



PREPARED FOR
TAMWORTH REGIONAL COUNCIL

Urban Stormwater Management Plan

TAMWORTH

JUNE 2023

NW30190



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Document Information

Prepared for: Tamworth Regional Council

Project Name: Urban Stormwater Management Plan -
Tamworth

File Reference: NW30190_RevD_Tamworth USMP.docx

Job Reference: NW30190

Date: June 2023

Version Number: RevD

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16/06/2023

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16/06/2023

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
RevA	19/10/2021	Draft Urban Stormwater Management Plan	MG, MM, KS	SC, TH
RevB	18/05/2022	Draft Urban Stormwater Management Plan	MM, SS, SC, SLV	SC
RevC	30/04/2023	Final Draft Urban Stormwater Management Plan	SS, SHP, AB, HR	MG
RevD	16/06/2023	Final Draft Urban Stormwater Management Plan	SS	MG



EXECUTIVE SUMMARY

Stantec (formerly Cardno) have been commissioned by Tamworth Regional Council to develop an Urban Stormwater Management Plan for Tamworth. This update has been undertaken to define the existing stormwater management issues and to investigate possible management strategies to update the existing Tamworth Urban Stormwater Management Plan (USMP) in accordance with the requirements of the New South Wales Government (NSW) Office of Local Government (OLG).

Tamworth is located in north-east NSW, approximately 300km north of Sydney. It sits within the Tamworth Regional Council (TRC) Local Government Area (LGA) and is the largest urban area within the LGA.

The Study Area is approximately 300km² and comprises of Tamworth North, Tamworth South, Tamworth East, Tamworth West, Calala, Taminda, Westdale, Nemingha, Oxley Vale, Warral, Wallamore, Hallsville, Kingswood, Moore Creek, Gidley and Hillvue.

All the available data, including studies and reports, for the Study Area was reviewed to help establish the existing catchment conditions and to identify the stormwater management issues within the catchment.

Key issues for stormwater in Tamworth have been identified as:

- > Poor Water Quality (Elevated nutrients, suspended solids and turbidity levels)
- > High Salinity
- > Degraded Waterway Conditions and Loss of Habitat
- > Loss of Environmental Flows

- > Flooding
- > Community Indifference to Stormwater Management
- > Loss of Community Access and Recreation
- > Risk to Community Health and Safety
- > Ineffective stormwater management and adoption of best practices
- > Lack of comprehensive database to assess the nature and magnitude of stormwater problems and identify suitable solutions
- > Drainage systems that terminate in the Peel River cause pollution, sediment transport and streambank erosion; and
- > Water quality is severely impacted during major flood events as some sections of the Tamworth wastewater reticulation system (including major carrier mains and pumping stations) are inundated during major flood events.

Consultation has been an integral part of this study. There are many external agencies with stormwater related interests in the area. A letter of introduction to the study was sent to the key external stakeholder agencies along with an invitation to be involved in the project. In addition, internal engagement with relevant Council departments was undertaken to identify potential stormwater management measures (structural and non-structural) and recognise any opportunities for possible future collaboration.

A comprehensive list of potential structural and non-structural stormwater management measures for the study area was developed. The measures comprised of five main approaches:

- > Asset Management;
- > Education and Awareness;
- > Maintenance and Monitoring;
- > Planning and Development; and
- > Stormwater Infrastructure.

A Multi-Criteria Assessment (MCA) approach was adopted for the comparative assessment of all options identified. This approach uses a subjective scoring system to assess the merits of various options against economic, social, and environmental criteria. The principal merits of such a system are that it allows comparisons to be made between alternatives using a common index. Each option is given a score according to how well the option meets specific considerations.

Capital and ongoing costs have been estimated based on previous experience, consultation with Council, and industry standards and are divided into indicative ranges or 'bins' to allow for a high-level comparison of options to be undertaken.

Ranking may result in multiple options with the same score having the same rank, resulting in what may appear to be ranking 'gaps,' where there are not.

The following are the most highly ranked non-structural options (ranked 1 to 8) as an outcome of this assessment:

Non-Structural Options

- > Rank 1: M3 – Weed control / management programs within the stormwater channels;
- > Rank 1: M4 – Regularly maintain grassed areas within and adjacent to open urban stormwater channels;
- > Rank 3: M2 – Investigate the feasibility of planting native vegetation along the existing stormwater channels;
- > Rank 4: M11 – Develop a maintenance schedule for the existing Council owned GPTs
- > Rank 4: M12 – Develop a wetland management plan for Peel High wetland;
- > Rank 4: M13 – Develop a wetland management plan for Heritage Park (Orley Dr) wetland; and seventh highest ranking
- > Rank 7: P15 - Investigate co-location benefits of integrating WSUD into detention systems
- > Rank 8: P16 - Extend the stormwater management levy to include development corridors

The following are the most highly ranked structural options (ranked 1 to 7) as an outcome of this assessment:

Structural Options

- > Rank 1: S38 - Investigate the opportunity to install a wetland on Barnes Gully north of Bridge St
- > Rank 2: S32 - Bicentennial Park WSUD
- > Rank 3: S5 – Bund on Moore Creek Road
- > Rank 3: S6 - Moore Creek culvert upgrade and channel maintenance
- > Rank 3: S8 - Raglan Street inlet upgrade
- > Rank 3: S34 - Formalisation and revegetation of Swan St channel
- > Rank 7: S7 - Detention basin upstream of Regans Rd Kingswood
- > Rank 7: S11 – Flood Storage in Darling St Park and Pump Out

All the management options were compiled into an implementation program that provides a holistic view of the management options and allows for regular monitoring and reporting by Council.

GLOSSARY

Australian Height Datum (AHD)	A standard national surface level datum approximately corresponding to mean sea level.
Average Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare, but it would be relatively large. The 1% AEP event is equivalent to the 1 in 100-year Average Recurrence Interval event.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random. That is, an event of a certain magnitude may occur several times within its estimated return period.
Cadastral, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the mainstream.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g., some roads may be designed to be overtopped in the 1% AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Drainage	Any activity that intentionally alters the hydrological regime of any locality by facilitating the removal of surface or ground water. It may include the construction, deepening, extending, opening, installation or laying of any canal, drain or pipe, either on the land or in such a manner as to encourage drainage of adjoining land.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood Planning Area	Defined by the <i>Floodplain Development Manual</i> (NSW Gov, 2005) as the area of land below the Flood Planning Level (FPL) equal to the 1% AEP flood level plus a 0.5 m freeboard
Flood hazard	Potential risk to life and limb caused by flooding.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e., flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Management options/strategies	The measures which might be feasible for the management of a particular area.

Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.
Probable maximum flood (PMF)	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a more detailed explanation see Average Recurrence Interval.

ACRONYM AND ABBREVIATIONS

ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
ASS	Acid Sulphate Soils
CBD	Central Business District
CRM	Customer Request Management
CSP	Community Strategic Plan
DA	Development Application
DAWE	Department of Agriculture, Water and the Environment
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change and Water
DLWC	Department of Land and Water Conservation
DPE	NSW Department of Planning and Environment
EIA	Effective Impervious Areas
EMC	Event Mean Concentration
EPBC	Environment Protection and Biodiversity Conservation
EPA	Environment Protection Authority
EP&A Act 1979	Environmental Planning and Assessment Act 1979
FPL	Flood Planning Level
FPM	Flood Planning Manual
FRMS&P	Floodplain Risk Management Study and Plan
FS	Flood Study
GIS	Geographic Information System
GMS	Growth Management Study

GPT	Gross Pollutant Trap
IWCM	Integrated Water Cycle Management
LEP	Local Environmental Plan
LGA	Local Government Area
LSPC	Local Strategic Planning Statement
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NSW	New South Wales
OLG	Office of Local Government
OSD	On-Site Detention
PMF	Probable Maximum Flood
PMST	Protected Matters Search Tool
SES	State Emergency Services
SQID	Stormwater Quality Improvement Device
TDS	Total Dissolved Solids
TEC	Threatened Ecological Communities
TIA	Total Impervious Area
TLA	Total Land Use Area
TN	Total Nitrogen
TP	Total Phosphorus
TRC	Tamworth Regional Council
TSS	Total Suspended Solids
TRDCP 2010	Tamworth Regional Development Control Plan 2010
TRLEP 2010	Tamworth Regional Local Environmental Plan 2010
USMP	Urban Stormwater Management Plan
WSUD	Water Sensitive Urban Design

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1 INTRODUCTION

Stantec have been commissioned by Tamworth Regional Council to develop an Urban Stormwater Management Plan for the study area of Tamworth.

Tamworth Regional Council (Council) is responsible for providing public stormwater systems for effectively draining the urban catchments within its Local Government Area (LGA). Council now intends to update the existing Tamworth Urban Stormwater Management Plan (USMP) in accordance with the requirements of the New South Wales Government (NSW) Office of Local Government (OLG).

The updated USMP will facilitate a co-ordinated management of stormwater within Tamworth to achieve ecological sustainability, social, and economic benefits from sound stormwater management practices. This update has been undertaken to define the existing stormwater management issues within the Tamworth study area and to investigate possible management strategies to reduce the impact of these issues on the community and environment.

1.1 STUDY OBJECTIVES

The objectives of the study are to:

- > To identify and describe the various potential urban stormwater (quality and quantity) management issues;
- > To review the stormwater provisions in Council's existing environmental planning policies and instruments;
- > To identify and assess potential management measures;
- > To assess the benefits and cost of the potential management strategies; and
- > To prioritise strategies and develop an implementation program.

The aim of the USMP is to integrate stormwater management objectives with Council's asset management framework, thus allowing a holistic and long-term approach to urban stormwater management.

1.2 REPORT STRUCTURE

This Report summarises the following:

Section 2 – Study Area: Provides relevant background on the Study Area;

Section 3 – Data Collection and Review: Presents a review of the previous related studies conducted in the area, the data reviewed as part of the study, and the various development controls and policies that are relevant to the Study Area;

Section 4 – Catchment Profiling: Describes the topography, climate, waterways, geology, ecology, soils, demographics, water quality, and land use in the Study Area;

Section 5 – Baseline Water Quality Assessment: Summarises the water quality through assessment of recorded data and conceptual modelling to identify current stormwater quality issues in the study area;

Section 6 – Consultation: Summarises the consultation process and the outcomes of stakeholder and community engagement;

Section 7 – Urban Stormwater Management Systems: Describes the current urban stormwater system characteristics, function of drainage infrastructure, and identifies the impacts of urbanisation on receiving waterways. Defines the goals and objectives to assist with prioritisation of issues and development of management measures;

Section 8 – Urban Stormwater Management Measures: Provides discussion on possible management strategies to improve stormwater management in the Study Area. Summarises the quadruple bottom line – social, economic, environmental and governance assessment of options and prioritisation of measures for inclusion in Council's schedule of works; and

Section 9 – Urban Stormwater Management Implementation Plan: Compiles the management measures into an implementation program.

2 STUDY AREA

Tamworth is located in north-east NSW, approximately 300km north of Sydney. It sits within the Tamworth Regional Council (TRC) Local Government Area (LGA) and is the largest urban area within the LGA. The Study Area is approximately 300km² and comprises of Tamworth North, Tamworth South, Tamworth East, Tamworth West, Calala, Taminda, Westdale, Nemingha, Oxley Vale, Warral, Wallamore, Hallsville, Kingswood, Moore Creek, Gidley and Hillvue.

Tamworth sits within the floodplain of the Peel River which flows in a north-westerly direction through the study area. North Tamworth and East Tamworth sit on the Northern bank of the river and West Tamworth, South Tamworth and Hillvue all sit on the southern bank. There are several tributaries that flow into the Peel River within the Study Area and a major confluence, 5km upstream of Tamworth CBD, where the Peel River and the Cockburn River meet.

The Study Area is shown in **Map A1** in **Appendix A** and **Figure 2-1**.

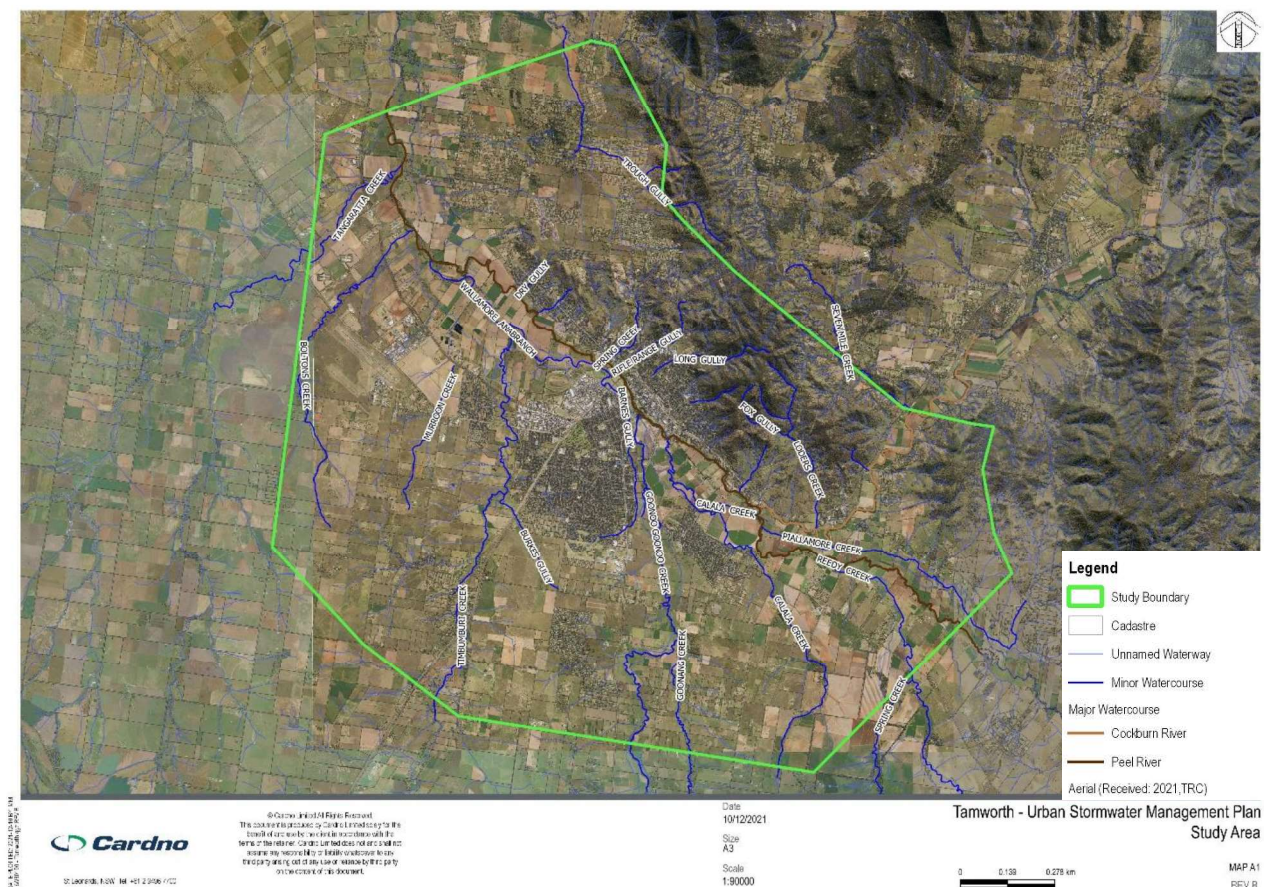


Figure 2-1 Tamworth Study Area

3 DATA COLLECTION AND REVIEW

This section presents a review of available data, policies, plans, and previously prepared studies that are applicable for Tamworth. The objective of the review was to identify stormwater management opportunities and constraints.

3.1 PREVIOUS STUDIES

3.1.1 Tamworth Urban Area Stormwater Management Plan (Willing and Partners, 2000)

In 2000 Tamworth Regional Council (then Tamworth City Council) developed the Tamworth Urban Area Stormwater Management Plan (USMP) in response to the NSW Environment Protection Authority (EPA) notice requiring all NSW Councils to develop an USMP. The plan was developed in accordance with the Managing Urban Stormwater Council Handbook (1997). The USMP aimed to facilitate a co-ordinated management of stormwater within the following catchments:

- > North Tamworth (NT) – CBD, North Tamworth, East Tamworth, Oxley Vale;
- > Cockburn River (CR) – Nemingha;
- > Goonoo Goonoo Creek (GG) – West Tamworth, Calala, part of South Tamworth; and
- > Timbumburi Creek (TC) – Taminda, Westdale, Coledale, part of South Tamworth.

The key objectives of the USMP included:

- > An improvement in the quality of receiving waters of the Tamworth urban catchments;
- > A decrease in the nutrients exported from the urban areas;
- > An increase in the amount of sediment captured from the urban areas;
- > An increase in the amount of litter captured from the urban areas;
- > Projects to improve Stormwater quality are publicised and where possible should involve the community;
- > Involve schools throughout Tamworth in Stormwater projects and monitoring as appropriate; and
- > Areas of bank erosion within the urban areas to be prohibited and progressively remediated.

A broad range of short and long-term options to address the urban stormwater management issues were developed and ranked in consultation with community and stakeholders. These options were of two general types:

- > Non-Structural Options
 - Education campaigns;
 - Litter reduction and improved collection;
 - Improved street sweeping;
 - Council staff education and training;
 - Auditing maintenance practices;
 - Planning review and controls;
 - Stormwater monitoring and auditing;
- > Structural Options
 - On-Site Detention (OSD);
 - Detention Basins;
 - Infiltration Basins;

- Aquifer Storage and retrieval (ASR);
- Floodways / Engineered Waterways;
- Stormwater Quality Improvement Device (SQID);
- Sand filters; and
- Ponds / wetland.

An implementation schedule was developed for the management options which included overall ranking of the options and timing of implementation. **Table 3-1** summarises the implementation schedule of the Tamworth Urban Area Stormwater Management Plan and the current status of these actions.

Table 3-1 Summary of Actions from the Tamworth USMP

Rank	Actions	Location	Implementation Timeframe	Current Status
1	Continue to assess the adequacy of litter bins in popular public / recreational areas and for special events	All	Year 1 and Ongoing	Ongoing
2	Council investigate in principle the policy of applying an annual charge for drainage services on each parcel of rateable land within the defined "Urban Area" of \$50	All	Year 1	A \$25 charge was adopted for residential properties and \$25/350m ² of commercial properties.
3	1) Channel works 2) GPT	TC	Year 1	Complete
4	A comprehensive building standard be developed by Council for development within saline areas	All	Year 1	Incomplete
5	Review Council maintenance and construction practices for erosion and sediment control, including grading of road shoulders	All	Year 1	Ongoing
6	Expand existing Stormwater working group to include members of the community and interest group representatives	All	Year 1 and Ongoing	Incomplete
7	1) Total catchment management and revegetation 2) Clearing sediment out of culverts on Manilla Rd	NT	Year 2	1) Incomplete 2) Complete
8	SQID – Goonoo Goonoo Creek Calala	GG	Year 1	Incomplete – GPTs installed at Calala Creek
9	SQID – Coledale	TC	Year 2	Complete
10	SQID – Coledale	TC	Year 1	Complete
11	Review design guidelines for new subdivisions, new developments and re-developments	All	Year 3 and Ongoing	Development guidelines updated regularly but does not have specifications for water quality
12	SQIDs installed around carpark	NT	Year 3	Incomplete
13	Include environmental awareness education in staff training program	All	Year 3 and Ongoing	Incomplete
14	Increased street sweeping in commercial area of catchment Southgate	GG	Year 3 and Ongoing	Incomplete
15	SQID	TC	Year 3	Site has been developed – No SQID
16	SQID installed in Bicentennial Park	NT	Year 4	Incomplete
17	Drain stencilling across the City	All	Year 4 and Ongoing	Incomplete
18	SQID installed above rail line	NT	Year 5	Incomplete
19	SQID	NT	Year 6	Incomplete
20	Expand stormwater monitoring and auditing (testing program)	All	Year 3 and Ongoing	Incomplete
21	Provision to install GPT during future drainage upgrade	GG	Year 3	Complete
22	SQID at Beaufort St	TC	Year 3	Incomplete
23	SQID in concrete channels upstream of Marius St	NT	Year 7	Incomplete

Rank	Actions	Location	Implementation Timeframe	Current Status
24	Public education and awareness campaign on excessive watering, companion animal waste, car washing, Stormwater friendly gardens and recycling	All	Year 7 and Ongoing	Incomplete
25	Wetland, near sewer pump station below Glenglarvin Dr	NT	Year 7 and Ongoing	Complete
26	Education campaign targeted at Building and Construction industry on the implementation of soil and water management controls during construction	All	Year 8 and Ongoing	Incomplete
27	Regulate and enforce erosion and sediment control plans	All	Year 8 and Ongoing	Ongoing
28	Improved street sweeping practices in the City	All	Year 8 and Ongoing	Incomplete
29	SQID	GG	Year 8	Incomplete
30	Augmentation of three pipes and pass through a SQID	GG	Year 9	Incomplete
31	SQID	TC	Year 10	Incomplete
32	SQID on headwalls along concrete lined drain	NT	Beyond Year 10	Incomplete
33	SQID in Viaduct Park	NT	Beyond Year 10	Incomplete
34	SQID	GG	Beyond Year 10	Incomplete
35	SQID between Levee and Peel St	NT	Beyond Year 10	Incomplete
36	Council / DLWC to ensure that any tree clearing proposed on a development application is compatible with the assessed salinity hazard of the site	All	Beyond Year 10	Incomplete
37	SQID	CR	Beyond Year 10	Incomplete
38	1) Wetland / Pond feature 2) Trash rack	GG	Beyond Year 10	Incomplete
39	Co-ordinate with schools in the City to include environmental issues associated with stormwater within the school curriculum. Develop further with Council education officer	All	Beyond Year 10	Incomplete
40	SQID	NT	Beyond Year 10	Incomplete
41	SQID near Carthage – White St intersection	NT	Beyond Year 10	Incomplete
42	SQID	GG	Beyond Year 10	Incomplete
43	SQID	CR	Beyond Year 10	Incomplete
44	SQID	NT	Beyond Year 10	Complete
45	Monitor as catchment develops and implement strategies as required	TC	Beyond Year 10	Ongoing
46	SQID on outlet, floodgate	GG	Beyond Year 10	Incomplete
47	Evaluate and implement strategies during Taminda Levee works	TC	Beyond Year 10	Complete
48	Undertake industrial / commercial investigation programs in conjunction with industry / commerce awareness programs	All	Beyond Year 10	Incomplete
49	Formalise drainage in conjunction with development	TC	Beyond Year 10	Ongoing
50	Sealing of urban unsealed road shoulders	TC	Beyond Year 10	Ongoing
51	Street sweeping in industrial area	TC	Beyond Year 10	Ongoing

3.1.2 Integrated Water Cycle Management (IWCM) Evaluation Study Report (Hunter Water Australia, 2012)

In 2012 TRC commissioned the IWCM Evaluation Study Report. The study outlined the existing conditions, water resources and urban water services of the key TRC catchments, as well as identifying IWCM issues. It was determined by the study that all IWCM issues were currently being met by the business-as-usual scenario, negating the need for an IWCM Strategy Study. It was recommended that the identified IWCM and key data gap be addressed by a review within 5 years of the completed study.

The key stormwater issues identified by the study for Tamworth include:

- > Drainage systems that terminate in the Peel River cause pollution, sediment transport and streambank erosion; and
- > Water quality is severely impacted during major flood events as some sections of the Tamworth wastewater reticulation system (including major carrier mains and pumping stations) are inundated during major flood events.

In February 2011, TRC received funding from the Federal Department of Sustainability, Environment, Water, Population and Communities, under its Water for the Future, Strengthening Basin Communities: Planning Component – Round 2, to investigate, plan and design a range of stormwater reuse opportunities. A summary of these options investigated, and the current status of the options are outlined in **Table 3-2**.

Table 3-2 Summary of Options from 2011 Strengthening Basin Communities: Planning Component – Round 2 Project

ID	Options	Current Status
1	Stormwater harvesting and storage for proposed new racing precinct at Taminda	Complete
2	Stormwater harvesting and storage from Fitzroy Street and Tamworth CBD area for distribution and reuse in Bicentennial Park for irrigation, refilling of ponds, operation of water features, and public toilet flushing	Bores installed for potable water use reduction instead
3	Stormwater harvesting and storage at TRC's George Street drainage reserve for distribution and reuse on Gipps Street sporting fields for irrigation of sporting fields	Bores installed for potable water use reduction instead

3.1.3 Flooding Assessments

Several flooding assessments of the Tamworth area have been commissioned by TRC in the past. The most relevant and recent assessments are detailed in the sections below. Other studies that have formed the basis for the two most recent investigations include the following:

- > Tamworth Flood Study (DWR, 1990);
- > Floodplain Management Study – City of Tamworth (PPK, 1993);
- > Hydraulic Modelling of Peel River at Tamworth (Lyll & Associates, 2006);
- > Tamworth City Levees – Internal Drainage Study (Lyll & Associates, 2012); and
- > Arcadia Estate Subdivision Integrated Stormwater and Floodplain Management Strategy (Lyll & Associates, 2015).

3.1.3.1 East and North Tamworth Drainage Study (Lyll & Associates, 2021)

The East and North Tamworth Drainage Study was completed by Lyll & Associates in 2021 to define the nature of local catchment flooding in the urbanised parts of East and North Tamworth. The investigation built upon the existing 2012 study by Lyll & Associates which defined flood behaviour behind three levees which had been constructed to protect parts of Tamworth from riverine flooding.

The 2021 drainage study included a review of available hydrologic and hydraulic data and previous investigations, a hydrological component (RAFTS and ILSAX), a hydraulic component (TUFLOW) and a flood mitigation component. The study has considered seven (7) potential flood mitigation options presented in the 2012 study and reassessed their relevance and effectiveness in the current climate. The study found two (2) options have become no longer feasible and some modifications were required to the remaining five (5) options. These options are detailed in **Table 3-3**.

Table 3-3 Summary of Flood Mitigation Options (Lyll & Associates, 2021)

Option ID	Suggested Action	Conclusion
Option 1	O'Connell Street Pressure Line: The upgrade of the O'Connell Street Pressure Line from its inlet at Marius Street on Rifle Range Gully to its point of discharge to the Peel River. This could comprise a new drainage line within Viaduct Park running parallel with O'Connell Street.	This option would alleviate flooding in several commercial properties located between Brisbane Street and Darling Street for the case where the flood gates are in their fully open position. Whilst this potential measure would also reduce peak flood levels by about 710 mm for the case where the flood gates are in their fully closed position, the reduction in the overall extent of land impacted by the 100 year ARI flood under these conditions is not significant. Recommended with potential modifications: 1. The removal of the temporary detention system and major intake structure that was proposed in the vicinity of Angora Park, for the reason that the present investigation has demonstrated that major overland flow bypasses this location during storms which result in the surcharge of the existing trunk drainage system. 2. Consideration should be given to constructing a new pressure line which extends from the trapped low point in the Main Northern Railway which is located between Darling Street and Brisbane Street to the Peel River via Bourke Street. 3. There would also be merit in extending the new trunk drainage line north as far as Raglan Street as this would assist in removing the damaging flooding that is experienced in existing residential

Option ID	Suggested Action	Conclusion
		development that is located along the western side of Bourke Street.
Option 2	Fitzroy Street Pressure Line Upgrade: This option involves the duplication of the existing 1500 mm diameter pressure line which runs along Fitzroy Street from the Main Northern Railway to the Peel River. The works would also involve improvements to the inlet arrangement located on the northern side of the Main Northern Railway. It would also be necessary to install a new length of 1500 mm diameter pipe through the existing levee bank, either by excavating a trench or by thrust boring methods.	Recommended – lower priority than Option 3 The benefits of this option in terms of a reduction in peak flood levels would generally be confined to commercial property located between Brisbane Street and Fitzroy Street for the case where the flood gates are in their fully open position. Whilst the reduction in peak flood levels is more wide spread for the case where the flood gates are in their fully closed position, the impact in terms of a reduction in peak flood levels is relatively minor, in the range 10-100 mm.
Option 3	White Street Pressure Line Upgrade: This option involves the duplication of the existing 1200 mm diameter pressure line which runs along White Street from the Main Northern Railway to the Peel River. Unlike the Fitzroy Street pressure line option, it would not be necessary to install a new section of the pipe in the levee bank, as site inspection and survey shows the presence of a redundant section of 1200 mm diameter pipe at this location. The main concern with this option is the ability to pressurise the new drainage line given the limited opportunities available for improving the inlet capacity north of the Main Northern Railway Line.	Recommended – priority over Option 2 The benefits of this option in terms of a reduction in peak flood levels are more widespread than for Option 2, but are generally confined to commercial property located between Bourke Street and White Street for the case where the flood gates are in their fully open position. Whilst the reduction in peak flood levels is more wide spread for the case where the flood gates are in their fully closed position, the impact in terms of a reduction in peak flood levels is relatively minor, in the range 100-200 mm.
Option 4	Jaycees Park and Prince of Wales Park Trunk Drainage Upgrade: This option involves improvements to the existing trunk drainage line which runs through the two parks.	Not longer feasible following the construction of the Eastpoint shopping complex and commercial development.
Option 5	Combination of Options 1 to 4	Modified to Option 1 (with modification above) and 3. The implementation of all four potential measures would have a significant impact on the extent of inundation behind the CBD Levee for the case where the flood gates are in their fully open position. Whilst the benefits in terms of a reduction in peak 100 year ARI flood levels for the case where the flood gates are in their fully closed position is greater than 200 mm, the overall extent of land impacted by the 100 year ARI flood under these conditions is still not significant.
Option 6	Combination of Options 1 and 2	Option to be abandoned. The implementation of these two measures would reduce the impact of flooding on existing development located to the west of Fitzroy Street for the case where the flood gates are in their fully open position. Similar to the findings of modelling the two potential measures individually, the benefits in terms of a reduction in peak 100 year ARI flood levels for the case where the flood gates are in their fully closed position, whilst greater than 200 mm, does not significantly reduce the overall extent of land impacted by the 100 year ARI flood.
Option 7	This option involves the installation of three low head/high volume flood evacuation pump stations for lifting capacity of 9m ³ /s (Option 7A) or 18m ³ /s (Option 7B)	Not Recommended - they rely of flow first discharging to the pondage before it can be pumped to the Peel River. Whilst the implementation of the Option 7B pump stations would reduce peak 100 year ARI flood levels directly behind the levee by up to 940 mm for the case where the flood gates are in their fully closed position, the number of commercial properties which would be rendered flood free is limited to two or three.

3.1.3.2 Tamworth City-Wide Flooding Investigation (Lyll & Associates, 2019)

The Tamworth City-Wide Flooding investigation was completed in 2019 by Lyll & Associates to define both overland flow and mainstream flooding patterns in the city of Tamworth. The investigation had four primary components:

- > Review of available data and previous investigations;
- > Community consultation;
- > Hydrologic investigation; and
- > Hydraulic investigation.

As part of the community consultation, a community newsletter and questionnaire was distributed by TRC to flood affected residents and business owners located on the Peel River, Goonoo Goonoo Creek and Timbumburi Creek floodplains. Approximately 790 newsletters and questionnaires were distributed, with a total of 101 completed questionnaires returned via prepaid mail.

The results from the Tamworth City-Wide Flooding Investigation hydrologic and hydraulic modelling provide insight into the extent of flood inundation, and the residential and commercial properties impacted around Peel River, Goonoo Goonoo Creek, Timbumburi Creek, Murroon Creek, Boltons Creek and Tangaratta Creek, as well as the impacts of flooding and overland flow on the South Tamworth rural lands and urbanised areas of Tamworth City.

The recommendations from this flooding investigation are listed below:

- > There is considerable uncertainty as to the accuracy of the stream flow data that has been relied upon for the purpose of undertaking the present investigation, with the underestimation of peak flows, especially for the larger historic flood events, possibly resulting in an underestimation of design peak flows in the Peel River at Tamworth (as derived by the flood frequency analysis). As it was not within the scope of the present investigation to resolve this issue, it is recommended that this be investigated in detail during the preparation of the future *Floodplain Risk Management Study and Plan* for Tamworth;
- > In addition to expanding the present investigation to include the definition of overland flow and mainstream flooding behaviour in the remainder of Tamworth, it is recommended that an investigation be undertaken into the impact lowering ground levels in the North Tamworth Sports Fields (both soccer and rugby) will have on peak flood levels along the line of the CBD and Taminda Levees;
- > Assessments should also be undertaken into the feasibility of raising the crest heights of both the CBD Levee and the Taminda Levee to reinstate the design freeboard. Council should survey peak river heights along both the CBD and Taminda Levees following the next major flood on the Peel River so that a check can be undertaken of the flood slope which is being generated by the TUFLOW model; and
- > It is also recommended that Council update its flood policy to reflect the varying nature of the flood hazard at Tamworth. For example, the updated flood policy should include a graded sets of controls which are specific to areas subject to mainstream and minor tributary flooding, as well as major overland flow. A series of maps should also be incorporated in the updated flood policy which are based on the findings of the present investigation.

These recommendations are being considered in the development of the City-Wide Flood Risk Management Plan expected to be completed 2023.

3.1.3.3 *Tamworth City Levees Internal Drainage Study (Lyll & Associates, 2012)*

Lyll and Associates Consulting Water Engineers completed an internal drainage study of the Tamworth City Levees in 2012 for Tamworth Regional Council (TRC). The investigation considers the 'Central Business District Levee', the 'Western Levee', and the 'Taminda Levee' and undertook hydrological and hydraulic modelling to investigate the flooding behind the levees, flood planning levels behind the levees, provisional flood hazard and potential impacts of climate change, and potential flood mitigation measures.

The outcomes of the investigation recommended that further investigations be undertaken by TRC to define flood behaviour in the urbanised parts of the catchment which lie to the north (upslope) of the Main Western Railway Line and the CBD Levee. The justification supporting this recommendation where:

- > The present investigation identified the potential for inter-catchment transfers of flow to occur at several locations north of the Main Western Railway Line. The potential for stormwater to approach the CBD Levee via alternative routes has major implications on flood behaviour in the area and the identification of the most appropriate measures for managing the flood risk in the area.
- > The implementation of alternative measures in the middle and upper reaches of the existing stormwater drainage network, such as flood retarding basins and channel improvement works, could improve the effectiveness of the flood modification measures identified as part of the present investigation.
- > Blockages in the existing stormwater drainage network due to the accumulation of debris have the potential to increase the severity of flooding behind the CBD Levee. A comprehensive understanding of the range over which peak flood levels could vary under differing blockage conditions is required before an informed decision can be made on the most appropriate measures for managing the flood risk in the area.

3.2 PLANNING GUIDELINES

3.2.1 Blueprint 100

The *Tamworth Regional Blueprint 100* was adopted by TRC on 26 May 2020. The Blueprint was intended to be prepared in three parts with other subsequent tasks proposed following these parts:

- > *Tamworth Blueprint 100 Part 1: Overall Strategy (2020a)*: This plan brings together all the key elements of TRC's large number of plans, strategies, precinct plans and masterplans into a single document, hence the term 'Blueprint'. It guides and promotes the development of the Tamworth Region to 2041.
- > *Tamworth Blueprint 100 Part 2: Local Strategic Planning Statement (LSPS) (2020b)*: This is a new statutory plan introduced by the NSW State Government. Unlike Part 1 it has a narrower focus on land use planning. It includes the land use vision, priorities, actions and approaches to monitor success. It takes its direction from Part 1 and distils the land use planning issues into a LSPS in accordance with Section 3.9 of the Environmental Planning and Assessment Act 1979 (EP&A Act 1979) and the DPIE guidelines to underpin future land use planning relating to master planning, Development Control Plan (DCP) amendments and Local Environmental Plan (LEP) amendments including the potential comprehensive review of the Tamworth Regional Local Environmental Plan 2010 (TRLEP 2010).
- > *Tamworth Blueprint 100 Part 3: Growth Management Strategy (GMS)*: The Growth Management Strategy takes its direction from the LSPS and details the land release strategy for the Region with the supporting infrastructure requirements. This Strategy is currently being developed in preparation for public exhibition. It will establish the basis for growth of the region and address key issues including housing choice and diversity, economic projections, infrastructure planning, towns and villages, rural lands, large lot and rural residential lands planning.
- > Other planned tasks within the Blueprint 100 framework include:
 - A review of the TRLEP 2010 to be aligned and directed by the Blueprint series of plans;
 - A review of the delivery plan included in Part 1 regarding how Council will deliver on the Community Strategic Plan (CSP) (Council's contract with the community) over a four-year period; and
 - Tamworth Integrated Transport Masterplan, which is currently underway and will pick up on the transport aspects from Blueprint including all modes; road, rail, cycle, walkway and public transport. It is integrated with the land use growth areas.

To date only Part 1 and 2 of the Blueprint 100 have been released, therefore these two documents have been reviewed and summarised in further detail in the following sections.

3.2.1.1 Tamworth Blueprint 100 Overview

The Blueprint 100 responds directly to the New South Wales Government's land use planning priorities and decisions to 2036. The overall planning framework for TRC and how the blueprint fits within this framework is shown in the diagram in **Figure 3-1** (extracted from Figure 1 of TRC 2020a). As shown below there are many planning guidelines and plans that fit within the framework and fall under the Blueprint 100 umbrella.

Responsible land use planning will be important in guiding future development to accommodate the expected population increase within the region. According to the Blueprint 100, as of 2019 the LGA had a population of 63,000, by 2041 that is expected to increase to 80,000, with targets of 100,000 by this time with stimulated growth programs. This represents an additional 17,000 – 37,000 residents within the LGA in the next 22 years, which will require an extensive amount of development in the region to facilitate this growth.

There are eight (8) priority themes of Blueprint 100 Part 1. Within each of the eight themes there are a series of priority initiatives that provide direction and within these priorities are specific actions identified as targets for the blueprint. Some of these themes, priorities and actions are relevant to the Study Area of this USMP, as well as relevant to the fields of stormwater quantity, quality and flooding as discussed in the following sections.

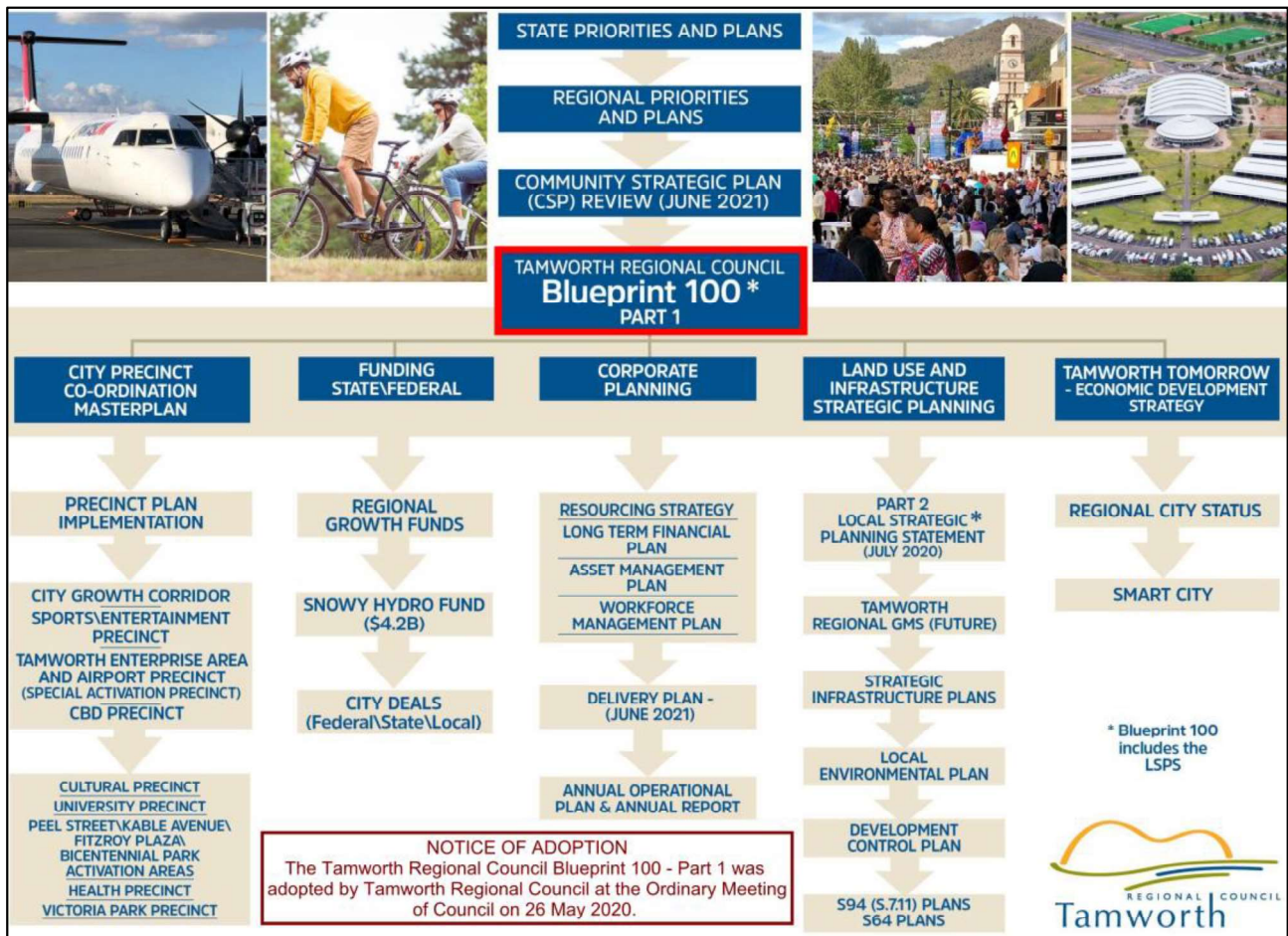


Figure 3-1 Tamworth Regional Council's plans and policies diagram (Source: TRC, 2020a)

The 8 themes of Part 1 are carried over into the Local Strategic Planning Statement (LSPS) of Part 2. Using these themes as a basis, more detailed and narrower land use and planning specific priorities and actions are identified. Most of the actions for Part 2 are specific to land use planning, however some make specific reference to water sensitive urban design and flooding and are noted in the following sections.

3.2.1.2 Relevance to Study Area

Tamworth City, being the largest in the LGA is a key focus of the Blueprint 100. Within the second priority theme (*Facilitate smart growth and housing choices*), a specific growth strategy is outlined for Tamworth including identified future growth areas and key road upgrades. This strategy is shown in **Figure 3-2**. The growth strategy includes new residential development precincts surrounding the city, an upgrade to the Central Business District (CBD), new commercial growth areas near Longyard and the airport, and new health and university precincts.

A priority of this second theme is also for a “strong and vibrant Tamworth City Centre”, with a vision provided for the section from Peel Street to Bicentennial Park. Overall, the plan is for intensification of development within the city centre to facilitate more visitors to the area.

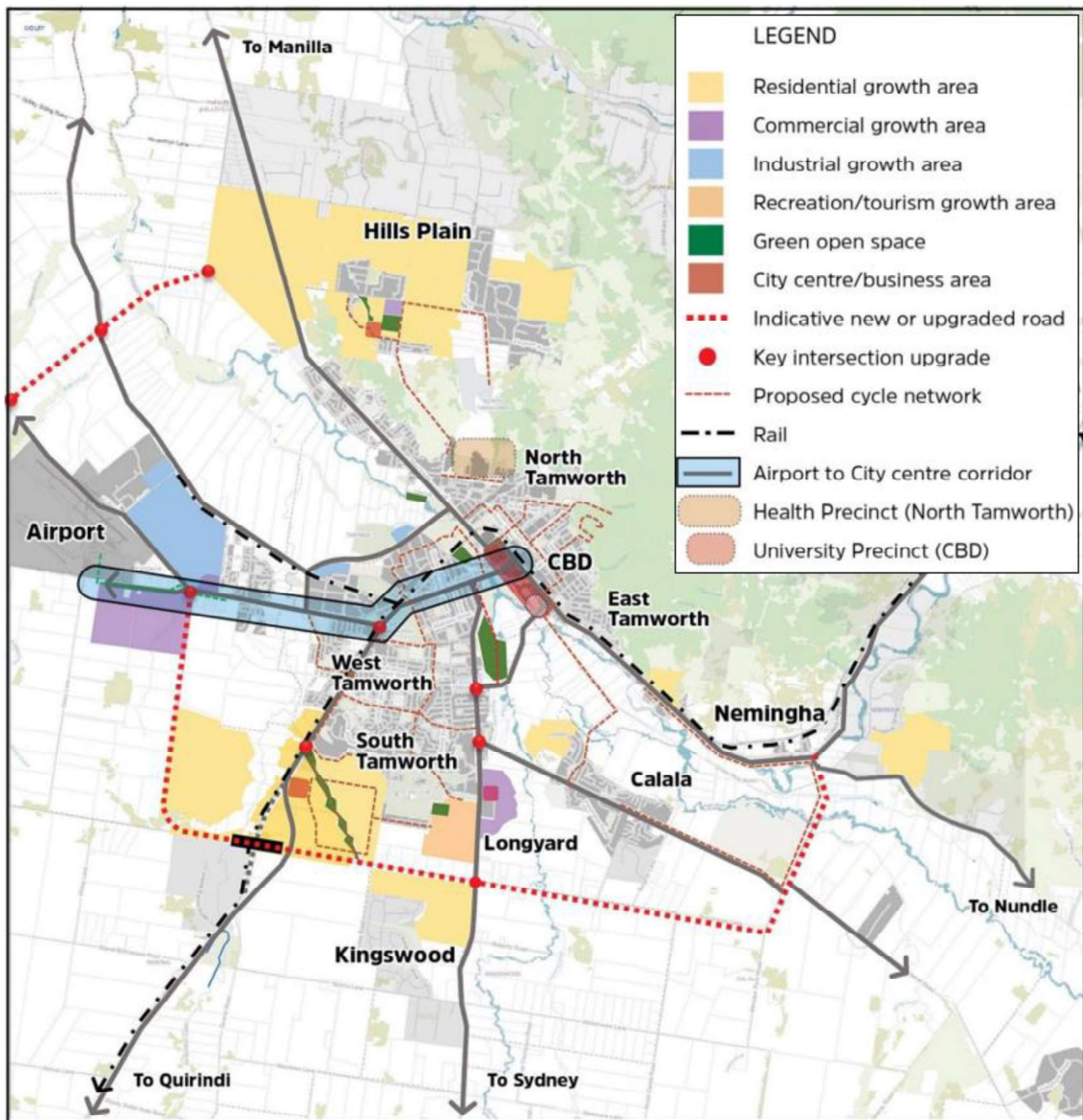


Figure 3-2 Growth Strategy Components for Tamworth City and Surrounds (Source: TRC, 2020a)

Within the fourth themes of the blueprint (Build resilient communities) a summary of the LGA's largest urban areas is provided with the initiatives that are relevant to each as shown in **Figure 3-3**. For Tamworth, all initiatives are relevant; social and communications, affordable housing, public transport, and special employment.

