southfront

Moonta, Moonta Bay & Port Hughes Stormwater Management Plan

170 Greenhill Road Parkside SA 5063
P 08 8172 1088 F 08 8271 2055 www.southfront.com.au

southfront

Moonta, Moonta Bay & Port Hughes Stormwater Management Plan

District Council of the Copper Coast

Ref: 12026-3G

Revision	Date	Author	Details
D	5 July 2013	DK	Draft Issued for Comment
E	19 August 2013	DK	Draft Plan for Consultation
F	18 September 2013	DK	Revised Draft Plan for Consultation
G	02 December 2013	DK	Final Plan Issued for Approval

Contents

Tables

Figures

Appendices

Executive Summary

Southfront, in collaboration with URPS and SARDI were engaged by the District Council of the Copper Coast to prepare a Stormwater Management Plan (SMP) for the townships of Moonta, Moonta Bay and Port Hughes.

A project Steering Committee was employed consisting of Council, the Environment Protection Authority (EPA), the Department of Planning, Transport and Infrastructure (DPTI) and the Northern & Yorke Natural Resources Management Board (NYNRMB).

This Plan has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2006).

Study Area and Environment

The total catchment area is 54 km^2, which is comprised of the Moonta Mines catchment as well as 11 other major catchments covering the townships of Moonta, Moonta Bay & Port Hughes (with the exception of the Dunes Development at Port Hughes). The topography of the catchment area is a gently undulating plain with relict seif dunes, which act to separate the Study Area into a number of distinct hydrological catchments draining to the coast. These catchments are generally not sufficient to have formed creek channels or watercourses.

Moonta has a mean annual average rainfall of 370mm, with the majority of rainfall occurring between the months of April and October. Although the annual average rainfall is relatively low, history has shown that there have been several major flood events documented from the 19th Century to the present day. The significant rural components of the catchment have the potential to generate major flows within the urban areas as flood waters make their way to the coast.

The Study Area has a transient population of approximately 4,000 people, with many residents choosing to reside within the area during the Summer months, and then leaving the region during Winter. The region is known for its coastal attraction and amenity and it's capacity to provide "sea change" living. The wider Moonta area is also a popular holiday and retirement destination.

The majority of development within the region is mostly zoned as Residential, with other zones including the Urban Coast, Local Centre, Tourist Accommodation, Deferred Urban, Rural Living, Town Centre, General Industry and Commerce/Industry.

The current minimum allotment size of 900 m^2 will reduce to 450 m^2 over the next 3-4 years following the staged rollout of the Community Wastewater Management System (CWMS) which is currently under construction. This will create the potential for significant infill development within the catchment.

Existing stormwater drainage within the Study Area consists of a network of open channels and underground stormwater drainage networks, with a greater coverage of formal drainage infrastructure being present in the more recently developed areas compared to areas that have been established for many decades. There are also several natural depressions (ponds / wetlands) that have the capacity to contain surface water following major rainfall events.

Stormwater Management Objectives

The objectives of the Stormwater Management Plan include the following:

- Provide an acceptable level of protection from flooding;
- Manage the quality of runoff and effect on the receiving waters (marine environment);
- Identify opportunities for stormwater harvesting;
- Promote WSUD measures that can maximise the potential to achieve multi-objective outcome;
- Attain desirable planning outcomes associated with new development;
- Promote sustainable management of stormwater infrastructure, including maintenance.

The proposed targets adopted in this SMP are shown in the table below:

Design Principle	Proposed Target
Flood Protection Service Level	5/100 year ARI for minor/major drainage systems
Water Conservation	Outdoor - best practice irrigation
Water Quality	Reduction in SS 80%, P 60%, N 45%, GP 90%
Integrated Design	Engagement of Stakeholders at relevant stages

This Plan has predominantly met the proposed targets for each design principle shown above.

Hydrological Modelling

A DRAINS model of the urban catchment was developed using information derived from a previous ILSAX model prepared for the township as well as a Digital Terrain Model (DTM), construction drawings of recently designed drains and site inspection.

A detailed analysis of aerial photography and development zoning was undertaken to determine the total impervious area fractions within the urban catchment which were found to vary from 0.35 to 0.75.

A RORB model was developed for the rural components of the overall catchment including the Moonta Mines catchment. Due to these catchments being characterised by high rainfall losses, it was found that runoff was not generated during storms with an Average Recurrence Interval (ARI) of less than 20 years.

Hydrological modelling was undertaken for both the "existing" and the "ultimate" development scenarios. The existing scenario conservatively assumed that all the currently vacant lots were developed. The ultimate scenario assumed that further infill development had occurred as a result of the implementation of the CWMS and that the rezoning that has been proposed in Council's Better Development Plan (BDP) had been implemented.

Moonta Mines Catchment

The 1,650 ha Moonta Mines catchment to the north east of Moonta forms the largest rural catchment within the Study Area. The site is understood to be owned by Crown Lands and is under the care and control of the National Trust.

The Moonta Mines catchment has the potential to contribute significant runoff to the township, with overflows flowing through Catchment 1 via the main open channel and into Clem McAuley Park. Anecdotal evidence suggests small discharges are generated by the site every year.

It is suspected that runoff from the site is contaminated, although the degree and nature of contamination is not well understood. Further testing of water quality being discharged from the mine site (which is outside of the scope of this Plan) would be required to form a conclusive view.

Assessment of Existing Drainage Performance

The DRAINS model of the existing drainage system was executed for various rainfall events ranging from the 1 year to the 100 year ARI. The results of the modelling were analysed to determine drainage deficiencies in both pipes and pits. A list of the drainage networks that perform below the 5 year ARI target performance standard is shown in the table below.

