Regional Council of Goyder

Burra SMP

BURRA STORMWATER MANAGEMENT PLAN

December 2020

Final Report

Project Team

Geoff Fisher

Dr Li Li

Felicity Hewett

Michael Di Matteo

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Document History and Status

Issue	Version	Issued to	Qty	Date	Project Manager	Approved
Draft	V1.3	RCG	1	12/8/19	GF	GF
Consultation Draft	V2.3	RCG	1	07/7/20	GF	GF
Consultation Draft	V3_2	RCG	1	08/9/20	GF	GF
Final	V4_2	RCG	1	18/12/20	GF	ML

Printed:	December 18, 2020
Last Saved:	December 18, 2020
File Name:	P16501 Burra SMP_Final for Council Approval_v4_2 201218
Project Manager:	Geoff Fisher
Client:	Regional Council of Goyder
Project:	Burra SMP
Name of Document:	Burra Stormwater Management Plan
Document Version:	V4.2
Job Number:	P16501

Disclaimer

This document is for the exclusive use of the client for which it was prepared and is not to be relied upon by any other person. Water Technology Pty Ltd has made reasonable efforts to ensure that the information provided is accurate, but errors and omissions can occur, and circumstances can change from the time that the report or document was prepared. Therefore, except for any liability that cannot be excluded by law, Water Technology Pty Ltd excludes any liability for loss or damage, direct or indirect, from any person relying (directly or indirectly) on opinions, forecasts, conclusions, recommendations or other information in this report or document.

Table of Contents

1 Introduction 5
1.1 Background 5
1.2 History and Nature of the Problem in the Region 5
1.3 Consultation and Development of Plan 6
1.4 Legislative Context 6
2 Description of Catchment Area 8
2.1 Study Area Boundary 8
2.2 Land Use 10
2.3 Climate 10
2.4 Rainfall Record 10
2.5 Streamflow Record 11
2.6 Geology and Soil Structure 11
2.7 Population and Likely Future Growth 12
2.8 Catchment Condition and Receiving Environments 12
3 Existing Stormwater Infrastructure 16
4 Identification of Problems and Opportunities 18
4.1 Potential for Flooding within the Catchment 18
4.2 The Impact of Flooding 24
4.3 Opportunities for Better Managing Flood Risk 25
4.4 Impacts of Future Development on Flooding 26
4.5 Stormwater Quality within Streams and Receiving Waters 26
4.6 Opportunities for Stormwater Reuse 28
4.7 Opportunities for Environmental Enhancement 29
5 Stormwater Management Objectives 30
5.1 Stormwater Management Objectives 30
6 Stormwater Management Strategies 33
6.1 Approach to Developing Mitigation Strategies 33
6.2 Non-Structural Flood Management Measures 34
6.3 Structural Flood Mitigation Measures including Local Runoff Management Measures 37
6.4 Effectiveness of Flood Mitigation Works 52
6.5 Impact of Mitigation Measures on Downstream Environments and Stream Stability 53
6.6 Management and Regular Maintenance of Drainage Infrastructure and Watercourses (M1) 54
6.7 Water Quality 54
6.8 Stormwater Harvesting and Reuse 57
6.9 Watercourse Rehabilitation (WQ2-WQ7) 59
6.10 Complimentary small scale stream rehabilitation works (WQ8a and WQ8b) 64
6.11 Cultural Considerations 65
7 Recommendations 66
7.1 Structural and Non-Structural Measures 66
7.2 Environmental, Social and Economic Opportunities/Benefits 67

7.3 Water Affecting Activities 67
8 Potential Funding and Arrangements and Opportunities 68
8.1 Introduction 68
9 Priorities and Timeframes for Implementation 70
10 Responsibilities for Implementation 72
10.1 Responsibilities and Partners 72
10.2 Responsibilities for Maintenance 72
11 Review of the Stormwater Management Plan 74
12 Community Feedback of the Draft SMP 75
13 References 76

List of Tables

Table 2-1 Flow Gauges 11
Table 2-2 Surface Watercourses Environmental Values 15
Table 4-1 Properties at Risk of Overfloor Flooding in a 100 Year ARI Event 24
Table 4-2 Flood Damages Calculations Unit Rates for Direct Tangible Losses 25
Table 5-1 Summary of Management Strategies Showing Linkages with SMP Objectives and Targets 32
Table 6-1 Stormwater Treatment Performance for the Proposed Wetland 57
Table 6-2 Riparian Survey Results Summary 61
Table 6-3 Rehabilitation Priority Setting Criteria 62
Table 6-4 Rehabilitation Priority Setting Results 63
Table 7-1 Recommendations 66
Table 9-1 Summary of Priorities 70
Table 10-1 Implementation Responsibilities 72

List of Figures

Figure 2-1 Burra Township Catchment Area 9
Figure 2-2 Monthly Rainfall and Evaporation 10
Figure 2-3 Location of Permanent Pools in Burra Creek Catchment 13
Figure 3-1 Spatial Location of Existing Stormwater Infrastructure 17
Figure 4-1 Flood Inundation Extent – Burra Creek Flooding 100 Year ARI Flood 19
Figure 4-2 Flood Hazard Ratings (Adapted from SCARM 2000) 20
Figure 4-3 Flood Hazard Map – 100 Year ARI Event on Burra Creek 20
Figure 4-4 Flood Inudation Map – 100-Year ARI Event from Local Drainage System 21
Figure 4-5 Roads Not Safe for Traffic Movements During a 100-Year ARI Flood 23
Figure 6-1 Flood Warning Damage Savings (Bureau of Transport Economics (2001)) 35
Figure 6-2 Flood inundation map pre levee works 100 year ARI flood 38
Figure 6-3 Burra River Levee Map Extent of Works 39
Figure 6-4 Flood Inundation Map Post Levee Works 100-Year ARI Flood 40
Figure 6-5 Flood Inundation Map for Burra Creek Tributary Crossing Queen Street and Chapel Street with the Existing Infrastructures 42
Figure 6-6 Flood Inundation Map for Burra Creek Tributary Crossing Queen Street and Chapel Street with the Mitigation Levee 43
Figure 6-7 Flood Inundation Map for Paxton Terrace Drainage System with the Existing Infrastructures 44

Figure 6-8 Flood Inundation Map for Paxton Terrace Drainage System with the Mitigation Measures..... 45
Figure 6-9 Flood Inundation Map for St Just Street Drainage System with the Existing Infrastructures 46
Figure 6-10 Flood Inundation Map for St Just Street Drainage System with the Mitigation Pit and Pipe System47
Figure 6-11 Flood Inundation Map for Tregony Street Drainage System with the Existing Infrastructures 48
Figure 6-12 Flood Inundation Map for Tregony Street with the Mitigation Infrastructures..... 49
Figure 6-13 Flood Inundation Map for Goyder Hwy and Stronach Street Drainage System with the Existing Infrastructures 50
Figure 6-14 Flood Inundation Map for Goyder Hwy and Stronach Street Drainage System with the Mitigation Infrastructures 51
Figure 6-15 Pre and Post Works Road Trafficability Map 53
Figure 6-16 Proposed Location of the Spring Street Wetland 56
Figure 6-17 Riparian Rehabilitation Reaches..... 60
Figure 6-18 Riparian Works Program Outline..... 64

Appendices

Appendix A: Flood Inundation and Flood Hazard Maps

Appendix B: Flood Hydrology Review

Appendix C: DRAINS Catchment Parameters

Appendix D: Revegetation Template

Appendix E: Assessment of Priorities

Appendix F: Implementation Plan

Appendix G: Riparian Survey

Appendix H: Flood Damages Methodology Summary

Appendix I: Community Feedback Submission and Table of Responses

1 Introduction

1.1 Background

The Regional Council of Goyder (Council) has engaged Water Technology Pty Ltd (formerly) Australian Water Environments Pty Ltd to collate a Stormwater Management Plan (SMP) for Burra.

Burra Township is located 162 km from the Adelaide CBD and is a well-known for its pastoral and historical mining past. The town itself is located on Burra Creek amongst the Bald Hill Ranges with adjacent hill slopes surrounding Burra.

The purpose of SMPs is outlined by the Stormwater Management Authority (SMA), as follows - to manage stormwater on a total catchment basis with the relevant Natural Resources SA board, local government authorities and state government agencies. The aim is to work together to develop, implement and fund a coordinated and multi-objective approach to stormwater management in the area. This allows for consistent management that addresses existing problems and identifies opportunities for providing a range of benefits through multi-objective planning, including stormwater reuse where feasible.

This SMP investigates ways to alleviate existing stormwater and flooding problems to provide flood protection for public and private assets. It aims to assess flood mitigation options, investigate opportunities for stormwater reuse, including Managed Aquifer Recharge (MAR), without compromising flow management or flood mitigation infrastructure. The SMP also explores opportunities for environmental enhancement in the design of stormwater infrastructure. Environmental enhancement may be in the form of improved water quality and reduced roadside erosion, and increased biodiversity. The SMP assesses and prioritises stormwater management options in accordance with the format recognised in the SMA's SMP Guidelines with verification against Council wide assessment criteria.

This SMP for Burra highlights a range of works that could be undertaken. The report therefore contains a range of recommended actions and suggests priorities for consideration.

However, it is likely that the availability and timing of funding and resources will also play a role in determining the order and staging of these actions and Council will require assistance in the form of funding and/or resources from stakeholders as well as funding from potential sources such as:

- Australian Government - grants and subsidies
- State Government of South Australia - grants and subsidies
- Private sector – developer contributions
- Council – administration, implementation and funding
- Community – volunteer support

The availability of resources from the above sources and the priorities of funding partner organisations will therefore also influence the final order in which works are undertaken.

1.2 History and Nature of the Problem in the Region

The township of Burra has experienced flooding since settlement, and this has become more apparent over recent years. Flooding events have been known to cause inundation and property damage, disruption to road and private infrastructure, including the main business district of Burra.

Much of the stormwater infrastructure in Burra is aging and in need of replacement. However, design details and drainage service standards have not been regularly recorded and documented making it difficult for Council to determine appropriate strategies for the upgrade of the stormwater network and addressing issues of flooding in the township. Due to the historical nature of Burra Township, there are features such as the bluestone edging that is required to be preserved. This adds some unusual complexity to stormwater management approaches.

Furthermore, Council's flood mapping for the Burra Creek is limited. Council has limited details regarding the magnitude (and severity) of flooding in the township of Burra. This lack of critical flood mapping for the township of Burra makes it difficult for Council to make informed decisions on stormwater infrastructure replacements and upgrades.

Current flooding in Burra is mainly caused by fluvial flooding from overflows of the Burra Creek and its tributaries and by local flooding from runoff generated from the hill slopes adjacent to the town during large rainfall events. The community of Burra is either directly or indirectly affected by stormwater flooding.

In the region's 1993 floods, the banks of Burra Creek were broken at several locations, and the township was impacted mainly from overflowing and flooding across roads, private property and business district.

There have also been examples of flooding from the smaller tributaries most notably in 1983 when heavy thunderstorms created localised flooding issues for Burra, particularly along Commercial and Thames Streets.

Council is also concerned about the quality of water in the river system and the impacts the town may be having on water quality, particularly with respect to downstream ecosystems.

1.3 Consultation and Development of Plan

Council was successful in applying for funding from the SMA's Stormwater Management Fund to assist in preparing the floodplain mapping and this SMP.

The SMP was developed under the direction of a Project Steering Group / Committee, comprising staff from the Council, Department of Planning, Transport and Infrastructure (DPTI) on behalf of the SMA, and Department of Environment, and Natural Resources (DEWNR) on behalf of Natural Resources the SA Murray-Darling Basin.

1.4 Legislative Context

The Local Government (Stormwater Management) Amendment Act 2007 came into operation on 1 July 2007. This established the Stormwater Management Authority and new financing and governance arrangements for stormwater management and flood mitigation throughout South Australia.

The SMA implements the Stormwater Management Agreement and operates as the planning, prioritising and funding body in accordance with the Agreement. The SMA is charged with:

- Working with Councils to facilitate and coordinate catchment stormwater management planning;
- Allocation of State funding to projects in coordination with Council and other sources of financing; and

- Facilitating cooperative action by all relevant public authorities in the planning, construction and maintenance of stormwater management works.

The framework established by the Stormwater Management Act requires councils to prepare stormwater management plans on a catchment basis, and to implement infrastructure works in accordance with the catchment plans.

The process and content by which stormwater management plans are developed have been formalised by the State Government via the SMA in a guideline entitled Stormwater Management Planning Guidelines.

South Australia's legislative framework provides a number of other legislative tools and policy tools to address water management ranging from state-wide legislation to regional and local policy.

One of the key mechanisms for achieving the desired outcomes of integrated water management is to ensure that the objectives of the stormwater management plan meet and contribute to other State and National natural resource management policies and strategies. These strategies in turn assist in the implementation of the desired water management outcomes for townships.

This SMP has been developed in accordance with the requirements of the Stormwater Management Planning Guidelines.

2 Description of Catchment Area

2.1 Study Area Boundary

Burra Township is located 162 km from the Adelaide CBD and is a pastoral and historical tourist town in the mid-north of South Australia, including churches, cemeteries, railway structure, historic mining buildings and mines and dwellings. It lies east of the Clare Valley in the Bald Hills ranges, part of the northern Mount Lofty Ranges, and on Burra Creek.

The area for stormwater management plan is shown as outlined in Figure 2-1.

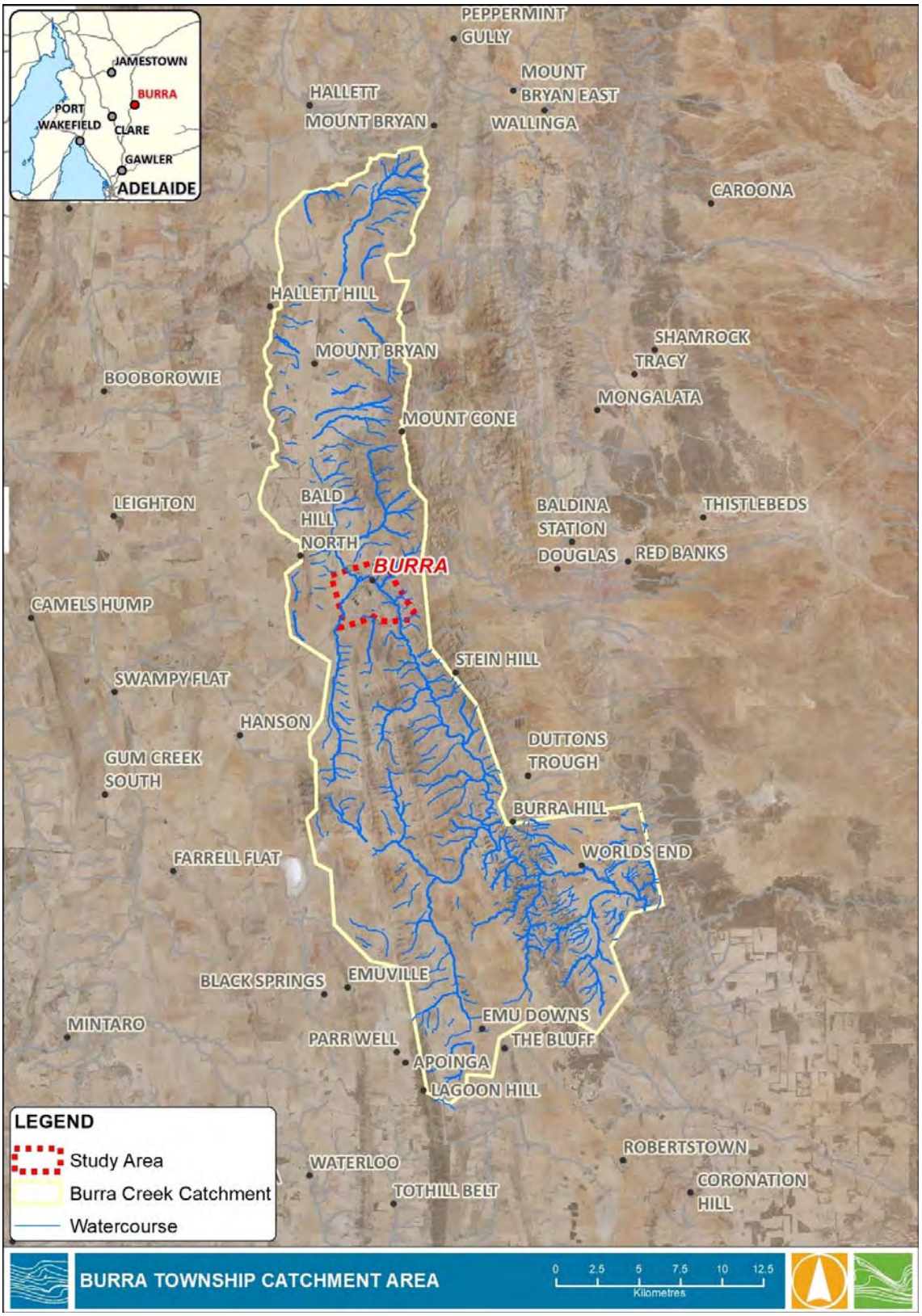


FIGURE 2-1 BURRA TOWNSHIP CATCHMENT AREA

2.2 Land Use

Burra town began as a single company mining township by 1851. When the mine was exhausted and closed, the population reduced but the township has continued to support regional pastoral and agricultural activities. Today the town continues as a centre for its surrounding farming communities and, being one of the best-preserved towns of the Victorian era in Australia, as a historic tourist centre.

2.3 Climate

The climate in the study area is semi-arid but follows broadly Mediterranean patterns of hot, dry summers (low rainfall) and cool, relatively wet winters. Although the predominant wet period is during winter-spring, summer storms can deliver large volumes of water during short periods of time resulting in extreme flood events in the catchment. The most significant flooding of the past four decades occurred during January 1993.

The long-term average rainfall information for Burra (based on data from the Bureau of Meteorology (BoM)) is approximately 430 mm per annum. The average monthly rainfall and evaporation is shown in Figure 2-2. The average precipitation for each month shows that most precipitation occurs in the 6-month period between May and October. The total precipitation in this period is distributed relatively evenly across each month. The lowest rainfalls throughout the region occur from January through to March.

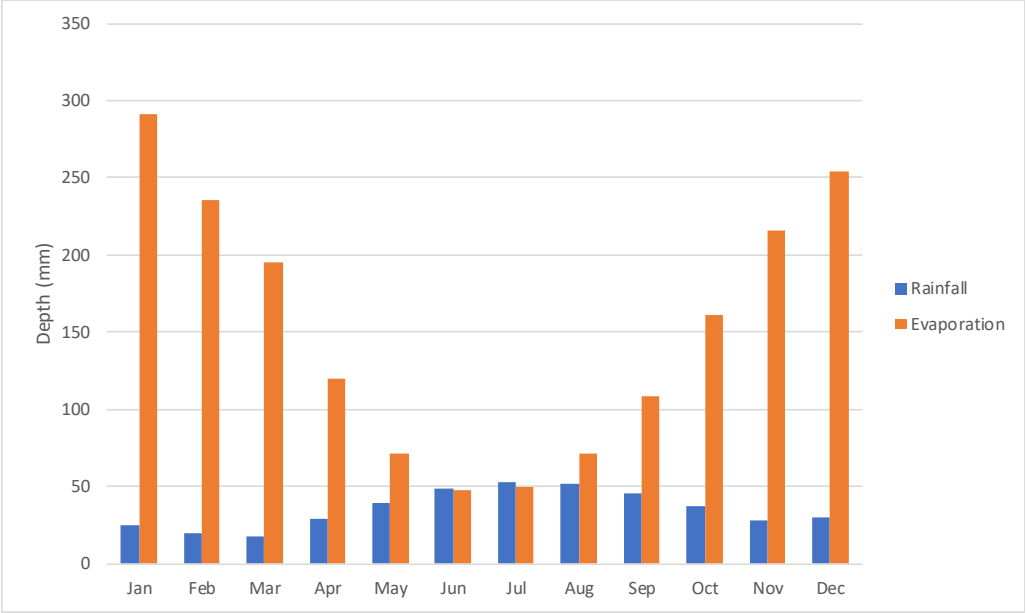


FIGURE 2-2 MONTHLY RAINFALL AND EVAPORATION

2.4 Rainfall Record

There was identified to be a lack of suitable rainfall gauges/stations (which provide daily rainfall data and some pluviometer data) around the Burra Creek catchment. On this basis it was determined that any attempts to calibrate the hydrological model to a single or multiple high flow events would produce results of little value due to the uncertainty around rainfall inputs. Therefore, a range of design rainfall durations along with the related rainfall intensities were used for this SMP. The design rainfall intensity was estimated based on 2016 rainfall IFD data obtained from BoM.

2.5 Streamflow Record

A streamflow gauge used as part of the calibration downstream of Burra Creek at the Worlds End (A4260536), operated by DEW (Department for Environment and Water), has a length of available streamflow data, 36 years (1974 to 2009). Operation of the flow gauge has not been continuous, with its closure in 2009. Whilst the gauge is no longer operated, it has still provided a useful source of data to support hydrological assessments for this SMP.

TABLE 2-1 FLOW GAUGES

Flow Gauging Station No.	Station Name	Data Availability	River
A4260536	Burra Creek at Worlds End	January 1974-July 2009	Burra Creek

In addition, DEW has operated (and continues to do so) several project related gauges upstream and downstream of the towns ship. These are of limited value for flood frequency analyses because of their length of record and poor rating information. However, data from the gauge located at the Just Street Ford (A4261149) was able to be used to assist in the estimation of low flows for water quality modelling purposes.

2.6 Geology and Soil Structure

The township of Burra is located within the Adelaide Geosyncline which comprises a thick sequence of variably folded and faulted sedimentary layers including slate, quartzite, tillite and dolomite. Sediments of the Burra Group dominate the local geology within 5 km of Burra township.

The hydrogeology of the district has been thoroughly analysed and reported in Deane et. al. (2008) and the following discussion provides a summary of this information.

The dominant aquifers within the district are fractured slate, sandstone, calcareous siltstone and carbonates. These are generally of low yield (due to low fracture density) and of marginal quality and are also difficult to predict in terms of the extent of fracturing and distribution of water quality.

The dominant aquifer is the Skillogalee Dolomite which represents a localised, highly transmissive zone due to localised faulting and dissolution. This formation hosted the copper deposits mined in the Burra open cut and dewatering of this unit was required to facilitate mining.

Shallow stony loamy soils with loamy texture contrast soils characterize hillslopes. Deep sandy loam texture contrast soils, and deep gradational sandy loams to loams occur on lower slopes and flats.

The Burra Creek land system comprises undulating to steep land grading to the main creek channel. The steeper slopes are very rocky, and much of the gentler sloping land is only semi arable due to the rocky outcrop and shallow stony soils. The deeper soils are highly erodible and there is evidence of significant erosion on the past. Given the nature of the soils, the slopes, erosional history and marginal rainfall conditions, there is only limited potential for cropping. Careful grazing management is needed to maintain protective surface cover and to prevent further water course erosion.

2.7 Population and Likely Future Growth

Burra comprises two Census Collector Districts: 4030604 and 4030605, and in the 2006 Census there were 978 persons usually resident in Burra. Of this population, 15.5% were children aged between 0-14 years and 36.6% were persons aged 55 years and older. This is a decrease of 38 persons since the 2001 Census. The median age of persons in Burra in 2006 was 46 years, compared with 37 years for persons in Australia.

Council's Strategic Directions Report 2012/13 included information on population projections and stormwater management derived from its Water Supply Investigation (2005) and the Draft climate Change and Natural Resources Management Plan (January 2011). Using a base population of 978 persons in 2006, it is projected that the population of Burra will be 1185 in 2036, which represents an increase of 207 people should Burra grow at the same rate of increase in population for Yorke and Lower North Statistical Division to the 2006 population of Burra at 5-yearly intervals. (*Source: Population Projections for South Australia and Statistical Division, 2006-36 (Medium Series), December 2010 release (Department of Planning and Local Government, Government of South Australia 2010)*).

However, in terms of growth, Burra is not seen as a major 'growth' centre and has actually experienced a decline in population in more recent times. Nevertheless, it is remains important for Burra to retain and enhance its historic town centre and village character. This will be balanced with promoting increased tourism services, attractive town entries and rural hinterland, whilst still allowing for modest, managed residential growth should that eventuate. Suitable infill opportunities exist, as well as existing and proposed rural living development land options, to cater for modest growth in line with what might be expected by Council and the community.

A series of policy improvements and zoning considerations have been explored over recent years and Council completed its review of Development Plan and various amendments, with the consolidation of its Development Plan occurring in November 2016.

Council's Development Plan in accordance with the *Development Act 1993* contains a wide range of general provisions that are designed to achieve a balance between development whilst also promoting the biodiversity of the region, as well as protecting the natural resources on which the economy of the region is heavily reliant on, whilst also ensuring people and properties are protected from flooding (and other hazards).

2.8 Catchment Condition and Receiving Environments

The Burra Creek catchment arises in undulating terrain surrounding Mt Bryan, north of Burra, and is aligned north south from its upper catchment to the Burra Gorge. Here, its alignment turns east west as it passes between the rocky ridges on the eastern side of the Mount Lofty Ranges and out to the Murry Darling Depression. Whilst considered part of the Murray-Darling Basin, surface flows from the catchment to the main stem of the river area as the lower reaches are essentially floodout plains and lack defined drainage. The last time that catchment-wide flow is known to have reached the River Murray was in 1941, although it is thought to have occurred a number of times prior to this since European settlement.

The key biodiversity asset in the catchment is the permanent groundwater dependent ecosystem south of Burra, comprising deep pools linked by the permanently flowing creek (see Figure 2-3). Permanent water refuge sites provide a point from which water dependent organisms can redisperse out into the landscape when high flow events occur. The Burra Creek pools are

ecologically significant for their potential ability to support different suites of species as water level, flow and water quality change. Sites of permanent water are significant in the terrestrial landscape as a source of water for birds and reptiles and mammals whose feeding ranges and paths of migration may be partially defined by the spatial distribution of water.

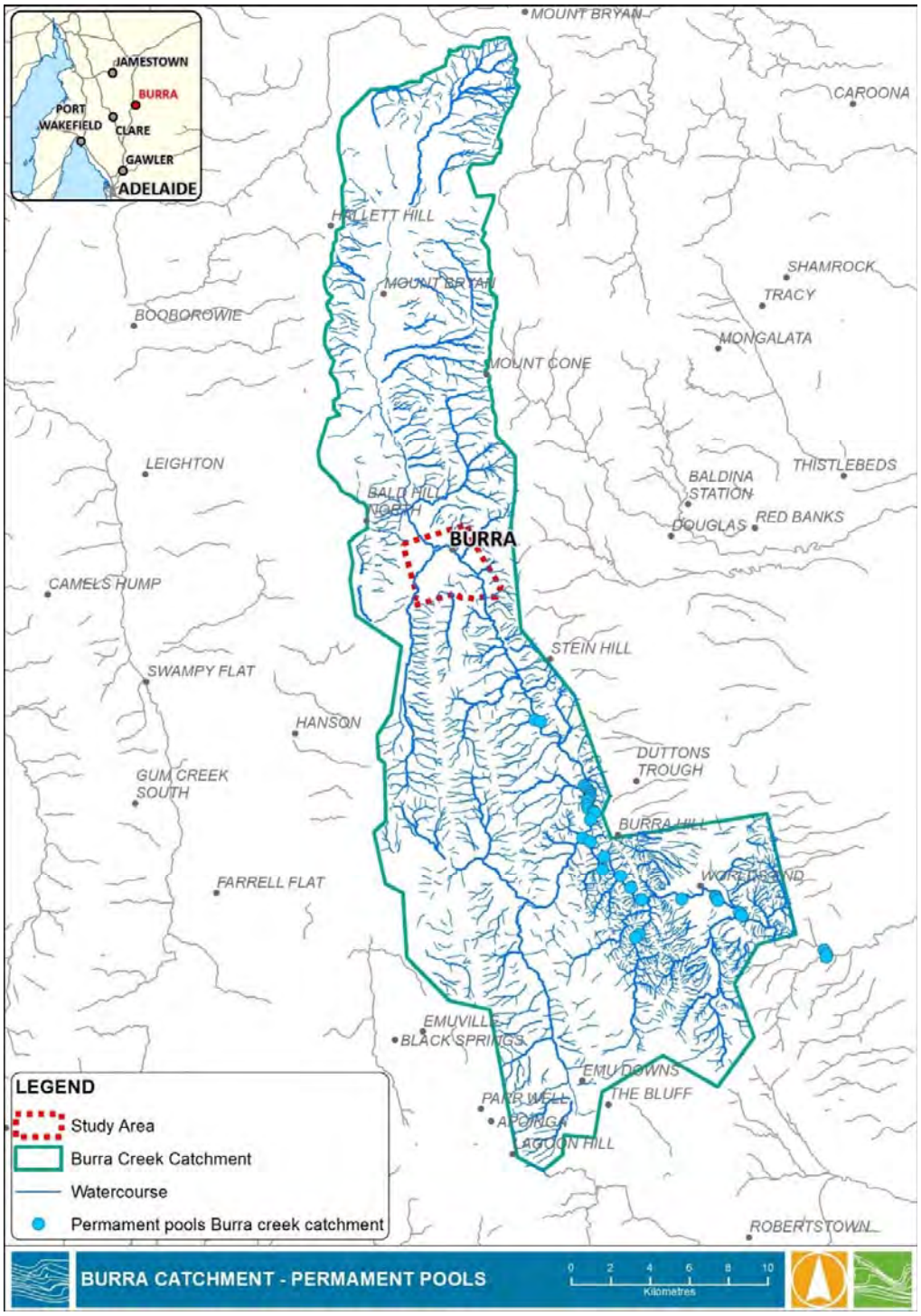


FIGURE 2-3 LOCATION OF PERMANENT POOLS IN BURRA CREEK CATCHMENT

Much of the Burra Creek catchment has been cleared and is grazed. In many places along Burra Creek riparian vegetation is reduced to scattered River Red Gum (*Eucalyptus camaldulensis*) canopy with an understorey of introduced grasses. The Burra Gorge retains some more diverse riparian understorey including Native Myrtle (*Myoporum mountanum*), native herbs and sedges. The permanent pools frequently support Common Reed (*Phragmites Australis*) and Bulrush (Typha sp) with some occurrences of Shore Clubrush (*Schoenoplectus litoralis*) and Spiky Clubrush (*Schoenoplectus pungens*). Beds of Sea Rush (*Juncus Kraussii*) and Spiny Flat Sedge (*Cyperus Gymnocaulos*) may be present in riparian areas that have lower grazing pressure. Areas of permanent water support aquatic submerged species such as Chara, Nitella and Triglochin sp. The saline lower catchment pools support Ruppia maritima, and important food source for waterbirds.

Burra Creek in the vicinity of the main township of Burra has recently been the subject of a concept plan aimed at improving both amenity and biodiversity value. Any water requirements of the revegetation undertaken as part of the redevelopment should be considered in any future water resource management of Burra Creek.

Environmental Values

Environmental values are those that the community place on the environmental services. The strategy underpinning the determination of the environmental values for the SMP is the National Water Quality Management Strategy (NWQMS).

The main objective of the strategy is to enable Council and community groups to ensure the health of water bodies and waterways nationally. These objectives are (but not limited to):

- To ensure the water quality monitoring of waterways and regulation for the discharging of pollutants into waterways adheres to the agreed water quality objectives;
- Provide a strategic direction for the management of all watercourses as well as protecting ecosystems and not compromising the economic wellbeing of the community; and
- Prioritise funding for environmental management which will ultimately lead to improved water quality.

Environmental values, consistent with the National Water Quality Management Strategy (Agriculture and Resource Management Council of Australia and New Zealand, 1994) were established for Burra, in consultation with the Steering Committee and the local community.

The agreed environmental values are identified in the table that follows.

TABLE 2-2 SURFACE WATERCOURSES ENVIRONMENTAL VALUES

Environmental Values	Supporting Details
Aquatic Ecosystems	Supporting pristine or modified **Aquatic Ecosystems – HD (see below)**
	Highly disturbed systems (**HD**). These are degraded systems likely to have lower levels of naturalness. These systems may still retain some ecological or conservation values that require protecting. Targets for these systems are likely to be less stringent and may be aimed at remediation and recovery or retaining a functional but highly modified ecosystem that supports other environmental values also assigned to it (e.g. primary industries).
Primary Industries	**Irrigating** crops such as vines, lucerne, etc
	Water for **farm use** such as in fruit packing or milking sheds, etc
	Stock watering
Recreation & Aesthetics	**Secondary recreation** with indirect contact with water such as boating, canoeing or sailing
	Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing
Cultural & Spiritual	**Cultural and spiritual** values including the cultural values of traditional owners

The above environmental values should be protected from the effects of pollution and waste discharges. Some of the environmental values are more tolerant to changes in water quality than others which may be more vulnerable.

The National Water Quality Management Strategy does not try to rank different values – it assigns water quality targets to meet each specific environmental value. The water quality targets are then assigned to the resource based on the quality required to meet all the different environmental values. This typically results in the “Aquatic Ecosystems” values setting the resource targets because these are usually the most stringent. Adopting a “Highly Disturbed” rating for “Aquatic Ecosystems” results in less stringent targets than if moderately disturbed or slightly disturbed ratings were adopted.

3 Existing Stormwater Infrastructure

The existing stormwater network within Burra is largely limited to overland flow through open channels or roadside drainage. Underground drainage is limited to short sections of pipe and under road culverts. Flow is largely conveyed via channels which discharge directly to Burra Creek. These channels flow primarily through vacant allotments in both the north and south of the township. A number of the channels are under capacity and require augmentation or upstream detention to mitigate against flooding.

There is also evidence of erosion just downstream of the weir on Burra Creek which requires stabilisation.

Based on the multiple site inspections conducted by Water Technology, data supplied by Council and a range of stakeholders and anecdotal evidence, the relative lack of a formal drainage infrastructure is contributing to the magnitude of the flooding issue in Burra. Council is progressively dealing with these drainage deficiencies on a case by case basis.

Existing stormwater infrastructure is shown in Figure 3-1.

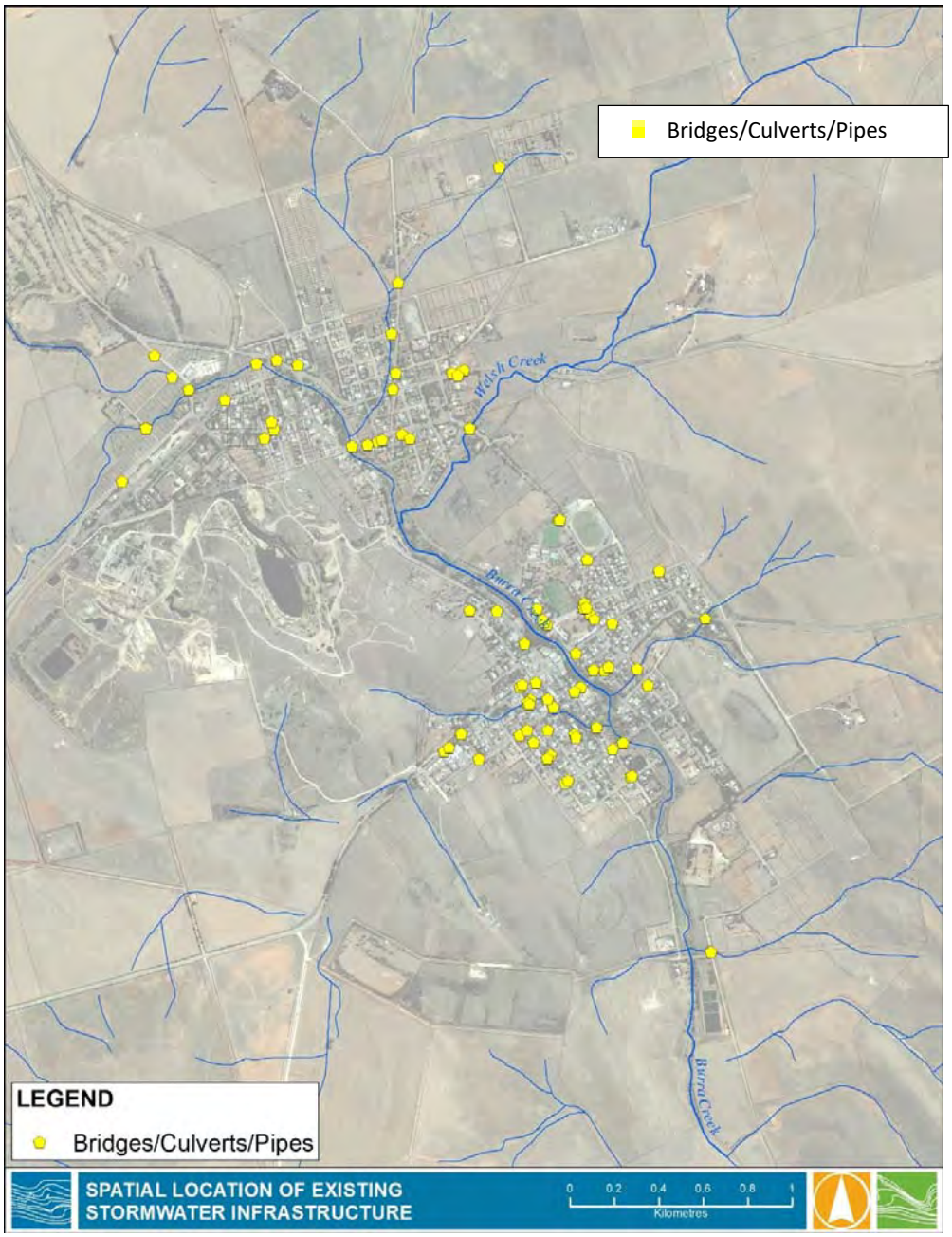


FIGURE 3-1 SPATIAL LOCATION OF EXISTING STORMWATER INFRASTRUCTURE

Council has recognised the need to gather more detailed information with respect to its drainage infrastructure and has initiated a separate investigation to collect and document these details.

4 Identification of Problems and Opportunities

4.1 Potential for Flooding within the Catchment

4.1.1 Floodplain Hydraulic Modelling and Mapping Overview

The floodplain hydraulic modelling work comprised of:

- Floodplain mapping to show riverine flooding from the Burra Creek; and
- Flood mapping for localised rainfall events over the town and from local catchments surrounding the township. This mapping highlights the performance of the local stormwater drainage network.

Regional flooding from Burra Creek used the hydrological model XPRAFTS to estimate the 1 in 20, 50, 100 year ARI events, while local township runoff and runoff surrounding slopes were estimated from a series of DRAINS models, which estimated flow paths and flood extents for the 1 in 2, 5, 20 and 100-year ARI floods.

Hydrographs from the DRAINS and XPRAFTS models were used as input boundary conditions for a new TUFLOW model that was developed to assess the mitigation options for reducing flood risk from the Burra Creek, as well as for testing and improving the local drainage system performance.

Topographic information was obtained for the study area through a series of soft photogrammetry analyses. The soft photogrammetry picked up spot height information from aerial photography with the following characteristics:

Accuracy:	10cm resolution
Horizontal:	+/- 0.1m RMSE
Vertical:	+/- 0.08m (68% c.i., 1σ)
	+/- 0.17m (95% c.i., 2σ)
	0.5m contour interval with a network of ground control points

Flood inundation maps (for existing conditions scenario) are provided in Appendix A. The inundation extents for the 100-year ARI flood from the Burra Creek is also illustrated below in Figure 4-1.

