
CAB_CW11	Constructed Wetland, Darley Road Park Caboolture
CAB_CW13	Constructed Wetland, Cobb Road Burpengary
CAB_CW14	Constructed Wetland, Robbs Rd, Morayfield
CAB_CW15	Constructed Wetland, Williamson Road Burpengary
LPR_CW08	Constructed Wetland, Old North Road Strathpine
LPR_CW10	Constructed Wetland, Leitchs Road Brendale
BUR_CW01	Constructed Wetland, Moorina Road Morayfield
BUR_CW04	Constructed Wetland, Bassett Road Burpengary
BUR_CW05	Constructed Wetland, Old Gympie Road Burpengary

Appendix D Traffic Light Assessment Results

Asset ID	LGIP Assessment ID	Score	Asset ID	LGIP Assessment ID	Score	Asset ID	LGIP Assessment ID	Score
UPR_CW01	UPR_CW01	7	9	CAB_CW09	7	CAB_CW11	CAB_CW11	5
BUR_WR04	BUR_WR04	7	12		7	CAB_CW14	CAB_CW14	5
BUR_WR05	BUR_WR05	7	13		7	BUR_CW02	BUR_CW02	5
BUR_WR06b	BUR_WR06b	7	53		7	BUR_CW06	BUR_CW06	5
BUR_WR10	BUR_WR10	7	56		7	LPR_CW03	LPR_CW03	5
BUR_WR12	BUR_WR12	7	10a	CAB_NCD10	7	LPR_CW11	LPR_CW11	5
HAY_WR06	HAY_WR06	7	10b	CAB_NCD10	7	LPR_WR16	LPR_WR16	5
HAY_WR09	HAY_WR09	7	3a	CAB_BB03	7	RED_WR03	RED_WR03	5
HAY_WR10	HAY_WR10	7	3c	CAB_BB03	7	55	CAB_NCD55	5
HAY_WR12	HAY_WR12	7	3b	CAB_BB03	7	BCC_CW01	BCC_CW01	4
HAY_WR13	HAY_WR13	7	BUR_WR07		6	LPR_CW07	LPR_CW07	4
HAY_WR15	HAY_WR15	7	6		6	LPR_CW10	LPR_CW10	4
HAY_WR17	HAY_WR17	7	54	CAB_BB54	6	PUM_CW01	PUM_CW01	4
HAY_WR18	HAY_WR18	7	CAB_CW16	CAB_CW16	6	PUM_CW02	PUM_CW02	4
LPR_WR04	LPR_WR04	7	BUR_WR01	BUR_WR01	6	CAB_CW04	CAB_CW04	5
LPR_WR05	LPR_WR05	7	BUR_WR03	BUR_WR03	6	CAB_CW15	CAB_CW15	4
LPR_WR07	LPR_WR07	7	BUR_WR06a	BUR_WR06a	6	LPR_CW01	LPR_CW01	4
LPR_WR09	LPR_WR09	7	BUR_WR11	BUR_WR11	6	BUR_CW03	BUR_CW03	3
LPR_WR11	LPR_WR11	7	BUR_WR13	BUR_WR13	6	BUR_CW04	BUR_CW04	3
LPR_WR13	LPR_WR13	7	HAY_WR01	HAY_WR01	6	BUR_CW05	BUR_CW05	3
LPR_WR14	LPR_WR14	7	HAY_WR02	HAY_WR02	6	LPR_CW04	LPR_CW04	3
LPR_WR15	LPR_WR15	7	HAY_WR05	HAY_WR05	6	LPR_CW05	LPR_CW05	3
LPR_WR17	LPR_WR17	7	HAY_WR07	HAY_WR07	6	LPR_CW08	LPR_CW08	3
LPR_WR18	LPR_WR18	7	HAY_WR16	HAY_WR16	6	LPR_CW09	LPR_CW09	3
LPR_WR20	LPR_WR20	7	LPR_WR21	LPR_WR21	6	CAB_CW01	CAB_CW01	3
LPR_WR23	LPR_WR23	7	RED_WR01	RED_WR01	6	CAB_CW03	CAB_CW03	3
LPR_WR24	LPR_WR24	7	11		6	CAB_CW07	CAB_CW07	3
RED_WR02	RED_WR02	7	CAB_WR2	CAB_WR2	6	CAB_CW10	CAB_CW10	3
1		7	CAB_WR21	CAB_WR21	6	CAB_CW13	CAB_CW13	3
2	CAB_NCD02	7	CAB_WR23	CAB_WR23	6	BUR_CW01	BUR_CW01	2
4		7	LPR_CW02	LPR_CW02	5	LPR_CW06	LPR_CW06	2
5		7	LPR_WR08	LPR_WR08	5	LPR_CW12	LPR_CW12	2
7		7	LPR_WR19	LPR_WR19	5	CAB_CW02	CAB_CW02	2