Catchment	Drains with Insufficient Performance Standard
1	Ellen Street, Frances Street, Moonta Road, George Street, Majors Road, James Street, North Terrace
2	Moonta Road (outlet)
3	Marine Parade
4	Bay Road, Challa Ct, Martin Street, Roach Court, Victoria Street, Coast Road
5	Lyndon Avenue, Nankivell Street, Westside Avenue, Highview Grove, Loller Street
6	Rossiters Road, Stocker Street, Tipara Court
7A	Trelawney Street, Moontana Avenue, Bray Street
7B	Trembath Street
7C	Richards Terrace, Trenerry Place
8	Minnipa Drive, Minnie Terrace, Cowling Court, Snell Avenue, Dowling Drive
9	N/A
10	Minnie Terrace
11	Port Hughes Beachfront Carpark

Floodplain Mapping

Floodplain mapping of the Study Area was carried out in 1D/2D using TUFLOW software. Floodplain maps for the 10, 20, 50 and 100 year ARI events have been produced and are shown in Appendix B.

The mapping was carried out for both the "existing" and "ultimate" development scenarios as described in the table below.

Scenario	Assumptions
Existing	Existing infrastructure with existing levels of development (assuming all currently vacant allotments have been developed)
Future	Proposed drainage upgrades modelled with the ultimate level of development as per planned re-zoning and infill development expected over a 30 year horizon

Floodplain mapping results showed that there are several flood prone regions within the catchment. A brief outline of flood prone areas in each of the 11 major catchments is shown in the table overleaf.

Catchment	Locations of Flood Prone Land (all ARI events)
1	Ellen Street, Milne Terrace, Queen Square, Old Wallaroo Road, Crutchett Road, Haylock Road, Chapman Road, Majors Road, North Terrace
2	Moonta Road, Carlisle Road, Coast Road
3	Minimal Flooding
4	Bay Road, Martin Street, Roach Court, Recreation Road
5	Nankivell Street, Westside Avenue, Loller Street
6	Rossiters Road, Stocker Street, Tipara Court, Coast Road, Kemp Place, Kitto Road
7A	Trelawney Street, Francis Place, Bray Street
7B	Simms Cove Road, Hicks Street
7C	Richards Terrace, Trenerry Place
8	Minnipa Drive, Furner Crescent, Snell Avenue, Dowling Drive
9	Snell Avenue, Dowling Drive
10	Minnie Terrace
11	Port Hughes Beachfront Carpark

Based on the results of the floodplain mapping and drainage performance assessment, a number of flood mitigation options and improvements to existing drainage infrastructure have been proposed within this Plan. Proposed improvements include drainage upgrades (capacity increases, installation of new infrastructure in areas that were determined to be deficient), additional detention storage, channel upgrades, creation of bunds and levees and improvements to existing outfalls. The proposed solutions aim to provide a balance between the targeted drainage performance, feasibility and cost.

A number of non-structural mitigation options were also presented in the Plan. These include development controls around flood protection, stormwater reuse and water quality as well as a plan for improving the community flood response and preparedness.

Water Sensitive Urban Design

Ten out of the eleven major catchments within the Study Area drain to the Spencer Gulf. Pollution sources within stormwater that impact on these receiving waters include:

- Gross pollutants (larger objects, floating litter and 'green' waste)
- Sediment
- Dissolved pollutants (nutrients, hydrocarbons and coloured dissolved organic matter)
- Pathogens

An assessment of the pollutant loads within stormwater discharges to the receiving waters was undertaken using the MUSIC model. The model was executed for 4 different scenarios including a baseline model with no water quality improvement measures in place, an existing model with the effect of existing swales and basins incorporated into the simulation, as well as two scenarios showing the effect of the proposed WSUD measures for both the existing and ultimate development scenarios.

A number of WSUD measures were proposed within the catchment including vegetated treatment swales, bio-retention basins, stormwater harvesting measures and gross pollutant traps. It was also recommended that Council maintain its current Rainwater Tank Policy which stipulates rainwater tanks between 5,000 litres and 22,000 litres depending on the allotment size.

The results of the modelling showed that implementing the proposed WSUD measures would significantly reduce pollutant loads as shown below:

- Total Suspended Solids - 73% reduction
- Total Phosphorus - 61% reduction
- Total Nitrogen - 54% reduction
- Gross Pollutants - 87% reduction

Flood Damages

Estimates of flood damages provide stakeholder groups with important information that can be used to prioritise flood mitigation measures. The magnitudes of flood damages

The magnitudes of flood damages are dependent upon a number of factors including property values, property size and the preparedness of the community to respond to the threat of flooding. These factors (and others) were included in the damages assessment calculations.

Damages assessments were performed for the 10, 20, 50 and 100 year ARI events by considering both the depth and extents of inundation for each event and applying stage-damage curves to this data.

Our damages estimates did not consider the following items:

- Damage to public infrastructure
- Damage to crops and stock losses
- Losses to vehicles
- Intangible losses.

The total reduction in direct tangible damages when comparing the future scenario to the existing scenario is shown the table below.

ARI (yrs)	Existing Scenario Damages	Future Scenario Damages	Potential Reduction to Damages
10	$0.58m	$0.34m	**$0.24m**
20	$2.07m	$0.96m	**$1.11m**
50	$5.82m	$2.66m	**$3.16m**
100	$11.33m	$8.50m	**$2.84m**

Community Consultation

Following the completion of the Draft Stormwater Management Plan, a community engagement plan was developed for the community consultation process.

Community consultation was undertaken on the Draft SMP to:

- Communicate the general content of the Draft SMP, specifically findings of investigations (e.g. flood plain mapping) and proposed stormwater management strategies; and
- Gather community feedback in relation to the proposed stormwater management strategies, including the prioritisation of strategies.

Feedback received and collated in this report was considered in developing the Final SMP. A Community Information Session was held in Moonta on Thursday 17 October 2013 where members of the public were invited to drop in to this session to find out more about the Draft SMP and provide feedback.

Overall the feedback received during the consultation process indicated that there is a strong level of support for the Stormwater Management Plan, with the importance of the proposed flood mitigation and WSUD measures rated as very important.