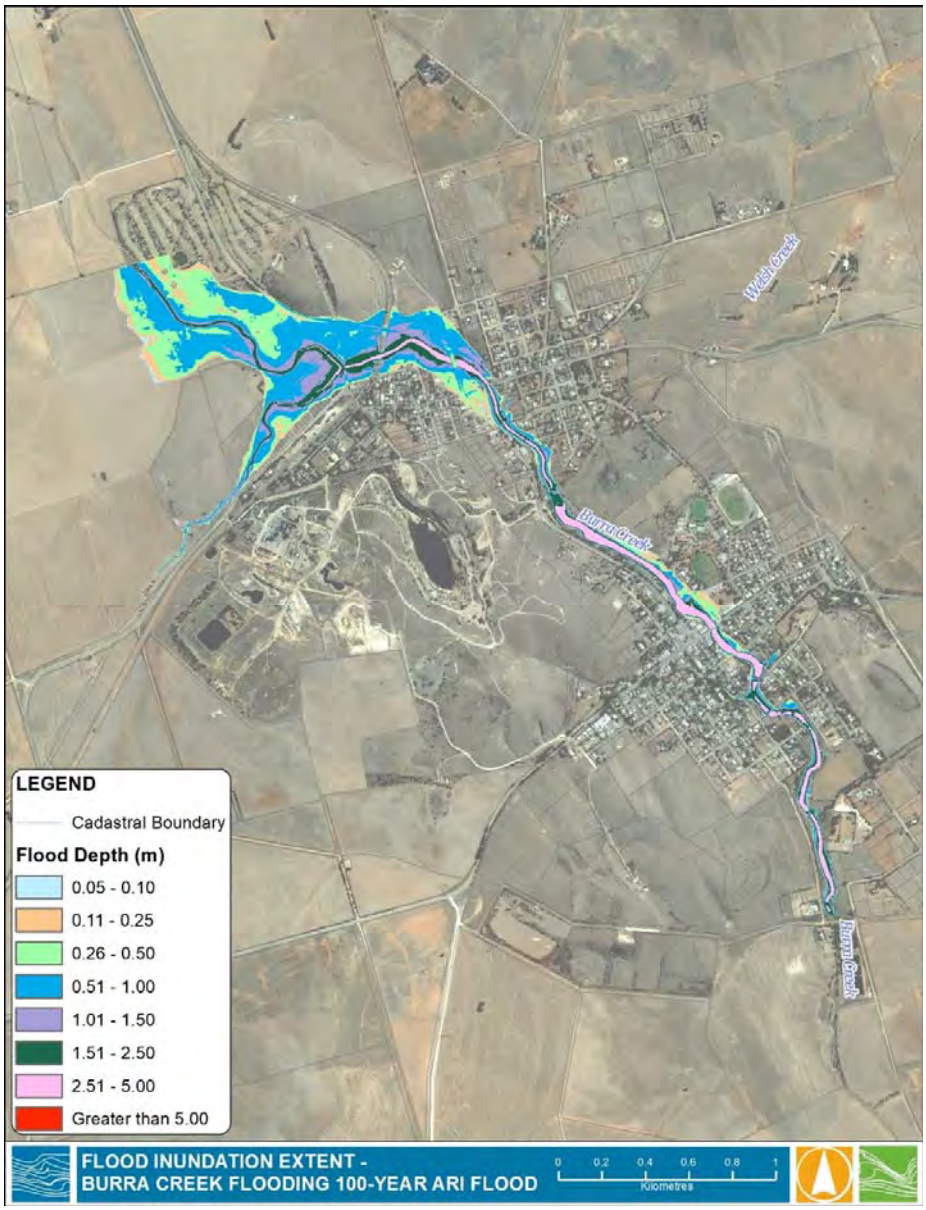


FIGURE 4-1 FLOOD INUNDATION EXTENT – BURRA CREEK FLOODING 100 YEAR ARI FLOOD

4.1.2 Floodplain Hazard Mapping

Flood hazard mapping assesses the combined effects of flood depth and velocity on hazard to people and property. Hazard was classified by the rating system, illustrated in the Flood Hazard Ratings figure below (Figure 4-2). This classification was based on SCARM Report 73, Floodplain Management in Australia (SCARM 2000).

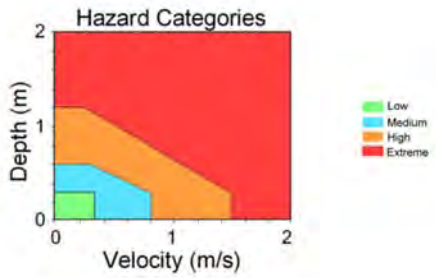


FIGURE 4-2 FLOOD HAZARD RATINGS (ADAPTED FROM SCARM 2000)

A flood hazard map for the 100-year ARI flood event for the Burra Creek through Burra is presented in Figure 4-3.

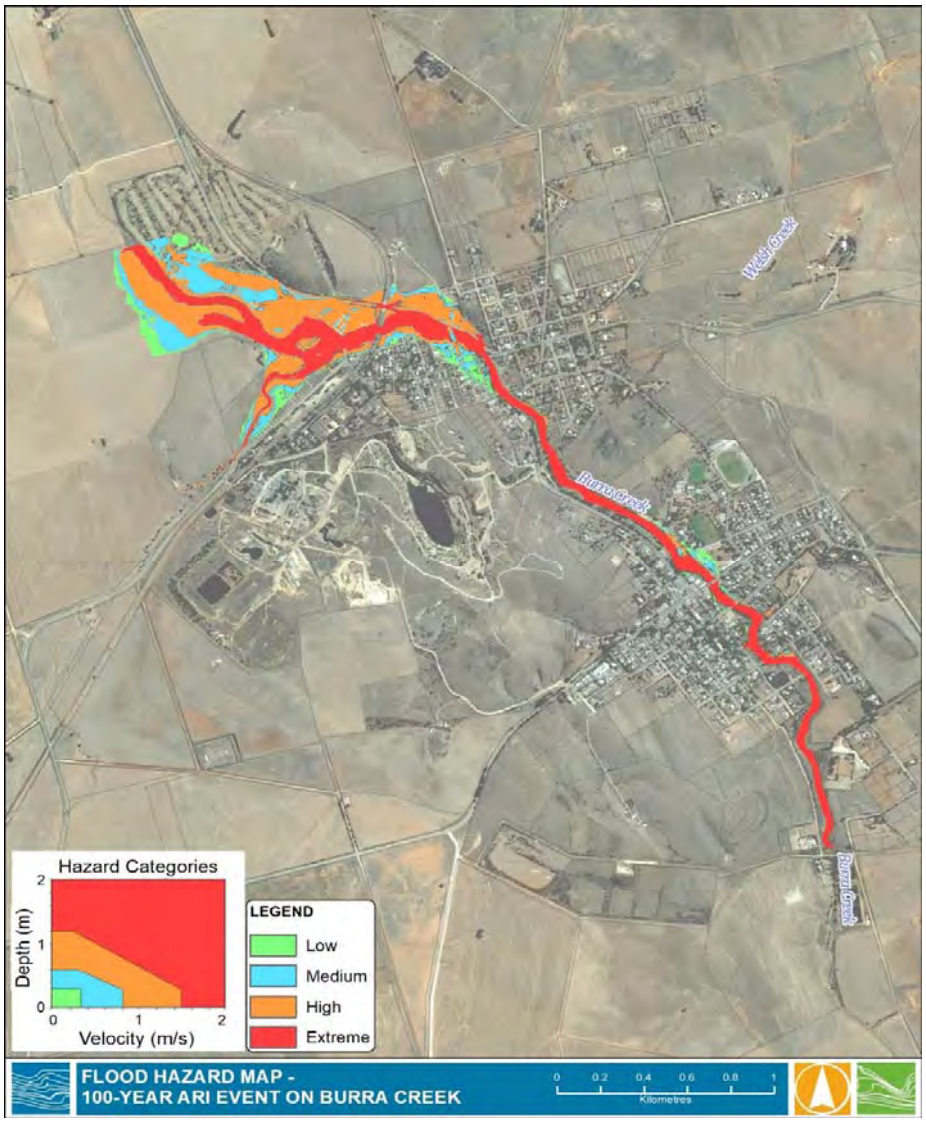


FIGURE 4-3 FLOOD HAZARD MAP – 100 YEAR ARI EVENT ON BURRA CREEK

4.1.3 Local Flooding

Flooding from the surrounding areas and rainfall falling directly over the township of Burra was estimated through the combined use of a DRAINS model and TUFLOW. The stormwater system assets gathered by the Council were built into the TUFLOW model and the system performance was tested. The estimate flood extents for a localised 100-year ARI storm over Burra is presented in Figure 4-4.

The DRAINS model catchment delineation and catchment statistics are provided in Appendix C.

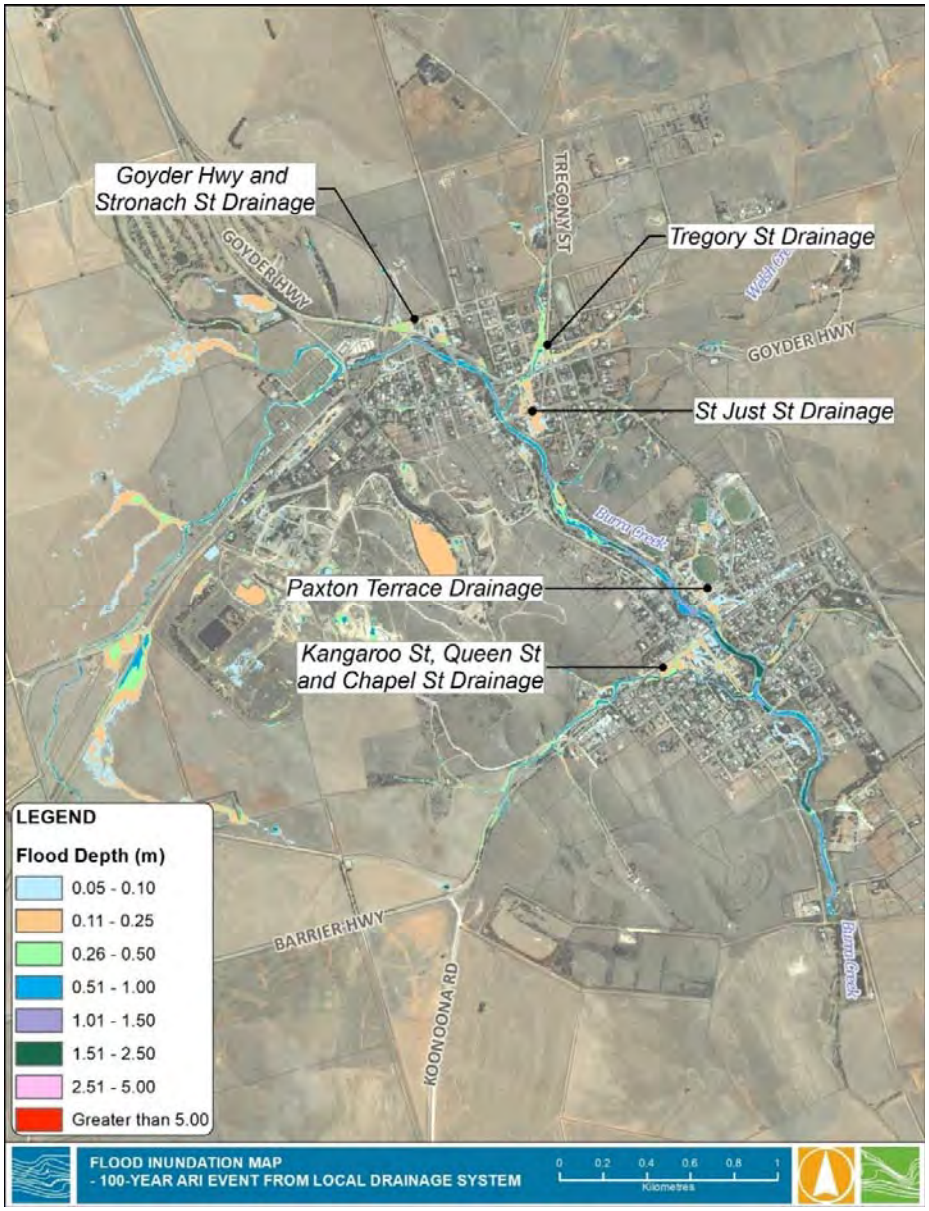


FIGURE 4-4 FLOOD INUDATION MAP – 100-YEAR ARI EVENT FROM LOCAL DRAINAGE SYSTEM

The above process highlighted a number of areas where the Council internal drainage system can become compromised during an intense local storm, as illustrated above.

Furthermore, the process highlighted which parts of the street drainage system can be expected to restrict traffic movement through the town. A road traffic-ability map for the 100-year ARI local and Burra Creek flood events is presented in Figure 4-5, which delineates those sections of road which would be considered unsafe for traffic movements.

It should be noted that the trafficability and inundation maps exclude water depths less than 50 mm (recognising that this is the limit of modelling reliability given the available ground elevation data).

Also, the modelling assumes that culverts and pipes are able to flow and are not blocked, hence it is possible that there will be other sections of road that become impassable should obstructions block culverts or significantly impede flow over and above constrictions that are normally present (it is understood that trafficability was compromised historically along other areas of Commercial Street not shown in mapping, and it is expected that these depths were either shallow or caused by unexpected blockages).

FIGURE 4-5 ROADS NOT SAFE FOR TRAFFIC MOVEMENTS DURING A 100-YEAR ARI FLOOD

4.1.4 Opportunities

The SMP can assist with achieving improved protection from flooding by providing guidance on:

- Formulising drainage paths to limit flooding of properties in the township;
- Ensuring drainage infrastructure is appropriate for conveying flows, eg culvert capacities;
- Appropriate finished floor levels to prevent over bank flooding from the tributaries entering buildings in the town;
- Reducing any restriction to flows caused by inefficient drainage systems; and
- Options for mitigating flooding.

The SMP can also seek opportunities to support Council's Development Plan regarding hazards (such as flooding) as well as the promotion of Water Sensitive Design and good Water Catchment Area management through the general provisions of its Development Plan.

4.2 The Impact of Flooding

Flooding in Burra has been caused by a number of factors, such as overflows of the Burra Creek and its tributaries and inadequate stormwater drainage infrastructure within the town. Flooding events have been known to cause inundation and property damage, as well as disruption to road and other infrastructure.

The local community has raised concerns about poor performing drainage infrastructure. Similarly, flows along Burra Creek and its tributaries can overtop the banks causing inundation of roads and backyards.

Flood maps and aerial photography were used to identify properties at risk of flooding in each hazard zone. The number of properties in Burra currently at risk of (overfloor) flooding in a 100 year ARI event is shown in Table 4-1.

TABLE 4-1 PROPERTIES AT RISK OF OVERFLOOR FLOODING IN A 100 YEAR ARI EVENT

Burra Creek and Tributary Flooding	No. of properties at risk of flooding for various Floods		
	5% AEP	2% AEP	1% AEP
Dwellings	15	27	54
Commercial/Industrial Buildings	7	28	31

The number of people at risk of flooding in a 100 year ARI event was determined by analysing the number of dwellings at risk of flooding (50 dwellings) and the average number of people per dwelling, which according to the Australian Bureau of Statistics 2011 Census is an average of 2.5 people per dwelling in Burra (ABS, 2013). Therefore, there are nearly 125 people at risk of flooding in Burra in a 100-year ARI flood event.

Economic Issues

The estimated potential physical flood damages from a 100 year ARI flood in Burra are in the order of 3.5 million dollars. (Refer Appendix H for methodology). Flood damage unit rates used in the calculations are presented in Table 4-2.

TABLE 4-2 FLOOD DAMAGES CALCULATIONS UNIT RATES FOR DIRECT TANGIBLE LOSSES

Item	Unit	Rate
Sealed Road	km	$25,000
Unsealed Road	km	$11,000
House over floor flooding	per house	$32,500
Commercial Building	per building	$20,900
Grazing Land	ha	$300

The improved flood protection strategies in this SMP are expected to reduce property damages, road damages, damage to goods and possessions, loss of income or services, as well as response and recovery costs. This will result in savings for Council and people.

Social Issues

The social impacts of flooding and poor stormwater management are often difficult to quantify in monetary terms. These impacts are related to the physical and mental health of individuals, environmental impacts and disruption to essential community services and operations. They can include aspects such as the following:

- Loss of life, personal injury and associated losses and expenses;
- Destruction of memorabilia (e.g. family photos);
- Loss of heritage and cultural features;
- Loss of amenity, recreational value and aesthetics;
- Increased medical costs and reduced life expectancy associated with increases in levels of sickness in a community following a disaster;
- Emotional stress and mental illness associated with experiencing damage to family homes and businesses, including:
    - Replacement of damaged property, particularly if there is no flood insurance or it is insufficient;
    - Living in temporary accommodation;
    - Children attending a different school;
    - Death of pets; and
    - Loss of business goodwill.
    -

Opportunities

The SMP can assist with addressing/improving drainage, development, economic and social issues by providing practical and cost-effective options to mitigate flooding, providing guidance on planning/development controls, and options for the community to adopt in order to be better prepare for flood events.

4.3 Opportunities for Better Managing Flood Risk

This SMP explores opportunities for better managing the risk of flood, including structural and non-structural flood mitigation measures. Non-structural measures include aspects such as flood

preparedness and better integration between stormwater management, Council's Development Plan and development/planning controls.

Structural mitigation measures are to focus on detaining peak flows and upgrading infrastructure, particularly to address flooding issues from the Caravan Park of Burra, as well as more effective management of street drainage.

4.4 Impacts of Future Development on Flooding

It is understood that Council's desire is for Burra to retain its village character, but still to allow for managed growth to support the economic prosperity of the region.

To this end Council has rezoned land considered suitable for further development in its Regional Council of Goyder Development Plan (2016) and made provision for the management of water resource and biodiversity impacts, as well as flood hazards though its Development Plan and Development Assessment processes.

It is important to understand what impacts future development may have on flooding. Any development will need to take into account the flood extent and depth maps prepared for this SMP to reduce the risk of being flooded, as well as to reduce any impact they may have on flood paths and flood behaviour.

The Development Plan does not include Floodplain Mapping, and Council has required this SMP to investigate ways to alleviate existing stormwater and flooding problems to provide flood protection for public and private assets.

Discussions with Council staff indicate that Burra has experienced a decline in population and growth in recent years and has not been experiencing any pressures for "urban" consolidation. Furthermore, Council's Development Plan includes requirements on developers to ensure there are no net increases in runoff because of development and hence no future development impacts are expected requiring addition al measures to be included within this SMP.

4.5 Stormwater Quality within Streams and Receiving Waters

Issues

Erosion becomes a problem when it is significantly exacerbated by human activities that alter stream flows or directly impact on the channel, such as vegetation clearance, grazing, in-stream infrastructure and watercourse excavation. Loss of sediment from bed and banks results in poor water quality and sedimentation of pools, riffle zones and other important aquatic habitats. Watercourse flow is a major factor in bank erosion. Poorly aligned road and drainage infrastructure can lead to bank erosion. For example, under-sized culverts that cannot cope with storm drainage can result in flooding and damage as water overtops the structure. Poorly aligned structures can redirect stream flow into the bank causing bank erosion, and other poorly designed structures can result in bank scouring and erosion downstream. It is therefore important that in-stream infrastructure at Burra is positioned correctly within the watercourse and constructed at a capacity to handle expected flood flows.

Surface water quality in the Burra Creek catchment is understood to be highly variable and very dependent on flow. Measures to control erosion and sedimentation arising from stormwater and flooding in Burra can help protect water quality and ecological health of these downstream environments. Land management practices can also impact on watercourse vegetation, surface runoff and stream flows, bed and bank erosion processes and water quality.

Opportunities

The SMP will ensure any proposed drainage infrastructure at Burra is fit for purpose so it can cope with the expected flood flow.

The SMP will explore a range of measures aimed at controlling erosion and sedimentation in Burra to help protect water quality and ecological health of these downstream environments. In addition, improvements in Council's development and planning controls can also be identified in the SMP to encourage and enforce appropriate land management practices.

Options are identified to better manage land to maintain and improve water quality where possible, such as establishing wetlands and roadside infiltration systems to provide a filtering function and to enhance the local visual amenity.

In addition, the design of stormwater infrastructure will consider potential environmental enhancement and benefits to watercourses and receiving environments, such as through stream rehabilitation, e.g. weed and exotic tree management programs, and improved methods of fencing along watercourses.

Government strategies and targets

Opportunities for improving water quality and the health of receiving environments will help to ensure that stormwater runoff does not impair the health of receiving environments, such as the Burra Creek. The SMP can assist this by estimating the quality of runoff and developing mitigation strategies aimed at protecting water quality. The SMP aims to reduce the pollutant load of stormwater and is guided by the State Government's targets for stormwater quality.

In addition, the SMP will help support the following Council Development Plan objectives:

- to protect natural resources, such as:

  Objective 2: Protection of the quality and quantity of South Australia's surface waters, including inland and underground waters.

- The Development Plan also includes principles of development controls that aim to manage the quality of stormwater runoff, such as:

  Water Sensitive Design -

  Principle 7: Development should be sited and designed to:

  (a) capture and re-use stormwater, where practical
  (b) minimise surface water runoff
  (c) prevent soil erosion and water pollution
  (d) protect and enhance natural water flows
  (e)protect water quality by providing adequate separation distances from watercourses and other water bodies
  (f) not contribute to an increase in salinity levels
  (g) avoid the water logging of soil or the release of toxic elements
  (h) maintain natural hydrological systems and not adversely affect:
  (i) the quantity and quality of groundwater
  (ii) the depth and directional flow of groundwater
  (iii) the quality and function of natural springs.

Water Catchment Areas

Principle 20: Development should ensure watercourses and their beds, banks, wetlands and floodplains are not damaged or modified and are retained in their natural state, except where modification is required for essential access or maintenance purposes.

The SMP aims to support the South Australian Murray-Darling Basin Natural Resources Management (SAMDB NRM) resource condition targets for a range of natural resources management issues - the most relevant issues and their targets are outlined below:

- Significant native species and ecological communities:
  - By 2030, increase the ecological function and resilience of native ecosystems, and make sure native species and ecological communities at lower or no greater risk of extinction.
- Sustainable and productive landscapes:
  - By 2030, protect and improve soil and land to support the productive capacity and natural resources of the region.
- A clean and healthy atmosphere with effective adaptation to climate change:
  - By 2030, reduce net greenhouse gas emissions in the SA Murray-Darling Basin in line with state targets.
  - By 2030, all natural resource managers have the capacity to adapt to climate change impacts.
- Communities contributing to the management of natural resources:
  - By 2030, people have the capacity to manage natural resources sustainably.
  - By 2030, all planning, policy and investment decisions consider natural resources management (ecological, social and economic).

The newly formed Northern and Yorke Landscape Board is yet to set new resource condition targets, hence those of the previous SAMDB NRM remain relevant to this SMP.

4.6 Opportunities for Stormwater Reuse

Opportunities for stormwater harvesting and reuse will help to support the Government strategies described below.

- The South Australian Government's Stormwater Strategy (2011) has targets for the Greater Adelaide region as well as providing the basis for stormwater management in regional areas of the State. It supports the State Government's water security plan "Water for Good" (2009) target of harvesting 15 GL/year in regional areas by the year 2050.
- The Regional Council of Goyder (Council) and the community engaged Australian Water Environments (AWE) to develop an Integrated Water Management Plan (IWMP) for Burra (2012) with the aim of water-proofing the region. This is to be done by diversifying the availability of water resources via assessing the future water requirements of the region; identifying future potential water sources, including those created through stormwater capture and wastewater treatment and reuse; and identifying the appropriate strategies to secure water appropriately to enable future supply and demands.
- Council's Development Plan encourages development to be sited and designed to capture and re-use stormwater, where practical.

- Burra Creek is within SA Murray-Darling Basin region Prescribed Water Resources Area and the associated Water Allocation Plan (WAP) places controls on the development and use of surface water and groundwater resources. Council will need to comply with the requirements of the WAP particularly in relation to pursuing any water harvesting activities from the Burra Creek or its tributaries.

In the case of Burra, our assessment has indicated that reuse would require further investigation to prove its feasibility as there are likely to be significant constraints. Constraints include the variable nature of the aquifer and that Burra Creek is already a water stressed system making increased extractions undesirable. Collection of runoff from roof areas may be the most appropriate option for stormwater harvesting in Burra.

4.7 Opportunities for Environmental Enhancement

Opportunities for environmental enhancement in association with construction of stormwater infrastructure, including managing stormwater to enhance water dependent ecosystems, have been considered.

The design of stormwater infrastructure in this SMP has considered potential environmental enhancement and benefits to watercourses and receiving environments, such as through improvements to water quality, better management of stormwater flows, stream rehabilitation and biodiversity (e.g. weed and exotic tree management programs), and improved methods of fencing along watercourses.

The SMP explores the effectiveness of building wetlands at the downstream of the Burra Creek and the wetland system can provide a stormwater filtering function as well as enhance the local visual amenity by greening the town. During subsequent design stages, a subsurface biofiltration system may be preferred to a wetland. Such a system would be a viable alternative to the ephemeral wetland system modelled herein.

In addition, community responses to the draft plan highlighted potential opportunities to further enhance the biodiversity and amenity of Burra Creek and its tributaries. Whilst the scale of these opportunities is insufficient to achieve the desired water quality objectives of this plan, they none the less have merit on a local scale and would locally improve the micro-climate at a site through increased retention of water in the watercourse.

5 Stormwater Management Objectives

5.1 Stormwater Management Objectives

With consideration of technical investigations and information, community consultation and SMA Guidelines, the following stormwater management objectives have been developed for Burra.

5.1.1 An Acceptable Level of Flood Protection

The SMP seeks an acceptable level of protection from flooding for the community as well private and public assets.

Objective F1: Properties are protected from over floor flooding of dwellings or commercial properties in a 100 year ARI flood event.

Objective F2: Main transport routes are trafficable in a 100 year ARI flood event.

In order to be trafficable a road needs to have a continuous flood free lane equivalent to one vehicle width wide (assumed to be 3m).

Objective F3: Street drainage (minor drainage system) performs to a 1 in 2 ARI standard.

This was interpreted to mean that two-way movement of traffic along roads would be possible, (i.e., a 5 metre wide section of road is flood free).

5.1.2 Water Quality of Runoff and Receiving Environments

Objective Q1: Runoff from the town should not impair the environmental values of receiving environments.

The environmental values were defined as:

- Primary Industries: Water for stock and irrigation
- Aquatic Ecosystems: Water to support highly disturbed systems
- Recreation and Aesthetics: Visual appearance (i.e. no contact with water)
- Cultural and Spiritual: Water does not impair the cultural values of the receiving environments.

Objective Q2: The township treatment system should provide sufficient levels of treatment to reduce pollutant load export rates in accordance with the SA Water Sensitive Urban Design Guidelines (2013). The following treatment levels were adopted.

- 80% reduction in Total Suspended Solids
- 60% reduction in Total Phosphorus
- 45% reduction in Total Nitrogen
- 90% reduction in litter/gross pollutants

Objective Q3: Improve the condition of watercourses to increase their ecological and biodiversity values and functions, and to minimize any potential for stream erosion.

5.1.3 Stormwater Harvesting and Reuse

Objective R1: Seek opportunities for the efficient reuse of stormwater for beneficial purposes, whilst safeguarding the requirements of the Water Allocation Plan.

Objective R2: Seek opportunities to incorporate WSUD systems in the drainage network to capture road runoff to replenish soil moisture for maintenance of street trees and plantings.

Objective R3: Encourage on-site use of stormwater by encouraging the installation of rainwater tanks, detention and retention systems.

5.1.4 Environmental Protection and Enhancement

Objective P1: To promote the use of effective planning policies for new development to ensure that there is no increase in risk to existing and future properties and people.

Objective P2: To promote the use of effective planning policies for new development to deliver desirable planning outcomes for open space, recreation and amenity.

Objective P3: To incorporate stormwater treatment systems within growth areas to further improve council's existing treatment train system so as to achieve overall treatment targets for the town.

5.1.5 Sustainable Management of Stormwater Asset, Including Maintenance

Objective M1: Develop an appropriate stormwater asset management system which has consideration of maintenance requirements and costs.

5.1.6 Linkage of Proposed Management Strategies to SMP Objectives

Proposed management strategies and their linkages with the stormwater management objectives and targets are shown in Table 5-1.

The strategies are assigned a unique label and number corresponding with the overarching stormwater management objective, as follows: Flood management: F1, F2, etc.; Water quality improvement: WQ1, WQ2, etc.; Water reuse: R1, R2, etc.; Environmental protection and enhancement: P1, P2, etc.; and Asset Management: M1, M2, etc..

Details of the management strategies are presented in Section 6.

TABLE 5-1 SUMMARY OF MANAGEMENT STRATEGIES SHOWING LINKAGES WITH SMP OBJECTIVES AND TARGETS

Objective	1. Flood management			2. Water quality improvement			3. Water reuse			4. Environmental protection and enhancement			5. Asset management
Sub-Objective	*F1*	*F2*	*F3*	*Q1*	*Q2*	*Q3*	*R1*	*R2*	*R3*	*P1*	*P2*	*P3*	*M1*
Flood management strategies													
Strategy F1 – Levee Earthworks along Burra Creek	■	■	■										
Strategy F2 – Burra Creek Tributary Crossing Kangaroo Street, Queen Street and Chapel Street Drainage System Upgrade	■	■	■										
Strategy F3 – Paxton Terrace Drainage System Upgrade	■	■	■										
Strategy F4 – St Just Street Drainage System Upgrade	■	■	■										
Strategy F5 – Tregony Street Drainage System Upgrade	■	■	■										
Strategy F6 – Goyder Hwy and Stronach Street Drainage System Upgrade	■	■	■										
Water quality improvement strategies													
Strategy WQ1 – Spring Street Wetland				■	■	■							
Strategy WQ2 – Riparian Rehabilitation Reaches MC1-MC2				■		■							
Strategy WQ3 – Riparian Rehabilitation Reaches TR1				■		■							
Strategy WQ4 – Riparian Rehabilitation Reaches MC3-MC4 (incl WQ8b)				■		■							
Strategy WQ5 – Riparian Rehabilitation Reaches TR2				■		■							
Strategy WQ6 – Riparian Rehabilitation Reaches TR4, TR5, TR6 (incl WQ8a)				■		■							
Strategy WQ7 – Riparian Rehabilitation Reaches TR7				■		■							
Water reuse strategies													
Strategy R1 – Rainwater tank incentive scheme				■			■	■	■				
Environmental protection and enhancement strategies													
Strategy P1 – Flood preparedness program - re flood warning system and community awareness program	■	■	■							■	■	■	■
Strategy P2 – Development / planning controls	■	■	■							■	■	■	■
Asset management strategies													
Strategy M1 – Drainage asset management plan													■

6 Stormwater Management Strategies

6.1 Approach to Developing Mitigation Strategies

The proposed mitigation strategies that are outlined in the following sections have been developed on the basis of the stormwater management objectives, technical investigations, feedback received from the Steering Committee, Elected Members and the local community and the requirements of the SMA Guidelines.

The project has been overseen by representatives from Council, and DPTI (on behalf of the SMA). Meetings with these organisations were held throughout the project to discuss progress and issues arising, as well as to confirm the approach to technical investigations and consultation.

The main stormwater/flooding issues raised by Council and its community related to local stormwater runoff, flows from Burra Creek and flows associated with the tributaries in town.

Poor performing drainage infrastructure was seen as the cause of regular local flooding problems.

More frequent maintenance of the drainage infrastructure and watercourses is considered desirable as there was often litter, sediment and other debris along the roads and drains. Fences, weirs and blocked culverts across creeks are also likely to exacerbate flooding problems, as was the growth of exotic vegetation choking the waterways. There would appear to be opportunities for improved stormwater management through more frequent maintenance, upgraded infrastructure, development and planning controls, as well as watercourse rehabilitation and onsite stormwater reuse.

The proposed mitigation strategies have also had their effectiveness and impact in terms of performance, social, economic and environmental issues considered.

A brief summary of this is provided below:

- Public Safety: Measured by the number of properties that would be protected from medium and higher hazard ratings.
- Option Resilience: The capacity of the mitigation option to perform over a range of flood magnitudes and frequencies. Includes consideration of performance of an option should its design standard be exceeded.
- Damage Reduction: Reduction in flood damage costs.
- Cost of Works: Whole of life costs associated with any works or ongoing recurrent expenditure (e.g. includes cost of repeating education and awareness programs in subsequent years).
- Environmental: Impacts on biodiversity and stream stability.
- Public Concern: Level of likely acceptance of the measure.
- Ongoing Maintenance: The costs and practicalities associated with ongoing maintenance liabilities.
- Economic Development: The opportunity for future economic growth as a result of the mitigation measure being implemented.

The process has involved placing an emphasis on actions that are effective but do not necessarily rely on structural works. These are typically the most resilient and cost effective. Therefore, the hierarchy

of solutions has the non-structural options as highest priority, such as land use planning, community awareness and emergency management, leading to structural measures as a last resort.

For any proposed works that affect private property, negotiations with the landowner would need to be held to discuss options for using the land and potential land acquisition.

The approach to developing stormwater management is to formalise the drainage system without compromising the town's historic character. In addition to the proposed measures outlined below, the road network's function of conveying high flows will continue.

Strategies for managing flooding and stormwater runoff, and opportunities for improving water quality, the local amenity and potential reuse are described in the following sections.

Whilst each strategy was developed to address specific management objectives and suggested priorities are also provided, it should also be noted that the availability and timing of funding and resources will determine the order and staging of the recommended works.

The recommended strategies in this report are assigned a unique label and number, such as:

- Preparedness and planning: P1, P2, etc
- Flood management: F1, F2, etc
- Water Quality: WQ1, WQ2, etc
- Reuse: R1, R2, etc

6.2 Non-Structural Flood Management Measures

Recommended non-structural measures include a community flood preparedness program and improvements to development and planning controls.

In addition to structural measures aimed at controlling flooding, there is a range of non-structural measures that can assist in achieving this outcome and minimise the impacts of flooding in the future. Non-structural measures are typically highly cost effective and can be implemented over much shorter timeframes. Both structural and non-structural approaches are to be incorporated within an overarching management plan for Burra.

Examples of non-structural measures are described in the following sections.

6.2.1 Flood Preparedness (P1)

A well-coordinated flood awareness program for the community has the potential to reduce the risk of flood damage.

Flood preparedness is a cost effective non-structural means of reducing damages as a result of a flood. Flood preparedness is basically about helping people to be aware of the flood risk and how best to respond to it. Flood preparedness programs in this context are considered in four phases: flood awareness, flood warning, response and recovery. They form the key elements of a total flood warning system (Commonwealth of Australia, 2009).

A flood preparedness program is recommended for Burra with a particular focus on a community awareness/education program (to be implemented every 5 years). This may involve community meetings and information booklets, and support for property flood response planning.

The key elements of a total flood warning system are outlined below.

Flood Awareness

A flood awareness program for people in Burra is an important aspect of reducing the risk of flood damage. A targeted community awareness program, to build on from the Burra township's 'Floodsafe' program would assist the community in being better prepared and able to respond to flood risks and events is recommended.

The program is based on the SA State Emergency Service's (SES) highly successful community education and awareness raising 'Floodsafe' program. It would include awareness activities such as informing the community through discussions with individual households, Council's newsletters, public presentations, articles in local media, information included on Council's website, and information about a flood emergency kit.

A coordinated education program is one means of ensuring this information is effectively disseminated. The development of such programs is essential for ensuring that landholders can take full advantage of flood warnings.

Flood Warning

Research has demonstrated that flood warning can substantially reduce the damage costs associated with flooding. Generally, the greater the warning time, and the more prepared the community are then the greater the savings may be. A well-informed community can reduce the costs associated with a flood by around 20% with only 2 hours warning whilst with 12 hours warning costs can be reduced by around 60% (BTE, 2001), refer Figure 6-1.

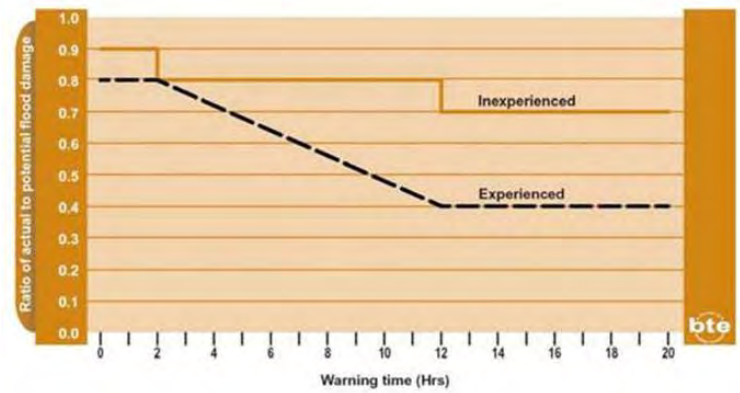


FIGURE 6-1 FLOOD WARNING DAMAGE SAVINGS (BUREAU OF TRANSPORT ECONOMICS (2001))

At Burra there is a relatively short period of time from the onset of rainfall in the catchment to the time of peak flooding in the town (typically between 6 to 18 hours) for regional scale flooding issues, and even less (2 hours or less) for localised rainfall causing street flooding issues in the township.

Nevertheless, the benefits of flood warning were recognised by the Bureau of Meteorology, and there are a series of nearby rain gauges that could be used to assist Council with flood alert warnings. In particular, existing rain gauges at Caltowie, Hallett, Burra, Yongala and Yunta are all on the Bureau's real-time rainfall recording/reporting system and the existing water level recording gauge at St Just St Ford could assist Council and emergency services by alerting them to periods of higher rainfall, intensity of rainfall and rising water levels in the Burra Creek.

The Saint Just Street ford site provides an ideal reference point for the determination of rainfall flood thresholds on which preliminary warnings or flood alerts could potentially be issued.

Flood Response

The flood response phase (and to a lesser extent the recovery phase) is highly influenced by the experience or knowledge people have of the likely behaviour and nature of a flood event. There are a range of actions people can do with their property before and during a flood that can substantially reduce the damage costs. Many of these measures are very simple and easily implemented. To be effective landholders potentially affected by flooding need to be aware of their options and response strategies.

The response of emergency services during a flood is obviously also a key factor in reducing flood damages and threats to public safety. Integrated disaster response plans are an important means for helping to ensure emergency services can effectively respond. Whilst not wishing to suggest that current response services are deficient (because they are not), the regular review of these plans and the conduct of "dry run" flood response exercises can be effective ways of ensuring emergency response staff and volunteers are aware of the issues, hazards, and opportunities that might be presented to them during a real flood event. Such initiatives should be effectively supported.

Flood Recovery

The recovery phase post-flood is critical to reducing social disruption and long-lasting health issues associated with trauma (and in extreme cases disease), as well as ensuring communities can get back to "normal" as soon as possible and thereby contain the overall damage costs.

A flood preparedness program is recommended for Burra. The focus of the system should be on a community awareness/education program (ideally repeated every 5 years) and the development of rainfall – flooding thresholds to support an early flood alerting system. These are identified in the recommendations table as P1 (refer Table 7-1).

6.2.2 Development and Planning Controls (P2)

The Development Plan is a statutory document that controls and manages all forms of development within the Burra and Regional Council of Goyder area. It sets out a range of development zones, maps and rules (Objectives and Principles) to help ensure that development occurs in a well-managed way and takes account of relevant environmental, infrastructure, urban design, heritage and community requirements (Strategic Directions Report 2012/13).

Planning controls within Council's Development Plan (last Consolidated in November 2016) provide a framework to plan and build in a manner that incorporates stormwater management. Council already has information in its Development Plan to help guide development in terms of stormwater runoff volumes, water quality and reuse aspirations. To improve the effectiveness of the Development Plan, Council may consider including specific water quality targets identified in the State Government's targets and the Natural Resources SA's resource condition targets as described earlier in this SMP.

In relation to stormwater reuse, Council's Development Plan may be improved by including the reuse targets outlined in the State Government's Stormwater Strategy and "Water for Good" plan. It could also be improved by providing specifications for the provision of rainwater tanks when undertaking new residential development for toilet or garden usage. For example, Council could recommend larger capacity rainwater tanks in the township area than what is currently required under the Building Code (which is a 1000 litre tank).

It is recommended that Council enforces its current flood hazard requirements in its Development Plan, such as not allowing development on land where the risk of flooding is likely to be harmful to safety or damage property. In addition, to avoid buildings being constructed too low and thus

potentially at risk of flooding, it is recommended that, even outside of designated flood areas, finished floor levels of new developments are a minimum of 300mm above surrounding land levels.

Development and planning controls are included in the list of recommendations as P2 in Table 7-1 R.

6.3 Structural Flood Mitigation Measures including Local Runoff Management Measures

Management strategies have been developed that focus on reducing the risk of flooding from watercourses and local flash flooding. Mitigation measures aim at protecting properties from inundation in a 1 %AEP flood event.

Recommended structural measures focus on protecting the main business district of Burra and immediately surrounding residential properties from flooding of the Burra Creek and as well as providing improved performance from Council's stormwater drainage system.

The recommended mitigation measures are described below and shown in the figures that follow.

6.3.1 Flooding from the Burra Creek (F1)

Consultation with Council indicated the desired level of flood protection from Burra Creek flooding in Burra was 100-year ARI. Only if that was not achievable or practicable should a lower level of protection be considered.

A number of structural options were initially assessed but it quickly became apparent that the scale of works would need to be significant and comprehensive (i.e. throughout the town). The primary option that was carried forward was:

- Channel levee earthworks – Levee works along the Burra Creek was mainly at the northwest of the Burra township along Barrier Hwy to pass the design flood event. The areas to be specifically targeted included between Barrier Hwy and Ludgvan St, Barrier Hwy Bridge, as well as the Burra Creek along the Burra Caravan Park.

This major option is discussed in more detail below.

Channel Levee Earthworks

The current flood inundation map indicates that two sections of channel levee would be needed to avoid the flooding (refer Figure 6-2). As can be seen from Figure 6-3, the earthen levee would need to extend along Goyder Hwy from the old railway, passing Taylor St, Barrier Hwy, till Sancreed St. Another section of the levee requires works near the Caravan Park (Bridge Terrace) and the Burra Motor Inn (Market St). The height of the levee would typically be no more than 500 mm, including provision for freeboard.