Indicates removed due to Council comments/site constraints

Appendix E Site Inspections



SIte No.	Street
1	FERNBROOK DRIVE
10	AVOCADO DRIVE
10	AVOCADO DRIVE
12	CARDINAL CIRCUIT
13	FRIARS COURT
2	PARISH ROAD
3	LYNFIELD DRIVE
3	LYNFIELD DRIVE
3	LYNFIELD DRIVE
4	ACEMIA DRIVE
53	SCHOFIELD CIRCUIT
56	GROGAN ROAD PARK
7	LAGUNA PLACE
9	CHRISTOPHER PLACE

Site Inspections

LEGEND

Bioretention Site

N

0 500 1,000m

Approx. Scale

Site 1 - Fernbrook Drive, Morayfield

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 2 - Parish Road, Caboolture

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 3 - Lynfield Drive, Caboolture

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 4 - Acemia Drive, Morayfield	LEGEND	
	Drainage Stormwater Pipes Bioretention Site	N 0 20 40m Approx. Scale

Site 7 - Laguna Place, Caboolture

LEGEND

- Drainage
- Stormwater Pipes
- Bioretention Site

N

0 20 40m

Approx. Scale

Site 9 - Christopher Place, Morayfield

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 10 - Avocado Drive, Caboolture South

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 12 - Cardinal Circuit, Caboolture

LEGEND

- **Drainage**
- **Stormwater Pipes**
- **Bioretention Site**

N

0 20 40m

Approx. Scale

Site 13 - Friarscourt Road, Bellmere

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 53 - Schofield Circuit, Caboolture

LEGEND

Drainage

Stormwater Pipes

Bioretention Site

N

0 20 40m

Approx. Scale

Site 56 - Grogan Road Park, Morayfield

LEGEND

- Drainage
- Stormwater Pipes
- Bioretention Site

Site ID	Name
BUR_WR05	Caccini Crescent Park, Burpengary
BUR_WR06b	Symphony Crescent Park, Burpengary
BUR_WR12	Matterhorn Drive Park, Narangba
HAY_WR10	Mercury Parades Reserve, Mango Hill
HAY_WR12	Parsons Boulevard Park, Deception Bay
HAY_WR15	Lipscombe Road Park (South), Deception Bay
HAY_WR18	Carramar Reserve, Dakabin
LPR_WR07	Alleena Park, Bray Park
LPR_WR11	One Mile Golf Course Reserve, Joyner
LPR_WR13	Kupidabin Park, Samford Village
LPR_WR15	Bleakley Park, Albany Creek
LPR_WR17	H T Ireland Reserve, Eatons Hill
LPR_WR18	Branch Creek Road Park, Warner
LPR_WR23	Gary Jenkins Park, Petrie
RED_WR02	Plume park (North) Redcliffe