General feedback received is summarised below:

- Overall the Draft SMP is a good plan, and a step forward for Council in managing stormwater;
- Opportunities exist to use stormwater for irrigation, for example on golf courses;
- Support for management of flooding issues in Moonta and water conservation;
- Concerns about how proposals will be funded and possible rate rises, keen that Council pursue State and Commonwealth Government funding;
- View that a high priority should be accorded to management of stormwater runoff to the sea, cliff erosion, and better management of coastal outlets;
- Concern around previous development decisions and the impact on stormwater management;
- Suggestion that more natural areas be established to improve the health of the environment;
- View that better planning and engineering decisions around new development should be part of flood mitigation;
- Concern around current discharges from private property to the coast;
- View that ongoing costs of implementing the Draft SMP should be no greater than current stormwater management costs, that the costs of implementing the SMP should be transparent, and that rates should not increase to fund SMP works - grant funding be sought instead.

Feedback relating to specific locations is as follows:

- Specific concern that the proposed works at Simms Cove Road will result in beach degradation
- Concern around proposed stormwater retention on private land at Rossiters Road
- Identification of current flooding issues:
  - On Bay Road at Moonta Bay affecting private property;
  - At the northern end of Charles Street at Port Hughes – erosion and marine discharge, some flooding of private property, concern that an existing stormwater easement is not identified in the Draft SMP;
  - On Edward Street and Minnie Terrace at Port Hughes; and
  - On Ryan Street at Moonta – concern that Draft SMP does not account for information previously provided to Council or local topography.
- View that the SMP is a very high priority for Moonta Bay in terms of flood mitigation, and that the area around Chapman Road, Hollis Court and North Terrace should be the highest priority;
- View that Gardener/Ryan Street drains be given high priority in the staging of McAuley Park upgrade works;
- Suggestion that the area north west of North Terrace where birds currently nest become a wetland, which would be a community and tourism asset, though private land would need to be purchased.

Stormwater Management Plan

The proposed Plan summarises the proposed flood mitigation and WSUD measures that are described in detail in the body of the report. All proposed works have been assigned priorities (High / Medium / Low) and we have estimated both the capital and recurrent costs for implementation. Approximately $20 million of flood mitigation and WSUD measures have been proposed in this Plan, although it should be noted that several projects would be eligible for funding from the Stormwater Management Authority by virtue of the contribution catchments exceeding 40 hectares.

Supporting activities have been nominated in the Plan including:

- Surface water management of the Moonta Mines area
- Management of coastal outlets and cliff faces
- Periodic assessment of development trends
- Integration with open space master planning

A summary of the proposed measures is shown in the following tables and includes a description of the proposed works, costing information, the proposed performance standard as well as a description of other benefits applicable to each upgrade.

Stormwater Management Plan Works Summary - Major Flood Damage Reduction

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	McAuley Park and Open Channel Upgrades[1]	1,890,000	20,000	100 years	High - severely reduced flood extents	High - biodiversity enhancement and increased amenity and recreation
High	Moonta Road Open Drain[1]	840,000	10,000	20 years	High - provides containment of flood flows	Improved amenity
High	Marilyn Street to Chapman Road Drain, Channel & Basin[1]	1,250,000	5,000	10 years	High - protects several properties	Reduce excessive gutter flows
High	Bay Road Drainage and Kerbing[1]	1,260,000	10,000	10 years	High - protects several properties	Improved overland flow path capacity
High	Kitto Road Embankment and Drainage	150,000	-	100 years	High - protects several properties	Minimal work required to achieve flood mitigation benefit
High	Caroline to Milne Street Drainage	570,000	-	10 years	High - protects several properties	-
High	Rossiters Road Stage 1 Drainage[1]	1,190,000	10,000	10 years	High - provides formal stormwater conduit	Reduce excessive gutter flows, erosion protection
Medium	Rossiters Road East Drainage[1]	840,000	10,000	10 years	High - allows for safer future development	-
Medium	Minnipa - Dowling Street Drainage Upgrade	700,000	-	20 years	High - protects several properties	-
Total		**8,690,000**	**65,000**			

[1] Project eligible for Stormwater Management Authority funding, based on the 40ha contributing area criteria

Stormwater Management Plan Works Summary - Medium - Low Flood Damage Reduction

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	Simms Cove Road Drainage, and Erosion Protection (Option A)[1,2]	840,000	20,000	10 years	Low during existing scenario but will cater for future redevelopment	Environmental - Prevents erosion of cliff faces, stormwater harvesting
High	George / William / Henry Street Drainage	490,000	5,000	10 years	Medium	Reduce excessive gutter flows, improves amenity
Medium	Emerson to Minnie Terrace Drainage	890,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Brokenshire to Moonta Road Drain and Basin	500,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street	1,990,000	-	10 - 20 years	Medium	
Medium	North Terrace Drainage	690,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Drainage Easement Investigation	N/A	N/A	>10 years	Medium	Update of Council records
Low	Tipara / Trelawney Street Drainage	390,000	-	10 years	Medium	-
Low	Caroline to Robert Drainage	460,000	-	20 years	Medium	Reduce excessive gutter flows
Low	Port Hughes / Trenerry Road Outlets	80,000	-	20 years	Low	-
Low	Randolph Street Drain	580,000	-	10 years	Medium	Reduce excessive gutter flows
Low	Hills Street & Majors Road	170,000	-	10 years	Medium	Reduce excessive gutter flows
Total[2]		**7,080,000**	**25,000**			

[1] Project eligible for Stormwater Management Authority funding, based on the 40ha contributing area criteria

[2] Only Option A has been presented in the table above due to capital and recurrent costs being higher than those for Options B and C