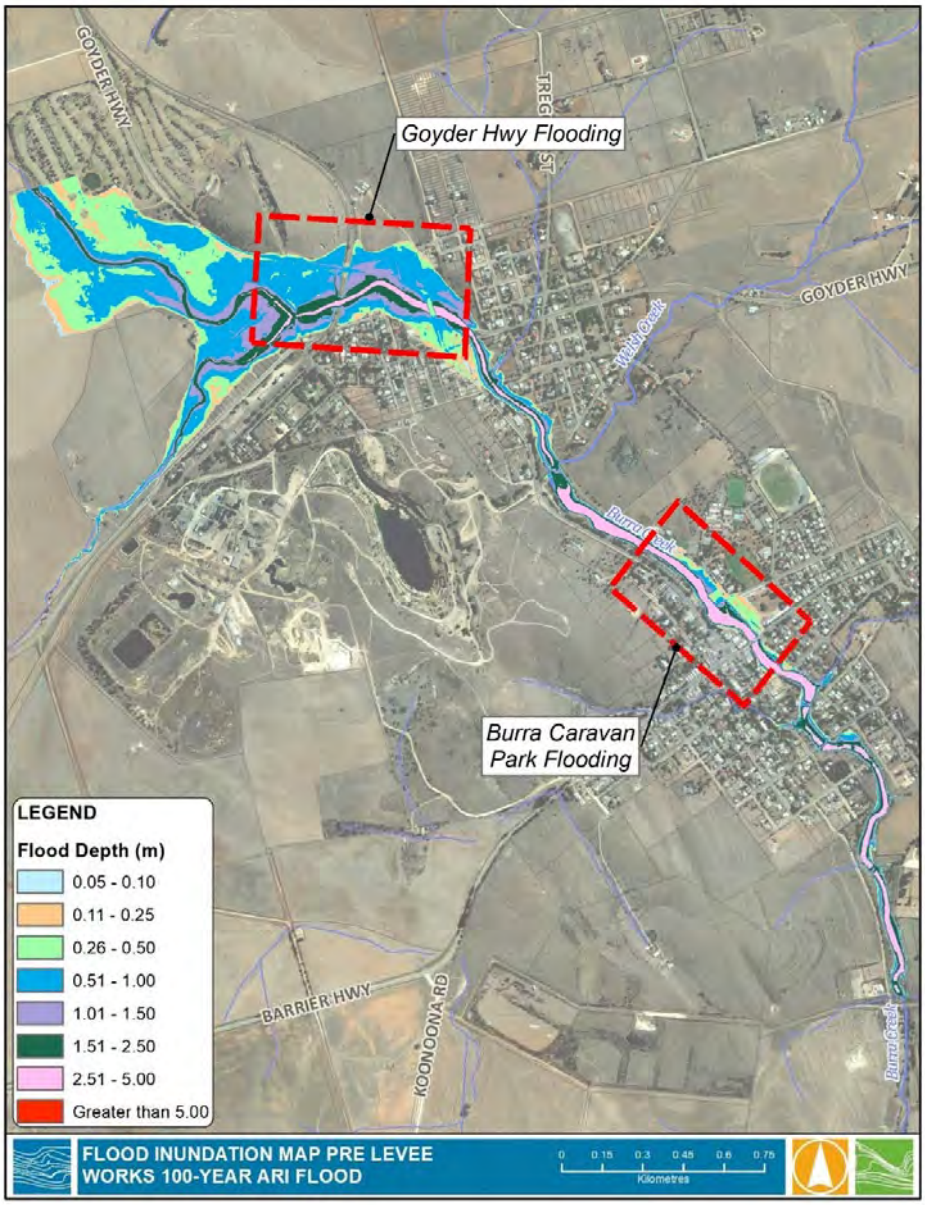


FIGURE 6-2 FLOOD INUNDATION MAP PRE LEVEE WORKS 100 YEAR ARI FLOOD

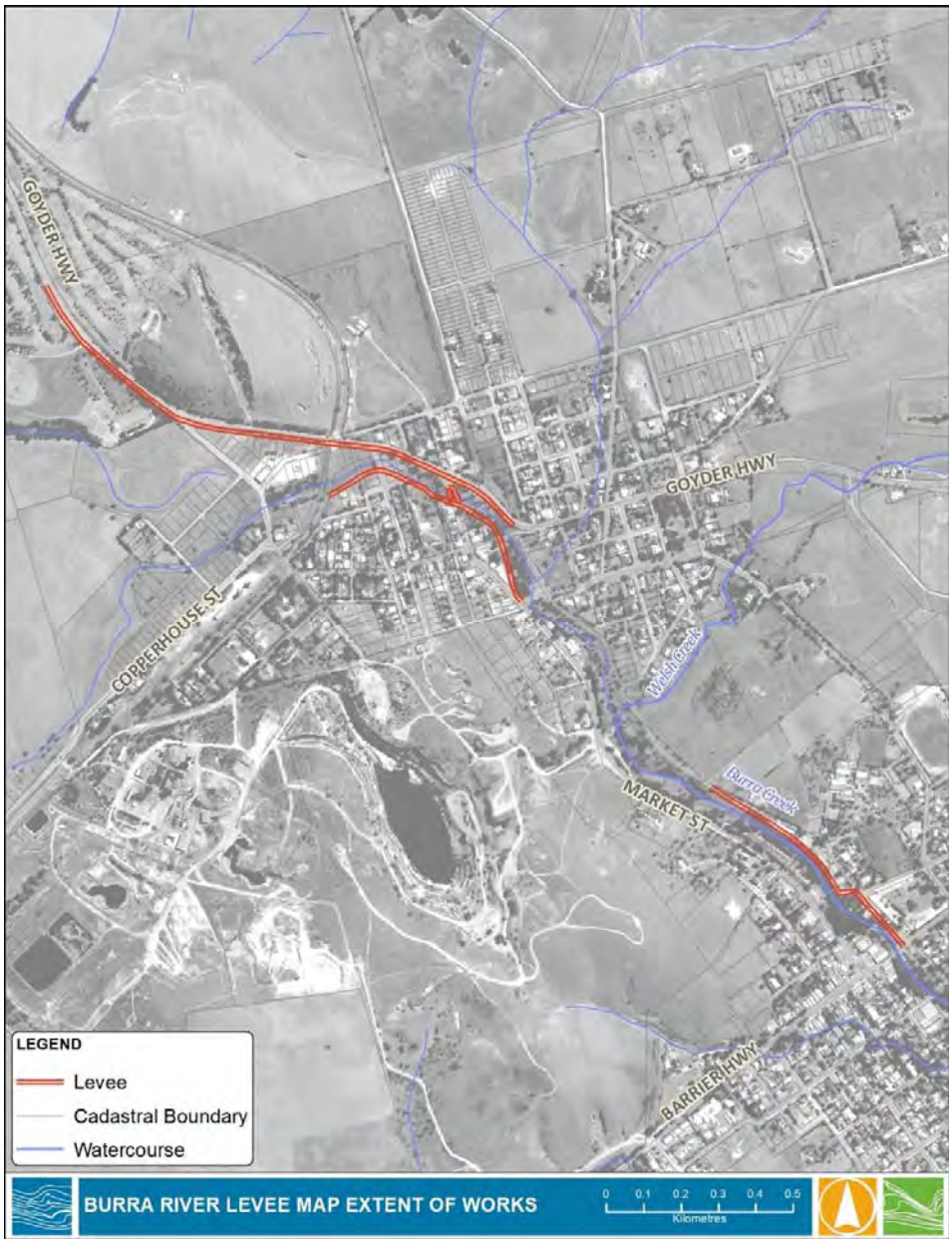


FIGURE 6-3 BURRA RIVER LEVEE MAP EXTENT OF WORKS

At the levee section near the caravan park there is a local drainage outfall adjacent the heritage cottages that will require a non-return flap to avoid back flow from Burra Creek during the 100 year ARI flood.

This option is included in Table 7-1 as option F1.

The works are shown to be very effective for the township (refer Figure 6-4) but do create some afflux (increase in water levels upstream). There are four flood prone properties in this area which would be subject to over floor flooding before the levee works. The depth of flooding on these properties could be increased by 200mm or more, but the likelihood of flooding is not increased.

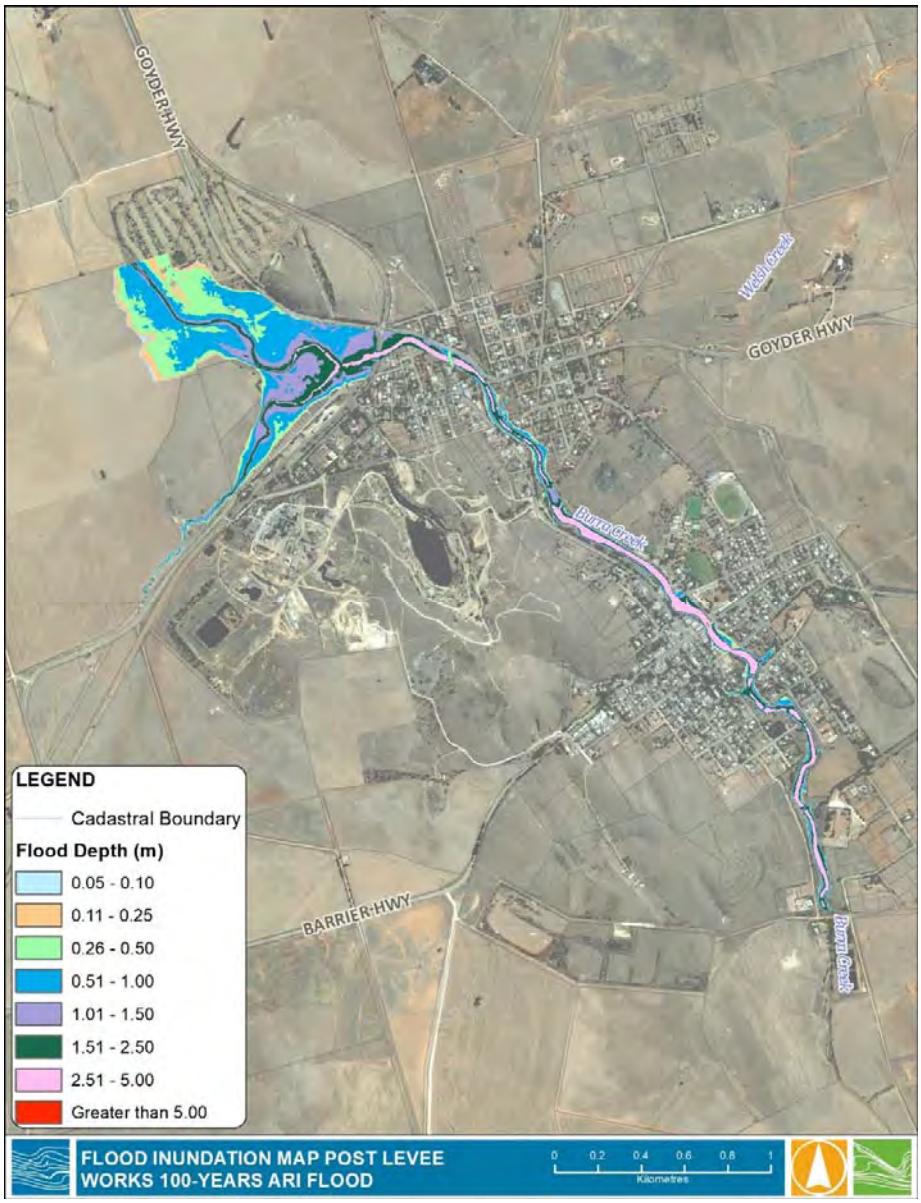


FIGURE 6-4 FLOOD INUNDATION MAP POST LEVEE WORKS 100-YEAR ARI FLOOD

6.3.2 Upgraded Stormwater Infrastructure

The areas highlighted of greatest concern for Council with respect to local drainage systems and performance were reviewed and structural measures developed to address these issues. Each one of the areas is discussed in turn below.

Most of these systems have been developed from coarse ground elevation data that, whilst suitable for floodplain mapping, is not of sufficient accuracy to support detailed hydraulic design of street drainage systems. Hence, all sites require detailed engineering survey data to be collected to support subsequent hydraulic and civil designs along with preparing more reliable cost estimates.

Furthermore, although Council has provided some urban cross drain information, there is very limited information available on the invert and some of the details for existing infrastructure (i.e. bridge size and inverts). Notwithstanding these data issues, the conceptual design work conducted herein has estimated the required infrastructure size necessary to avoid flooding issues.

Burra Creek tributary crossing Kangaroo Street, Queen Street and Chapel Street Drainage (F2)

Flooding occurs in Burra Creek tributary crossing Queen Street and Chapel Street as a result of inadequate capacity of this tributary and local stormwater inflows (refer Figure 6-5). The system presently consists of a series of bridges and pipes and culverts along the road to divert the road flood waters into the tributary and eventually into the Burra Creek. The proposed system includes:

- A levee running along the northeast side of the tributary from Kangaroo Street, Queen Street, Chapel Street and finishing before Upper Thames Street.

The levee would mostly only need to be around 500 mm high, apart from a short section upstream of Queen Street where there is low section of bank and the levee height would approach 800 mm in order to provide 300 mm freeboard. There are sections where space is limited along the levee alignment and (subject to adjoining landholder discussions) sections of the levee may need to be formed with a concrete upstand or a raised planter box arrangement should a softer landscape outcome be preferred.

The present infrastructure and proposed infrastructure are illustrated below.

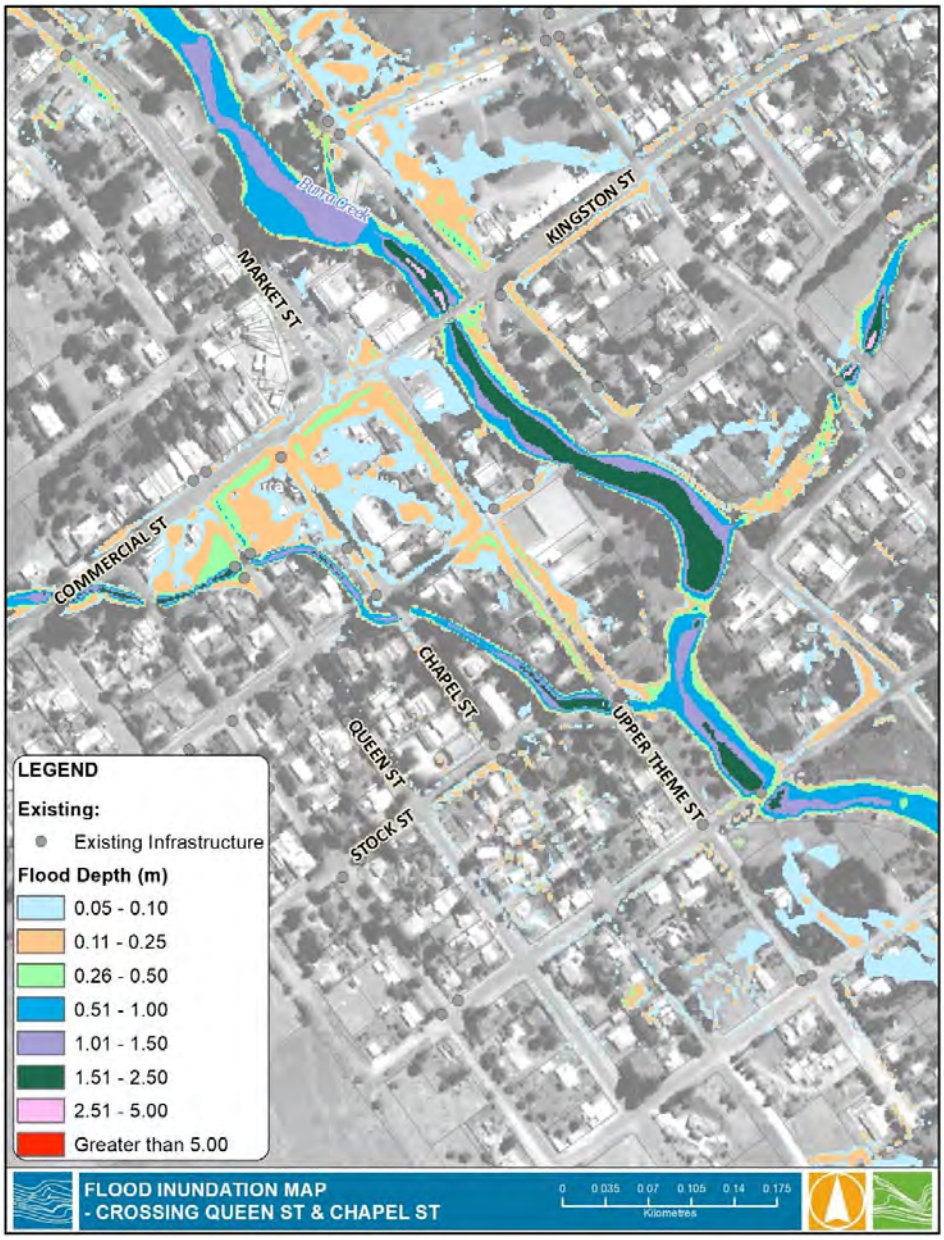


FIGURE 6-5 FLOOD INUNDATION MAP FOR BURRA CREEK TRIBUTARY CROSSING QUEEN STREET AND CHAPEL STREET WITH THE EXISTING INFRASTRUCTURES

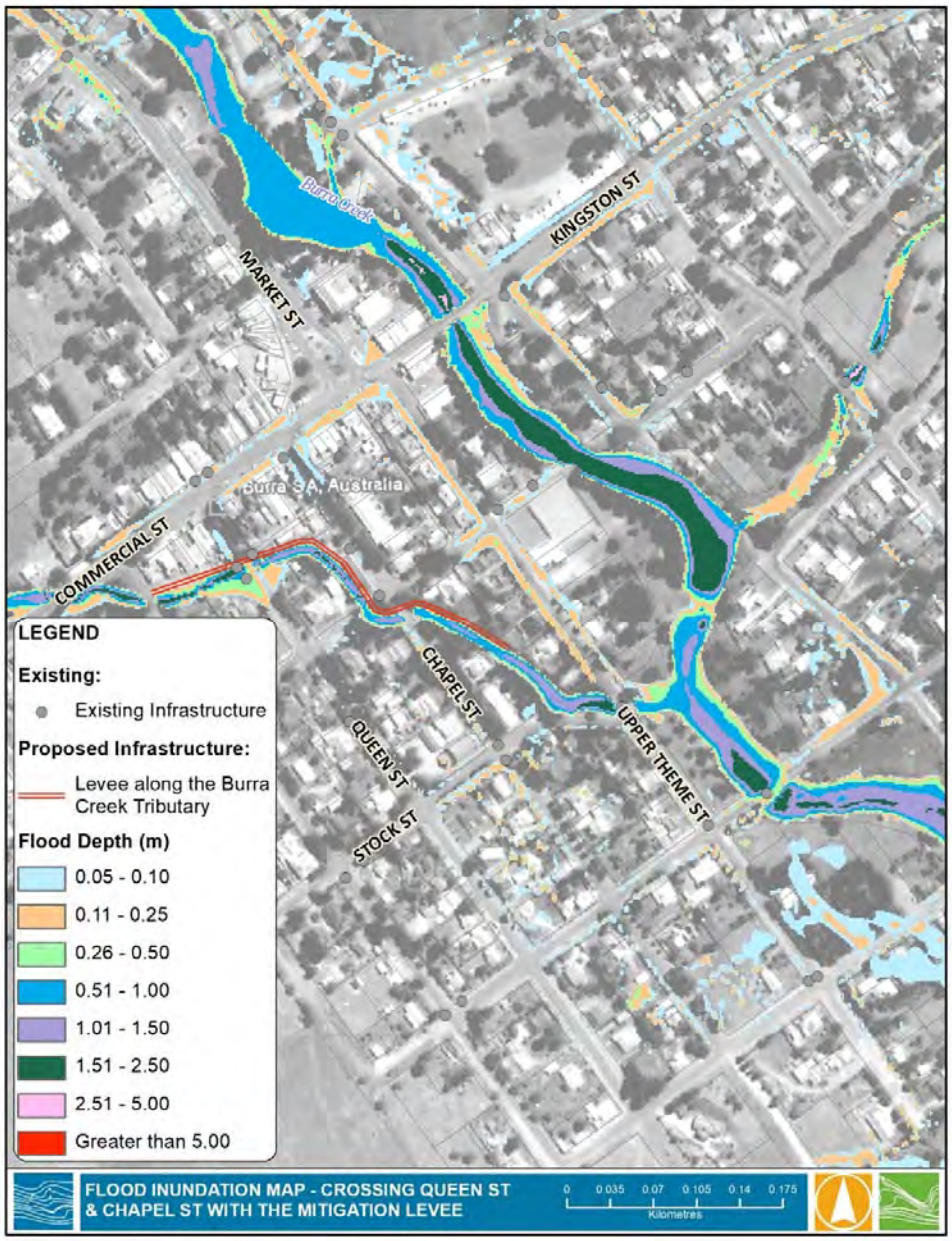


FIGURE 6-6 FLOOD INUNDATION MAP FOR BURRA CREEK TRIBUTARY CROSSING QUEEN STREET AND CHAPEL STREET WITH THE MITIGATION LEVEE

This work is considered of highest priority for the local drainage works and so Council has proceeded with an engineering survey and detailed design of the works.

Paxton Terrace Drainage System (F3)

Flooding potential from this drainage system (Creek 3) occurs because of the small capacity of the swales that run north to south along Smelts Road near the oval and east to west along Paxton Terrace between Welsh Place and Bridge Terrace before going into the culverts under the corner of Paxton Terrace and Bridge Terrace and discharging into the Burra Creek. There is also no formalised method of transferring road drainage (pit and pipe system) into the open channel, hence flooding of properties and roads is expected in a 100-year ARI event.

The proposed system upgrade includes widening and deepening the swale along Smelts Road near the oval, a pipe along Smelts Road between the location where the swale ends and Paxton Terrace to direct water from the widened swale, along with a series of pits and pipes along Paxton Terrace all the way to Bridge Terrace to divert water from eastern side of Paxton Terrace and to replace the swale between Welsh Place and Bridge Terrace. Furthermore, a raised garden (levee) along Welsh Place is proposed to stop water flowing along Kingston St into the Paxton Square Cottages area. The present infrastructure and proposed infrastructure are illustrated below.

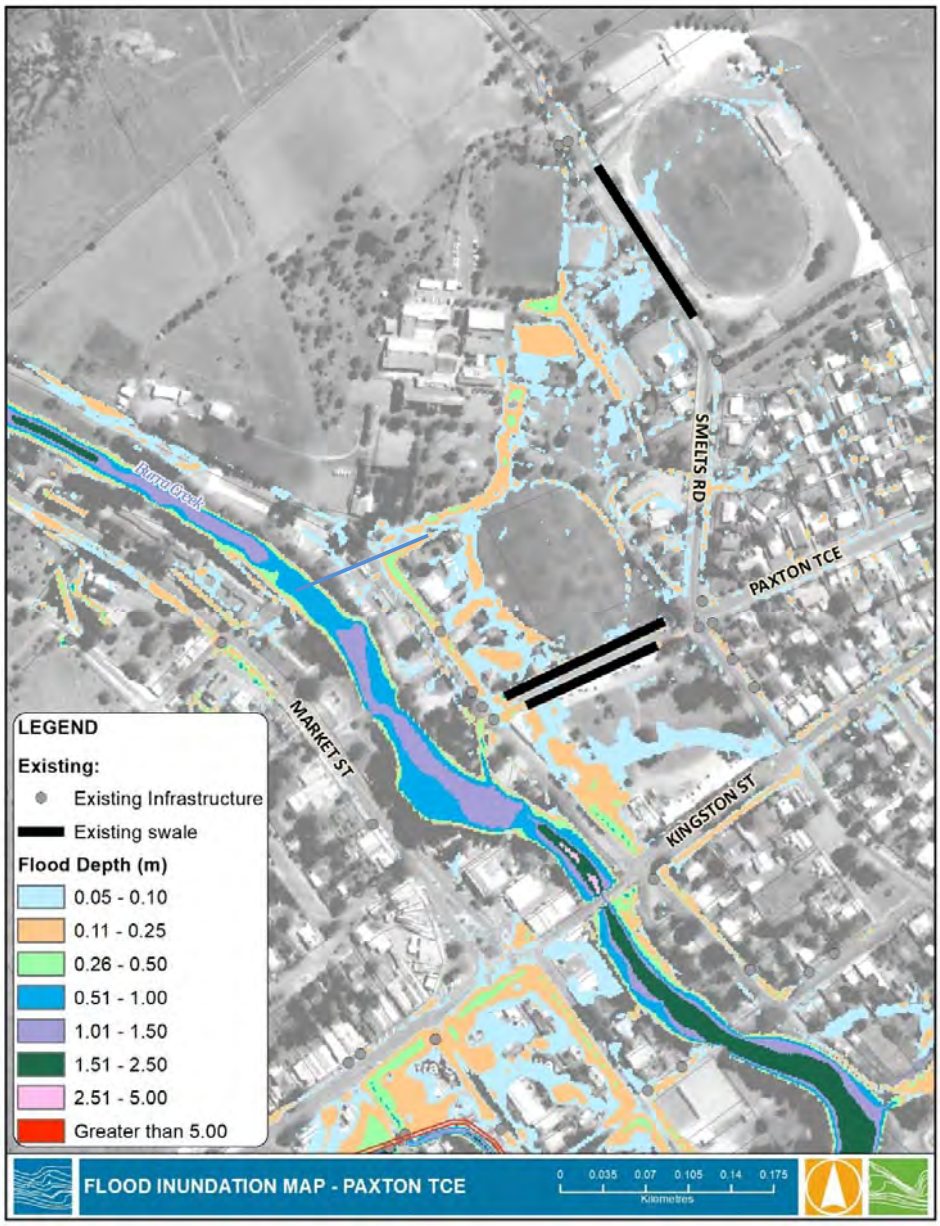


FIGURE 6-7 FLOOD INUNDATION MAP FOR PAXTON TERRACE DRAINAGE SYSTEM WITH THE EXISTING INFRASTRUCTURES

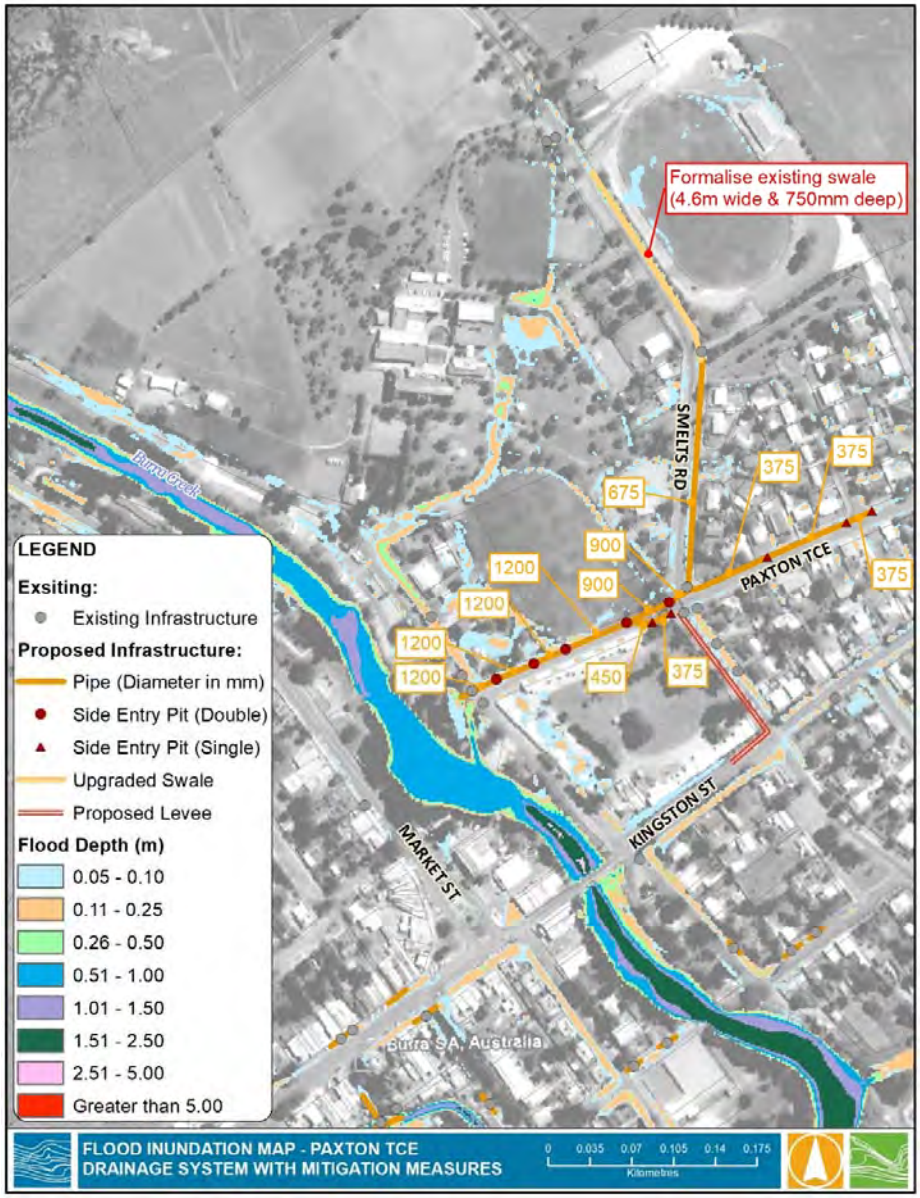


FIGURE 6-8 FLOOD INUNDATION MAP FOR PAXTON TERRACE DRAINAGE SYSTEM WITH THE MITIGATION MEASURES

St Just Street Drainage (F4)

The St Just Street drainage system currently has roadside swales and culverts under the driveways to divert water from north and east of the St Just Street into the Burra Creek. However, there are significant scour and insufficient capacity issues existing for the swale and culverts. A series of pits and pipes are proposed to replace the current swales and culverts to improve localised flooding issues along St Just Street and collect runoff from north and east catchments and direct this runoff into the Burra Creek. The existing swales would be backfilled as part of the pipe laying process.

The system is illustrated below in the following figures.

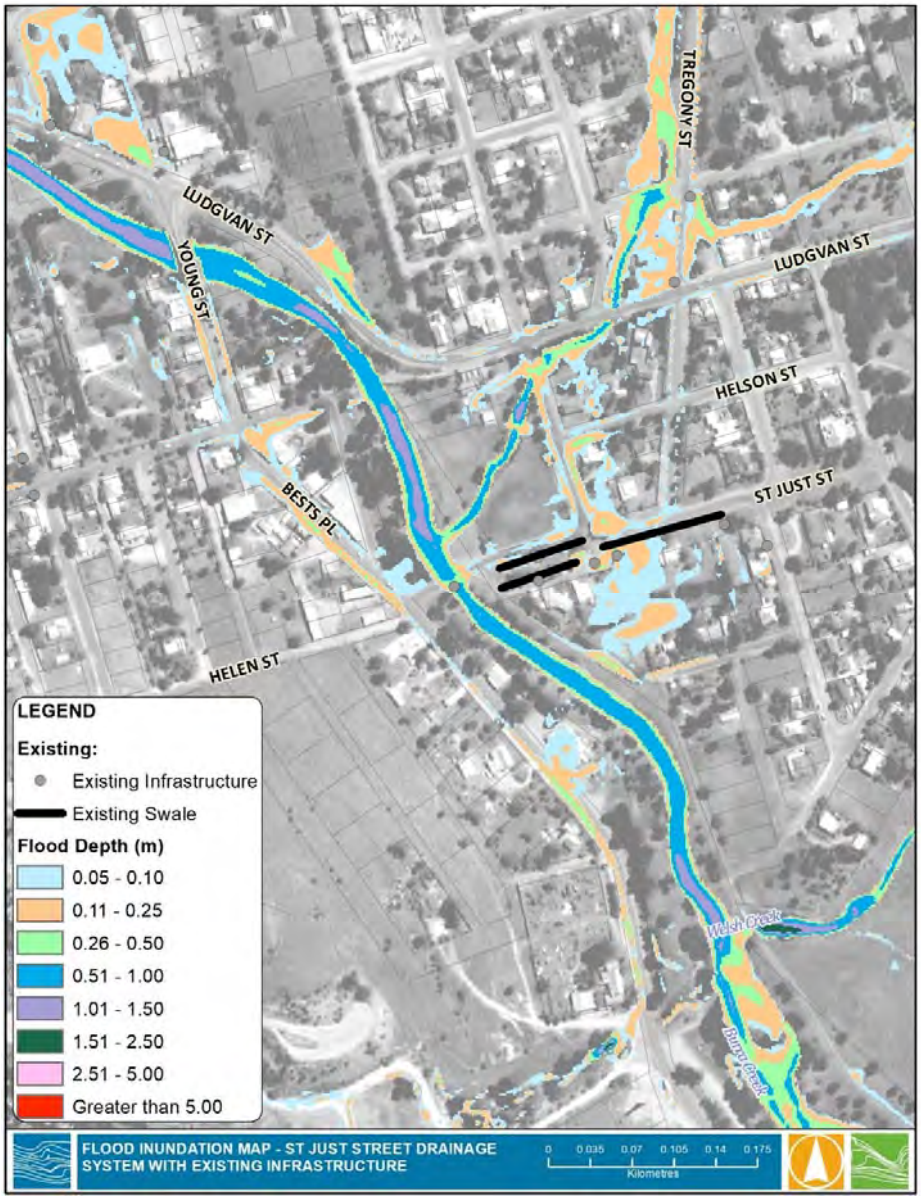


FIGURE 6-9 FLOOD INUNDATION MAP FOR ST JUST STREET DRAINAGE SYSTEM WITH THE EXISTING INFRASTRUCTURES

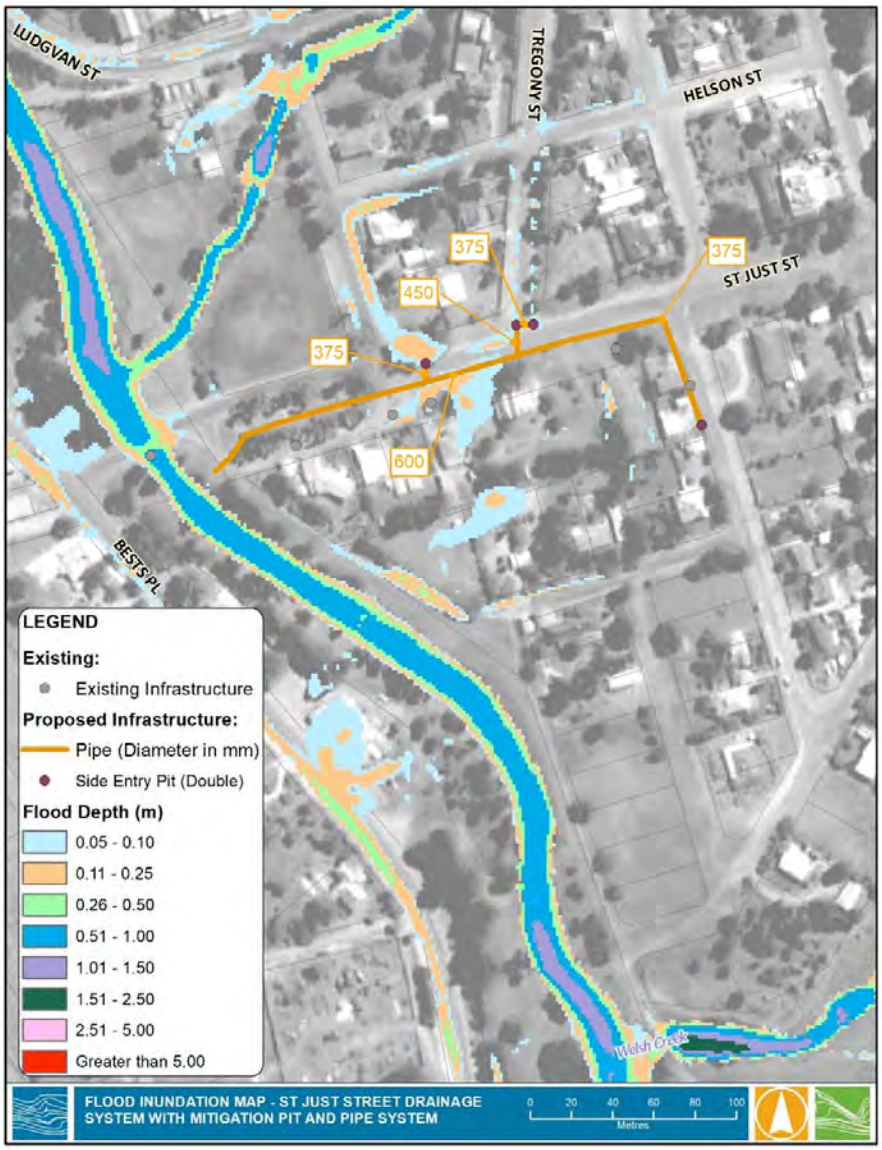


FIGURE 6-10 FLOOD INUNDATION MAP FOR ST JUST STREET DRAINAGE SYSTEM WITH THE MITIGATION PIT AND PIPE SYSTEM

Tregony Street Drainage System (F5)

The Burra Creek at Tregony Street Tributary collects runoff from the semi-rural catchment north of Mevagessey Street and then passes through the northern part of the Burra township, running adjacent to Ludgavan Street, where another Burra Creek tributary collecting runoff from the rural catchment east of Penclawdd Street, before crossing Ludgvan street and discharging in the Burra Creek. Modelling indicates that the open channel section through the north part of township is under capacity and so the work required to increase capacity would either involve channel widening or mitigating the flows from the rural catchment upstream. The channel widening approach was not preferred because it would require acquisition of private property. The alternative approach of providing flood detention would involve building a basin to provide 4.1 ML flood detention storage. Some channel trimming and clearing would still be required in places. Furthermore, a levee is

proposed along the southern side of Ludgvan St/Goyder Hwy to reduce the runoff flowing to St Just Street.