Site Inspections

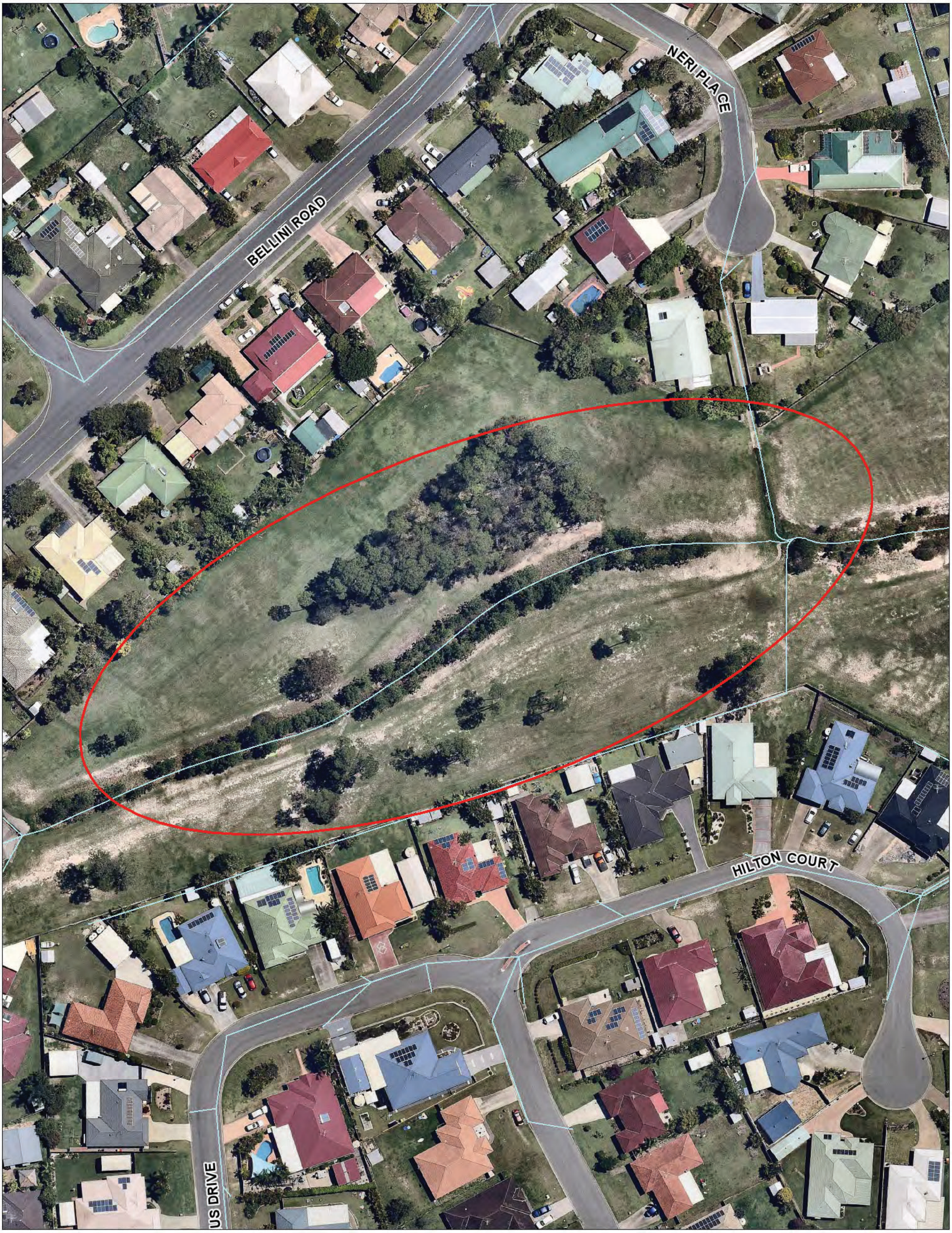
LEGEND

WSUD Opportunity

N

0 500 1,000m

Approx. Scale



BUR_WR05
Caccini Crescent Park, Burpengary

LEGEND

Waterway

Stormwater Drainage

WSUD Opportunity

N

0 20 40m

Approx. Scale

BUR_WR06b
Symphony Crescent Park, Burpengary

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

BUR_WR12
Matterhorn Drive Park, Narangba

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

HAY_WR12
Parsons Boulevard Park, Deception Bay

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

HAY_WR15
Lipscombe Road Park (South), Deception Bay

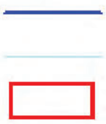
LEGEND

- Waterway
- Stormwater Drainage
- WSUD Opportunity

N

0 20 40m

Approx. Scale



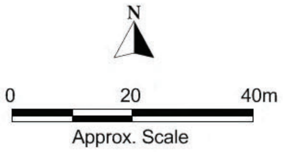
RED_WR02
Plume park (North) Redcliffe

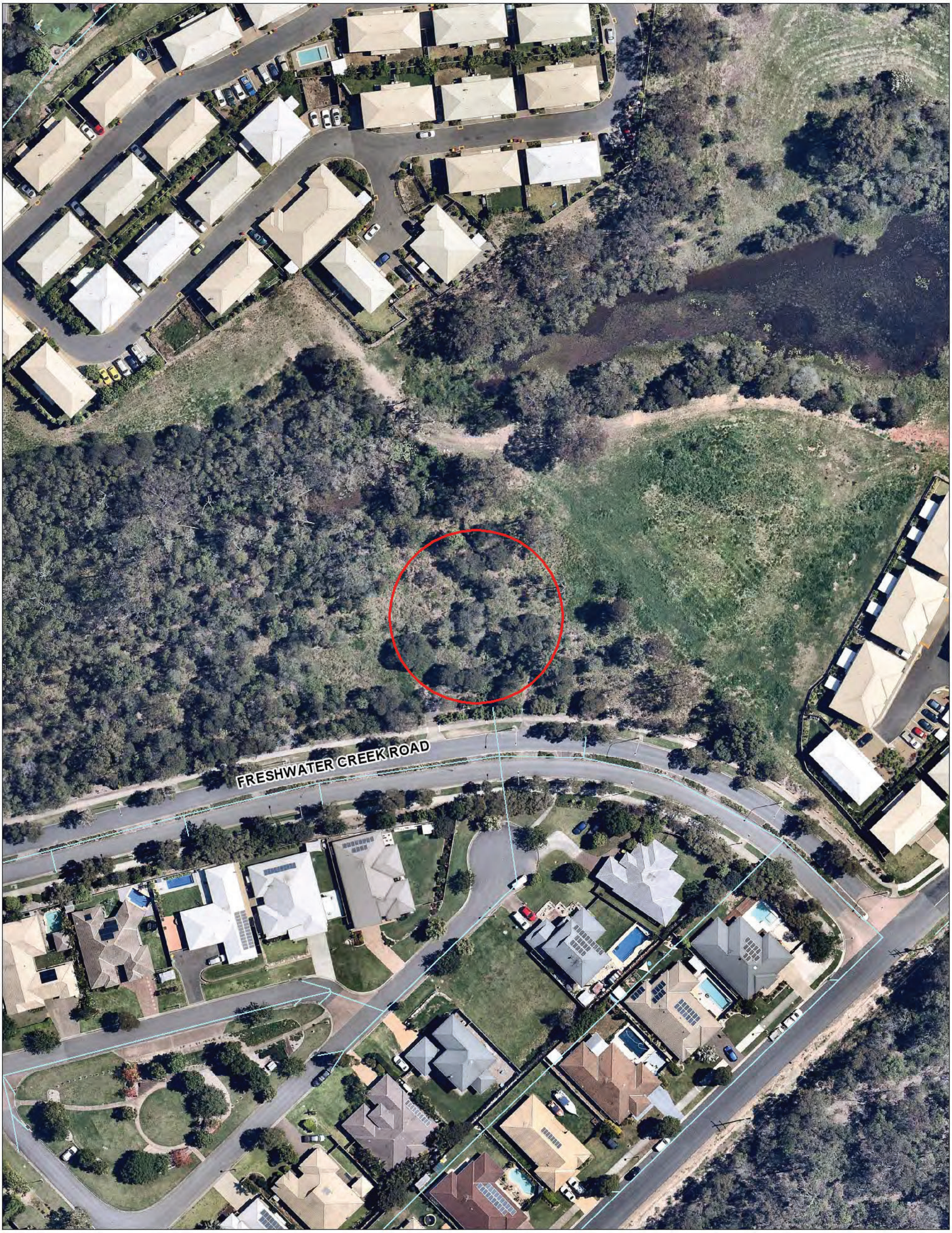
LEGEND

Waterway

Stormwater Drainage

WSUD Opportunity





HAY_WR10
Mercury Parades Reserve, Mango Hill

LEGEND

Waterway

Stormwater Drainage

WSUD Opportunity

N

0 20 40m

Approx. Scale

HAY_WR18
Carramar Reserve, Dakabin

LEGEND

- **Waterway**
- **Stormwater Drainage**
- **WSUD Opportunity**

N

0 20 40m

Approx. Scale

LPR_WR23
Gary Jenkins Park, Petrie

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N

0 20 40m
Approx. Scale

LPR_WR11
One Mile Golf Course Reserve, Joyner

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

LPR_WR18
Branch Creek Road Park, Warner

LEGEND

Waterway

Stormwater Drainage

WSUD Opportunity

N

0 20 40m

Approx. Scale

LPR_WR07
Alleena Park, Bray Park

LEGEND

Waterway

Stormwater Drainage

WSUD Opportunity

N

0 20 40m

Approx. Scale

LPR_WR17
H T Ireland Reserve, Eatons Hill

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N

0 20 40m
Approx. Scale

LPR_WR15
Bleakley Park, Albany Creek