Stormwater Management Plan Works Summary - WSUD Projects

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Benefit[1]	Works Supporting Drainage Upgrade	Water Quality Benefit	Other Benefits
High	Coastal Outlet / Cliff Top Management	N/A	N/A	-	Yes	High - due to WSUD / GPT's at each outlet	Minimise erosion of cliff faces, improved amenity
High	McAuley Park WSUD and Harvesting	1,790,000	30,000	Up to 70 ML/yr	Yes	High - provides instream treatment	Biodiversity enhancement and increased amenity and recreation
High	Simms Cove Road WSUD	80,000	5,000	Up to 36 ML/yr	Yes	High	Environmental - Prevents erosion of cliff faces
High	Moonta Road Open Drain & WSUD	180,000	10,000	-	Yes	High - extensive treatment train	Improved amenity
High	Chapman Road, Channel & Basin	150,000	5,000	-	Yes	Medium - treatment using WSUD principles	Improved amenity
Medium	Bay Road WSUD & GPT	140,000	10,000	-	Yes	Medium	-
Medium	Caroline to Milne Street Harvesting	300,000	15,000	Up to 8 ML/yr	Yes	-	-
High	George / William / Henry Street WSUD	280,000	15,000	Up to 24 ML/yr	Yes	Medium - rain gardens remove some pollutants	Reduce excessive gutter flows, improves amenity
Medium	Rossiters Road West GPT	60,000	5,000	-	Yes	Low - GPT at outlet only	
Medium	Emerson to Minnie Terrace WSUD	300,000	15,000	Up to 37 ML/yr	Yes	-	

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Benefit[1]	Works Supporting Drainage Upgrade	Water Quality Benefit	Other Benefits
Medium	Rossiters Road East WSUD	220,000	10,000	-	Yes	High - extensive treatment train	-
Medium	Brokenshire to Moonta Road Basin	150,000	10,000	-	Yes	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street GPT	60,000	5,000	-	Yes	Low - GPT at outlet only	
Low	Bray Street WSUD	180,000	10,000	-	No	High	
Low	Hicks Street WSUD	240,000	10,000	-	No	High	
Low	Richards Terrace WSUD	90,000	5,000	-	No	Medium	
Total		**4,220,000**	**160,000**				

[1] Harvesting benefit based on the availability only - further investigation into the storage, demand and possible configuration of harvesting schemes is required to refine these values.

1 Introduction

This Stormwater Management Plan (SMP) for the townships of Moonta, Moonta Bay and Port Hughes has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2006).

The Plan provides an overview of the existing catchments and issues relating to current stormwater management. It also provides an overview of the opportunities to improve stormwater management to both address flood protection and the sustainable management of this resource and the environment.

This Plan has been developed in accordance with the guideline framework whereby the productive and sustainable use of stormwater, reduction of pollution impacts, and enhancement of natural watercourses and ecosystems are key principles, in addition to flood minimization.

The strategies outlined in this Plan are proposed as a means of ensuring that the above goals are achieved in an integrated and coordinated manner. This document contains:

- A summary of existing information relevant to management of stormwater in the catchment;
- Catchment specific objectives for management of stormwater runoff from the catchment;
- Potential management strategies that may be used to meet the identified management objectives;
- Estimated costs and benefits associated with each of the strategies
- A clear definition of the priorities, responsibilities and timeframe for implementation of the Stormwater Management Plan.

In addition to Council staff, the Plan has been prepared in consultation with relevant State Government departments and agencies including the Northern and Yorke Natural Resources Management Board, Environment Protection Authority and Department of Planning, Transport and Infrastructure.

2 Catchment Features

2.1 Catchment Boundary

The catchment boundary adopted for this Stormwater Management Plan is shown in Figure 2.1.

The total catchment area is 54 km^2, which is comprised of the Moonta Mines catchment as well as 11 other major catchments (10 of which drain to Spencer Gulf). Some catchments have numerous drain outfalls to the Gulf.

2.2 Topography

The topography of the catchment area is a gently undulating plain with relict seif dunes, which act to separate the Study Area into a number of distinct hydrological catchments draining to the coast. These catchments are generally not sufficient to have formed creek channels or watercourses.

The central Moonta township, located approximately 3km from the coastline has an elevation ranging from 14 – 28 mAHD. The lowest developed areas are located at the northern end of Moonta Bay, where land levels are as low as 4m AHD. Other coastal areas of Moonta Bay and Port Hughes are generally located on land that is at least above 8m AHD.