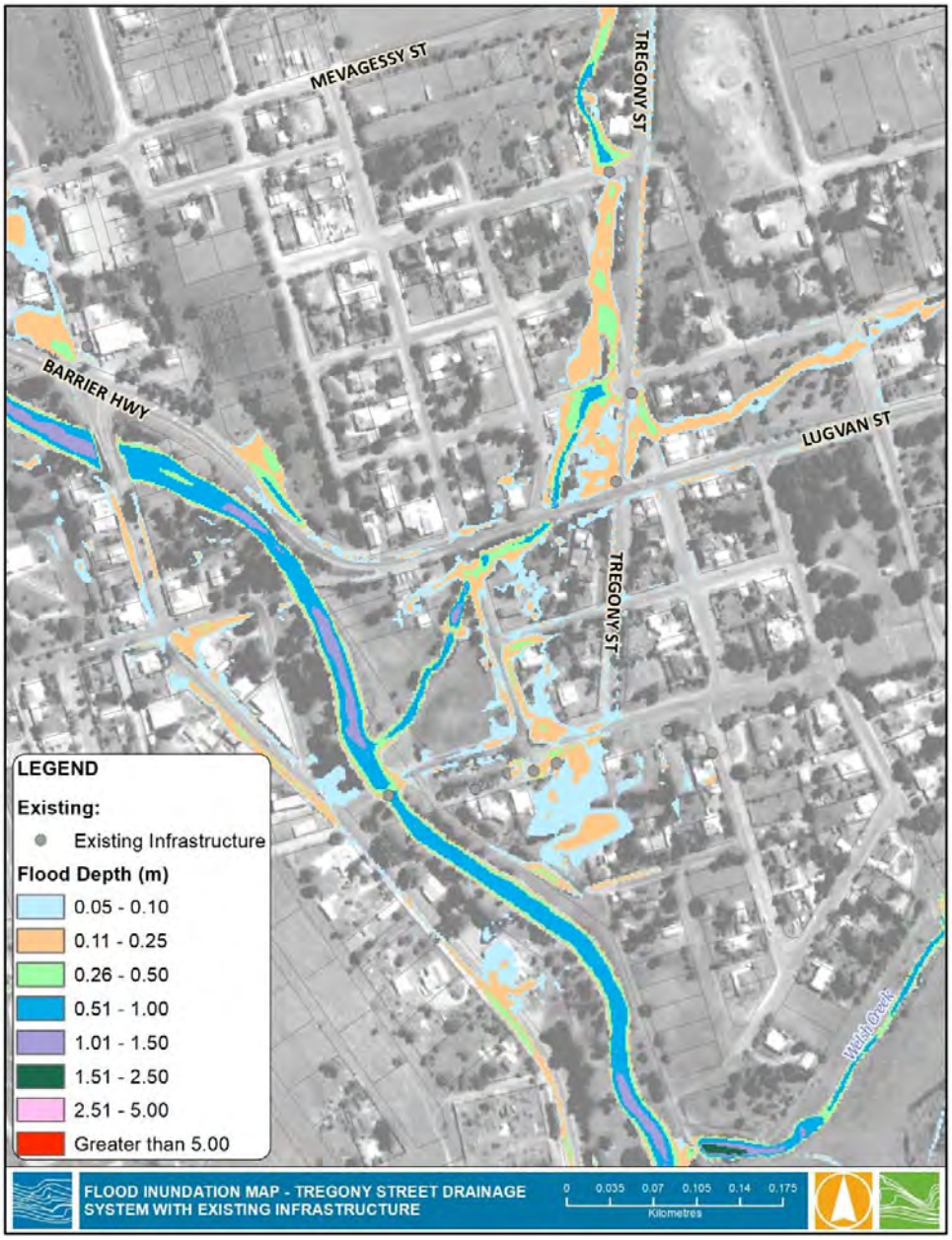


FIGURE 6-11 FLOOD INUNDATION MAP FOR TREGONY STREET DRAINAGE SYSTEM WITH THE EXISTING INFRASTRUCTURES

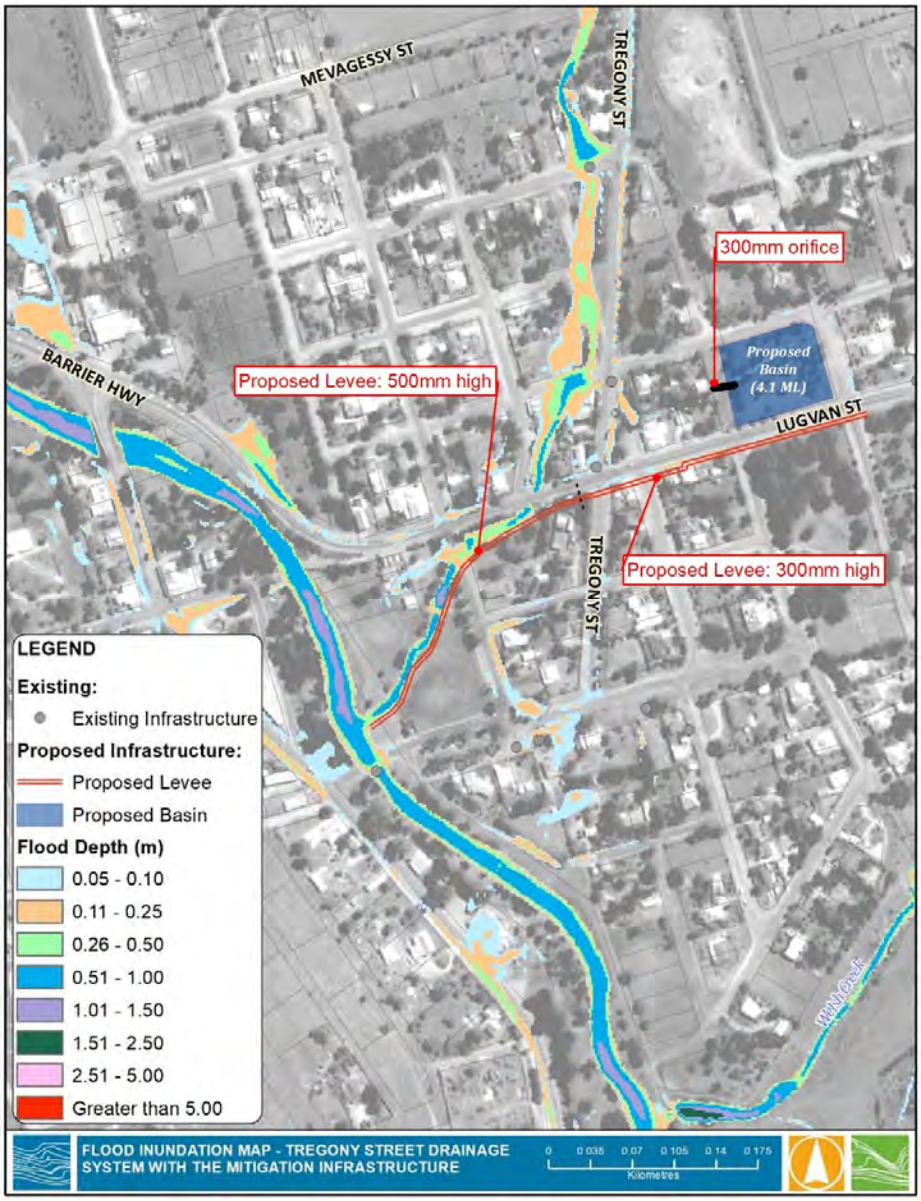


FIGURE 6-12 FLOOD INUNDATION MAP FOR TREGONY STREET WITH THE MITIGATION INFRASTRUCTURES

Goyder Hwy and Stronach Street Drainage System (F6)

Runoff from the north and northwest of Goyder Hwy runs along the old railway and Goyder Hwy roadside swale towards the Burra Creek. Runoff flowing down Goyder Hwy and old railway track presently meets at north of Goyder Hwy near east of Taylor Street and flows into Burra Creek through a culvert. These two flow paths create overland flooding issues for Goyder Hwy and a few properties in proximity to it. A formalised pipe drainage system that involves increasing the existing culvert capacity under the Goyder Highway by adding a new additional 1200 mm pipe upstream of Taylor Street to divert the water into Burra Creek to address this potential flooding issue. The suggested system configuration is illustrated below.

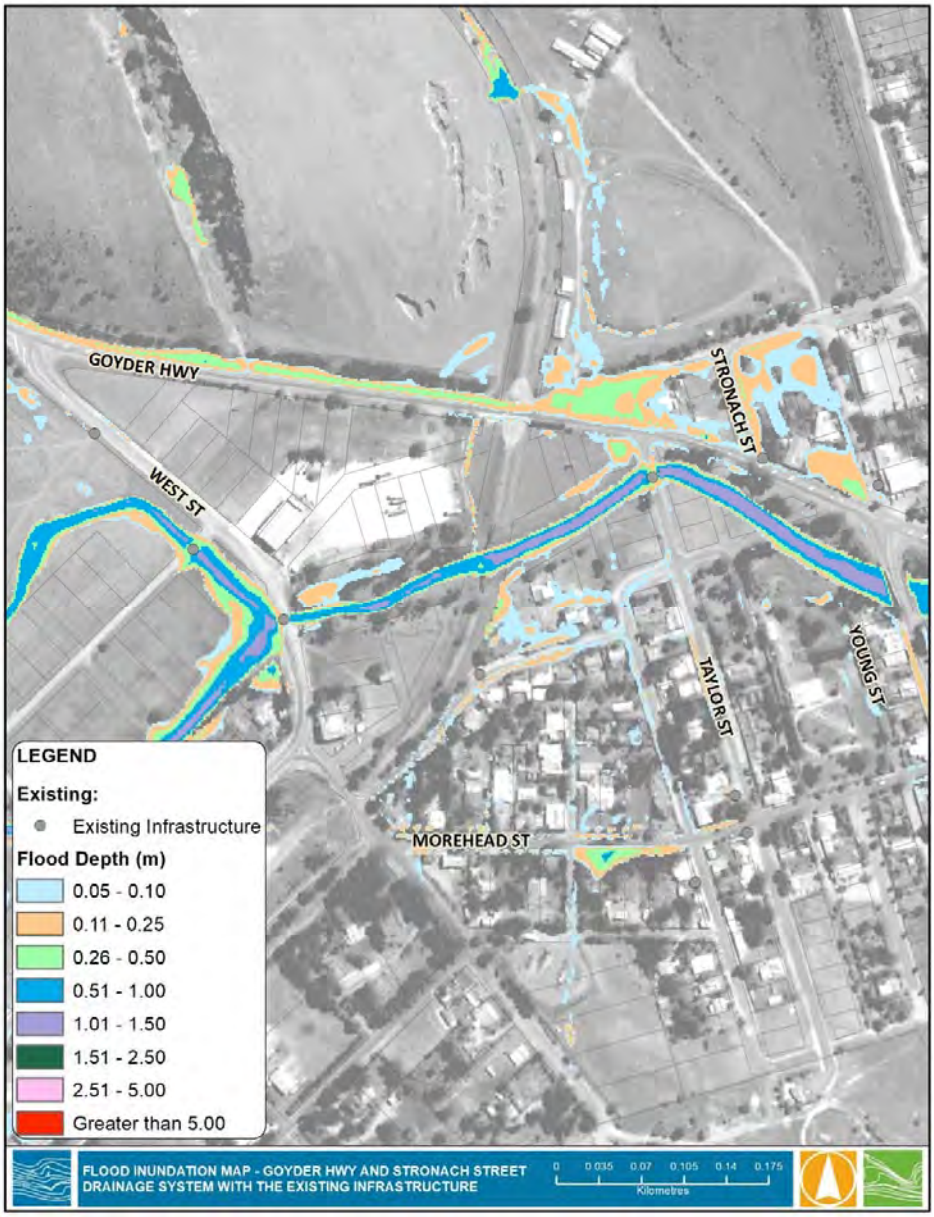


FIGURE 6-13 FLOOD INUNDATION MAP FOR GOYDER HWY AND STRONACH STREET DRAINAGE SYSTEM WITH THE EXISTING INFRASTRUCTURES

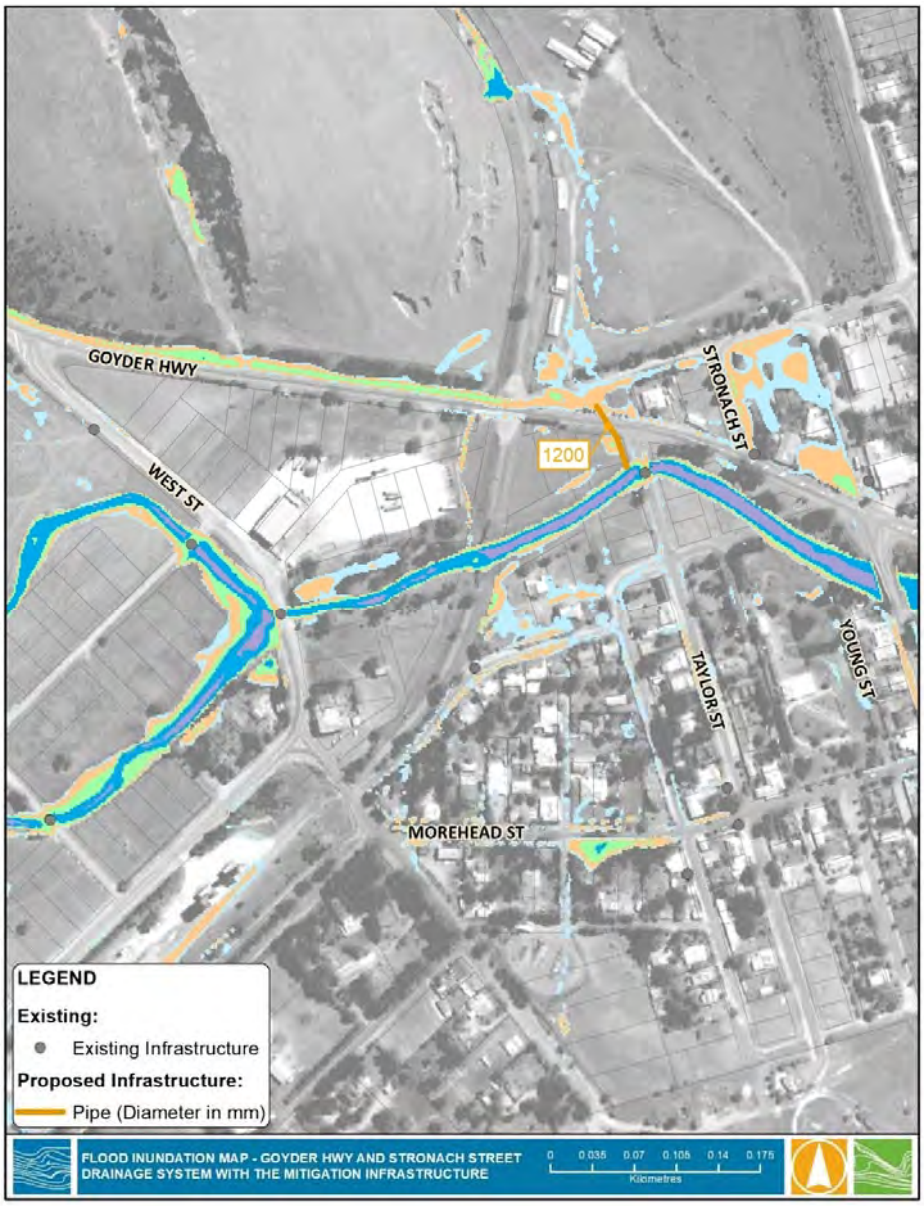


FIGURE 6-14 FLOOD INUNDATION MAP FOR GOYDER HWY AND STRONACH STREET DRAINAGE SYSTEM WITH THE MITIGATION INFRASTRUCTURES

6.4 Effectiveness of Flood Mitigation Works

6.4.1 Properties Protected

In Burra there are 85 properties at risk of flooding in the 100 year ARI from either the Burra Creek or its major tributaries in Burra.

The suggested localised works associated with Burra Creek levee works should protect 75 of these properties. These works correspond to items F1, F2, F3, F4, F5 and F6.

In addition, there are three properties whereby the works upstream of the township (works F1 would result in an incremental increase in flood depth but do not increase the likelihood of flooding.

6.4.2 Trafficability of Road Network

The existing Trafficability of roads was presented in Figure 4-5.

Objectives of this SMP include main transport routes are trafficable in a 100-year ARI flood event, and the town's street network is trafficable at the 1 in 2 ARI event. The existing condition (ie pre-mitigation) is that Burra Roads are expected to remain trafficable during a 1 in 2 ARI event (refer mapping in Appendix A).

The measures to mitigate local and regional flooding will help improve trafficability of the road network and achieve these objectives. The trafficability of the roads both before and post works is illustrated in Figure 6-15.

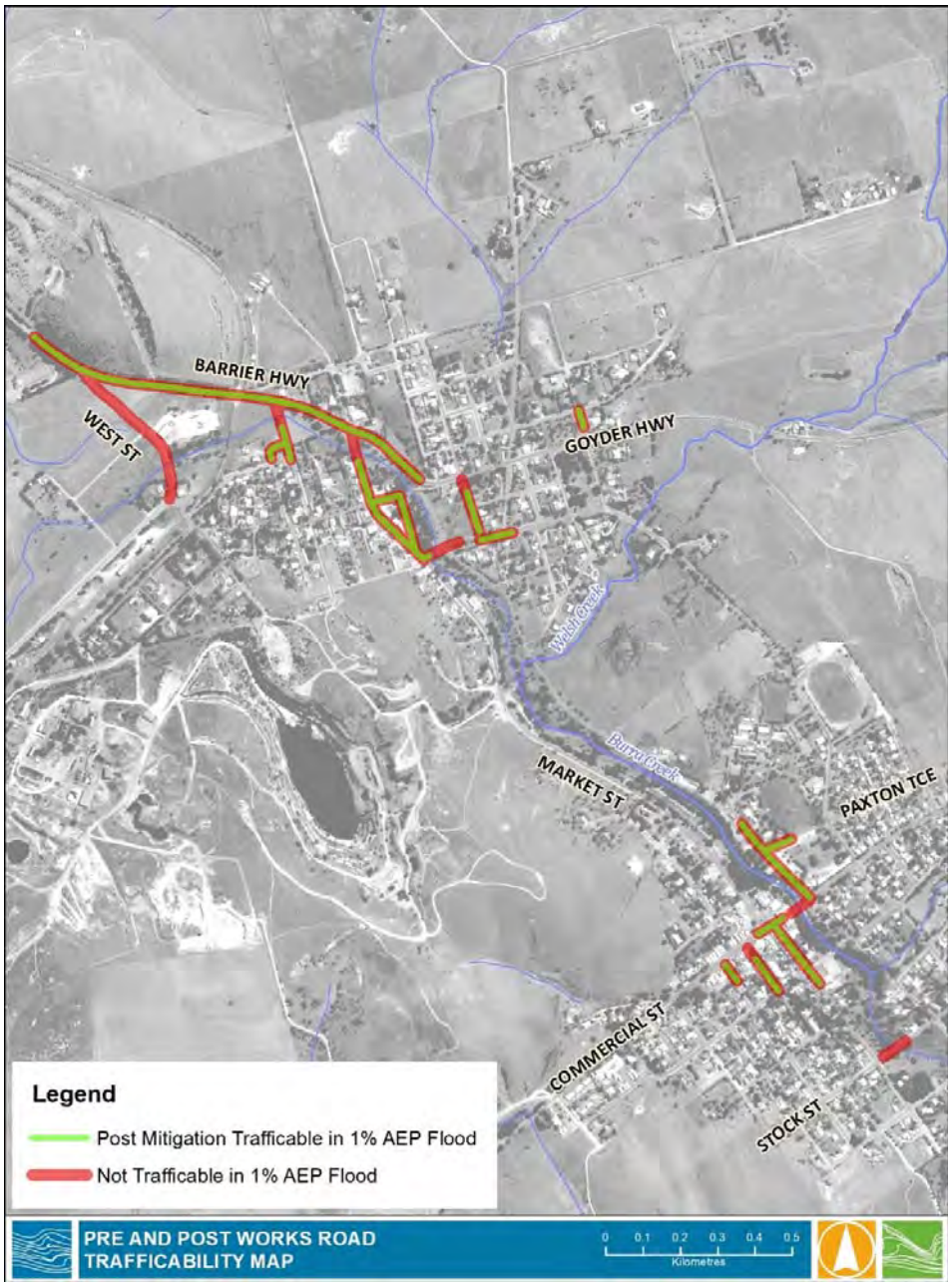


FIGURE 6-15 PRE AND POST WORKS ROAD TRAFFICABILITY MAP

6.5 Impact of Mitigation Measures on Downstream Environments and Stream Stability

It is important to understand the impact of the proposed mitigation measures on downstream environments, such as higher flow velocities that may cause erosion issues.

The flood management measures for the localised flooding issues could result in localised increase in scour at the outfalls to the Burra Creek. Hence final designs at those locations will need to provide adequate scour protection. This, in conjunction with watercourse rehabilitation works, will help protect downstream environments by reducing the risk of stream instability, erosion and sediment transport.

6.6 Management and Regular Maintenance of Drainage Infrastructure and Watercourses (M1)

Regional Council of Goyder has a current Asset Management Plan. The plan estimates a maintenance value for transport infrastructure at $175k in 2020/21, including drainage, footpaths, kerbing, foot bridges, parks and reserves, and council-wide bin replacement and tree planting.

A survey of existing stormwater assets along Burra Creek and its tributaries was carried out as part of this SMP. Recommendations and priorities for additional asset management works are provided in Appendix F. These should be reviewed and incorporated into Council's Asset Management Plans.

The effectiveness of stormwater drainage infrastructure and watercourses is influenced by whether or not they are maintained and free of blockages. It is recommended that Council maintain the drainage paths and infrastructure in a manner to ensure they perform as designed, i.e. to enable efficient flow of water.

WSUD assets require routine and renewal maintenance in order to maintain functional performance at desired levels of service. It is recommended that council investigates the potential to incorporate WSUD asset maintenance planning into their open space maintenance budget. This would facilitate the funding of maintenance of WSUD assets and enable multiple benefits (water quality, amenity, biodiversity) to be achieved through maintenance expenditure.

In relation to fences across watercourses, it is also recommended that Council, in conjunction with the Northern and Yorke Landscape Board, assesses the suitability of stream fencing that may be in place, and identifies the need for any upgrade/modification to existing fences as appropriate. It is anticipated that this work would be done in partnership with landholders and the Landscape Board.

These actions are included in the list of recommendations as M1 in Table 7-1Table 7-1 R.

Further information and recommendations on the maintenance of watercourses and stormwater infrastructure located in private and public land is provided in section 10.2 of this report.

6.7 Water Quality

Recommendations for improving water quality include increasing the effective use of rainwater tanks and the construction of a formalised natural treatment system near Spring Street.

6.7.1 Water Quality Targets

This SMP explores options to improve water quality and to achieve the following targets:

- Environment Protection (Water Quality) Policy 2003:
  - Total Suspended Solids (TSS): 20 mg/L;
  - Total Phosphorus (TP): 0.5 mg/L; and
  - Total Nitrogen (TN): 5 mg/L.
- State Government's Department of Water and Natural Resources (WSUD) 2013:
  - TSS reduced by 80 per cent;
  - TP reduced by 60 per cent;
  - TN reduced by 45 per cent; and
  - Gross pollutants (GP) reduced by 90 per cent.

6.7.2 Water Sensitive Urban Design Options to Improve Water Quality

Technical investigations and a site inspection of Burra was undertaken to assess the township's potential to integrate Water Sensitive Urban Design (WSUD) measures into the existing landscape to help improve water quality. The following section describes the following WSUD options to improve water quality:

- Wetland
- Rainwater tanks
- Riparian Rehabilitation.

A description of the riparian works is provided in Section 6.9, the other two strategies are outlined below.

Spring Street Wetland (WQ1)

The benefits of installing an ephemeral wetland to assist in improving water quality were explored in this SMP. The proposed Spring Street wetland is tested to improve water quality by detaining water and removing pollutants, as well as other benefits such as enhancing amenity, biodiversity values and providing storage for future reuse. The proposed location of the wetland can be shown in Figure 6-16.

Runoff from Burra township stormwater system flows down the Burra Creek and is directed into the wetland via a low diversion weir. The wetland has been designed to have a surface area of 25,000 m^2, providing an available storage volume for treatment of approximately 62.5 ML. The wetland has a maximum and operating depth of 2.5m.

The effectiveness of the Spring Street wetland in improving water quality and a comparison against water quality targets is described in the following section of this report.

Should Council prefer, a subsurface biofiltration system could be used in lieu of a wetland. A final decision on the form of treatment can be made through subsequent design stages. The operating arrangements (eg inflow diversion arrangements) would be similar.

FIGURE 6-16 PROPOSED LOCATION OF THE SPRING STREET WETLAND

Rainwater Tanks

Rainwater tanks can also provide some water quality benefits. Rainwater tanks can have an impact on minor flows (less than 5-year ARI) in the downstream drainage system. They can also reduce the total volume of stormwater discharged from allotments and as a result are likely to be of benefit in reducing the impact of stormwater on the downstream receiving environment.

It is recommended that Council promote the effective use of rainwater tanks in the existing township as well as in new development areas and incorporate WSUD systems within Council infrastructure works (e.g. road upgrades) and streetscape upgrades. A further discussion on rainwater tanks is provided under the water reuse section of this SMP.

6.7.3 Water Quality Improvements

An evaluation of the treatment systems was undertaken using the MUSIC model to understand their effectiveness in improving water quality.

Analysis of the catchment area and land uses was undertaken to determine the likely pollutants at Burra. These attributes were modelled using the computer software program 'MUSIC' (Model for Urban Stormwater Improvement Conceptualisation). This program enables the user to quantify stormwater volumes and quality as well as to develop conceptual design for treatment systems.

The MUSIC model developed encapsulates the entire Burra Urban catchment including the potential development at the time of modelling.

The effectiveness of the wetland system was tested. The model was run over an extended time frame of 56 years (1961-2017) and for two scenarios: low flow from the rural catchments (i.e. normal years) and relatively high flow from the rural catchments (i.e. 10 year ARI or even larger year ARI). Over this period the average pollutant reduction levels for normal flow and high flow years were demonstrated in Table 6-1.

TABLE 6-1 STORMWATER TREATMENT PERFORMANCE FOR THE PROPOSED WETLAND

Analyte	Normal flow years treatment performance (% reduction)	High flow years treatment performance (% reduction)	State Government target (% reduction)
TSS	84	66	80
TP	81	60	60
TN	72	51	45

Treatment best practice criteria for TP, TN, and TSS are met for normal flow years, although the criteria of the Total Suspended Solids for high flow years did not meet the target. The improvement in water quality supports Council's Development Plan principles relating to managing and improving the quality of stormwater runoff. It also helps support the SAMDB NRM's resource condition targets relating to maintaining and improving water quality in aquatic environments.

6.8 Stormwater Harvesting and Reuse

Obtaining permission to harvest and reuse stormwater in Burra is unlikely as it is within the Burra Prescribed Water Resources Area. Instead, the use of rainwater tanks and other at-source WSUD measures such rain gardens and roadside vegetation watering systems should be promoted.

Overview

Opportunities for harvesting and reusing stormwater were explored, particularly in relation to reusing stormwater to irrigate garden verges, the oval, and other sporting sites. However, there is limited scope for stormwater reuse in Burra as there are likely to be constraint, such as variable nature of the aquifer and that Burra Creek is already a water stressed system making increased extractions undesirable.

The River Murray Prescribed Watercourse Area has controls on the development and use of surface water and groundwater resources. If Council (or any organisation) were to pursue water harvesting from the Burra Creek or its tributaries, or to develop a Managed Aquifer Recharge system, then it would need to comply with the requirements of the Water Allocation Plan (WAP) for the River Murray Prescribed Watercourse Area.

A review of the WAP requirements identified that the harvesting of stormwater in Burra would be considered as an extraction of the water resource from the Burra Creek catchment. Discussions with the South Australian Murray-Darling Basin Natural Resources Management Board (the Board) have at this stage highlighted that stormwater reuse for Burra would not support the requirements of the WAP, particularly in regard to the requirements of extraction.

Managed Aquifer Recharge (MAR)

MAR is the process of adding stormwater and/or treated wastewater to aquifers in a controlled environment. The purpose of MAR is to allow for the storage and extraction of reuse water for beneficial use, be this for amenity, horticultural or commercial use, or for providing alternative water resources particularly in extended dry periods.

It would be difficult to determine the suitability of a Burra MAR scheme without preliminary testing of existing bores given the available information indicates fractured rock aquifers and a fault line beneath the subsurface of the immediately surrounding (~2km) area. Difficulties that may be encountered include:

- Low injection and extraction rates and volumes where boreholes have low yields;
- Clogging of fractures; and
- Inadequate recovery of injected water due to nature of fractures (injected water may move beyond influence of pumping hence not be able to be recovered).

Rainwater Tanks (R1)

An alternative approach to a centralised stormwater harvesting system utilising wetlands and MAR is to adopt a distributed approach utilising rainwater tanks. Rainwater tanks can reduce the impact of stormwater on the town's drainage system and downstream receiving environments.

The extensive use of rainwater tanks is considered to be a practical at-source alternative to larger centralised MAR schemes. Furthermore, the cost of the harvesting system is effectively passed on directly to the individual landholder who benefits from the scheme.

The amount of rainfall (or roof runoff) a property can capture, store and use annually is dependent on factors including:

- The annual rainfall;
- The roof area connected to the tank;
- How much rainwater is used and when it is used;
- The capacity to draw on a backup supply; and

- The capacity of the tank.

The key to this approach is to have a secure backup supply so that water in the rainwater tank can be used as a first option to supply household and garden needs in the winter and spring periods whilst over summer supplies can be sourced from the alternative supply (i.e. mains water).

Water from the tanks can be used without additional treatment for garden watering, toilet flushing, in the hot water system or other non-potable uses, particularly if larger tanks are utilised. Potable use is now also becoming more economically viable through emerging onsite UV and other technologies. The use of rainwater tanks in this way can significantly reduce the demand for mains water from the town.

It is therefore recommended that Council promote the effective use of rainwater tanks in the existing township as well as in new development areas. Ideally Council should promote a minimum tank size of 10kL to maximise the benefits rainwater tanks can provide. There is also the potential for Council to further encourage the installation and use of rainwater tanks by offering additional rebates to the rebates already available from SA Water.

It is also recommended that Council incorporate WSUD systems within Council infrastructure works (e.g. road upgrades) and streetscape upgrades

These recommendations are reflected in recommendation R1 in Table 7-1.

6.9 Watercourse Rehabilitation (WQ2-WQ7)

A detailed riparian survey of the Burra Creek was undertaken as a part of this SMP to identify areas of remnant native vegetation to protect and conserve, as well as identifying stream stability (erosion issues) and ecology issues. The need for mitigation measures was also identified by those earlier surveys and priorities established for the works. A rehabilitation protocol was developed to assist in the assessment, protection and rehabilitation of sites.

The survey and rehabilitation process utilises a reached-by-reach approach whereby discrete sections of watercourse are identified that can be managed independently (within a whole of catchment framework) from each other.

In the first instance the Burra Creek was identified in the township as being shown in Figure 6-17 and each main watercourse section was then subsequently divided into discrete management reaches. The start and end of the reaches were defined by:

- A notable change in vegetation type or structure; and/or
- A notable change in the geomorphology of the river.

In practice, most of these changes occurred at anthropogenic structures such as bridges and fords. Reaches were labelled in descending order moving upstream. Each reach has been labelled with an alpha numeric identifier. For example, MC1 refers to the most upstream reach on the main channel section of the Burra Creek, TR1 refers to the most upstream tributary of the Burra Creek.

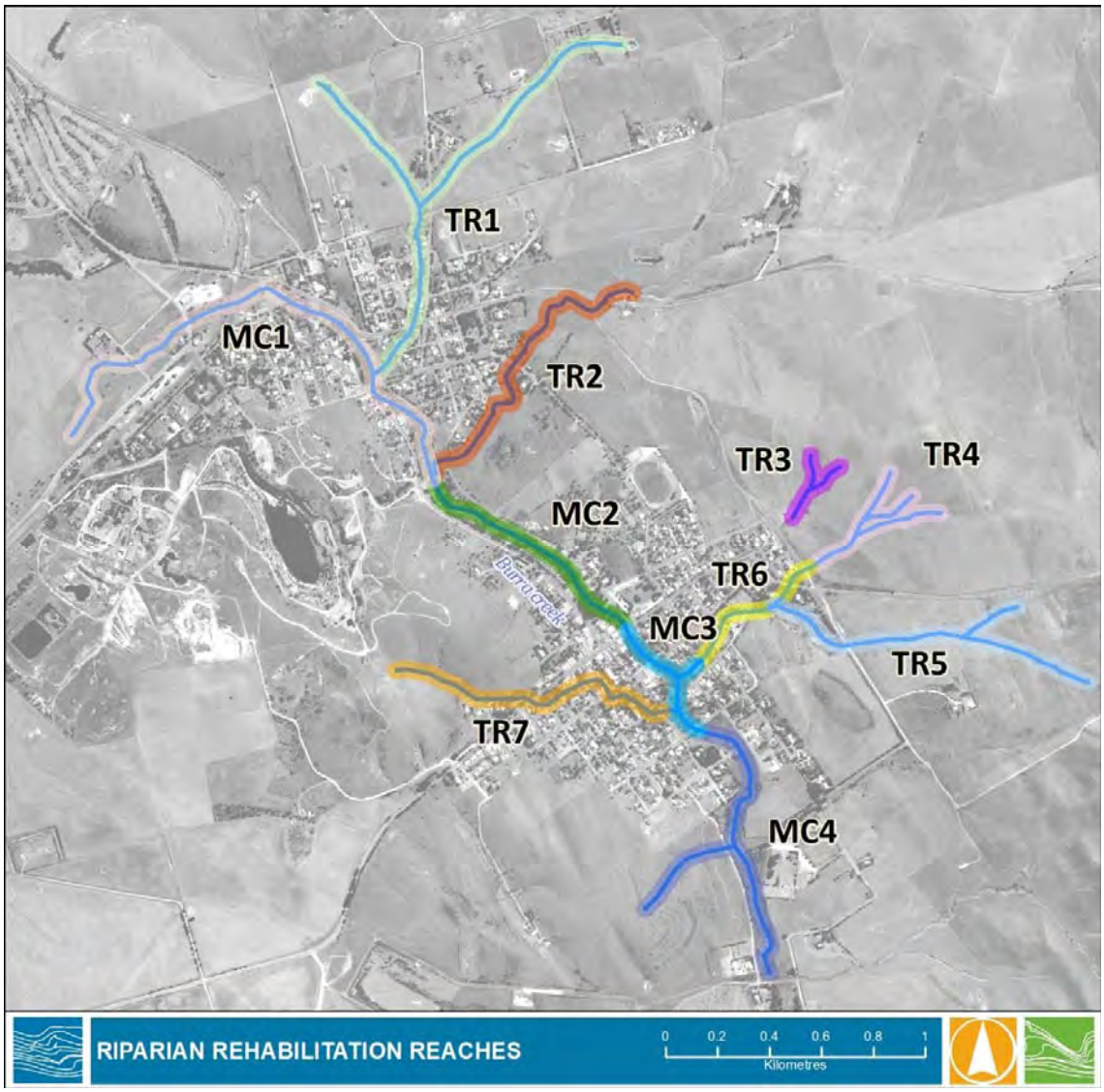


FIGURE 6-17 RIPARIAN REHABILITATION REACHES

Data collection was based on the protocol Quantifying the Health of Ephemeral Rivers (QHER) developed by Justin Costelloe (Melbourne University for the Department of Water, Land and Biodiversity Conservation). This protocol focuses on collecting data regarding the geomorphology of the channel, vegetation of the riparian zone, erosion of the bed and banks of the channel, and the location of anthropogenic structures relative to the site.

The results of the survey are described in detail in Appendix G. A high-level summary is provided in Table 6-2.

TABLE 6-2 RIPARIAN SURVEY RESULTS SUMMARY

Reach Identifier	Issues / Features
MC1	Watercourse disconnected from floodplain. Weedy and stable creek bed with minor bank erosion and scour issues. Half-blocked and blocked stormwater outlet and culvert visible. Bed instabilities evident in the swale along southern side of St Just Street.
MC2	Watercourse disconnected from floodplain, good canopy cover from higher strata vegetation (trees) but less dense mid and understory plants present. Mostly native vegetation in channel section of riparian zone. Minor bank erosion and stormwater outlet scour issues with some bed stability works required.
MC3	Watercourse disconnected from floodplain, good canopy cover from higher strata vegetation (trees) but less dense mid and understory plants present. A mixture of native and exotic vegetation in channel section of riparian zone. Moderate scour issues with some bed stability works required.
MC4	Watercourse disconnected from floodplain, good canopy cover from higher strata vegetation (trees) but less dense mid and understory plants present. More native vegetation in channel section of riparian zone. Bank erosion with no major bed stability issues. Investigate opportunity for wetland treatment area.
TR1	Weedy but stable creek bed. Blocked culvert under Suncreed Street visible and signs of bed deepening visible at junction of TR1 and the Burra Creek. There are limited opportunities for works given access and space constraints.
TR2	Watercourse is all in private land, weedy and stable. Scour at the downstream of the culvert near the intersection of TR2 and the Burra Creek visible. There are limited opportunities for works given access constraints.
TR3	Swale and embankment visible along the gravel road parallel to Paxton Terrace, diverting water from TR3 to TR4 through a gravel road ford crossing.
TR4	Watercourse disconnected from floodplain. Weedy and stable creek bed visible upstream of a bridge locating under Paradise Street-Kooringa Road. Scour issues at the upstream of the bridge. Rocky bank on the left bank and rocky creek bed visible at the downstream of the bridge. There are limited opportunities for works given access constraints.
TR5	Weedy and stable creek bed and banks.
TR6	Weedy and stable creek bed at the upstream of a bridge locating under Welsh Place/Ayers Street. Significant erosion issues visible downstream of the bridge and scour protection or culvert upgrade works required. Natural rock exposed downstream of the bridge. Miner's Dugouts c, 1850 visible in this section. Bad Scour immediately upstream of a bridge locating under the path near the junction of TR6 and Burra Creek, and scour protection works required. There are limited opportunities for works given access constraints.
TR7_1	Watercourse disconnected from floodplain, good canopy cover from higher strata vegetation (trees) but less dense mid and understory plants present. Mostly exotic vegetation in channel section of riparian zone. Weedy and stable creek bed. Some bank erosion issues, and severe stormwater outlet scour present that needs to be repaired. Some trees and fallen trees need to realign to avoid affecting bed stability.

Reach Identifier	Issues / Features
TR7_2	Watercourse disconnected from floodplain. Mostly exotic vegetation in channel section of riparian zone. Weedy and stable creek bed. Increase diversity of plantings and manage weeds. Significant bridge abutment cracking and spoiling concrete that need to repair.

The QHER was employed to give an indication of the health of a stream. This was not the only objective of the Burra riparian surveys and as such the protocol was modified to also allow priority setting for rehabilitation. The modification included providing descriptive information about the site and management actions required for the area.

The criteria for priority setting (Table 6-3) falls under three major categories: the state of the native vegetation, the availability of area for a rehabilitation program, and erosion issues at the site.

TABLE 6-3 REHABILITATION PRIORITY SETTING CRITERIA

Description	Categories (score)	Max Score
State of native vegetation		
Connectivity between riparian and rising ground	Present (1), Absent (0)	1
Canopy health	Average health score (1, 2, 3, 4, 5)	5
Native vegetation layers	Overstory, understory, groundcover (score 1 each up to total of 3)	3
Bed vegetation	None (0) exotic (1), mix native and exotic (2), native (3)	3
Regeneration of native canopy/shrubs	Present (1), Absent (0)	1
Longitudinal coverage of native canopy vegetation	<10% (0), 10-25% (1), 25-50% (2), 50-75% (3), >75% (4)	4
Availability of area for rehabilitation		
Space available for revegetation in current state	Present (1), Absent (0)	1
Erosion Issues		
Sediment movement	Active (0), stable (1), very stable (2)	2
Severity of bank erosion	None (3), minor (2), moderate (1), severe (0)	2
Bank stabilisation required	No (1), Yes (0)	1
Other erosion control required	No (1), Yes (0)	0

The category, availability of area for rehabilitation, is provided to give an indication of the current availability of the riparian zone for revegetation plantings. Some of the sites in the study area have restricted access to the riparian zone as the surrounding land use is private property. As such these areas are not identified as priorities for rehabilitation at this point in time, unless Council embarks on a major channel widening program including property acquisition which is not recommended solely for watercourse rehabilitation purposes.

The results from the priority setting exercise are shown below in Table 6-4.

TABLE 6-4 REHABILITATION PRIORITY SETTING RESULTS

		Scores for Ranking Priorities			
		Vegetation	*Space*	*Erosion*	***Overall***
Reach Identifier	**MC1**	7	1	3	**11**
	MC2	12	1	4	**17**
	MC3	12	1	3	**16**
	MC4	12	1	2	**15**
	TR1	8	0	3	**11**
	TR2	8	0	4	**12**
	TR3	5	1	4	**10**
	TR4	4	0	3	**7**
	TR5	6	1	3	**10**
	TR6	6	1	1	**8**
	TR7_1	9	1	4	**14**
	TR7_2	9	1	3	**13**

A suggested works program for riparian works is outlined in Figure 6-18. The works program groups individual reaches into larger works packages for efficiency purposes but effectively works could be undertaken on an individual reach basis if that more readily met council budgeting requirements. A key task in the rehabilitation is revegetation. Given the critical importance of the revegetation phase of rehabilitation work, a revegetation template has been provided in Appendix D. The template focusses on colonising riparian plants with a mixture of strata and species – these should be the priority for plantings, with an emphasis on low (grasses, sedges, ground covers) and mid strata species (shrubs). Notwithstanding this, effort should be made to use seed collected from locally existing native species. Planting local species promotes successful plant establishment because those plants have already successfully established in the area and there is increased potential for interaction with animals in the area for pollination and seed dispersal. Seeds should also be collected from the nearest possible native or remnant vegetation to make sure that they are from a similar soil type.

In addition, it is likely that local revegetation activities will identify other species that are of value for revegetation and can be included, proved they are locally native species with appropriate provenance. In this regard it is important that Council and the community continue to liaise with the Northern and Yorke Landscape Board to ensure species proposed for planting are the most appropriate for that specific site.