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

LPR_WR13
Kupidabin Park, Samford Village

LEGEND
Waterway
Stormwater Drainage
WSUD Opportunity

N
0 20 40m
Approx. Scale

Appendix F Schedule of Works

Table F-1 Schedule of Works, Stormwater Quality Infrastructure

LGIP ID	Location	Service Catchment	Infrastructure Type	Treatment Area (m2)	CAPEX (aquistion cost)	Acquisition Costs ($2020)	Estimated Timing	5 Year cohort
BUR_WR12	Matterhorn Drive Park, Narangba	Burpengary Creek	Ephemeral Wetland	5,400	$ 934,200	$ 934,200	2021	2026-2031
CAB_BB03	Lynfield Drive Park, Caboolture	Caboolture River	Bioretention Basin	3,360	$ 1,081,920	$ 1,081,900	2021	2026-2031
CAB_RV01	Bel Air Estate Park, Bellmere	Caboolture River	Rehabilitation and Revegetation	7,766	$ 137,225	$ 137,200	2021	2021-2026
CAB_RV20	Visentin Road Park, Morayfield	Caboolture River	Rehabilitation and Revegetation	48,333	$ 854,044	$ 854,000	2021	2031-2036
CAB_RV03	3 Mainsail Drive, Caboolture Sth	Caboolture River	Rehabilitation and Revegetation	10,077	$ 178,061	$ 178,100	2021	2026-2031
BUR_WR11	May St Park, Deception Bay	Burpengary Creek	Bioretention Basin	585	$ 188,370	$ 188,400	2022	2021-2026
CAB_BB54	Wararba Cres, Caboolture	Caboolture River	Bioretention Basin	1,000	$ 322,000	$ 322,000	2022	2026-2031
CAB_WR21	Beech Drive Park, Morayfield	Caboolture River	Constructed Wetland	3,533	$ 713,666	$ 713,700	2022	2021-2026
CAB_RV13	Beech Drive Park, Morayfield	Caboolture River	Rehabilitation and Revegetation	17,294	$ 305,585	$ 305,600	2022	2026-2031
CAB_RV02	Allan Road Park, Bellmere	Caboolture River	Rehabilitation and Revegetation	21,077	$ 372,431	$ 372,400	2022	2031-2036
LPR_RV6	Tweedale Reserve, Petrie	Lower Pine River	Rehabilitation and Revegetation	5,771	$ 101,974	$ 102,000	2022	2031-2036