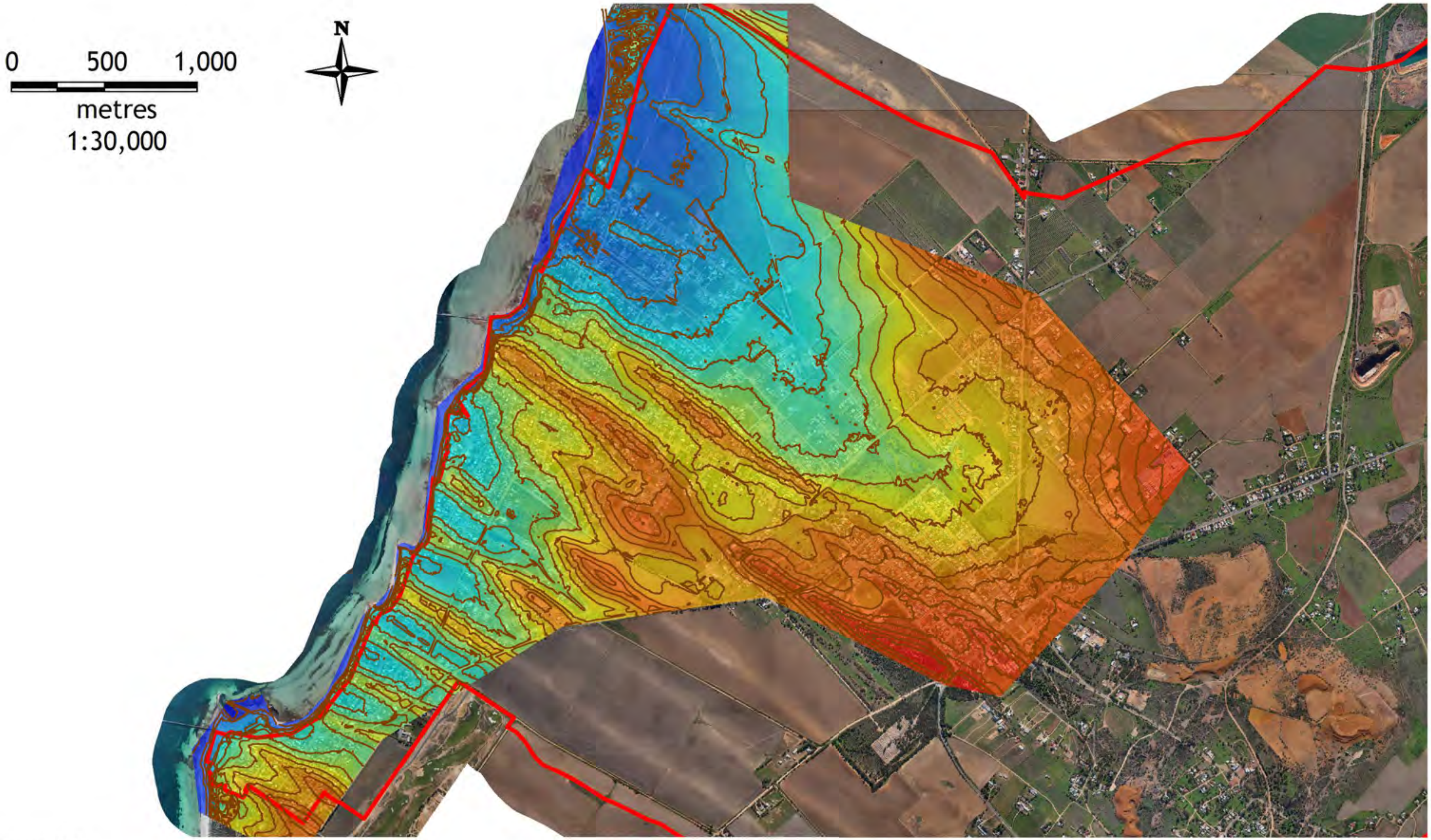
A digital terrain model (DTM) of the developed portions of the Study Area was acquired to assist in various aspects of the preparation of this Stormwater Management Plan. The digital terrain model and 2m contours derived from this data are shown in Figure 2.2.

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 2.1
Catchment Plan



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary, Contours)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 2.2

Study Area Contour Plan (2m Interval)

2.3 Stormwater Infrastructure

2.3.1 Existing Infrastructure

The District Council of the Copper Coast does not currently maintain a formal asset database of existing stormwater infrastructure, however asset information for the purposes of this Stormwater Management Plan has been collated from field observations and construction drawings.

Figure 2.3 shows the location and extent of existing stormwater infrastructure within the catchment. A summary profile of existing infrastructure is provided in Table 2.1 below.

Table 2.1 Stormwater Infrastructure Profile Summary

Asset	Quantity
Pipes	13,500m
150 dia	*3%*
225 dia	*4%*
300 dia	*10%*
375 dia	*39%*
450 dia	*8%*
525 dia	*5%*
600 dia	*26%*
675 dia	*5%*
Box Culverts	1,188m
375 width	*3%*
450 width	*20%*
600 width	*9%*
900 width	*2%*
1200 width	*64%*
2700 width	*2%*
Inlets	274
Gross Pollutant Traps	2
Open channels	5,916m
Detention Basins	12
Pump Stations	1
Wetlands, Water storages	7
Harvesting and Reuse Scheme	0

It is noted that the adjoining Port Hughes 'Dunes' development, which is excluded from the Stormwater Management Plan area, incorporates a self contained stormwater management system comprised of underground drainage, wetlands, storage dams and reuse of stormwater for irrigation of the golf course.

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary, Stormwater Infrastructure)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 2.3

Existing Stormwater Infrastructure

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary, Stormwater Infrastructure)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 2.4

Existing Stormwater Infrastructure Age

2.3.2 Stormwater Asset Age

A significant component of the existing stormwater assets have been constructed as part of land developments in the last 10 years, and hence have a theoretical remaining useful life of approximately 90 years. While little information is available on the asset age of the older stormwater drainage systems, data on the construction dates of Council's stormwater assets has been broadly categorised based on available construction drawings, and is shown in Figure 2.4.

2.3.3 Previously Known Stormwater Management Issues

Information in relation to locations where drainage problems are experienced and stormwater management deficiencies exist across the Study Area was collated from Council records and previous drainage studies. A list of locations where issues have been experienced is shown in Table 2.2.

Table 2.2 Previously Known Stormwater Management Issues

Location	Category of Issue
Bay Road (particularly near Marilyn St)	Flooding
Ryan Street	Flooding
Simms Cove Road	Uncontrolled discharge, erosion of cliff face
Rossiters Road / Coast Road Intersection	Flooding / uncontrolled discharge
Nankivell Street	Flooding
Percy Street	Flooding
Monmouth Street	Flooding
Old Wallaroo Road - Crutchett Road	Flooding
Carlisle Street - Moonta Road	Flooding
Elphick Street & Snell Avenue	Flooding
Lyndon Avenue / Pattison Crescent	Flooding
Seagate Moonta Bay Motel	Erosion / Sedimentation
Minnie Terrace - Dowling Drive Intersection	Flooding
Majors Road	Flooding
Ellen Street / Caroline Street intersection	Flooding