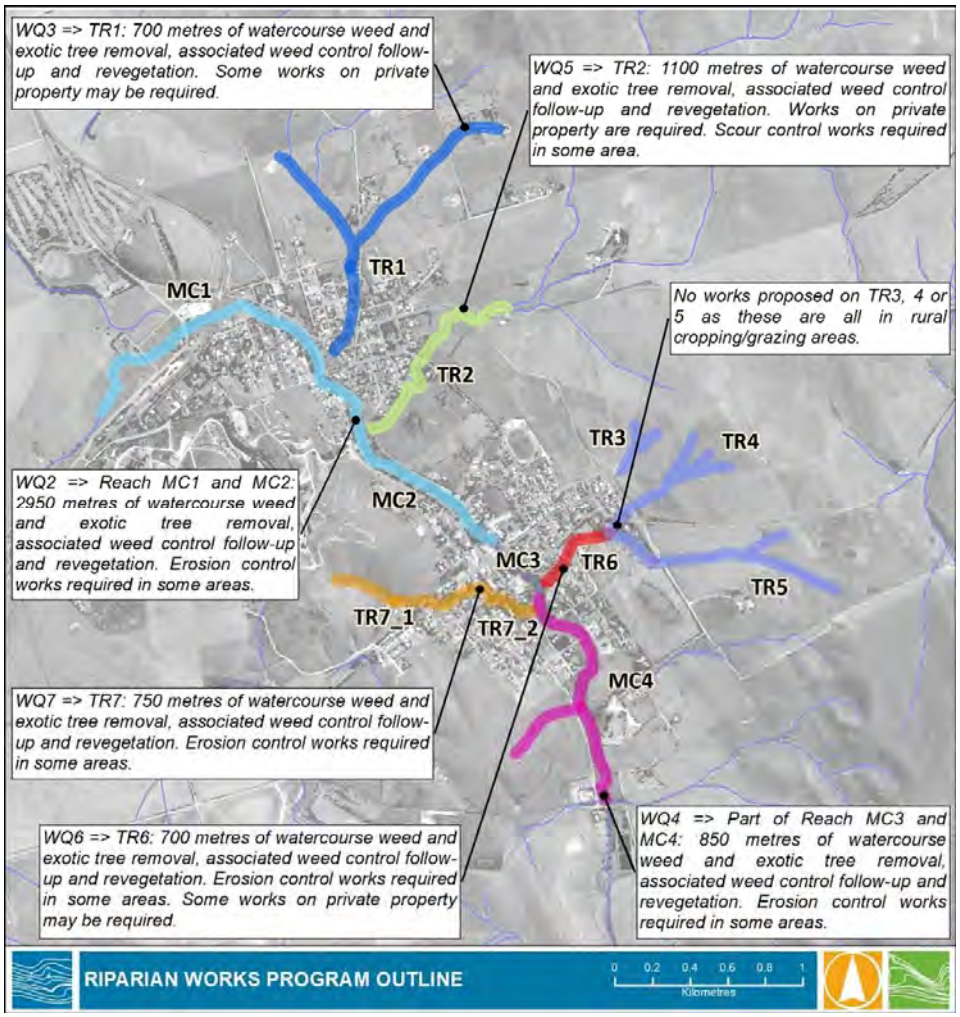


FIGURE 6-18 RIPARIAN WORKS PROGRAM OUTLINE

6.10 Complimentary small scale stream rehabilitation works (WQ8a and WQ8b)

During the consultation period comments were received highlighting a number of small scale works that could be undertaken to locally improve the aesthetics and biodiversity. Whilst these measures are not sufficient to achieve the desired water quality improvements sought by Council and state government stakeholders, they non-the-less would provide a local improvement in amenity and biodiversity. The main opportunities raised included:

- Behind the Ambulance Station just downstream from the St Just St Ford which is also fed by the Tregony Street swale;
- By the Mine Store adjacent to Welsh Creek or an alternative/complementary system upstream from the Bowling Club footbridge, enabling pedestrian movement across the creek, and landscaping work adjacent to the Bowling Club;
- At the Miners Dugouts where in fact, water remains on a regular basis after even modest rainfall (which is located within TR6); and
- At the existing weir and embankment downstream of the tributary (TR6) junction with the main watercourse (MC3).

Of these, opportunities that coexist within proximity of suggested major SMP works and will not potentially compromise flood conveyance are most likely to provide the greatest opportunities for implementation. In this regard:

- Significant works are recommended for the Ayers Street crossing of Tributary TR6, which is just a short distance upstream of the Miners Dugout. Inclusion of localised biodiversity actions along this tributary from Ayers Street to the junction of Burra Creek would potentially add significant community value to an otherwise standard engineering project. This initiative is therefore incorporated as WQ8a, as a subset of WQ6. It is further suggested that this site be used as a pilot site to demonstrate effective riparian rehabilitation actions.
- The embankment and weir on the main Burra Creek channel downstream of the bowling club, is highlighted as highlighted as requiring remedial works. The design of these remedial works could be expanded to include a review of the functionality of the existing structures and their integration with a wider opportunity stretching upstream to the foot bridge adjacent the bowling club. This initiative is therefore incorporated as WQ8b, as a subset of WQ4.

Should these works be pursued it is important that they are undertaken within a whole of reach context and hence have been included as “subprojects” of major reaches rather than standalone projects. That is not to say that they need to wait until the works along that full reach are undertaken, but they do need to be designed within that whole of reach context.

6.11 Cultural Considerations

The township of Burra and it surrounds have a rich cultural history associated with settlement and pre-settlement times.

Cultural water has been included as an environmental value associated with the waters and physical form of Burra Creek (within the SMP study area), but little is specifically known of those requirements at this time. As a guiding principle the works and measures have had regard to natural environment water requirements of the Burra Creek, as reflected in the environmental values associated with aquatic ecosystems and anticipates that this will at least contribute towards meeting cultural water requirements of the Ngadjuri people until such time as their specific requirements can be articulated.

The works and measures included with the SMP have had regard to this history and have been designed to protect known cultural areas of significance from flooding whilst also ensuring such areas are not impacted by works and measures included in the SMP.

7 Recommendations

7.1 Structural and Non-Structural Measures

Recommendations include structural measures aimed at improving stormwater and flood management, opportunities for stormwater harvesting and reuse, as well as several non-structural measures.

Recommendations with their associated costs and benefits are provided in Table 7-1. This table also identifies if the catchment area of the proposed works is greater than 40ha. This is the threshold catchment area that the SMA applies for funding.

TABLE 7-1 RECOMMENDATIONS

Recommended works	SMP Objective (catchment area)	Preliminary construction cost estimate	Benefits	
			Number of properties protected	Other
F1: Levee Earthworks along Burra Creek	>40 ha	$ 810,000	30	Improved road trafficability.
F2: Burra Creek Tributary Crossing Kangaroo Street, Queen Street and Chapel Street Drainage System	>40 ha	$150,000	25	Improved road trafficability.
F3: Paxton Terrace Drainage System	>40 ha	$350,000	12	Improved road trafficability.
F4: St Just Street Drainage	<40 ha	$380,000	9	Improved road trafficability.
F5: Tregony Street Drainage System	>40 ha	$600,000	3	Improved road trafficability.
F6: Goyder Hwy and Stronach Street Drainage System	<40 ha	$100,000	2	Improved road trafficability.
M1: Regular maintenance of stormwater drainage infrastructure and watercourses, in accordance with Council's Asset Management Plan requirements.	<40 ha	$10,000	-	Improved road trafficability. Community recognition of Council initiative.
P1: Flood preparedness program – re-establishment of a flood warning system and community awareness program	>40 ha	$40,000	All	Increased community wellbeing and resilience to flooding.
P2: Development / planning controls	<40 ha	-	-	Better planning outcomes.
R1: Harvesting and Reuse: Promote the use of rainwater tanks and increase minimum size to 10,000L.	<40 ha	$3,000	-	Reduction in mains water use.
WQ1: Water Quality Spring Street Wetland	>40 ha	$2,500,000	-	Downstream environments and biodiversity.
WQ2 – Riparian Rehabilitation reaches MC1 – MC2	> 40 ha	$1,190,000	-	Downstream environments and biodiversity
WQ3 – Riparian Rehabilitation reaches TR1	> 40 ha	$570,000	-	Downstream environments and biodiversity
WQ4 – Riparian Rehabilitation reaches MC3 – MC4: Incorporating WQ8b	> 40 ha	$720,000	-	Downstream environments and biodiversity
WQ5 – Riparian Rehabilitation reaches TR2	> 40 ha	$830,000	-	Downstream environments and biodiversity
WQ6 – Riparian Rehabilitation reaches TR4, TR5, TR6: Incorporating WQ8a	> 40 ha	$650,000	-	Downstream environments and biodiversity
WQ7 – Riparian Rehabilitation reaches TR7	> 40 ha	$610,000	-	Downstream environments and biodiversity

7.2 Environmental, Social and Economic Opportunities/Benefits

Environmental enhancement opportunities resulting from the recommended actions in this SMP are predominantly based on the improvements to water quality and better management of stormwater flows. These actions will help to protect the receiving environment of the Burra Creek.

The improved infrastructure aimed at flood control recommended in this SMP will provide social benefits, including improved public safety, protection of property and continuity of community services. The increased standard of drainage and regular infrastructure maintenance will help to prevent nuisance flooding. This will alleviate community frustration and help maintain business trade in the town.

Non-structural measures, such as flood preparedness programs, flood warning systems and education will improve the community's capacity to prepare for and manage stormwater issues, as well as create a stronger sense of security within the community. Planning controls (e.g. Council's Development Plan) provide a framework to plan and build in a manner that incorporates stormwater management.

There are also economic benefits as there will not be the same damage costs as there would be without the stormwater infrastructure. The measures help to prevent flooding which will result in less disruption to business trade and transport routes, and also avoid economic losses arising from stormwater issues. The improvements to stormwater management may have a positive impact on business confidence and attract future economic investment in the area.

7.3 Water Affecting Activities

Council may be required to seek a permit for Water Affecting Activities (WAA) from Natural Resources SA under Section 75(3)(k) of the Natural Resources Management Act 2004. WAA relate to works around watercourses that have the potential to compromise the use or quality of water resources, or the capacity for natural systems to restore or maintain water quality.

Examples of activities that may require a WAA permit are proposed detention basins, wetland and watercourse rehabilitation works.

The conditions under which the Board will grant or refuse a permit may be outlined in either the Regional NRM Plan or a relevant water allocation plan (WAP). Where a WAP exists (and outlines policies for any given water affecting activity) the policies within the WAP will be used as the basis for the assessment of the permit application.

Natural Resources SA has determined a process for granting exemptions to local government and other statutory authorities for particular WAAs that would otherwise require a permit. Best practice operating procedures are approved procedures developed by eligible authorities to exceed minimum standards of operations for a range of water activities undertaken.

8 Potential Funding and Arrangements and Opportunities

8.1 Introduction

A review of potential funding mechanisms for stormwater management by local government was undertaken by Jeff Tate Consulting in 2014. His report identified a range of potential funding mechanisms, the key ones being as follows:

- Local Government general revenue;
- State Government general revenue;
- Recurrent grants and special purpose grants from the Australian Government;
- Use of operating surpluses (current and retained) from general government;
- Australian-State-Local funding agreement;
- Special purpose funds;
- Infrastructure contributions;
- Levies/charges
    - State-wide
    - Catchment wide
    - Council wide
    - Polluter-pay charges
    - Vehicle charges
    - Other fines/charges;
- Revenue from stormwater sales;
- Separate rates;
- Private Public Partnerships – to facilitate private sector involvement in varying ways – direct financing.

A stormwater management plan that has been approved by the SMA and gazetted, is in a good position to attract funding contribution from the SMA to implement the recommendations. The SMA has the discretion to contribute more or less than 50% of the cost of certain works and may elect to contribute to the cost of works in a catchment of less than 40 ha, provided that those works form part of an approved Stormwater Management Plan. To assist in identifying funding opportunities with the SMA, the catchment sizes for the structural measures are provided in Table 7-1.

Council can incorporate stormwater management strategies in its Infrastructure and Asset Management Plans; however, it will need to seek funding contributions from other sources, as described below. The availability and timing of funding and resources will determine the order and staging of the works.

A review of the above potential mechanisms identified the following as being the most likely funding mechanisms for financing the implementation of the Burra SMP. Potential funding partners for each recommendation is provided in the detailed Implementation Plan in Appendix F and Table 10-1 and are summarised in the sections that follow.

8.1.1 Capital Funding Potential Partners

Potential funding partners for Council in relation to capital works will vary depending on the nature of the works. The most likely sources are highlighted below.

Drainage Flood Mitigation Works (or components thereof)

- DPTI: Replacement of bridges that are presently undersized and would need to be replaced should that be the preferred major mitigation approach of Council.
- SMA potential funding for catchments greater than 40ha for flood management, water quality and water reuse.
- Regional Development Board (RDB): Regional Development Fund aims to drive economic growth and productivity by investing in regional infrastructure, creating jobs and new opportunities for regional South Australia. Such funding may contribute to the infrastructure works as those listed above for the SMA.

Flood Preparedness Program (Community awareness/education program, e.g. Floodsafe)

- SES.

Water Quality / Biodiversity

- The Northern and Yorke Landscape Board may be a potential partner for establishing the proposed watercourse rehabilitation through the town and establishment of the verge infiltration pits and biofiltration pits and wetland.
- Local community groups have expressed strong interest in supporting the development of a pilot project and with the developments of a small number of localised bio-diversity and amenity improvement projects. They have already contributed many hundreds of hours of in-kind support through revegetation initiatives and hence their contributions should be incorporated (but not taken for granted) within any riparian works program where there this is strong alignment in objectives. The suggested biodiversity works at the Miner Dugouts would appear to present an ideal pilot project site.
- Private Public Partnership should a landholder contribute to works as part of a land subdivision proposal or a desire to rehabilitate the watercourse flowing through their property as part of a wider property plan.

Water Reuse / Harvesting

- Australian Government (Water security funding).
- Private Public Partnership should an external demand for water be identified in the future.

8.1.2 Funding of Maintenance Activities

Ongoing maintenance activities are likely to need to be funded from within Council's rate base.

Identifying a separate special purpose levy for drainage maintenance is unlikely to be very popular for ongoing maintenance work.

A small revenue stream would be possible should an external demand for stormwater supply be identified. However, provision for any such supply should only be undertaken on a fully commercial basis.

In addition, Council could enlist community input via activities such as revegetation programs and 'Citizen Science' activities to monitor water quality, flora and fauna, and thereby assist with reviewing the implementation and condition of Burra Creek and its tributaries.

9 Priorities and Timeframes for Implementation

The SMA Guidelines recommend that the highest priorities are for works and measures that reduce flood hazard and protect life and property. In accordance with the multi-objective approach to stormwater management, greater weighting should be placed on strategies that also provide opportunities for stormwater reuse, and improvement to water quality, open space/local amenity, biodiversity and recreation.

A qualitative assessment of the recommended strategies has been undertaken to determine their ranking and priorities. This assessment is shown Appendix E.

A detailed 10 year program for implementing the recommended strategies has been developed for Council, refer to the Implementation Plan in Appendix F. It provides information on the priorities, timeframes, costs, benefits and potential funding partners.

Notwithstanding this preferred list of actions and timing, the availability and timing of funding and resources will determine the order and staging of the works.

A summary of the priorities is provided below in Table 9-1.

TABLE 9-1 SUMMARY OF PRIORITIES

Priority	Timeframe 0 - 1 yr 1 - 5 yrs 5 - 10 yrs	Recommendations	Capital Cost ($)	Recurrent Cost ($ pa)
High	0 - 1	M1: Asset management and regular maintenance of stormwater drainage infrastructure and watercourses	$10,000	$5,000
High	0 - 1	P2: Development / planning controls	-	-
High	1 - 5	P1 - Flood preparedness program – establishment of rainfall thresholds for flood warning system	$20,000	$5,000
High	1 - 5	P1 - Flood preparedness program - Community education program - e.g. Floodsafe. (Community/education officer role and associated materials).	$20,000	$1,000
High	5 - 10	F1: Levee Earthworks along Burra Creek.	$ 810,000	$16,000
High	1 - 5	F2: Burra Creek Tributary Crossing Kangaroo Street, Queen Street and Chapel Street Drainage.	$150,000	$3,000
High	1 - 5	F4: St Just Street Drainage.	$150,000	$7,500
Low	5 - 10	WQ1: Water Quality Construction of the Spring Street wetlands.	$2,500,000	$10,000
Medium	1 - 5	F3: Paxton Terrace Drainage System	$350,000	$7,000
Medium	1 - 5	F5: Tregony Street Drainage	$600,000	$12,000
Low	5 - 10	F6: Goyder Hwy and Stronach Street Drainage System	$100,000	$2,000
Low	1 - 5	R1: Harvesting and Reuse: Promote the use of rainwater tanks and increase minimum size to 10,000L.	$3,000	Landholder responsibility
Low	5 - 10	WQ2 – Riparian Rehabilitation reaches MC1 – MC2	$1,190,000	$50,000

Priority	Timeframe 0 - 1 yr 1 - 5 yrs 5 - 10 yrs	Recommendations	Capital Cost ($)	Recurrent Cost ($ pa)
Low	5 - 10	WQ3 – Riparian Rehabilitation reaches TR1	$570,000	$10,000
Low	5 - 10	WQ4 – Riparian Rehabilitation reaches MC3 – MC4 WQ8b – Localised biodiversity and amenity improvements in main watercourse downstream of footbridge	$720,000	$12,000
Low	5 - 10	WQ5 – Riparian Rehabilitation reaches TR2	$830,000	$12,000
Low	5 - 10	WQ6 – Riparian Rehabilitation reaches TR4, TR5, TR6 WQ8a – Localised biodiversity and amenity improvements adjacent Miners Dugouts	$650,000	$11,000
Low	5 - 10	WQ7 – Riparian Rehabilitation reaches TR7	$610,000	$10,000

10 Responsibilities for Implementation

10.1 Responsibilities and Partners

Responsibilities and potential partners with Council for implementing the recommendations in this SMP are presented in Table 10-1.

TABLE 10-1 IMPLEMENTATION RESPONSIBILITIES

Recommendation	Responsibility and Potential Partners
M1: Asset management and regular maintenance of stormwater drainage infrastructure and watercourses.	Council, and in partnership with landholders, local community groups and the Landscape Board as appropriate
P2: Development / planning controls	Council
P1: Flood preparedness program – re-establishment of flood warning thresholds to link with BoM rain gauge	Council, with potential partnership and/or funding from BoM and SMA (flood warning system); and SES (community education program)
P1: Flood preparedness program - Community education program - e.g. Floodsafe (Community/education officer role and associated materials)	Council to lead with assistance from SES where appropriate.
F1: Channel levee works along Burra Creek	Council, and in partnership with landholders and the Landscape Board and SMA as appropriate.
F2: Burra Creek tributary crossing Kangaroo Street, Queen Street and Chapel Street drainage	Council
WQ1: Water Quality Construction of the Spring Street wetland	Council, and in partnership with the Landscape Board and SMA as appropriate
F4: St Just Street drainage system	Council
F3: Paxton Terrace drainage system	Council, and in partnership with landholders and the SMA as appropriate
F5: Tregony Street drainage system	Council, and in partnership with the SMA as appropriate
F6: Goyder Hwy and Stronach Street drainage system	Council
R1: Harvesting and Reuse: Promote the use of rainwater tanks and increase minimum size to 5000L.	Council
WQ2-WQ8 Riparian Works	Council, Northern and Yorke Landscape Board, and in partnership with the local community.

10.2 Responsibilities for Maintenance

The maintenance of watercourses and stormwater infrastructure that is located in **road reserves and council owned land** is normally the responsibility of the council concerned. For **other land** however, there is no legislation specifically identifying this as council's responsibility. Instead, it is the landowner's responsibility under the *Natural Resources Management Act* to maintain their land and watercourses in good condition in line with natural resource management practices. Any stormwater infrastructure constructed on **other land** is not the responsibility of the council to maintain unless the council has an interest in the land through an easement etc.

Maintenance of watercourses in good condition may include actions such as removal of weeds and removing any obstacles to flow (e.g. fallen branches, poorly constructed/inappropriate fencing). The Landscape Board could also assist landowners and local community groups by providing information on appropriate natural resource management practices including information on best practice for the maintenance of watercourses.

The community within Burra have already provided many hours (hundreds) of input to weed control and revegetation programs but ongoing technical and physical support to these groups is needed to ensure that past efforts can be supported, and results can be improved further.

Information on watercourse management can be found on the following page of the South Australian Murray Darling Basin NRM's website:

https://www.naturalresources.sa.gov.au/samurraydarlingbasin/water/managing-water-resources

Councils may also acquire, through an approved and gazetted stormwater management plan, the legislative responsibility to maintain watercourses in other land, including the power to enter such land (with reasonable notice) and to carry out works and infrastructure in accordance with the approved stormwater management plan. The legislative provision for this is contained in the Local Government (Stormwater Management) Amendment Act 2007.

It is important that the council puts in place the appropriate administrative arrangements to facilitate ongoing maintenance of any permanent infrastructure established on other land as part of this stormwater management plan. Unless otherwise agreed with the landowner, council must take on responsibility for permanent stormwater infrastructure that is to be placed on other land by taking an interest in the land. Examples of such an interest include an easement, a Land Management Agreement (under the Development Act) with the landowner (which would go on the title of the land), or land acquisition.

Furthermore, ongoing maintenance of works and measures is critical for their ongoing operation and effectiveness. This includes simple things such as desilting and clearing debris blocking culverts as well as weed management, if unattended to these "minor" issues can significantly exacerbate flooding issues and compromise biodiversity and amenity. It is recognised that budgets for maintenance are always difficult to maintain, hence ease of ongoing maintenance is an important consideration for the design and installation phases of establishing on ground works. Council should therefore require its designers to demonstrate how they have considered maintenance as part of any design it has prepared.

11 Review of the Stormwater Management Plan

It is anticipated that this Stormwater Management Plan will be a 'living document' that is periodically reviewed to take account of current knowledge, changing conditions within the catchment and changing community attitudes to the management of stormwater and other water resources making up the urban water cycle.

To ensure that this occurs, it is expected that Council initiates a review of this Plan at least every 5 years and that the proposed works and strategies to be adopted for the subsequent 10 year period will be identified.

The SMA recognises that the Plan may need to be amended to account for modifying or elevating the priority of the recommended actions as a result of unforeseen circumstances. This is providing that the proposed changes are consistent with the overall strategy and properly integrate with any existing or proposed infrastructure, including any Stormwater Management Plan for an adjoining catchment.

12 Community Feedback of the Draft SMP

The draft SMP was made available for comment by Council in accordance with Council's consultation, policies and procedures over a 4 week period in late 2020. One detailed submission from the Burra Revegetation Group that covered all aspects of the draft Plan.

A number of additional actions were included in this final plan that increase the effort in biodiversity and amenity aspects in response to community as well as recognition of the contributions that community could make in terms of assisting with implementing the plan.

The full submission and table of responses are included in Appendix I of this final plan.

13 References

Australian Water Environments (2012) Goyder: Integrated Water Management Plan (IWMP) for Burra

Department of Environment, Water and Natural Resources – DEWNR Soil and Land Program--Burra Creek Land System Report

South Australian Murray Darling Basin Natural Resources Management Board (2014): Natural resources management plan, Volume A, Strategic plan

South Australian Murray Darling Basin Natural Resources Management Board (2017): Natural resources management plan, Volume B, Board Business and Operational Plan

Regional Council of Goyder (2012): Strategic Directions Report Draft for Community Consultation

Department of Planning, Transport and Infrastructure (2016): Development Plan for Regional Council of Goyder

Department of Planning and Local Government (2011): Mid North Region Plan – A volume of the South Australian Planning Strategy

Regional Council of Goyder (2019): Goyder Master Plan 2018-2033

Regional Council of Goyder (2019) Annual Business Plan and Budget 2019/20 *Ten year Long Term Financial Plan 2019-29*

Australian Bureau of Statistics - 2011 Census (latest issues released at 11:30 AM (AEST) 28/03/2013)

Bureau of Transport Economics (2001) Economic Costs of Natural Disasters in Australia

Commonwealth of Australia (2009) Flood Preparedness, Manual 20 Australian Emergency Manual Series

Costelloe, J (2005) *QHER Draft Protocol*, Melbourne University

Deane, D, Graves. C, Magarey, PD & Phipps, L (2008). Preliminary Assessment of the Impacts of Water Resource Development on Burra Creek Catchment, DWLBC Report 2008/01, Department of Water, Land and Biodiversity Conservation, Adelaide

Department for Water (2011) Stormwater Strategy - The Future of Stormwater Management, Government of South Australia

Department of Environment, Water and Natural Resources (2013) Water Sensitive Urban Design – Creating more liveable and water sensitive cities in South Australia, Government of South Australia

Rutherford I., Jerie K.& Marsh N. (2000) *A Rehabilitation Manual for Australian Streams Volumes 1 &2*. CRC for Catchment Hydrology, Monash University.

SCARM (2000) Floodplain Management in Australia: Best Practice Principles and Guidelines. SCARM Report 73, CSIRO Publishing, Australia

Water for Good (2009) Government of South Australia

Australian Water Environments (2014) A Findings Report for the Gawler River Flood Mitigation Scheme: Hydrology Review

Australian Water Environments (2019) Clare Stormwater Management Plan (Draft)

Australian Water Environments (2010) Light River Floodplain Mapping – Hydrological Modelling Report

Olesen, L., Löwe, R. and Arnbjerg-Nielsen, K. (2017) Flood Damage Assessment: Literature review and recommended procedure. Cooperative Research Centre for Water Sensitive cities, Melbourne, Australia

Handmer, J., Reed, C., and Percovich, O. (2002) Australian Disaster Resilience Manal 27: Disaster Loss Assessment Guidelines, 2002, Australian Institute for Disaster Resilience CC BY-NC

Appendix A: Flood Inundation and Flood Hazard Maps

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER:
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

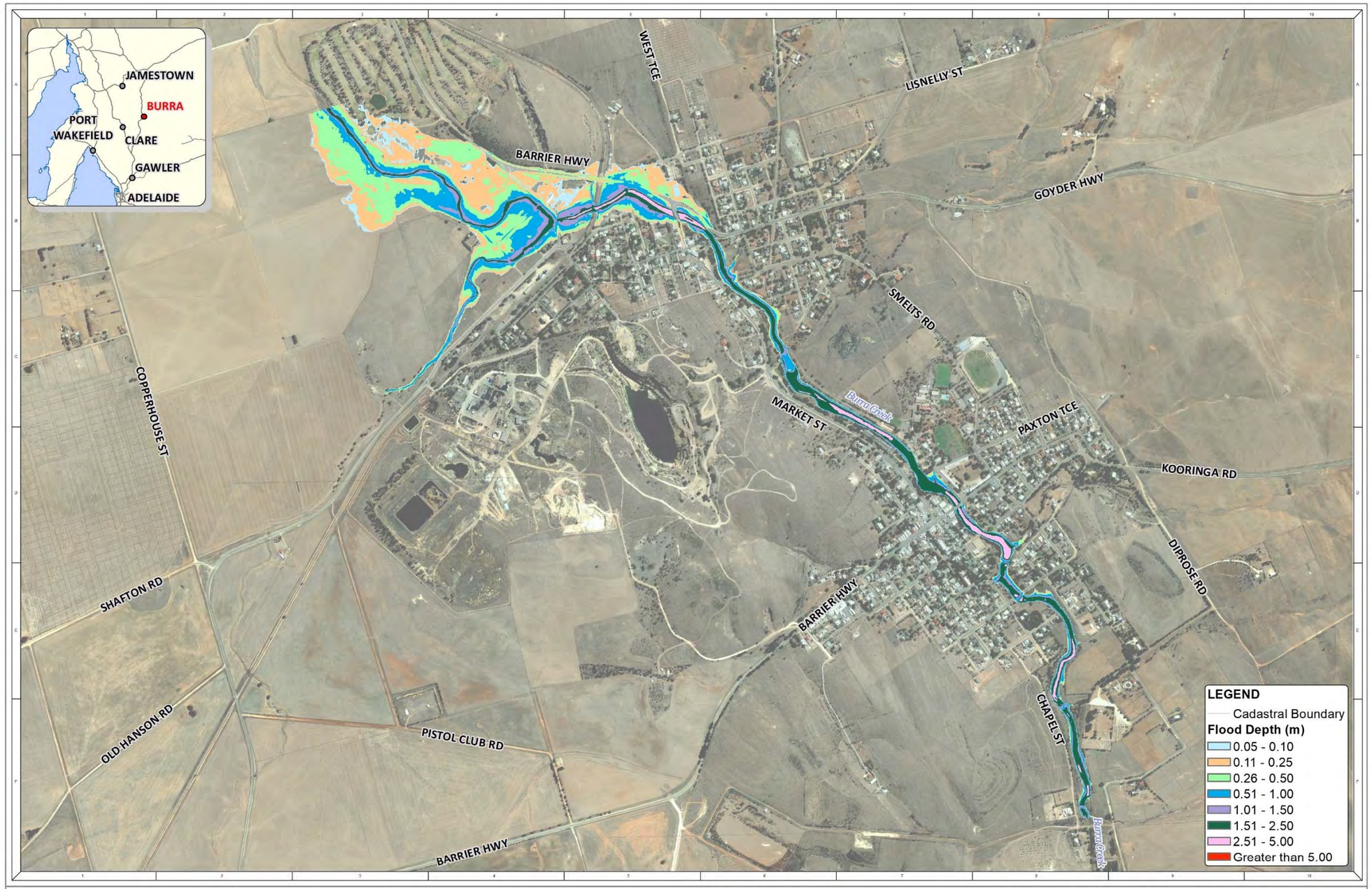
1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Catchment Node Locations

REFERENCE: F:\Synergy\Projects\111081\Maps_SMP\Spatial\Report\Spatial\mxd\SMP\Figure4.mxd

DATE: [illegible] SHEET: 1 of 1 Figure 4



NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER:
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

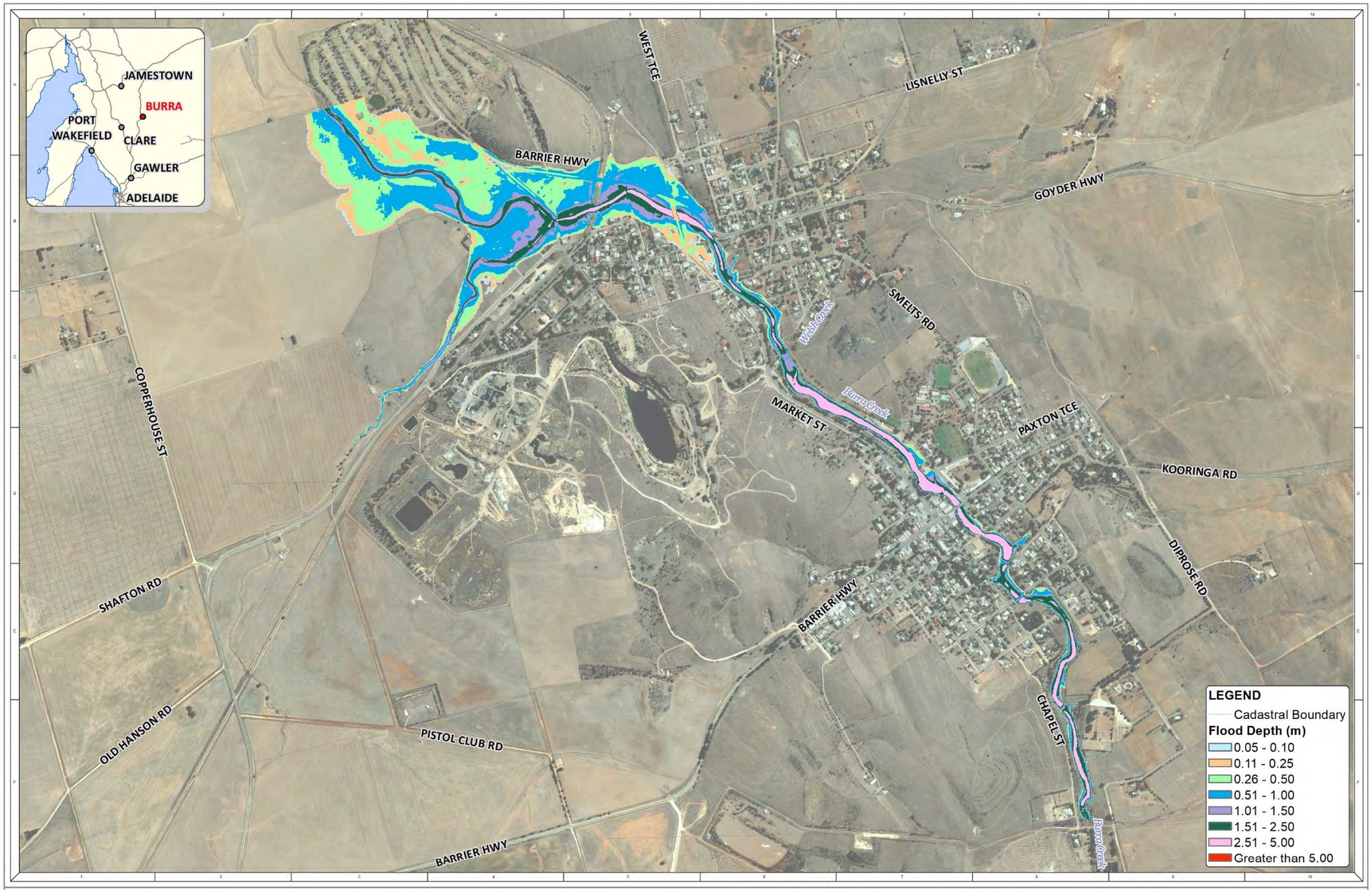
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 20 year ARI 6hr Flood Inundation

- Regional (RRR inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 FIGURE 1



NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is defective nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

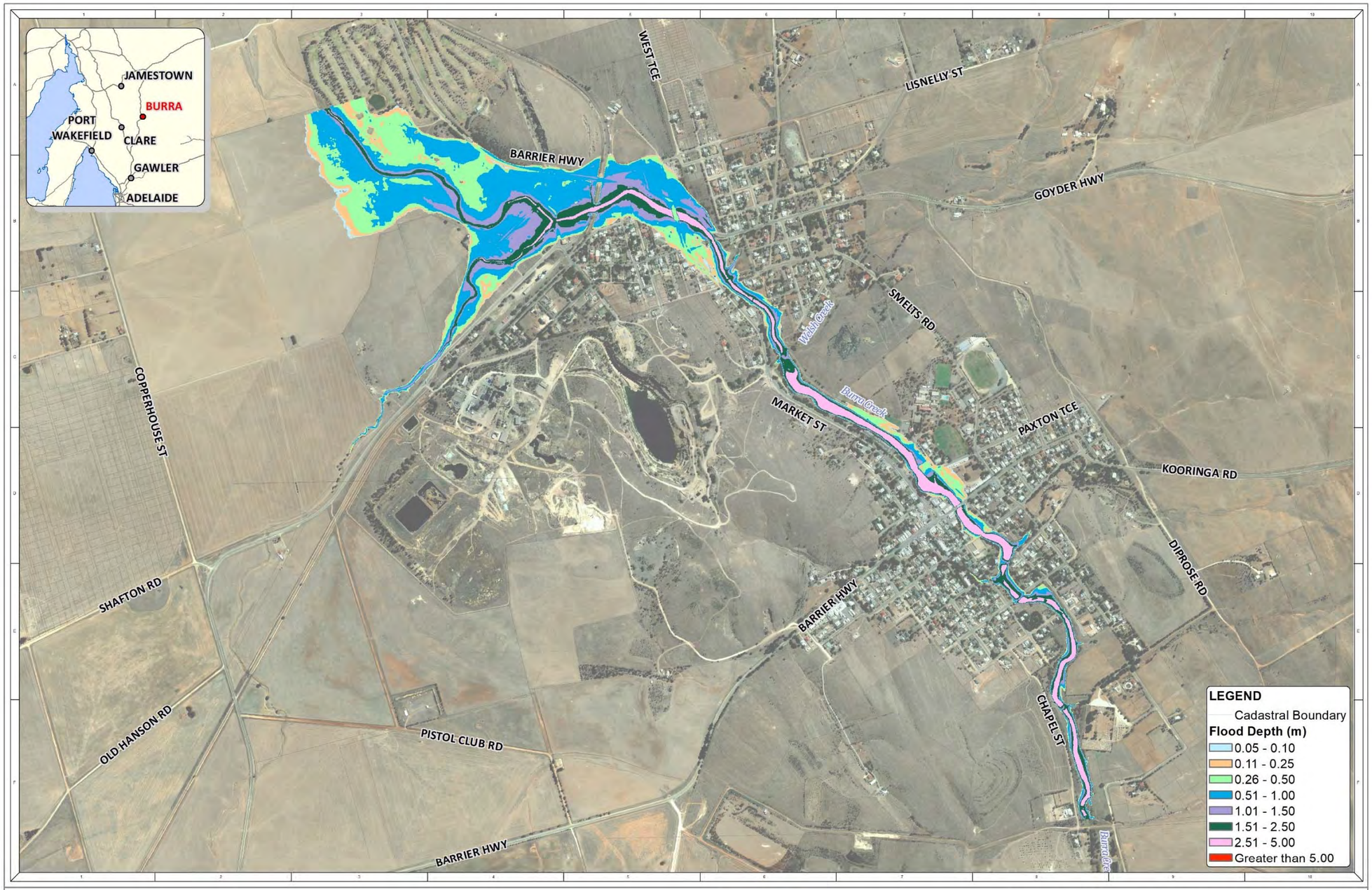
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 50 year ARI 9hr Flood Inundation

- Regional (RRR inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 5



NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER:
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 100 year ARI 18hr Flood Inundation

- Regional (RRR inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 5

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 2 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 13

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is defective nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, CREATIVE & ENVIRONMENTAL CONSULTANTS

1 in 5 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 13

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is defective nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 10 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: SHEET: 1 of 1 Figure 13

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instruction of Regional Council of Goyder for their specific use.

DISCLAIMER
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is definitive nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 20 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 FIGURE: 16

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instructions of Regional Council of Goyder for their specific use.

DISCLAIMER:
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is defective nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 50 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 15

NOTE:
Water Technology Pty. Ltd. has prepared this document in accordance with instructions of Regional Council of Goyder for their specific use.

DISCLAIMER:
The Regional Council of Goyder and Water Technology Pty. Ltd. does not warrant that this document is defective nor free from error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Contains maps.sa.gov.au, Images Aerometrex 2011

0 0.15 0.3 0.6 Kilometres

1:15,000 at A3

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

1 in 100 year ARI Flood Inundation

- Local (DRAINS inlfow) - filter 50mm

REFERENCE: [illegible]

DATE: [illegible] SHEET: 1 of 1 Figure 18

Appendix B: Flood Hydrology Review

1. Data Review

There was identified to be a lack of suitable rainfall gauges around the Burra Catchment. On this basis it was determined that any attempts to calibrate the hydrological model to a single or multiple high flow events would produce results of little value due to the uncertainty around rainfall inputs.

2. Flood Frequency Analysis

Where suitable stream flow information is available, design peak flows estimated from a hydrological model may be compared to the estimated peak flows from a flood frequency analysis. A similar process can be followed for flood volume. This is important to provide greater confidence around the estimated design flow rate and volume.

The streamflow gauge used as part of the calibration downstream of Burra Creek at the Worlds End (A4260536) has a length of available streamflow data, 36 years (1974 to 2009). A flood frequency analysis was undertaken on the annual maximum peak flow for the period 1974 to 2009, which were given in Table 1. A Log-Pearson III (LP III) distribution and Generalised Extreme Value (GEV) distribution were fitted using FLIKE. Fifteen low flows (less than $2m^3/s$) were censored from the analysis. Figure 1 and Figure 2 display the flood frequency analysis plots for the respective fits. The outcomes from the flood frequency analysis within this data set are shown in Table 2 and Table 3.

Table 1: Worlds End Annual Maximum Flows

Year	Date	Maximum Annual Flow (m^3/sec)	Year	Date	Maximum Annual Flow (m^3/sec)
1974	30 January	190.75	1992	25 September	70.91
1975	26 October	1.15	1993	25 January	234.73
1976	4 October	6.28	1994	6 June	0.16
1977	21 February	1.33	1995	14 January	67.49
1978	7 August	15.31	1996	1 October	19.39
1979	27 September	41.30	1997	1 November	15.82
1980	28 June	36.55	1998	7 February	0.23
1981	22 July	36.24	1999	2 October	24.87
1982	10 October	0.09	2000	21 February	41.93
1983	2 March	63.86	2001	24 September	0.17
1984	24 March	0.43	2002	25 November	0.31
1985	6 December	1.80	2003	28 June	2.10
1986	16 August	5.45	2004	8 December	27.03
1987	19 February	46.92	2005	21 June	0.14
1988	4 May	0.13	2006	21 January	3.36
1989	8 May	0.78	2007	22 October	1.23
1990	13 July	0.13	2008	2 November	17.63
1991	19 September	13.39	2009	14 June	0.52

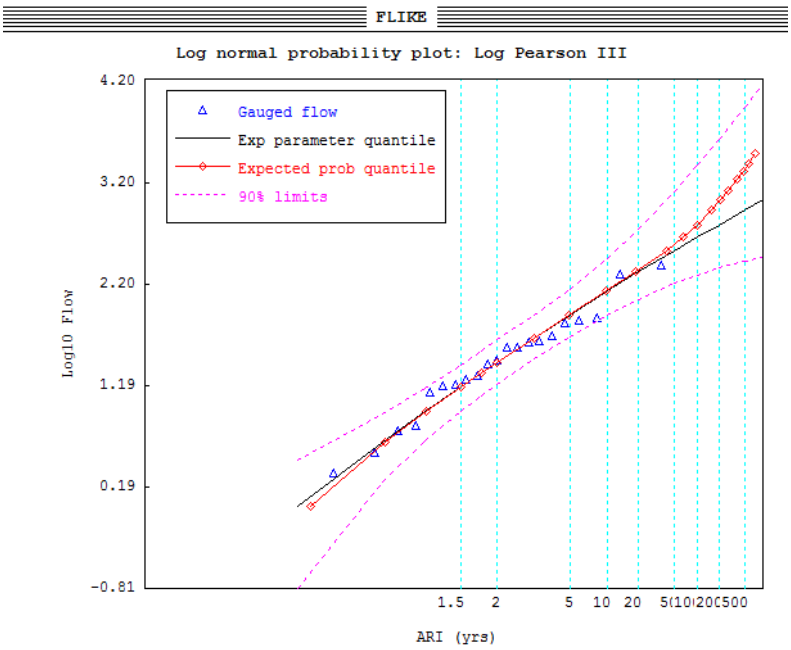


Figure 1 Flood frequency analysis (LP III distribution) – Burra Creek at Worlds End

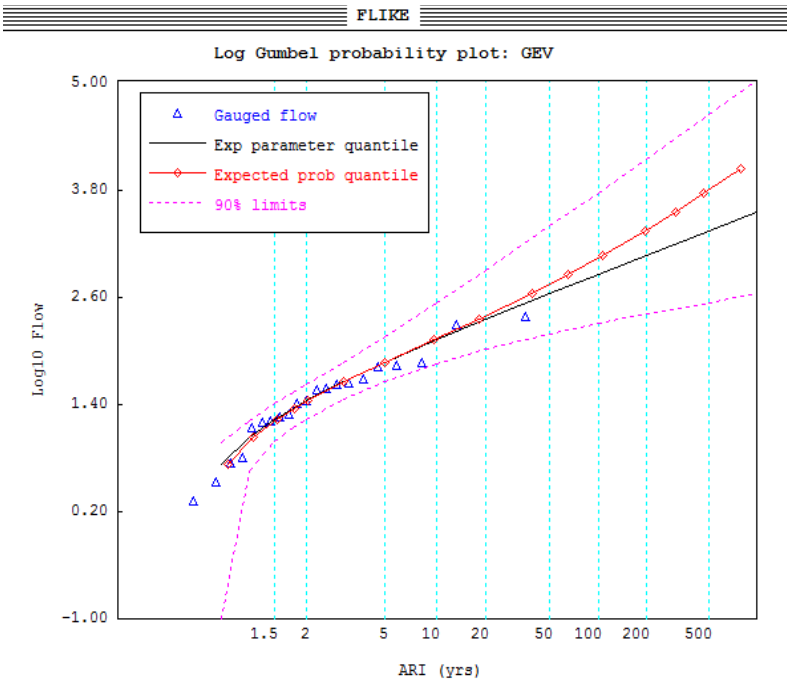


Figure 2 Flood frequency analysis (GEV distribution) – Burra Creek at Worlds End

Table 2 Burra Creek at Worlds End LP III flood frequency flows

ARI	Predicted Flow (m^3/sec)	5% Confidence Limit (m^3/sec)	95% Confidence Limit (m^3/sec)
10	130	75.4	274
20	201	108	525
50	323	155	1235
100	440	188	2232
200	582	219	4016
500	811	256	8403

Table 3 Burra Creek at Worlds End GEV flood frequency flows

ARI	Predicted Flow (m^3/sec)	5% Confidence Limit (m^3/sec)	95% Confidence Limit (m^3/sec)
10	128	70.4	327
20	217	101	777
50	422	151	2388
100	689	195	5605
200	1117	248	13439
500	2108	337	41605

This design peak flow rate for 1 in 100 year ARI has compared with a few previous studies to verify the results. The result for the comparison is shown in Table 4. A good comparison was noted between previous studies outputs and the Log Pearson III flood frequency results.