BUR_WR06b	Symphony Crescent Park, Burpengary	Burpengary Creek	Natural Channel Design	5,900	$ 3,290,725	$ 3,290,700	2023	2026-2031
CAB_NCD55	The Billabongs Parkland, Morayfield	Caboolture River	Natural Channel Design	2,650	$ 1,478,038	$ 1,478,000	2023	2026-2031
LPR_WR15	Bleakley Park, Albany Creek	Lower Pine River	Bioretention Basin	1,100	$ 354,200	$ 354,200	2023	2026-2031
LPR_WR13	Kupidabin Park, Samford Village	Lower Pine River	Ephemeral Wetland	2,400	$ 415,200	$ 415,200	2023	2026-2031
LPR_CW03	Normanby Way Strathpine	Lower Pine River	Constructed Wetland	7,067	$ 1,427,534	$ 1,427,500	2024	2021-2026
CAB_RV19	Shangrila Street Park, Burpengary	Caboolture River	Rehabilitation and Revegetation	17,913	$ 316,523	$ 316,500	2025	2026-2031
LPR_CW01	Scouts Crossing Rd Park, Brendale	Lower Pine River	Constructed Wetland	14,593	$ 2,947,786	$ 2,947,800	2025	2026-2031
BUR_CW02	Burpengary Sportsgrounds, Burpengary	Burpengary Creek	Constructed Wetland	13,400	$ 2,706,800	$ 2,706,800	2026	2021-2026
CAB_CW09	Christopher Place Park Morayfield	Caboolture River	Constructed Wetland	2,267	$ 457,934	$ 457,900	2026	2021-2026
CAB_CW04	Lower King St Park, Caboolture	Caboolture River	Constructed Wetland	38,800	$ 7,837,600	$ 7,837,600	2026	2021-2026
CAB_RV17	Havenwood Street Park, Burpengary	Caboolture River	Rehabilitation and Revegetation	4,637	$ 81,936	$ 81,900	2026	2031-2036
LPR_WR11	One Mile Golf Course Reserve, Joyner	Lower Pine River	Constructed Wetland	1,700	$ 343,400	$ 343,400	2026	2026-2031
LPR_WR18	Boxwood Court Park, Warner	Lower Pine River	Constructed Wetland	3,033	$ 612,666	$ 612,700	2026	2021-2026
UPR_NCD01	Tullamore Park, Dayboro	Upper Pine River	Natural Channel Design	2,250	$ 1,254,938	$ 1,254,900	2026	2021-2026
CAB_NCD04	Male Road Park, Caboolture	Caboolture River	Natural Channel Design	1,100	$ 613,525	$ 613,500	2027	2021-2026