With respect to relevant priorities and actions identified within the Blueprint for Tamworth City Centre:

- Priority 4.13: Develop a recreational lake on the Peel River: The Peel River currently offers mainly visual amenity for users of Bicentennial Park and other public spaces along the river. The opportunity is to create a small lake, possibly via building a weir to enable water related recreational activities such as swimming, canoeing, boating etc. The specific action is to investigate the possibility of using the Peel River through the Tamworth City Centre considering the potential building of a weir, the ecological consequences of such a project, and potential business opportunities related to water-based recreation.

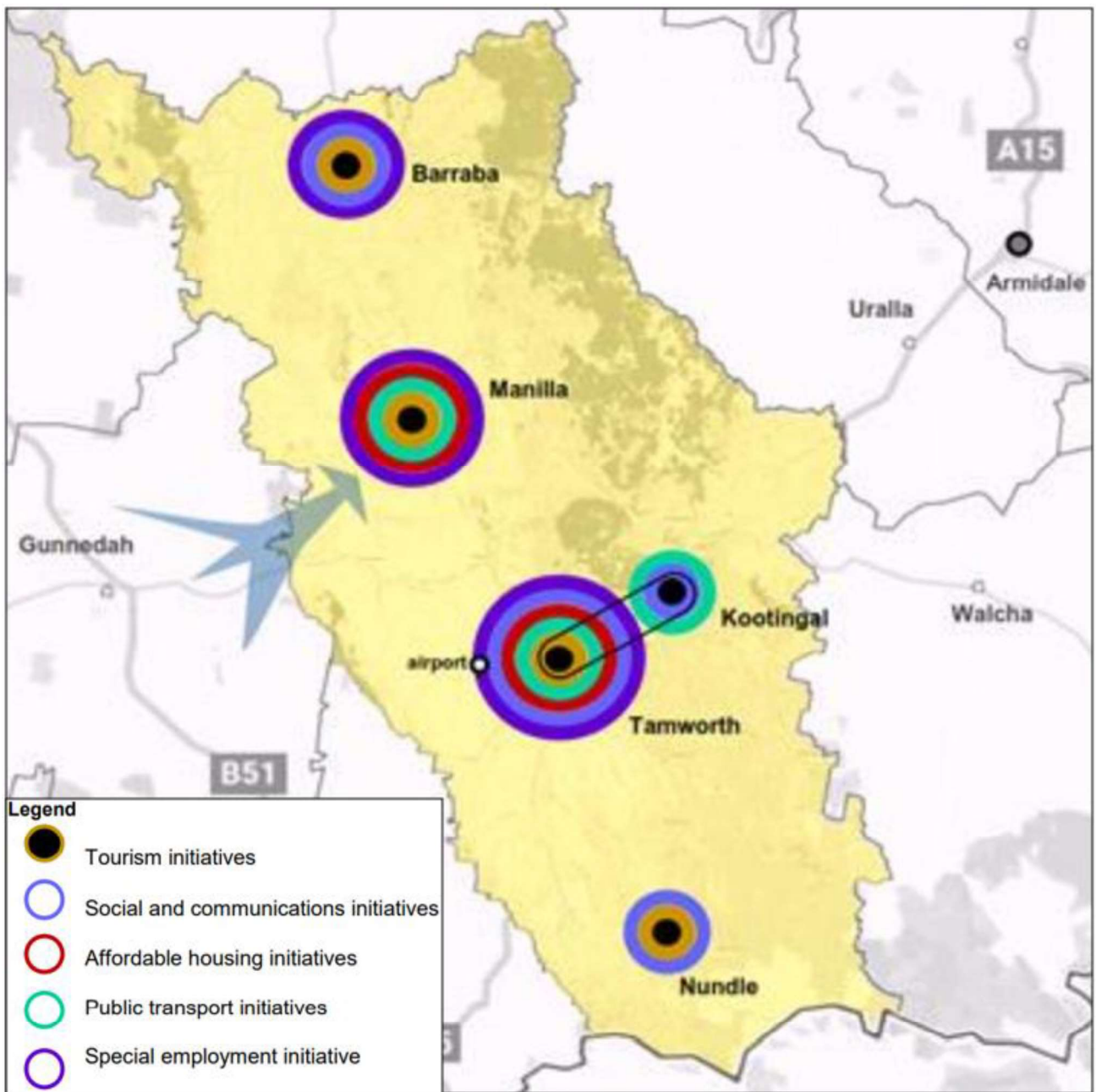


Figure 3-3 TRC Community Network (Source: TRC, 2020a)

3.2.1.3 Relevance to Water Sensitive Urban Design

The Blueprint 100 has set the following regionally focused goals:

- > A strong and dynamic regional economy;
- > A healthy environment with pristine waterways;
- > Strong infrastructure and transport networks for a connected future; and
- > Attractive and thriving communities.

Of the core goals of the regional plan, maintaining a healthy environment and pristine waterways is seen as a critical outcome in the region, which is also a key goal of this USMP. Of the 8 themes of the blueprint, the relevant priorities and actions for stormwater quality and quantity and water re-use are listed below:

- > Priority 1.2: Encourage water conservation across the region. Relevant actions include:
 - Providing clear instructions for the installation of BASIX tanks so that tanks will pass inspection and not require auditing (this will allow tank water to be used on gardens during water restrictions);
 - Exceeding BASIX requirements via incentives / rebates. Require or incentivise larger rainwater tanks, artificial turf, and groundcover. Extend this to existing buildings / dwellings;
 - Investigate greater incentives for the use of mulch to enhance water efficiency; and
 - Capturing all available water from Council buildings for re-use.
- > Priority 1.4: Promote sustainable water and wastewater urban planning and design approaches, relevant actions include:
 - Formulate guidelines, policies in the DCP, and apply pre-application procedures to ensure new developments are master planned to achieve the most sustainable water, wastewater and waste outcomes;
 - Incorporate water-wise design in the public realm and sports areas. Consider:
 - Alternatives for active open space – tactile / sensory garden, synthetic courts, multidisciplinary, bush food garden, sand / compacted gravels, BMX track;
 - Detention basins – drought tolerant design, below ground tanks, use of infiltration cells; and
 - Building effective public open spaces that are not expanses of lawn.
- > Priority 2.2: Better managed rural-residential development, relevant actions include:
 - Identify the blue/green networks (drainage reserves that combine as parks with cycleway / walkways) in new greenfield areas to reduce drainage cost for greenfield development.
- > Priority 6.2: Improve practices related to low impact stormwater management, relevant actions include:
 - Collate existing low impact stormwater guidelines and link them to Tamworth Regional Council policies. Include urban design measures that control and manage stormwater;
 - Promote these stormwater guidelines through Tamworth Regional Council's communications; and
 - Influence developers and designers at the early stages of their master planning.
- > Priority 6.3: Ensure sustainable design of facilities, infrastructure and development, relevant actions include:
 - Incorporate energy efficiency design in all current and new facilities. Considering roof capture, ground water usage, recycled water and LED lighting;
 - Achieve efficiencies and sustainability for whole of life maintenance of facilities, including site selection based on water security / rationalisation of parks and sports precincts;

- Require the quality of development designs submitted to the Council to be improved, including their sustainability aspects; and
- Require the quality of infrastructure built, and accepted by, the Council to be robust, durable, sustainable, and low maintenance.

With respect to the more detailed land use planning priorities and actions identified in Part 2 of the blueprint (TRC, 2020b), under the fifth theme [Design with Nature (DN)] several actions relate to WSUD:

- > DN1: Require the quality of development designs submitted to the Council to be improved, including their sustainability aspects supported by urban design guidelines;
- > DN2: Require the quality of infrastructure built, and accepted by the Council to be robust, durable, sustainable, and low maintenance aided by inclusion of low impact stormwater guidelines to link to TRC policies to control and manage stormwater; and
- > DN5: Identify the blue/green networks in new greenfield areas to reduce drainage cost for greenfield development considering water sensitive urban design while still requiring superior open space outcomes.

3.2.1.4 *Relevance to Floodplain Management*

The Blueprint 100 notes that environmental hazards, such as drought, flooding, bushfire, severe storms, salinity, contaminated land, and land degradation can occur within the region and cause major loss or harm to the community and the environment. The plan also notes land use planning is an effective management tool in minimising the impact of these hazards at both the strategic and detailed level. Any land prone to environmental hazards should not be developed and risks should be avoided.

No priority themes or actions in Part 1 make specific mention of flood risk management, however several actions make reference to promoting safe and sustainable development practices that inherently includes accounting for flood risk within future developments.

With respect to the more detailed land use planning priorities and actions identified in Part 2 of the blueprint (TRC, 2020b), under the fifth theme (Design with nature) note the following action relating to flooding:

- > DN6: Complete and utilise mapping for flooding, bushfire hazards, vegetation and biodiversity and support renewable energy initiatives.

3.2.2 **Tamworth Regional Local Environmental Plan 2010**

The NSW Planning Reforms require all local governments to prepare their planning instruments in accordance with a new standard instrument LEP. The key features of these reforms are:

- > An objective of reducing the number and layers of planning instruments;
- > Provision of a standard LEP template for Councils to conform to;
- > All mandatory controls to be included in the LEP;
- > Mandatory timeframe for Council to prepare a new LEP (3-5 years);
- > Rationalise and clarify the DCP relationship to LEP; and
- > Replace Master Plans with DCPs and staged Development Applications (DA).

Under this process, TRC developed an LEP which was gazetted in 2010, referred to as TRLEP 2010.

There are no sections of the TRLEP 2010 that specifically deal with stormwater quantity and quality treatment.

Section 5.21 Flood Planning of the LEP (updated 14/07/2021) outlines controls and objectives for land considered to be in a flood planning area which is defined by the *Floodplain Development Manual* (NSW Gov, 2005) as the area of land below the Flood Planning Level (FPL) equal to the 1% AEP flood level plus a 0.5 m freeboard. The objectives of this section are:

- > To minimise the flood risk to life and property associated with the use of land;
- > to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change; and
- > to avoid adverse or cumulative impacts on flood behaviour and the environment; and

- > to enable the safe occupation and efficient evacuation of people in the event of a flood.

As of mid-2021, NSW DPIE also released a new Flood Prone Land Policy Update. Included within this policy is draft flood LEP text which provides some updates to the current TRLEP 2010 language:

- > Several new objectives have been added to the updated text including a reference to cumulative impacts, enabling safe and appropriate uses of land, and enabling safe evacuation from the land;
- > The requirements for development consent have been updated with reference to cumulative impacts, no significant alteration of flow distributions and velocities, safe and efficient evacuation, no unsustainable social and economic costs to the community, no potential for hazardous material, and to be consistent with any relevant floodplain risk management plan adopted by the Council;
- > A new clause has been added specifically for consideration of climate change in development consent for the design life of the development;
- > A new flood clause has been added to the update called the “Special Flood Considerations” clause. The clause relates to; a) sensitive, vulnerable and critical uses, b) hazardous industry or hazardous material storage establishments, and c) any other land uses requiring controls in relation to risk to life considerations. Unlike the previous flood clause that was below for the FPL, the Special Flood Considerations clause relates to land located between the FPL and up to the Probable Maximum Flood (PMF); and
- > A new flood clause has been added to the update called the “Regional Evacuation Consideration Area”. The objective is to protect the capacity of regional evacuation routes during extreme flood events, and to support vehicular connectivity of development to regional evacuation routes. Regional Evacuation Consideration Area is the area that is identified in a relevant regional flood evacuation strategy or flood related state emergency sub-plan by NSW State Emergency Service (SES).

3.2.3 Tamworth Regional Development Control Plan 2010

Tamworth Regional Development Control Plan 2010 (TRDCP 2010) outlines development controls for six development categories, which include stormwater drainage related development controls. In addition, specific development controls are defined for all flood affected land, as well as specific controls for each urban centre. Discussion of stormwater and flood related development controls from the TRDCP 2010 are included in the following sections.

3.2.3.1 Stormwater Related Controls

TRDCP 2010 under Step 2 has development controls related to stormwater drainage for subdivision development types as follows:

- > The servicing strategy, including preliminary engineering designs shall include consideration of flows up to the 1 in 100-year Average Recurrence Interval (ARI) for existing natural flow, existing developed flow and post developed flow;
- > Minor flows are to be designed to a 1 in 5-year ARI;
- > Location of major flows are to be defined to a designated overland flow path up to a 1 in 100-year ARI. Where the path traverses private property, it shall be dedicated as a drainage reserve unless a natural drainage line (as indicated by blue line on the topographic map);
- > Detention basins are not a preferred solution;
- > Where drainage is required to the rear of the lot, inter-allotment drainage shall be located in easements in favour of the upstream properties benefitted by the easement.

In addition for site / location specific development controls, stormwater drainage related controls are also applied in Step 4. Within the Study Area of Tamworth there are a number of site-specific controls:

- > Longyard Business Precinct:
 - Development applications shall include an assessment of the impact of the stormwater discharge on downstream capacity and water quality; and
 - Information to assist in the preparation of this assessment is available from Council.

- > Hills Plain Development Controls:
 - Each lot is required to be designed to ensure dwelling site access outside the designated stormwater drainage areas;
 - There shall be no disturbance within 20 metres of the top of the bank of natural creek and drainage lines as identified in the Concept Plan. The 20-metre buffer from the drainage lines may be incorporated into new lots adjoining the drainage reserve however a building envelope will need to be identified outside the buffer; and
 - Suitable scour protection to be provided at all discharge points to existing creek lines.

Finally, under Step 5 discretionary standards for proposals not subject to “Type of Development” and where deemed to satisfy criteria are not achieved. For subdivisions these discretionary standards for stormwater drainage are as follows:

- > Stormwater drainage systems must be designed to prevent stormwater damage to the built and natural environment and ensure acceptable levels of health, safety and amenity;
- > The stormwater drainage system must reduce nuisance flows to a level which is acceptable to the community;
- > The stormwater drainage system should be easily accessed and economically maintained;
- > The stormwater drainage system should utilise open space in a manner compatible with other uses;
- > The stormwater drainage system must control flooding and provide escape routes for overland flows for high frequency storm occurrences; and
- > Council will only consider alternative forms of drainage including methods of on-site disposal such as retention and/or detention basins where it can be demonstrated that there is no other practical solution available. In assessing the suitability of such systems, Council will take into account ease of maintenance, public safety risk, proven functionality and cost liability for Council.

3.2.3.2 Flood Related Controls

TRDCP 2010 under Step 4 has development controls related to flood affected properties. The flood affected maps for the LGA are included within Appendix C of the TRDCP 2010, but flood affected land also includes site specific flood mapping. Other sites that have applicable flood controls are properties protected by levees which must include consideration of inundation resulting from a levee breach (failure of overtopping) or stormwater ponding when the river system is in flood.

The general flood related controls from the TRDCP 2010 include:

- > Flood free vehicle access is required for all lots created by subdivision;
- > For development of existing lots, where flood free vehicle access is not possible, the development must be able to achieve safe wading criteria as specified in Figure L1 of the Flood Planning Manual (FPM);
- > No building or work (including land filling, fencing, excavation) shall be permitted on flood affected land where in the opinion of Council, such building or work will obstruct the movement of floodwater or cause concentration or diversion of floodwaters;
- > DA must demonstrate the building or structure can withstand the force of flowing floodwaters, including debris and buoyancy forces as appropriate;
- > A survey plan prepared by a registered surveyor showing existing ground levels, finished ground levels, finished floor levels, flood levels and location of existing/proposed buildings and safe evacuation path on the site relative to Australian Height Datum (AHD).
- > All materials used in construction shall be flood compatible; and
- > Development must be designed in accordance with the Flood Proofing Guidelines (refer Discretionary Development Standards).

For residential developments the following flood related controls apply:

- > Floor levels of all habitable rooms, or rooms with connection to sewer infrastructure shall not be less than 500mm (freeboard) above the 1% ARI flood level, except for those properties between the Ogunbil Bridge and Dungowan Dam where the applicable flood height is 500mm above the Sunny Day Failure of Dungowan Dam;
- > Upon completion and prior to the occupation (where relevant), a certificate by a registered surveyor showing the finished ground and floor levels conform to approved design levels shall be submitted to Council;
- > Additions to existing buildings will be only be permitted, with limitations, as follows:
 - where the floor level of the proposed addition is located below the standard 1% ARI or the Sunny Day Failure of Dungowan Dam for properties between the Ogunbil Bridge and Dungowan Dam, the maximum increase in floor area is not to exceed 10% of the floor area of the existing dwelling; or
 - where the floor level of the proposed addition is located above the standard 1% ARI or the Sunny Day Failure of Dungowan Dam for properties between the Ogunbil Bridge and Dungowan Dam, the maximum increase in habitable floor space shall not exceed 100m²;
- > Rebuilding part of a dwelling may be permitted provided the building maintains the same dimensions which result in the same impact on flood behaviour; and
- > For subdivision developments, residential subdivision will not be permitted where any lot to be created will be fully inundated by a 1% ARI event and the creation of such lot will create the potential for increased intensity of development on flood liable land.

Commercial / retail / industrial developments shall incorporate measures to seal or flood proof buildings, to avoid activities or fittings susceptible to flood damage, or to store the contents of buildings above the 1% ARI level.

For land filling developments the following flood related controls apply:

- > Land filling proposals are to demonstrate consideration of AS3798;
- > Survey plan prepared by a registered surveyor is required, showing the contour levels of natural surface, any existing fill and the designed contour levels for the finished work;
- > A report certified by a consulting engineer is required to detail the impact of the proposed fill on adjoining properties and, where levee banks are proposed, and the methods of internal drainage;.
- > Applications shall be accompanied by a construction management plan to show
 - Source of fill, including contamination assessment;
 - An assessment of the impact of haulage vehicles on roads;
 - Precondition report of all haulage routes;
 - Details of method of compaction of fill and associated impacts: control of dust, sedimentation, water quality impacts, noise and vibration; and
 - Contingency for containment of fill in the event of a flood during placement.

For non-residential rural buildings the following flood related controls apply:

- > Not permitted in “floodways”.

Finally, under Step 5 discretionary standards for proposals not subject to “Type of Development” and where deemed to satisfy criteria are not achieved. For subdivisions these discretionary standards for flood related controls are as follows:

- > Development should be consistent with the principles and standards of the Flood Plain Management Manual (NSW Government);
- > Development must ensure safety to life and property;
- > Development on flood affected land must be structurally capable of withstanding the effects of flowing floodwaters including debris and buoyancy forces;

- > Development must not increase the risk or implications of flooding to existing areas;
- > Development on flood affected land must incorporate the Flood Proofing Guidelines in Appendix B;
- > If flood free access is not possible, the development must be able to achieve safe wading criteria as specified in Figure L1 of the FPM;
- > For industrial development:
 - Variation to the design flood planning level may be approved where Council considers strict adherence to the designed floor level to be unreasonable or unnecessary;
 - Council may require that all electrical installations and wiring be above the flood standard and that building materials and services are in accordance with the Flood Proofing Guidelines; and
- > For non-residential rural buildings where it is not practical to locate floor levels above the 1% flood level, materials used in construction must be capable of withstanding inundation by floodwaters.

3.2.4 Strategic Plans

There are two open space strategic plans for Tamworth Regional Council:

- > Tamworth Regional Council Sport and Recreation Strategic Plan – Summary Report (TRC, 2020c)
- > Tamworth Regional Council Sport and Recreation Strategic Plan (TRC, 2020d)

In Figure 11 of TRC, 2020d it is noted that there are 67 facilities for sport and recreation within Tamworth.

Of the two strategic plans, the nominated challenges included water security with many sport and recreation facilities across the Tamworth region are heavily reliant on the availability of water, particularly for irrigation of playing fields. Also included in challenges was flood prone areas, with one of Tamworth's key sport and recreation precincts, Riverside Sports Complex, is located on a flood prone area alongside the Peel River, close to the centre of Tamworth. While this location has benefits, such as access to water for irrigation, it also has challenges associated with the need for innovative designs to meet the specific requirements for flood prone areas.

Included within the actions of the plan is continuing to reduce reliance on potable water to irrigate sports grounds and increase alternative water sources (e.g., increasing stormwater capture and re-use and improvements to irrigation).

3.2.5 Masterplans

TRC have prepared several local masterplans for the LGA. The masterplans within the Study Area are:

- > Tamworth Bicentennial Park Master Plan (TRC, 2020e);
- > Viaduct Park, Tamworth Master Plan (TRC, 2020f); and
- > Victoria Park Master Plan (TRC, 2020g).

The Bicentennial Park master plan assigns areas as shown in **Figure 3-4**. It shows that there are flood reserve / riverside precinct along the extent of Peel River.

For Victoria Park master plan there are proposed modifications of ponds in Area 4, and a proposed detention basin and Long Gully riparian corridor in Area 7.

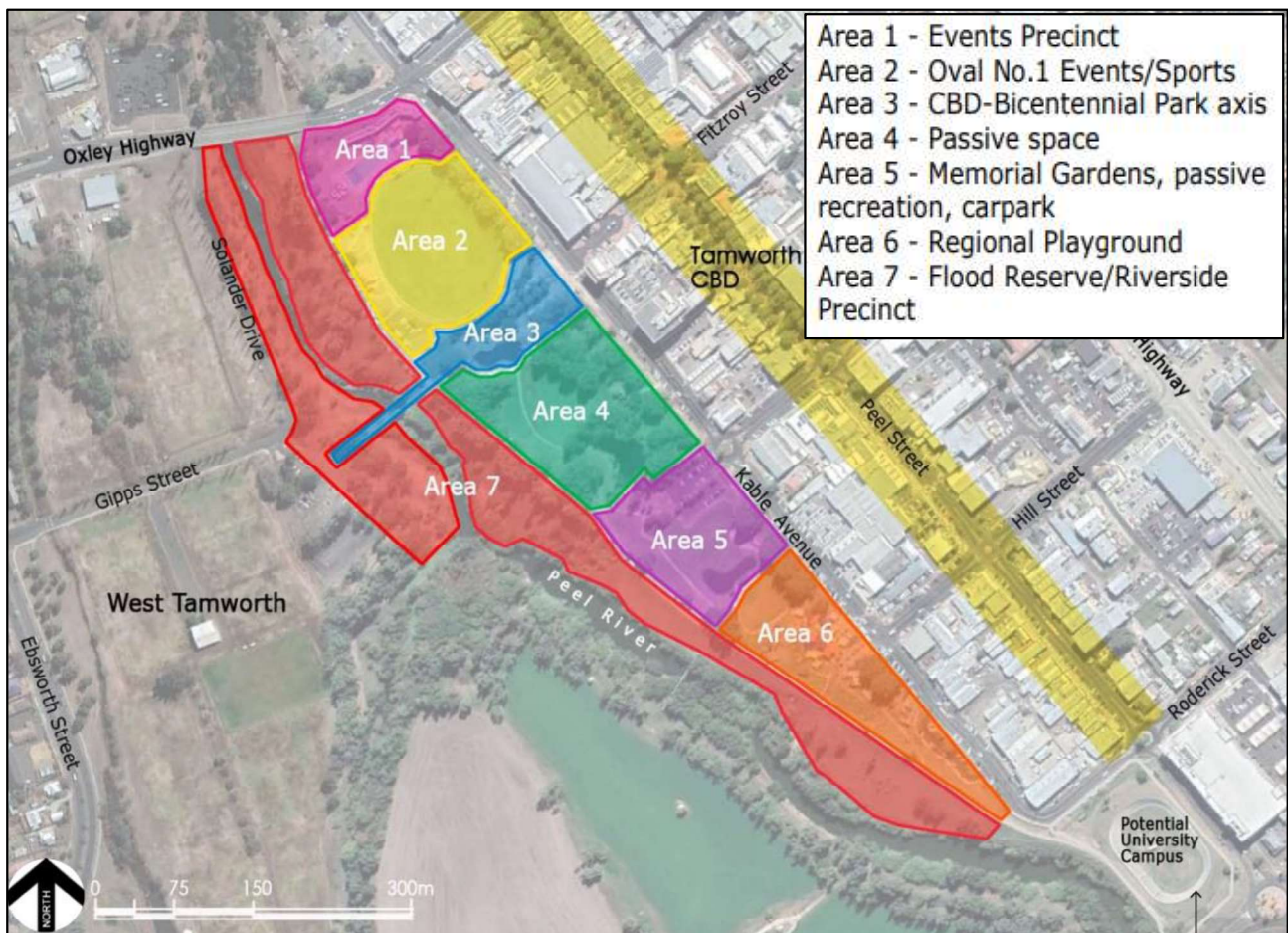


Figure 3-4 Bicentennial Park Areas Diagram (TRC, 2020e)

3.2.6 Development Plans

To accommodate the future growth of the LGA, Tamworth currently has one significant land release, Hills Plain, which accommodates both urban and rural residential estates. There are also numerous development areas within the existing boundaries of the study area (IWCM, TRC 2012) as shown in **Figure 3-5**.

The development plans provided within the study area are illustrated in **Figure 3-6** and **Figure 3-7** and listed below:

- > Arcadia (King + Campbell, 2019); and
- > Tamworth Global Gateway Park (Tamworth Regional Council, 2020) off Wallamore Road.

Construction commenced for the Tamworth Global Gateway Park and surrounding roadworks in late 2020.

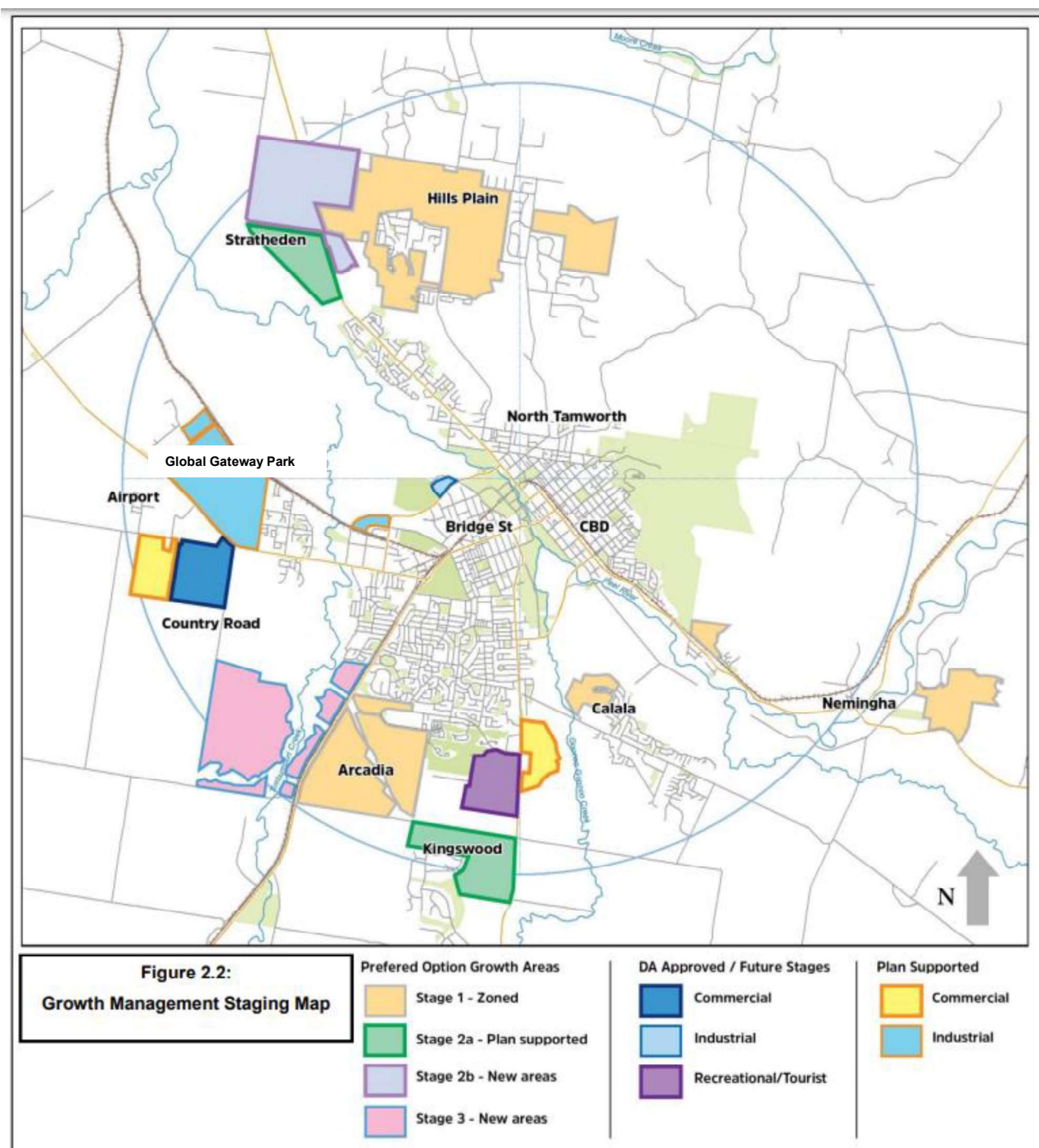


Figure 3-5 Growth Management Staging Map (Blueprint 100)

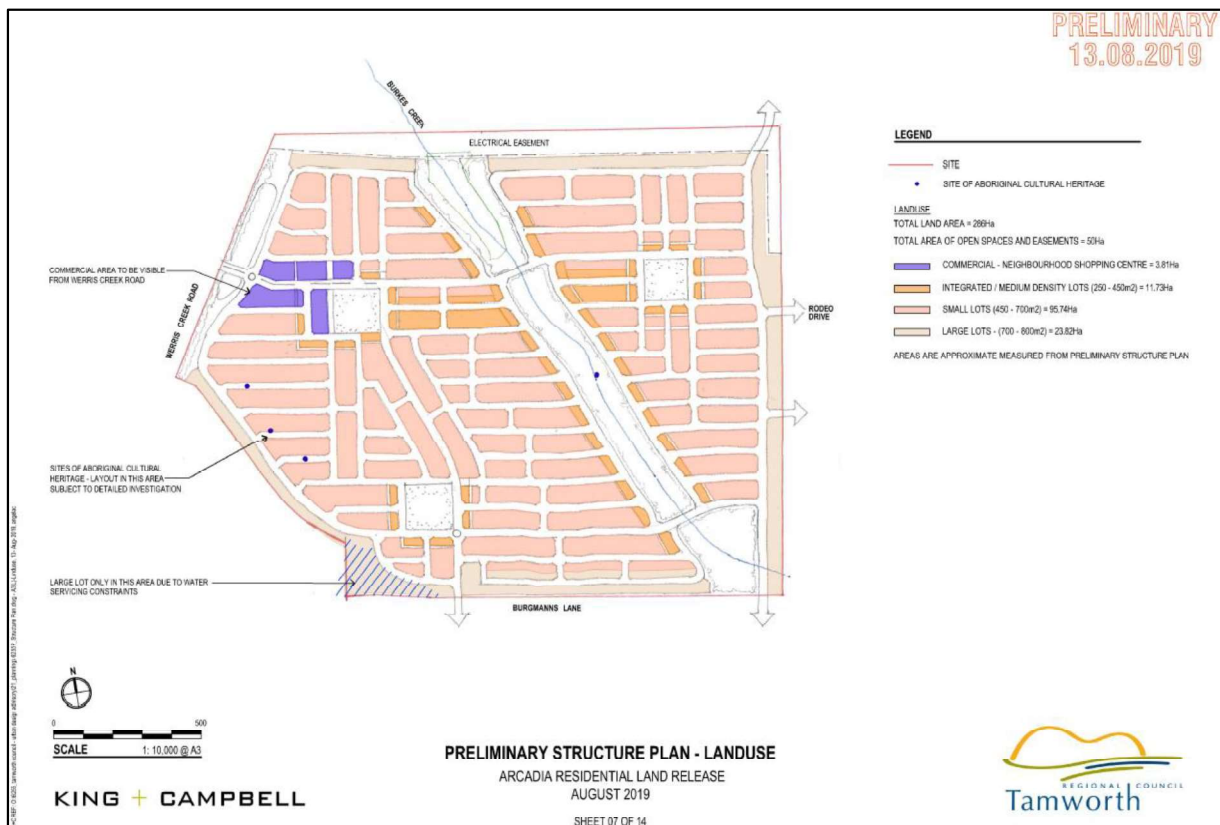


Figure 3-6 Arcadia Development Plan (2019)

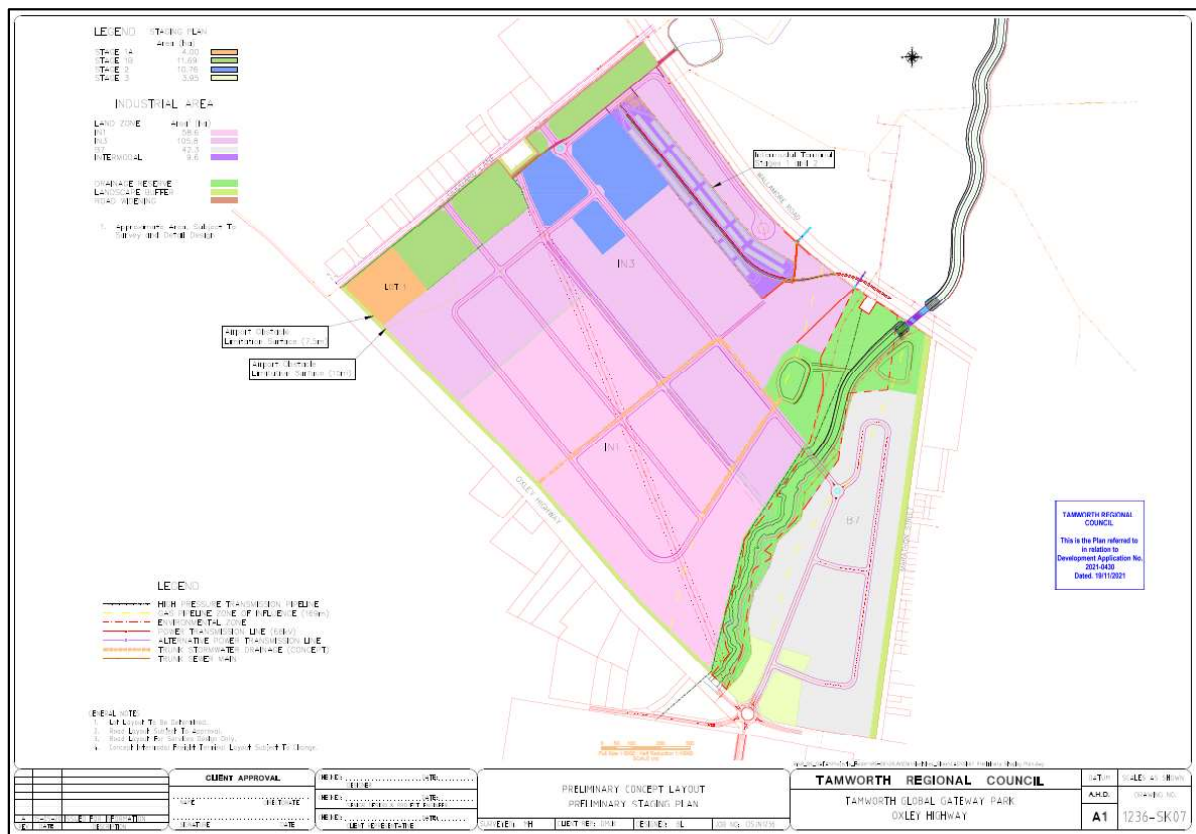


Figure 3-7 Tamworth Global Gateway Park Development Plan (2020)

3.2.7 Construction Specifications

3.2.7.1 TRC Engineering Design Standards for Subdivisions & Developments

The TRC Engineering Design Standards for Subdivisions & Developments Version 1 were published and adopted by TRC in March 2019. Sections of the standards relevant to urban stormwater management in Tamworth include the following:

- > 2. Minimum Standards for Roads:
 - 2.7.4 Batters – Specify grade requirements and location of catch drains to be incorporated into stormwater drainage design;
 - 2.7.7 Vehicular Crossing and Accesses – Specify culvert or drain requirements (including hydraulic capacity) for crossings that cross open channel drains;
- > 3. Minimum Standards for Stormwater Drainage Design:
 - 3.5.6 – Specify recurrence intervals for different designs (residential, commercial, rural areas, major systems and more);
 - 3.6 Hydrology – Specifications for hydrological calculations;
 - 3.7 Design of piped Drainage Systems – Design specifications for aspects of drainage systems (pit inlets, drainage pits, pipeline);
 - 3.8 Design of Overland Drainage Systems – Design specifications for hydraulic design and open channel designs;
 - 3.9 Inter-Allotment Drainage – Design specifications for inter-allotment drainage where roof water and surface water cannot be discharged directly to the street gutter system;
 - 3.10 Stormwater Detention and Retention – Specifications of design considerations, requirements and objectives for detention and retention systems including On-site Detention Design (OSD) design; and
 - 3.11 Drainage Corridor Tenure – Specifications for stormwater discharge when designed to discharge onto land other than existing drainage easements, drainage reserve, public road or other legal point of discharge

3.2.7.2 TRC Construction Specifications for Civil Works

The TRC Construction Specifications for Civil Works describes specifications to be addressed and included in applications for Developer Infrastructure Works within the TRC local government area. The following sections are relevant to urban stormwater management.

- > C101 Development Construction-General;
- > C220 Stormwater Drainage;
- > C221 Pipe Drainage; and
- > C222 Precast Box Culverts.

3.2.7.3 TRC Standard Drawings

TRC's latest standard drawings were published in March 2019 and include the following relevant to urban stormwater management:

- > Road
 - G001: Service allocations – urban residential;
 - G002: Service allocations – rural residential;
 - G004: Kerb drainage connections and adaptors;
 - RD001: Typical rural cross section;
 - RD002: Typical urban cross section;
 - RD003: Kerb profiles;
 - RD004: Kerb ramps;
 - RD008: Driveways urban residential;
 - RD009: Driveways industrial;
 - RD010: Driveways rural access across table drains;
- > Stormwater
 - SW001: Sag pit with lintel and grate – pipe under kerb;
 - SW002: Drop pit with lintel and grate – pit under kerb;
 - SW003: On grade kerb inlet pit with lintel and grate – pipe under kerb;
 - SW004: On grade kerb inlet pit with lintel and grate – pipe behind kerb;
 - SW005: On grade kerb inlet pit with lintel and grate – pipe under carriageway;
 - SW006: On grade kerb inlet pit with lintel and grate – roll type kerb;
 - SW007: Junction pit and grated inlet pit;
 - SW008: Surface inlet pit and surcharge pit;
 - SW009: Inter allotment drainage pit;
 - SW010: Subsoil drainage;
 - SW011: Access chamber roof slab reinforcement details;
 - SW012: Stormwater pipe bedding;
 - SW013: Pipe to box culver connection;
 - SW014: Stormwater pipe bulkhead and concrete pipe extension; and
 - SW015: Stormwater pit step iron ladder details.

3.3 GEO-SPATIAL DATA

3.3.1 Hydraulic Structures

The locations of existing flood mitigation basins in Tamworth have been provided in geo-spatial format and is depicted in **Map A2** in **Appendix A**. The data provided includes the following details:

- > Object ID;
- > Asset Number;
- > TRC Acquisition Date;
- > Description (e.g., Detain Grass, Sediment, Combo Grass); and
- > Surface Area.

3.3.2 Water Quality Infrastructure

The locations of existing Gross Pollutant Traps (GPTs) in Tamworth have been provided in geo-spatial format and is depicted in **Map A3** in **Appendix A**. The data provided includes the following details:

- > Object ID;
- > Asset Number;
- > Type (e.g., Surface Inlet Pit, Septic Tank, Litter Basket);
- > Description;
- > Construction Date;
- > Material;
- > Width;
- > Height;
- > Length; and
- > Additional Comments (e.g., can't access, lids locked).

3.3.3 Stormwater Network

The Tamworth stormwater network has been provided in geo-spatial format and includes end structures, pipes, pits, surface drains and culverts. The location of the assets within the Tamworth stormwater network are depicted **Map A4** in **Appendix A** and the data provided includes the following details:

- > Object ID;
- > Asset Number;
- > TRC Acquisition Date;
- > Description;
- > Diameter;
- > Invert Values; and
- > Length.

The Tamworth inter-allotment network has been provided in geo-spatial format and includes end structures, pipes, pits and surface drains. The location of the assets within the Tamworth inter-allotment network are depicted in **Map A5** in **Appendix A** and the data provided includes the following details:

- > Object ID;
- > Asset Number;
- > TRC Acquisition Date;

- > Description;
- > Diameter;
- > Invert Values; and
- > Length.

3.3.4 Aerial Imagery

The aerial imagery provided by TRC covers the entire Tamworth Study Area. It is considered to be of a resolution suitable for this investigation.

3.3.5 Topographic Data

At the time of this investigation, 5m grid size topographic data from 2019 which covers the entire Tamworth Study Area and a 0.5m grid size topographic data from 2012 -2013 which covers most of the Tamworth Study Area with an exception of 1.05km² of missing data at the southern end of the Study Area, was available. The combination of the two data sets is considered suitable to be used for this investigation.

3.4 STORMWATER INFRASTRUCTURE

3.4.1 Stormwater Priorities

Council has a list of the stormwater priority projects for 2021. The list has ranked all projects across the TRC based on priority. The projects relevant to the Tamworth Study Areas are listed in **Table 3-4** in priority order, along with their cost estimate and current status.

These priorities involve the upgrading of existing or construction of new stormwater infrastructure and includes but is not limited to the following activities:

- > Bund upgrades;
- > Pipe and Culvert Upgrades;
- > Inlet Upgrades;
- > Road and Drainage reshape; and
- > Detention Basin Construction.