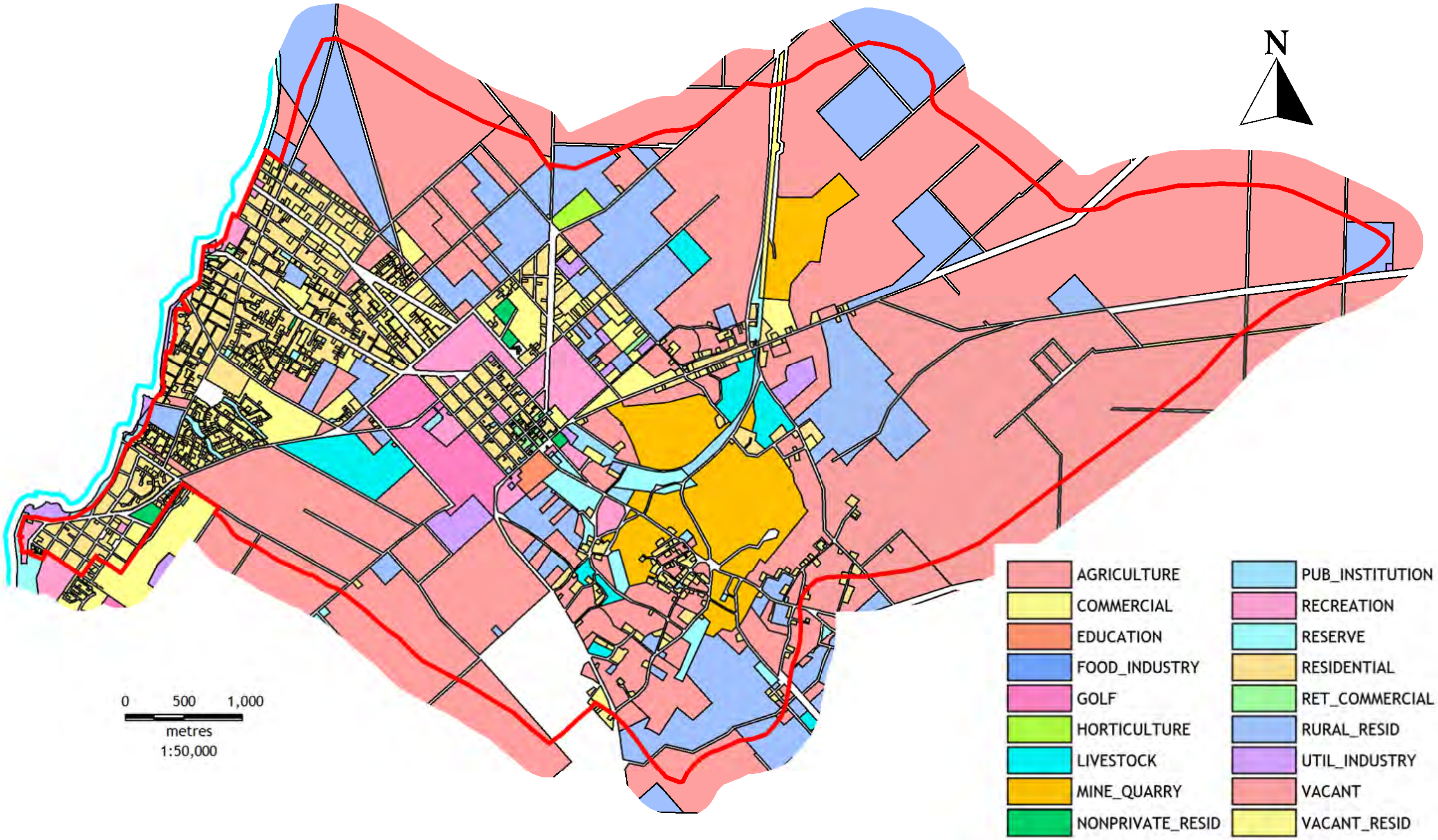
2.4 Existing Land Use

Moonta was established following the discovery of large, rich deposits of copper in 1861, with the town subsequently laid out in 1863. The population of Moonta in 1875 grew to 12,000, but has since declined following cessation of primary copper mining operations in 1923. Prior to the 1860s, the land was covered by open scrub and Eucalyptus mallee woodland.

In recent years, the satellite towns of Port Hughes and Moonta Bay have been the subject of significant interest from land developers, with several land subdivisions in the local area.

The Catchment 1 area also encompasses large agricultural and rural residential areas (refer Figure 2.5). The agricultural areas surrounding Moonta are used predominantly for growing barley and wheat.

The eastern extent of Catchment 1 also includes part of the Historic Conservation (Moonta Mines) zoned area (refer Figure 2.6) which is understood to not be subject to future residential development. Mining activity in this area has been largely abandoned. A more detailed description of the Moonta Mines Catchment is presented in Chapter 5.



Data Sources:
DPLG (Land Use)
Southfront (Catchment Boundary)

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

southfront

Figure 2.5

Generalised Land Use (from DPLG)

2.5 Land Development Potential

2.5.1 Introduction

The way in which stormwater is currently managed in the Moonta, Moonta Bay and Port Hughes area is the product of the urban development that has occurred in years gone by. At the same time, the way in which urban development continues to occur in the area will significantly impact upon future stormwater management.

To help understand these issues, an assessment of development potential has been undertaken to identify recent and anticipated development trends in the study area. The assessment is based upon analysis of:

- Existing Development Plan policy
- Recent development trends (i.e. what is happening 'on the ground')
- Recent DPTI data regarding recently constructed dwellings, land divisions, and land supply for future urban development
- 2006-2026 population projections prepared by the then Department of Planning and Local Government in 2011
- Anticipated changes to development policy in-line with Council and State Government urban growth goals
- Demographic characteristics from the ABS 2011 Census as they relate to urban development.

This assessment also includes a review of Council's Development Plan to identify any potential barriers to the effective implementation of the Stormwater Management Plan.

2.5.2 Existing Development Policy Context

The majority of urban development within the study area is located within the Residential Zone, although other zones in the study area include the Urban Coast, Local Centre, Tourist Accommodation, Deferred Urban, Rural Living, Home Industry, Town Centre, Recreation (parklands) Historical Conservation, General Industry and Commerce/Industry Zones. The current zoning is shown in Figure 2.6.

Within Copper Coast's Residential Zone and much of the Council area, the minimum site area is 900sqm where effluent disposal is required on-site, and 450sqm where effluent disposal occurs off-site. This means that for much of the Residential Zone within the study area, the minimum site area is 900 sqm because effluent must be treated on-site.