CAB_WR2	Pinegrove Rd Park, Morayfield	Caboolture River	Natural Channel Design	1,450	$ 808,738	$ 808,700	2027	2021-2026
LPR_NCD01	Francis Road Drainage Reserve, Bray Park	Lower Pine River	Natural Channel Design	3,500	$ 1,952,125	$ 1,952,100	2027	2021-2026
BUR_CW06	Claverton Drive Park & Reserve, Burpengary	Burpengary Creek	Constructed Wetland	3,600	$ 727,200	$ 727,200	2028	2031-2036
CAB_NCD10	Kate McGrath's Koala Park, Caboolture Sth	Caboolture River	Natural Channel Design	8,100	$ 4,517,775	$ 4,517,800	2028	2021-2026
LPR_CW02	Piggott Reserve, Strathpine	Lower Pine River	Constructed Wetland	1,467	$ 296,334	$ 296,300	2028	2026-2031
CAB_NCD02	Parish Park, Caboolture	Caboolture River	Natural Channel Design	4,000	$ 2,231,000	$ 2,231,000	2029	2021-2026
CAB_NCD01	Ruby Street Park, Caboolture	Caboolture River	Natural Channel Design	1,750	$ 976,063	$ 976,100	2029	2021-2026
LPR_CW04	Learmonth Street, Strathpine	Lower Pine River	Constructed Wetland	9,733	$ 1,966,066	$ 1,966,100	2029	2026-2031
BUR_WR01	Crendon Street Park, Burpengary	Burpengary Creek	Constructed Wetland	3,733	$ 754,066	$ 754,100	2030	2031-2036
CAB_NCD03	Jensen Road Park, Caboolture	Caboolture River	Natural Channel Design	1,550	$ 864,513	$ 864,500	2030	2021-2026
SID_NCD01	Desmond Street Park, Narangba	Sideling Creek	Natural Channel Design	1,900	$ 1,059,725	$ 1,059,700	2030	2026-2031
BUR_WR03	Narangba Sports Centre, Narangba	Burpengary Creek	Natural Channel Design	3,300	$ 1,840,575	$ 1,840,600	2033	2026-2031
BUR_WR05	Caccini Crescent Park Burpengary	Burpengary Creek	Natural Channel Design	6,350	$ 3,541,713	$ 3,541,700	2035	2031-2036
CAB_NCD05	Grace College, Caboolture	Caboolture River	Natural Channel Design	3,750	$ 2,091,563	$ 2,091,600	2036	2021-2026