Table 3-4 2021 Tamworth Stormwater Priorities

Priority	Site	Project	Cost	Status
1	Bournes Lane Channel Upgrade	Add to existing bund protecting property (563 Moore Creek Road), Construct new bund ~0.5m above soffit of culvert to the north and west of upstream headwall	\$30,000.00	Planning
2	Moore Creek Road	Upsize exiting pipe culverts to 3 x 900x1200 RCBC. Clear downstream channel.	\$180,000.00	Planning
3	South Kingswood Basin	5500m ³ basin in Council owned land south of Kingswood. Outlet sized to discharge at capacity of downstream channels.	\$130,000.00	Planning
5	Long Gully	Upgrade inlet (1m bund) at Raglan Street	\$100,000.00	Planning
7	CWA Park Pump Out	Pump out from CWA park	\$120,000.00	Planning
8	Rifle Rang Gully	Upgrade inlet (additional 0.5m headwall at Victoria Street)	\$50,000.00	Planning
10	Darling Street Pump Out	Storage in Park and Pump out	\$120,000.00	Planning
12	White Street	600mm pipe from 63 Raglan to White Street / Levine Intersection	\$176,200.00	Planning
14	Long Gully	Victoria Park detention	\$500,000.00	Planning
15	Denne Street - Gipps to Bridge	450mm Piped Drainage	\$175,000.00	Planning
17	Manilla Road	375mm Pipe Drainage	\$50,000.00	Planning
18	Kent Street	825mm pipe from Belmore Street to Goonoo Goonoo Road	\$346,800.00	Planning
21	Hall Street	600mm pipe from Bushland Ave to Rail	\$182,500.00	Planning
22	Armidale Road	375mm Pipe Drainage	\$50,000.00	Planning
29	Hills Plains Detention	Additional Basin to reduce peak flows and reduce velocities in frequent events	\$300,000.00	Planning
31	Viaduct Park gates open outlet	Storage in Park and Pump out	\$512,000.00	Planning
32	Rifle Rang Gully	Detention in TAFE land	\$500,000.00	Planning

Priority	Site	Project	Cost	Status
33	Garrieties Gully	New Pressure Tunnel (1500mmØ 2.5m of head in Murray reserve)	\$4,500,000.00	Planning
36	George Street	375mm pipe to join to existing	\$40,000.00	Planning
38	Greg Norman Drive	375mm Pipe Drainage	\$50,000.00	Planning
39	Marius/Hunt Street	New 675mm Line and kerb and gutter	\$165,000.00	Planning
40	Skillshare Park Detention	Increase basin capacity and overflow spill way	\$75,000.00	Planning
42	Baufort Street Basin	Storage in the cemetery land and channel upgrade	\$30,000.00	Planning
43	Jewry Street	900mm pipe along Jewry Street	\$536,300.00	Planning
43	Swan Street rehab	Reconstruct scour protection	\$200,000.00	Planning
43	Phoenix Street rehab	Reconstruct scour protection	\$50,000.00	Planning
43	Hercules Street	New 750mm pipe	\$250,000.00 (Outstanding works cost)	Partially constructed

Map A6 in **Appendix A** highlights the location of the 2021 Stormwater priorities for the Tamworth Study Area. These priorities have been incorporated in to the final list of options and multi-criteria assessment undertaken for this project in Section 9.1.

3.4.2 Stormwater Resolutions

TRC Customer Request Management (CRM) resolutions log recorded several enquiries regarding drainage or flood and storm damage in the Tamworth Study Area. The enquiries are recorded and resolved where possible. The enquiries within the Tamworth Study Area are summarised in Table 3-5. **Map A6 in Appendix A** highlights the location of these enquiries.

Table 3-5 Tamworth CRM Resolutions

ID	Date	Location	Category	Description	Status
TRC2021-10512	17/06/2021	Calala	Drainage - Stormwater/gutter	Interallotment drainage insufficient capacity	Not Council's Responsibility
TRC2021-09981	28/05/2021	Kingswood	Drainage - Stormwater/gutter	Road flooding into property	No record
TRC2021-09736	18/05/2021	Taminda	Drainage - Stormwater/gutter	Road flooding into property	Resolved – berm reinstated in street
TRC2021-09696	17/05/2021	East Tamworth	Drainage - Stormwater/gutter	Road damage due to flooding	No Action Required
TRC2021-09017	19/04/2021	West Tamworth	Drainage - Private Land	Road flooding into property	No record
TRC2021-08180	23/03/2021	Kingswood	Drainage - Private Land		Not Council's Responsibility – recommended future table drain works
TRC2021-07978	17/03/2021	Bective	Drainage - Stormwater/gutter	Road culvert failure	Resolved – advice provided
TRC2021-07803	12/03/2021	Nemingha	Drainage - Stormwater/gutter	Road flooding into property	No record
TRC2021-07763	11/03/2021	Westdale	Drainage - Stormwater/gutter	Flooding from adjacent properties and Wylie Place Reserve	Resolved – 300 mm hump installed
TRC2021-07480	3/03/2021	North Tamworth	Drainage - Stormwater/gutter	Road flooding into property	Not Council's Responsibility
TRC2021-07348	1/03/2021	Oxley Vale	Drainage - Stormwater/gutter	Road flooding into property	No Action Required
TRC2021-07231	25/02/2021	Tamworth	Drainage - Stormwater/gutter -	Road flooding into property	No record
TRC2021-07227	25/02/2021	North Tamworth	Drainage - Stormwater/gutter	Drainage easement scour	No record
TRC2021-07216	25/02/2021	North Tamworth	Tamworth Parry - Tar Roads	Road flooding into property	Issue Resolved – pit repair and street sweeping
TRC2021-06122	27/01/2021	Kingswood	Drainage - Stormwater/gutter	Road flooding into property	Issue Resolved
TRC2021-05546	14/01/2021	Kingswood	Drainage - Stormwater/gutter	General property flooding	Issue Resolved
TRC2021-05155	5/01/2021	Kingswood	Drainage - Stormwater/gutter	General property flooding	Issue Resolved
TRC2021-05080	5/01/2021	Moore Creek	Drainage - Stormwater/gutter/ Tamworth Parry - Tar Roads	Driveway washout	Not Council's Responsibility
TRC2021-05061	4/01/2021	Oxley Vale	Drainage - Stormwater/gutter	Road flooding into property	Issue Resolved – pool bund installed
TRC2021-05060	4/01/2021	Kingswood	Drainage - Stormwater/gutter	Insufficient drainage easement	Issue Resolved
TRC2021-04947	4/01/2021	Kingswood	Drainage - Stormwater/gutter	Property damage	Issue Resolved
TRC2021-04761	22/12/2020	East Tamworth	Drainage - Stormwater/gutter	Council reserve and road flooding into property	Not Council's Responsibility
TRC2021-03291	30/10/2020	Nemingha	Drainage - Stormwater/gutter	Road damage due to flooding/ insufficient road drainage	Issue Resolved - maintenance

ID	Date	Location	Category	Description	Status
TRC2021-03262	29/10/2020	Hillvue	Drainage - Stormwater/gutter	Council reserve sediment runoff	Issue Resolved – gutter maintenance
TRC2021-02103	22/09/2020	Moore Creek	Drainage - Stormwater/gutter	Road flooding	Issue Resolved – table drain works
TRC2021-00932	7/08/2020	Moore Creek	Drainage - Stormwater/gutter	Basin/floodway silt build-up and scour	Issue Resolved
TRC2020-07598	7/04/2020	Calala	Drainage - Stormwater/gutter	General property flooding	Issue Resolved
TRC2020-07556	6/04/2020	Bective	Drainage - Stormwater/gutter	Insufficient road drainage	No Action Required
TRC2020-06755	10/03/2020	North Tamworth	Drainage - Stormwater/gutter	Insufficient drainage in easement	Issue Resolved – channel works
TRC2020-06369	28/02/2020	Hillvue	Drainage - Stormwater/gutter	Insufficient road drainage	Issue Resolved – Flood Study investigations ongoing
TRC2020-05644	13/02/2020	North Tamworth	Drainage - Stormwater/gutter	Insufficient drainage in easement	Not Council's Responsibility
TRC2020-05602	12/02/2020	Oxley Vale	Drainage - Stormwater/gutter	Road flooding into property	Issue Resolved
TRC2020-05590	12/02/2020	Moore Creek	Drainage - Stormwater/gutter	Open drain flooding property	Not Council's Responsibility – trees planted in drains
TRC2020-05551	12/02/2020	Moore Creek	Drainage - Stormwater/gutter	Insufficient road drainage	Issue Resolved – drainage reserve diversion
TRC2020-05545	12/02/2020	Moore Creek	Drainage - Stormwater/gutter	Road flooding into property	Issue Resolved
TRC2020-05532	12/02/2020	Moore Creek	Drainage - Stormwater/gutter	Road flooding into property/ Insufficient road drainage	Issue Resolved – unapproved neighbour works issued letter of direction
TRC2020-05454	10/02/2020	East Tamworth	Drainage - Stormwater/gutter	Railway culvert causing flooding	Issue Resolved
TRC2020-05410	10/02/2020	East Tamworth	Drainage - Stormwater/gutter	Insufficient road drainage	Issue Resolved
TRC2020-05383	10/02/2020	East Tamworth	Drainage - Stormwater/gutter - Tamworth Parry - Tar Roads	Insufficient road drainage	Issue Resolved
TRC2020-05382	10/02/2020	East Tamworth	Drainage - Stormwater/gutter - Tamworth Parry - Tar Roads	Road flooding into property	Issue Resolved
TRC2020-05363	10/02/2020	Moore Creek	Drainage - Stormwater/gutter	Open drain flooding property	Issue Resolved
TRC2020-01938	17/09/2019	East Tamworth	Drainage - Stormwater/gutter - Tamworth Parry - Tar Roads	Council reserve sediment runoff	No Action Required
TRC2019-09768	3/06/2019	West Tamworth	Drainage - Stormwater/gutter - Tamworth Parry - Tar Roads	Property flooding from adjacent property drainage	Issue Resolved
TRC2019-08019	1/04/2019	East Tamworth	Drainage - Stormwater/gutter	Insufficient rail drainage easement	Issue Resolved – channel maintenance
TRC2018-05680	13/03/2018	Moore Creek	Drainage - Stormwater/gutter	Road flooding into property	No Action Required

ID	Date	Location	Category	Description	Status
TRC2018-03163	5/12/2017	North Tamworth	Tamworth Parry - Tar Roads and TRC Flood Management Basin	Drainage easement/basin overflow	To consider
ROAD2016/0178	24/08/2015	Calala	Drainage - Stormwater/gutter	Road flooding into property	No record
ROAD0356/2014	19/11/2013	Kingswood	Drainage - Stormwater/gutter	Road flooding into property	No record
ROAD0228/2012	29/09/2011	North Tamworth	Drainage - Private Land	Lot drainage	No record – property owner responsibility
ROAD1011/2011	14/12/2010	Calala	Flood and Storm Damage	Increased runoff from development	No record
ROAD1395/2009	1/05/2009	Calala	Flood and Storm Damage	Road flooding into property	No record
ROAD0847/2009	16/12/2008	Calala	Flood and Storm Damage	Road flooding into property	No record
ROAD0670/2009	3/12/2008	West Tamworth	Flood and Storm Damage	Road flooding into property	No record
ROAD0666/2009	3/12/2008	Moore Creek	Flood and Storm Damage	Open drain flooding property	No record

The key themes from the CRM resolutions log was flooding in properties caused by insufficient road drainage or conveyance, constituting 51% of recorded complaints as illustrated in Figure 3-8. Further common complaints were related to flooding originating from easements and sediment or gravel transport due to high velocity runoff.

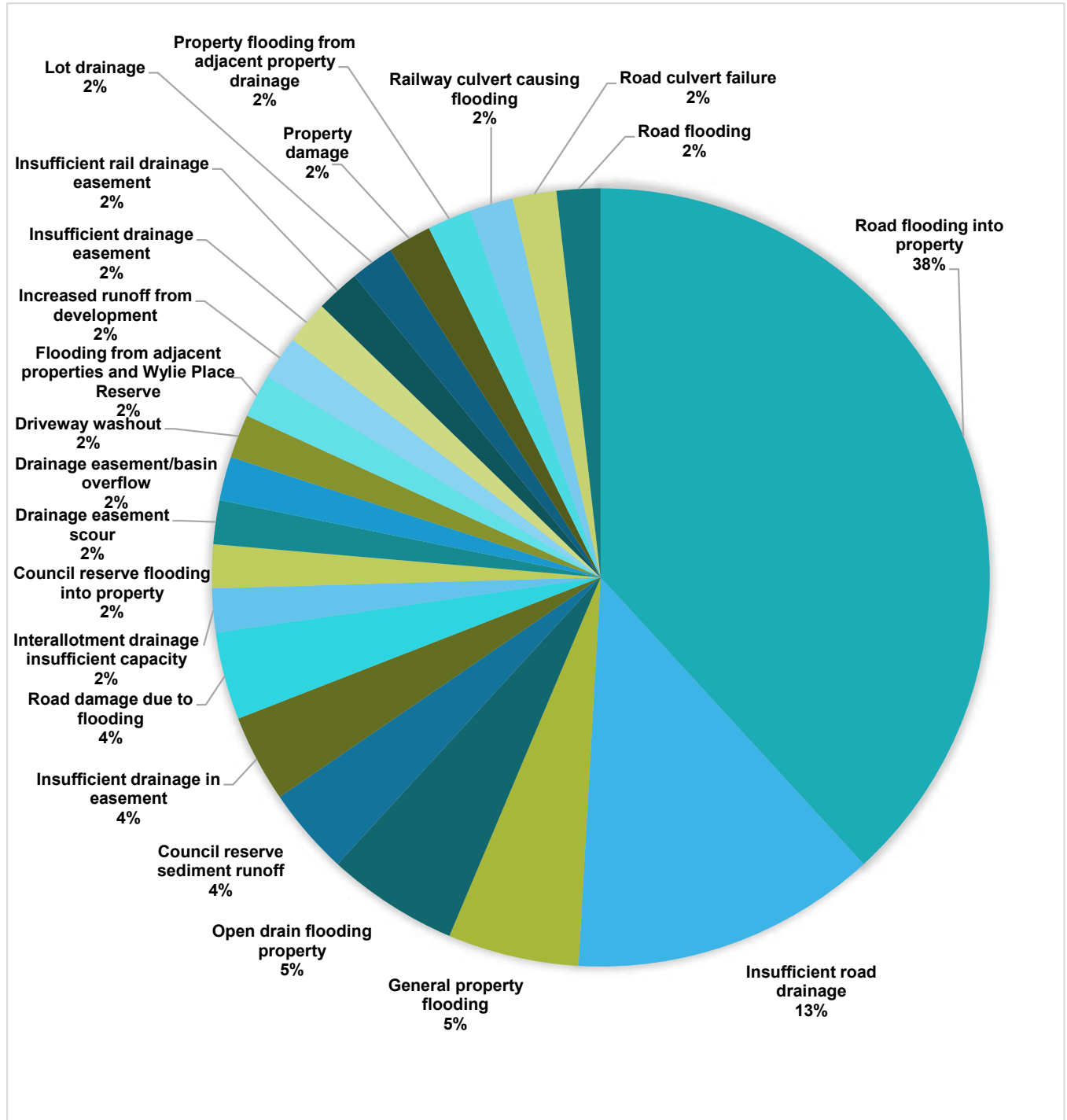


Figure 3-8 Key Themes from CMR Logs

4 CATCHMENT PROFILING

4.1 TOPOGRAPHY AND DRAINAGE

The Peel River runs through the Tamworth Study Area from the south-eastern boundary through to the northern end. Several tributaries meet the Peel River within the Study Area including the confluence of the Peel and Cockburn River which occurs approximately 4.5km upstream of the Tamworth CBD.

The north-eastern boundary of the Study Area follows a ridge line which reaches a maximum elevation of 820mAHN approximately within the Study Area. This ridge line drops off significantly and flattens out for the residential area of East Tamworth.

The Peel River is at a level of approximately 403mAHN when it enters the Study Area and leaves the Study Area 2.5km downstream at an elevation of approximately 353mAHN. The area of Tamworth on the western bank of the Peel River is relatively flat with an average grade of approximately 1% leading to the river.

4.2 CLIMATE

The climate characteristics for Tamworth sourced from the Bureau of Meteorology website is provided in **Table 4-1** below. The climate characteristics are sourced from the Tamworth Airport AWS Station (Site Number 055325), which is located approximately 10km from Tamworth.

Tamworth experienced an average maximum temperature of 31.8°C in summer and 17.4°C in winter. Rainfall tends to be summer dominant, and evaporation exceeds rainfall by almost 3:1 in some areas. The average annual evaporation is 1,970mm varying from around 2mm/day in June/July to around 8-9mm/day in the summer months (IWCM Study, TRC 2012).

The highest rainfall was recorded in November 2008 with a precipitation of 283.6mm, followed by February 2012 with a precipitation of 257.6mm. Climate change projections for the Tamworth region are expected to slightly increase in summer rainfall and decrease in winter (DECCW, 2010).

Table 4-1 Monthly Climate Data (year 1992 – 2021 for temperature and 1993 - 2021 for rainfall)

Month	Mean Maximum Temperature (°C)	Mean Minimum Temperature (°C)	Mean Monthly Rainfall (mm)	Lowest Recorded Rainfall (mm)	Highest Recorded Rainfall (mm)
January	33	17.7	60.2	0.2	227.6
February	31.6	17	74.4	0.8	257.6
March	29.3	14.5	54.9	0	162
April	25.5	10	25.1	0	123
May	20.7	6	29.7	0.2	80.2
June	17.1	3.7	54.4	1.2	169
July	16.5	2.3	41	1.8	154.3
August	18.5	2.7	38.1	0	100
September	22.1	5.8	42.9	0.8	132.6
October	25.7	9.7	55.3	10.6	121.6
November	28.7	13.3	78.4	3	283.6
December	30.8	15.7	80.7	0	223.6

4.3 LAND USE AND ZONING

Based on the TRLEP 2010 land use zone mapping for the Study Area has been shown in **Figure A7** in **Appendix A** and **Figure 4-1**. Land use in Tamworth is predominantly General Residential, with 75% of the LGA population residing in the Tamworth urban area and Primary Production Small Lots with some areas classified Low Density Residential, Large Lot Residential, and Transition.

Retail is the area's largest employer with agriculture being the largest industry, particularly poultry. Commercial, industrial and agricultural waste can be seen to have negatively impacted water quality in the region as outlined in Section 5.

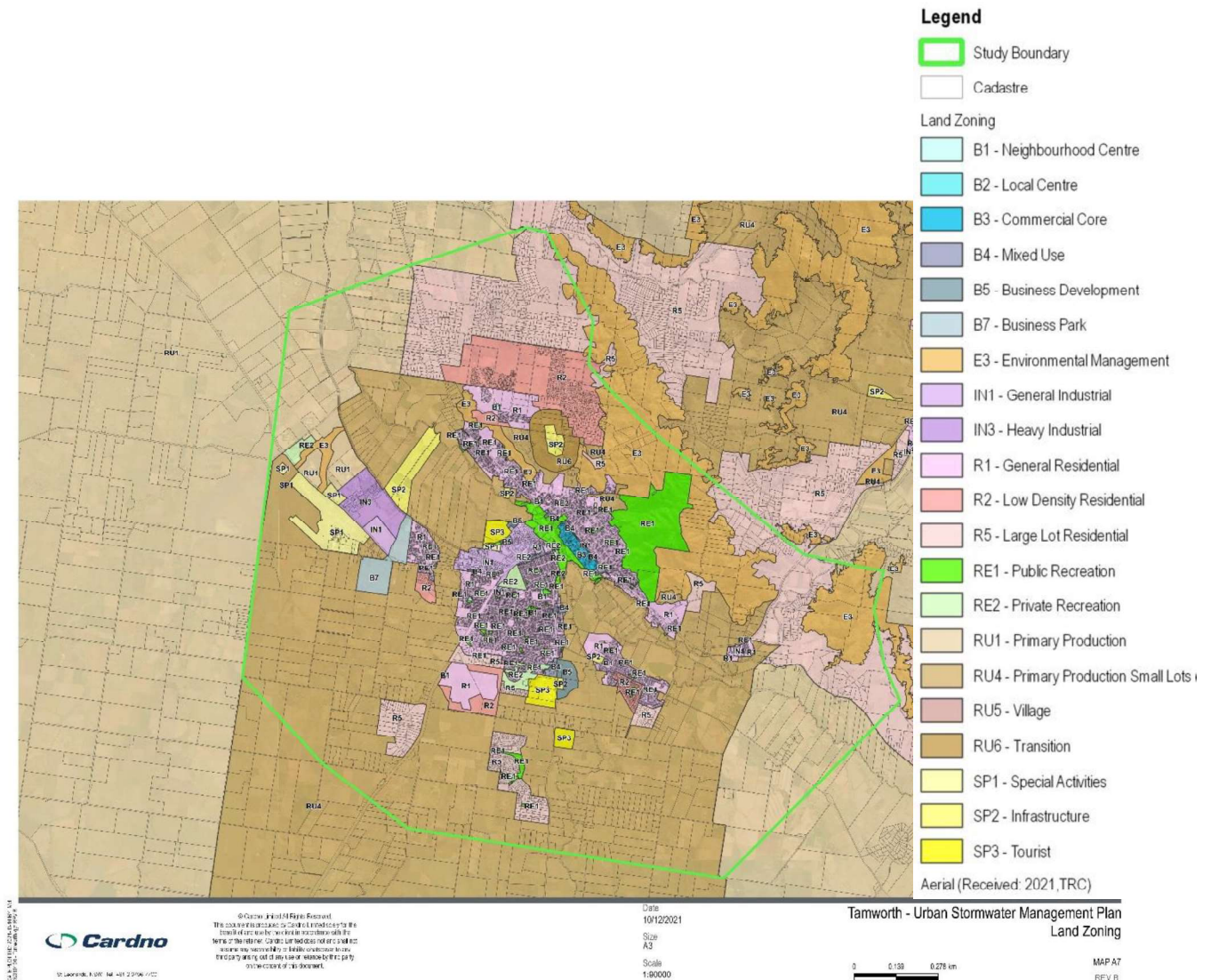


Figure 4-1 Land Use and Zoning

4.4 LEVEE SYSTEM

4.4.1 Town Levees

Areas of Tamworth are protected by a levee system - CBD Levee, Taminda Levee, and Western Levee from mainstream flooding.

4.4.1.1 CBD Levee

The CBD Levee was originally constructed in the 1930s to protect existing commercial development located along the northern bank of the Peel River, between Murray Street and Bligh Street. The levee has been raised on several occasions most recently in 1996-1997 to provide 1m of protection against the 100-year ARI design flood event. The levee is principally an earth embankment and is up to 4.2 metres in height. A catchment of 10km² drains from behind the CBD levee into the Peel River.

A visual audit was conducted of the levee in September 2019 determining it to be in a generally acceptable condition. It was recommended that remediation be carried out to increase the height of the levee at the noticeable low point, smooth the levee crest and remove vegetation encroachment. These works have either been actioned or programmed as part of the ongoing works program for delivery.

4.4.1.2 Taminda Levee

Taminda Levee was originally privately built and ran along the northern side of the Tamworth Racecourse. The levee was upgraded in 2008-2009 to form a 2.7km long levee to protect commercial and industrial property located in the Taminda area. The levee comprises of two relatively short sections of reinforced concrete block wall where it runs along the northern side of Ebsworth Street between Barnes Street and Plain Street and earth embankment where it runs from Plain Street around the northern and western sides of the Tamworth Racecourse where it ties into the high ground at Jewry Street. A 4.5km² catchment drains to either Barnes Gully or the Wallamore Anabranch from behind the Taminda Levee.

A visual audit was conducted of the levee in September 2019 determining it to be in a generally acceptable condition. It was proposed to install a floodgate immediately on the culvert outlet if the invert is lower than the 1% AEP flood level and structural concrete blocks to be filled to manufacturers specifications where left hollow. These recommendations have been incorporated into the ongoing works program for delivery.

4.4.1.3 Western Levee

The Western Levee was constructed in 2002-2003 and protects existing residential and commercial development located on the eastern side of Goonoo Goonoo Road between Margaret Street and Mathews Street. The levee is of earth embankment type construction and is up to 5.6 metres in height. A 1.94km² catchment drains to Barnes Gully from behind the Western Levee.

A visual audit was conducted of the levee in September 2019 determining it to be in a generally acceptable condition. Post-fire returfing and general remediation of surface cracking, ruts and retaining wall damage was completed by concreting the crest of the levee. Additional recommendations have been incorporated into the ongoing works program for delivery.

4.4.2 Flood Gates

One of the key features governing local catchment flood behaviour in Tamworth is the position of thirty-nine (39) manually operated penstock type flood gates operated by TRC. Of the thirty-five (35) floodgates adjacent to the three levees, 19 are located at the CBD levee, 6 at the western levee and 10 adjacent to Taminda levee.

The flood gates are designed to control backwater flooding behind the levees as shown in **Figure 4-3** to **Figure 4-4**.



Figure 4-2 CBD Levee Flood Gates Locations

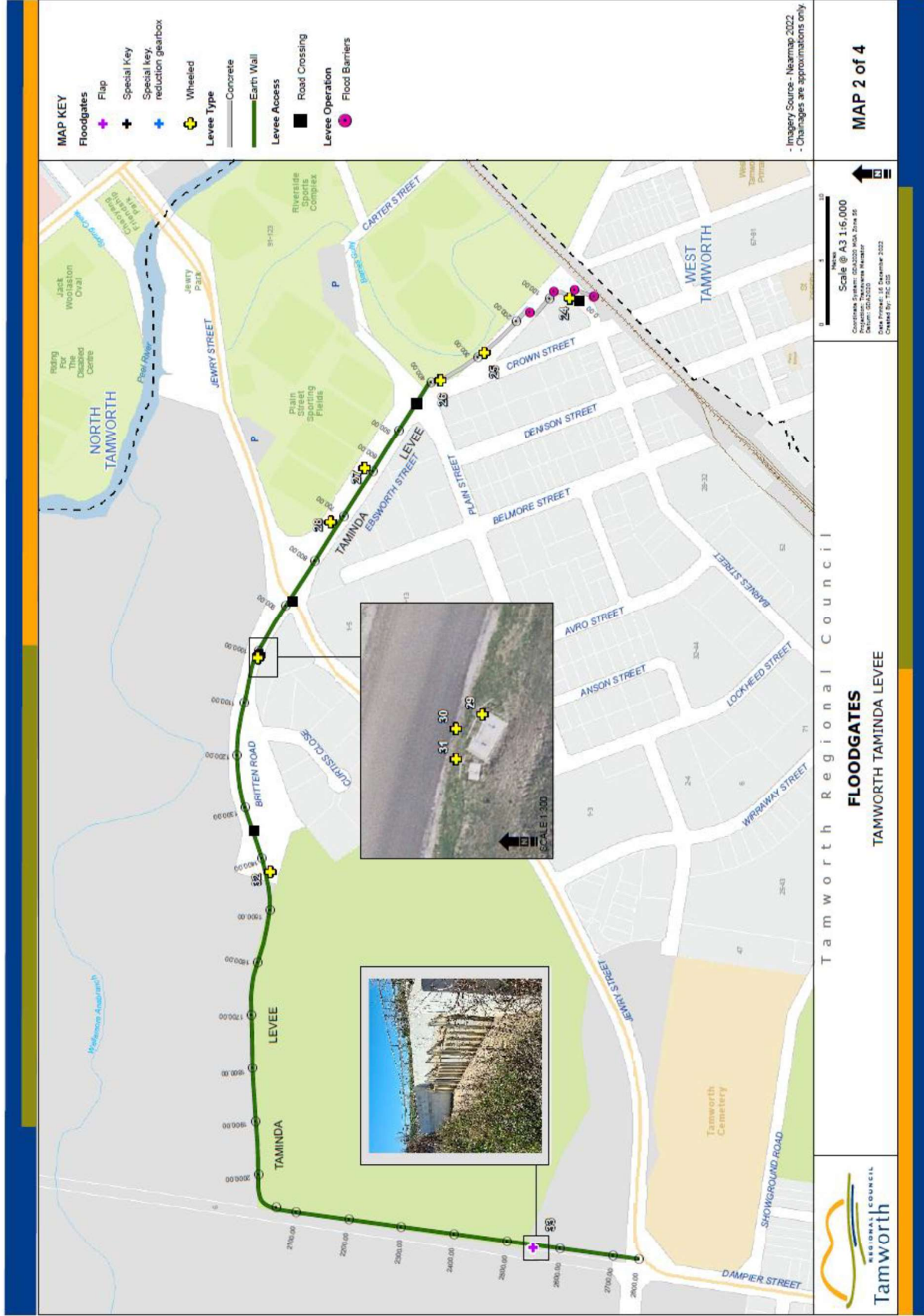


Figure 4-3 Taminda Levee Flood Gates Locations

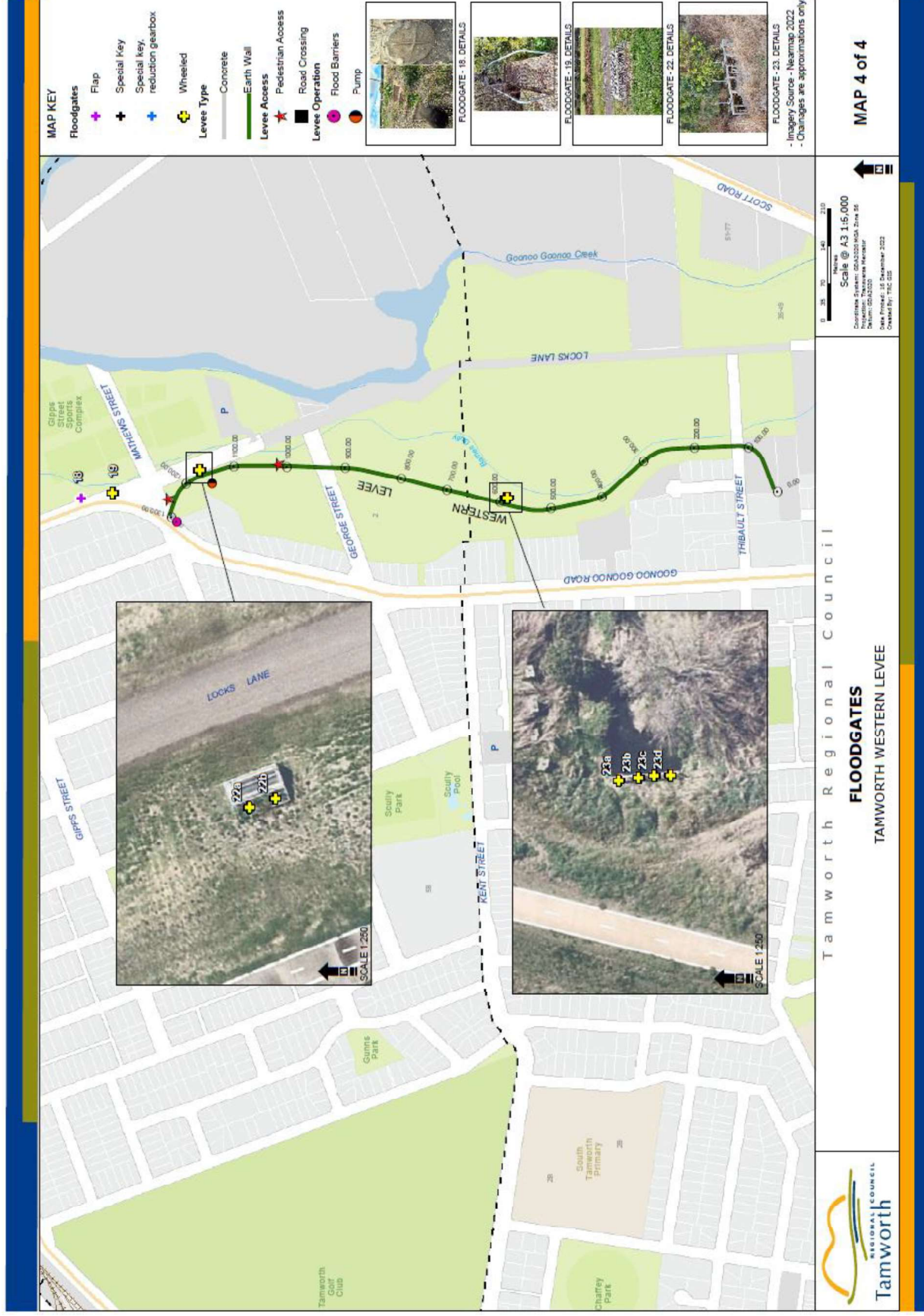


Figure 4-4 Western Levee Flood Gates Locations



4.5 FLOOD BEHAVIOUR

Tamworth City is located on the Peel River resulting in a floodplain through the city centre that narrows significantly near the centre of Tamworth and raises the water levels and velocities during flood events. Flooding of the Peel River occurs most frequently in summer when rainfall is typically double that of winter months (IWCM, TRC 2012).

Two significant floods have been recorded to have occurred in Tamworth prior to the installation of gauges, these are noted below:

- > February 1864; and
- > 1910.

Gauges were later installed and water level recording commenced in January 1925. Since then, several minor, moderate and major floods have occurred. The most significant are noted below:

- > February 1955 major flood event, reached 7.16m and reportedly remained elevated for 4 days;
- > January 1962 major flood event, reached 6.86m;
- > November 2000 major flood event, reached 6.26m; and
- > November 2008 major flood event, reached 6.00m.

More recent flood events have been recorded in February 1971, January 1974, January- February 1976, January 1984, and December 2010.

Local catchment flooding in the Study Area is limited to respondents to a questionnaire distributed as part of a 2012 investigation by Lyall & Associates. Responses indicated commercial properties within the Tamworth CBD are subject to flooding during storms which surcharge from the local stormwater drainage system and several residential properties located behind the Western Levee were affected by local catchment runoff during periods of intense rain.

4.6 CATCHMENT WATERWAYS

The Peel River runs through the Tamworth Study Area in the headwaters of the Namoi River Basin. The Peel River has a catchment upstream of Tamworth of approximately 3080km² which includes the catchments of the Cockburn River and Goonoo Goonoo Creek. Two water supply dams are located in the Peel River catchment upstream of Tamworth, the largest of which is the Chaffey Dam. Several tributaries join the Peel River in the Tamworth Study Area including Timbumburi Creek, Spring Creek, Rifle Range Gully, Goonoo Goonoo Creek, Murroon Creek, Boltons Creek, Tangaratta Creek and the Cockburn River.

Namoi Catchment Management Authority undertook an assessment of overall river health in the Peel Valley in 2004 (Namoi River Styles Report). The findings of the report show that the Peel Valley sub-catchment has around 50% of assessed streamlines in poor condition, particularly to the western lower lying areas of the catchment. **Figure 4-5** shows the waterway conditions within the Peel Valley catchment through Tamworth have been identified to be in poor condition.

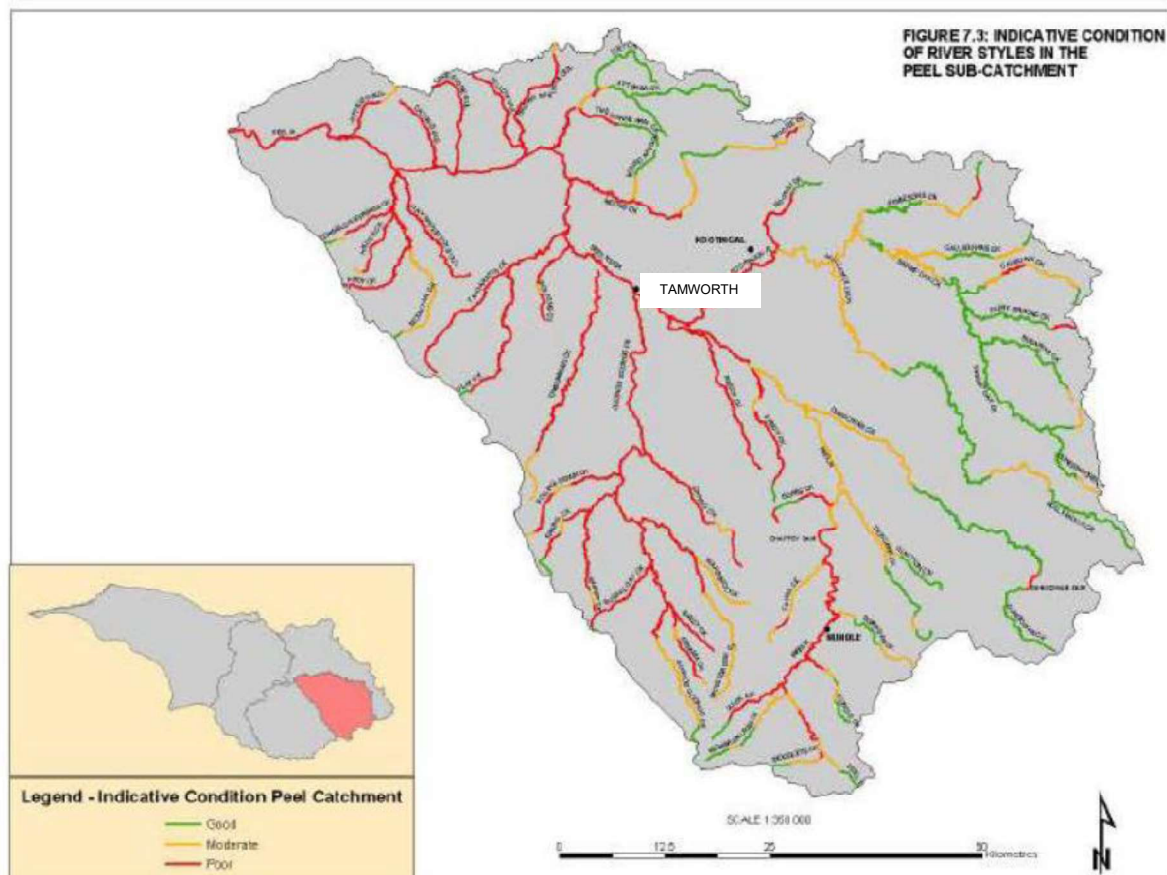


Figure 4-5 Waterway Conditions within the Peel Valley Catchment (Namoi CMA, 2004)

There are multiple WaterNSW gauges located along Peel River. The key gauge identified for the study area is the (419024) Peel River at Upstream Paradise Weir with an available discharge data set between 1974 to 2023. The discharge against water level relationship is illustrated in Figure 4-6 and daily discharge statistics are shown in Figure 4-7.

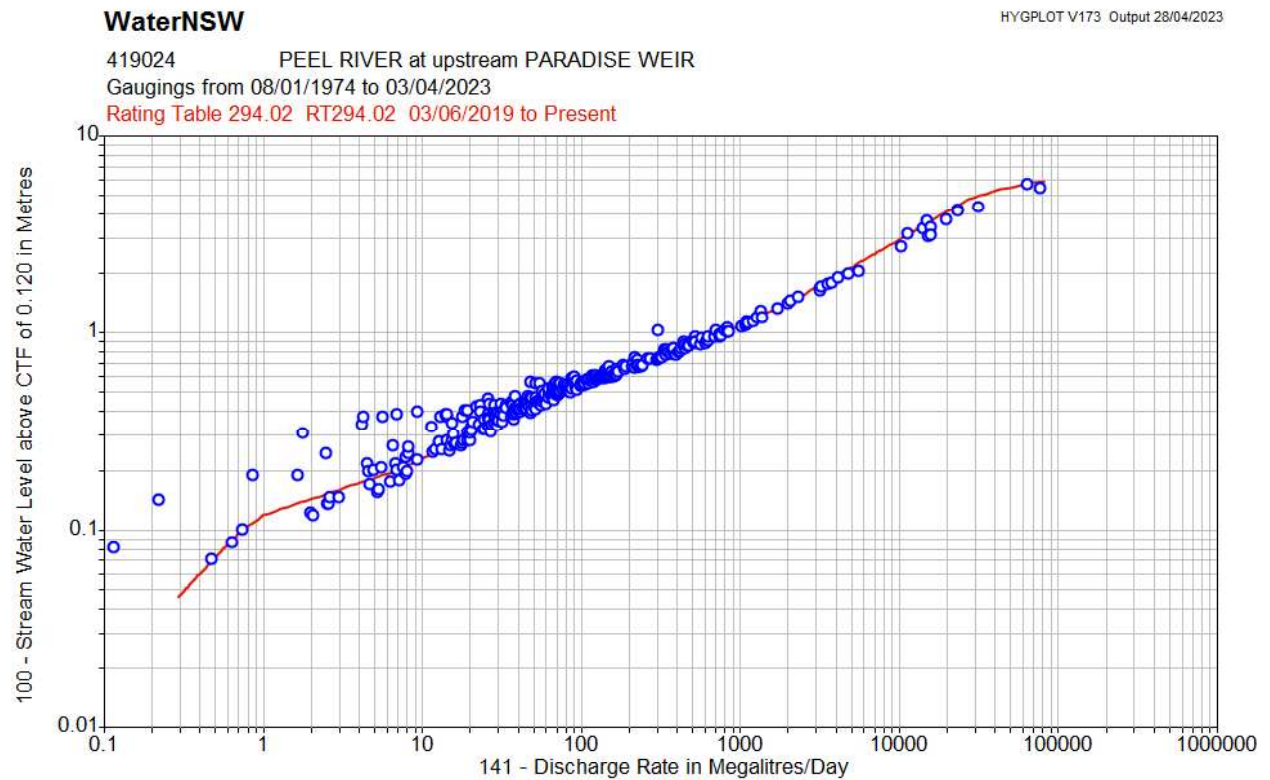


Figure 4-6 Discharge Rate vs. Stream Level for (419024) Peel River at Upstream Paradise Weir

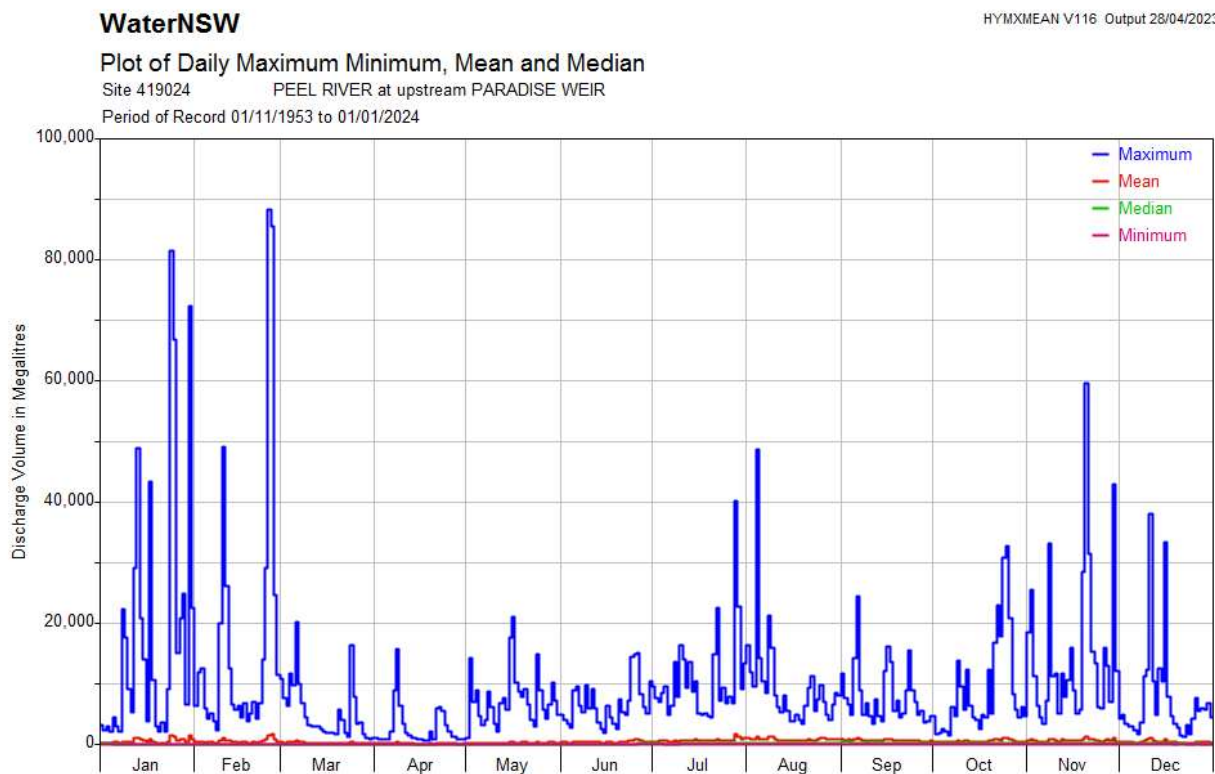


Figure 4-7 Daily Discharge Statistics for (419024) Peel River at Upstream Paradise Weir

Additional gauge datasets for the region include:

- > 419006 (Peel River at Carroll Gap)
- > 419009 (Peel River at Tamworth)
- > 419015 (Peel River at Piallamore)
- > 419045 (Peel River D/S Chaffey Dam)
- > 419069 (Peel River at Chaffey Dam - Storage Gauge)
- > 419070 (Peel River at Tamworth Water Supply)
- > 419073 (Peel River at Appleby Crossing)
- > 419074 (Peel River at Bective)
- > 419081 (Peel River at Tarroona)
- > 419096 (Peel River at Chaffey Dam Outlet)

4.7 SOIL AND GEOLOGY

4.7.1 Soil Landscape

The soils within the Study Area include alluvial, transferal, residual, erosional, colluvial and disturbed terrain (refer to **Map A8** in **Appendix A**). Under the Australian Soil Classification, they are classified as Chromosols, Vertosols, Dermosols, Ferrosols and Sodosols.

The soils landscapes within the Tamworth area are illustrated on the eSPADE map with data sourced from the NSW Soil and Landscape Information System (SALIS) (DPIE, 2019). The soils landscapes within the Study Area include Duri, Goonoo Goonoo, Peel, The Forest, Orchard Creek, Daruka, Parnell, Spring Creek, Fullwoods Hills and Disturbed Terrain. A description of these soil landscapes and their characteristics is provided in **Table 4-2**.