Table 4 Comparison of 1 in 100 year ARI design peak flow rate for Burra Creek at Worlds End and other rivers

Name	Catchment Area (km^2)	1 in 100 year ARI peak flow rate (m^3/sec)
Burra Creek	541	440(LP III)/689(GEV)
Gawler River (Australian Water Environments, 2014)	1069	702
Light River (Australian Water Environments, 2010)	1620	968
Hutt River (Australian Water Environments, 2019)	46.8	55.3

3. RRR Modelling

XP-RAFTS was used as the platform to develop a Rural Runoff Routing Model (RRR model). The RRR modelling approach was developed by Dr David Kemp in the 1990's to overcome some of the limitations with the existing models (i.e. RORB, RAFTS and WBNM). These limitations include the influence of model structure on predicted flow and the capacity to only deal with one runoff process. Parameters such as catchment area, vectored slope, storage coefficient, percent impervious area, surface roughness and rainfall loss are used to simulate the catchment response to a specific storm and to generate design hydrographs where required. XP-Rafts uses the Laurenson non-linear runoff routing procedure to develop a sub-catchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or design storm utilizing Intensity-Frequency-Duration (IFD) data together with dimensionless storm temporal patterns as well as standard AR&R 2016 data.

3.1. Sub-Catchment Data

The basic model structure consists of nodes which represent each sub-catchment area. Links provide a connection between nodes and simulate channel routing effects.

For computational purposes, the catchment is sub-divided into a series of sub-catchments which are differentiated by drainage sub-division, rain gauge location, topography and land use or soil type. Discharges are computed at the outlet of each sub-catchment.

10 metre contour were used to identify the catchment boundaries and major flow paths. Due to the lack of suitable rainfall gauges around the Burra catchment, the catchment was sub-divided into two sub-catchments. One sub-catchment was at the upstream of Burra creek flowing into Burra town, where a design hydrograph was generated for estimating regional flow flowing into Burra. The second sub-catchment was at Worlds End, where there is a flow gauge available for XP-RAFTS model calibration.

Sub-catchment areas were calculated using the topographic maps along with the contour data. The areas were 194km^2 and 371km^2 for Burra sub-catchment and Worlds End sub-catchment, respectively.

3.2. Key Parameter Selection

The RRR model manual produced by Dr David Kemp outlines both the methodology and the key parameters derived for 15 gauged catchments in the Mount Lofty Ranges predominately between Scott Creek in the south to South Para in the north. The RRR approach assumes three separate runoff processes. These processes include:

1. Basedflow – Related to the steady state groundwater system.
2. Capillary fringe flow – Slow flow with lag but less than for baseflow.
3. Overland flow – Fast response time.

There is significant evidence to suggest channel lag is linear and could be highly correlated to main stream length. For this reason, a generalised parameter has been developed to represent the channel characteristic flood wave velocity (V_c). The V_c is used to determine the channel storage lag parameter (k).

The key parameters adopted from the previous calibration to gauged catchments included V_c and catchment characteristic lag parameter (c_p).

XP-RAFTS include an option to account for rainfall losses, which is a simple approach that allows an initial loss followed by a proportional loss. Both initial loss and proportional losses can vary during a flood event. RRR models was run with the loss parameters being set as the mean of the fitted loss parameter values for each of the three runoff processes to test the predictions from the model against the flood frequency information. The loss parameters were then adjusted by obtaining a best match for the peak flow rate and flood volume. As for the other parameters, the mean of the fitted loss parameters has been adopted for the development of the design hydrographs.

A summary of the key parameter values selected for the relevant processes are presented in Table 5.

Table 5 Key Parameters for RRR model

Parameter	
V_c (m/s)	1
Baseflow Characteristic Lag Parameter (C_{p1})	1.21
Capillary Fringe Flow Characteristic Lag Parameter (C_{p2})	0.25
Overland Flow Characteristic Lag Parameter (C_{p3})	0
Initial Loss Process 1 (mm)	0
Proportional Loss Process 1	0.74
Initial Loss Process 2 (mm)	18.4
Proportional Loss Process 2	0.63
Initial Loss Process 3 (mm)	80.8
Proportional Loss Process 3	0.73

3.3. Model Results

The model was run with a range of design storm durations along with the related rainfall intensities. The rainfall intensity was estimated based on 2016 rainfall IFD data obtained from Bureau of Meteorology (BoM).

Table 6 provides a summary of the predicted peak flows from the RRR model in comparison the flood frequency information for Burra Creek at Worlds End for 1 in 20, 1 in 50 and 1 in 100 average recurrence interval (ARI).

Table 6 Flood frequency analysis and RRR model results for Burra Creek at Worlds End

ARI	Flood Frequency Analysis (LP III)	RRR 6hr Peak (m^3/sec)	RRR 9hr Peak (m^3/sec)	RRR 12hr Peak (m^3/sec)	RRR 18hr Peak (m^3/sec)	RRR 24hr Peak (m^3/sec)
20	201	201	200	199	200	201
50	323	324	324	317	319	309
100	440	441	441	443	442	434

4. Flow Volumes

It has been understood for some time that the extent of flooding on the floodplain depends on the volume of flood waters as well as the peak flow of the flood. Hence an assessment of observed and modelled flood volumes was undertaken.

This is particularly important for wide flat catchments or in the case arid areas where often large flood volumes can be associated with intense storms that exceed conventional loss model approaches, which typically involve fitting losses to more frequent smaller events. Fortunately, in the case of Burra Creek, there have been a number of significantly large events on which runoff volumes have been recorded and could be used to develop a flow volume frequency relationship. The model calibration process then also had regard to critical flood volumes as well as peak flow rate and guided the selection of a realistic critical storm duration.

The assessment was based on the same historical flow time series at the Worlds End gauging stations as the flood frequency analysis for annual peak flow rate. Flood volume frequency was determined using annual series approach and, based on the size of the catchment to Worlds End, a 3-day duration for calculating the flood volume was considered appropriate. The annual series for Worlds End was shown with LP III distribution. These were compared with the modelled hydrograph volumes from XP-RAFTS model for several design storm durations. Results of the flow volume analysis are shown in Table 7.

Table 7 Burra Creek at Worlds End 3-day flow volume against design storm runoff

ARI	Volume (ML) Annual Series (LP III)	RRR 6hr Volume (ML)	RRR 9hr Volume (ML)	RRR 12hr Volume (ML)	RRR 18hr Volume (ML)	RRR 24hr Volume (ML)
20	13209	15710	16390	16850	17700	18170
50	24580	24150	25390	25650	27140	28080
100	36569	32080	33780	34840	36680	38020

5. Burra Creek Hydrograph at Burra

The setup of the XP-RAFTS model incorporated two nodes where hydrographs could be extracted and reviewed.

Firstly, a hydrograph was required at Worlds End to compare the flood frequency analysis results from the gauged flows against the design flow and volumes. Once a critical design storm event was selected it was then considered that the hydrograph generated at the second print point (Burra) would be representative of the design hydrograph. This would need to be subject to further validation through comparing the peak water levels from the TUFLOW model against historical observations through Burra.

6. Summary

From the above analysis, the critical storm duration for peak flow and flow volume was 6 hour for the 1 in 20 year ARI, 9 hour for the for 1 in 50 year ARI, and 18 hour for the 1 in 100 year ARI. These critical flow time series are shown in Figure 3 and will be used in the Burra TUFLOW model as the regional inflows. Flood inundation maps will then be generated using TUFLOW model for pre- and post-mitigation cases for these three design events.

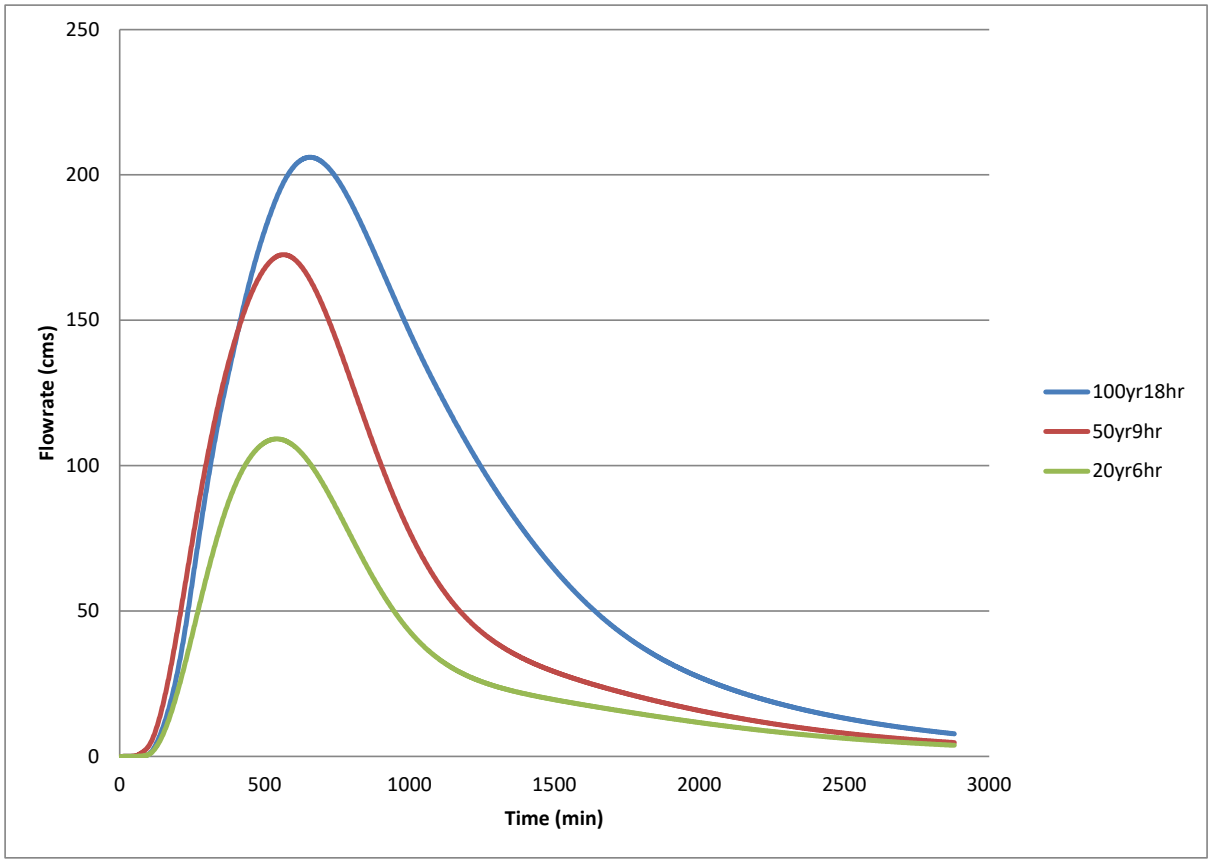


Figure 3 XP-RAFTS modelled Burra Creek hydrographs for 20, 50 and 100 year ARI events at Burra

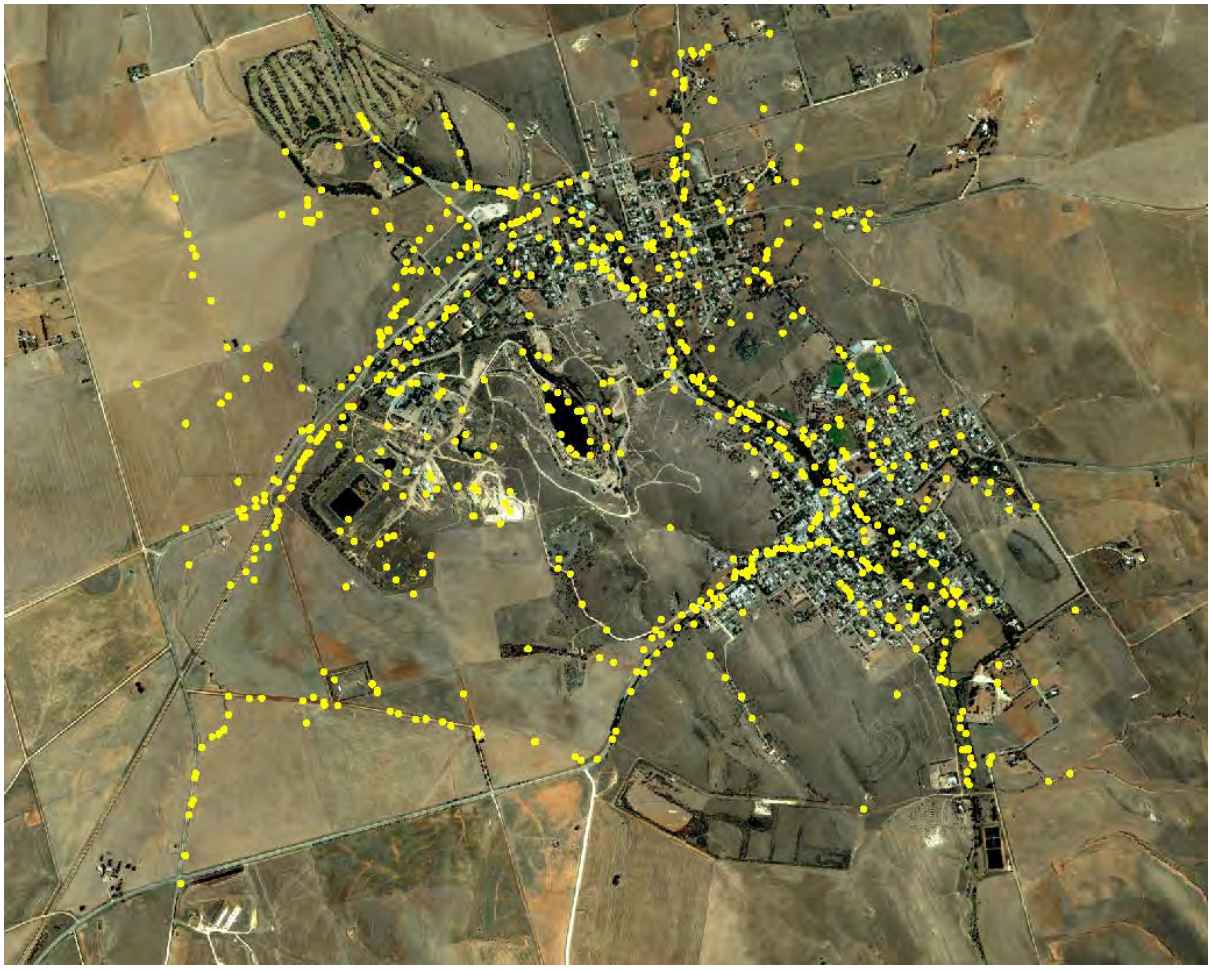
Appendix C: DRAINS Catchment Parameters

DRAINS model parameters and Catchment Nodes for local input hydrographs for TUFLOW model:

ISLAX Model Parameters

Parameter	Value
Paved (impervious) area depression storage	1 mm
Grassed (pervious) area depression storage	5 mm
Antecedent moisture condition	2.5

Catchment Node Locations



Catchment Details

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 0	2.41	0	308248.1	6272874	Cat 42	8.2402	30	308445.9	6272555
Cat 1	1.27	0	308662.4	6273356	Cat 43	10.5863	0	306460.6	6272819
Cat 2	2.6	0	308380	6273293	Cat 44	2.3697	0	307750.4	6272679
Cat 3	1.49	0	308260.6	6273269	Cat 45	0.9287	0	308575.6	6272657
Cat 4	5.69	0	308308.2	6273278	Cat 46	1.2072	0	307234.6	6272663
Cat 5	0.74	0	308356.1	6273266	Cat 47	7.4922	0	307558.2	6272657
Cat 6	1	0	308317	6273260	Cat 48	1.4769	0	307333.5	6272654
Cat 7	5.99	0	308269.3	6273140	Cat 49	0.9419	0	307501.3	6272627
Cat 8	2.1	0	308269.3	6273110	Cat 50	1.229	0	307768.3	6272654
Cat 9	2.8	0	308134	6273086	Cat 51	0.6102	0	307489.6	6272645
Cat 10	2.92	0	308635.5	6273014	Cat 52	0.8879	0	308776.8	6272681
Cat 11	1.79	0	308395.2	6273056	Cat 53	0.6279	0	307432.4	6272639
Cat 12	1.87	0	308407.5	6273053	Cat 54	0.5159	0	307456.7	6272635
Cat 13	2.21	0	308794.4	6272841	Cat 55	0.3747	30	308271.4	6272610
Cat 14	0.64	0	307186.5	6272984	Cat 56	3.4987	0	307603.2	6272616
Cat 15	3.35	0	306799.4	6272982	Cat 57	0.4586	30	308431.3	6272587
Cat 16	0.81	0	308284.4	6272933	Cat 58	3.1539	0	307681.6	6272597
Cat 17	2.92	0	306874	6272876	Cat 59	5.9343	0	306559.1	6272600
Cat 18	2.67	0	306823	6272942	Cat 60	1.1343	30	308134.4	6272405
Cat 19	1.41	0	307015.3	6272690	Cat 61	1.6097	30	307813.9	6272552
Cat 20	2.21	0	308671.2	6272761	Cat 62	1.2877	0	308891	6272549
Cat 21	0.72	0	306814.3	6272960	Cat 63	1.5673	0	308962.3	6272531
Cat 22	0.83	0	308284.8	6272797	Cat 64	1.4761	0	306613	6272531
Cat 23	2.33	0	306703.1	6272843	Cat 65	0.6794	0	307195.7	6272540
Cat 24	0.75	0	308251.6	6272852	Cat 66	0.6293	0	307597.8	6272540
Cat 25	1.06	0	307489.4	6272936	Cat 67	0.3408	30	308182.5	6272492
Cat 26	1.01	0	307057.7	6272733	Cat 68	0.9837	0	308653.2	6272366
Cat 27	0.51	0	307204.5	6272933	Cat 69	1.8448	0	305959	6272609
Cat 28	6.37	30	308230.4	6272783	Cat 70	0.1202	0	309115.5	6272537
Cat 29	1.5	0	307252.4	6272813	Cat 71	0.2758	30	307693.4	6272507
Cat 30	0.21	0	306982.5	6272783	Cat 72	1.7341	30	308296.3	6272447
Cat 31	1.34	30	308274.3	6272639	Cat 73	0.8686	30	308479.9	6272501
Cat 32	1.54	0	308799.1	6272837	Cat 74	2.4149	30	308284.4	6272489
Cat 33	2.66	30	308224.3	6272762	Cat 75	1.2673	0	309091.7	6272498
Cat 34	1.91	30	308236.4	6272729	Cat 76	0.7212	0	309029.2	6272552
Cat 35	0.33	0	308281.7	6272717	Cat 77	1.7373	0	306559.3	6272576
Cat 36	0.67	0	307825.7	6272714	Cat 78	1.0314	0	307117.5	6272471
Cat 37	0.92	30	308239.1	6272714	Cat 79	4.1696	30	307972.7	6272444
Cat 38	2.59	30	308239.3	6272519	Cat 80	8.231	0	306443.3	6272531
Cat 39	1.08	30	308230.2	6272699	Cat 81	1.0225	30	307570.6	6272525
Cat 40	2	0	308700.9	6272693	Cat 82	0.378	30	308203.6	6272443
Cat 41	0.75	0	306877.5	6272759	Cat 83	1.6272	30	307485.3	6272490

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 84	0.7308	30	307922.9	6272285	Cat 127	1.1377	0	308008.6	6272198
Cat 85	0.5222	30	308230	6272346	Cat 128	2.1469	0	309148.3	6272227
Cat 86	1.1156	0	307288.6	6272478	Cat 129	0.1943	0	308044.3	6272162
Cat 87	1.8367	0	308881.8	6272483	Cat 130	0.2298	30	307703.2	6272327
Cat 88	1.008	30	307981.3	6272432	Cat 131	1.8956	0	308663.9	6272234
Cat 89	0.5237	30	308318.3	6272369	Cat 132	1.868	30	307288.4	6272171
Cat 90	10.7072	0	306016.6	6272444	Cat 133	0.5031	30	307436.4	6272320
Cat 91	2.1079	30	307765.3	6272504	Cat 134	1.0238	0	306964.2	6272202
Cat 92	0.512	30	307990.5	6272375	Cat 135	5.0594	0	306579.1	6272494
Cat 93	0.1555	30	308269.4	6272354	Cat 136	2.465	30	308215.1	6272114
Cat 94	0.7364	30	307804	6272412	Cat 137	3.2018	0	306121	6272141
Cat 95	0.3428	0	308650.5	6272351	Cat 138	2.1875	30	307075.1	6272276
Cat 96	0.2971	30	307339.6	6272344	Cat 139	0.5495	30	307513.1	6272264
Cat 97	1.4492	0	306039.4	6272381	Cat 140	1.2222	30	307858.3	6272386
Cat 98	3.9848	0	308707.3	6272411	Cat 141	0.368	30	307228.2	6272108
Cat 99	0.6831	0	308638.2	6272262	Cat 142	0.6168	30	307192.6	6272072
Cat 100	1.2449	0	308644.2	6272330	Cat 143	3.7674	0	308811.2	6272096
Cat 101	0.6615	30	308242.7	6272303	Cat 144	2.185	0	308573.4	6272072
Cat 102	2.2844	0	307067.2	6272416	Cat 145	0.7515	30	307069.7	6272006
Cat 103	0.3764	30	307875.9	6272375	Cat 146	1.073	0	306943.4	6272075
Cat 104	0.4469	30	308161.2	6272291	Cat 147	1.5361	30	308251.8	6272039
Cat 105	2.9902	30	307252.7	6272348	Cat 148	3.5559	30	308485.2	6272040
Cat 106	1.7012	0	306052.6	6272344	Cat 149	5.1048	0	308405.2	6271784
Cat 107	1.7693	30	308600.2	6272280	Cat 150	1.4734	30	307942.5	6272249
Cat 108	0.9791	30	307510.1	6272498	Cat 151	0.4573	0	307987.1	6272207
Cat 109	1.6703	30	307486.3	6272387	Cat 152	0.5357	0	307812.5	6272299
Cat 110	0.4279	30	307537.6	6272510	Cat 153	0.0563	0	307033.5	6272045
Cat 111	0.6933	30	307612.4	6272429	Cat 154	1.8439	0	306888.8	6271999
Cat 112	0.2445	30	307690.4	6272402	Cat 155	30.6453	0	306553.9	6272504
Cat 113	0.8828	30	307795.5	6272489	Cat 156	11.1139	0	306283.5	6271922
Cat 114	1.6167	30	308251.6	6272259	Cat 157	1.0427	30	307447.3	6272229
Cat 115	1.0841	0	308653.6	6272255	Cat 158	0.9244	30	306955.9	6272072
Cat 116	0.6885	0	307009.5	6272315	Cat 159	0.6661	0	308033.4	6272153
Cat 117	0.268	0	307045	6272372	Cat 160	0.5751	0	307569.5	6272074
Cat 118	0.492	0	307006.4	6272280	Cat 161	1.2638	30	307051.5	6271963
Cat 119	0.1594	30	307699.4	6272378	Cat 162	1.0646	30	307789.5	6272297
Cat 120	0.79	30	308051.5	6272234	Cat 163	2.5973	0	307576.8	6272252
Cat 121	0.44	30	308200.4	6272240	Cat 164	1.5863	0	308770.2	6272071
Cat 122	0.7494	30	308566.4	6272231	Cat 165	0.1244	0	307012.6	6271946
Cat 123	1.73	0	309103.5	6272468	Cat 166	2.5534	30	308260.1	6271949
Cat 124	1.4492	0	306036.1	6272260	Cat 167	0.3999	0	308284.4	6271922
Cat 125	6.7348	0	306937.8	6272471	Cat 168	0.9341	30	307149.6	6271891
Cat 126	0.4575	30	308087.6	6272207	Cat 169	0.4937	0	308980.3	6271918

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 170	3.4072	0	309160	6271917	Cat 213	0.3147	30	307054.3	6271859
Cat 171	0.5132	30	307125.1	6272032	Cat 214	0.4046	30	309106.9	6271725
Cat 172	1.9171	30	307183.3	6272062	Cat 215	0.8154	30	307033.4	6271766
Cat 173	2.5045	0	308215.4	6272084	Cat 216	0.155	30	309217.5	6271696
Cat 174	0.7608	0	306895.7	6271973	Cat 217	1.1247	0	306715.7	6271749
Cat 175	0.9477	0	308149.5	6272083	Cat 218	0.3824	0	308224.2	6271847
Cat 176	1.3178	0	308170.2	6272024	Cat 219	0.9545	0	306760.3	6271793
Cat 177	1.1011	0	308722.6	6271993	Cat 220	2.3305	0	307540.6	6271910
Cat 178	1.4079	0	308398.4	6271922	Cat 221	1.7942	0	309304.7	6271688
Cat 179	0.7313	30	307231	6272105	Cat 222	1.2674	30	309115.4	6271561
Cat 180	0.7569	0	309001.7	6271891	Cat 223	2.8042	0	308394.6	6271719
Cat 181	2.2459	0	309199.1	6271926	Cat 224	3.3277	0	308575.5	6271670
Cat 182	0.7801	0	309271.5	6271727	Cat 225	1.4297	0	307852.9	6271649
Cat 183	0.725	0	308211.9	6271916	Cat 226	0.3869	0	308554.2	6271635
Cat 184	4.4218	0	306193.8	6271928	Cat 227	0.788	30	309220.4	6271643
Cat 185	0.6755	30	306892.6	6271940	Cat 228	1.5526	0	309460.2	6271635
Cat 186	2.0555	30	308923.9	6271565	Cat 229	1.521	30	307057.4	6271766
Cat 187	0.8625	0	309031.1	6271847	Cat 230	0.9134	0	308485.2	6271673
Cat 188	3.0736	0	306376.8	6271844	Cat 231	2.4814	30	309409.3	6271541
Cat 189	0.5101	0	308227.5	6271874	Cat 232	0.4106	30	307156.7	6271709
Cat 190	0.4207	0	308275.3	6271931	Cat 233	0.0665	30	308976.9	6271602
Cat 191	0.4285	30	306973.9	6271957	Cat 234	1.5617	30	309121.2	6271592
Cat 192	5.7655	0	306282.4	6271786	Cat 235	1.1855	0	306202.6	6271706
Cat 193	1.5226	0	307788.6	6271639	Cat 236	0.8596	30	306977.9	6271731
Cat 194	1.7029	30	309058.5	6271799	Cat 237	1.6863	30	309126.1	6271486
Cat 195	0.458	0	308350.7	6271799	Cat 238	0.7252	0	308341.4	6271769
Cat 196	1.1146	30	309080.9	6271795	Cat 239	1.0645	0	306007.3	6271583
Cat 197	2.0348	30	308985.8	6271726	Cat 240	2.0367	0	307169.8	6271796
Cat 198	0.5803	30	306829.7	6271856	Cat 241	5.2609	0	307643.4	6271747
Cat 199	4.2502	0	306388.8	6271838	Cat 242	1.0821	0	308427.1	6271618
Cat 200	0.6794	30	307024.4	6271930	Cat 243	3.4126	30	308818.4	6271553
Cat 201	0.5826	30	309100.6	6271784	Cat 244	0.7433	0	309391.4	6271538
Cat 202	1.3061	0	305785.5	6271761	Cat 245	1.8576	0	309287	6271442
Cat 203	1.381	0	307906.3	6271763	Cat 246	0.9932	30	306934.2	6271730
Cat 204	0.6202	0	308314.6	6271790	Cat 247	1.2515	30	306973.5	6271724
Cat 205	0.7675	30	309091.1	6271750	Cat 248	1.395	0	308610.9	6271604
Cat 206	2.641	30	309001.6	6271747	Cat 249	1.4609	0	307264.4	6271646
Cat 207	0.4191	30	306982.8	6271739	Cat 250	0.1088	30	308815.1	6271519
Cat 208	0.9508	30	306937.7	6271802	Cat 251	0.3121	30	308861.1	6271523
Cat 209	0.1993	0	308230.3	6271736	Cat 252	1.2	0	309532.8	6271526
Cat 210	1.6452	30	309010.5	6271442	Cat 253	0.7826	30	309196.6	6271503
Cat 211	0.9024	0	306790.3	6271830	Cat 254	0.2184	0	306652.4	6271565
Cat 212	0.6992	0	308362.4	6271745	Cat 255	0.6262	0	306535.7	6271547

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 256	1.108	0	308074.5	6271727	Cat 299	0.0558	30	308907.3	6271269
Cat 257	1.1818	0	307234.4	6271502	Cat 300	0.5141	0	306544	6271424
Cat 258	0.54	0	308728.3	6271542	Cat 301	0.1756	0	308809.8	6271361
Cat 259	0.1608	30	308836.7	6271493	Cat 302	0.4948	30	308908.5	6271274
Cat 260	0.1259	0	306628.6	6271535	Cat 303	1.1736	0	308700.1	6271483
Cat 261	1.3074	0	309466.2	6271330	Cat 304	0.94	0	308743.5	6271436
Cat 262	0.7651	0	308722.6	6271472	Cat 305	0.4701	0	306529.3	6271404
Cat 263	0.8509	0	307279.6	6271532	Cat 306	0.1874	0	308686.5	6271346
Cat 264	0.2359	30	309135	6271436	Cat 307	10.5808	0	306534.7	6271745
Cat 265	0.2129	0	306616.6	6271520	Cat 308	0.7121	30	308914.4	6271269
Cat 266	2.9291	0	306748	6271658	Cat 309	0.6009	30	309253.6	6271225
Cat 267	0.3681	0	309505.5	6271451	Cat 310	0.4541	0	306442.1	6271242
Cat 268	5.2189	0	308197.1	6271808	Cat 311	0.1699	30	308962.2	6271229
Cat 269	0.4928	30	309160.8	6271407	Cat 312	6.9369	30	309380.4	6271234
Cat 270	2.0295	30	309001.1	6271337	Cat 313	0.4854	0	306490.3	6271331
Cat 271	1.127	30	308950.6	6271406	Cat 314	1.3394	0	306520.6	6271376
Cat 272	0.1596	0	306556.3	6271445	Cat 315	0.3903	0	306484.6	6271289
Cat 273	0.416	30	308963	6271401	Cat 316	0.5016	30	308968	6271193
Cat 274	0.906	0	308530.8	6271650	Cat 317	1.7657	0	307333.2	6271280
Cat 275	0.2223	0	308518.9	6271630	Cat 318	2.5141	0	307699.3	6270922
Cat 276	0.2526	30	309175.8	6271370	Cat 319	1.7631	0	309669.7	6271316
Cat 277	3.0121	30	308756	6271421	Cat 320	1.0238	0	308890.5	6271151
Cat 278	3.936	0	308344.4	6271679	Cat 321	0.9133	0	306247.1	6271184
Cat 279	0.5499	0	306601.5	6271502	Cat 322	0.6557	30	309076.1	6271169
Cat 280	10.6727	0	308499.8	6270965	Cat 323	10.6899	0	306244.3	6271319
Cat 281	0.235	30	308821.7	6271343	Cat 324	1.6983	0	306796.7	6271421
Cat 282	1.283	0	308961.7	6271318	Cat 325	0.3471	30	309064.6	6271181
Cat 283	0.727	0	306430.3	6271421	Cat 326	0.828	0	306427.4	6271166
Cat 284	0.6703	0	307117.4	6271355	Cat 327	1.8188	0	308653.1	6271004
Cat 285	1.6231	0	308494.3	6271597	Cat 328	0.9934	30	309103.6	6271148
Cat 286	2.14	0	307982.7	6271446	Cat 329	0.5082	0	306421.6	6271139
Cat 287	1.2867	30	309211.5	6271337	Cat 330	1.0034	30	308959.8	6271010
Cat 288	0.6979	0	308572.7	6271625	Cat 331	1.051	0	306326	6271204
Cat 289	0.4615	30	309025.4	6271313	Cat 332	1.5866	0	306424.6	6271184
Cat 290	1.1766	0	308558.1	6271560	Cat 333	0.4788	30	309154.7	6271118
Cat 291	0.9483	0	308562.1	6271480	Cat 334	1.5133	0	306916.1	6271297
Cat 292	2.436	0	307318.1	6271295	Cat 335	0.2238	30	309361.2	6270989
Cat 293	1.2858	0	308707.8	6271554	Cat 336	1.0604	0	309445.5	6271073
Cat 294	1.6454	30	308866.7	6271385	Cat 337	0.9467	0	306412.1	6271112
Cat 295	0.6504	30	309355	6271189	Cat 338	1.3535	0	307147.3	6271283
Cat 296	0.2028	0	308986.7	6271295	Cat 339	1.3844	30	308851.6	6271106
Cat 297	0.7209	0	307120.3	6271335	Cat 340	2.1669	0	307009.8	6271362
Cat 298	0.4908	30	309007.5	6271280	Cat 341	0.864	0	306709.6	6271094

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 342	1.2947	0	307315	6271161	Cat 385	0.2107	30	308578.4	6270926
Cat 343	1.14	0	308749.5	6271052	Cat 386	1.1026	30	308653.7	6270988
Cat 344	0.8028	30	309313.8	6271025	Cat 387	2.3799	0	307810.2	6270761
Cat 345	0.7501	30	309093.7	6271048	Cat 388	2.8165	30	309280.5	6270860
Cat 346	1.6025	30	309241.1	6271034	Cat 389	0.4225	30	309538.1	6270764
Cat 347	1.2859	30	309352.5	6270997	Cat 390	0.4728	30	308410.5	6270788
Cat 348	2.6149	30	309396.7	6270845	Cat 391	1.0233	30	309163.8	6270914
Cat 349	2.5233	0	309595.5	6271324	Cat 392	1.3173	0	308677.8	6270995
Cat 350	0.3362	0	306889.4	6271034	Cat 393	0.332	30	309085.6	6270902
Cat 351	2.7949	0	307438.4	6271127	Cat 394	0.9423	30	309012.9	6270831
Cat 352	0.3479	0	308692.2	6271013	Cat 395	1.7755	30	309520.3	6270625
Cat 353	3.3433	0	306372.9	6271085	Cat 396	0.4441	30	308761	6271016
Cat 354	0.7539	0	306925.4	6271064	Cat 397	0.6865	30	309463.3	6270800
Cat 355	1.5054	0	306952.7	6271070	Cat 398	0.4206	30	308452.2	6270791
Cat 356	1.09	30	308581.6	6270938	Cat 399	9.6405	0	306319.3	6270965
Cat 357	4.1828	0	309754.7	6271274	Cat 400	1.2347	30	308986.2	6270995
Cat 358	0.545	0	308599.6	6270996	Cat 401	1.3322	0	308262.7	6270711
Cat 359	0.6404	30	309403.2	6270953	Cat 402	0.7101	30	308845.4	6271031
Cat 360	0.5608	0	309464	6270863	Cat 403	0.9138	30	309034.7	6270988
Cat 361	0.8517	0	308581.4	6270968	Cat 404	2.3321	0	308508.3	6270906
Cat 362	1.054	30	309235.3	6270992	Cat 405	0.4597	0	309088.6	6270725
Cat 363	0.8814	30	309420.1	6270944	Cat 406	0.1811	30	309333.9	6270713
Cat 364	3.8774	0	309872	6271203	Cat 407	0.6099	0	308170.9	6270691
Cat 365	0.4599	30	308899.1	6271050	Cat 408	0.3444	0	309373.2	6270734
Cat 366	2.6585	0	306382.7	6271019	Cat 409	0.7148	30	309220.8	6270689
Cat 367	5.6234	0	308210	6271107	Cat 410	0.887	30	309298.5	6270749
Cat 368	7.5651	0	307756.3	6270900	Cat 411	1.6893	0	307921.2	6270641
Cat 369	0.6115	30	308560.6	6270911	Cat 412	1.626	30	309304.5	6270845
Cat 370	0.1927	30	308788.6	6271010	Cat 413	0.2383	30	309211.2	6270699
Cat 371	0.6192	30	308812.7	6271013	Cat 414	0.761	30	308542.2	6270902
Cat 372	0.4331	30	309103.5	6270947	Cat 415	1.2353	0	309160.4	6270758
Cat 373	0.3177	30	308728.4	6271013	Cat 416	1.759	0	308143.3	6270641
Cat 374	1.5209	30	309451.5	6270815	Cat 417	0.68	30	308773.4	6271013
Cat 375	0.8782	30	309496.6	6270824	Cat 418	1.0441	0	309076.1	6270758
Cat 376	4.0873	0	306274.6	6271157	Cat 419	8.2596	0	306319.8	6270872
Cat 377	0.7508	30	309523.8	6270815	Cat 420	0.9184	30	309328.7	6270692
Cat 378	0.8081	30	309511.4	6270803	Cat 421	8.5283	0	309517.4	6270676
Cat 379	1.2315	0	306736.5	6270839	Cat 422	0.6516	0	308125.4	6270608
Cat 380	1.6919	0	308437.2	6270843	Cat 423	2.5784	0	308149.6	6270536
Cat 381	0.5955	30	309085.6	6270959	Cat 424	0.8824	0	308427.9	6270761
Cat 382	2.379	0	309661.5	6270779	Cat 425	0.8486	30	308983.3	6270857
Cat 383	0.6208	30	309007.3	6270836	Cat 426	0.8433	30	309460.3	6270590
Cat 384	0.6439	30	309544.9	6270752	Cat 427	0.8741	0	308205.9	6270581