However, Council's Moonta, Moonta Bay and Port Hughes CWMS project will eventually connect most of the study area's urbanised neighbourhoods (as shown in Appendix A) to an off-site effluent disposal system. As the project is rolled-out over the next five years, this will create considerable infill development potential as the minimum allotment size decreases from 900 sqm to 450 sqm.

The Residential Zone provides limited policy guidance regarding the impacts of new development on stormwater infiltration/run-off.

Sitting just outside the study area, the Residential (Golf Course) Zone incorporates provisions that encourage new development to harvest and retain stormwater on-site for irrigation and drinking, including one Principle of Development Control regarding the provision of tanks with a capacity of at least 5000 litres for new detached dwellings.

Council-Wide policy in the Copper Coast Development Plan seeks to limit the site coverage of dwellings to 35% of the site, with outbuildings such as carports and verandas to cover no more than an additional 15% of the site. This seeks to ensure that at least 50% of allotments are not covered by buildings or structures, increasing the likelihood that infiltration can occur (noting that planning policy cannot prevent the paving of yards).

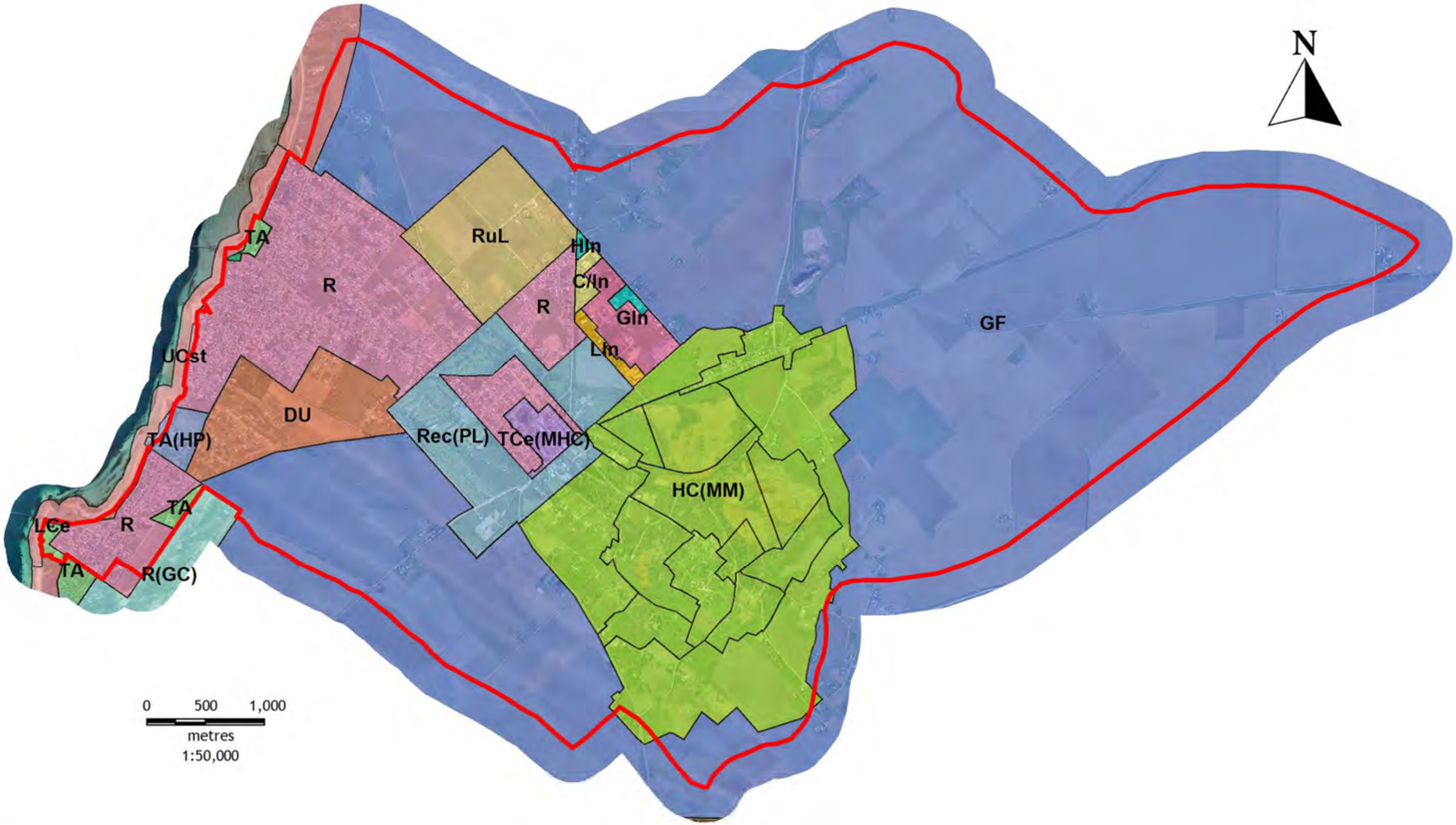
In addition, a number of provisions that address Water Sensitive Design are contained under the heading of "Natural Resources" in the Council-Wide section of the Development Plan. These provisions cover a number of stormwater related issues seeking to maximise conservation, minimise consumption and encourage re-use of water resources. PDC 8 in this section of the plan, for example, states that water discharged from a development site "should not exceed the rate of discharge from the site as it existed in pre-development conditions".

The Copper Coast Development Plan has not undergone its conversion to the South Australian Planning Policy Library (SAPPL) format. When this conversion takes place (likely in the next five years or so), Council's Development Plan will be updated with the standardised planning polices from the State Government's "library" of planning policy.

These include provisions under the heading of "Natural Resources" that address a range of stormwater issues, including ensuring that development maximises the use of water resources, protects stormwater from pollution, protects and enhances the quality of receiving waters and prevents the risk of downstream flooding. While a number of these policies already exist, the conversion of Council's Development Plan into this format will provide the opportunity to update these provisions with the latest policy regarding water sensitive urban design. Such policy will also support the implementation of works resulting from the Stormwater Management Plan.