Table 4-2 Soil landscapes in the Study Area (Source: DPIE, 2019)

Landscape	Description and limitations
Duri (du)	Landscape— 560.1 km² extensive undulating to rolling low hills and hills on Devonian and Carboniferous sedimentary rocks of the Duri Hills. Local relief <100m (mostly <60m); slopes <10%; elevation 360 – 540 m. Mostly cleared open-woodland and grassland used for agriculture. Landscape Variant dua— western variant; may have slightly different limitations due to westerly aspect and association with different geology types on the western side of the Melville Ranges. Soils— extremely complex due to rapid changes in underlying lithology. Generally dominated by duplex soils such as moderately deep, moderately well-drained Red and Brown Chromosols (Noncalic Brown Soils; Red-brown Earths) with minor occurrences of shallow, very well-drained Rudosols (Lithosols) around rock outcrops. Deep, imperfectly drained Red Vertosols (Red Clays) and deep to very deep, imperfectly drained Red and Brown Chromosols (Non-calclac Brown Soils) and possibly some Sodosols (Solodic Soils) occur along drainage lines and on sodic bedrock. Qualities and Limitations— Complex soils; localised dieback; localised poor drainage; localised engineering hazard; gully erosion risk; inherent erosion risk; localised permanently high watertables; localised known discharge and recharge area; localised high run-on; localised dryland salinity; localised seasonal waterlogging; localised shallow soils; sheet erosion risk; localised wind erosion risk (under traditional cultivation). Soil materials have localised low wet strength; organic topsoils; stoniness; localised sodicity; localised high structural decline hazard; erodibility; localised hardsetting surfaces; and low permeability.
Goonoo Goonoo (gn)	Landscape— 42.1 km² floodplains dominated by predominantly basaltic alluvium, which runs through the Duri Hills, originating in the Liverpool Ranges. Local relief <9m; slopes <2%; elevation 370 – 650 m. Main landform elements include sinuous confined floodplains with occasional low (<1m) levees and swamps. Woodland with grass understorey, >80% cleared for grazing with some cultivation. Soils— soil types are diverse but individually locally extensive. In decreasing order of importance, soil types encountered include very deep to giant, imperfectly drained Brown Sodosols (Solodic Soils); deep to giant, imperfectly drained Black Vertosols (Black Earths); very deep to giant, poorly drained Grey Vertosols (Grey Clays); shallow, moderately well-drained Calcareous Rudosols (calcareous Alluvial Soils); and deep to giant, imperfectly drained Brown Vertosols (Brown Clays). Qualities and Limitations— localised dieback; localised poor drainage; flood hazard; engineering hazard; localised groundwater pollution hazard (highly calcareous soils); gully erosion risk; inherent erosion risk; permanently high watertables; localised known discharge areas; known recharge area; high run-on; localised dryland salinity; localised seasonal waterlogging; sheet erosion risk. Soil materials have localised high plasticity; localised low wet strength; some organic topsoils; stoniness; sodicity; localised high erodibility; some hardsetting topsoils; low permeability; and subsoil salinity.
Peel (pe)	Landscape— 50.7 km² level to gently undulating floodplains of the Peel and Lower Cockburn Rivers in the Duri Hills. Local relief <9; slopes <1%; elevation 355 – 400 m. Main landform elements include broad floodplains with deeply incised channels and low to prominent narrow levees, prior streams, meander scrolls and oxbow billabongs. Riparian woodland and open-forest, mostly cleared for agriculture. Soils— soil types are individually extensive, but random in distribution. In decreasing order of dominance, soil types encountered include giant, moderately well-drained Black Dermosols (Chernozems); very deep, imperfectly drained Calcareous Black Vertosols (calcareous Black Earths); very deep, imperfectly drained Haplic Black Vertosols (Black Earths); and moderately deep, moderately well-drained Brown Chromosols (Red-brown Earths).

Landscape	Description and limitations
	Qualities and Limitations— localised dieback; flood hazard; localised engineering hazard; groundwater pollution hazard for effluent disposal; productive arable land; high run-on. Soil materials have high organic matter (topsoils and subsoils); sporadic low permeability; low wet bearing strength; moderate to high foundation hazard; high shrink swell potential; flood risk; high run-on; seasonal waterlogging; and water erosion risk.
The Forest (fo)	Landscape— 11.3 km² long very gently to gently inclined footslopes and broad drainage plains on alluvium derived from Devonian argillite and greywacke hills and mountains in the steep northeastern Duri Hills. Local relief <120m; slopes <8%; elevation 360 – 520 m. Woodland, mostly cleared for cultivation and grazing. Soils— upper to mid-footslopes are dominated by very deep to giant, moderately well-drained to poorly drained Red Chromosols (Red-brown Earths). Lower footslope areas have deep to giant, imperfectly drained Red Ferrosols (Euchrozems). Some lower footslope and drainage plain areas have very deep to giant, imperfectly drained Red Vertosols (Red Clays). Qualities and Limitations— engineering hazard; gully erosion risk; inherent erosion risk; potential recharge area; high run-on; sheet erosion risk. Soil materials have localised plastic subsoils; low wet strength; high shrink-swell; localised organic topsoils; high erodibility; hardsetting topsoils; low permeability; and structural decline hazard.
Orchard Creek (oc)	Landscape— 18.9 km² gently to moderately inclined footslopes on alluvium and colluvium derived from Devonian argillite and greywacke hills and mountains in the steeper north-eastern Duri Hills physiographic region. Local relief <120m; slopes 8-20%; elevation 370 – 550 m. Woodland, mostly cleared for grazing. Soils— soils have low variability; soil type is determined by slope, with soils generally becoming deeper and more sodic downslope. Mid to upper footslopes are dominated by moderately deep to very deep, moderately well-drained Red Chromosols (Non-calcic Brown Soils on upper slopes; Red-brown Earths on mid-footslopes). Giant, imperfectly drained Brown Sodosols (Solonetz ; Solodic Soils) occur on lower footslopes. Qualities and Limitations— gully erosion risk; inherent erosion risk; potential recharge area; high run-on; sheet erosion risk. Soil materials have hardsetting surfaces; locally low wet strength; organic topsoils; localised sodicity (subsoils); locally high erodibility; low permeability; and structural decline hazard.
Daruka (da)	Landscape— 38.8 km² steep to very steep hills and mountains on Devonian cherty argillites, argillites and greywacke in the north-eastern Duri Hills. Local relief 120 – 340 m; slopes 30 – 100%; rock outcrop <10%; elevation 360 – 831 m. Woodland, 40% cleared for grazing. Soils— soils are fairly consistent and predictable, with shallow, well-drained Leptic Rudosols (Lithosols) on crests and near rock outcrop. Deep, well-drained Red Chromosols (Red-brown Earths, and Non-calcic Brown Soils) on sideslopes. Qualities and Limitations— localised groundwater pollution hazard; gully erosion risk; inherent erosion risk; localised mass movement risk; poor moisture availability; known recharge area; rockfall hazard; rock outcrop; high run-on; shallow soils; sheet erosion risk; steep slopes; woody weeds. Soil materials have low wet strength; organic matter; localised sodicity; and low permeability.
Parnell (pl)	Landscape— 47.7 km² rolling to steep hills on Devonian and Carboniferous metasediments of the southern Duri Hills. Local relief <200m; slopes 10 – 45%; elevation 410 – 750 m. Narrow crests with maximal to waning upper slopes and waning hummocky mid to lower slopes. Woodland with grass and shrub understorey, 95% cleared for grazing. Soils— rounded crests and gentler upper slopes are dominated by moderately deep, moderately well drained Red Chromosols (Non-calcic Brown Soils). Rocky crests and outcrop areas are dominated by shallow, moderately well-drained loamy Tenosols and Rudosols (Lithosols). Mid to lower slopes are dominated by moderately deep, moderately well drained Red Chromosols (Non-calcic Brown Soils) or moderately deep imperfectly drained Brown Vertosols (Brown Clays) depending on dominant geology. Qualities and Limitations— localised dieback; gully erosion risk; inherent erosion risk; localised mass movement hazard; potential recharge area; localised high run-on (lower slopes); localised shallow soils; sheet erosion risk; localised steep slopes. Soil materials have high organic matter; low permeability; stoniness; and localised subsoil alkalinity
Spring Creek (sc)	Landscape— 2.9 km² rolling to very steep hills on Devonian Moore Creek Limestone in the steeper north-eastern Duri Hills. Local relief <120m; slopes generally 12 – 25% but occasionally to 50%; extensive rock outcrop; elevation 430 – 580 m. Open-woodland, partially cleared for light grazing. Landscape Variant sca—transferral footslope variant with slopes ranging 5 – 12%.

Landscape	Description and limitations
	Soils—soils are variable according to depth of weathered limestone material across the slope. Shallow, well-drained Leptic Tenosols (Rendzinas) are common where soil depth is shallow and around rock outcrop. Shallow, well-drained Red Dermosols (Red Earths; some Calcareous Red Earths) are common on gentler slopes, small depressions and benches. Moderately deep, well-drained Red Chromosols (Redbrown Earths) common on lower slopes. Qualities and Limitations— localised engineering hazard (land subsidence from loading of cavernous limestone); groundwater pollution hazard; localised mass movement risk; poor moisture availability; known recharge area; shallow soils; localised sheet erosion risk; steep slopes; woody weeds. Soil materials have high erodibility; stoniness; hardsetting surfaces; high permeability; high organic matter (topsoils); and alkalinity.
Fullwods (fh)	Landscape— 77.9 km² rocky crests and steeper sideslopes of hills and low hills on Carboniferous and Devonian sedimentary rocks in the Tamworth Fold Belt. Local relief <70m; slopes 5-20%, but generally 10%; rock outcrop <20%; elevation 400 – 500 m. Woodland 85% cleared for grazing and some cultivation. Landscape Variant fh a— western variant occurring on the western side of the Melville Ranges, in association with different soil landscapes. Soils— soils can be locally highly variable over tens of metres or homogenous depending on variability in underlying geology. Generally crests are dominated by moderately deep, moderately well-drained Haplic Red Chromosols (Non-calcic Brown Soils). Sideslopes are dominated by shallow, moderately well-drained Vertic Red Chromosols (Red-brown Earths), with very deep poorly drained Yellow and Brown Sodosols (Solodic Soils) on some lower slopes. Where soils are derived from more clay mineral-rich rocks, deep, well-drained Red Ferrosols (Euchrozems) grade into very deep, moderately well-drained Black and Brown Vertosols (Black Earths; Brown Clays). Qualities and Limitations— complex soils; localised engineering hazard; inherent erosion risk; localised poor moisture availability; localised known recharge area; localised rock outcrop; shallow soils; sheet erosion risk. Soil materials have localised low wet strength; organic topsoils; high erodibility; hardsetting topsoils; and low permeability.
Warral Station (ws)	Landscape— 72.8 km² drainage plains, small alluvial plains and fans on alluvium derived from Permian and Carboniferous metasediments and sedimentary rocks of the Duri Hills. Local relief <30m; slopes 0.2-2%; elevation 370-600m. Woodland and open-woodland, >70% cleared for grazing. Landscape Variant wsa— broad, gently undulating plains thought to be terraces or stagnant alluvial plains. May be subject to less frequent flooding. Soils— soils are diverse and are virtually random in distribution according to stream deposition patterns. Individual soil types are normally locally extensive (over hundreds of metres), but some areas are more variable. Soil types included in this landscape are very deep, poorly drained Subnatric or Mott led Subnatric Brown Sodosols (Solodic Soils); very deep, moderately well-drained Red Dermosols (Euchrozems); very deep, poorly drained Brown Vertosols (Brown Clays); very deep, imperfectly drained Red Vertosols (Red Clays); very deep, moderately well-drained Calcic Calcarosols (calcareous Chernozems); and occasional Black Vertosols (Black Earths). Qualities and Limitations— localised dieback; localised poor drainage; flood hazard; localised engineering hazard; gully erosion risk; localised permanently high watertables; known discharge areas; known recharge area; high run-on; localised dryland salinity; localised seasonal waterlogging; sheet erosion risk. Soil materials have localised foundation hazard; localised engineering hazard; seepage scalds; high plasticity (subsoils); low wet strength (subsoils); high shrink-swell; sodicity (subsoils); localised salinity; low permeability; and highly variable moisture availability.
Disturbed Terrain (xx)	Landscape – Level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Local relief <10 m, slopes <30%. Landfill includes soil, rock, building and waste materials. Original vegetation completely cleared, replaced with turf or grassland. Soils – turfed fill areas commonly capped with up to 40 cm of sandy loam or up to 60 cm of compacted clay over fill or waste materials. Limitations – Dependent on nature of fill material. Mass movement hazard, unconsolidated low wet strength materials, impermeable soil, poor drainage, localised very low fertility and toxic materials.

4.7.2 Surface Geology

The Tamworth urban area is comprised of several different geological formations including:

- > Tamworth Group of the Devonian (undifferentiated volcanoclastic sediments, limestone);
- > Yarrimie Formation of the Devonian (argillite, chert, siliceous siltstone, limestone, arenite, pebble conglomerate);
- > Parry Group of the Devonian and Carboniferous (mudstone, sandstone, radiolarian argillite, conglomerate, limestone, lava sills and minor chert, breccia and siltstone);
- > Quaternary alluvium, undivided (Channel and floodplain alluvium; gravel, sand, silt, clay. Gravel includes sedimentary and igneous rock clasts);
- > Goonoo Goonoo Mudstone of the Late Devonian and Early Carboniferous (massive, laminated mudstone with subordinate thin beds and lenses of arenite and a marker bed of limestone; and
- > Wombramurra Arenite of the Devonian and Carboniferous. Part of the Goonoo Goonoo Mudstone formation (Zone of lenses of polymictic conglomerate and lithic wackes interbedded with Goonoo Goonoo Mudstone).

4.7.3 Acid Sulphate Soils

The TRCLEP 2010 defines Acid Sulphate Soils (ASS) as “*naturally occurring sediments and soils containing iron sulphides (principally pyrite) or their precursors or oxidation products, whose exposure to oxygen leads to the generation of sulphuric acid (for example, by drainage or excavation)*”. These soils are more likely to occur in low-lying areas of coastal floodplains and are also locally associated with saline Sulphate-rich groundwater in some agricultural areas or with freshwater wetlands. In an undisturbed and waterlogged state, ASS generally pose no or low risk. However, the sulphuric acid produced from the oxidation of ASS when exposed can negatively impact on the surrounding environment including a reduction in water quality, fish kill and plant death. Sulphuric acid produced by the soils can also corrode and weaken certain structures and building foundations.

There is no available ASS mapping within Tamworth under the Tamworth LEP. The CSIRO Australian Soil Resource Information System maps the land in and around Tamworth as having a Low to Extremely Low Probability of Occurrence of ASS.

4.7.4 Contaminated Land

Contaminated land refers to any land which contains a substance at such concentrations as to present a risk of harm to human or environmental health, as defined in the *Contaminated Land Management Act 1997*. Contamination issues need to be considered at the flood management options development and design stage.

The NSW DPIE regulates contaminated land sites and maintains a record of written notices issued by the NSW EPA in relation to the investigation or remediation of site contamination.

The EPA Contaminated Land Record was searched on 30 September 2021 to determine whether any notices had been issued under the *Contaminated Land Management Act 1997* within Tamworth Regional Council LGA. A total of eleven notices relating to five sites were found within the Tamworth LGA. Of these, three are located within Tamworth city, as listed in **Table 4-3**.

Table 4-3 Tamworth city sites listed on the EPA contaminated land record

Site Name	Address	Notice Description
Coles Express Tamworth	251-253 Goonoo Goonoo Road, South Tamworth	Amendment or Repeal of order or notice – 2 current Approved Voluntary Management Proposal – 1 current Declaration of Significantly Contaminated Land – 1 current
Elgas Depot (former gasworks)	115 Marius Street, Tamworth	Amendment or Repeal of order or notice – 1 current Preliminary Investigation Order or Notice – 1 current
Gunnedah Road Site	49 Gunnedah Road, Tamworth	EHC Act Revocation Notice – 1 former Section 35 EHC Act Order – 1 former

The List of NSW Contaminated Sites notified to the EPA was searched on 30 September 2021. The search was conducted for in the urban area of Tamworth and returned twenty-one results which are listed in **Table 4-4**.

Table 4-4 Sites in Tamworth listed on the EPA list of NSW contaminated sites notified to EPA

Site	Address	Activity	EPA Management Class	Coordinates
Caltex Service Station	350-362 Armidale Road, East Tamworth	Service Station	Regulation under CLM Act not required	-31.11401974, 150.9613327
Caltex Service Station and Depot Nemingha	428 Armidale (previously 16 New England Highway) Road, Nemingha	Service Station	Regulation under CLM Act not required	-31.12425169, 150.9909054
Hayes Transport Services	10 Manilla Road, Oxley Vale	Other Petroleum	Regulation under CLM Act not required	-31.06991417, 150.9101381
Coles Express Tamworth	251-253 Goonoo Goonoo Road, South Tamworth	Service Station	Contamination currently regulated under the CLM Act	-31.1118945, 150.9228523
Caltex Service Station	2 Kathleen Street (corner Kent Street), South Tamworth	Service Station	Regulation under CLM Act not required	-31.10361712, 150.9186343
Caltex Tamworth Service Station	109 Gunnedah Road, Tamworth	Service Station	Regulation under CLM Act not required	-31.09723226, 150.8955299
Curlew Crescent	19-29 Curlew Crescent, Tamworth	Metal Industry	Regulation under CLM Act not required	-31.06963607, 150.9069306
Former Service Station, Fitzpatrick Super Fund, Tamworth	210 Goonoo Goonoo Road, Tamworth	Service Station	Regulation under CLM Act not required	-31.10613594, 150.9234143
Gunnedah Road Site	49 Gunnedah Road, Tamworth	Other Industry	Contamination formerly regulated under the CLM Act	-31.09574904, 150.9021583
Elovera Former Sheep Dip	703 Ascot Calala Road, Tamworth	Cattle Dip	Regulation under CLM Act not required	-31.1801846, 150.962897
Housing NSW	29-33 White Street, Tamworth	Other Petroleum	Regulation under CLM Act not required	-31.0915651, 150.9357811
BP Tamworth Service Station and Depot	27-29 Gunnedah Road, Tamworth	Other Petroleum	Under assessment	-31.09642128, 150.9058193
Former Mobil Service Station	373-375 Armidale Road, Tamworth	Service Station	Regulation under CLM Act not required	-31.10122679, 150.9441341
Kensell's Mitsubishi	11-14 Kable Avenue, Tamworth	Other Petroleum	Regulation under CLM Act not required	-31.08921565, 150.9273063
Caltex Star Tamworth	21 White Street, Tamworth	Service Station	Regulation under CLM Act not required	-31.09255137, 150.9341709
Former Service Station Tamworth	(Cnr Scott Rd) 254-256 Goonoo Goonoo Road, Tamworth	Service Station	Regulation under CLM Act not required	-31.1118945, 150.9228523
Cleanaway Operations Pty Ltd	31 Gunnedah Road, Tamworth	Other Industry	Under assessment	-31.09621029, 150.9051567
Elgas Depot (former gasworks)	115 Marius Street, Tamworth	Gasworks	Under preliminary investigation order	-31.08546191, 150.926437
Proposed ALDI Store Tamworth	194-196 Peel Street, Tamworth	Other Industry	Under assessment	-31.08522053, 150.9260054
Mobile Depot	9 Hinkler Road, Taminda	Other Petroleum	Regulation under CLM Act not required	-31.09584286, 150.9040493
Woolworths Petrol	119 Bridge Street, West Tamworth	Service Station	Regulation under CLM Act not required	-31.09358262, 150.9167693

4.7.5 Groundwater and Salinity

Groundwater near Tamworth is generally good quality within the Peel Alluvial aquifer with a thickness of around 15m to 20m and suitable for stock and domestic, irrigation and town water supply purposes. (IWCM, TRC 2012).

Urban salinity is however present in Tamworth, with salinity problems prevalent in the Longyard Golf Course area and adjoining residential zones (IWCM, TRC 2012). Salinity is exacerbated by tree clearing, over-watering, disruption of natural drainage lines and overflow of septic tanks and sullage pits (TRC Salinity and Groundwater Management Policy).

4.8 FLORA AND FAUNA

A search of the Australian Department of Agriculture, Water and the Environment (DAWE) Protected Matters Search Tool (PMST) for matters of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was undertaken on 1 October 2021 adopting a 10km buffer (DAWE 2021). A copy of the PMST results is included in **Appendix B**.

The search indicated that 37 threatened species and 12 migratory species have the potential to occur within a 10km radius of the Tamworth. Of the listed threatened species 13 are known to occur (5 birds, 1 fish, 1 frog, 4 mammals, 1 reptile and 1 plant) and of the migratory species 2 species are known to occur.

A search of the DPIE BioNet Atlas was undertaken on 1 October 2021 to assess the potential for threatened species to occur within the Study Area that are listed under the *Biodiversity Conservation Act 2016* (BC Act) and/or the EPBC Act (DPIE 2021). A total of 28 threatened fauna and flora species and one threatened population was recorded within 10km from the Study Area. The sightings consisted of one frog species, one bird population, fifteen bird species, eight mammal species and three flora species. These species are:

- > Booroolong Frog (*Litoria booroolongensis*) listed as endangered under the BC Act;
- > Australian Brush-turkey population in the Nandewar and Brigalow Belt South Bioregions (*Alectura lathamii*) listed as an endangered population under the BC Act;
- > Little Eagle (*Hieraaetus morphnoides*) listed as vulnerable under the BC Act;
- > Square-tailed Kite (*Lophoictinia isura*) listed as vulnerable under the BC Act;
- > Black Falcon (*Falco subniger*) listed as vulnerable under the BC Act;
- > Little Lorikeet (*Glossopsitta pusilla*) listed as vulnerable under the BC Act;
- > Swift Parrot (*Lathamus discolor*) listed as endangered under the BC Act;
- > Turquoise Parrot (*Neophema pulchella*) listed as vulnerable under the BC Act;
- > Powerful Owl (*Ninox strenua*) listed as vulnerable under the BC Act;
- > Brown Treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*) listed as vulnerable under the BC Act;
- > Speckled warbler (*Chthonicola sagittata*) listed as vulnerable under the BC Act;
- > Regent Honeyeater (*Anthochaera phrygia*) listed as critically endangered under the BC Act;
- > Black-chinned Honeyeater (eastern subspecies) (*Meliphreptus gularis gularis*) listed as vulnerable under the BC Act;
- > Varied Sittella (*Daphoenositta chrysoptera*) listed as vulnerable under the BC Act;
- > Dusky Woodswallow (*Artamus cyanopterus cyanopterus*) listed as vulnerable under the BC Act;
- > Hooded Robin (south-eastern form) (*Melanodryas cucullata cucullata*) listed as vulnerable under the BC Act;
- > Diamond Firetail (*Stagonopleura guttata*) listed as vulnerable under the BC Act;
- > Spotted-tailed Quoll (*Dasyurus maculatus*) listed as vulnerable under the BC Act;
- > Koala (*Phascolarctos cinerus*) listed as vulnerable under the BC Act;
- > Squirrel Glider (*Petaurus norfolcensis*) listed as vulnerable under the BC Act;
- > Grey-headed Flying-Fox (*Pteropus poliocephalus*) listed as vulnerable under the BC Act;
- > Yellow-bellied Sheath-tail-bat (*Saccolaimus flaviventris*) listed as vulnerable under the BC Act;
- > Large Bent-winged Bat (*Miniopterus orianae oceanensis*) listed as vulnerable under the BC Act;
- > Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) listed as vulnerable under the BC Act;
- > Large Bent-winged Bat (*Miniopterus orianae oceanensis*) listed as vulnerable under the BC Act;
- > Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) listed as vulnerable under BC Act;
- > Bluegrass (*Dichanthium setosum*) listed as vulnerable under BC Act; and
- > Magenta Lilly Pilly (*syzygium paniculatum*) listed as endangered under the BC Act.

The records for these species are distributed within the Study Area and surrounds.

4.9 VEGETATION

The PMST indicated that four threatened ecological communities (TECs) are likely to or may occur in the area, namely:

- > Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland (Critically Endangered under the EPBC Act);
- > New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands (Critically Endangered under the EPBC Act);
- > Weeping Myall Woodlands (Endangered under the EPBC Act); and
- > White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Critically Endangered under the EPBC Act).

A review of DPIE's vegetation mapping for the Border Rivers Gwydir – Namoi Region (NSW OEH, 2016) shows that the vegetation in and around Tamworth is characterised predominately by dry sclerophyll forests and grassy woodlands. The following Plant Community Types (PCTs) were identified and are shown in **Map A9** in **Appendix A**.

- > PCT 1: Candidate Native grasslands;
- > PCT 84: River Oak Rough-barked Apple red gum box riparian tall woodland (wetland) of the Brigalow Belt South Bioregion and Nandewar Bioregions;
- > PCT 433: White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion;
- > PCT 434: White Box grass shrub hill woodland on clay loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion;
- > PCT 435: White Box-White Cypress Pine shrub grass hills woodland in the Brigalow Belt South Bioregion and Nandewar Bioregion;
- > PCT 588: White Box – White Cypress Pine shrubby hills open forest mainly in the Nandewar Bioregion;
- > PCT 589: White Box – White Cypress Pine – Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion;
- > PCT 591: White Box shrubby open forest on hills mainly in the Nandewar Bioregion; and
- > PCT 599: Blakelys Red Gum-Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion.

4.10 DEMOGRAPHICS

The demographic characteristics of the Tamworth urban area, comprising the suburbs of Calala, Daruka, East Tamworth, Hallsville, Hillvue, Kingswood, Moore Creek, Nemingha, North Tamworth, Oxley Vale, South Tamworth, Taminda, Tamworth, Tintinhull, Warral, Westdale and West Tamworth. Population data for was sourced from the Australian Bureau of Statistics (ABS) 2016 Census Data and aggregated to produce an overall synopsis for the region. A summary of the demographic data collected is listed below (ABS, 2021):

- > The population of Tamworth (Significant Urban Areas) from the 2016 Census data was 41,006.
- > The median age of people living in Tamworth (Significant Urban Areas) is 37 with children aged 0-14 making up 20.5% of the population and people aged over 65 making up 17.8% of the population;
- > Of the population in Tamworth (Significant Urban Areas) 84.4% were born in Australia. The most common countries of birth outside of Australia were England (1.1%), Philippines (1%) New Zealand (0.7%), India (0.5%), and Korea, Republic of (South) (0.4%);
- > English was the only language spoken in approximately 88% of homes in Tamworth (Significant Urban Areas). The most common languages spoken at home other than English included Mandarin, Tagalog, Korean, Filipino and Cantonese;
- > The most common occupations in Tamworth (Significant Urban Areas) included Professionals (18.7%), Labourers (14.8%), Technicians and Trades Workers (14.3%), Clerical and Administrative Workers (12.1%) and Community and Personal Service Workers (11.1%);
- > The median weekly income in Tamworth (Significant Urban Areas) for individuals aged 15 years and over was \$652, compared to the NSW median of \$664. This trend of below average income for Tamworth (Significant Urban Areas) compared to the NSW average was also evident for family (\$1,450 compared to \$1,780 for NSW) and household incomes (\$1184 compared to \$1,486 for NSW); and
- > In Tamworth (Significant Urban Areas) on the day of the Census, the most common methods of travel to work for employed people was by car (72.7% as the driver and 6.4% as passengers) and working from home (3.4%). Other responses were by walking (3.3%) and by truck (1.3%).

4.11 WATER QUALITY

The NSW Government have previously undertaken a State of the Catchments assessment for the Namoi region in 2010, to determine the riverine ecosystem condition using water quality, macroinvertebrate, fish, and hydrology indicators. The outcome of the water quality assessment is illustrated in **Figure 4-8**, highlighting Goonoo Goonoo Creek and Peel River at Appleby Crossing as having the lowest comparative water quality for the Tamworth area. These sites are additionally shown to be more polluted than the nearby Cockburn and Namoi River sites that were independently assessed for the Kootingal-Moonbi and Manilla USMPs.

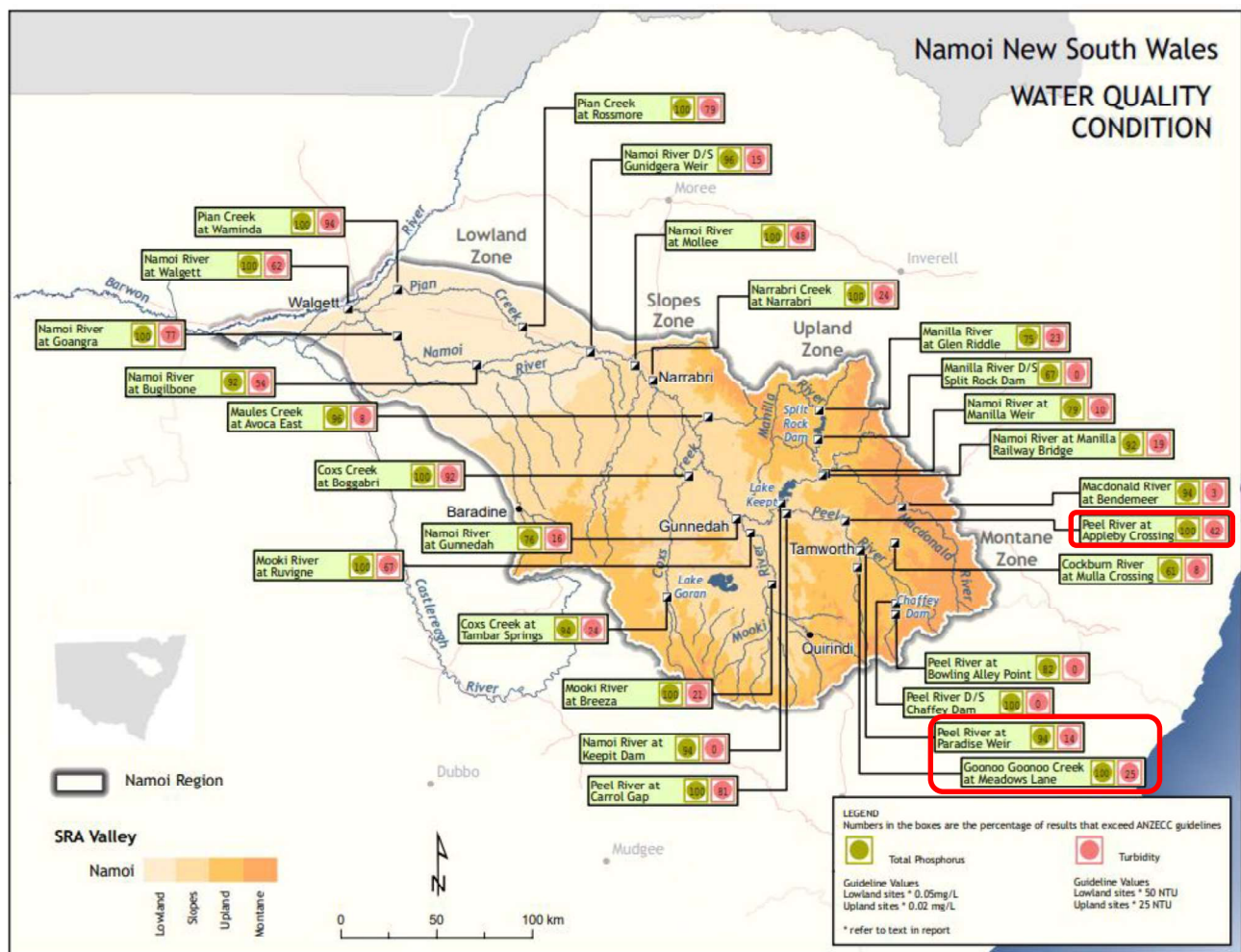


Figure 4-8 Riverine Water Quality Condition (NSW Government, 2010)

The DPIE *Water quality technical report for the Namoi surface water resource plan area (SW14) (2020)* concluded the Peel River at Paradise Weir site water quality index rating was good (**Figure 4-9**) and comparatively better than all other published testing sites in the region which is a clear improvement on the 2010 condition based on phosphorous and turbidity.

A key discrepancy in the studies is the comparison between ANZECC (2000) and Basin Murray River Basin Plan (2012) targets in the 2010 and 2020 studies, respectively, however the comparative condition between sites in each study remains relevant. The completion of new wastewater treatment plant for Tamworth and phosphorus reuse farm in 2010 lowered total phosphorus results from 2013 to 2015 suggesting the works reduced nutrient inputs to the Peel River and scored more favourably in the 2020 assessment.

The DPIE 2020 study found the Peel River at Paradise Weir was at medium risk but with low likelihood to health of water dependant ecosystems being impacted by turbidity, pH, phosphorus, and nitrogen, as well as high risk of low dissolved oxygen, likely due to sediment settling out of the water column, high nutrient concentrations, increased light penetration and increased photosynthesis from aquatic plant growth.

The Paradise Weir site is also located in a large pool, which may be encouraging aquatic plant growth (DPIE, 2020).

Erosion and high salt stores in the geology of the region mean tributary streams such as Goonoo Goonoo, Creek contributes saline flows and salt load into the Peel despite some impacts being diluted by flows from the upstream Chaffey Dam. Water releases from the upstream Chaffey Dam could contribute to channel erosion and increased turbidity in the Peel River, however discharges are typically small and cold-water pollution impacts are minimal.

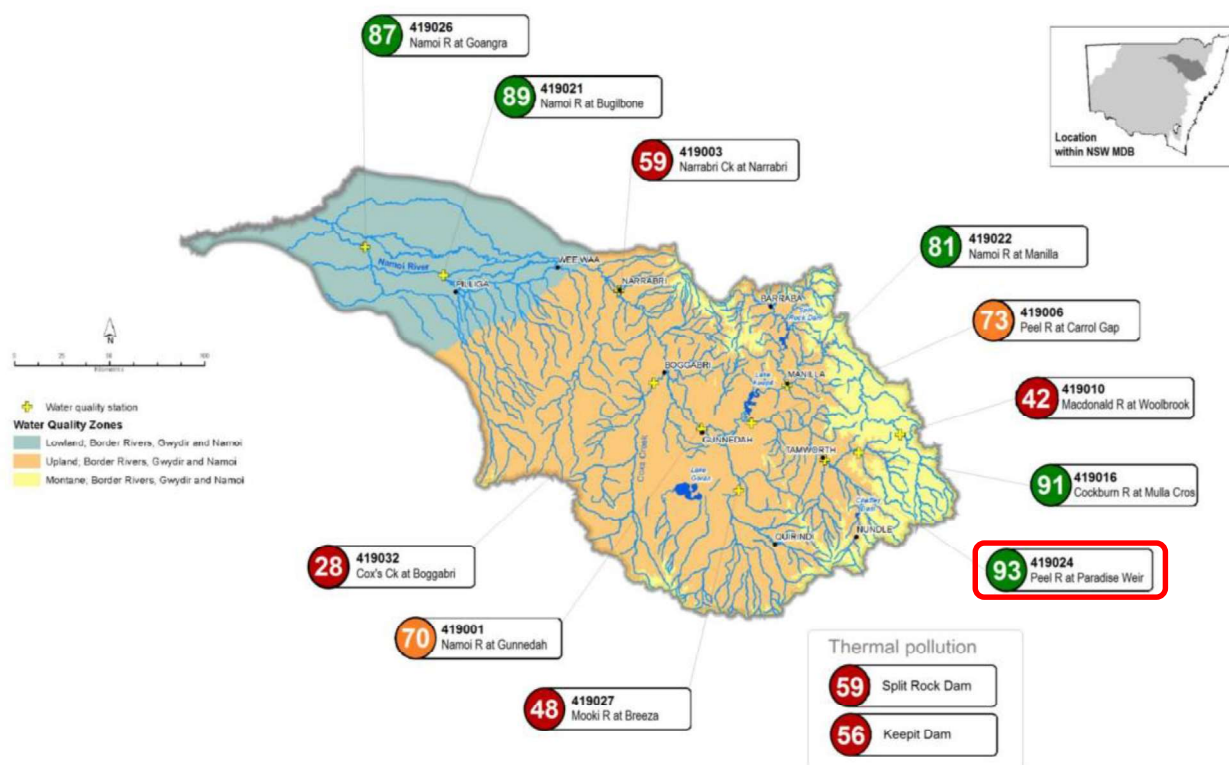


Figure 4-9 Namoi surface water resource plan water quality (DPIE, 2020)

Based on comparison between the Namoi, Cockburn and Peel River results from the DPIE 2020 study in Table 4-5 and Figure 4-10, the Namoi River was shown to exhibit the most nutrient and electrical conductivity concerns relating to lower flows and higher temperatures. The Peel River overall demonstrated the highest turbidity and total suspended solids (TSS) loading which likely correlates to higher scour potential in the geology of the region and river. However, the site at Paradise Weir was awarded a high turbidity index comparative to Basin Plan (2012) targets in the upland zone for Tamworth.

Table 4-5 Water quality index for the Namoi WRPA 2010-2015 (Table 10) (DPIE, 2020)

Site Name	Rating	WaQI	Total N	Total P	Turbidity	pH	DO
Macdonald River at Woolbrook	Poor	42	20	14	92	70	33
Namoi River at Manilla Railway Bridge	Good	81	83	86	83	55	98
Cockburn River at Mulla Crossing	Good	91	87	89	96	94	83
Peel River at Paradise Weir	Good	93	95	96	95	86	90
Peel River at Carroll Gap	Fair	73	61	68	54	96	95
Mooki River at Breeza	Poor	48	58	16	44	69	84
Coxs Creek at Boggabri	Poor	28	25	10	15	63	66
Namoi River at Gunnedah	Fair	70	67	55	56	98	90
Narrabri Creek at Narrabri	Poor	59	71	27	41	95	91
Namoi River at Bugilbone	Good	89	87	82	87	94	92
Namoi River at Goangra	Good	87	81	83	83	93	100

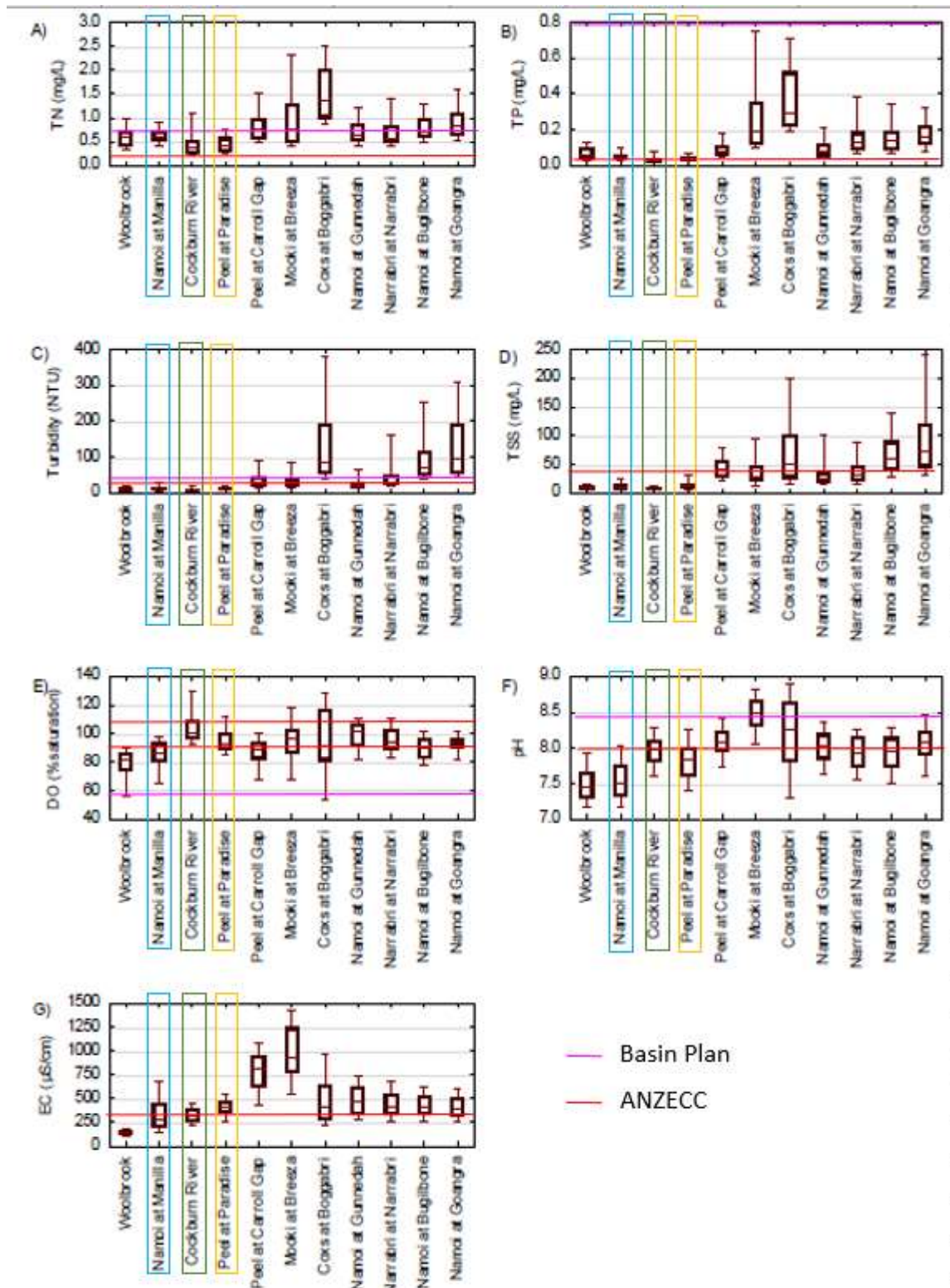


Figure 4-10 Water quality box and whisker plots for the Namoi WRPA 2010-2015 (DPIE, 2020)

Algal blooms within the Namoi region were identified as a possible risk in the Murray-Darling Basin Plan.

Additional water quality analysis to establish the baseline condition for the study area based on current available information is summarised in Section 5.

4.12 SITE VISIT

Detailed site inspection was undertaken on 15th and 16th November 2021 with Council staff. The site visit provided the opportunity to familiarise with the Study Area and inspect key features and major stormwater infrastructure. The locations visited included:

- > Bicentennial Park including the existing levee and flood gates;
- > Orley Drive / Heritage Park Wetland;
- > Peel High Wetland;
- > Detention basins in North Tamworth;
- > Peel River downstream of Jewry Street;
- > Swan Street channel next to the sewage treatment plant;
- > Tamida detention basin;
- > GPT located near the golf course;
- > GPT located at southern end of Cole Rd;
- > Jockey club detention basin;
- > Rifle Range Gully channel near TAFE;
- > Spring Creek channel at Johnston Street; and
- > Various locations along Peel River.

Some photos from the site inspection are provided in **Appendix C**.

5 BASELINE WATER QUALITY ASSESSMENT

5.1 WATER QUALITY DATA MONITORING

Local water quality varies naturally due to various factors, including the nature of landforms and land use the waters are draining from (such as soils, slope), or rainfall and runoff patterns (ephemeral or permanent streams). Water quality monitoring in conjunction with flow monitoring across long-term timeframes and inclusive of wet and dry periods are therefore highly valuable for understanding the catchment condition.

This study additionally incorporates a summary of potential pollutant sources and impacts, as well as a summary of the findings for the historical water quality monitoring that has been undertaken.

5.1.1 Streamwatch Monitoring

It is known that six high schools in the Tamworth Area historically monitored water quality at one site each, as listed below. At present, data for the following test sites have not been provided. It is recommended that sampling data that is available is assessed as part of the proposed educational programs (Section 8.2) to incorporate community ownership and deeper understanding of the need for catchment management practices.

1. Peel River at Farrer;
2. Peel River at Jewry Street weir;
3. Peel River 300m downstream of Swan Street Sewerage Treatment Plant;
4. Cockburn River upstream of Johnson Bridge;
5. Timbumburi Creek at Gunnedah Road Bridge; and
6. Timbumburi Creek at Peel Technology High wetland.

Samples were historically tested for various chemical, physical and biological parameters. At the time of developing this USMP, Council advised that these monitoring programs are currently not been undertaken.

5.1.1 River Monitoring

The 2000 USMP identified water quality monitoring programs entering the Cockburn and Peel River in the Tamworth catchment area. As part of this study, it was determined that Council and WaterNSW has operated a regular sampling program at five (8) locations near the Tamworth area to monitor baseline data on water quality. The sampling results include data recorded since 1976 to 2021 that were reported at inconsistent intervals with significant data gaps. These are:

1. Council Monitoring
 - a) Peel River at Calala Pump Station;
 - b) Upstream of Goonoo Goonoo Creek;
 - c) Downstream of Goonoo Goonoo Creek at the footbridge; and
 - d) Peel River at Wetland;
 - e) Dungowan Dam Offtake @ 4m, 10m and 18m
2. WaterNSW Monitoring
 - a) Peel River at Paradise Weir (419024)

Council provided discrete water quality results for various chemical, physical, and biological parameters at the testing sites with variable records that limit comparative analysis between sites for specific data ranges. The Dungowan Dam Offtake sites were not assessed as part of this study.