BRI_RG01	Bribie	Bribie Island	Raingardens	694	789,247	$ 789,200	2021-2026	2026-2031
BC_RG01	Brisbane Coastal	Brisbane Coastal	Raingardens	810	$ 920,789	$ 920,800	2021-2026	2021-2026
PUM_RG01	Pumicestone	Pumicestone Passage	Raingardens	964	$ 1,096,177	$ 1,096,200	2021-2026	2021-2026
STAN_RG01	Stanley River	Stanley River	Raingardens	733	$ 833,094	$ 833,100	2021-2026	2021-2026
BRI_RG02	Bribie	Bribie Island	Raingardens	366	$ 416,547	$ 416,500	2026-2031	2026-2031
BC_RG02	Brisbane Coastal	Brisbane Coastal	Raingardens	540	$ 613,859	$ 613,900	2026-2031	2026-2031
CAB_RG01	Caboolture	Caboolture River	Raingardens	13,930	$ 15,838,633	$ 15,838,600	2026-2031	2026-2031
LPR_RG01	Lower Pine	Lower Pine River	Raingardens	4,447	$ 5,056,019	$ 5,056,000	2026-2031	2026-2031
PUM_RG02	Pumicestone	Pumicestone Passage	Raingardens	1,118	$ 1,271,565	$ 1,271,600	2026-2031	2026-2031
STAN_RG02	Stanley River	Stanley River	Raingardens	713	$ 811,171	$ 811,200	2026-2031	2026-2031
BRI_RG03	Bribie	Bribie Island	Raingardens	127	$ 144,695	$ 144,700	2031-2036	2026-2031
BC_RG03	Brisbane Coastal	Brisbane Coastal	Raingardens	540	$ 613,859	$ 613,900	2031-2036	2021-2026
BUR_RG01	Burpengary	Burpengary Creek	Raingardens	1,077	$ 1,224,590	$ 1,224,600	2031-2036	2026-2031
CAB_RG02	Caboolture	Caboolture River	Raingardens	12,819	$ 14,574,733	$ 14,574,700	2031-2036	2021-2026
LPR_RG02	Lower Pine	Lower Pine River	Raingardens	6,455	$ 7,338,904	$ 7,338,900	2031-2036	2031-2036
PUM_RG03	Pumicestone	Pumicestone Passage	Raingardens	540	$ 613,859	$ 613,900	2031-2036	2031-2036
STAN_RG03	Stanley River	Stanley River	Raingardens	848	$ 964,636	$ 964,600	2031-2036	2031-2036

BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.

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BMT in Environment

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