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 428	8.6444	0	309703.5	6270485	Cat 471	3.0126	0	306685.1	6270416
Cat 429	0.9771	0	308330	6270734	Cat 472	11.2753	0	309554.8	6270171
Cat 430	0.8007	0	309457.7	6270530	Cat 473	0.683	0	306877.5	6270356
Cat 431	0.8404	0	309034.3	6270791	Cat 474	0.6883	0	309579	6270063
Cat 432	3.0077	0	308539.6	6270722	Cat 475	0.1236	0	309661.8	6270042
Cat 433	1.2486	30	309151.8	6270924	Cat 476	1.8523	0	309567.9	6270101
Cat 434	4.3866	0	306637.3	6270452	Cat 477	1.7283	0	309542.2	6270096
Cat 435	0.7553	30	309247.3	6270656	Cat 478	1.0336	0	309931.5	6269945
Cat 436	0.6052	0	309205.6	6270708	Cat 479	0.9332	0	309674	6270068
Cat 437	1.2672	0	309442.6	6270470	Cat 480	1.2942	0	307948.8	6270146
Cat 438	20.687	0	307564.1	6270558	Cat 481	1.3886	0	306538.7	6270322
Cat 439	1.9427	0	308317.5	6270671	Cat 482	0.6174	0	309587.5	6270029
Cat 440	0.7424	0	309540.3	6270275	Cat 483	2.0812	0	306637.8	6270302
Cat 441	2.3124	0	309700.4	6270404	Cat 484	11.848	0	308461.1	6270425
Cat 442	9.2773	0	310054.9	6270734	Cat 485	1.6942	0	309583.2	6269909
Cat 443	1.0769	0	309498.2	6270401	Cat 486	1.3059	0	309664.3	6270035
Cat 444	1.5381	0	309700.2	6270398	Cat 487	2.1052	0	307328.9	6270191
Cat 445	0.7217	0	308537.1	6270335	Cat 488	1.3712	0	309559.7	6269996
Cat 446	3.897	0	309869.4	6270407	Cat 489	7.8812	0	306202.9	6270344
Cat 447	6.988	0	308563.2	6270890	Cat 490	1.1929	0	307879.5	6270056
Cat 448	13.1837	0	306877.5	6270367	Cat 491	2.5805	0	309562.3	6269957
Cat 449	1.4093	0	307270.4	6270352	Cat 492	1.1228	0	307099.5	6270239
Cat 450	0.7887	0	308059.3	6270455	Cat 493	2.0478	0	307777	6270068
Cat 451	3.609	0	307951.9	6270494	Cat 494	7.4611	0	307804.5	6270053
Cat 452	0.6581	0	308533	6270344	Cat 495	1.2975	0	307337.1	6270164
Cat 453	20.7824	0	307891.2	6270515	Cat 496	6.8065	0	307593.6	6270134
Cat 454	1.1532	0	309151	6270653	Cat 497	1.1333	0	307213.2	6270207
Cat 455	18.146	0	306280.2	6270908	Cat 498	2.8631	0	309091.5	6269810
Cat 456	2.9099	0	306637.4	6270317	Cat 499	3.1849	0	307054.2	6270236
Cat 457	2.4611	0	309434.2	6270415	Cat 500	4.7764	0	306973.6	6270263
Cat 458	2.5281	0	306352.1	6270332	Cat 501	3.2615	0	306697	6270299
Cat 459	1.4283	0	308089.6	6270446	Cat 502	2.1937	0	306199.4	6270257
Cat 460	3.2458	0	309529.3	6270242	Cat 503	6.9851	0	306556.5	6270218
Cat 461	5.6136	0	309326.6	6270557	Cat 504	4.3152	0	306181.4	6270191
Cat 462	2.4223	0	308584.9	6270240	Cat 505	2.1281	0	306157.3	6270170
Cat 463	2.9548	0	308032.4	6270365	Cat 506	0.7056	0	306022.4	6269801
Cat 464	3.5389	0	308392.3	6270527	Cat 507	1.7313	0	306049.2	6269970
Cat 465	0.3853	0	307964.7	6270182	Cat 508	4.1116	0	306032.2	6269852
Cat 466	2.6154	0	307597.3	6270137	Cat 509	2.5218	0	306002.5	6269618
Cat 467	4.9654	0	306079.5	6270110	Cat 510	1.4108	0	305985.8	6269492
Cat 468	2.2544	0	309529.6	6270197	Cat 511	6.5033	0	310027.7	6269990
Cat 469	1.0932	0	309560.6	6270101	Cat 512	0.7611	0	306587.8	6270337
Cat 470	5.7827	0	309244	6270350	Cat 513	3.63	0	307175.4	6270226

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 514	0.1808	0	308104.4	6270495	Cat 557	0.3705	0	307194.4	6272952
Cat 515	0.5292	0	309450	6270500	Cat 558	1.9353	0	308047.3	6273221
Cat 516	0.8706	0	308170.1	6270620	Cat 559	0.7515	0	308662.4	6271505
Cat 517	2.5809	0	306854.9	6270398	Cat 560	2.1889	0	309441.4	6270418
Cat 518	0.9653	0	308092.1	6270552	Cat 561	4.7685	0	309461.3	6270408
Cat 519	0.3868	30	309490.3	6270762	Cat 562	0.5181	30	307859.9	6272468
Cat 520	0.5047	30	309115.5	6270927	Cat 563	0.6523	30	307931.7	6272433
Cat 521	0.4916	30	308505	6270883	Cat 564	0.2622	30	307898.5	6272315
Cat 522	0.6905	30	308926.6	6271046	Cat 565	0.2714	0	307863	6272315
Cat 523	1.5448	30	309159	6270926	Cat 566	0.9639	30	307899.5	6272286
Cat 524	0.6719	30	308884.7	6271043	Cat 567	0.2798	30	307986.3	6272209
Cat 525	0.1157	0	308719.7	6271013	Cat 568	0.2192	30	308049.4	6272235
Cat 526	0.2562	30	308871.2	6271134	Cat 569	0.6499	30	307986.5	6272212
Cat 527	0.2948	0	309754.2	6271189	Cat 570	0.475	30	308011.1	6272201
Cat 528	0.5958	0	307705.2	6270966	Cat 571	1.7015	0	308084.8	6272169
Cat 529	1.1269	0	306995.3	6271253	Cat 572	1.2193	30	308087.3	6272172
Cat 530	4.8632	0	307920.9	6271475	Cat 573	0.1892	30	307938.8	6272428
Cat 531	2.097	30	309216.6	6271093	Cat 574	0.3828	30	307910.1	6272382
Cat 532	1.243	0	308591	6271451	Cat 575	0.6648	30	308018.8	6272325
Cat 533	0.5848	0	309658.5	6271266	Cat 576	0.5399	0	307102.5	6271262
Cat 534	1.6356	0	309053.8	6271202	Cat 577	1.5808	0	307244.2	6271297
Cat 535	1.4487	30	309229.4	6271389	Cat 578	0.8592	0	307315.4	6271164
Cat 536	0.3248	0	309367.8	6271388	Cat 579	0.2863	0	307500.7	6272616
Cat 537	0.1482	30	308994.2	6271457	Cat 580	0.5624	0	307483	6272630
Cat 538	0.4652	30	308984.7	6271577	Cat 581	0.6858	0	307297.5	6272654
Cat 539	0.8316	0	307363.7	6271779	Cat 582	0.8824	0	307297.4	6272676
Cat 540	1.4657	0	308588.3	6271618	Cat 583	0.2624	30	307495.5	6272441
Cat 541	0.6241	0	308329.4	6271774	Cat 584	1.8171	30	307449.8	6272477
Cat 542	0.2616	0	307942.7	6271775	Cat 585	0.2881	0	307327.2	6272393
Cat 543	1.2352	0	308286.4	6271914	Cat 586	1.1514	0	307001.6	6272273
Cat 544	0.5048	0	308092.7	6272100	Cat 587	0.3846	0	307037.5	6272279
Cat 545	1.5733	30	307579.4	6272259	Cat 588	1.9891	0	307204.5	6272327
Cat 546	0.9312	30	308134.6	6272372	Cat 589	0.7691	0	307280.1	6272384
Cat 547	0.2113	0	308698.5	6272399	Cat 590	2.0155	30	307150.8	6272276
Cat 548	0.154	0	307525.3	6272503	Cat 591	0.9834	0	307063.6	6272727
Cat 549	0.699	30	308205.6	6272461	Cat 592	1.4431	0	307203.6	6272598
Cat 550	0.7558	30	307608.5	6272548	Cat 593	1.5235	0	307254.4	6272510
Cat 551	1.8233	0	308744.9	6272497	Cat 594	2.9776	0	306929.9	6272480
Cat 552	0.4539	30	308265.1	6272503	Cat 595	0.4349	0	306571.5	6272504
Cat 553	0.3496	0	308989.1	6272545	Cat 596	3.3287	0	306622.8	6272643
Cat 554	0.2424	0	307773.4	6272596	Cat 597	3.0698	0	306868	6272548
Cat 555	0.2982	0	308282.5	6272915	Cat 598	0.6253	30	307229.4	6272110
Cat 556	1.627	0	306831	6272932	Cat 599	0.5597	30	307195	6272105

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 600	0.6958	0	306323.4	6271015	Cat 643	0.9747	0	307408.3	6271481
Cat 601	0.3509	0	306324	6271236	Cat 644	1.9506	0	307333.8	6271436
Cat 602	0.4415	0	306272.2	6271195	Cat 645	1.0673	0	307754.3	6271468
Cat 603	0.4422	0	306363.8	6271259	Cat 646	3.058	0	307714.5	6271532
Cat 604	0.7987	0	306363.2	6271230	Cat 647	1.1113	0	307669.7	6271643
Cat 605	0.8002	0	306428.4	6271316	Cat 648	1.2782	0	307699.3	6271724
Cat 606	1.2451	0	306701.9	6271484	Cat 649	2.5881	0	307611.2	6271891
Cat 607	2.1621	0	307105.3	6271520	Cat 650	0.9826	0	307747.8	6271679
Cat 608	0.6198	0	306926	6271571	Cat 651	1.0601	0	306938.4	6270272
Cat 609	1.0402	0	306892.6	6271454	Cat 652	5.1007	0	306053.1	6269990
Cat 610	2.9386	0	306926.6	6271355	Cat 653	1.8252	0	306125.1	6270158
Cat 611	0.6878	0	306722.8	6271563	Cat 654	0.6904	0	306298.3	6270332
Cat 612	0.4264	0	306718.3	6271610	Cat 655	0.8083	0	306040.9	6269868
Cat 613	0.9142	30	307003.7	6272136	Cat 656	1.5532	0	306004.4	6269618
Cat 614	0.6064	30	306986.5	6272123	Cat 657	3.6662	0	306022.6	6270941
Cat 615	0.6621	0	306963.4	6272105	Cat 658	4.0873	0	306267.7	6271155
Cat 616	0.3785	30	306932.3	6272006	Cat 659	7.585	0	306211.8	6270847
Cat 617	1.1696	0	306925.7	6272006	Cat 660	0.4296	0	308392.3	6270812
Cat 618	1.2325	0	307084.4	6270902	Cat 661	0.4264	0	308348.6	6270776
Cat 619	1.3238	0	307123.1	6270983	Cat 662	0.7837	0	308313.3	6270748
Cat 620	1.403	0	306919.6	6270930	Cat 663	0.3681	0	307804.6	6271638
Cat 621	1.1961	0	306961.7	6270872	Cat 664	1.6613	0	307658.2	6271660
Cat 622	1.9384	0	307043.5	6270806	Cat 665	0.9284	0	307819.7	6271598
Cat 623	2.0713	0	306568.9	6271449	Cat 666	2.4459	0	306003.8	6271106
Cat 624	2.5861	0	306748.7	6271148	Cat 667	0.2022	0	306877.5	6271782
Cat 625	1.8726	0	306771.7	6271047	Cat 668	0.3671	30	306928.5	6272003
Cat 626	1.0648	0	306898.6	6271977	Cat 669	0.303	30	308105.3	6272393
Cat 627	1.2502	0	306569.7	6271512	Cat 670	2.2498	0	306382.3	6271835
Cat 628	3.6139	0	306577.9	6271562	Cat 671	0.8707	30	309013	6271433
Cat 629	0.5652	0	306846.4	6271874	Cat 672	0.0535	30	307942.5	6272426
Cat 630	0.5137	30	306958.9	6271859	Cat 673	0.8687	0	308923.6	6271317
Cat 631	0.7372	30	306896.9	6271804	Cat 674	1.0509	0	307483.6	6271185
Cat 632	0.5394	30	306992	6271832	Cat 675	1.1423	0	306582	6272504
Cat 633	1.6266	0	306767.2	6271661	Cat 676	0.9113	30	309073.5	6271066
Cat 634	0.4303	30	306951.2	6271723	Cat 677	1.9517	0	309526.4	6270625
Cat 635	0.2488	0	306566.1	6271554	Cat 678	0.487	30	308952.5	6271169
Cat 636	1.0136	0	307654	6271880	Cat 679	0.2903	30	308888.1	6271166
Cat 637	3.0678	0	307924	6271637	Cat 680	0.0972	30	308875.8	6271143
Cat 638	1.0323	0	307849.1	6271502	Cat 681	1.0305	0	308233.7	6273176
Cat 639	2.412	0	307846.4	6271439	Cat 682	0.8193	30	308340	6272209
Cat 640	2.4424	0	307780.9	6271442	Cat 683	0.6124	0	307175	6271730
Cat 641	1.6103	0	307480.6	6271271	Cat 684	18.3156	0	306167.1	6271673
Cat 642	2.1117	0	307462.4	6271220	Cat 685	2.1256	0	308665.4	6271577

Name	Area (ha)	% Impervious	x coordinate	y coordinate	Name	Area (ha)	% Impervious	x coordinate	y coordinate
Cat 686	1.8768	0	306409.5	6271325					
Cat 687	1.3509	0	309084	6271262					
Cat 688	0.9855	30	308381.1	6270752					
Cat 689	3.7067	0	308243	6270656					
Cat 690	0.379	30	309025.6	6270812					

Appendix D: Revegetation Template

				Planting Zone #						
				Bed	Riparian			Outer		
Strata	Species Name	Common Name	Life form & Habit	Aquatic - Stream Bed	Rising Ground - Lower Banks	Upper Banks - Bank Top	Floodplain	High Ground - Bounding Banks	Preferred Zone & Ecological Notes ##	Propagation Method
1	*Eucalyptus camaldulensis var. camaldulensis*	River Red Gum	Tall Tree	X	XX	XX	XX	X	Requires high moisture level &/or ground water. Juveniles & adults will tolerate prolonged flooding. Regenerates readily especially after flood event. Will occupy all zones where suitable moisture regime & can be used to stabilise stream bed and banks where flow impediment not an issue and/or flow ephemeral.	Seed
1	*Eucalyptus leucoxylon ssp. pruinosa*	Inland South Australian Blue Gum	Tall Tree			X	X	XX	Adapted to local non-riparian environment but will benefit from raised moisture levels on outer edges of riparian zone. Will not tolerate flooding or water logging.	Seed
2	*Acacia pycnantha*	Golden Wattle	Small Tree			XX	X	XX	Largely terrestrial, but benefits from raised moisture regime in well drained areas of permanent watercourses and along ephemeral streams.	Seed
2	*Acacia retinodes var. retinodes (hill form)*	Wirilda	Small Tree		X	XX	XX	XX	Associated with extra moisture and heavy soils in well drained sites on banks and outer riparian areas of permanent watercourses and ephemeral streams.	Seed
2	*Allocasuarina verticillata*	Drooping Sheoak	Small Tree			XX		XX	Terrestrial, but benefits from raised moisture regime in well drained areas of permanent watercourses and along ephemeral streams and adapted to rocky, steep banks with shallow soils, often associated with watercourses.	Seed
2	*Exocarpos cupressiformis*	Native Cherry	Small Tree			XX		XX	Largely terrestrial, but benefits from raised moisture regime in well drained areas of permanent watercourses and along ephemeral streams.	Hard to prop. Use if avail.
2	*Melaleuca lanceolata ssp. lanceolata*	Dryland Tea-tree	Small Tree to Tall Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime in well drained areas of permanent watercourses and along ephemeral streams and adapted to rocky, steep banks associated with watercourses.	Seed
2	*Myoporum montanum*	Native Myrtle	Small Tree to Tall Shrub		X	XX	X	XX	Benefits from extra moisture and found on heavy soils in well drained sites on banks and outer riparian areas of permanent watercourses and ephemeral streams.	Cutting
2	*Pittosporum phylliraeoides var. microcarpa*	Native Apricot	Small Tree			XX		XX	Largely terrestrial, but benefits from raised moisture regime in well drained areas of permanent watercourses and along ephemeral streams.	Seed
3	*Acacia acinacea*	Wreath Wattle	Spreading Medium Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained upper banks or on the outer riparian areas of watercourses.	Seed
3	*Acacia myrtifolia var. myrtifolia*	Myrtle Wattle	Small to Medium Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained upper banks or on the outer riparian areas of watercourses & adapted to rocky, steep banks associated with watercourses.	Seed
3	*Acacia paradoxa*	Kangaroo Thorn	Spreading Large Shrub			XX	X	XX	Forms dense, tall thickets along ephemeral streams and suited to well drained sites on permanent watercourses. Will tolerate very brief periods of waterlogging. Good protective habitat for small birds.	Seed
3	*Banksia marginata*	Silver Banksia	Tall Shrub			XX	XX	XX	Associated with extra moisture and heavy soils in well drained sites on banks and outer riparian areas of permanent watercourses and ephemeral streams. Will tolerate periods of waterlogging. Likely to have been widespread along ephemeral streams in region before settlement. Provides rich nectar source.	Seed

				Planting Zone #						
				Bed	Riparian			Outer		
Strata	Species Name	Common Name	Life form & Habit	Aquatic - Stream Bed	Rising Ground - Lower Banks	Upper Banks - Bank Top	Floodplain	High Ground - Bounding Banks	Preferred Zone & Ecological Notes ##	Propagation Method
3	*Bursaria spinosa*	Sweet Bursaria	Tall Shrub			XX	X	XX	Terrestrial, but benefits from raised moisture regime on well drained upper banks or on the outer riparian areas of watercourses & adapted to rocky, steep banks associated with watercourses.	Seed
3	*Callistemon rugulosus var. rugulosus*	Scarlet Bottlebrush	Spreading Large Shrub		XX		XX		Adapted to poorly drained, low lying areas. Requires high moisture level & will tolerate prolonged inundation and waterlogging, Can be used to stabilise stream bed and banks where flow impediment not an issue and flow ephemeral. Provides dense habitat for birds and rich nectar source.	Seed
3	*Callistemon teretifolius*	Needle Bottlebrush	Small to Medium Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained sites and adapted to rocky, steep banks associated with watercourses.	Seed
3	*Correa glabra*	Rock Correa	Large Erect Shrub			XX		XX	Terrestrial, well drained sites, shallow and rocky soils, open or shaded.	Cuttings
3	*Dodonaea viscosa*	Sticky Hop-bush	Large Shrub			XX		XX		Seed
3	*Eutaxia microphylla var. microphylla (erect)*	Common Eutaxia	Small Shrub			XX		XX		Seed
3	*Grevillea lavandulacea*	Spider-flower	Small Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained sites.	Cutting/seed
3	*Melaleuca acuminata*	Mallee Honey Myrtle	Large Shrub			XX		XX	Terrestrial, well drained site, non-clay soils.	Seed
3	*Olearia ramulosa*	Twiggy Daisy-bush	Small to Medium Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained sites and adapted to rocky, steep banks associated with watercourses.	Seed
3	*Pultenaea largiflorens*	Twiggy Bush-pea	Small to Medium Shrub			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained sites and adapted to rocky, steep banks associated with watercourses.	Seed
3	*Rhagodia parabolica*	Mealy Saltbush	Spreading Medium Shrub			XX		XX	Terrestrial, well drained sites. Normally associated with drier rainfall areas to west of Clare.	Cutting/seed
3	*Spyridium parvifolium*	Dusty Miller	Medium Shrub			XX		XX	Terrestrial, well drained sites and adapted to rocky, steep banks associated with watercourses.	Cutting/seed
4	*Ajuga australis*	Australian Bugle	Herb			XX		XX	Attractive terrestrial herb, stabilises banks.	Root Cutting
4	*Atriplex semibaccata*	Berry Saltbush	Low Shrub, Spreading			XX		XX	Forms mats on bare areas, terrestrial, but benefits from raised moisture regime.	Seed
4	*Carex bichenoviana*	Notched Sedge	Small Tussock			XX	X	XX	Benefits from extra moisture, low, dense tussocks form good ground cover.	Seed
4	*Dianella revoluta var. revoluta*	Black-anther Flax-lily	Tall Tussock Spreading			XX	X	XX	Terrestrial, spreading tussocks species, forms large clumps, good for ground stabilisation on well drained banks, bare ground and rocky slopes. Attractive foliage and flower heads.	Seed , root cuttings
4	*Einadia nutans ssp. nutans*	Climbing Saltbush	Low Shrub, Spreading			XX	X	XX	Terrestrial, but benefits from raised moisture regime on well drained sites.	Seed

				Planting Zone #						
				Bed	Riparian			Outer		
Strata	Species Name	Common Name	Life form & Habit	Aquatic - Stream Bed	Rising Ground - Lower Banks	Upper Banks - Bank Top	Floodplain	High Ground - Bounding Banks	Preferred Zone & Ecological Notes ##	Propagation Method
4	*Enchylaena tomentosa var. tomentosa*	Ruby Saltbush	Low Shrub, Spreading			XX		XX	Terrestrial, but benefits from raised moisture regime on well drained sites and adapted to rocky, steep banks associated with watercourses.	Seed
4	*Goodenia albiflora*	White Goodenia	Herb			XX		XX	Attractive terrestrial herb, stabilises banks.	Root Cutting
4	*Kennedia prostrata*	Scarlet Runner	Groundcover			XX		XX	Terrestrial ground cover, attractive flower.	Seed
4	*Lepidosperma viscidum*	Sticky Sword-sedge	Tussock			XX		XX	Terrestrial, dense tussock.	Seed
4	*Lomandra densiflora*	Soft Tussock Mat-rush	Tussock			XX		XX	Terrestrial, dense tussock.	Seed
4	*Lomandra multiflora ssp. dura*	Hard Mat-rush	Tussock			XX		XX	Terrestrial, dense tussock.	Seed
4	*Myoporum parvifolium*	Creeping Boobialla	Groundcover			XX		XX	Forms large spreading blanket, good for stabilisation and cover on bare ground. Terrestrial, but benefits from raised moisture regime on well drained sites.	Seed
4	*Scaevola albida*	Pale Fanflower	Herb			XX		XX	Attractive terrestrial herb, stabilises banks.	Root Cutting
4	*Teucrium sessiliflorum*	Mallee Germander	Herb			XX	X	XX	Upright herb, forms spreading mats. Benefits from raised moisture regime on well drained sites.	Root Cutting
4	*Themeda triandra*	Kangaroo Grass	Tall Grass			XX	X	XX	Tall grass forms attractive perennial thickets, especially where moisture level higher on deeper soils.	Seed
4	*Vittadinia sp.*	New Holland Daisy	Herb			XX		XX	Upright herb, spreads readily on bare ground. Use locally occurring species.	Seed
4	*Wahlenbergia stricta ssp. stricta*	Tall Bluebell	Herb			XX	X	XX	Upright herb, forms mats and spreads readily in areas with raised moisture levels. Attractive flower.	Cutting/seed
5	*Bolboschoenus caldwellii*	Salt Club-rush	Tall Sedge or Reed < 1.2m	XX	XX		XX		Attractive bright green blade foliage. Adapted to growing in damp areas, regularly inundated or shallow, permanently inundated areas up to 0.3m depth. Does not restrict flow.	Seed
5	*Carex appressa*	Tall Sedge	Sedge Clump <0.5m	XX	XX				Attractive bright green blade foliage growing in low, small, dense clumps. Adapted to growing in damp areas, shallow regularly inundated or permanently waterlogged areas up to 0.2m depth. Plant on wet edges or on waterlogged floodplain areas.	Seed
5	*Carex tereticaulis*	Rush Sedge	Sedge, spreading Clump < 1.0m	XX	XX		XX		Attractive spreading, tall blue-green clumps. Adapted to grow in shallow regularly inundated or permanently waterlogged areas up to 0.2m depth. Plant on wet edges, permanently waterlogged floodplain areas or shallow mainstream.	Seed
5	*Cyperus vaginatus*	Stiff Flat-sedge	Sedge Clump < 1.0m	XX	XX		XX		Attractive green flowering heads growing in tall, dense clumps often lining edge of water. Adapted to growing in shallow, regularly inundated or permanently waterlogged areas up to 0.2m depth. Plant on wet edges or on waterlogged floodplain areas.	Seed
5	*Cyperus gymnocaulos*	Spiny Flat-sedge	Sedge < 1.0m	XX	XX	X	XX		Adapted to growing in damp areas with seasonal or infrequent inundation. Plant in riparian areas just off permanent water line or in areas subject to waterlogging or flooding.	Seed
5	*Eleocharis gracilis*	Slender Spike-rush	Sedge <0.5m	XX	XX				Small, thin sedge often growing on very edge of permanent waterline. Adapted to growing in shallow, regularly inundated or permanently waterlogged areas up to 0.1m depth. Plant on wet edges or on waterlogged floodplain areas.	Seed
5	*Isolepis cernua*	Nodding Club-rush	Sedge Clump < 1.0m		XX	XX	XX		Adapted to growing in damp areas with seasonal or infrequent inundation. Plant in riparian areas just off permanent water line or in areas subject to waterlogging or flooding.	Seed

				Planting Zone #						
				Bed	Riparian			Outer		
Strata	Species Name	Common Name	Life form & Habit	Aquatic - Stream Bed	Rising Ground - Lower Banks	Upper Banks - Bank Top	Floodplain	High Ground - Bounding Banks	Preferred Zone & Ecological Notes ##	Propagation Method
5	*Juncus subsecundus*	Finger Rush	Rush Clump < 1.0m		XX	XX	XX		Adapted to growing in damp areas with seasonal or infrequent inundation. Plant in riparian areas just off permanent water line or in areas subject to waterlogging or flooding.	Seed
5	*Schoenoplectus validus*	River Club-rush	Rush/Reed Clump < 1.5m	XX					Tall round, dark-green reed. Adapted to growing in permanent streams, up to 1.0m depth. Requires permanent Lays down readily to allow flow over in flood events - does not restrict flow.	Seed

1 = Large tree
2 = Small tree
3 = Small to Medium Shrubs
4 = Ground hugging shrubs, Groundcovers, Tussocks, Herbs, Grasses, Ferns, Annuals
5 = Riparian & Aquatic species

Ecological notes relate to conditions in Clare Valley generally where flows are largely ephemeral, watercourses generally temporary and areas with permanent pools few.

Planting zone notes relate to conditions in main Hutt River within Clare township.
Aquatic - Stream Bed = the zone that is permanently wet where the watercourse retains permanent water.
Rising Ground - Lower Banks = the zone adjacent to the aquatic zone in a permanent stream, where there is extra moisture associated with the watercourse flow and that is inundated during flood events.
Upper Banks - Bank Top = similar to Rising Ground - Lower Banks, but less often inundated directly but extra moisture is still available in the soil and subsoil areas.
Floodplain = zone that is often inundated and may retain water fro some time after major floods. It may be adjacent to the rising ground and inside the banks in some stream sections while in others it may be above the stream banks but inside the bounding banks.
High Ground - Bounding Banks = the zone where there is rarely if ever, inundation but vegetation benefits directly from the raised moisture regime in this environment.
X X = preferred zone X = suitable for zone

Appendix E: Assessment of Priorities

Considerations:	Ranking system:
Level of flood risk	Low = 1 in 100 ARI, Medium = 1 in 50 ARI, High = 1 in 20 ARI
Number of properties protected (%age) - based on properties (dwellings) at risk in 1 in 100ARI	Low = <20%, Medium = 20%-50%, High = >50% properties protected
Cost effectiveness ($ per property)	Low = >$250,000, Medium = $100,000-$250,000, High = <$100,000
Catchment area greater than 40ha	Low = <40ha, High = >40ha
Water quality improvement	Low = <20%, Medium = 20%-50%, High = >50% of proportion of catchment/township benefiting from treatment
Water harvesting and reuse	as per community aspiration
Community aspiration	Low = <20%, Medium = 20%-50%, High = >50% importance

Town: Burra

Recommendation	**Current flood exposure**	**Number of properties protected**	**Number of properties protected (% of 75 dwellings)**	**Cost**	**Cost per property**	**Costs effectiveness**	**Catchment area greater than 40ha**	**Water quality improvement**		**Water harvesting and reuse**	**Community aspiration**	**Low Medium High**
								Catchment wide benefit	**Township only benefit**			
M1: Asset mamangement as per Council's AMP and regular maintenance of stormwater drainage infrastructure and watercourses	High	-	Medium	$10,000	-	Medium	Low				High	H
P2: Development / planning controls	High	-	Medium	-	-	High	High				Low	H
P1 - Flood preparedness program – establishment of a flood warning thresholds to support a flood warning system	High	-	High	$20,000	-	High	High				Medium	H
P1 - Flood preparedness program - Community education program - e.g. Floodsafe (Community/education officer role and associated materials)	High	-	Medium	$20,000	-	High	High				Medium	H
F1 – Channel levee works along Burra Creek	High	30	High	$810,000	$27,000	High	Low				High	H
F2: Burra Creek tributary crossing Kangaroo Street, Queen Street and Chapel Street drainage	High	25		$150,000	$6,000	High	Low				High	H
F4: St Just Street drainage system	Medium	9		$150,000	$16,667	High	Low				Medium	H
F3: Paxton Terrace drainage system	Medium	12		$350,000	$29,167	High	Low				Medium	M
F5: Tregony Street drainage system	High	3		$600,000	$200,000	Medium	High				Low	M
F6: Goyder Hwy and Stronach Street drainage system	Medium	2		$100,000	$50,000	High	Low				Medium	L
Q1: Water Quality: Construction of the Spring Street wetlands				$2,500,000	-		High	High	High		Medium	H
Riparian Works Program (all activities)				$4,600,000	-		High	Medium	Medium			L
R1: Harvesting and Reuse: Promote the use of rainwater tanks and increase minimum size to 5000L.				$3,000	-		Low			Low	Low	L
total				*$9,313,000*								

Appendix F: Implementation Plan

Burra Stormwater Management Plan – Implementation Plan

Priority	Timeframe 0 - 1 yr 1 - 5 yrs 5 - 10 yrs	Project/ Activity and Location	Capital Cost ($)	Recurrent Cost ($ pa)	Flood Mitigation Benefit *Measures:* *(P) – Properties Affected* *(properties protected by measures in the 1 in 100 ARI event)*	Water Harvesting Benefit *Measures:* *(V) – Volumetric* *(Q) – Qualitative*	Water Quality Benefit *Rating:* *(H) - High* *(M) - Medium* *(L) – Low*			Other Benefits *Rating:* *(H) - High* *(M) - Medium* *(L) – Low* Qualitative description of benefit	Potential funding partners with Council
							Benefit to whole of catchment	Benefit to township only	Qualitative description of benefit		
High	0 - 1	M1: Asset management in accordance with Council AMP and regular maintenance of stormwater drainage infrastructure and watercourses	$10,000	$5,000	Effective drainage and therefore reducing risk of flooding.	-	-	-	-	Improved sense of security and wellbeing amongst the community.	-
High	0 - 1	P2: Development / planning controls	-	-	Reduced risk and cost of flooding to properties and people.	-	-	-	-	Better planning and development outcomes. Improved sense of security and wellbeing amongst the community.	-
High	1 - 5	P1 - Flood preparedness program – establishment of rainfall thresholds for flood warning system	$20,000	$5,000	Increase awareness and preparedness would reduce damages and social disturbance (including stress)	-	-	-	-	Provides a warning for flood events which provides time for preparation and therefore reduces the risk and impact of flooding. Community awareness raised and people are empowered to protect their properties and response – thereby significantly reducing flood damages. Improved sense of security and wellbeing amongst the community.	BoM, SMA
High	1 - 5	P1 - Flood preparedness program - Community education program - e.g. Floodsafe. (Community/education officer role and associated materials).	$20,000	$1,000	- Increase awareness and preparedness would reduce damages and social disturbance (including stress)	-	-	-	-	Gain community support for implementation and ongoing management of the stormwater management measures. Build the capacity of the community to prepare for floods as well as reduce risk of flooding. Improve the community's sense of worth and feeling of security.	SES
High	5 - 10	F1: Levee Earthworks along Burra Creek.	$ 810,000	$16,000	30 properties protected	-	-	-	-	Improved road trafficability	SMA
High	1 - 5	F2: Burra Creek Tributary Crossing Kangaroo Street, Queen Street and Chapel Street Drainage.	$150,000	$3,000	25 properties protected	-	-	-	-	Improved road trafficability	SMA
High	1 - 5	F4: St Just Street Drainage.	$150,000	$7,500	9 properties protected	-	-	-	-	Improved road trafficability	-
Low	5 - 10	WQ1: Water Quality Construction of the Spring Street wetlands.	$2,500,000	$3,000		-	High	High	TSS: 81.9% reduction TP: 72.1% reduction TN: 49.7% reduction	Protection of downstream environment from township runoff and upstream rural runoff.- Increased biodiversity in Burra Creek within township.	NRM, SMA
Medium	1 - 5	F3: Paxton Terrace Drainage System	$350,000	$7,000	12 properties protected	-	-	-	-	Improved road trafficability	SMA
Medium	1 - 5	F5: Tregony Street Drainage	$600,000	$12,000	3 properties protected	-	-	-	-	Improved road trafficability, reduced disruption to business and main economic area of township.	SMA
Low		F6: Goyder Hwy and Stronach Street Drainage System			2 properties protected					Improved road trafficability	-

Priority	Timeframe 0 - 1 yr 1 - 5 yrs 5 - 10 yrs	Project/ Activity and Location	Capital Cost ($)	Recurrent Cost ($ pa)	Flood Mitigation Benefit *Measures:* *(P) – Properties Affected* *(properties protected by measures in the 1 in 100 ARI event)*	Water Harvesting Benefit *Measures:* *(V) – Volumetric* *(Q) – Qualitative*	Water Quality Benefit *Rating:* *(H) - High* *(M) - Medium* *(L) – Low*			Other Benefits *Rating:* *(H) - High* *(M) - Medium* *(L) – Low* Qualitative description of benefit	Potential funding partners with Council
							Benefit to whole of catchment	Benefit to township only	Qualitative description of benefit		
Low	5 - 10	WQ2 – Riparian Rehabilitation reaches MC1 – MC2	$1,190,000	$50,000	Reduction in flood levels downstream of Pioneer Avenue.	-	Medium	High	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	5 - 10	WQ3 – Riparian Rehabilitation reaches TR1	$570,000	$10,000	-	-	Medium	Medium	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	5 - 10	WQ4 – Riparian Rehabilitation reaches MC3 – MC4: Incorporating WQ8b	$720,000	$12,000	-	-	Medium	High	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	5 - 10	WQ5 – Riparian Rehabilitation reaches TR2	$830,000	$12,000	-	-	Medium	Medium	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	5 - 10	WQ6 – Riparian Rehabilitation reaches TR4, TR5, TR6: Incorporating WQ8a	$650,000	$11,000	-	-	Medium	Medium	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	5 - 10	WQ7 – Riparian Rehabilitation reaches TR7	$610,000	$10,000	-	-	Medium	Medium	Protection of drainage infrastructure, reduced mobilisation of sediment and increased bank stability.	Protection of downstream environments and increased biodiversity in township area.	NRM
Low	1 - 5	R1: Harvesting and Reuse: Promote the use of rainwater tanks and increase minimum size to 10,000L.	$3,000	Landholder responsibility	-	minor	-	-		Water savings	SA Water

Appendix G: Riparian Survey

Burra Creek and Tributaries Township Watercourse Survey

Contents

Burra Creek and Tributaries 1
Township Watercourse Survey 1
Overview Notes: 3
Study Area – Burra Creek from Barrier Highway to Spring Street 3
Riparian Survey - Key Map 4
Burra Creek Reach 1– West St Ford to St Just Ford 5
Burra Creek 2 – St Just St Ford to Commercial St Bridge—Bridge 5 6
Burra Creek 3 – Commercial St Bridge (Bridge 5) to Stock St Ford (Bridge 7) 7
Smith Creek 4 – Stock St Ford to Section near Challoner Terrace (along Burra Creek) 8
Smith Creek Tributary 1 – Mevagessey St to St Just St Ford 9
Burra Creek Tributary 2 (Welsh Creek)- Smelts Rd to Creek St 10
Burra Creek Tributary 3 – Paxton Terrace to Paradise St 11
Burra Creek Tributary 4, 5 and 6 – Paradise St to the intersection of Tributary 6 & Main Creek 12
Burra Creek Tributary 7a – Barrier Hwy to Queen St 13
Burra Creek Tributary 7b – Queen/Harry St to Lower Thames St 14

Overview Notes:

- The watercourse was inspected on 4th and 5th of October 2018
- Throughout the reaches inspected there were a range of weeds common to watercourses including Castor Oil, Olives, Kikuyu, Pepper Trees etc. It is our understanding Council has a long term plan for weed removal and management with subsequent revegetation with native plant species. As such comment has been limited to stability related issues.
- Overall, the channel stability along Burra Creek and its tributaries through the Burra township is good and there are few large stability issues.
- For the purposes of this investigation the left bank is defined in the direction of flow (looking downstream).
- When implementing any intrusive works on the bank or where removing significant areas of weeds, revegetation or some other protection such as jute matting should be employed to protect the exposed bank from erosion from rain or watercourse flows. These works should only be undertaken under the guidance of an experienced watercourse manager.

Study Area – Burra Creek from Barrier Highway to Spring Street

Riparian Survey - Key Map

Burra Creek Reach 1– West St Ford to St Just Ford

Creek between West St ford/culvert and Taylor St ford/culvert. Weedy and stable creek bed upstream of the West St ford. Natural rocky bed near West St ford. Minor bank erosion visible. No vegetation on the creek bed between the railway bridge-bridge 1 and West St ford. Weedy but stable creek bed between railway bridge (bridge 1) and the Taylor St ford.	Creek between Taylor St ford/culvert and Bridge 2, which is located at the T-junction of Barrier Highway & Goyder Highway. Scour visible immediately downstream of the Taylor St ford/culvert. Stormwater outlet visible on the left bank. Weedy and stable creek bed. Twin culverts visible on the left bank crossing Barrier Hwy.	Creek between Bridge 2 and St Just St ford. Weedy and stable creek bed. A bridge (bridge 3), crossing the creek near the corner of Morehead St visible. Almost blocked stormwater outlet with tree growing on top of it visible at the right bank downstream of bridge 3. Concrete scour protection on the creek bed visible. A fallen gum tree visible.	Creek near St Just St Ford. Stable and well vegetated. Tributary 2 enters Burra Creek upstream of ford. A small drainage swale along southern side of St Just St and enters Burra Creek downstream of the ford. The drainage swale has several cross over culverts for driveway entrances. Bed instabilities evident in the swale, and are migrating up its length, potentially undermining the driveway culverts. Culvert at the end of the drainage swale to transfer water into the main creek is half blocked.
Recommendation: **Manage weeds, monitor the bank erosion.** **Priority: Low**	**Recommendation:** **Manage weeds; repair scour downstream of the Taylor St Ford.** **Priority: Medium**	**Recommendation:** **Clear the blocked stormwater outlet ad remove tree.** **Manage weeds and revegetate** **Priority: Medium**	**Recommendation:** **Clear the half-blocked culvert.** **Install grade control (rock armouring) along base of drainage swale to stabilise the swale or install pipe system to protect property access and stop sediment being washed into Burra Creek.** **Priority: High**

Burra Creek 2 – St Just St Ford to Commercial St Bridge—Bridge 5

Creek between St Just St Ford and the section near the Burra Mine Historic Site. Weedy and stable creek bed. Stormwater outlet visible on the right bank. Localised small scour pool with rocks visible near the two big gum trees. Stormwater outlet visible at the right bank. Stormwater outlet with scour on the left bank visible. Minor bank erosion visible.	Creek between the Burra Mine Historic Site and the floodplain mound, where the main creek separates into two. Weedy creek bed without water. Not many native plants visible. Bed scouring on floodplain visible. Main creek separates into two when passing a mound and re-joins after passing the flood plain erosion area. Stormwater outlet with scour at outlet also visible.	Creek between section with floodplain mounding and the three arched bridge (bridge 4), near the caravan park. This section of creek is full of water. More local plants and trees visible. Stormwater outlet visible at the left bank. Stormwater outlet visible with scour issue at the right bank of upstream of bridge 4.	Creek between bridge 4 and the big bridge under Commercial St (bridge 5). A weir holds the water in the pool. A small side channel joins to the main creek with the bubbling water flowing along it (pumped groundwater being used to keep the main pool topped up). A stormwater outlet also visible near the main weir.
Recommendation: **Increase diversity and density of plantings, manage weeds.** **Monitor the stormwater outlet scour and bank erosion.** **Priority: Med**	**Recommendation:** **Monitor for signs of change in condition and repair the flood plain erosion if this does not naturally restabilise.** **Priority: Medium**	**Recommendation:** **Monitor for signs of change in condition. Provide extra rock protection at stormwater outlet.** **Priority: Low**	**Recommendation:** **Monitor for signs of change in condition.** **Priority: Low**

Burra Creek 3 – Commercial St Bridge (Bridge 5) to Stock St Ford (Bridge 7)

Creek near Bridge 5. Stormwater outlets visible at both upstream and downstream of bridge 5. Native plants visible under and upstream of bridge 5.	Creek between bridge 5 and instream small dam with cracked spillway. Native trees and bushes visible. A foot bridge—bridge 6, is under repair. Two services pipes visible across the creek upstream of bridge 6.	Creek around the instream small dam and spillway. Very bad scour visible at the end and side of the spillway. Water flows underneath the spillway causing scour under the spillway. The rest of the creek bed stable but weedy.	Creek between the dam and the Stock St Ford—bridge 7. Creek bed stable. Native plants and revegetation visible. Stock St ford with culvert. Stormwater outlets visible at both upstream and downstream of bridge 7. Large area of scour at downstream of bridge 7 visible.
Recommend monitor for signs of change in condition. **Priority: Low**	**Recommendations:** **Monitor for signs of change in condition.** **Priority: Low**	**Recommendations:** **Provide scour protection around sipllway area (approximately 100 m^3 of rock required). Alternatively could remove embankment and revegetate. Manage weeds.** **Priority: High**	**Recommendations:** **Manage weeds and monitor for signs of change in condition scour downstream of Stock Street. Provide Scour protection to downstream right bank to prevent damage to adjoining property.** **Priority: Medium/High**

Burra Creek 4 – Stock St Ford to Section near Challoner Terrace (along Burra Creek)

Weedy creek bed visible. More gum trees and other native plants visible. One area on the right bank near the house has exposed bank. Rock scour protection visible on top of the right bank near to the end of Allen St towards to Burra Creek. Rubbish in the creek bed visible. A pipe visible in the creek.
Possible opportunity for inline wetland to be installed near Challoner Terrace to improve the water quality from township. Scour visible along the overland flow from a tributary coming across Chapel St to the main creek.