WaterNSW have provided both discrete and telemetric water quality results for the (419024) Peel River at Paradise Weir (upstream of Scott Road) testing site. Turbidity, electrical conductivity and stream water level were the only telemetrically recorded parameters from December 1995 to November 2021 with major data gaps. Discrete sampling for various chemical, physical and biological parameters was also undertaken from June 1970 to November 2021 at various intervals. Mean Daily Volume was additionally recorded in discrete samples from April 1996 to March 1999.

Details of the water quality samples collected at each testing site near the Tamworth study area over the specified timeframes are included in **Appendix D**. The location of the Council and WaterNSW monitoring sites are illustrated in **Map A11 in Appendix A** and **Figure 5-1**.

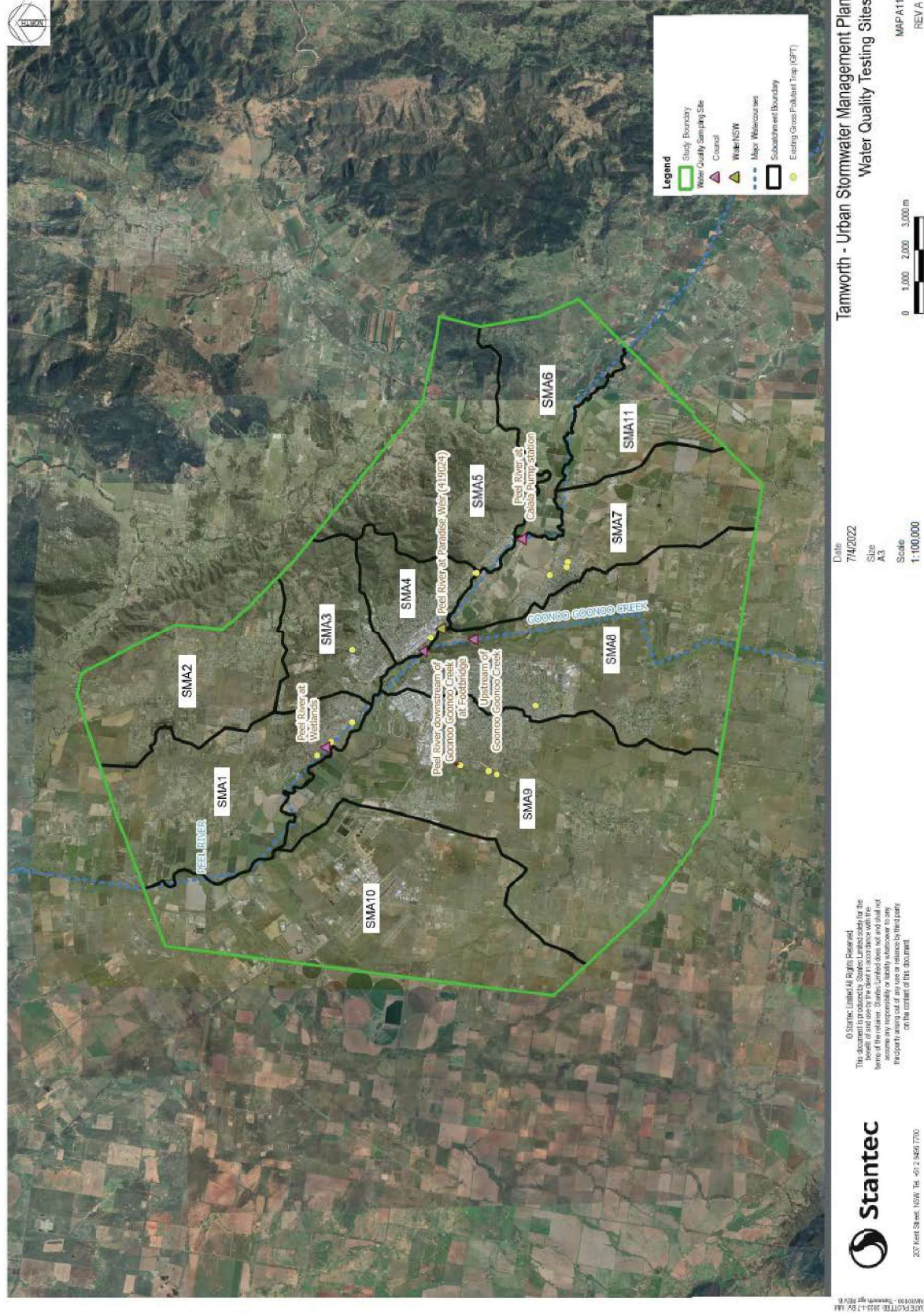


Figure 5-1 Council and WaterNSW Water Quality Monitoring Sites

5.2 RECORDED WATER QUALITY ASSESSMENT

5.2.1 Catchment Water Quality Objectives

At present, there are no local standards for water quality provided by TRLEP 2010. Hence the water quality assessment was carried out against:

- > NSW Water Quality and River Flow Objectives (<https://www.environment.nsw.gov.au/ieo/>);
- > Guidelines for Managing Risks in Recreation Water (Australian Government, 2008);
- > Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000); and
- > Murray-Darling Basin Plan (2012) Objectives (Chapter 9.16 – 9.18 and Schedule 11)

As the local and regional waterways of Tamworth are within the upland zone of the Namoi River region, the trigger values referenced in the guideline were indicators that apply to a highly disturbed freshwater waterway or inland river ecosystem across South-East Australia and developed for the objective of maintenance or improvement of water quality for a long term (50 year) period.

The Department of Environment NSW have developed eleven Water Quality Objectives (WQOs) for NSW rivers and estuaries and provide guideline levels to assist water quality planning and management:

1. Aquatic ecosystems
 - a. Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term
2. Visual amenity
3. Secondary contact recreation
4. Primary contact recreation
5. Livestock water supply
6. Irrigation water supply
7. Homestead water supply
8. Drinking water - Disinfection only, or
9. Drinking water - Clarification and disinfection
10. Drinking water - Groundwater
11. Aquatic foods (cooked)

For the purposes of this study, the water quality objective for the protection of Aquatic Ecosystems (1) has been assessed where limited data is available for comparison to key indicators. Primary and secondary contact recreation objectives have also been identified as valuable for the specific and have been reported on where appropriate.

5.2.2 Water Quality Benchmarking

Water quality condition is described as the percentage of samples exceeding the selected trigger. There are two methods of benchmarking recorded water quality values as per Section 7.4.4 of the ANZECC standard and defined below:

1. Comparison against default trigger values (either as per ANZECC or Basin Plan which is less conservative)
2. Comparison against site-specific trigger values representative of the 80th percentile value for the recorded performance indicators (statistical analysis outside current scope)

Trigger values are defined as the concentration (or load) of the key performance indicators measured for the ecosystem, below which there exists a low risk that adverse biological (ecological) effects will occur. They indicate a risk of impact if exceeded and should 'trigger' some action, either further ecosystem specific investigations or implementation of management/remedial actions.

Assessing whether the exceedance means a risk of impact to the NSW Water Quality Objective requires site-specific investigation for some parameters. For the Protection of Aquatic Ecosystems Objective in NSW, the ANZECC 2000 Guidelines provide default trigger values for major physio-chemical stressors in Tables 3.3.2 and 3.3.3 and for Toxicants in Table 3.4.1. These are not adjusted for site-specific trigger values as any exceedance of the values will result in ecological degradation.

The **default ANZECC trigger values have been adopted for this study as per Table 5-1** as specified in the NSW Water Quality Objectives for the Namoi region as opposed to the less conservative target values in the current Basin Plan (Table 5-2). This approach has been adopted for this study as local assessments should not be skewed by Basin-level approaches that would apply if they were of a magnitude requiring coordinated action (e.g. river operations) and so where more than one target applies at a given location, the expectation is that achieving the most stringent target (ANZECC, 2000) would ensure all environmental values are met.

Table 5-1 Water Quality Benchmark Trigger Values for Upland River (ANZECC 2000)

Parameter	Units	Trigger Values	Clause
Algae	cells/mL	>15,000	Table 5.2.2
Aluminium	mg/L	pH>6.5: 0.055	Table 3.4.1
Ammonia	mg/L	0.9	Table 3.4.1
Arsenic	mg/L	0.013-0.024	Table 3.4.1
Boron	mg/L	0.37	Table 3.4.1
Cadmium	mg/L	0.0002	Table 3.4.1
Chloride	mg/L	25-40	Table 3.4.1
Chlorine	mg/L	0.003	Table 3.4.1
Chlorophyll-a	mg/L	NA to upland rivers	Table 3.4.1
Chromium (total)	mg/L	0.001	Table 3.4.1
Copper	mg/L	0.0014	Table 3.4.1
Dissolved Oxygen	% Saturation	90-110	Table 3.3.2
Dissolved Oxygen	mg/L	9.4-10.6	Conversion
Faecal coliforms	cfu/100mL	< 150 faecal coliforms per 100 mL primary recreation < 1000 faecal coliforms per 100 mL secondary recreation	Table 5.2.2
Herbicides	mg/L	Atrazine<0.013 Simazine < 0.0032 Trifluralin < 0.0026-0.5	Table 3.4.1 Table 5.2.4
Radioactivity	Bq/L	Gross Alpha/Beta < 0.1 (recreational)	Table 5.2.3
Lead	mg/L	0.0034	Table 3.4.1
Manganese	mg/L	1.9	Table 3.4.1
Mercury	mg/L	0.00006	Table 3.4.1
Nickel	mg/L	0.011	Table 3.4.1
Nitrate	mg/L	0.7	Table 3.4.1
Nitric Oxide	mg/L	0.015	Table 3.4.1
o-xylene	mg/L	0.35	Table 3.4.1

Parameter	Units	Trigger Values	Clause
Pesticides	mg/L	Acephate < 0.02 Chlorpyrifos < 0.00001 Diazinon < 0.01 Dicamba < 0.3 Dicofol < 0.1 Dimethoate < 0.1 Disulfoton < 0.006 Diuron < 0.04 Endosulfan < 0.04 Esfenvalerate < 0.000001 (Table 3.4.1) Fluometuron < 0.1 Metolachlor < 0.8 Molinate < 0.0034 (Table 3.4.1) Omethoate < 0.0004 Propargite < 1 Parathion < 0.000004-0.03 Pendimethalin < 0.6 Permethrin < 0.3 Profenofos < 0.0006 Sulprofos < 0.02 2,4,5-T < 0.002	Table 5.2.4
pH	pH	6.5-8 <i>Changes of more than 0.5 pH units from the natural seasonal maximum or minimum should be investigated.</i>	Table 3.3.2
Phenol	mg/L	0.32	Table 3.4.1
Salinity/EC	µS/cm	30-350 <i>Note that salinity levels vary widely, both within and between systems. Locally applicable salinity concentration and load targets are given in catchment plans, within the frameworks of the NSW Salinity Strategy</i>	Table 3.3.3
Selenium (Total)	mg/L	0.005	Table 3.4.1
Silver	mg/L	0.00005	Table 3.4.1
Sulphate	mg/L	<1000	Section 4.3.3.4
Temperature	°C	> 80%ile, < 20%ile (15–35°C for recreation)	Table 3.3.1, Table 5.2.2
Total Nitrogen	mg/L	0.25	Table 3.3.2
Total Phosphorus	mg/L	0.02 <i>Note that total phosphorus levels above 100 micrograms/litre have been consistently recorded in the areas of the Peel and Namoi Rivers. Development of local guideline trigger values for these areas may be necessary. See "Tailoring Water Quality Objectives to local conditions"</i>	Table 3.3.2
Total Suspended Solids	mg/L	40 <i>Suspended solids increase turbidity with phytoplankton, zooplankton, and bacterial blooms, suspended organic and humic acids, and suspended silt and clay particles. In some instances, this is advantageous, because it inhibits the growth of nuisance algae and macrophytes. However, suspended solids can cause gill irritations and tissue damage to aquatic animals, while they can also shield food organisms and clog filters (Zweig et al. 1999).</i>	Table 4.4.2
Turbidity	NTU	25 <i>In general values in the lower part of the range will be found in rivers and streams during low flows and/or in more vegetated catchments. Values in the higher part of the range will be found in rivers and streams in high flows and lower in the catchment (particularly inland catchments). For lakes and reservoirs, in general the higher values will be found in waterbodies that are shallow or in areas with dispersive soils.</i>	Table 3.3.3
Zinc	mg/L	0.008	Table 3.4.1

Table 5-2 Water Quality Benchmark Values for Zone B2 Streams Namoi Valley Upland Zone (Murray River Basin Plan 2012)

Benchmark	Annual Median Value
Turbidity (NTU)	30
Total Phosphorus (mg/L)	0.08
Total Nitrogen (mg/L)	0.75
Dissolved oxygen (mg/L; or saturation (%))	60–110%
pH	7.5-8.5
Salinity	NA
Temperature	Monthly median between the 20%ile and 80%ile of natural monthly water temperature
Pesticides, heavy metals, and other toxic contaminants	the protection of 95% of species ((values in table 3.4.1 of the ANZECC Guidelines not to be exceeded) All as per triggers above other than: Selenium < 0.011mg/L Mercury < 0.0006

5.2.3 Water Quality Data Results

Details showing the key water quality datasets against the default trigger values is included in **Table 5-3** in upstream to downstream order (left to right). Availability of comparative data for all sites was limited in establishing clear priorities for water quality intervention in the urban area.

Goonoo Goonoo Creek upstream of the Peel River confluence shows the highest concentration of salts and electrical conductivity (EC) that can be attributed to the smaller volume of flow through the creek for dilution comparative to the Peel River (due to upstream Chaffey Dam releases) and the largest proportion of agricultural runoff. It is highly recommended that revegetation efforts, agricultural practice, erosion and salinity management measures be adopted for the Goonoo Goonoo Creek contributing catchment with priority.

The assessment of all sites showed an overall increasing trend in nutrients, and salinity correlating to the decreasing trend in discharge within the Peel River and Goonoo Goonoo Creek. These trends are expected to continue to worsen with climate change projections.

Greater water softness as the result of dissolved salts increases the toxicity potential of heavy metals and other toxicants which have been shown to be accumulating within the Peel Wetland and the river system that will likely continue to be exacerbated by industry, road runoff and agricultural practices unless mitigated. It is clear that the relative reliance on Gross Pollutant Trap (GPT) infrastructure to date is contributing to overall visual amenity but failing to address rising salinity, nutrient and toxicant concerns for the catchment.

Fluctuations in the overall total nitrogen (TN) and phosphorus (TP) levels across all test sites observed were reflective of the seasonal variability in relation to the stream levels. Periods of low rainfall and increased temperatures result in increased nutrient levels, limited flushing of pollutants downstream and increased microbial growth. Whilst the wetlands were inaccessible during the site visit, aerial imagery shows the wetlands may be relatively dry during seasonal periods, contributing to poor water quality outcomes and vegetation die-off which supports the water quality assessment conclusions.

Statistical analysis shows an increasing trend in the TN and TP levels at the Peel River Wetland and is projected to continue to rise in the future due to increasing development areas entering the wetland site. It is recommended that a wetland monitoring and restoration program to improve macrophyte vegetation coverage and remove potentially contaminated silt build-up be investigated. It is also highly recommended that proprietary products to remove sediments, hydrocarbons and heavy metal toxicants be investigated for primary treatment prior to flow discharge to the wetland.

The wastewater treatment plant commissioned in 2010 to divert phosphorus to a reuse farm in Taminda is unable to be assessed due to lack of data downstream of the plant, however the DPIE 2020 study outlined in Section 4.11 attests to the functionality of this scheme. It is recommended that opportunities to establish a more circular economy be investigated in the future for nutrient reuse to limit waterway degradation.

It is recommended that TRC further investigate possible water quality impacts due to potential sewer or septic tank overflows which is outside the scope of this study.

Table 5-3 Water Quality Testing Site Observations - % Exceeding Triggers

Testing Site	Peel River at Calala Pump Station		Peel River at Paradise Weir (419024)		Goonoo Creek		Goonoo Creek Downstream		Peel River Wetlands		Trigger
	Discrete	Discrete (N1268, 419024)	Telemetric	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	
Observations	Some risk of depleted oxygen levels which could increase (in addition to EC) with climate change and rising temperatures despite colder existing stream temperature. High risk to recreational users due to faecal coliforms and toxicants such as zinc, chromium, copper, nitric oxide and mercury loading in addition to temperatures below recommended values.	Maximum total phosphorous of 3.48 in Jan 2004 correlates with maximum turbidity of 3700 NTU and a major flow event. Surge of phosphorous could be the result of sewer overflow and/or nutrient build-up due to dry period preceding the event. Increasing trend with a surge of phosphorous in May 2018 – upstream of treatment plant phosphorous reuse scheme. Some risk of depleted oxygen levels which could increase (in addition to EC) with climate change and rising temperatures despite colder existing stream temperature. Risk to recreational users.	Telemetric data showed a decreasing trend in discharge (1974-1988) and turbidity (1995-1999) and an increasing trend in EC (1995-2021) and temperature (1995-2021), likely to be exacerbated by future climate change impacts. The highest turbidity instance was recorded in Oct 1996, inconsistent with proportional catchment responses to similarly moderate flow events at the time. This suggests catchment-specific actions such as land clearing, or construction likely contributed to the 1040 NTU level. The median turbidity of 33 exceeds ANZECC and Basin Plan levels from the relatively forested and agricultural runoff. The lack of downstream turbidity data limits quantification of comparative peri-urban runoff and influence of the Goonoo Goonoo Creek confluence.	Low flow correlation with elevated EC. High chloride and salt levels (reflected in EC) correlates to low hardness of water and high toxicity potential of heavy metals. Lack of further toxicant data limits the quantification of toxicity potential. Higher chlorine levels may also indicate elevated inorganic loading and greater discoloration potential. Lower concentrations of salts and sulphate are observed at the downstream Goonoo Creek site due to dilution from Peel River and upstream Chaffey Dam releases. A slight increase in aluminium levels is evident at the downstream site however these remain below ANZECC trigger values.	Low flow correlation with elevated EC. High chloride and salt levels (reflected in EC) correlates to low hardness of water and high toxicity potential of heavy metals. Lack of further toxicant data limits the quantification of toxicity potential. Higher chlorine levels may also indicate elevated inorganic loading and greater discoloration potential. Lower concentrations of salts and sulphate are observed at the downstream Goonoo Creek site due to dilution from Peel River and upstream Chaffey Dam releases. A slight increase in aluminium levels is evident at the downstream site however these remain below ANZECC trigger values.	Low flow correlation with elevated EC. High chloride and salt levels (reflected in EC) correlates to low hardness of water and high toxicity potential of heavy metals. Lack of further toxicant data limits the quantification of toxicity potential. Higher chlorine levels may also indicate elevated inorganic loading and greater discoloration potential. Lower concentrations of salts and sulphate are observed at the downstream Goonoo Creek site due to dilution from Peel River and upstream Chaffey Dam releases. A slight increase in aluminium levels is evident at the downstream site however these remain below ANZECC trigger values.	Low flow correlation with elevated EC. High chloride and salt levels (reflected in EC) correlates to low hardness of water and high toxicity potential of heavy metals. Lack of further toxicant data limits the quantification of toxicity potential. Higher chlorine levels may also indicate elevated inorganic loading and greater discoloration potential. Lower concentrations of salts and sulphate are observed at the downstream Goonoo Creek site due to dilution from Peel River and upstream Chaffey Dam releases. A slight increase in aluminium levels is evident at the downstream site however these remain below ANZECC trigger values.	Low flow correlation with elevated EC. High chloride and salt levels (reflected in EC) correlates to low hardness of water and high toxicity potential of heavy metals. Lack of further toxicant data limits the quantification of toxicity potential. Higher chlorine levels may also indicate elevated inorganic loading and greater discoloration potential. Lower concentrations of salts and sulphate are observed at the downstream Goonoo Creek site due to dilution from Peel River and upstream Chaffey Dam releases. A slight increase in aluminium levels is evident at the downstream site however these remain below ANZECC trigger values.	High nutrient levels and coliforms are expected within the wetland. Elevated heavy metal levels of zinc, copper and chromium indicate a risk of accumulated toxicants and impacts to public and ecosystem health. The influx of chloride and salts from the Goonoo Creek confluence is unable to be effectively traced without downstream data but is a likely contributor to high toxicity potential in the lower testing site.	High nutrient levels and coliforms are expected within the wetland. Elevated heavy metal levels of zinc, copper and chromium indicate a risk of accumulated toxicants and impacts to public and ecosystem health. The influx of chloride and salts from the Goonoo Creek confluence is unable to be effectively traced without downstream data but is a likely contributor to high toxicity potential in the lower testing site.	
	Algae	0%	NA	NA	NA	NA	NA	NA	NA	15,000 cells/mL	
	Aluminium	0%	NA	NA	0%	0%	0%	0%	NA	55 mg/L	
	Ammonia	0%	0%	NA	NA	NA	NA	NA	5%	0.9 mg/L	
	Arsenic	3%	0%	NA	NA	NA	NA	NA	Inconclusive	0.013 mg/L	
	Boron	0%	0%	NA	NA	NA	NA	NA	NA	0.37 mg/L	
	Cadmium	0%	0%	NA	NA	NA	NA	NA	3%	0.0002 mg/L	
	Chloride	0%	29,32%	NA	NA	98%	98%	98%	NA	25 mg/L	
	Chlorine	NA	NA	NA	NA	14%	5%	5%	NA	0.003 mg/L	
	Chromium	25%	0%	NA	NA	NA	NA	NA	34%	0.001 mg/L	
	Copper	19%	38%	NA	NA	NA	NA	NA	82%	0.0014 mg/L	
	Dissolved Oxygen	42% < 90%	64% < 90%, 53% < 90%	NA	NA	NA	NA	NA	NA	90-110%	
	Faecal Coliforms	83% (total), max = 42000. 57% (faecal), max = 9600	75% (total), max = 36700	NA	NA	NA	NA	NA	45%	150-1000 cfu/100mL	

Testing Site	Peel River at Calala Pump Station	Peel River at Paradise Weir (419024)	Goonoo Creek Upstream	Goonoo Creek Downstream	Peel River Wetlands	Trigger
Herbicides	Discrete	Discrete (N1268, 419024)	Telemetric	Discrete	Discrete	Table 3.4.1
Lead	NA	2% Atrazine	NA	NA	NA	0.0034 mg/L
Manganese	0%	33%	NA	NA	0%	1.9 mg/L
Mercury	0%	0%	NA	NA	0%	0.00006 mg/L
Nickel	13%	Inconclusive	NA	NA	Inconclusive	0.011 mg/L
Nitrate	0%	NA	NA	NA	0%	0.7 mg/L
Nitric Oxide	3%	6%	NA	NA	NA	0.015 mg/L
o-xylene	100%	53%	NA	NA	33%	0.35 mg/L
Pesticides	NA	0%	NA	NA	NA	Table 5.2.4
Phenols	NA	Inconclusive	NA	NA	NA	0.32 mg/L
pH	Inconclusive	NA	NA	NA	0%	6.5-8
Electrical Conductivity (EC)	71% >8 median = 8.1 100% >30, none > 350. median = 260	26% >8, 42% >8 median = 8 59%, 38% >350 (uncomp), 78% >350 (at 25°C)	53 >8 median = 8.1 98% > 350	89% >8 median = 8.2 100% > 350	NA	30-350 µS/cm
Kushka2010>> Selenium	Inconclusive	NA	NA	NA	NA	0.005 mg/L
Silver	Inconclusive	NA	NA	NA	NA	0.00005 mg/L
Sulphate	0%	0%	0%	0%	NA	1000 mg/L
TSS	NA	17%, 8%	NA	NA	NA	40 mg/L
Temp	68% <15°C max = 21 min = 8.8	41% <15°C, 27% <15°C max = 31 min = 7.9	NA	NA	NA	15-35°C
Total Nitrogen	NA	83%, 81%	NA	NA	97%	0.25 mg/L
Total Phosphorous	NA	73%, 4%	NA	NA	100%	0.02 mg/L
Turbidity	7%	28%, 12%	NA	NA	NA	25 NTU
Zinc	10%	38%	NA	NA	54%	0.008 mg/L

5.3 CONCEPTUAL WATER QUALITY MODELLING

5.3.1 MUSIC Model Set-Up

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was used to develop a water quality model for the existing conditions incorporating information gathered through data collection and review (**Section 3**), catchment characteristics (**Section 4**) and site visit.

The model was created to estimate the existing pollutants generated from the urban area and the efficacy of the existing treatment measures within the study area. It is noted that Council currently does not have any water quality targets in the DCP.

The model was prepared in accordance with the NSW MUSIC Modelling Guidelines (BMT WBM-2015) and the Using MUSIC in Sydney Drinking Water Catchment, (WaterNSW, 2019).

5.3.1.1 Source Nodes

For water quality modelling purposes, the Stormwater Management Areas (SMA) developed for the study area, have been considered as the catchments. The catchments are shown in **Figure 5-2**. These catchments have been further divided into sub-catchments for MUSIC model set-up based on the TRLEP 2010 land use zone mapping for the Study Area as shown in **Figure A7** in **Appendix A**. Land use in Tamworth is predominantly General Residential, Environmental Management, Primary Production Small Lots with some areas classified Low Density Residential, Large Lot Residential, and Transition.

Suitable source nodes and Effective Impervious Areas (EIA) were assigned to the various land uses within each sub-catchment. These are discussed in detail in **Section 5.3.2** below.

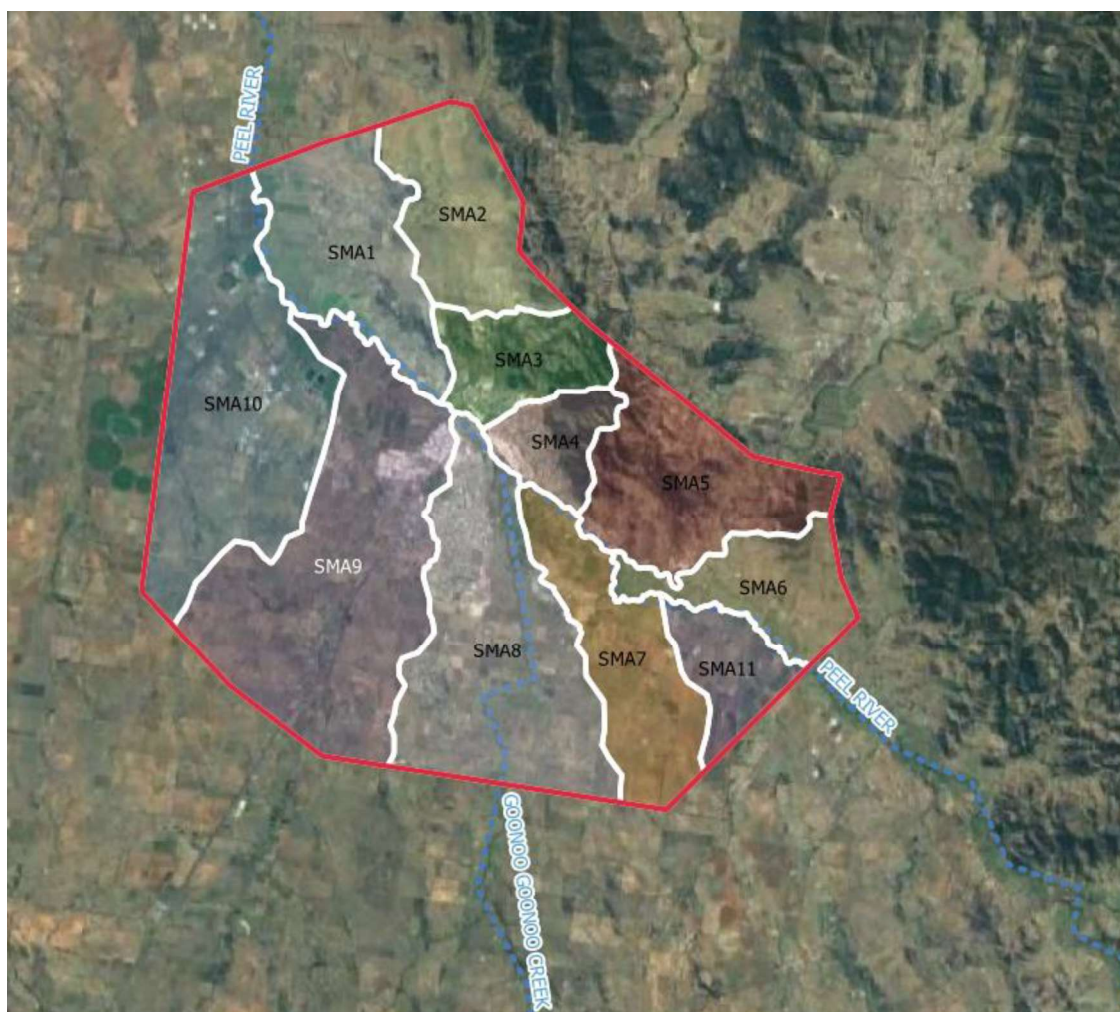


Figure 5-2 Water Quality Catchments

5.3.1.2 Climate Data

To ensure reasonable predictions of runoff are made, rainfall data were sourced from the eWater for the nearest daily rainfall station 055054 at Tamworth Airport, which 6-minute rainfall data were available from 16/08/1958 – 25/12/1992.

This period has some missing data, therefore; thirty (30) years of continuous rainfall data from 1959 to 1989 was used for the model. This period has minimal missing data, and the average annual rainfall is representative of the long-term average annual rainfall, details are summarized in **Table 5-4**.

Table 5-4 Meteorological Data

Station	055054
Location	Tamworth Airport
Data Period	01/01/1959 – 01/01/1989
Number of Years	30
Average Annual Rainfall (mm)	649
Long Term Average Annual Rainfall (1993-2022)	642.4
Time step (min)	6

Evapotranspiration data was included as monthly average values from the closest available station at Tamworth airport (Station 055054) and is listed in **Table 5-5**.

Table 5-5 Average Daily Evapotranspiration by Month (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
8.6	8.1	6.9	4.6	2.9	2.0	2.1	3.0	4.4	6.0	7.6	8.6

The resulting meteorological time series graph is shown in **Figure 5-3**. This climate data is considered representative of Tamworth and adheres to the MUSIC Modelling guidelines.

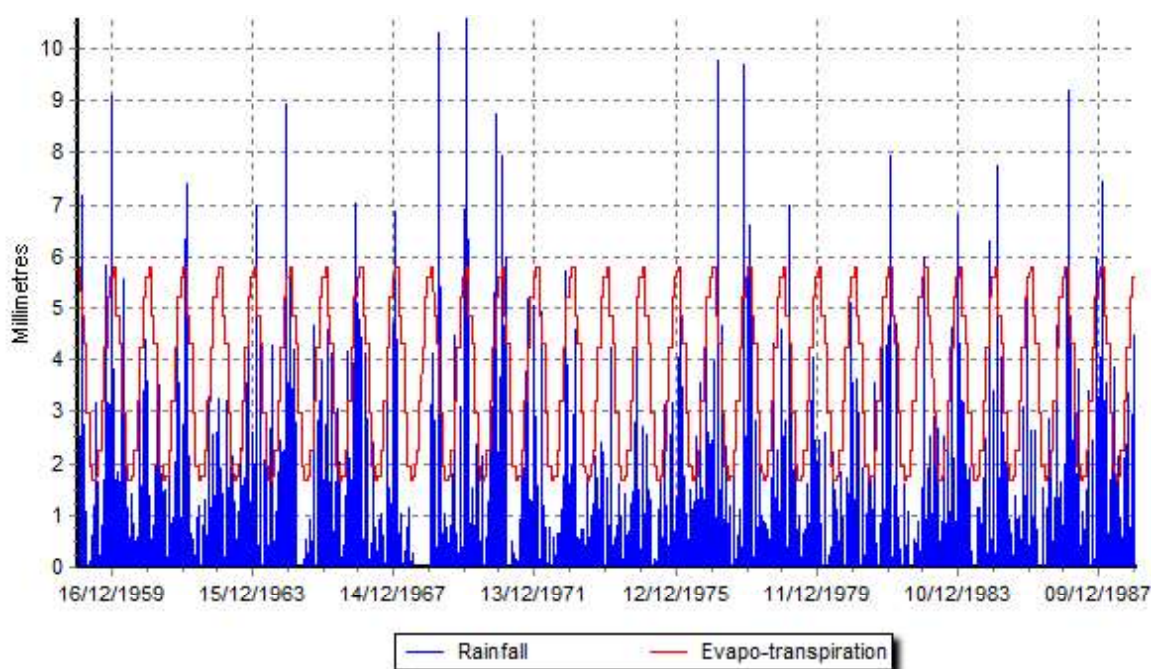


Figure 5-3 Meteorological Time Series

5.3.1.3 Rainfall Runoff Parameters

The adopted rainfall-runoff parameters for the existing scenario are provided in **Table 5-6**.

Table 5-6 Rainfall Runoff Parameters

Parameter	Value
Rainfall threshold (mm)	1
Soil storage capacity (mm)	54
Initial storage (% capacity)	25
Field capacity (mm)	51
Infiltration capacity coefficient - a	180
Infiltration capacity exponent - b	3
Initial depth (mm)	10
Daily recharge rate (%)	25
Daily base flow rate (%)	25
Daily deep seepage rate (%)	0

5.3.1.4 Pollutant Generation

In MUSIC, stormwater quality is characterised by event mean concentrations (EMC) for storm flow and base flow conditions. In this study, the EMC were adopted from the NSW MUSIC Modelling Guidelines. Base flow and storm flow parameters for various land uses within the study area are summarised in **Table 5-7** and **Table 5-8**.

Table 5-7 Base Flow Pollutant Concentration Parameters

Land use	TSS Log10 Values		TP Log10 Values		TN Log10 Values	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Business	1.20	0.17	-0.85	0.19	0.11	0.12
Industrial	1.20	0.17	-0.85	0.19	0.11	0.12
Rural Residential	1.15	0.17	-1.22	0.19	-0.05	0.12
Agricultural	1.30	0.13	-1.05	0.13	0.04	0.13
Re-vegetated land	1.15	0.17	-1.22	0.19	-0.05	0.12
Forest	0.78	0.13	-1.22	0.13	-0.52	0.13

Table 5-8 Storm Flow Pollutant Concentration Parameters

Land use	TSS Log10 Values		TP Log10 Values		TN Log10 Values	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Business	2.15	0.32	-0.60	0.25	0.30	0.19
Industrial	2.15	0.32	-0.60	0.25	0.30	0.19
Rural Residential	1.95	0.32	-0.66	0.25	0.30	0.19
Agricultural	2.15	0.31	-0.22	0.30	0.48	0.26
Re-vegetated land	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24

5.3.1.5 Existing Treatment Nodes

There are sixteen (16) Gross Pollutant Traps (GPTs) as well as two water quality treatment wetlands located within the Study Area. The location of the GPTs is shown in **Map A3** in **Appendix A**. The wetlands are currently not included in Council's GIS system and were identified during the site visits. These devices have been suitably included in the model as treatment nodes.

5.3.1.5.1 Existing Gross Pollutant Traps

Due to insufficient information available for the existing GPTs within the study area including their treatment efficiency, all GPTs are assumed to provide adequate treatment as per MUSIC modelling requirements and has been modelled with the pollutant removal rates provided below:

- > Up to 75% reduction in Total Suspended Solids (TSS) based on the transfer function relationship shown in **Table 5-9**;

Table 5-9 GPT Specification for TSS

Input (mg/L)	Output (mg/L)	%Removal
0	0	0
20.8	8	61.5
40.3	14.1	65
60.6	19.3	68.2
79.3	23.4	70.5
99.9	26.9	73.1
121	30	75.2

- > 30% reduction in Total Phosphorus (TP);
- > 21% reduction in Total Nitrogen (TN); and
- > 100% reduction in Gross Pollutants (GP).

5.3.1.5.2 Existing Wetland

Since there is not much information available for the two existing wetlands - Orley Drive / Heritage Park Wetland and Peel High Wetland, their parameters have been assumed based on aerial photographs, Tamworth 0.5m DEM and MUSIC modelling guidelines for a generic wetland. These are summarised in **Table 5-10**.

Table 5-10 Wetland Specification

Parameter	Orley Drive / Heritage Park Wetland	Peel High Wetland
Surface Area (m ²)	4900	4500
Extended Detention depth (m)	0.3	0.4
Permanent Pool Volume (m ³)	1470	1800
Initial Volume (m ³)	1470	1800
Exfiltration Rate (mm/h)	0	0
Evaporative Loss as % of PET	125	125
Equivalent Pipe Diameter (mm)	200	200
Overflow Weir Width (m)	5	5

5.3.2 Catchment Schematisation

Using the MUSIC modelling guidelines, suitable source nodes and effective impervious areas (EIA) were assigned to the various land uses within each SMA for the existing scenario based on aerial imagery. These are discussed in the following sections.

5.3.2.1 Catchment SMA1

There are three existing GPTs and one wetland located within this catchment. Based on the areas draining into these water quality treatment devices, this catchment was divided into five sub-catchments discharging into Peel River. **Table 5-11** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA1. The SMA1 sub-catchments are shown in **Figure A12** in **Appendix A** and MUSIC model overview is shown in **Figure 5-4**.

Table 5-11 MUSIC Source Nodes for Catchment SMA1

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area-TIA (ha)	Total Impervious Area-TIA (ha)	EIA Factor (Directly Connected)	EIA Subcatchment (%)
SMA1-01	GPT and then to Peel River	E3	SMA1-01-Forest	0%	16.77	0.00	0.00	0%
		R1	SMA1-01-01-Residential	60%	28.75	17.25	0.60	36%
		RE1	SMA1-01-Revegetated land	5%	1.39	0.07	1.00	5%
		RU4	SMA1-01-02-Residential	90%	3.46	2.08	0.60	54%
SMA1-02	GPT and then to Wetland and Peel River	E3	SMA1-02-Forest	0%	16.15	0.00	0.00	0%
		R1	SMA1-02-Residential	60%	34.57	20.74	0.60	36%
		RE1	SMA1-02-Revegetated land	5%	2.41	0.12	1.00	5%
		RU4	SMA1-02-Agricultural	0%	3.21	0.00	0.00	0%
SMA1-03	Wetland and then to Peel River	E3	SMA1-03-Forest	0%	15.88	0.00	0.00	0%
		R1	SMA1-03-01-Residential	60%	33.84	20.30	0.60	36%
		R2	SMA1-03-02-Residential	5%	3.79	0.19	0.60	3%
		RE1	SMA1-03-Revegetated land	5%	2.48	0.12	1.00	5%
		RU4	SMA1-03-Agricultural	0%	9.56	0.00	0.00	0%
SMA1-04	GPT then to Peel River	R1	SMA1-04-Residential	60%	3.51	2.11	0.60	36%
		RU4	SMA1-04-Agricultural	0%	0.16	0.00	0.00	0%
SMA1-05	Peel River	B1	SMA1-05-Commercial	5%	5.22	0.26	0.80	4%
		E3	SMA1-05-Forest	0%	53.35	0.00	0.00	0%
		R1	SMA1-05-01-Residential	40%	200.52	80.21	0.60	24%
		R2	SMA1-05-02-Residential	15%	199.82	29.27	0.60	9%
		R5	SMA1-05-Rural Residential	5%	745.51	37.28	1.00	5%
		RE1	SMA1-05-Revegetated land	5%	11.31	0.56	1.00	5%
		RU1	SMA1-05-01-Agricultural	0%	632.36	0.00	0.00	0%
		RU4	SMA1-05-02-Agricultural	0%	605.78	0.00	0.00	0%
		SP2	SMA1-05-Industrial	10%	7.27	0.73	0.90	9%

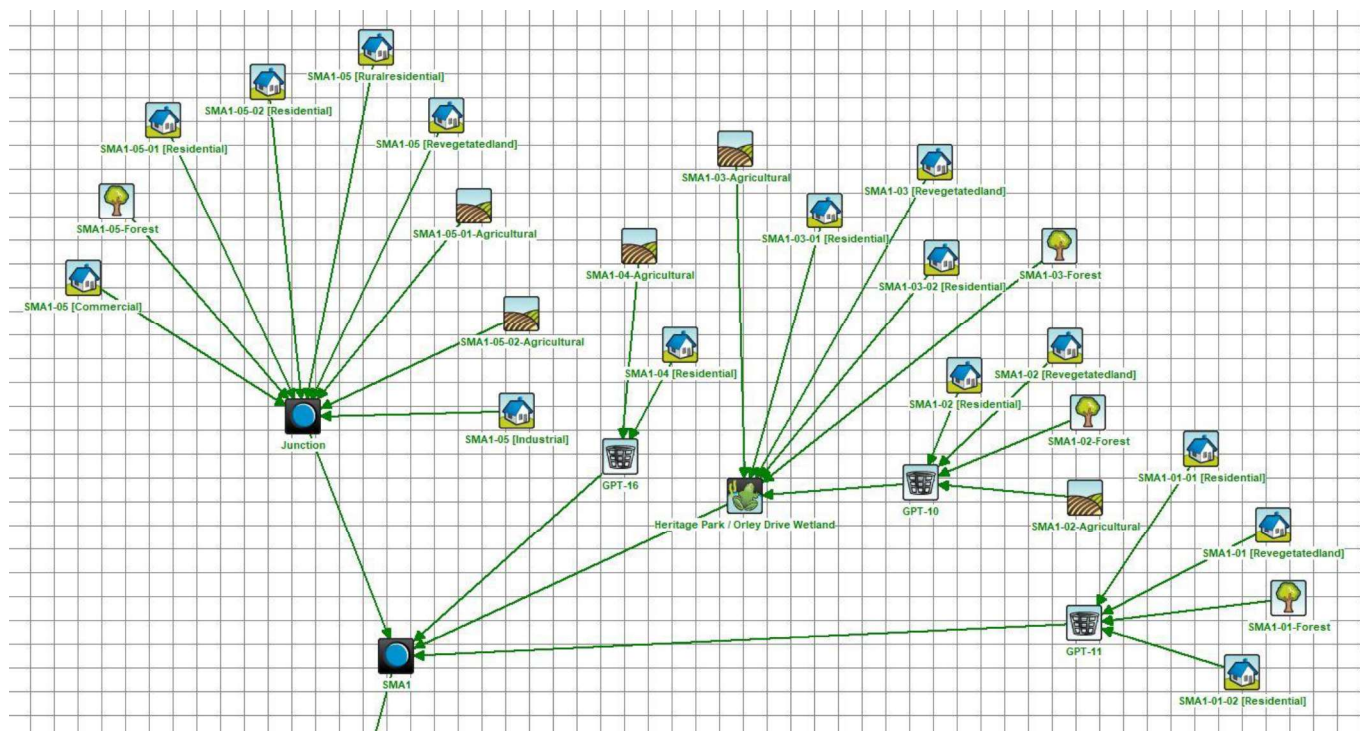


Figure 5-4 MUSIC Model Overview for SMA1

5.3.2.2 Catchment SMA2

There are no water quality treatment devices located within this catchment. Hence, this catchment was divided into only one sub-catchment discharging into Peel River. **Table 5-12** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA2. The SMA2 sub-catchments are shown in **Figure A13** in **Appendix A** and MUSIC model overview is shown in **Figure 5-5**.

Table 5-12 MUSIC Source Nodes for Catchment SMA2

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA Subcatchment (%)
SMA2-01	Peel River	E3	SMA2-01-Forest	0%	149.65	0.00	0.00	0%
		R1	SMA2-01-01-Residential	10%	81.24	8.12	0.60	6%
		R2	SMA2-01-02-Residential	35%	689.03	241.16	0.60	21%
		R5	SMA2-01-Re-Rural Residential	5%	950.62	47.53	1.00	5%
		RU1	SMA2-01-01-Agricultural	0%	222.33	0.00	0.00	0%
		RU6	SMA2-01-02-Agricultural	0%	43.21	0.00	0.00	0%
		SP2	SMA2-01-Revegetated land	5%	0.57	0.028	1.00	5%

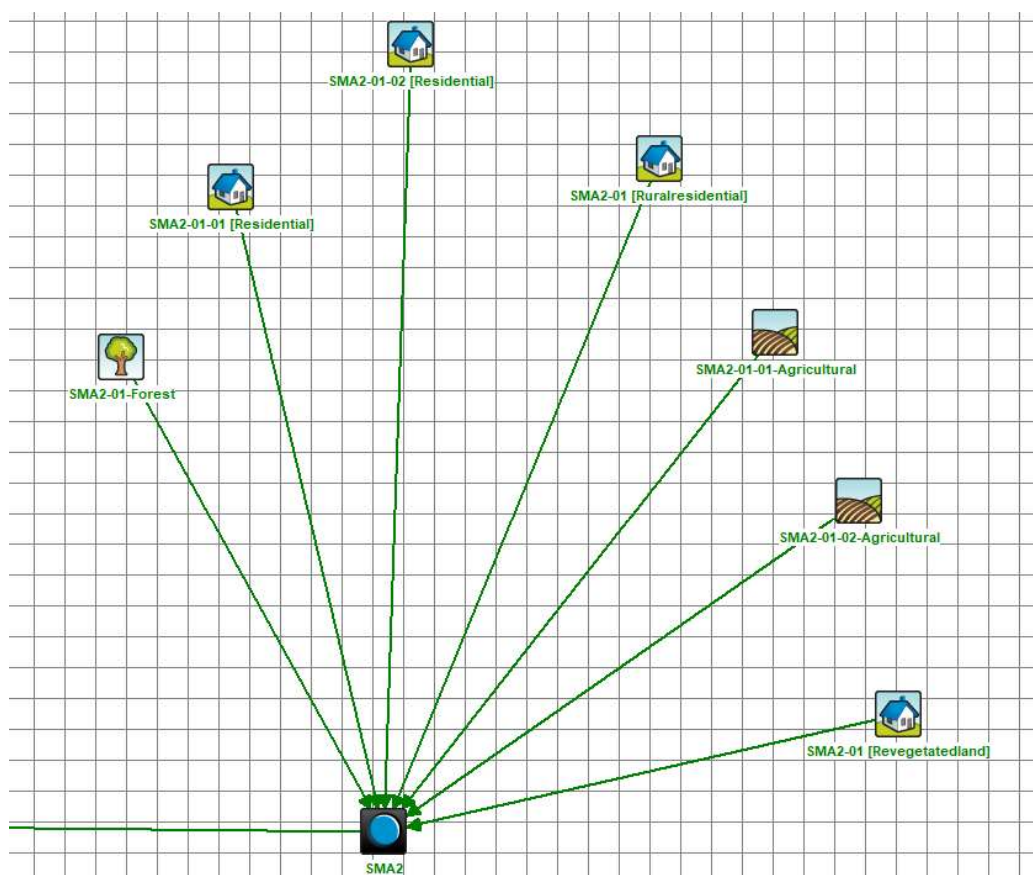


Figure 5-5 MUSIC Model Overview for SMA2

5.3.2.3 Catchment SMA3

There is one GPT located within this catchment. Based on the area draining into this water quality treatment devices, this catchment was divided into two sub-catchments discharging into Peel River. **Table 5-13** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA3. The SMA3 sub-catchments are shown in **Figure A14** in **Appendix A** and MUSIC model overview is shown in **Figure 5-6**.

Table 5-13 MUSIC Source Nodes for Catchment SMA3

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA3-01	GPT and then to Peel River	R1	SMA3-01-Residential	35%	1.67	0.58	0.60	21%
		RU4	SMA3-01-Agricultural	0%	0.53	0.00	0.00	0%
SMA3-02	Peel River	B1	SMA3-02-01-Commercial	90%	1.31	1.18	0.80	72%
		B3	SMA3-02-02-Commercial	70%	1.14	0.80	0.80	56%
		B4	SMA3-02-01-Industrial	60%	7.71	4.62	0.90	54%
		E3	SMA3-02-01-Forest	0%	563.07	0.00	0.00	0%
		R1	SMA3-02-01-Residential	70%	263.31	184.32	0.60	42%
		R2	SMA3-02-02-Residential	10%	71.840	7.184	0.60	6%
		R5	SMA3-02-02-Forest	0%	15.074	0.00	0.00	0%
		RE1	SMA3-02-Revegetated land	5%	68.92	3.45	1.00	5%
		RE2	SMA3-02-03-Commercial	25%	0.86	0.22	0.80	20%
		RU4	SMA3-02-Agricultural	0%	173.49	0.00	0.00	0%
		RU6	SMA3-02-03-Forest	0%	173.10	0.00	0.00	0%
		SP2	SMA3-02-02-Industrial	5%	48.71	2.43	0.90	5%

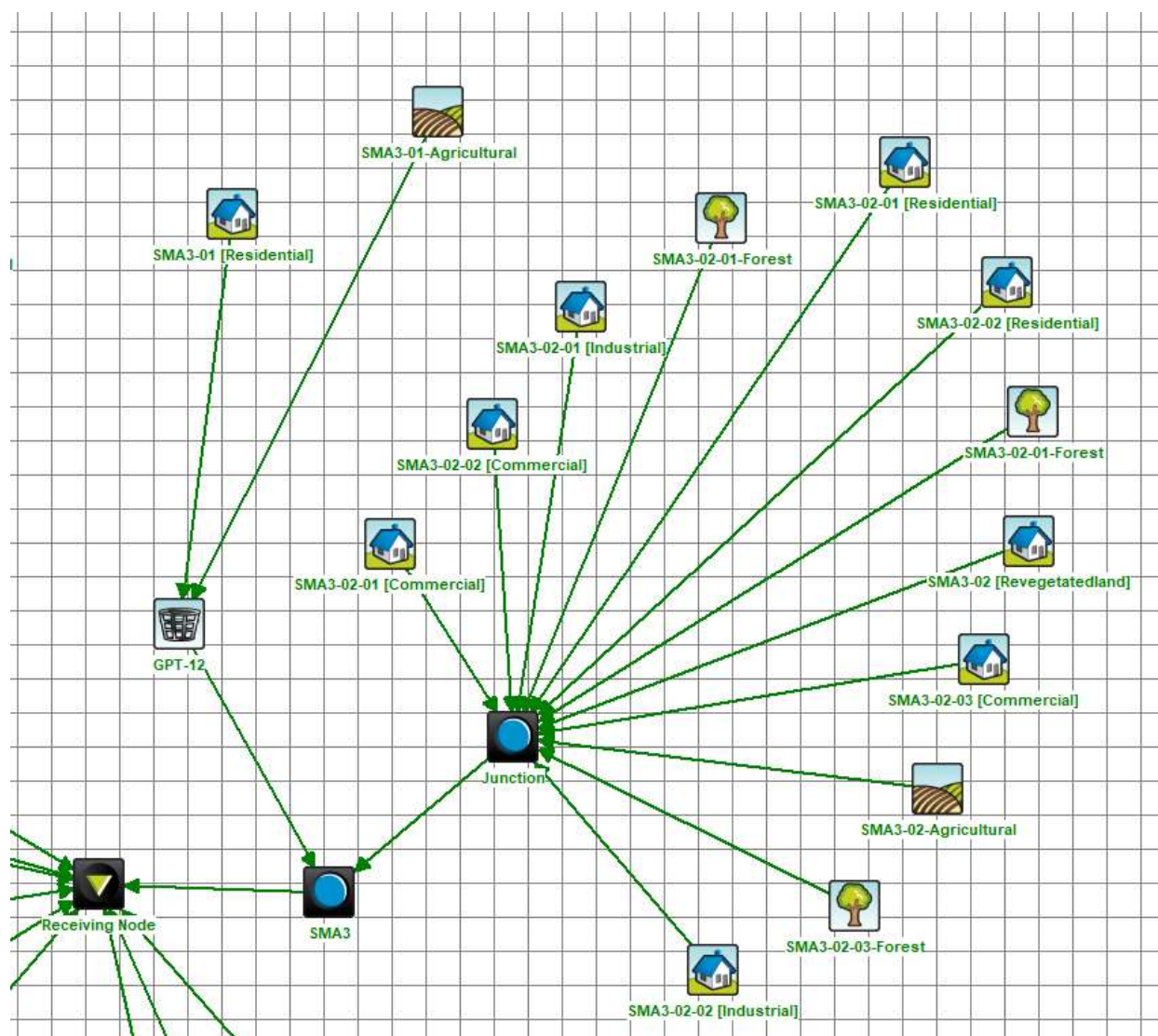


Figure 5-6 MUSIC Model Overview for SMA3

5.3.2.4 Catchment SMA4

There are two GPTs located within this catchment. Based on the areas draining into these water quality treatment devices, this catchment was divided into three sub-catchments discharging into Peel River. **Table 5-14** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA4. The SMA4 sub-catchments are shown in **Figure A15** in **Appendix A** and MUSIC model overview is shown in **Figure 5-7**.

Table 5-14 MUSIC Source Nodes for Catchment SMA4

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA4-01	GPT and then to Peel	B3	SMA4-01-Commercial	90%	12.48	11.23	0.80	72%
		B4	SMA4-01-Industrial	80%	1.01	0.81	0.90	72%
		R1	SMA4-01-Residential	70%	7.87	5.51	0.60	42%
SMA4-02	GPT and then to Peel River	R1	SMA4-02-Residential	15%	5.77	0.86	0.60	9%
		RU4	SMA4-02-Revegetated land	5%	0.11	0.01	1.00	5%
		RE1	SMA4-02-Forest	0%	8.09	0.00	0.00	0%
SMA4-03	Peel River	B3	SMA4-03-01-Commercial	80%	68.22	55.63	0.80	64%
		B4	SMA4-03-01-Industrial	80%	15.77	12.62	0.90	72%
		E3	SMA4-03-01-Forest	0%	6.44	0.00	0.00	0%
		IN1	SMA4-03-02-Industrial	50%	3.28	1.64	0.90	45%
		R1	SMA4-03-Residential	70%	305.94	214.16	0.60	42%
		RE1	SMA4-03-02-Forest	0%	443.97	0.00	0.00	0%
		RE2	SMA4-03-03-Industrial	30%	0.84	0.25	0.90	27%
		RU4	SMA4-03-02-Commercial	10%	41.12	4.11	0.80	8%

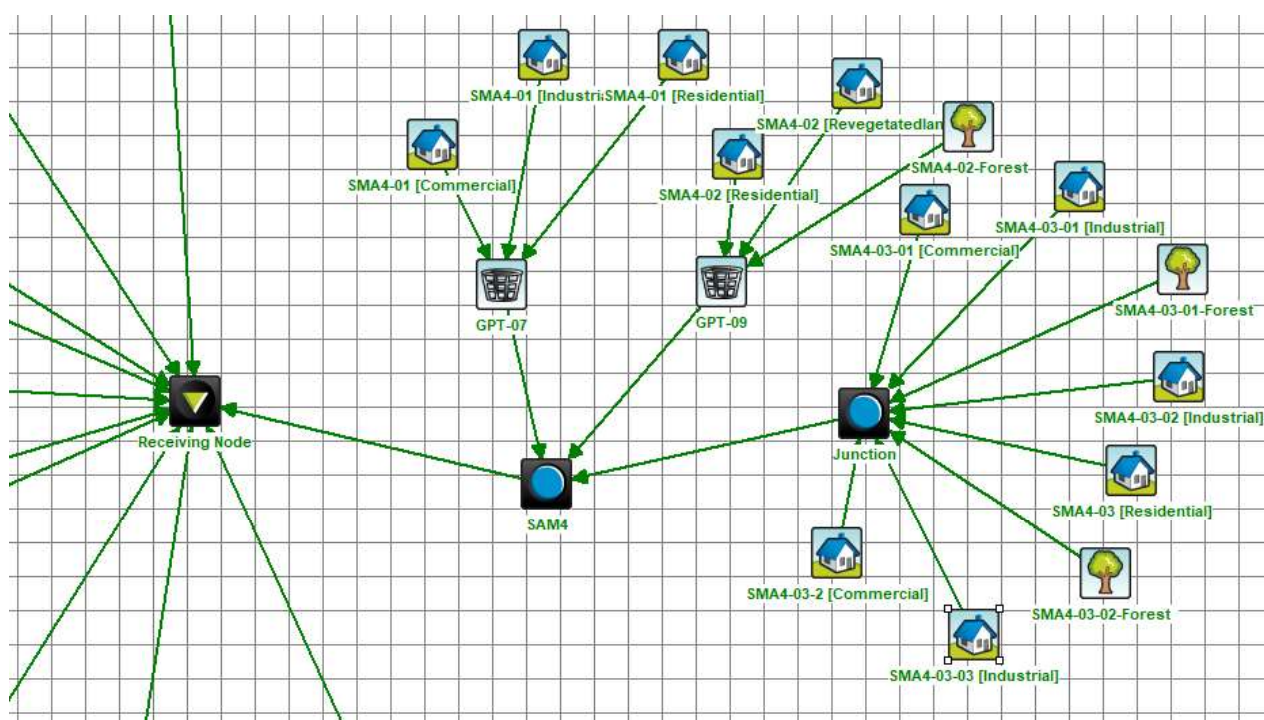


Figure 5-7 MUSIC Model Overview for SMA4

5.3.2.5 Catchment SMA5

There are no water quality treatment devices located within this catchment. Hence, this catchment was divided into just one sub-catchment discharging into Peel River. **Table 5-15** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA5. The SMA5 sub-catchments are shown in **Figure A16** in **Appendix A** and MUSIC model overview is shown in **Figure 5-8**.

Table 5-15 MUSIC Source Nodes for Catchment SMA5

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA5-01	Peel River	B4	SMA5-01-01-Industrail	45%	1.31	0.59	0.90	41%
		E3	SMA5-01-01-Forest	0%	1202.63	0.00	0.00	0%
		IN1	SMA5-01-02-Industrail	50%	7.07	3.53	0.90	45%
		R1	SMA5-01-Residential	50%	141.74	70.87	0.60	30%
		R5	SMA5-01-Rural Residential	5%	813.21	40.66	1.00	5%
		RE1	SMA5-01-02-Forest	0%	123.47	0.00	0.00	0%
		RU1	SMA5-01-03-Forest	0%	36.41	0.00	0.00	0%
		RU4	SMA5-01-Agricultural	0%	448.83	0.00	0.00	0%

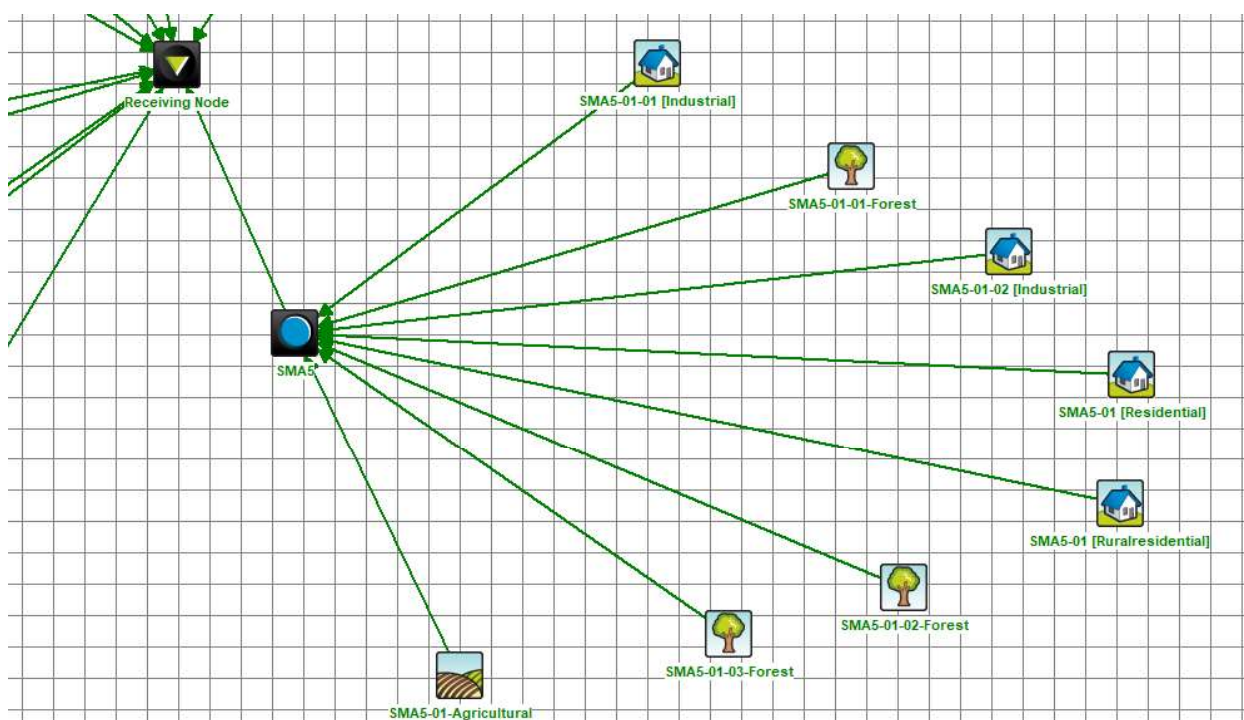


Figure 5-8 MUSIC Model Overview for SMA5

5.3.2.6 Catchment SMA6

There are no water quality treatment devices located within this catchment. Therefore, this catchment was divided into only one sub-catchment discharging into Peel River.

Table 5-16 provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA6. The SMA6 sub-catchments are shown in **Figure A17** in **Appendix A** and MUSIC model overview is shown in **Figure 5-9**.

Table 5-16 MUSIC Source Nodes for Catchment SMA6

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (directly Connected)	EIA (% Subcatchment)
SMA6-01	Peel River	E3	SMA6-01-Forest	0%	222.50	0.000	0.00	0%
		R5	SMA6-01-Rural Residential	5%	640.97	32.05	1.00	5%
		RU1	SMA6-01-01-Agricultural	0%	439.21	0.000	0.00	0%
		RU4	SMA6-01-02-Agricultural	0%	269.33	0.000	0.00	0%

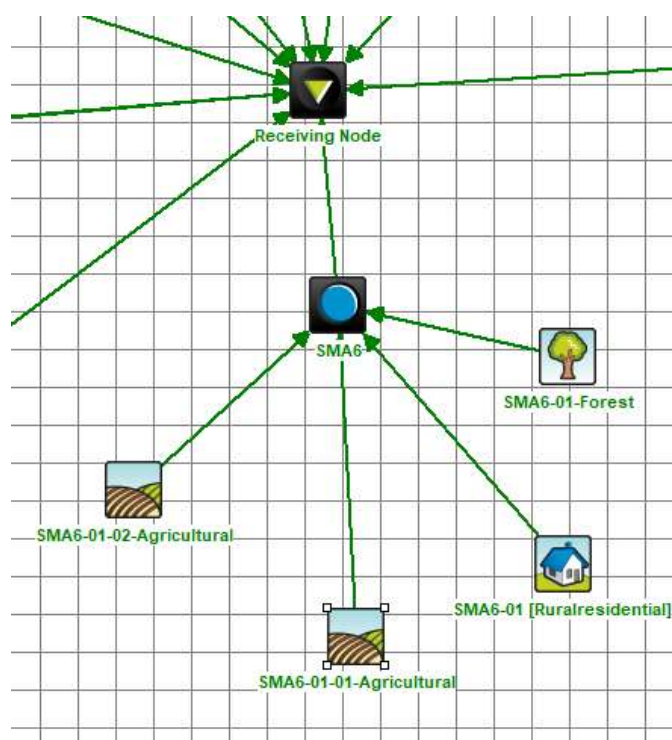


Figure 5-9 MUSIC Model Overview for SMA6

5.3.2.7 Catchment SMA7

There are three GPTs located within this catchment. Based on the areas draining into these water quality treatment devices, this catchment was divided into four sub-catchments discharging into Calala Creek. **Table 5-17** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA7. The SMA7 sub-catchments are shown in **Figure A18** in **Appendix A** and MUSIC model overview is shown in **Figure 5-10**.

Table 5-17 MUSIC Source Nodes for Catchment SMA7

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area-TLA (ha)	Total Impervious Area-TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA7-01	GPT and then to Peel River	R1	SMA7-01-Residential	60%	10.32	6.19	0.60	36%
		R5	SMA7-01-Rural Residential	5%	1.35	0.07	1.00	5%
SMA7-02	GPT and then to Peel River	R1	SMA7-02-Residential	60%	5.83	3.50	0.60	36%
		R5	SMA7-02-Rural Residential	5%	0.69	0.03	1.00	5%
SMA7-03	GPT and then to Peel River	R1	SMA7-03-01-Residential	60%	5.04	3.02	0.60	36%
		R2	SMA7-03-02-Residential	50%	9.06	4.53	0.60	30%
		RE1	SMA7-03-Revegetated land	5%	0.92	0.05	1.00	5%
SMA7-04	Peel River	R1	SMA7-04-01-Residential	60%	136.49	81.89	0.60	36%
		R2	SMA7-04-02-Residential	50%	20.23	10.11	0.60	30%
		R5	SMA7-04-Rural Residential	5%	28.53	1.43	1.00	5%
		RE1	SMA7-04-Revegetated land	5%	9.26	0.46	1.00	5%
		RU1	SMA7-04-01-Agricultural	0%	469.69	0.00	0.00	0%
		RU4	SMA7-04-02-Agricultural	0%	1688.48	0.00	0.00	0%

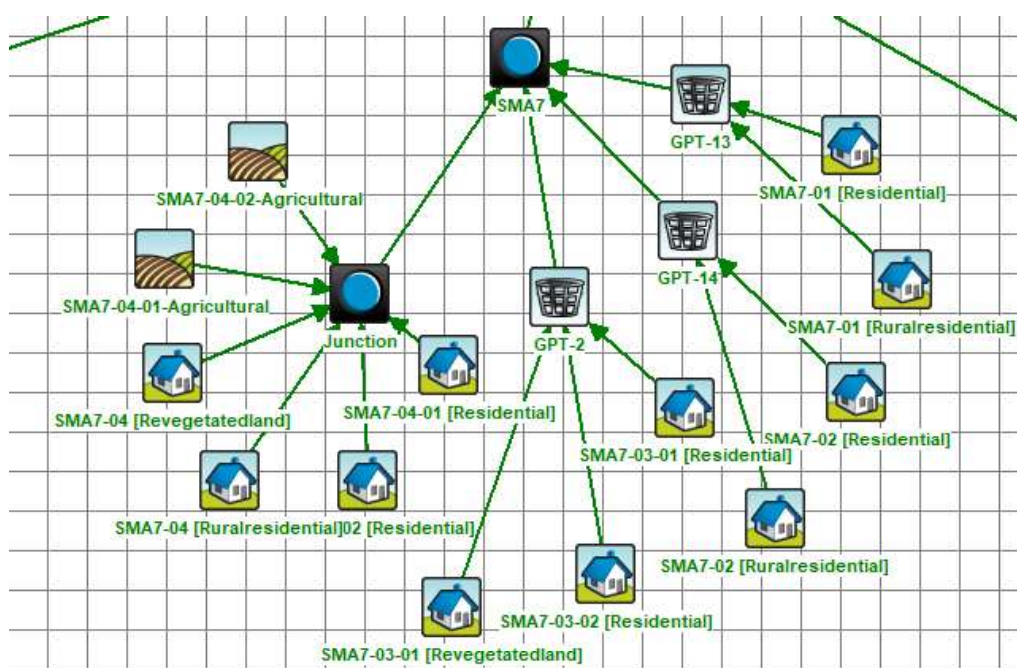


Figure 5-10 MUSIC Model Overview for SMA7

5.3.2.8 Catchment SMA8

There is one GPT located within this catchment. Based on the areas draining into this water quality treatment devices, this catchment was divided into two sub-catchments discharging into Barnes Gully. **Table 5-18** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA8. The SMA8 sub-catchments are shown in **Figure A19** in **Appendix A** and MUSIC model overview is shown in **Figure 5-11**.

Table 5-18 MUSIC Source Nodes for Catchment SMA8

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA8-01	GPT and then to Peel River	R1	SMA8-01-Residential	70%	29.77	20.84	0.60	42%
		RE1	SMA8-01-Revegetated land	5%	1.07	0.05	1.00	5%
SMA8-02	Peel River	B1	SMA8-02-01-Commercial	90%	3.68	3.31	0.80	72%
		B4	SMA8-02-01-Industrial	60%	40.28	24.17	0.90	54%
		B5	SMA8-02-02-Commercial	10%	64.97	6.50	0.80	8%
		IN1	SMA8-02-02-Industrial	80%	20.88	16.71	0.90	72%
		R1	SMA8-02-01-Residential	70%	553.34	387.34	0.60	42%
		R2	SMA8-02-02-Residential	50%	37.91	18.95	0.60	30%
		R5	SMA8-02-01-Rural Residential	5%	307.25	15.36	1.00	5%
		RE1	SMA8-02-Revegetated land	5%	147.63	7.38	1.00	5%
		RE2	SMA8-02-01-Agricultural	0%	75.80	0.00	0.00	0%
		RU4	SMA8-02-02-Agricultural	0%	3045.36	0.00	0.00	0%
		SP2	SMA8-02-03-Industrial	10%	16.54	1.65	0.90	9%
		SP3	SMA8-02-03-Commercial	30%	134.03	40.21	0.80	24%

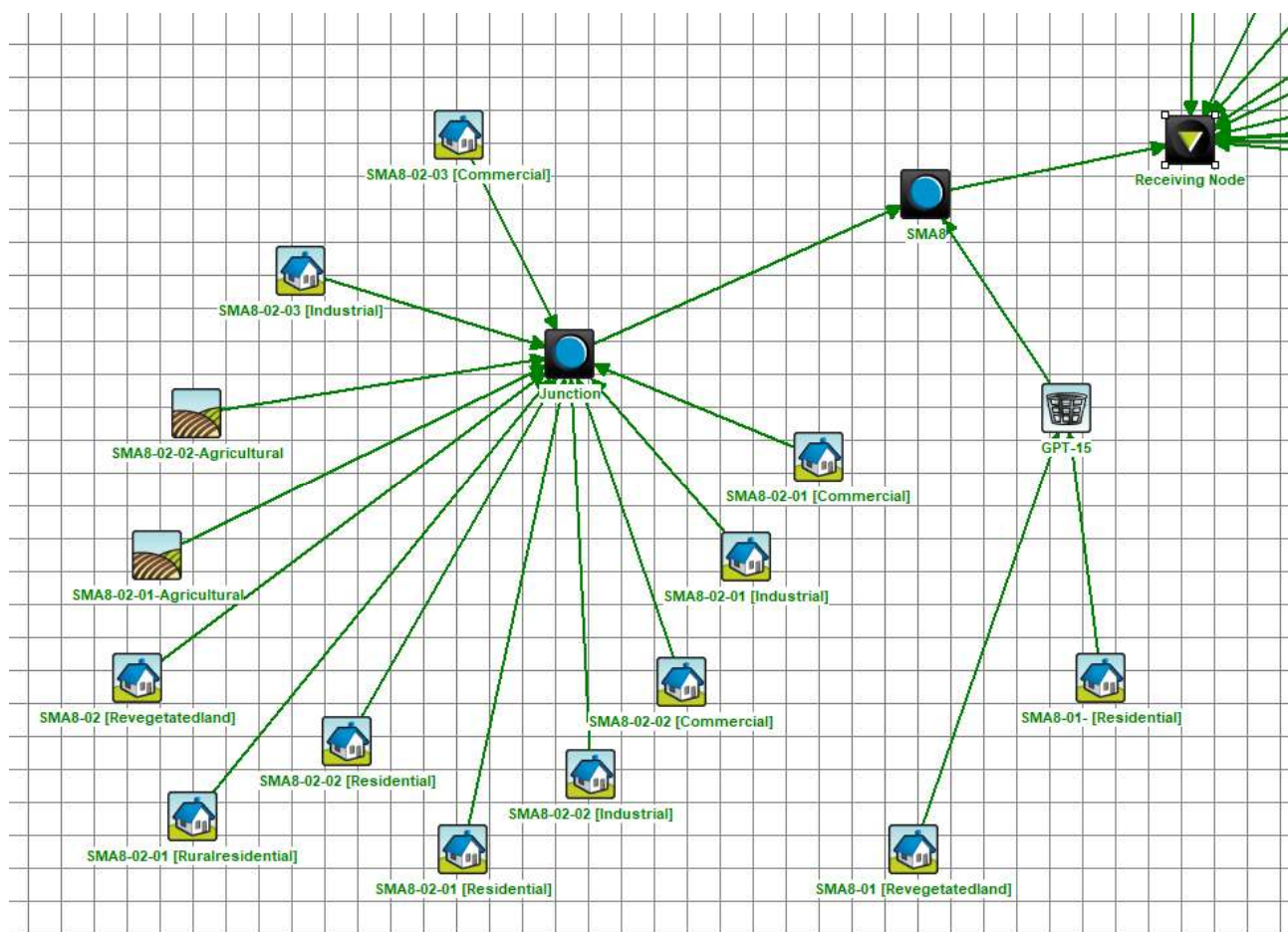


Figure 5-11 MUSIC Model Overview for SMA8

5.3.2.9 Catchment SMA9

There are six GPTs and one wetland located within this catchment. Based on the areas draining into these water quality treatment devices, this catchment was divided into eight sub-catchments discharging into Timbumburi Creek / Burkes Gully. **Table 5-19** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA9. The SMA9 sub-catchments are shown in **Figure A20** in **Appendix A** and MUSIC model overview is shown in **Figure 5-12**.

Table 5-19 MUSIC Source Nodes for Catchment SMA9

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA Subcatchment (%)
SMA9-01	GPT then to Peel	R1	SMA9-01-Residential	60%	1.45	0.87	0.60	36%
SMA9-02	GPT then to Peel	R1	SMA9-02-Residential	60%	0.68	0.41	0.60	36%
SMA9-03	GPT then to Peel	R1	SMA9-03-Residential	60%	0.96	0.58	0.60	36%
SMA9-04	GPT to Peel River	R1	SMA9-04-Residential	60%	9.91	5.95	0.60	36%
		RU4	SMA9-04-Agricultural	0%	0.75	0.00	0.00	0%
SMA9-05	GPT then to Peel River	R1	SMA9-05-Residential	60%	136.01	81.61	0.60	36%
		RE1	SMA9-05-Revegetated land	5%	14.77	0.74	1.00	5%
		RU4	SMA9-05-Agricultural	0%	0.73	0.00	0.00	0%
SMA9-06	GPT then to Peel River	B1	SMA9-06-Commercial	40%	1.67	0.67	0.80	32%
		R1	SMA9-06-Residential	60%	58.39	35.03	0.60	36%
		RE1	SMA9-06-Revegetated land	5%	4.28	0.21	1.00	5%
SMA9-07	Wetland then to Peel River	R1	SMA9-07-Residential	60%	14.18	8.51	0.60	36%
SMA9-08	Peel River	B1	SMA9-08-01-Commercial	60%	2.41	1.45	0.80	48%
		B4	SMA9-08-01-Industrial	80%	4.19	3.35	0.90	72%
		B5	SMA9-08-02-Commercial	60%	15.77	9.46	0.80	48%
		B7	SMA9-08-03-Commercial	25%	0.17	0.04	0.80	20%
		IN1	SMA9-08-02-Industrial	80%	226.466	181.173	0.90	72%
		R1	SMA9-08-01-Residential	30%	521.63	156.49	0.60	18%
		R2	SMA9-08-02-Residential	10%	158.50	15.85	0.60	6%
		R5	SMA9-08-Rural Residential	5%	287.02	14.35	1.00	5%
		RE1	SMA9-08-01-Revegetated land	5%	15.16	0.76	1.00	5%
		RE2	SMA9-08-02-Revegetated land	5%	45.37	2.27	1.00	5%
		RU4	SMA9-08-Agricultural	0%	4256.47	0.00	0.00	0%
		SP1	SMA9-08-04-Commercial	10%	12.35	1.23	0.80	8%
		SP2	SMA9-08-03-Industrial	2%	81.97	1.64	0.90	2%
		SP3	SMA9-08-05-Commercial	10%	53.95	5.39	0.80	8%

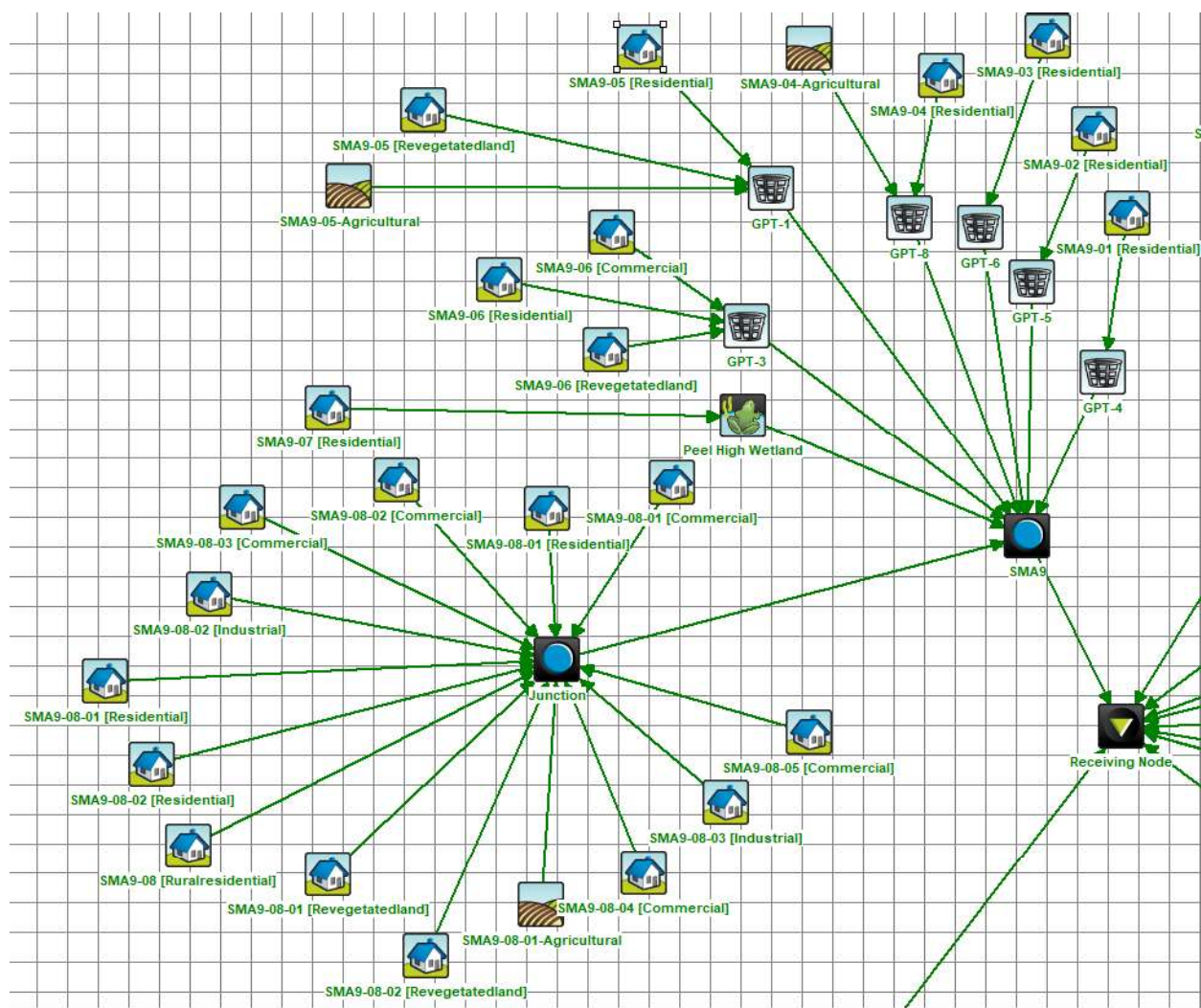


Figure 5-12 MUSIC Model Overview for SMA9

5.3.2.10 Catchment SMA10

There are no water quality treatment devices located within this catchment. Therefore, this catchment was divided into only one sub-catchment discharging into Peel River. **Table 5-20** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA10. The SMA10 sub-catchments are shown in **Figure A21** in **Appendix A** and MUSIC model overview is shown in **Figure 5-13**.

Table 5-20 MUSIC Source Nodes for Catchment SMA10

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA10-01	Peel River	B7	SMA10-01-01-Commercial	5%	192.92	9.65	0.80	4%
		E3	SMA10-01-Forest	0%	86.37	0.00	0.00	0%
		IN1	SMA10-01-01-Industrial	2%	67.98	1.36	0.90	2%
		IN3	SMA10-01-02-Industrial	25%	254.80	63.70	0.90	23%
		R1	SMA10-01-Residential	40%	13.31	5.32	0.60	24%
		RE2	SMA10-01-Revegetated land	5%	43.52	2.18	1.00	5%
		RU1	SMA10-01-01-Agricultural	0%	1263.73	0.00	0.00	0%
		RU4	SMA10-01-02-Agricultural	0%	2344.12	0.00	0.00	0%
		SP1	SMA10-01-02-Commercial	20%	330.62	66.12	0.80	16%
		SP2	SMA10-01-03-Industrial	10%	98.31	9.83	0.90	9%

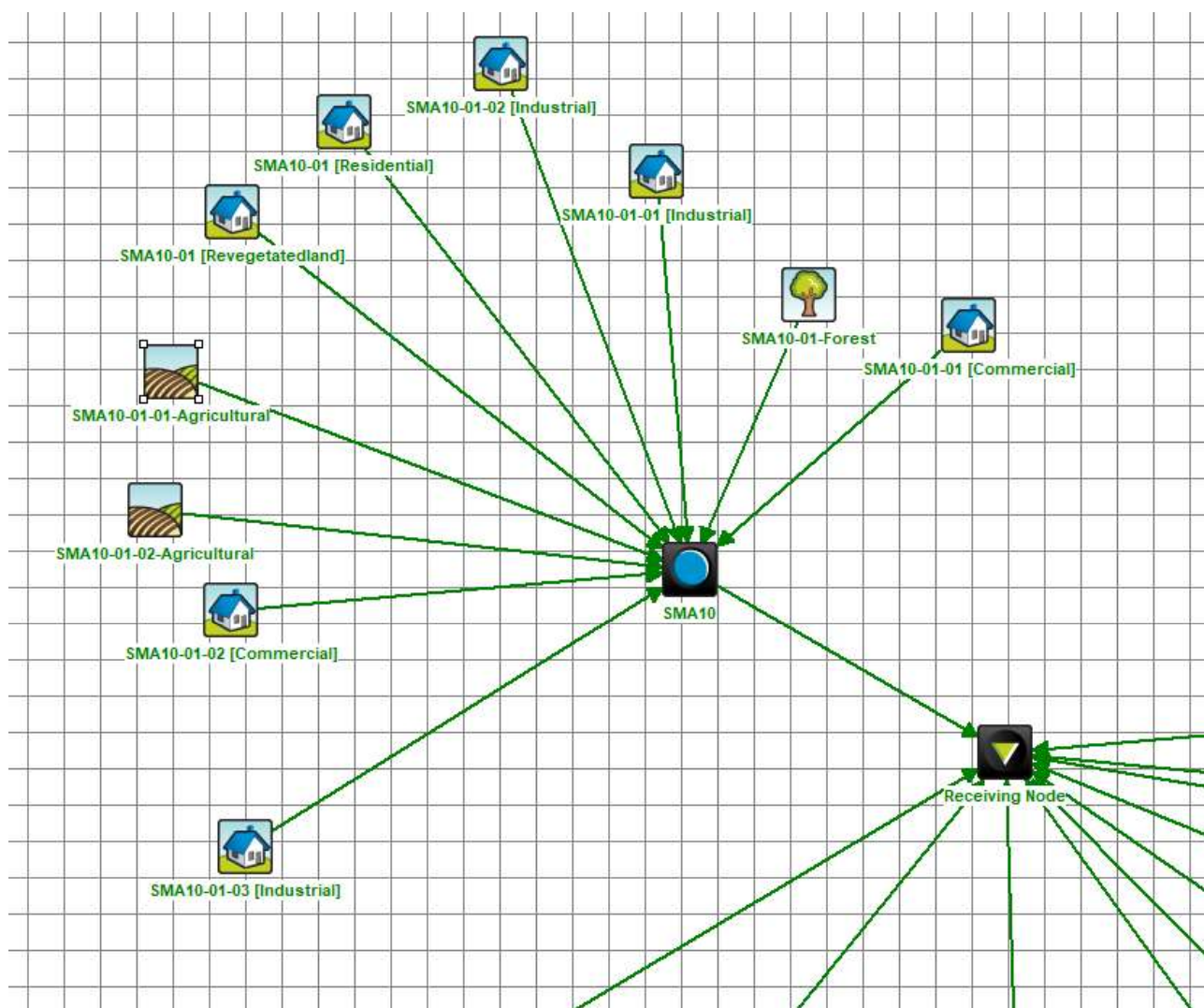


Figure 5-13 MUSIC Model Overview for SMA10

5.3.2.11 Catchment SMA11

There are no water quality treatment devices located within this catchment. Therefore, this catchment was divided into only one sub-catchments discharging into Reedy Creek / Peel River. **Table 5-21** provides a breakdown of the source nodes and their EIA used to develop the MUSIC model for SMA11. The SMA11 sub-catchments are shown in **Figure A22** in **Appendix A** and MUSIC model overview is shown in **Figure 5-14**.

Table 5-21 MUSIC Source Nodes for Catchment SMA11

Catchment Name	Outlet Node	Land Zoning	MUSIC Node	% Impervious	Total Land Use Area- TLA (ha)	Total Impervious Area- TIA (ha)	EIA Factor (Directly Connected)	EIA (% Subcatchment)
SMA11-01	Peel River	RU1	SMA11-01-Agricultural -1	0%	980.16	0.00	0.00	0%
		RU4	SMA11-01-Agricultural -2	0%	90.80	0.00	0.00	0%

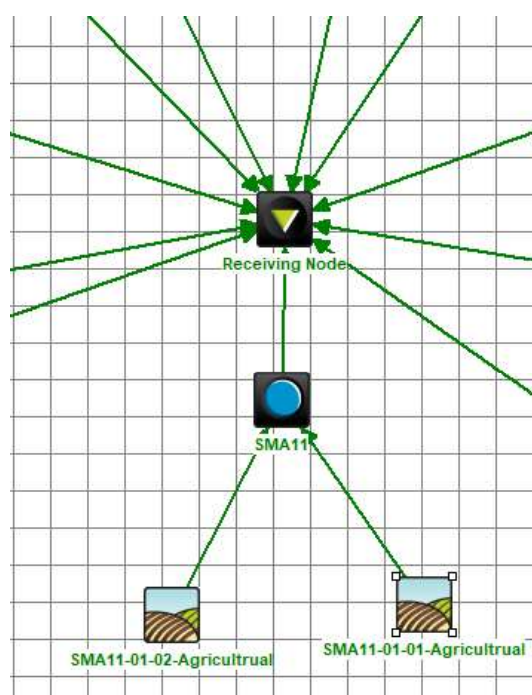


Figure 5-14 MUSIC Model Overview for SMA11

5.4 BASELINE MUSIC MODEL RESULTS

The results from the MUSIC modelling are presented in **Table 5-22**. The results show the annual loads of pollutants currently being discharged into Peel River from Tamworth subcatchments. Subcatchment SMA9 is contributing the greatest pollutant loading despite the Peel Wetlands and six existing GPTs intercepting flows prior to discharging to Peel River due to the being the largest subcatchment.

A comparison between the pollutant loading per hectare of catchment is outlined in **Table 5-23** and shows that Subcatchment **SMA4 (East Tamworth) is contributing the greatest overall pollutant load** on a unit basis due to 14% of the subcatchment consisting of industrial and commercial land uses. The **highest amount of phosphorous is estimated to be generated from subcatchment SMA11** on a unit basis from agricultural land use and shows a similarly high nutrient level for subcatchments SMA7 and 8 which are also predominantly agricultural. The predominantly forested areas of SMA5 and 6 appear to be the least contributing to catchment pollutant generation.

Table 5-22 MUSIC Model Results

Catchment	Pollutant - Mean Annual Load (kg/yr) Total Suspended Solids			Pollutant - Mean Annual Load (kg/yr) Total Phosphorus			Pollutant - Mean Annual Load (kg/yr) Total Nitrogen			Pollutant - Mean Annual Load (kg/yr) Gross Pollutants		
	Sources	Residual Load	%Reduction	Sources	Residual Load	%Reduction	Sources	Residual Load	%Reduction	Sources	Residual Load	%Reduction
SMA1	384000	381000	0.9	1070	1070	0.2	6330	6310	0.2	33800	32300	4.6
SMA2	248000	248000	0.0	541	541	0.0	3910	3910	0.0	54900	54900	0.0
SMA3	185000	184000	0.1	376	375	0.1	2730	2730	0.0	32100	32100	0.1
SMA4	236000	233000	1.1	392	390	0.4	3020	3010	0.3	49100	48000	2.2
SMA5	185000	185000	0.0	493	493	0.0	3510	3510	0.0	21500	21500	0.0
SMA6	123000	123000	0.0	455	455	0.0	2540	2540	0.0	6750	6750	0.0
SMA7	352000	348000	1.2	1240	1240	0.2	6530	6340	0.2	18100	16400	9.7
SMA8	798000	787000	1.3	2370	2360	0.3	13300	13300	0.3	90900	87700	3.5
SMA9	952000	939000	1.4	2930	2910	0.5	15800	15700	0.4	94200	89100	5.4
SMA10	611000	611000	0.0	2150	2150	0.0	11200	11200	0.0	39100	39100	0.0
SMA11	132000	132000	0.0	574	574	0.0	2680	2680	0.0	0	0	0.0
Total	4200000	4170000	0.8	12600	12600	0.2	71300	71200	0.2	441000	428000	2.9

Table 5-23 MUSIC Model Pollutant Contribution Comparison

	Total Catchment Area (ha)	Total Suspended Solids (kg/ha)	Total Phosphorus (kg/ha)	Total Nitrogen (kg/ha)	Gross Pollutants (kg/ha)	Sum of Pollutants (kg/ha)
SMA1	2637.07	144.48	0.41	2.39	12.25	159.53
SMA2	2136.65	116.07	0.25	1.83	25.69	143.85
SMA3	1390.73	132.30	0.27	1.96	23.08	157.62
SMA4	920.91	253.01	0.42	3.27	52.12	308.82
SMA5	2774.67	66.67	0.18	1.27	7.75	75.87
SMA6	1572.01	78.24	0.29	1.62	4.29	84.44
SMA7	2385.89	145.86	0.52	2.66	6.87	155.91
SMA8	4478.51	175.73	0.53	2.97	19.58	198.81
SMA9	5925.21	158.48	0.49	2.65	15.04	176.65
SMA10	4695.68	130.12	0.46	2.39	8.33	141.29
SMA11	1070.96	123.25	0.54	2.50	0.00	126.29

5.5 WATER QUALITY CONCLUSIONS

A quality assessment between projected MUSIC modelling results and the recorded results from sampling sites were undertaken. A comparison of MUSIC modelling results to the corresponding gauge sampling sites were undertaken in Table 5-23. SMA10 is outside of the influence of any of the testing sites as shown in Figure 5-15.