Recommendation:
Revegetate the creek bank with native grasses where needed, remove rubbish from creek, monitor for changes in condition, i.e. the tributary scour.
Investigate opportunity for wetland treatment area.
Priority: Med

Burra Creek Tributary 1 – Mevagessey St to St Just St Ford

Creek between Mevagessey St to Truro St. Natural but weedy creek bed upstream of Mevagessey St is consider stable. Similar condition maintained all the way downstream to Truro St, passing through a private house backyard. A small culvert crosses Truro St.	Creek between Truro St and bridge 9, under Ludgvan St. Weedy but stable creek bed through private land. A natural open creek down to Dye St, then becomes an artificial open channel between houses. Natural open channel again after passing a small foot bridge.	Creek around bridge 9. A foot bridge (bridge 8) crossing the creek near the upstream of bridge 9. Weedy and stable creek bed visible. Stormwater outlet visible on the right bank between bridge 8 and 9. A service pipe crosses the creek just upstream of bridge 9.	Creek between bridge 9 and the intersection of tributary 1 & main creek (near to St Just St Ford). A small blocked culvert visible crossing Sancreed St (near the Courthouse, Police Station, Lock-up and Stable 1856). Scour visible at downstream of the blocked culvert, may be caused by the water flowing over Sancreed St. Two big culverts providing driveway access to dwellings between Sancreed St and Burra Creek. Signs of bed deepening visible at junction.
Recommendations: **Manage weeds and monitor for changes in condition.** **Priority: Low**	**Recommendations:** **Manage weeds, monitor for changes in condition.** **Priority: Low**	**Recommendations:** **Manage weeds, monitor for changes in condition.** **Priority: Low**	**Recommendations:** **Check blocked culvert under Suncreed St and clean out.** **Manage weeds, monitor for changes in condition, investigation bed deepening.** **Priority: Medium**

Burra Creek Tributary 2 (Welsh Creek)- Smelts Rd to Creek St

Creek along Tributary 2 (Welsh Creek) to the main creek. This tributary is all in private land. Looks weedy and stable. A culvert visible at the intersection of tributary 2 and main creek, with downstream scour.

Recommendation:
Manage weeds, repair the culvert downstream scour.

Priority: Low

Burra Creek Tributary 3 – Paxton Terrace to Paradise St

Creek along Tributary 3 and Paxton Terrace.

Swale and embankment visible along the gravel road parallel to Paxton Terrace, diverting water from Tributary 3 to Tributary 4 through a gravel road ford crossing.

Recommend monitor for changes in condition.

Priority: Low

Burra Creek Tributary 4, 5 and 6 – Paradise St to the intersection of Tributary 6 & Main Creek

Creek around bridge 10, located under Paradise St-Kooringa Rd. Weedy creek bed visible upstream of bridge. Scour visible upstream of bridge 10. Rubbish in tributary in private property visible downstream of bridge 10. Rocky bank on the left bank and rocky creek bed.	Creek around bridge/culvert/ford 11, at Diprose Rd crossing. Weedy creek bed and banks. A pipe visible under the road.	Creek between the intersection of Tributary 4, 5 & 6 and bridge 12, located under Welsh Place/Ayers St. This section of the creek is in private land. Looks weedy but creek bed appears to be stable. An old bridge (dead man bridge) located a short distance upstream of bridge 12. Large erosion issue visible downstream of bridge 12, as water flows appear to have over topped the road and scoured downstream headwall.	Creek between bridge 12 and bridge 13, (located along path near junction of Tributary 6 and Burra Creek), near Bridge St and Mitchell Flat (location of Sanctuary). A stormwater outlet visible at the left bank. Natural rock exposed downstream of bridge 12. Miner's Dugouts c,1850 visible in this section. Between bridge 13 and the mining area, creek bed stable and weedy. Bad scour immediately upstream of bridge 13.
Recommendations: **Monitor for changes in condition remove rubbish from tributary.** **Priority: Medium**	**Recommendations:** **Manage weeds, monitor for changes in condition.** **Priority: Low**	**Recommendations:** **Either provide additional scour protection to headwall or preferably upgrade culvert.** **Priority: High**	**Recommendations:** **Monitor condition of scour upstream of bridge 13.** **Provide scour protection at stormwater outlet pipe** **Priority: Medium**

Burra Creek Tributary 7a – Barrier Hwy to Queen St

Creek between bridges across Barrier Hwy (bridge 14) and along Kangaroo St (bridge 15). Upstream of bridge 14 is stable but weedy. Sediment deposits in creek. Creek bed stable. Weedy banks. Stormwater outlet scour visible. Rocky banks visible.	Creek between the bridge along Kangaroo St (bridge 15) and cross Kangaroo St (bridge 16). Pipes visible across the creek at upstream of bridge 15. Soil loss. weedy bed and banks. No native plants visible. Wing wall of bridge 16 needs to monitor. Very bad stormwater outlet erosion found at right bank. Stable bed.	Creek between Bridges crossing Kangaroo St (bridge 16) and a foot bridge (bridge 17) upstream of the arched bridge (bridge 18) near Queen St. Between bridge 16 and bridge 17, rock lined right bank in poor condition, somewhere already fail. A tree affects bed stability. Left soil bank needs trim, revegetate. Assume rock lined banks all along the right bank with the cover of a type of plant between bridge 16 and bridge 17. A pipe found across the creek upstream of bridge 17.	Creek between bridge 17, bridge 18 (the arched bridge) crossing Queen St/Harry St and bridge 19 crossing Bridge St W-Church St (near Chapel St). Stormwater outlets found at both rock lined banks between bridge 17 and bridge 18. Two services pipes crossing the creek upstream and downstream of bridge 18. Creek between bridge 18 and bridge 19. Several roof runoff pipes found at the left bank. Stormwater outlet found at the right bank. Pepper trees causing bank erosion. A fallen tree found near the old shed.
Recommendations: **Investigate source of sediment; manage weeds, monitor scour at the outlet.** **Priority: Low**	**Recommendation:** **Repair outlet erosion to avoid further damage to bridge wingwall.** **Priority: Medium**	**Recommend remove tree that affect the bed stability, repair the rock lined bed, revegetate left bank.** **Priority: Medium**	**Recommends:** **Remove the pepper trees and the fallen tree.** **Priority Medium**

Burra Creek Tributary 7b – Queen/Harry St to Lower Thames St

Creek near the bridge 19. Stormwater outlet visible at the left bank of upstream of the bridge, need flap gate to avoid water back flow on the street. Stormwater outlet visible at the right bank of the downstream of the bridge.	Creek between bridge 19, bridge 20 (bridge 20 and 21 are close to each other crossing Chapel St). Road runoff scour visible. Scour underneath the stone wall lined bank visible. Two stormwater outlets visible at the right bank downstream of bridge 20, one is blocked, the other is for road runoff. Bridge abutment cracked and leaning over. Spoiling concrete under bridge 20.	Creek between bridge 20 and bridge 21. Stormwater outlet visible at the left bank near upstream of the bridge 21, seems blocked. An overflow path on the right bank between bridge 20 and 21 for road runoff. Water gets behind the wing wall, may cause collapse of the bridge. Stormwater outlet at the left bank near downstream of bridge 21.	Creek between the bridge 21 and the culvert-bridge 22 under Lower Thames St. Stormwater outlet visible at the right bank side. No vegetation visible on the river bed, due to a few large pine trees. A big old chicken cage visible on the river bed. Quite a few old aged trees visible along the creek bed. Stormwater outlet visible at the left bank. Rock bank erosion visible on the left bank. Erosion head (Creek bed deepening) visible at the upstream of bridge 22. Water from road runoff drain goes underneath the wing wall of bridge 22 at upstream.
Recommendations: **Increase diversity of plantings, manage weeds.** **Priority: Medium**	**Recommendations:** **Manage weeds, provide toe protection to undercut sections of bank. Complete repairs to bridge.** **Priority: High**	**Recommendations:** **Direct road runoff water away from wing wall and repair scour. Monitor the wing wall.** **Priority: Medium**	**Recommendations:** **Manage weeds, monitor for signs of change in condition.** **Priority: Low**

Appendix H: Flood Damages Methodology Summary

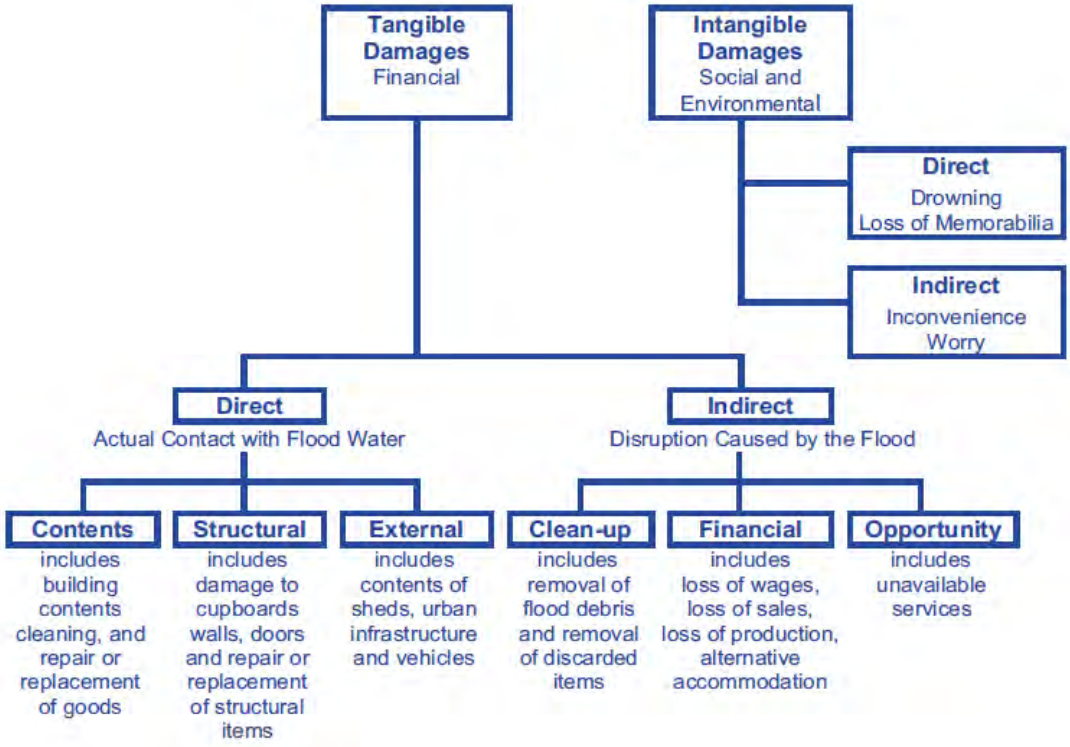
Flood Damages Calculation Summary

Introduction

The approach to be applied for estimating flood damages is consistent with Bureau of Transport Economics, 2001.

This approach allocates costs into two primary categories – tangible and intangible. Tangible damages are then further separated into direct and indirect costs.

The figure below illustrates the damage categorisation process. A description then follows along with a table of unit rates for different types of damages.



Source: Commonwealth of Australia, 2012

Direct tangible losses

Direct Tangible losses are the most straight forward and obvious. They are the losses that arise from the destruction of, or damage to, a man made physical asset. This includes losses as a result of damage to buildings, be they residential, commercial or industrial. They can be:

- private or public buildings;
- crops that are to be harvested for commercial sale and hence have a commercial value (whether or not they are naturally occurring);
- private or public infrastructure such as roads, railway lines, telecommunications, pipelines, electricity generation and distribution systems.
- vehicles and plant (e.g. mobile farm machinery);
- livestock; and
- the contents of buildings (e.g. furniture and fittings, retail stock, machinery and goods used for production of a commercial product).

Indirect tangible losses

Indirect tangible costs are costs incurred as a consequence of the event occurring, but are not related directly to the physical damage that has occurred. These costs include such things as the:

- marginal cost incurred by emergency service organisations in responding to the flood;
- equivalent cost of volunteers' time in assisting with the response effort;
- costs incurred by landholders in cleaning up after the flood, including their time;
- emergency assistance grants given to people to help them deal with urgent issues (e.g. alternative temporary accommodation, replacing a fridge, fixing damaged windows);
- disruption to business.

Of the above items the most difficult and contentious to quantify is the disruption to business. The Bureau of Transport Economics (2001) provides the following guidance:

> *"The cost of lost business is often included in the estimated cost of a disaster. The impact of a disaster can be devastating for businesses directly affected by that disaster, and local communities can suffer as a consequence. However, when examining the impact of the disaster from a national perspective, business disruption costs typically should not be included. This is because business disruption usually involves a transfer between producers, without a significant loss in national economic efficiency. There may be occasions when the transfer between producers involves additional costs, which would be a valid indirect cost of the disaster. Business disruption costs would be included if the event affected the nation's economy through an increase in the level of imports or a decrease in exports"*.

Intangible costs

This category includes all those items that can not be categorised as a direct or indirect tangible cost.

These costs include the:

- loss of life;
- costs associated with personal injury;
- increased medical costs / reduced life expectancy associated with increases in levels of sickness in a community following a disaster including stress related illnesses;
- disruption to households;
- loss of private memorabilia;
- loss of heritage values; and
- loss of items / features of cultural significance.

Intangible costs are those for which no market exists and hence there is no agreed method in place to quantify them. With respect to intangible losses the Bureau of Transport Economics (2001) advises that:

> *"The largest gap in the estimation of disaster costs is the inability to adequately estimate intangible costs. Evidence suggests that they are at least comparable with direct costs and possibly much larger. Research is needed to develop reliable methods to overcome this gap".*

Direct tangible losses calculations

Losses to the following items should be considered for Burra:

- Damage to buildings including their contents;
- Crop losses; and
- Damage to infrastructure.

Losses to vehicles have not been included as it was considered that mobile equipment could be readily relocated out of the flood zone.

Damages to buildings and their contents

Residential buildings

The number of residential buildings that potentially would suffer inundation for the various flood events can be separately estimated by overlaying the flood inundation maps for these events on landuse mapping and cadastre data sets. The estimates made in this way can be verified and adjusted where necessary by inspecting aerial photography so that obvious cases where a property might be inundated but the house may not. Cases where properties are inundated by shallow water depths of less than 150 mm should be excluded as in these cases it can be assumed that over floor flooding would not occur (and hence damages would be substantially less).

A stage damage curve relationship can sometimes be developed for residential properties through a process of floodplain modelling and property inspections. This information is not widely available therefore damage estimates are based on a damage cost per inundated house of $20,500 which is recommended in Read Sturgess and Associates, 2000 (in BTE, 2001). This figure was converted to 2020 dollars by applying a CPI adjustment to convert from 1999 to 2020 prices.

The cost of damage for properties where flooding occurs but the house is not inundated can be assumed to be negligible (a conservative simplification of the expected estimated damages). (These properties could be picked up in the cleanup costs if desired.

Large commercial buildings (excluding greenhouses)

BTE (2001) recommends that individual inspection of commercial buildings is the most effective means of quantifying damage costs. Where this is not possible, generic flood damage tables prepared by Smith (1994) and reported in BTE (2001) can be used. The costs to commercial properties were reviewed in the western suburbs of Adelaide and reported in Wright (2000). The detailed work by Wright (2000) however, applies to the western Adelaide suburb of Keswick and the results are not considered of relevance to the rural nature of the Burra For this reason the generic tables presented in BTE, 2001 should be used.

The generic flood damage tables present a range of costs based on building type (based on five value classes), area and depth of inundation. For the purposes of this assessment the mid range value class should be selected. A damage value of $20,900 per building was adopted (adjusted to 2020 values by CPI). The same verification process as for the residential properties can be used to exclude those commercial buildings for which over floor flooding was not anticipated.

Public Infrastructure Damages

Transport infrastructure – Roads

The damage rates proposed by Read Sturgess and Associates (2000) as reported in BTE (2001) were adjusted for CPI and applied.

A range of damage costs are available for different road constructions. The inundated road lengths can be categorised into sealed and unsealed roads with only those roads where the depth of flooding results in a flood extent beyond the road verge considered to be damaged.

Public services and utilities

Public infrastructure costs are likely to be minimal because most services are placed underground.

TABLE 1 : FLOOD DAMAGE UNIT RATES TABLE

Item	Unit	Rate	Source
Direct Tangible Rates			
Sealed Road	km	$25,000*	BTRE, 2001
Unsealed Road	km	$11,000*	BTRE, 2001
Services	km	not included	BTRE, 2001
House over floor flooding	per house	$32,500*	BTRE, 2001
Commercial Building	per building	$20,900*	BTRE, 2001
Grazing Land	ha	$300	Econ Search 2014

**Escalated by CPI.*

Indirect tangible damage estimates

Indirect costs are costs incurred as a consequence of the event occurring, but are not related directly to the physical damage that has occurred. These items are often not measured and can be difficult to accurately quantify. These items include things such as:

- Emergency Response;
- Relief costs/grants;
- Clean up costs residential;
- Clean up costs commercial; and
- Emergency accommodation.

BTE (2001) discuss the difficulty in estimating these losses at great length and conclude that wherever possible cost should be estimated directly but where this is not possible draw on their body of case study reviews to suggest that for flood damages, indirect tangible costs usually vary between 25 and 40 percent of the direct tangible costs. He higher bound estimate has been adopted for Burra.

In the case of Burra its not possible to estimate these costs directly as there have been no records kept with respect to these costs from previous floods.

Intangible costs

Intangible costs are all very difficult to estimate and in many cases no attempt is made to quantify them in monetary terms, but rather to simply acknowledge their existence and to take into consideration that they can be substantial, particularly in the case when costing marginal disaster

mitigation schemes. An extract from BTE (2001) follows that provides an outline of the scale of these costs.

> *"Available estimates of intangible costs suggest that they are very substantial.*
>
> *A frequently quoted example is that of the Buffalo Creek flood of 1972, which resulted from the collapse of a dam at a coal mine. There were 125 people killed (Erikson 1976). Almost all of the survivors suffered psychological problems and 625 of them sued the company. Stern (1976) estimated the losses to households using the schedule of compensation and trauma scale resulting from the court case. In a conceptually similar study, Allee et al. (1980) constructed a scale of trauma suffered by residents in Tug Fork in the United States and estimated the costs by use of the Veteran's Administration Compensation Scheme. Both studies gave an estimate of loss approximately double the direct damage suffered by the households.*
>
> *In the UK, flood-affected residents were interviewed after a number of floods. They were asked to compare the different impacts of the flood in terms of their relative severity (Parker, Green and Thompson 1987, p. 104). Stress and loss of memorabilia generally ranked above the impact of damage to house and contents. For many people, the effect of having their gardens damaged is similar to the loss of memorabilia. Yeo (2000) reported that a number of respondents to National Hazard Research Centre surveys were sad at the degraded state of their gardens following floods in 1998.*
>
> *One of the most comprehensive studies of the health effects of floods was that by Chamberlain, Hartshorn et al. (1981) of the 1974 Brisbane flood. The Chamberlain, Hartshorn et al. (1981) report showed that 14 months after the flood, 23 per cent of respondents to a survey had still not recovered from the effects of the experience.*
>
> *Anecdotal evidence of other disasters indicates that the emotional and psychological effects can last for decades."*
>
> *These few cases illustrate that there is little doubt that intangible costs faced by households as a result of flooding are very important."*

Appendix I: Community Feedback Submission and Table of Responses

Burra Revegetation Group

Incorporating the Burra Community Nursery

ABN 75 464 489 753 Box 249, Burra SA 5417

Chief Executive Officer
Regional Council of Goyder
1 Market Square
Burra SA 5417

Dear David

Burra Storm Water Management Plan (BSWMP) - Draft for Public Consultation, Your Ref 5.19.1.3

Firstly, I welcome the plan as a base document for future civil, environmental and recreational projects.

I have looked at the plan and encouraged others to consider it and make submissions.

Some concerns have been expressed about what appears to be an under-assessment of flows from the West, and especially from the 'Old Adelaide Road' valley.

Given the geography of Burra, most residents are impacted by handling of storm water one way or another. Historically, flooding played a major role in Burra's development, and re-enactments should be avoided.

The Creek especially focuses interest, through the role it plays in bringing Heritage, Environment and Amenity together. It plays a major part in how the town handles flooding and more frequently how it utilizes occasional rain events.

There are some aspects of the plan that simply reinforce work being undertaken, some as a result of addressing immediate risk events, others as long term upgrades and facility improvement.

The priorities the document outlines gives the community something to consider, and I suggest that in the stages of implementing the plan, we would welcome ongoing involvement, to not only assist in the promotion of the plan in the township, but so that Heritage, Environment and Amenity concerns are linked and incorporated.

I can illustrate that by the description of TR7 (refer pages 60 & 61) where the Heritage of the 'Mine Walk' needs to be addressed by its overlap with the proposed Environmental 'Riparian Rehabilitation', and the Amenity of the 'Bike Path' presently being developed.

I would also like to take the opportunity to point out that Attachment D: Revegetation Template in fact closely follows the EBS Ecology *Burra Creek Revegetation Action Plan - August 2013*, which has been the document that the Burra Revegetation Group and the Regional Council of Goyder has been using.

In implementing the 'Water Technology' plan, we would welcome the opportunity to systematically work together in a cooperative and coordinated manner.

Yours sincerely

Rob Perry
Chair, Burra Revegetation Group
14 October 2020

Attachments: Comments about various aspects of the Plan

Burra Storm Water Management Plan **Attachment#1**

Comments from Burra CMC Inc & Burra Revegetation Group

Sections 1 Introduction

See Attachment #2 - Historic Perspective

Sections 2 Description of the Catchment Area

Figure 2-1 Burra Township Catchment Area

This map does not provide sufficient detail to include the flows from Western Creeks

It is noted that Culverts and Pipes adjacent to Burra's Southern Entrance near the junction of the Old Adelaide/Koonoona Road are not included, and similarly this tributary is not addressed as presenting a significant flood risk

Figure 3.1 Spatial Location of existing Storm Water Infrastructure

Does not include drains and culverts on the main road into the township.

Section 4 Identification of Problems and Opportunities

Figure 4.3 Flood Inundation Map, and

Figure 4.4 Flood Hazard Map

These maps appear to understate issues of high flows from Western Creeks

Figure 4.5 Roads not Safe for Traffic Movement

In the events in the last 40 years, Copperhouse Road, Springbank Road and the Barrier Highway from its junction with Koonoona Road to the Burra Hospital, and Commercial Street and Kangaroo St intersection are also in question.

This appears to be supported by figure 6-5 Flood Inundation Map

The relatively recent flooding in Commercial Street (in particular January 1993 & December 1995 - estimated dates), and it can't have all come from the 'Mine Walk' (TR7) on Figure 6.17

Section 5 Stormwater Management Objectives

Figure 5.1 Summary of Management Strategies

Flood management - Strategies F1 - F6

Given varied feedback, we believe that ratepayers should be consulted and informed about this work before these plans are implemented.

Water Quality improvement
Spring Street Wetlands WQ1

We would question this location on the basis of the

- estimated cost and the
- likelihood of reliable storm water

We suggest that alternatives exist in the current creek-bed at several points where water collects after rain and flow events.

Specifically these points are:

- behind the Ambulance Station just downstream from the St Just St Ford which is also fed by the Tregony Street swale.
- by the Mine Store adjacent to Welsh Creek

We would contend that this would require no more than a .3 metre wall to hold significant water, without impeding floodwater in a large event.

An alternative/complementary system would be to construct a small Weir slightly upstream from the Bowling Club footbridge, enabling pedestrian movement across the creek, and landscaping work adjacent to the Bowling Club and the Miners Dugouts where in fact, water remains on a regular basis after even modest rainfall.

This would add to the Amenity of the creek by the gardens and provide a base for enhanced riparian growth. See recent photo.

The future of the current Weir and embankment at this point needs to be reviewed.

WQ 2 - WQ7 - Riparian Works Program

Our experience with use of riparian species in our revegetation work has revealed that regular and reliable water is required. The plan does not explain how this environment can be maintained in the tributaries identified given their random and infrequent flooding.

We would welcome discussion as to how these plans should be implemented, but would suggest that initially funding could be sought to clarify the process on a Pilot Project, with training for the Civil and Revegetation skill, enabling the process to be rolled out by Council and community volunteers to be working together.

P1 - Water re-use strategies.

People familiar with Burra's water supply history would be aware that almost all of the older properties in the community have extensive rainwater capturing systems.

It is fair to encourage new builds to include rainwater capture, and older properties should be encouraged to review their compliance with legislation about the mixed use of Rainwater and Mains supplies.

Section 6 Stormwater Management Strategies

We would support a Public Communication process about Floods within all Goyder communities.

We appropriateness and effectiveness on these various Civil works proposed, but observe that in their implementation stage that consideration be given to consequent maintenance work. For example, drain and mitigation structures should, were possible not inhibit day to day easy maintenance work such as mowing and access for equipment.

Comments from Section 4 above regarding Figure 4.5 apply to Road trafficability - we are concerned that not all roads are included.

Information about Water Quality, as outlined in 6.7 should be available to the community as a matter of course.

The comments made in Section 5 apply to Section 6.7.2 , and need not be repeated.

Section 7 Recommendations

Table 7-1 Recommendations outline a sequence of works which need to be discussed with the community, and in some instances a form of 'Cost Benefit Analysis' should be considered.

Section 8 Potential Funding and Arrangements and Opportunities

The availability of funds for a variety of projects will vary from time to time. It is suggested that protection of Heritage associated with Burra's National Heritage status may give access to additional funding sources.

It may be worth discussion with the Northern & Yorke Landscape Board (replacing the MRDB NRM) concerning access to Levies that the Council collects on their behalf.

Opportunities exist for Community input via activities such as 'Citizen Science' to monitor water quality, flora and fauna.

Section 9 Priorities and Timeframes for Implementation

There should be open discussion in the community regarding Priorities and Time-Frames, and rationale for the implementation needs to be clear.

Section 10 Responsibilities for Implementation

The Council is clearly the principal organisation identified in this report.

It should be pointed out that an average of around 500 Volunteer Hours per annum are provided by the Burra Revegetation Group. This work has largely been associated with Revegetation work undertaken since 2013, that is the last seven years.

We are surprised that this work was not observed by the consultants.

We suggest regular Community Consultation and Communication be established to support all parties in the implementation of this Plan.

Section 11 Review of Stormwater Management Plan

Ongoing review of the document is important.

Appendix D Revegetation Template

This section of the report basically replicates the EBS Ecology *Burra Creek Revegetation Action Plan - August 2013*, including

- the Creek sections as described. Refer to *<http://burrareveggroup.blogspot.com>*
- basically the same list of species as provided to Council and the Burra Revegetation Group by that plan
- it was funded by the (then) Murray Darling Basin NRM.

The Burra Revegetation Group has been actively propagating a variety of species for its planting activities, supplemented by the Council's Trees For Life seedlings.

The species identified in the BSWMP are largely included, but we observe that a number of locally growing native grasses are not included.

We would note that while we have had success in propagating riparian species, they have largely failed to survive the drought.

There have been a number of significant floods where flows from creeks along Springbank Road and Koonoona Road appear to have been overlooked in the report.
While it is understood that water from Mt Bryan and Firewood Creek are particulary significant inflows, we understand that when there have been widespread rain events (est January 1993), the flows to the West contribute to the flooding in the Burra Townhip.

Here is an article on the March 1983 flood, taken from The Burra Community News. The publication was sponsored by the Apex Club of Burra and District and was simply a photocopied A4 production, which filled the gap between the time the Burra Record ceased and the Burra Broadcaster started.
(Reproduced from the Burra School and Community News, 10th March 1983)

Flash Flood Inundates Burra

Last week tropical cyclones Ken and Elinore, which were situated over the Northwest and Northeast coasts of Australia respectively combined their efforts to feed into South Australia a moist unstable airstream which resulted in unseasonable tropical weather being experienced throughout the state.

During Wednesday afternoon and evening, accompanied by constant rumbling of thunder 38mm (1½ inches) of rain fell on Burra and some surrounding districts. During the afternoon one State Emergency Service crew was dispatched to Mt. Bryan to rescue two tractors that were bogged and soon to be submerged in what was, a few hours earlier, a dry and dusty dam. Another S.E.S. crew was sent to assist with flood relief in Clare but returned when required to help with the floods in Burra. At about 7.15p.m. the creek which flows through Kooringa broke its banks causing torrents of water to flow rapidly along Commercial and Thames Streets causing some flooding of business houses, but the hardest hit were the National Trust* cottages in Thames street, some of which had 30cms. Of water flowing through them at the peak of the flood. During the crisis sandbagging was swung into force by some S.E.S. members and volunteers whilst others blocked off roads and directed traffic around the worst affected areas.

Thursday morning saw the clean up operation of the streets and houses begin in earnest. A carpet, which had suffered severe damage had to be removed by S.E.S. members. The midday weather report, which predicted further storms to hit during mid afternoon put police and S.E.S. members on full alert and 250 sandbags were filled in readiness. At 3.00 p.m. a violent tropical thunderstorm unleashed 24mm (95 points) of rain and hail on Burra in 45 minutes. Flooding was extensive throughout Burra and at one stage 25 S.E.S. volunteers were working furiously protecting houses in Tregony Street, Burra North. During this operation two S.E.S. volunteers were swept down the water course suffering minor cuts and bruises.

At the peak of the storm, Police ordered that children were to remain at school until the danger had passed. School was dismissed 50n minutes later than normal. A 1000 gallon tank which had been picked up by floodwaters was smashed against the Ayres Street Bridge and reports of damage to roads including the new bitumenised road to the Redruth Gaol and the new bike track were received. Friday morning saw yet another storm, which hit at approximately 5.30 a.m. Twenty S.E.S. members and Police reported to the makeshift headquarters at the Council Office but only minor flooding, was experienced. On Saturday eight Burra S.E.S. members travelled to the Barossa Valley to assist in clean up operations in this very badly hit area.

Controller of the S.E.S. in Burra, Des James said that the townspeople had rallied together extremely well to combat the common crisis. Thirty-five townspeople registered with S.E.S. as volunteers giving valuable help to the fifteen S.E.S. members. The response from business houses with food and drink was excellent and much appreciated by the volunteers. The ladies of S.E.S. welfare were hard at work throughout the crisis preparing soup, food and hot and cold drinks.

Bags used during the food were loaned to S.E.S. by Collinsville, Adelaide and Wallaroo Fertilisers, Bruce Stockman and Angus McInnis. Thanks to Ivan Hirschausen for the use of s front-end loader and tarpaulins.

Any person who has any property of the S.E.S. ring D. James on 922290 or return to 3 East Street

* Note:- Although the paper stated that the cottages are owned by the National Trust, this was an error on their behalf. The cottages are *heritage listed*, but not owned by the National Trust.

Source: <https://burrasa.info/pages/disasters.html>

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
Section 1 Introduction Indicates flooding from western tributaries is understated	These tributaries are captured under the local flooding mapping in the report and these results suggest the areas referred to as being flooded in 1983 as being flooded to depths of between 200 to 500 mm. That is consistent with the description provided in the newspaper article extract provided in Attachment 2.	Have added paragraph to section 1 to highlight flooding issues in 1983 to reinforce that there are localised flooding issues as well as those associated with Burra Creek itself.
Section 2 Description of the Catchment Area Figure 2-1 Burra Township Catchment Area - This map does not provide sufficient detail to include the flows from Western Creeks It is noted that Culverts and Pipes adjacent to Burra's Southern Entrance near the junction of the Old Adelaide/Koonoona Road are not included, and similarly this tributary is not addressed as presenting a significant flood risk Figure 3.1 Spatial Location of existing Storm Water Infrastructure - Does not include drains and culverts on the main road into the township.	The map in this format is a requirement of the SMA to highlight the SMP area within the context of the total Burra Creek catchment. A number of gaps were identified and filled as part of the SMP preparation but that was not an exhaustive process. As noted in section 3, Council is aware that there are gaps in its infrastructure database, and these are progressively being addressed. The main culverts at road crossings have been included in the flood modelling based on our own site measurements whilst not necessarily appearing in Council's databases The flooding and drainage issues at this smaller scale are highlighted in the blown-up maps provided in section 6.	No change to report as the need to collect addition infrastructure data is accepted by Council and that process is underway, and major culverts that would influence the flood modelling have been included in the model.
Section 4 Identification of Problems and Opportunities Figure 4.3 Flood Inundation Map and Figure 4.4 Flood Hazard Map - These maps appear to understate issues of high flows from Western Creeks	The trafficability mapping is based on a combination of the Burra Creek Flooding and the localised flooding. There is a filter provided to the inundation areas in figure 4.3 (and 4.4) that means that any water depths less than 50 mm deep are not shown. Hence the local runoff from some of the townships areas and on the roads is	Comment included in report acknowledging that the areas of trafficability might be further compromised by blocked infrastructure.

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
Figure 4.5 Roads not Safe for Traffic Movement - In the events in the last 40 years, Copperhouse Road, Springbank Road and the Barrier Highway from its junction with Koonoona Road to the Burra Hospital, and Commercial Street and Kangaroo St intersection are also in question. This appears to be supported by figure 6-5 Flood Inundation Map The relatively recent flooding in Commercial Street (in particular January 1993 & December 1995 - estimated dates), and it can't have all come from the 'Mine Walk' (TR7) on Figure 6.17	not shown in the maps but is still used in the calculations of flow depths hence is still contributing to the creation of depths greater than 50 mm. This is consistent practice for the preparation of SMPs and recognises the limitations of the ground elevation data on which the modelling must be based. Further, a modelling assumption is that culverts are not blocked hence some of the issues previously experienced may have been as a result of blocked drainage infrastructure. It is also worth noting that the trafficability calculations do not require the road to be completely free, a 3m wide strip with depth less than 50mm is all that in required (as per Objective F2 in section 5.) It is expected that these details would be further evaluated during detailed design stages once more detailed ground survey information is made available – that is the normal process.	
Section 5 Stormwater Management Objectives Figure 5.1 Summary of Management Strategies Flood management - Strategies F1 to F6 - Given varied feedback, we believe that ratepayers should be consulted and informed about this work before these plans are implemented.	It is normal practice for Councils to consult further on the details of proposed mitigation works during subsequent design stages. The plans presented are concepts designs to highlight the effectiveness of strategies and to determine the scale of works required to achieve the management objective.	No change to report
Water Quality improvement Spring Street Wetlands WQ1 - We would question this location on the basis of the • estimated cost and the • likelihood of reliable storm water We suggest	The identified wetland system is the scale of works required to achieve the water quality objectives of the (previously) NRM Board.	Have included commentary from the submission in the report under a new strategy WQ8 and section 6.10.

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
that alternatives exist in the current creek-bed at several points where water collects after rain and flow events. Specifically, these points are: • behind the Ambulance Station just downstream from the St Just St Ford which is also fed by the Tregony Street swale. • by the Mine Store adjacent to Welsh Creek We would contend that this would require no more than a .3 metre wall to hold significant water, without impeding floodwater in a large event. An alternative/complementary system would be to construct a small Weir slightly upstream from the Bowling Club footbridge, enabling pedestrian movement across the creek, and landscaping work adjacent to the Bowling Club and the Miners Dugouts where in fact, water remains on a regular basis after even modest rainfall. This would add to the Amenity of the creek by the gardens and provide a base for enhanced riparian growth. See recent photo. The future of the current Weir and embankment at this point needs to be reviewed.	The suggestions provided are all good ideas but are not of sufficient scale to meet the overarching water quality objectives. We agree that these options have merit for increasing the retention of water in the base of the various watercourses and thereby could contribute to biodiversity and local amenity.	The two options that appear to offer the greatest opportunities are: • The option of landscaping near the Miners dugouts would appear to offer multiple benefits and potentially could be done as part of other infrastructure works (eg as part of upgrading culverts under Ayres Street); and • A review of the existing embankment/weir downstream of the bowling green footbridge which the report identifies requires attention. These have been included as new actions that forms a subset of other watercourse actions.
WQ 2 to WQ7 - Riparian Works Program - Our experience with use of riparian species in our revegetation work has revealed that regular and reliable water is required. The plan does not explain how this environment can be maintained in the tributaries identified given their random and infrequent flooding. We would welcome discussion as to how these plans should be implemented but would suggest that initially	The concept of a pilot project in partnership with the Landscape Board and Council is a good suggestion so that the skills and experiences of trained watercourse rehabilitation practitioners can shared with the local experiences of capable community volunteers.	Have included this as part of new strategy WQ8a to establish the Miners Dugout site as a pilot site.

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
funding could be sought to clarify the process on a Pilot Project, with training for the Civil and Revegetation skill, enabling the process to be rolled out by Council and community volunteers to be working together.		
P1 - Water re-use strategies. People familiar with Burra's water supply history would be aware that almost all of the older properties in the community have extensive rainwater capturing systems. It is fair to encourage new builds to include rainwater capture, and older properties should be encouraged to review their compliance with legislation about the mixed use of Rainwater and Mains supplies.	Noted – but this is consistent with our expectations.	Have reviewed text to ensure that this is the case. No changes made.
Section 6 Stormwater Management Strategies We would support a Public Communication process about Floods within all Goyder communities. We appropriateness and effectiveness on these various Civil works proposed but observe that in their implementation stage that consideration be given to consequent maintenance work. For example, drain and mitigation structures should, were possible not inhibit day to day easy maintenance work such as mowing and access for equipment.	Noted – Very relevant reminder that the design and implementation processes need to have regard to the maintenance aspects. The report highlights ongoing maintenance as an important strategy for Council in the recommendations.	Comment added to emphasise this point in section 10.2 noting that this is a design criteria that is highlighted already in section 6.1.
Road trafficability - we are concerned that not all roads are included.	All roads have been assessed subject to the availability of further survey data – additional future works may highlight additional areas of need, but we consider the highest priority ones are addressed in the plan.	No additional changes made to report.

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
Section 7 Recommendations Table 7-1 Recommendations outline a sequence of works which need to be discussed with the community, and in some instances a form of 'Cost Benefit Analysis' should be considered.	It is anticipated that implementation of any of the suggested actions would involve further consultation and liaison with interested community / stakeholders	Comment indicating ongoing dialogue with community and stakeholders included in Section 10.
Section 8 Potential Funding and Arrangements and Opportunities The availability of funds for a variety of projects will vary from time to time. It is suggested that protection of Heritage associated with Burra's National Heritage status may give access to additional funding sources. It may be worth discussion with the Northern & Yorke Landscape Board (replacing the MRDB NRM) concerning access to Levies that the Council collects on their behalf. Opportunities exist for Community input via activities such as 'Citizen Science' to monitor water quality, flora and fauna.	Noted. Good suggestion regarding community input – have added comment.	Included community as a potential project partner in Section 8 and also Section 10 (Table 10.1) that opportunities exist for Community partnership Included suggestion in Section 8 for community input via activities such as revegetation programs and 'Citizen Science' to monitor water quality, flora and fauna.
Section 9 Priorities and Timeframes for Implementation There should be open discussion in the community regarding Priorities and Time-Frames, and rationale for the implementation needs to be clear.	We would anticipate that this would occur at the very least through Council's normal annual budgeting consultation process	No changes made to report.
Section 10 Responsibilities for Implementation The Council is clearly the principal organisation identified in this report. It should be pointed out that an average of around 500 Volunteer Hours per annum are provided by the Burra Revegetation Group. This work has largely been	The revegetation activities were noted through the riparian survey work that was undertaken. An oversight not to have recognised this.	Comment added in section 10.

Comments from Burra CMC Inc & Burra Revegetation Group	Response	Report changes
associated with Revegetation work undertaken since 2013, that is the last seven years. We are surprised that this work was not observed by the consultants. We suggest regular Community Consultation and Communication be established to support all parties in the implementation of this Plan.		
Section 11 Review of Stormwater Management Plan Ongoing review of the document is important.	Noted	No change made to report.
Appendix D Revegetation Template	It is not surprising that two consultants would provide very similar advice in terms of plants species for revegetation – we would be concerned if there were significant differences.	Have added comment to report section that the species list provided is of a general nature primarily targeting colonising species. Local revegetation activities may identify other species that are of value for revegetation and can be included, proved they are locally native species with appropriate provenance.