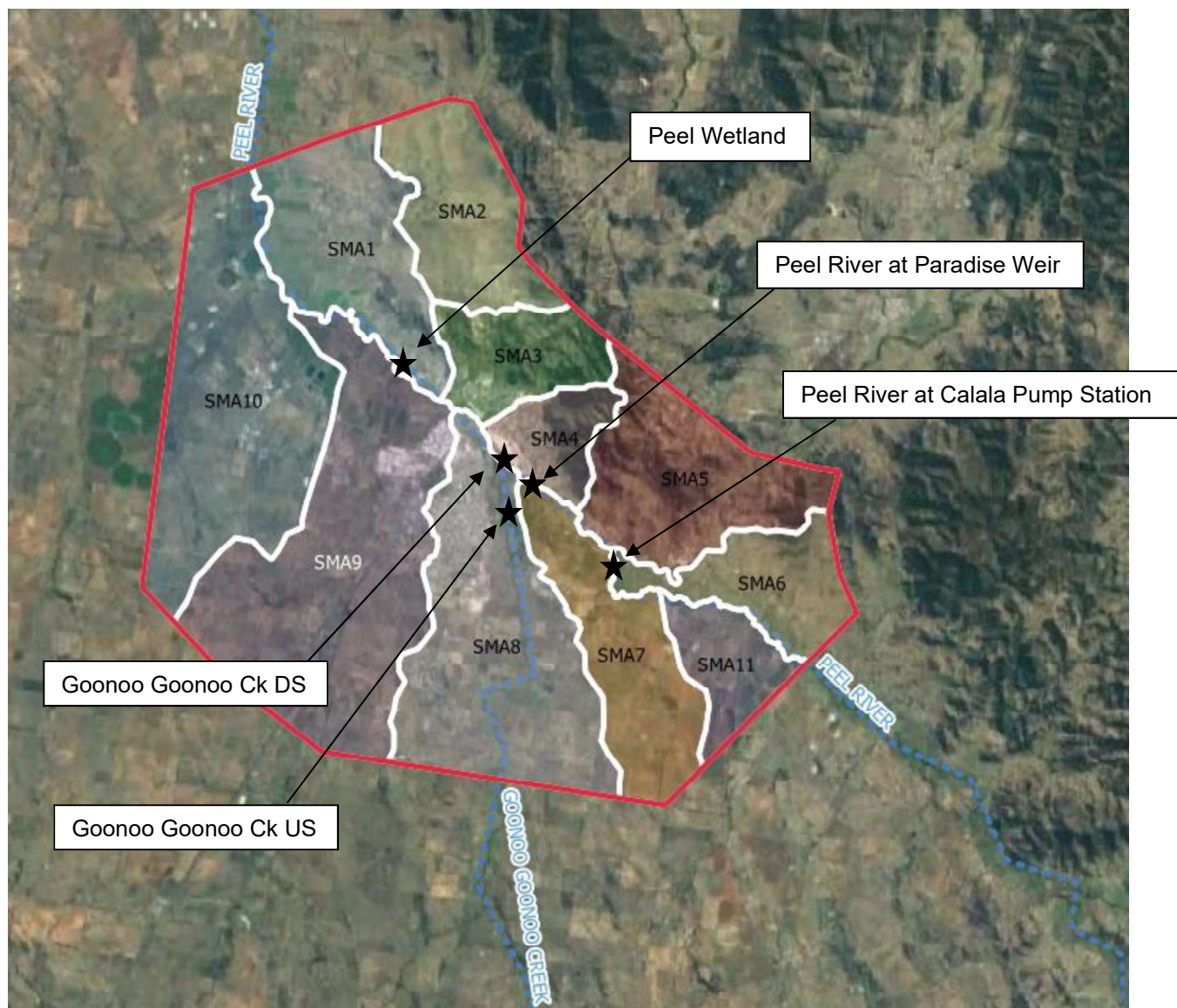


Figure 5-15 MUSIC Subcatchments Contributing to Testing Site Location

Table 5-24 MUSIC Model Pollutant Contribution Correlation to Testing Site

Testing Site	MUSIC subcatchment	Total Suspended Solids (kg/ha)	Total Phosphorus (kg/ha)	Total Nitrogen (kg/ha)	Gross Pollutants (kg/ha)	Sum of Pollutants (kg/ha)	
Peel River Calala PS	SMA6	78.24	0.29	1.62	4.29	84.44	Low dissolved oxygen potential and high nitric oxide correlation to high nutrients from agricultural sources
	SMA7	145.86	0.52	2.66	6.87	155.91	
	SMA11	123.25	0.54	2.50	0.00	126.29	
	Sum (kg/ha)	347.35	1.35	6.78	11.16	366.64	
Peel River Paradise Weir	SMA4	253.01	0.42	3.27	52.12	308.82	High nitrogen and phosphorous (since 2018) with moderate turbidity and nitric oxide present correlating to TN, TP, turbidity, and EC recorded data from agricultural sources. Metal toxicants likely correlated to industry in SMA4
	SMA5	66.67	0.18	1.27	7.75	75.87	
	SMA6	78.24	0.29	1.62	4.29	84.44	
	SMA7	145.86	0.52	2.66	6.87	155.91	
	SMA11	123.25	0.54	2.50	0.00	126.29	
	Sum (kg/ha)	667.03	1.95	11.32	71.03	751.33	
Goonoo Goonoo Ck US	SMA8	175.73	0.53	2.97	19.58	198.81	Moderate turbidity and high nutrients present likely correlation to high electrical conductivity from agricultural source
Goonoo Goonoo Ck DS	SMA4	253.01	0.42	3.27	52.12	308.82	High turbidity and high nutrients present likely correlation to high electrical conductivity from agricultural source
	SMA5	66.67	0.18	1.27	7.75	75.87	
	SMA6	78.24	0.29	1.62	4.29	84.44	
	SMA7	145.86	0.52	2.66	6.87	155.91	
	SMA8	175.73	0.53	2.97	19.58	198.81	
	SMA11	123.25	0.54	2.50	0.00	126.29	
	Sum (kg/ha)	842.76	2.48	14.29	90.61	950.14	
Peel Wetland	SMA1	144.48	0.41	2.39	12.25	159.53	High turbidity correlates to high recorded EC. High nutrients correlate to recorded data. Metal toxicants likely correlated to industry in SMA4 and SMA9. Highest influence from urban area of all testing sites demonstrated by highly elevated TN in both conceptual and monitored results (also showing elevated nitric oxide).
	SMA2	116.07	0.25	1.83	25.69	143.85	
	SMA3	132.30	0.27	1.96	23.08	157.62	
	SMA4	253.01	0.42	3.27	52.12	308.82	
	SMA5	66.67	0.18	1.27	7.75	75.87	
	SMA6	78.24	0.29	1.62	4.29	84.44	
	SMA7	145.86	0.52	2.66	6.87	155.91	
	SMA4	253.01	0.42	3.27	52.12	308.82	
	SMA9	158.48	0.49	2.65	15.04	176.65	
	SMA11	123.25	0.54	2.50	0.00	126.29	
	Sum (kg/ha)	1471.37	3.79	23.42	199.21	1697.8	

The lack of comparative data for the TN, TP and TSS at each testing site limits the drawing of conclusions between the monitored and modelled data, especially considering the upstream contribution of pollutants at the testing sites which are not captured in the subcatchment modelling in MUSIC. MUSIC is therefore a useful yet limited tool in understanding the water quality index of a stream or river and ongoing and expanded monitoring is highly recommended.

The MUSIC model results do however highlight the areas of the catchment where additional water quality treatment devices and management interventions should be targeted for specific pollutants.

As with the results of the monitored data, it is highly recommended that agricultural practice, erosion, and salinity management measures be adopted and revegetation efforts be implemented for the Goonoo Goonoo Creek contributing catchment areas (SMA7, SMA8 and SMA11).

It is recommended that a wetland monitoring and restoration program as per Section 8.3 to improve macrophyte vegetation coverage and remove potentially contaminated silt build-up at the Peel Wetlands (Orley Drive) and the Peel High wetlands. It is also highly recommended that proprietary products or engineered solutions (i.e. osmosis, UV etc.) to remove sediments, hydrocarbons and heavy metal toxicants be investigated for treatment prior to flow discharge to the wetland.

The areas with the greatest contribution of urban runoff (SMA4, SMA8 and SMA9) are recommended as priority areas for introduction of water sensitive urban design (WSUD) and proprietary products or solvents to remove sediments, hydrocarbons, and heavy metal toxicants. Section 8.5 highlights the urban-focused proposal for water quality assets as well as the recommendation for capturing and reusing rainwater in Section 8.1 which would reduce pollutant loading to the stormwater network.

Section 8.2 education programs provide an opportunity for influencing human behaviour that has led to degradation of water quality and produce a more environmentally conscious community, especially when targeted at youth.

Section 8.3 further highlights the recommendation for increased auditing and enforcement of industry and construction practices that could be leading to high sediment loading and toxicant contamination, as well practices such as street sweeping, and maintenance of existing water quality infrastructure.

Section 8.4 expands on a number of planning and control recommendations determined through the water quality assessments with special regard for:

- > Improve Council's Integrated management system (IMS) to control the use of chemicals near waterways
- > Review erosion control procedures on new developments. Provide relevant Council staff with training to enable this.
- > Stormwater Management requirements for new subdivisions needs to be reviewed and updated including consideration of Water Quality targets
- > Council to develop a WSUD policy
- > Council to adopt WSUD requirements as part of the DCP for long term planning
- > Staged approach to WQ targets in DCP
- > Stream Erosion Index (SEI) target in DCP
- > Incorporate waterway health as part of Council's sustainability strategy focus areas
- > Identify the blue/green networks (drainage reserves that combine as parks with cycleway / walkways) in new greenfield areas to reduce drainage cost for greenfield development
- > Collate existing low impact stormwater guidelines and link them to Tamworth Regional Council policies. Include urban design measures that control and manage stormwater. Promote these stormwater guidelines through Tamworth Regional Council's communications.
- > Empower developers and designers to consider urban stormwater management at the early stages of their master planning
- > Investigate co-locating opportunities for WSUD in detention systems
- > Water Sensitive Urban Design principles to be adopted in the current precinct planning process

6 CONSULTATION

Consultation with the community and stakeholders is an important component in the development of an Urban Stormwater Management Plan. Consultation provides an opportunity to collect feedback and observations from the community and stakeholders on problem areas and potential stormwater management measures.

The main consultation elements for this study are:

- > A call for information from all affected external stakeholders within the catchment;
- > Internal stakeholder interviews;
- > Public Exhibition of Urban Stormwater Management Plan; and
- > Collation and acknowledgement of written submissions during the public exhibition.

This process ensures that community / stakeholder participation is maximised during the development of the USMP.

6.1 AGENCY CONSULTATION

There are many agencies with stormwater related interests in the LGA. Key stakeholders were identified in consultation with Council. To best approach them, a letter of introduction to the study was sent to the key stakeholder agencies and an invitation to be involved in the project. It also included requests for any relevant data or information that they may have. An example of the letter is provided in **Appendix E**. These stakeholders were contacted by letter to identify whether the stakeholders might be able to provide input to the project.

Table 6-1 provides a summary of the stakeholders contacted and any responses provided.

Table 6-1 Stakeholder Contact Summary

Company	Contact Name and Position	Response Summary
Department of Planning, Industry and Environment	Director of the Local Tamworth DPIE office	The study be mindful of the New England North West Regional Plan 2036 and ensure consistency with any relevant sections such as Direction 10 – Sustainably manage and conserve water resources
Department of Primary Industry	Water Regulation Officer	No response received
North West Local Land Services	Communications Officer	No response received
WaterNSW	Water System Operations Manager, North	WaterNSW doesn't have any operational issues to be included in the Management Plan
Transport for NSW	Senior Manager, Community and Place (New England)	No response received
John Holland	Structures Superintendent	Walmar Road, Kootingal – periodic flooding / community complaints occur frequently at this location. Urban runoff appears to be directed towards the railway corridor from the new developments in Garden Street / Kootingal bowling club. Powerhouse on New England Highway, Tamworth – new developments on steep catchments direct urban runoff toward the railway corridor just east of the Powerhouse motel on the New England Highway. Development approval appears reliant on a swale drain within the railway corridor which has proven to be inadequate for generated flows. There also appears to be a missing drainage infrastructure to convey urban flows to the Peel river.
NSW Environment Protection Agency	Regional Operations Officer	EPA does not have any specific comments or areas of concerns at this point in time

6.2 COUNCIL STAFF INTERVIEWS

Meetings were held with relevant Council departments during the morning of 17 November 2021 at the TRC office. Input was sought to inform the development of the Urban Stormwater Management Plan. The purpose of the interviews was to present the Council staff from various departments an opportunity to inform their priorities, raise any concerns, identify any potential stormwater management measures (structural and non-structural), and recognise any opportunities for possible future collaboration.

Staff from the following departments were interviewed:

- > Water and Waste - Water and Environmental Operations;
- > Water and Waste - Sustainability (Water and Waste);
- > Water and Waste - Projects, Strategy and Infrastructure;
- > Planning & Compliance - Development Engineering;
- > Planning & Compliance - Development Engineering;
- > Planning & Compliance - Integrated Planning;
- > Planning & Compliance – Development;
- > Regional Services – Transport;
- > Regional Services – Asset and GIS;
- > Regional Services – Design; and
- > Regional Services – Project Planning and Delivery.

7 URBAN STORMWATER MANAGEMENT SYSTEMS

7.1 EXISTING STORMWATER MANAGEMENT SYSTEM

Urban stormwater infrastructure includes both drainage infrastructure and stormwater quality treatment infrastructure.

Stormwater drainage infrastructure within Tamworth includes stormwater pipes, pits, kerb and gutters, detention basins, an ornamental pond, open drains such as concrete channels, vegetated channels and natural drains such as gullies and creeks. Water quality infrastructure includes Gross Pollutant Traps (GPT) and two wetlands.

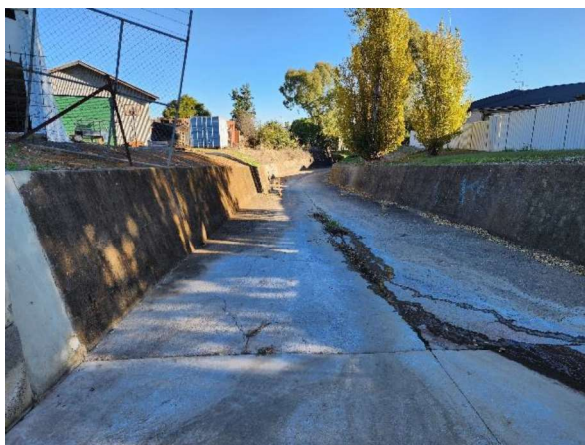
Table 7-1 provides a summary of the drainage infrastructure within the study area of Tamworth.

Table 7-1 Stormwater Drainage Infrastructure within Tamworth

Drainage Type	Description	Example
Pit and Pipe	Major or minor drainage system that receives stormwater runoff from buildings and hard surfaces such as roads and pavements; and diverts it to the underground stormwater system. Note due to the underground nature of the system, these assets are usually only visible at pit inlets or using asset locating technologies such as CCTV.	
Culverts	Structure at the outlet of the underground stormwater system or open conveyance of flows beneath roads and bridges	

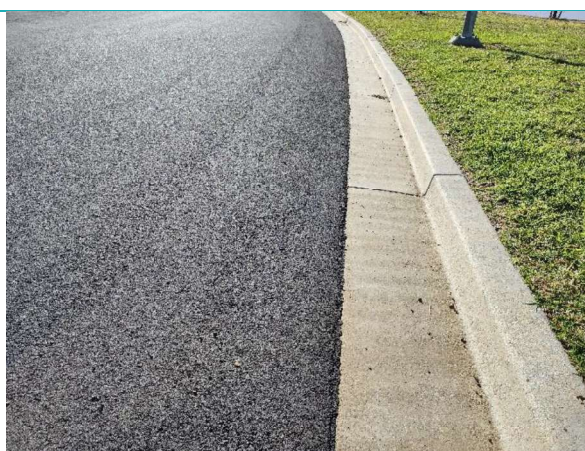
Open Concrete Channel

Traditional engineered concrete lined major drainage systems used to convey stormwater flows



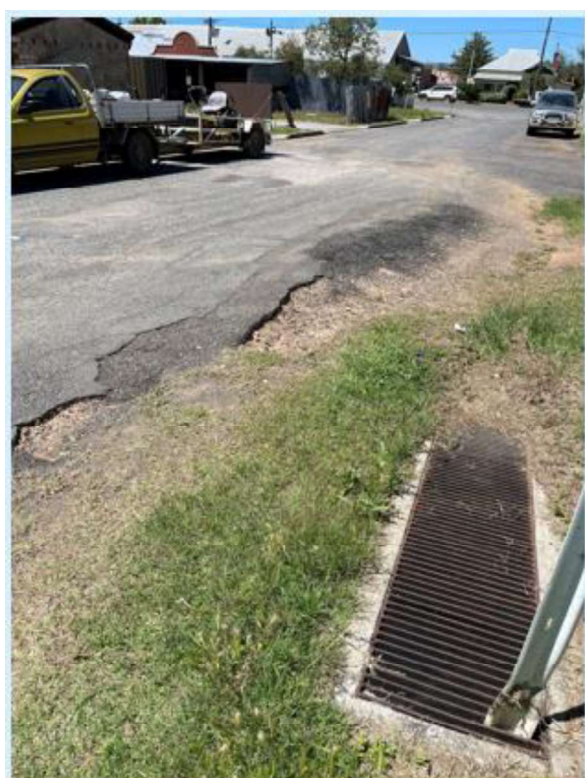
Kerb and Gutter

Receives stormwater runoff from road surfaces and directs it to underground stormwater system



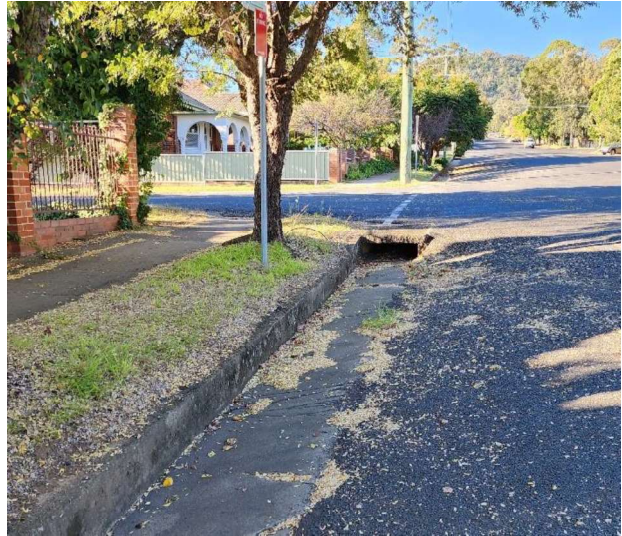
Inlet pits

Directs kerb and gutter stormwater runoff to underground stormwater system



Box inlets

Directs large stormwater runoff to underground stormwater system



Open drains

Traditional engineered concrete lined minor drainage systems used to convey stormwater flow



Grass drains

Traditional grass drains often located in easements to convey stormwater flows



Vegetated Channels

Vegetated open channels that convey stormwater and also provide some treatment



Natural channels, natural drains

Ephemeral streams and creeks that receive and convey stormwater runoff from the urban environment.



Ornamental Pond

Manmade construction, with some form of artificial liner to retain water for aesthetic purposes with marginal aquatic plantings and water quality benefits



Flood Levee

A physical barrier or embankment constructed along a major watercourse to contain flooding from overflowing to developed areas.



Flood Gate

Flood gate used to prevent backflow of water into the stormwater drainage network during riverine flooding



Gross Pollutant Trap (GPT)

Primary water treatment measure usually installed as part of a minor drainage diversion to screen low flows entering the stormwater network. Often used as a pre-treatment for secondary or tertiary WSUD assets.



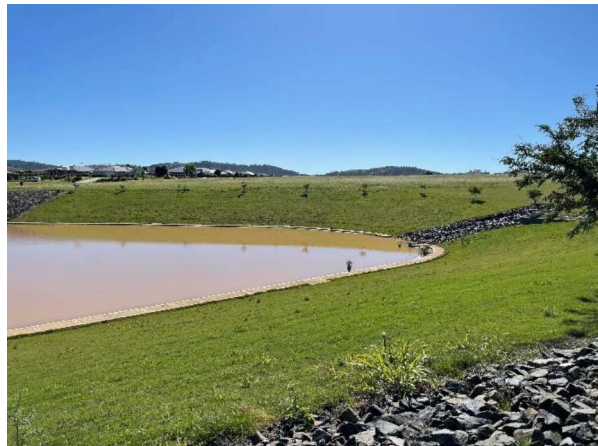
Wetland

Complex ecosystem characterised by extended storage of shallow water, which creates low-oxygen environments that support a range of macrophyte plants and microbes for treatment of water and ecological value. Generally sized in constructed scenarios to treat low flows via a series of pools with varying depth to support varying marsh zones.



**Detention
Basin**

Surface storage basins or facilities that provide flow control through attenuation of stormwater runoff. Often designed with a high-flow spillway and/or weir and low-flow outlet to downstream drainage.



7.2 STORMWATER MANAGEMENT ISSUES

To prepare a sound stormwater management plan it is important to identify and understand the stormwater related issues and concerns, and their causes. Stormwater management issues were identified through a process involving discussion with key stakeholders, review of existing information (including existing customer request management), site inspection and water quality monitoring. The issues have been grouped into three different categories and described in **Table 7-2**.

- > Environmental;
- > Social; and
- > Governance.

Table 7-2 Stormwater Management Issues

Type	Issue	Cause
Environmental	Poor Water Quality (Elevated nutrients, suspended solids and turbidity levels)	> Agriculture > Peak weather overflows from wastewater system > Untreated road and paved surface runoff > Detergent used in car washing > Pet excrement > Domestic Littering > Lack of planning controls such as water quality requirements for new developments > Poor erosion and sediment control measures on construction sites > New urban development
	High Salinity	> Land clearing > Decrease in groundwater flows due to increased impervious areas > Discharge of treated effluent
	Degraded Waterway Conditions and Loss of Habitat	> Modified hydrology resulting in changes in natural flow paths > Stream banks and channel erosion due to high flow velocities around the stormwater discharge outlets > Clearing of vegetation > Noxious weeds > Inadequate maintenance of creek vegetation including removal of weeds > Illegal dumping of litter and rubbish
	Loss of Environmental Flows	> Increase in impervious surfaces > Historical damming processes > Stormwater diversion schemes
Social	Flooding	> Increase in impervious surfaces > Inadequate and/or non-existent drainage in problem areas > Inadequate maintenance of existing drainage infrastructure > Minor drainage system not meeting best practice level of service
	Community Indifference to Stormwater Management	Lack of education and awareness of: > Importance of urban waterways > Impact of stormwater on waterway health > Land use and practices that contribute to degradation of urban waterways

Type	Issue	Cause
	Loss of Community Access and Recreation	> Loss of visual amenity > Poor water quality including odours and litter in waterways > Degraded access to waterways > Degraded nature of the waterways
	Risk to Community Health and Safety	> Hazardous flood depths and velocities during major rain events > Safety concerns with open stormwater channels > Mosquitoes breeding around ponded water at outlets and within channels
Governance	Ineffective stormwater management and adoption of best practices	> Lack of an integrated stormwater management plan > Inadequate communication internally between Council teams > No stormwater management committee within Council
	Lack of comprehensive database to assess the nature and magnitude of stormwater problems and identify suitable solutions	> Lack of sufficient data on Council stormwater drainage assets > Insufficient maintenance of existing stormwater drainage assets > No water quality monitoring programs > Insufficient funding available

7.3 STORMWATER MANAGEMENT OBJECTIVES

Based on the issues identified, stormwater management values and objectives have been developed. The Tamworth Urban Stormwater Management Plan (2000), Council's strategic document *Tamworth Regional Blueprint 100* (2020) and internal stakeholder feedback also form the basis for the development of the stormwater management objectives. These are document in **Table 7-3**.

Table 7-3 Stormwater Management Values and Objectives

Values	Objectives
Water Quantity	To minimise the occurrence of localised flooding associated with urban stormwater drainage. To minimise adverse impacts of stormwater runoff downstream of the urban drainage network. Appropriately manage stormwater as an integral part of the total water cycle balance within the Tamworth urban catchment.
Water Quality	To adopt and promote WSUD principle to maintain and / or improve the surface and groundwater quality within the Tamworth urban catchment. To consider community concerns and values in relation to water quality. Reducing diffuse pollutant loads during rainfall and runoff periods should be a key focus for improving water quality. It is also important in managing longer term impacts, such as sedimentation and polluted sediments.
Water Conservation	To maximise the storage and reuse of stormwater as a secondary source of water.
Ecosystem Health	To retain natural drainage systems and appropriately integrate stormwater systems into the natural and built environments. To restore, rehabilitate, and enhance existing vegetation within the stormwater drainage channels.
Community Involvement	To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater. To encourage continuous community involvement with the urban stormwater management.
Public Health	To minimise the public risk, including risk of injury or loss of life, to the community. To ensure stormwater drainage systems are planned, designed and managed with consideration and protection of community health and safety standards.
Economic Viability	To implement stormwater management systems that are sustainable and economically viable in the long term. To ensure stormwater is managed at a cost that is acceptable to the community, and that the levels of service and the contributions to costs are equitable.
Planning and Development	To minimise the impact of new urban development on the urban stormwater system. To ensure the delivery of best practice stormwater management through strategic planning and development.

8 URBAN STORMWATER MANAGEMENT MEASURES

A broad range of structural and non-structural options are available to address the stormwater issues identified in **Section 7.2**. The stormwater management options identified and assessed as part of this study comprises of five main approaches:

- > Asset Management;
- > Education and Awareness;
- > Maintenance and Monitoring;
- > Planning and Development; and
- > Stormwater Infrastructure.

Appendix G provides a detailed list of options that have been considered to address the stormwater management issues. Many of these have been identified in previous studies and some of them have already been implemented by Council. Of the list of options identified, a shortlist of options was selected to be included in the USMP based on expected effectiveness, viability, and in liaison with Council. These are described further in the following sections.

8.1 ASSET MANAGEMENT

The current stormwater assets within Tamworth provide valuable services to the area enabling a safe and reliable stormwater collection & discharge network to provide flood protection and prevention. In order to provide adequate service and benefits to community, these assets must be properly maintained and developed.

Council has been documenting details of the stormwater management assets within the study area. However, the information available is limited and have not been ground-truthed at many locations. Asset condition data is also not currently available resulting in lack of easily accessible information for maintenance planning. In addition, due to limited internal resources and funding, and a focus on capital works such as road rehabilitation, the maintenance requirements for stormwater drainage assets have been a lower priority. Limited improvement of poorly performing or ageing assets has occurred due to limited funding and renewals planning.

To address these issues, feasible asset management options were identified for implementation, and these are documented in **Table 8-1**.

Table 8-1 Asset Management Measures

Option ID	Option Description	Stormwater Management Objective Met
A1	Utilise a maintenance management system for planning, scheduling, and recording maintenance and inspections. Maintenance records will help identify issues and develop solutions. Council currently uses Reflect, which is an inspection and maintenance software, to maintain the roads and pavements within Tamworth. During the Council staff interviews, it was identified that extending the use of this software for stormwater management assets will allow the maintenance crews to accurately assess asset conditions and plan for rehabilitation and renewal.	Water Quantity Water Quality Public Health Economic Viability

Option ID	Option Description	Stormwater Management Objective Met
A2	Survey the existing stormwater network to improve the completeness of Council's dataset. Much of the existing dataset lacks invert level information that could be improved through survey and recordkeeping, starting with areas of increased flood risk.	Economic Viability
A3	Condition Assessment of Council's current stormwater infrastructure through field inspection starting with areas where failure has high-risk or consequence. The current condition of assets have been determined through theoretical degradation. This option will verify the stormwater management asset data base with field inspection and/or CCTV condition assessments to inform appropriate actions for those assets requiring maintenance, renewal or upgrade to improve performance including associated costs and priority. Option A2 and A3 are recommended to be undertaken in parallel to reduce labour efforts.	Water Quantity Public Health Economic Viability
A4	Council to develop a stormwater asset renewal program. Council currently has a pavement renewal program which allows regular maintenance and upgrades of the sealed road network. During the Council staff interviews, it was identified that a similar program be developed for stormwater asset renewal. This however will be subject to availability of suitable asset condition data (Option A3) and maintenance records (Option A1).	Water Quantity Public Health Economic Viability
A5	Investigate the stormwater benefits of capturing stormwater runoff from Council buildings for re-use. The <i>Tamworth Regional Blueprint 100</i> Priority 1.2 encourages water conservation through capture of stormwater runoff from Council buildings for reuse. Identified through internal stakeholder engagement.	Water Quantity Public Health Water Conservation
A6	Investigate the stormwater benefits of roof runoff capture, ground water usage, and recycled water for reuse. Achieve efficiencies and sustainability for whole of life maintenance of facilities, including site selection based on water security / rationalisation of parks and sports precincts. The <i>Tamworth Regional Blueprint 100</i> Priority 6.3 identifies practices related to low impact stormwater management including consideration of roof capture, ground water usage, and recycled water for reuse for facilities across parks and sports precincts.	Water Quantity Public Health Water Conservation

Option ID	Option Description	Stormwater Management Objective Met
A7	Clearly define the stormwater levy expenditure areas and budgets In accordance with Part 2 of The <i>Tamworth Regional Blueprint 100</i>, this option defines the stormwater levy expenditure areas and budgets.	Economic Viability

8.2 EDUCATION AND AWARENESS

Community education and awareness can play a significant role in the best practice management of stormwater within a catchment. People are often unaware that their activities (at work, while travelling or at home) can have an impact on stormwater and result in environmental degradation. Suitable education and awareness programs for various sectors of the community can provide a catalyst for a change in behaviour that contributes to stormwater pollution and volume.

Education and awareness are one of the non-structural methods that can be used in an integrated approach to best practice stormwater management, Education and awareness measures are described in **Table 8-2**.

Table 8-2 Education and Awareness Measures

Option ID	Option Description	Stormwater Management Objective Met
E1	Develop a drain stencilling education program. Drain stencilling is a program designed to raise awareness and reduce the impacts of stormwater pollution in rivers, creeks, and local waterways. The program involves various community groups stencilling stormwater drain lids with environmental messages. As many people are not aware that stormwater drain pipes carry water to the nearest creek or river without any form of treatment, the messages stencilled will remind the community that actions such as washing the car on the road or driveway, littering, sweeping or hosing leaves and dirt into gutters, and not picking up after their dog can directly affect the health of the local waterways. Involve community groups and school students with stormwater programs. Programs may include stencilling slogans over drain inlets and the installation of appropriate signs in strategic locations, promoting some early drainage awareness. Engaging External Environmental group Actively involve existing environmental groups such as Landcare, Rivercare and Catchment Management Committee (CMC) process and discuss relating to stormwater issues.	Water Quality Ecosystem Health Community Involvement
E2	Public education and awareness campaign on excessive watering, companion animal waste, car washing, Stormwater friendly gardens and recycling. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. This is yet to be implemented and as part of this study it was identified that there is benefited to include this option and extend it to Tamworth. Campaigns such as these will help raise knowledge and awareness within the community on stormwater management issues and the role, they can play by changing behaviours to reduce the impact to downstream environment.	Water Quality Ecosystem Health Community Involvement

Option ID	Option Description	Stormwater Management Objective Met
E3	Education campaign targeted at Building and Construction industry on the implementation of soil and water management controls during construction. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. This is yet to be implemented. When land is cleared of vegetation for construction, the soil is exposed and is vulnerable to erosion from rainfall events. Eroded soils lead to blocked drains and contribute to stormwater turbidity and waterways pollution. Engaging with the building and construction industry and increasing their knowledge and awareness on soil and water management controls during construction will help reduce the impact to downstream environment.	Water Quality Ecosystem Health Community Involvement Planning and Development
E4	Investigate current industrial / commercial stormwater management practices and develop industry / commercial stormwater awareness programs. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. This is yet to be implemented. Industrial and commercial areas are a major contributor to stormwater pollution and degrading waterways health. Careful site management by businesses in commercial and industrial areas is therefore critical to avoid damage to receiving waterways.	Water Quality Ecosystem Health Community Involvement
E5	Expand the current litter education program to incorporate stormwater and river health. Council currently has a litter education program which is run by the sustainability team and involves sharing information about waste management and sustainability practices with residents, students, and teachers. This program can be extended to incorporate stormwater management and waterways health.	Water Quality Ecosystem Health Community Involvement
E6	Incorporate WSUD in the current water efficiency education programs. Council currently has various water efficiency education programs which is run by the sustainability team. The programs aim at achieving water efficiencies in business, home and garden use. These programs can be extended to incorporating WSUD in homes and businesses.	Water Quantity Water Quality Water Conservation Ecosystem Health Community Involvement

Option ID	Option Description	Stormwater Management Objective Met
E7	Develop a stormwater pollution and management education program for local schools and community organisations. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. This is yet to be implemented. Local schools and community organisation can be a valuable resource to educate the wider local community. Partnerships can be formed, and education programs can be delivered through them to raise knowledge and awareness within the community on stormwater management issues and the role they can play to reduce the impact to the downstream receiving environment.	Water Quality Ecosystem Health Community Involvement
E8	Undertake community/environmental group led water quality monitoring (macroinvertebrate sampling) as part of other Council/community led events that enables community and school kids to monitor the quality and health of local waterways (e.g., Streamwatch). This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. Waterways are home for many small animals called macroinvertebrates. These animals generally include insects, crustaceans, molluscs, arachnids and annelids. They are sensitive to different chemical and physical conditions of the waterway and if there is a change in the water quality then the macroinvertebrate community may also change. Therefore, the richness of macroinvertebrate community composition in a waterway can be used to provide an estimate of waterway health. Council has previously undertaken community/school led water quality monitoring (macroinvertebrate sampling) as part of stormwater education in Tamworth which could be reinstated.	Water Quality Ecosystem Health Community Involvement
E9	Publish regular stormwater information on Council's website and, social media accounts. This option was identified in the Barraba 2000 Urban Stormwater Management Plan. This is yet to be implemented and as part of this study it was identified that there is benefit to include this option and extend it to Tamworth. This is the traditional engagement approach wherein Council disseminates regular stormwater management information through its website, social media and newsletters.	Water Quality Ecosystem Health Community Involvement

8.3 MAINTENANCE AND MONITORING

Stormwater management assets have a long life. The life cycle costs to provide stormwater management services includes operation, maintenance, renewal, acquisition, upgrade of existing and construction of new assets. Regular maintenance and monitoring of these assets will ensure that the asset functions effectively and for its intended lifespan. Suitable maintenance and monitoring options were identified for implementation, and these are documented in **Table 8-3**.

Table 8-3 Maintenance and Monitoring Measures

Option ID	Option Description	Stormwater Management Objective Met
M1	Compliance and monitoring program for private OSD systems (in combination with P6). The purpose of OSD is to control peak flow rates and peak time by temporality storing some of the rainfall runoff from a site and releasing the stored runoff at a controlled rate. To ensure the OSD functions effectively, it is essential that these systems are maintained regularly. A compliance and monitoring program for the private lot OSDs will allow Council to regularly inspect the OSD systems and ensure they are clean and functioning as per requirement.	Water Quantity Public Health Planning and Development
M2	Investigate the feasibility of planting native vegetation along the existing stormwater channels. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. There are many benefits to be gained from planting native vegetation in urban waterways such as stream banks and stormwater channels. They create habitat for native wildlife, improve water quality, and improve the local aesthetics and natural heritage. It is also often the cheapest form of revegetation.	Water Quantity Water Quality Ecosystem Health Community Involvement Economic Viability
M3	Weed control / management programs within the stormwater channels. This option was identified in the Barraba 2000 Urban Stormwater Management Plan. As part of this study it was identified that there is benefit to extend this option to Tamworth. The existing vegetation within the stormwater channels have been impacted by invasion of weeds. Urban stormwater typically contains elevated levels of plant nutrients phosphorus and nitrogen. This increases the nutrient levels in local vegetation. Weeds flourish in high nutrient environments and compete with indigenous species. When high nutrients are combined with the presence of weeds and the changed hydrological regime of urban areas, damaging ecological stress can be created to the downstream natural bushland areas in Peel River where the stormwater eventually discharges into.	Water Quality Ecosystem Health Community Involvement Economic Viability

Option ID	Option Description	Stormwater Management Objective Met
M4	Regularly maintain grassed areas within and adjacent to open urban stormwater channels. This option was identified in the Barraba 2000 Urban Stormwater Management Plan. As part of this study it was identified that there is benefit to extend this option to Tamworth. Regularly maintaining the grassed areas within and adjacent to open urban channels will enhance pollutant removal, provide some groundwater recharge, and reduce stormwater runoff volume.	Water Quality Ecosystem Health Community Involvement Economic Viability
M5	Implement a cost-effective strategy to improve proactive cleaning of stormwater structures. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan.. Regular cleaning of stormwater structures such as pits and pipes will reduce the potential for blockages and subsequently reduce localised flooding issues.	Water Quantity Ecosystem Health Public Health Economic Viability
M6	Increased street sweeping in commercial areas This option was identified in the Tamworth 2000 Urban Stormwater Management Plan.	Public Health Ecosystem Health
M7	Improved street sweeping practices in the City This option was identified in the Tamworth 2000 Urban Stormwater Management Plan.	Public Health Ecosystem Health
M8	Expand stormwater monitoring and auditing (testing program) This option was identified in the Tamworth 2000 Urban Stormwater Management Plan.	Planning and Development
M9	Additional sampling data from the testing sites This option was identified through WQ assessment outcome	Planning and Development
M10	Incorporate stormwater pollutant parameters in the existing water quality monitoring program (TSS/TP/TN) This option was identified through internal stakeholder engagement.	Planning and Development
M11	Develop a maintenance schedule for the existing Council owned GPTs This option was identified through internal stakeholder engagement.	Water Quality Ecosystem Health Public Health Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
M12	Develop a wetland management plan for Peel High wetland This option was identified through internal stakeholder engagement.	Water Quality Ecosystem Health Public Health Planning and Development
M13	Develop a wetland management plan for Heritage Park / Orley Drive wetland This option was identified through internal stakeholder engagement.	Water Quality Ecosystem Health Public Health Planning and Development

8.4 PLANNING AND DEVELOPMENT

Good land use planning controls and stormwater management practices can improve the stormwater runoff quantity and quality without the need of hard engineering practices. Growth of urban areas increased urban density, commercial / industrial development, and lack / failure of stormwater infrastructure can lead to increased urban pollution of local ecosystems and localised flooding problems.

To help Council address the stormwater management issues feasible planning and development options were identified for implementation, and these are documented in **Table 8-4**. The Tamworth Regional Blueprint 100 has guided the development of these options. These options are more cost-effective in comparison to hard engineering options with a focus on minimisation and / or prevention of the issues related to stormwater management.

Table 8-4 Planning and Development Measures

Option ID	Option Description	Stormwater Management Objective Met
P1	Improve Council's Integrated Management System (IMS) to control the use of chemicals near waterways. This option was identified in the Tamworth 2000 Urban Stormwater Management Plan. This is yet to be implemented. The use of chemicals such as herbicides and pesticides near waterways can affect the aquatic flora and fauna. Improving the IMS to allow safe and effective practices will allow for responsible use of chemicals and reduce the impact on waterway health.	Water Quality Ecosystem Health
P2	Review erosion control procedures on new developments. Provide relevant Council staff with training to enable this. This option was identified in the Parry Shire 2000 Urban Stormwater Management Plan. As part of this study, it was identified that there is benefit to include this option and extend it to Tamworth. When land is cleared of vegetation for construction, the soil is exposed and is vulnerable to erosion from rainfall events. Eroded soils lead to blocked drains and contribute to stormwater turbidity and waterways pollution. Inspection and auditing of construction sites is typically conducted by Council and hence having suitable procedures in place with trained Council staff undertaking inspections, will ensure improved implementation of erosion control procedures.	Water Quality Ecosystem Health Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
P3	Stormwater management requirements for new subdivisions needs to be reviewed and updated including consideration of Water Quality targets. As is becoming increasingly common in Council's across NSW, specification of stormwater management and water quality targets in the DCP will provide developers and their consultants guidance for development applications to Council. These requirements can be high level relating to overall outcomes such as post-pre stormwater quantity requirements and nutrient and pollutant removal targets (TP, TN, TSS). Or these requirements can be very prescriptive relating not only to the desired outcomes but also Council's preferences with respect to acceptable treatment types, methods of analysis and modelling parameters and reporting. The best practice stormwater pollution reduction targets (adopted by most Councils in NSW) are: TP – 65% TN – 45% TSS – 85% Gross Pollutants – 90%	Water Quality Water Conservation Ecosystem Health Public Health Economic Viability Planning and Development
P4	Council to develop a WSUD policy. A WSUD policy will provide an overarching documentation of Council's water quality objectives and reduce the negative impact of development on the natural environment. The policy will provide a framework for new developments to improve stormwater quality and reduce potable water consumption. This policy will guide Council staff in development of short to medium term planning and will assist external stakeholders in interpreting Council's WSUD desired outcomes through documentation.	Water Quantity Water Quality Water Conservation Ecosystem Health Public Health Economic Viability Planning and Development
P5	Council to adopt WSUD requirements as part of the DCP. Similar to option P3, the inclusion of WSUD requirements within the DCP will provide developers and their consultants guidance for development applications to Council. Inclusion within the DCP will provide these requirements the backing of the planning control framework, providing Council greater legislative support to be able to enforce these requirements. It will also account for WSUD as a consideration in a consolidated set of development controls, simplifying the development application through limiting the number of policies and plans that need to be referenced.	Water Quantity Water Quality Water Conservation Ecosystem Health Public Health Economic Viability Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
P6	Develop an OSD policy and pilot program that specifies OSD sizing and orifice requirements at subcatchment scale (especially for smaller developments). OSD provides temporary storage of stormwater runoff to reduce the rate of runoff flowing onto other properties or into Council's drainage system. This is particularly important to reduce the chance of nuisance flooding downstream for the short, intense storm events. An OSD policy will define when an OSD system is required and the basic sizing requirements to be tested with a pilot program.	Water Quantity Public Health Planning and Development
P7	Review OSD requirements for subdivision of 5 or more lots. Allow private OSD for smaller subdivisions and public detention basins for larger subdivisions. As per the current TRC DCP, for residential (multi-dwelling) type of development, the developer must demonstrate no detrimental downstream flood impacts. Options include increasing downstream infrastructure, detention basins (less preferred) or underground detention. The ongoing maintenance of these assets is then transferred to Council. Due to the maintenance burden on Council, it is recommended that public detention basins be utilised for larger catchments. Lot scale individual detention systems may be acceptable for the smaller subdivisions.	Water Quantity Public Health Planning and Development
P8	Staged approach to WQ targets in DCP. Short term – Gross pollutant targets. Medium to long term – TSS/TP/TP targets. This option stages the approach to achieve option P3. In the immediate short term, gross pollutant reduction target can be adopted. In the medium term, TP, TN and TSS reduction targets can be adopted.	Water Quality Ecosystem Health Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
P9	Stream Erosion Index (SEI) target in DCP. Stream erosion is assessed using a measure of the increase in the relative frequency in flows from the site greater than the identified 'stream forming flow' resulting from the urbanisation of the catchment. The Stream Erosion Index (SEI) is defined by DPE as the post development duration of flows greater than the 'stream forming flow' divided by natural duration of flows greater than the 'stream forming flow'. This provides an appropriate means of assessing and addressing the impacts of urbanisation on the frequency of regular flows to the waterways. SEI will provide a means of waterway erosion assessment for new developments that will set easily reviewable outcomes based on simplified hydrologic and geomorphologic principles. This will help to ensure that waterway stability is considered for future developments as a requirement of development controls in the DCP. The DPE guidelines recommend a SEI of between 3.5-5.	Water Quality Ecosystem Health Planning and Development
P10	Incorporate waterway health as part of Council's sustainability strategy focus areas. Incorporating waterway health as a focus area within Council's sustainability strategy will ensure that the importance of waterways is continually considered in the future. As a strategic focus area, waterway health will have priority responses identified and promoted.	Water Quality Ecosystem Health Economic Viability Planning and Development
P11	Identify the blue/green networks (drainage reserves that combine as parks with cycleway / walkways) in new greenfield areas to reduce drainage cost for greenfield development. In accordance with Priority 2.2 of Blueprint 100, an up-to-date database of existing blue / green areas will simplify the initial WSUD assessment for Council. Identifying these existing networks around greenfield development sites will help to understand the baseline condition for water quality and ecosystem of the catchment and may offer opportunities to reduce drainage costs by encouraging use of existing networks rather than the design and construction of new networks of treatment.	Water Quantity Water Quality Community Involvement Ecosystem Health Economic Viability Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
P12	Collate existing low impact stormwater guidelines and link them to Tamworth Regional Council policies. Include urban design measures that control and manage stormwater. Promote these stormwater guidelines through Tamworth Regional Council's communications. In accordance with Priority 6.2 of Blueprint 100, this strategy looks to simplify the process for developers and other stakeholders in understanding Council's stormwater management requirements. This simplification through consolidation and through emphasis in communications improves the likelihood of positive stormwater management outcomes through stakeholders engaging in good faith with Council's requirements.	Economic Viability Planning and Development
P13	Empower developers and designers to consider urban stormwater management at the early stages of their master planning. In accordance with Priority 6.2 of Blueprint 100, this strategy looks to promote consideration of urban stormwater management from the beginning of planning for developers. By emphasising stormwater management considerations in discussions with developers, it will encourage development layouts that prioritise stormwater and water quality outcomes rather than tailoring non-best practice stormwater solutions to developments at the end of the planning and designing process.	Water Quantity Water Quality Water Conservation Ecosystem Health Economic Viability Planning and Development
P14	Complete and utilise mapping for flooding. A comprehensive flood mapping database will aid Council in reviewing and advising stakeholders such as developers of flood risk for sites throughout the LGA. This flood mapping could also be made publicly available on Council's website. While the information is already available through Flood Study reports on Council's website, the use of a consolidated flood mapping platform will assist in improving public flood awareness in the community and provide developers a better understanding of flood risk in the LGA.	Water Quantity Public Health Planning and Development
P15	Investigate co-location benefits of integrating WSUD into detention systems. In accordance with Priority 2.2 of Blueprint 100, leveraging existing systems to provide multiple benefits should be explored. Co-location of WSUD assets in detention systems can provide recreational and ecological opportunities in addition to flood mitigation. Safety considerations and improved community education on water in the landscape is recommended to complement the option.	Water Quantity Water Quality Ecosystem Health Economic Viability Planning and Development
P16	Extend the stormwater management levy to include development corridors to allow Council to raise stormwater management revenue in addition to that already provided through Council's general income	Planning and Development

Option ID	Option Description	Stormwater Management Objective Met
P17	Update Council flood policy to reflect the varying nature of the flood hazard at Tamworth. For example, the updated flood policy should include a graded sets of controls which are specific to areas subject to main stream and minor tributary flooding, as well as major overland flow. A series of maps should also be incorporated in the updated flood policy which are based on the findings of the present investigation. This option was identified from the Tamworth City-Wide Flooding Investigation (Lyll & Associates, 2019)	Planning and Development

8.5 STORMWATER INFRASTRUCTURE

Structural on-ground stormwater infrastructure measures were identified through discussion with Council staff, data collection, and site inspections. These measures are aimed at preventing / avoiding / reducing the likelihood of flood risks, improving stormwater runoff quality, and enabling water conservation through hard engineering. These options are discussed in **Table 8-5**. The locations of these options are shown in **Map A8** in **Appendix A**.

Table 8-5 Stormwater Infrastructure Measures

Option ID	Option Description	Stormwater Management Objective Met
S1	Upgrade of the O'Connell Street Pressure Line from its inlet at Marius Street on Rifle Range Gully to its point of discharge to the Peel River. This could comprise a new drainage line within Viaduct Park running parallel with O'Connell Street This option was identified from the East and North Tamworth Drainage Study (Lyll & Associates, 2021) as a modified component of Option 1. The works comprising this option include the separation of the two arms of the existing pressure line and the construction of a new pressure line. It would be necessary to construct an earth embankment across Macquarie Street to intercept flow which surcharges the existing culvert under the same named street immediately east of Angora Park. A short section of the existing concrete lined channel to the north of the playing field would also need to be rebuilt in order to redirect flows toward the inlet of the new pressure line. Land zone: Public Recreation	Water Quantity
S2	New pressure line between Darling Street and Brisbane Street to the Peel River via Bourke Street This option was identified from the East and North Tamworth Drainage Study (Lyll & Associates, 2021) as an extension of the options assessed. This option will involve constructing a new pressure line and extending the new trunk drainage line to reduce flood damaging at existing residential development. There would also be merit in extending the new trunk drainage line north as far as Raglan Street as this would assist in reducing flooding that is experienced in the existing residential development along the western side of Bourke Street. Land zone: General Residential	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S3	Duplication of the existing pressure line which runs along White Street from the Main Northern Railway to the Peel River. This option was identified from the East and North Tamworth Drainage Study (Lyall & Associates, 2021) as Option 3. Unlike the Fitzroy Street pressure line option (S5), it would not be necessary to install a new section of the pipe in the levee bank, as site inspection and survey shows the presence of a redundant section of 1200 mm diameter pipe at this location. The main concern with this option is the ability to pressurise the new drainage line given the limited opportunities available for improving the inlet capacity north of the Main Northern Railway Line. Land zone: General Residential	Water Quantity
S4	Duplication of the existing pressure line which runs along Fitzroy Street from the Main Northern Railway to the Peel River. This option was identified from the East and North Tamworth Drainage Study (Lyall & Associates, 2021) as Option 2 and was considered of lowest priority of the drainage study outcomes. The works could also involve improvements to the inlet arrangement located on the northern side of the Main Northern Railway. It may be necessary to install a new length of pipe through the existing levee bank, either by excavating a trench or by thrust boring methods. Land zone: Public recreation	Water Quantity
S5	Improve capture of flows on the southeast side of the Moore Creek Road and Bournes Lane intersection and convey to natural watercourse to the west. This option was identified from 2021 Tamworth Stormwater Priorities. Flows from the southeast of the Moore Creek Road and Bournes Lane intersection skip the culvert under Moore Creek Road and cross the road to the north running through several properties. Land zone: Low density Residential Lot in Rural Area	Water Quantity
S6	Upgrade culverts under Moore Creek Rd downstream of Woodswallow Cl. Improve capacity of downstream channel. This option was identified from 2021 Tamworth Stormwater Priorities. Overland capacity is currently limited by culverts which are proposed for upgrade. Land zone: Large Residential Lot	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S7	Detention basin upstream of Regans Rd Kingswood. This option was identified from 2021 Tamworth Stormwater Priorities. Construct a detention basin to reduce peak flows to the capacity of the downstream infrastructure ~4m³/s. Basin to be a 1m high fill wall with excavation to maximise volume with outlet structure Land zone: Public recreation	Water Quantity
S8	Upgrade inlet at Raglan Street This option was identified from 2021 Tamworth Stormwater Priorities. The headwall at Raglan Street limits the flow into the downstream box culverts. Increasing the head with a bund will increase flow in the culverts. Land zone: Public recreation	Water Quantity
S9	Pump out from CWA park This option was identified from 2021 Tamworth Stormwater Priorities. Pump out from north of the bridge. This area has pipes draining Peel Street and Kable Ave. The pump should be designed to have capacity to keep 20-year gates closed below floor levels. Land zone: Public recreation	Water Quantity
S10	Upgrade inlet at Victoria Street This option was identified from 2021 Tamworth Stormwater Priorities. The Rifle Range Gully piped drainage is limited by the headwall. Additional head at the headwall will increase the flows conveyed by the piped system. Land zone: General Residential	Water Quantity
S11	Storage in Darling St Park and Pump out This option was identified from 2021 Tamworth Stormwater Priorities. Pump out from north of the bridge. This area has pipes draining Peel Street and Kable Ave. The pump should be designed to have capacity to keep 20-year gates closed below floor levels. Land zone: Commercial Core	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S12	Piped drainage from Raglan to White Street / Levine Intersection This option was identified from 2021 Tamworth Stormwater Priorities. Pit and pipe to be designed to direct water not captured by the existing piped system to White Street causing property flooding. Land zone: General Residential	Water Quantity
S13	Victoria Park detention This option was identified from 2021 Tamworth Stormwater Priorities. Detention to be designed to reduce peak flows for events exceeding 20-year ARI. Land zone: Primary Production Small lots	Water Quantity
S14	Piped drainage from Denne Street - Gipps to Bridge This option was identified from 2021 Tamworth Stormwater Priorities. Piped drainage to the existing Bridge Street pit and pipe network is recommended. Land zone: General Residential Lot In Built-Up Area Including Half Road	Water Quantity
S15	Piped drainage at Manilla Rd This option was identified from 2021 Tamworth Stormwater Priorities. Water on the north of Manilla Road ponds and eventually spills into properties to the south. An additional pit and short section of pipe will improve the capture. Land zone: General Residential	Water Quantity
S16	Piped drainage from Belmore Street to Goonoo Goonoo Road This option was identified from 2021 Tamworth Stormwater Priorities. Flows from Belmore Street are not all captured in pit and pipe. These flows over top the kerb and gutter. Land zone: General Residential	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S17	Piped drainage from Bushland Ave to Rail This option was identified from 2021 Tamworth Stormwater Priorities. Existing drainage does not cater for major events through properties. Additional piped drainage is required to convey events larger than the 5-year ARI. Land zone: General Residential	Water Quantity
S18	Piped drainage at Armidale Rd This option was identified from 2021 Tamworth Stormwater Priorities. All water falling on this section of Armidale Road is directed down a driveway that requires diversion. Land zone: General Residential, Residential Lot in Built-Up Area	Water Quantity
S19	Additional Basin to reduce peak flows and reduce velocities in frequent events at Hills Plains Detention This option was identified from 2021 Tamworth Stormwater Priorities. Excessive scour is occurring due to the ongoing development of the area. A basin to reduce velocities is required. Council does not currently own this land but it is proposed public open space after development. Land zone: Low Density Residential Lot in Rural Area	Water Quality
S20	Storage in Viaduct Park and Pump out This option was identified from 2021 Tamworth Stormwater Priorities. Major events behind East Tamworth cause significant flooding even when the flood gates are open. There is an existing 900mm headwall near Viaduct Park which should be replaced with larger pit and pipe to convey more of the major events. Land zone: Public recreation	Water Quantity
S21	Detention in TAFE land This option was identified from 2021 Tamworth Stormwater Priorities. Detention within the TAFE land could be used to reduce the peak flows in Rifle Range Gully for major events. Land zone: Primary Production Small lots	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S22	New Pressure Tunnel in Murray reserve This option was identified from 2021 Tamworth Stormwater Priorities. Much of the east Tamworth Drainage issues are caused by Garrieties Gully which is not controlled through East Tamworth. A large line is required from the top of East Tamworth through to the river. Land zone: General Residential	Water Quantity
S23	Pipe to join to existing at George Street This option was identified from 2021 Tamworth Stormwater Priorities. Properties on Goonoo Goonoo Road are impacted by an overland flow. It is expected that this flow is coming from the George Street line which discharges to the kerb and gutter before being partially captured in a downstream pit. The existing pit locations are to be connected by a new pipe. Land zone: General Residential	Water Quantity
S24	Piped Drainage at Greg Norman Drive This option was identified from 2021 Tamworth Stormwater Priorities. The pipe on the southern side of Greg Norman Drive currently runs full and surcharges from the pit on the norther side of the road in large events. The grades do not allow water to flow to Barnes Gully. A new pit and short section of pipe could drain this water away from the affected properties. Land zone: General Residential	Water Quantity
S25	New drainage and kerb and gutter at Marius/Hunt Street This option was identified from 2021 Tamworth Stormwater Priorities. Flows down Hunt Street are not controlled at Marius Street. New pits and pipes are required in addition to kerb and gutter. Land zone: General Residential	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S26	Increase basin capacity and overflow spill way for Skillshare Park detention This option was identified from 2021 Tamworth Stormwater Priorities. The basin does not have a suitable major spillway. Major flows are directed into properties. The capacity should be increased and the spillway should be directed to the road reserve. Original flows are through lots Land zone: Public recreation	Water Quantity
S27	Storage in the cemetery land and channel upgrade at Baufort Street This option was identified from 2021 Tamworth Stormwater Priorities. This option was recommended to address the regular flooding of Baufort Street due to the tailwater conditions at the Jockey Club Flood Storage. Land zone: Public recreation	Water Quantity
S28	Piped drainage along Jewry street This option was identified from 2021 Tamworth Stormwater Priorities. Land zone: General Industrial	Water Quantity
S29	Reconstruct scour protection at Swan St This option was identified from 2021 Tamworth Stormwater Priorities. Land zone: Primary Production Small lots	Water Quantity Water Quality Public Health
S30	Reconstruct scour protection at Phoenix Street This option was identified from 2021 Tamworth Stormwater Priorities. Land zone: Heavy Industrial	Water Quantity Water Quality Public Health
S31	Piped drainage at Hercules St This option was identified from 2021 Tamworth Stormwater Priorities. Flows previously affecting properties are contained within the road reserve as a result of the modelled option. Land zone: General Residential	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S32	Bicentennial Park WSUD features This will provide a blue and green corridor with the dual purpose of community recreation and water quality function. The proposed system of a GPT and bioretention has the potential to remove up to 0.972kg per year of TP and 5.84kg per year of TN from entering Peel River in addition to 872kg and 185kg of TSS and Gross Pollutants, respectively. This option was identified through site visit. Land zone: Public recreation	Water Quality Water Quantity Public Health Ecosystem Health
S33	Install GPT at Jewry St culvert discharging into Peel River This option was identified through site visit. The proposed system could remove up to 8494kg per year of gross pollutants and litter from entering Peel River, in addition to 21800kg of TSS and 85kg of TN. Land zone: Public recreation	Water Quality Water Quantity Public Health Ecosystem Health
S34	Formalisation and revegetation of Swan St channel This option was identified through site visit. The combined swale and GPT has the potential to remove up to 10.3kg per year of TP and 33kg per year of TN from entering Peel River in addition to 11600kg and 2930kg per year of TSS and Gross Pollutants, respectively. Land zone: Primary Production Small lots	Water Quality Water Quantity Public Health Ecosystem Health
S35	Trap debris along Spring creek to improve channel This option was identified through site visit. Land zone: General Residential	Water Quality Water Quantity Public Health Ecosystem Health
S36	Trap debris along Rifle Range Gully to improve channel This option was identified through site visit. Land zone: Primary Production Small lots	Water Quality Water Quantity Public Health Ecosystem Health
S37	Investigate drainage augmentation in the area to alleviate the flooding issues along Armidale Rd This issue was raised by UGL, the owner of the pit within the rail corridor. Land zone: General Residential	Water Quantity

Option ID	Option Description	Stormwater Management Objective Met
S38	Investigate the opportunity to install a wetland on Barnes Gully north of Bridge St This option was raised by Council. The proposed system could remove up to 120.7kg per year of TP and 689kg per year of TN from entering Peel River. Land zone: Private recreation	Water Quality Water Quantity Public Health Ecosystem Health

Performance of options S34, S35, S33, S34, and S38 were assessed by modifying the baseline conditions MUSIC water quality model developed in **Section 5.3**. Outcomes of this is documented in **Appendix F** and summarised in the table above.

9 URBAN STORMWATER MANAGEMENT IMPLEMENTATION PLAN

9.1 MULTI CRITERIA ASSESSMENT

A Multi Criteria Assessment (MCA) approach was adopted for the comparative assessment of all options identified. This approach to assess the merits of various options is based on:

- > Social costs and benefits;
- > Economic costs and benefits;
- > Environmental costs and benefits; and
- > The decision making process (governance).

9.1.1 Scoring System

A scoring system was devised to subjectively rank each option against a range of criteria given the background information on the nature of the catchment. The scoring is based on the MCA approach, incorporating economic, social, environmental, and governance criterion. The criterion and scoring system adopted includes:

- > Economic
 - Capital costs
 - Ongoing costs
 - Feasibility
 - Staging of works
- > Social
 - Reduction in frequency of flooding
 - Visual Impact
- > Environmental
 - Number of pollutants removed
 - Improved water quality
 - Fauna / Flora impacts
- > Governance
 - Community support and executive commitment
 - Compatible with existing policies and plans

The scoring system summary is provided in Table 9-1.

The scoring previously undertaken by Council in the Stormwater Priorities 2021 has been incorporated into the MCA generally as variation in the Governance Category for Compatibility with Policies and Plans Criterion to capture Council preference.

Table 9-1 MCA Assessment – Scoring System

Category	Criterion	Description	Score				
			-2	-1	0	1	2
Economic	Capital Costs	Initial construction costs to Council	>\$1 million	\$500,000 - \$1 million	\$200,000 - \$500,000	\$100,000 - \$200,000	<\$100,000
	Ongoing Costs	Annual maintenance costs to Council	>\$50,000	\$20,000 - \$50,000	\$10,000 - \$20,000	\$1000 - \$10,000	<\$1000
	Feasibility	Establishes the feasibility of options based on constructability, and bureaucratic difficulties such as land acquisition and agreements with external agencies	There are a number of factors that pose a significant impact on the feasibility of the project	There are few factors that pose a potential impact on the feasibility of the project	May or may not be feasible	Likely to be feasible	Very likely to be feasible
	Staging of Works	Ability to stage proposed works	NA	NA	Works cannot be staged	Some minor components of the works may be staged	Significant components of the works can be staged
Social	Reduction in Frequency of Flooding	The impact of option on flooding for roads and other public and private areas	Increases the flooding risk for a significant area	Increases the flooding risk for a minor area	No change to flood risk	Reduces the flood risk for a minor area	Reduces the flood risk for a significant area
	Visual Impact	Impact of completed works on visual amenity or function of public domain	Significant loss of existing visual amenity or public domain	Minor loss of existing valued visual amenity or public domain	No change	Some improvement to visual amenity or public domain	Significant improvement to visual amenity or public domain
Environmental	Number of Pollutants Removed	This has been based on the types and number of pollutants removed	Significant loss of water quality	Minor loss of water quality	No improvement	Primary Treatment Only (Litter, large Sediments)	Secondary Treatment (Litter, Nutrients, Sediments, indeterminate Metals and Hydrocarbons)

Category	Criterion	Description	Score				
			-2	-1	0	1	2
Governance	Improved Water Quality	The impact of option on pollution reduction. This has been based on the annual removal of Total Nitrogen (TN)	NA	NA	No improvement	<150kg/year	>150kg/year
	Flora/Fauna Impact	Likely impacts on biodiversity	High negative impact	Slight negative impact	No Impact	Some Benefit	Considerable Benefit
	Community support and executive commitment	Potential support from the local community and internal stakeholders	Very unlikely to be supported	Unlikely to be supported	Neutral	Likely to be supported	Very likely to be supported
	Compatibility with policies and plans	Compliance with the planning policies requirements, and government regulations	Amendment required to either Council's current policies or plans	Slightly incompatible with Council's current policies or plans	Slightly incompatible with Council's current policies or plans, but could be grounds for reviewing policies or plans	Compatible with both Council's policies and plans	In line with and supported by Council's current policies or plans

The assignment of a score for each criterion for each option is shown in the completed matrix in **Appendix H**. The total score of each option was calculated by equally weighting criteria and summing the total. Each of the options was then ranked against each other based on the total scores, allowing identification of the referred options, namely those that provide the greatest benefit to the community. These total scores and rankings are also shown in **Appendix H**.

The rankings are proposed as the basis for selecting management options for prioritising their implementation. It is noted that both structural and non-structural options have been considered separately since it is difficult to directly compare these two types of measures.

Table 9-2 provides a ranked list of non-structural management options for consideration and **Table 9-3** provides a ranked list of structural management options for consideration.

Table 9-2 Summary of MCA of Non-Structural Options

Option Type	Option ID	Description	Total Score	Rank
Asset Management	A1	Utilise a maintenance management system for planning, scheduling, and recording maintenance and inspections. Maintenance records will help identify issues and develop solutions.	3.00	37
	A2	Survey the existing stormwater network to improve the completeness of Council's dataset.	3.00	32
	A3	Condition Assessment of Council's current stormwater infrastructure through field inspection starting with areas where failure has high-risk or consequence.	3.50	9
	A4	Council to develop a stormwater asset renewal program.	3.50	9
	A5	Investigate the benefits of capturing stormwater runoff from Council buildings for re-use	3.50	9
	A6	Investigate the benefits of roof runoff capture, ground water usage, and recycled water for reuse. Achieve efficiencies and sustainability for whole of life maintenance of facilities, including site selection based on water security / rationalisation of parks and sports precincts.	3.50	9
	A7	Clearly define the stormwater levy expenditure areas and budgets	3.50	9
Education and Awareness	E1	Develop a drain stencilling education program	3.50	9
	E2	Public education and awareness campaign on excessive watering, companion animal waste, car washing, Stormwater friendly gardens and recycling	3.50	9
	E3	Education campaign targeted at Building and Construction industry on the implementation of soil and water management controls during construction	3.50	9
	E4	Investigate current industrial / commercial stormwater management practices and develop	3.50	9

Option Type	Option ID	Description	Total Score	Rank
		industry / commercial stormwater awareness programs		
	E5	Expand the current litter education program to incorporate stormwater and river health	3.50	9
	E6	Incorporate WSUD in the current water efficiency education programs	3.50	9
	E7	Develop a stormwater pollution and management education program for local schools and community organisations	3.50	9
	E8	Undertake community/environmental group led water quality monitoring (macroinvertebrate sampling) as part of other Council/community led events that enables community and school kids to monitor the quality and health of local waterways (e.g. Streamwatch)	3.50	9
	E9	Publish regular stormwater information on Council's website and, social media accounts.	3.50	9
Maintenance and Monitoring	M1	Compliance and monitoring program for private OSD systems (in combination with P6)	3.00	32
	M2	Investigate the feasibility of planting native vegetation along the existing stormwater channels	4.50	3
	M3	Weed control / management programs within the stormwater channels	5.00	1
	M4	Regularly maintain grassed areas within and adjacent to open urban stormwater channels	5.00	1
	M5	Implement a cost-effective strategy to improve cleaning of stormwater structures	3.50	9
	M6	Increased street sweeping in commercial areas	3.25	28
	M7	Improved street sweeping practices in the City	3.25	28
	M8	Expand stormwater monitoring and auditing (testing program)	2.50	43
	M9	Additional sampling data from the testing sites	2.50	43
	M10	Incorporate stormwater pollutant parameters in the existing water quality monitoring program (TSS/TP/TN)	2.50	43
	M11	Develop a maintenance schedule for the existing Council owned GPTs	4.25	4
	M12	Develop a wetland management plan for Peel High	4.25	4

Option Type	Option ID	Description	Total Score	Rank
	M13	Develop a wetland management plan for Heritage Park	4.25	4
Planning and Development	P1	Improve Council's Integrated management system (IMS) to control the use of chemicals near waterways	2.50	43
	P2	Review erosion control procedures on new developments. Provide relevant Council staff with training to enable this.	3.00	32
	P3	Stormwater Management requirements for new subdivisions needs to be reviewed and updated including consideration of Water Quality targets	3.50	9
	P4	Council to develop a WSUD policy	3.50	9
	P5	Council to adopt WSUD requirements as part of the DCP	3.50	9
	P6	Develop an OSD policy and pilot program that specifies OSD sizing and orifice requirements at subcatchment scale (especially for smaller developments).	3.00	32
	P7	Review OSD requirements for subdivision of 5 or more lots. Allow private OSD for smaller subdivisions and public detention basins for larger subdivisions.	3.00	32
	P8	Staged approach to WQ targets in DCP Short term - GP targets - GPT requirements for detentions basins Medium to long term - TSS/TP/TP targets	3.50	9
	P9	Stream Erosion Index (SEI) target in DCP	3.00	32
	P10	Incorporate waterway health as part of Council's sustainability strategy focus areas	3.00	32
	P11	Identify the blue/green networks (drainage reserves that combine as parks with cycleway / walkways) in new greenfield areas to reduce drainage cost for greenfield development	3.00	32
	P12	Collate existing low impact stormwater guidelines and link them to Tamworth Regional Council policies. Include urban design measures that control and manage stormwater. Promote these stormwater guidelines through Tamworth Regional Council's communications.	3.00	32

Option Type	Option ID	Description	Total Score	Rank
	P13	Empower developers and designers to consider urban stormwater management at the early stages of their master planning	3.00	32
	P14	Complete and utilise mapping for flooding	3.25	28
	P15	Investigate co-location benefits of integrating WSUD into detention systems.	4.25	4
	P16	Extend the stormwater management levy to include development corridors to allow Council to raise stormwater management revenue in addition to that already provided through Council's general income	3.75	8
	P17	Update Council flood policy to reflect the varying nature of the flood hazard at Tamworth.	3.25	28

Table 9-3 Summary of MCA of Structural Options

Option Type	Option ID	Description	Total Score	Rank
Stormwater Infrastructure	S1	Upgrade of the O'Connell Street Pressure Line from its inlet at Marius Street on Rifle Range Gully to its point of discharge to the Peel River. This could comprise a new drainage line within Viaduct Park running parallel with O'Connell Street	3.25	27
	S2	New pressure line between Darling Street and Brisbane Street to the Peel River via Bourke Street	3.50	23
	S3	Duplication of the existing pressure line which runs along White Street from the Main Northern Railway to the Peel River	3.75	14
	S4	Duplication of the existing pressure line along Fitzroy Street from the Main Northern Railway to the Peel River	1.75	38
	S5	Bund on Moore Creek Road	4.50	3
	S6	Upgrade culverts under Moore Creek Road downstream of Woodswallow Cl. Improve capacity of downstream channel	4.50	3
	S7	Detention basin upstream of Regans Rd Kingswood	4.33	7
	S8	Raglan Street inlet upgrade	4.50	3
	S9	Pump out from CWA Park	4.00	11
	S10	Upgrade inlet at Victoria Street	3.75	14
	S11	Flood Storage in Darling Street Park and Pump Out	4.33	7
	S12	Piped drainage from Raglan Street to White Street / Levine Intersection	3.50	23
	S13	Victoria Park detention	4.08	10
	S14	Piped drainage from Denne Street - Gipps to Bridge	3.50	23
	S15	Piped drainage at Manilla Road	3.75	14
	S16	Piped drainage from Belmore Street to Goonoo Goonoo Road	3.25	27
	S17	Piped drainage from Bushland Ave to Rail	3.50	23
	S18	Piped drainage at Armidale Road	3.75	14

Option Type	Option ID	Description	Total Score	Rank
	S19	Additional Basin to reduce peak flows and reduce velocities in frequent events at Hills Plains Detention	3.58	20
	S20	Storage in Viaduct Park and Pump out	3.58	22
	S21	Detention in TAFE land	3.58	20
	S22	New Pressure Tunnel in Murray reserve	2.50	36
	S23	Pipe to join to existing at George Street	3.25	27
	S24	Piped drainage at Greg Norman Drive	3.25	27
	S25	New drainage and kerb and gutter at Marius/Hunt Street	3.25	27
	S26	Increase basin capacity and overflow spill way for Skillshare Park detention	3.25	27
	S27	Storage in the cemetery land and channel upgrade at Baufort Street	3.08	33
	S28	Piped drainage along Jewry Street	3.00	34
	S29	Reconstruct scour protection at Swan Street	3.75	14
	S30	Reconstruct scour protection at Phoenix Street	4.00	11
	S31	Piped drainage at Hercules Street	2.25	37
	S32	Bicentennial Park WSUD features	4.83	2
	S33	Install GPT at Jewry Street culvert discharging into Peel River	4.25	9
	S34	Formalisation and revegetation of Swan Street channel	4.50	3
	S35	Trap debris along Spring creek to improve channel	4.00	11
	S36	Trap debris along Rifle Range Gully to improve channel	3.75	14
	S37	Investigate drainage augmentation in the area to alleviate the flooding issues along Armidale Road	3.00	34
	S38	Investigate the opportunity to install a wetland on Barnes Gully north of Bridge Street	5.00	1

9.2 IMPLEMENTATION PLAN

The implementation plan for the measures is provided in **Table 9-4**. The plan includes:

- > Description of each option;
- > Estimated capital costs (design and construction) and operational costs (annual maintenance) – Capital and ongoing cost estimates provided for options in this report are preliminary only and more detailed cost estimates will be required during the concept and detailed design phase;
- > Ranking based on MCA as described in **Section 9.1**; and
- > Timeframe to complete (short, medium, long-term) – Short term (5 to 10 years) measures are relatively low in capital expenditure. Medium to long term (10 to 20 years) should be implemented as funding and opportunities arise including land availability.

Ranking may result in multiple options with the same score having the same rank, resulting in what may appear to be ranking 'gaps,' where there are not. Ranking has been done separately for non-structural and structural options in **Table 9-4**.

Where both sets of options have been collectively ranked, the highest scoring options could be:

- > Rank 1: M3 - Weed control / management programs within the stormwater channels
- > Rank 1: M4 - Regularly maintain grassed areas within and adjacent to open urban stormwater channels
- > Rank 1: S38 - Investigate the opportunity to install a wetland on Barnes Gully north of Bridge St
- > Rank 4: S32 - Bicentennial Park WSUD features
- > Rank 5: M2 - Investigate the feasibility of planting native vegetation along the existing stormwater channels
- > Rank 5: S5 - Bund on Moore Creek Road
- > Rank 5: S6 - Upgrade culverts under Moore Creek Rd downstream of Woodswallow Cl. Improve capacity of downstream channel
- > Rank 5: S8 - Raglan Street inlet upgrade
- > Rank 5: S34 - Formalisation and revegetation of Swan St channel

This shows that in most cases, a combination of non-structural and structural options can be implemented to address multiple benefits.

Table 9-4 Implementation Plan

Option Type	Option ID	Description	Cost		Ranking	Timeframe
			Capital	Ongoing		
NON-STRUCTURAL OPTIONS						
Maintenance and Monitoring	M3	Weed control / management programs within the stormwater channels	\$100,000 - \$200,000	\$1000 - \$10,000	1	Short term
Maintenance and Monitoring	M4	Regularly maintain grassed areas within and adjacent to open urban stormwater channels	<\$100,000	<\$1000	1	Short term
Maintenance and Monitoring	M2	Investigate the feasibility of planting native vegetation along the existing stormwater channels	<\$100,000	<\$1000	3	Short term
Maintenance and Monitoring	M11	Develop a maintenance schedule for the existing Council owned GPTs	<\$100,000	\$1000 - \$10,000	4	Short term
Maintenance and Monitoring	M12	Develop a wetland management plan for Peel High	<\$100,000	\$1000 - \$10,000	4	Short term
Maintenance and Monitoring	M13	Develop a wetland management plan for Heritage Park	<\$100,000	\$1000 - \$10,000	4	Short term
Planning and Development	P15	Investigate co-location benefits of integrating WSUD into detention systems.	<\$100,000	<\$1000	4	Medium to long term
Planning and Development	P16	Extend the stormwater management levy to include development corridors	<\$100,000	<\$1000	8	Short term
Asset Management	A3	Condition Assessment of Council's current stormwater infrastructure through field inspection starting with areas where failure has high-risk or consequence.	\$200,000 - \$500,000	<\$1000	9	Medium to long term
Asset Management	A4	Council to develop a stormwater asset renewal program.	<\$100,000	<\$1000	9	Short term
Asset Management	A5	Investigate the benefits of capturing stormwater runoff from Council buildings for re-use	<\$100,000	<\$1000	9	Short term
Asset Management	A6	Investigate the benefits of roof runoff capture, ground water usage, and recycled water for reuse. Achieve efficiencies and sustainability for whole of life maintenance of facilities, including site selection based on water security / rationalisation of parks and sports precincts.	<\$100,000	<\$1000	9	Short term
	A7	Clearly define the stormwater levy expenditure areas and budgets	<\$100,000	<\$1000	9	Short to long term
Asset Management	E1	Develop a drain stencilling education program	<\$100,000	<\$1000	9	Short term
Education and Awareness	E2	Public education and awareness campaign on excessive watering, companion animal waste, car washing, Stormwater friendly gardens and recycling	<\$100,000	<\$1000	9	Short term
Education and Awareness	E3	Education campaign targeted at Building and Construction industry on the implementation of soil and water management controls during construction	<\$100,000	<\$1000	9	Short term
Education and Awareness	E4	Investigate current industrial / commercial stormwater management practices and develop industry / commercial stormwater awareness programs	<\$100,000	<\$1000	9	Short term

Option Type	Option ID	Description	Cost		Ranking	Timeframe
			Capital	Ongoing		
Education and Awareness	E5	Expand the current litter education program to incorporate stormwater and river health	<\$100,000	<\$1000	9	Short term
Education and Awareness	E6	Incorporate WSUD in the current water efficiency education programs	<\$100,000	<\$1000	9	Short term
Education and Awareness	E7	Develop a stormwater pollution and management education program for local schools and community organisations	<\$100,000	<\$1000	9	Short term
Education and Awareness	E8	Undertake community/environmental group led water quality monitoring (macroinvertebrate sampling) as part of other Council/community led events that enables community and school kids to monitor the quality and health of local waterways (e.g. Streamwatch)	<\$100,000	<\$1000	9	Short term
Education and Awareness	E9	Publish regular stormwater information on Council's website and, social media accounts.	<\$100,000	<\$1000	9	Short term
Maintenance and Monitoring	M5	Implement a cost-effective strategy to improve cleaning of stormwater structures	<\$100,000	<\$1000	9	Short term
Planning and Development	P3	Stormwater Management requirements for new subdivisions needs to be reviewed and updated including consideration of Water Quality targets	<\$100,000	<\$1000	9	Short term
Planning and Development	P4	Council to develop a WSUD policy	<\$100,000	<\$1000	9	Short term
Planning and Development	P5	Council to adopt WSUD requirements as part of the DCP	<\$100,000	<\$1000	9	Short term
Planning and Development	P8	Staged approach to WQ targets in DCP Short term - GP targets - GPT requirements for detentions basins Medium to long term - TSS/TP/TP targets"	<\$100,000	<\$1000	9	Medium to Long term
Maintenance and Monitoring	M6	Increased street sweeping in commercial areas	<\$100,000	<\$1000	28	Short to Long term
Maintenance and Monitoring	M7	Improved street sweeping practices in the City	<\$100,000	<\$1000	28	Short to Long term
Planning and Development	P14	Complete and utilise mapping for flooding	<\$100,000	<\$1000	28	Short term
Planning and Development	P17	Update Council flood policy to reflect the varying nature of the flood hazard at Tamworth.	<\$100,000	<\$1000	28	Short term
Asset Management	A2	Survey the existing stormwater network to improve the completeness of Council's dataset.	\$100,000 - \$200,000	<\$1000	32	
Maintenance and Monitoring	M1	Compliance and monitoring program for private OSD systems (in combination with P6)	<\$100,000	<\$1000	32	Short term
Planning and Development	P2	Review erosion control procedures on new developments. Provide relevant Council staff with training to enable this.	<\$100,000	<\$1000	32	Short term
Planning and Development	P6	Develop an OSD policy and pilot program that specifies OSD sizing and orifice requirements at subcatchment scale (especially for smaller developments).	<\$100,000	<\$1000	32	Short term

Option Type	Option ID	Description	Cost		Ranking	Timeframe
			Capital	Ongoing		
Planning and Development	P7	Review OSD requirements for subdivision of 5 or more lots. Allow private OSD for smaller subdivisions and public detention basins for larger subdivisions.	<\$100,000	<\$1000	32	Medium to Long term
Planning and Development	P9	Stream Erosion Index (SEI) target in DCP	<\$100,000	<\$1000	32	Medium to Long term
Planning and Development	P10	Incorporate waterway health as part of Council's sustainability strategy focus areas	<\$100,000	<\$1000	32	Short term
Planning and Development	P11	Identify the blue/green networks (drainage reserves that combine as parks with cycleway / walkways) in new greenfield areas to reduce drainage cost for greenfield development	<\$100,000	<\$1000	32	Short term
Planning and Development	P12	Collate existing low impact stormwater guidelines and link them to Tamworth Regional Council policies. Include urban design measures that control and manage stormwater. Promote these stormwater guidelines through Tamworth Regional Council's communications.	<\$100,000	<\$1000	32	Short term
Planning and Development	P13	Empower developers and designers to consider urban stormwater management at the early stages of their master planning	<\$100,000	<\$1000	32	Short term
Asset Management	A1	Utilise a maintenance management system for planning, scheduling, and recording maintenance and inspections. Maintenance records will help identify issues and develop solutions.	\$100,000 - \$200,000	\$1000 - \$10,000	37	Short to long term
Maintenance and Monitoring	M8	Expand stormwater monitoring and auditing (testing program)	<\$100,000	<\$1000	43	Medium to Long term
Maintenance and Monitoring	M9	Additional sampling data from the testing sites	<\$100,000	<\$1000	43	Medium to Long term
Maintenance and Monitoring	M10	Incorporate stormwater pollutant parameters in the existing water quality monitoring program (TSS/TP/TN)	<\$100,000	<\$1000	43	Medium to Long term
Planning and Development	P1	Improve Council's Integrated management system (IMS) to control the use of chemicals near waterways	<\$100,000	<\$1000	43	Medium to Long term
Stormwater Infrastructure	S38	Investigate the opportunity to install a wetland on Barnes Gully north of Bridge Street	\$200,000 - \$500,000	\$1000 - \$10,000	1	Short term
Stormwater Infrastructure	S32	Bicentennial Park WSUD features	\$200,000 - \$500,000	\$1000 - \$10,000	2	Short term
Stormwater Infrastructure	S5	Bund on Moore Creek Road	<\$100,000	<\$1000	3	Short term
Stormwater Infrastructure	S6	Upgrade culverts under Moore Creek Rd downstream of Woodswallow Cl. Improve capacity of downstream channel	\$100,000 - \$200,000	<\$1000	3	Short term

Option Type	Option ID	Description	Cost		Ranking	Timeframe
			Capital	Ongoing		
Stormwater Infrastructure	S8	Raglan Street inlet upgrade	<\$100,000	<\$1000	3	Short term
Stormwater Infrastructure	S34	Formalisation and revegetation of Swan St channel	\$100,000 - \$200,000	\$1000 - \$10,000	3	Short term
Stormwater Infrastructure	S7	Detention basin upstream of Regans Rd Kingswood	\$100,000 - \$200,000	\$1000 - \$10,000	7	Short term
Stormwater Infrastructure	S11	Flood Storage in Darling St Park and Pump out	\$100,000 - \$200,000	\$1000 - \$10,000	7	Short term
Stormwater Infrastructure	S33	Install GPT at Jewry St culvert discharging into Peel River	\$100,000 - \$200,000	<\$1000	9	Short term
Stormwater Infrastructure	S13	Victoria Park detention	\$200,000 - \$500,000	\$1000 - \$10,000	10	Short term
Stormwater Infrastructure	S9	Pump out from CWA Park	\$100,000 - \$200,000	<\$1000	11	Short term
Stormwater Infrastructure	S30	Reconstruct scour protection at Phoenix Street	<\$100,000	\$1000 - \$10,000	11	Short term
Stormwater Infrastructure	S35	Trap debris along Spring Creek to improve channel	\$100,000 - \$200,000	\$1000 - \$10,000	11	Short term
Stormwater Infrastructure	S3	Duplication of the existing pressure line which runs along White Street from the Main Northern Railway to the Peel River	\$100,000 - \$200,000	\$1000 - \$10,000	14	Short term
Stormwater Infrastructure	S10	Upgrade inlet at Victoria Street	<\$100,000	<\$1000	14	Short term
Stormwater Infrastructure	S15	Piped drainage at Manilla Road	<\$100,000	<\$1000	14	Short term
Stormwater Infrastructure	S18	Piped drainage at Armidale Road	<\$100,000	<\$1000	14	Short term
Stormwater Infrastructure	S29	Reconstruct scour protection at Swan Street	\$100,000 - \$200,000	\$1000 - \$10,000	14	Short term
Stormwater Infrastructure	S36	Trap debris along Rifle Range Gully to improve channel	\$100,000 - \$200,000	\$1000 - \$10,000	14	Short term
Stormwater Infrastructure	S19	Additional Basin to reduce peak flows and reduce velocities in frequent events at Hills Plains Detention	\$200,000 - \$500,000	\$1000 - \$10,000	20	Short term
Stormwater Infrastructure	S21	Detention in TAFE land	\$200,000 - \$500,000	\$1000 - \$10,000	20	Short term
Stormwater Infrastructure	S20	Storage in Viaduct Park and Pump out	\$500,000 - \$1 million	\$10,000 - \$20,000	22	Short term
Stormwater Infrastructure	S2	New pressure line between Darling Street and Brisbane Street to the Peel River via Bourke Street	\$500,000 - \$1 million	\$10,000 - \$20,000	23	Short term
Stormwater Infrastructure	S12	Piped drainage from Raglan Street to White Street / Levine Intersection	\$100,000 - \$200,000	<\$1000	23	Short term
Stormwater Infrastructure	S14	Piped drainage from Denne Street - Gipps to Bridge	\$100,000 - \$200,000	<\$1000	23	Short term

Option Type	Option ID	Description	Cost		Ranking	Timeframe
			Capital	Ongoing		
Stormwater Infrastructure	S17	Piped drainage from Bushland Ave to Rail	\$100,000 - \$200,000	<\$1000	23	Short term
Stormwater Infrastructure	S1	Upgrade of the O'Connell Street Pressure Line from its inlet at Marius Street on Rifle Range Gully to its point of discharge to the Peel River. This could comprise a new drainage line within Viaduct Park running parallel with O'Connell Street	\$200,000 - \$500,000	\$1000 - \$10,000	27	Short term
Stormwater Infrastructure	S16	Piped drainage from Belmore Street to Goonoo Goonoo Road	\$200,000 - \$500,000	<\$1000	27	Short term
Stormwater Infrastructure	S23	Pipe to join to existing at George Street	<\$100,000	<\$1000	27	Short term
Stormwater Infrastructure	S24	Piped drainage at Greg Norman Drive	<\$100,000	<\$1000	27	Short term
Stormwater Infrastructure	S25	New drainage and kerb and gutter at Marius/Hunt Street	\$100,000 - \$200,000	<\$1000	27	Short term
Stormwater Infrastructure	S26	Increase basin capacity and overflow spill way for Skillshare Park detention	<\$100,000	\$1000 - \$10,000	27	Short term
Stormwater Infrastructure	S27	Storage in the cemetery land and channel upgrade at Baufort Street	<\$100,000	\$1000 - \$10,000	33	Short term
Stormwater Infrastructure	S28	Piped drainage along Jewry Street	\$500,000 - \$1 million	<\$1000	34	Short term
Stormwater Infrastructure	S37	Investigate drainage augmentation in the area to alleviate the flooding issues along Armidale Rd	\$100,000 - \$200,000	<\$1000	34	Short term
Stormwater Infrastructure	S22	New Pressure Tunnel in Murray reserve	>\$1 million	\$1000 - \$10,000	36	Short term
Stormwater Infrastructure	S31	Piped drainage at Hercules Street	\$200,000 - \$500,000	<\$1000	37	Short term
Stormwater Infrastructure	S4	Duplication of the existing pressure line along Fitzroy Street from the Main Northern Railway to the Peel River	\$500,000 - \$1 million	\$1000 - \$10,000	38	Short term

9.3 MONITORING, REPORTING AND EVALUATION

An effective monitoring and reporting system is a key component to track progress of the management measures. It will assist Council in directing funds / effort where it is most needed and in future decision making. Obtaining feedback on the success of the management options is also a critical aspect of effective management.

This study should be regarded as a dynamic document requiring review and modification over time. Catalysts for change may include availability of new data, new flood events and experiences, legislative changes and the availability of funding.

While management options are prioritised in this study, it is envisaged that these priorities will change over time due to changing circumstances. Accordingly, Council will have to regularly monitor and update priority actions on an annual basis in accordance with budget planning activities. Furthermore, a review of the study every five (5) to seven (7) years is warranted to ensure continuing relevance.

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