Summary and Implications for Stormwater Management

- Existing Council-wide policy addresses many of the planning policy aspects of water sensitive urban design
- With the exception of the Residential (Golf Course) Zone which is outside of the study area, there is limited planning policy encouraging the provision of rainwater tanks to reduce stormwater run-off
- Under the current Development Plan policy, it is likely that significant development potential within existing urbanised areas will be realised as the CWMS project is rolled out. This reduction in minimum site area will allow new subdivision, creating new residential allotments and development which increases stormwater run-off.



Data Sources:
DPLG (Development Zones)
Southfront (Catchment Boundary)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 2.6

Development Zones as at 13 June 2013

2.5.3 Recent Development Activity

The Department of Planning, Transport and Infrastructure monitor data regarding land division proposals, new dwelling constructions and the supply of development-ready land. Figure 2.7 on the following page shows the location of dwellings built in the five years to 2011, as well as land division proposals for Moonta, Moonta Bay and Port Hughes.

The map demonstrates that there has been considerable development activity in the study area. As well as new residential dwellings being constructed across the Residential Zones (the replacement of existing dwellings or development on previously undeveloped blocks), there is a concentration of new dwellings in a new subdivision bounded by Rossiters, Hughes and Coast Roads at Moonta Bay, which has increased impervious site coverage and stormwater runoff.

Land division activity is less widely spread across the study area, because of the current 900sqm minimum allotment size. It has been limited to key sites where very large allotments have been subdivided into 'town blocks', in addition to the subdivision at Moonta Bay.

It can reasonably be assumed that many of these new residential allotments created through land division will be developed with new dwellings that increase impervious coverage and thus stormwater run-off in coming years.

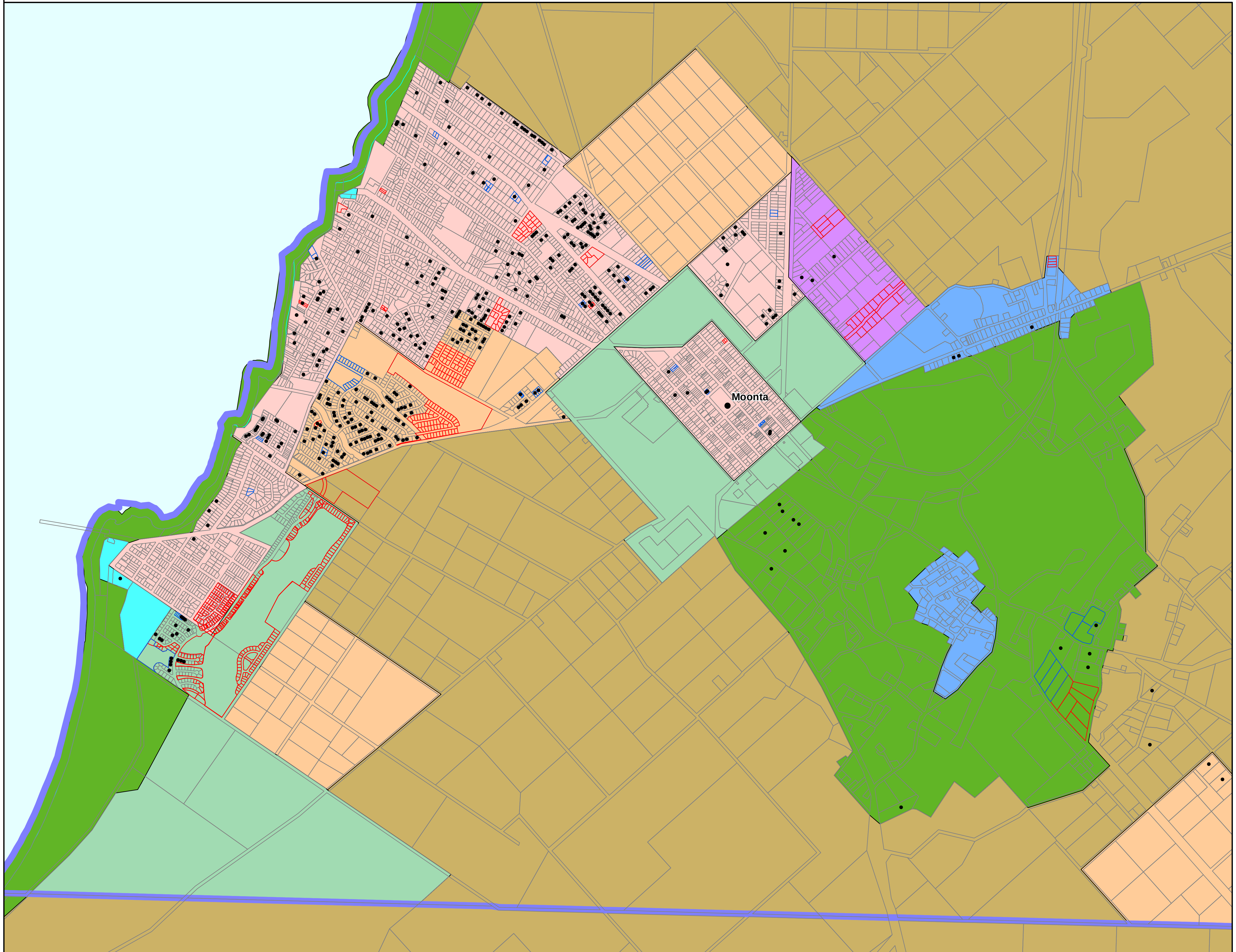
More recent residential development activity data for the twelve months to June 2012 identified the following data for Copper Coast Council (data for geographical areas smaller than LGA is unavailable):

Table 2.3 Recent Development Activity in the Copper Coast Council

	Sep-11	Dec-11	Mar-12	Jun-12	Year to June 2012
Proposed Lots in Subdivision Plans	8	71	3	19	101
Lots with a Certificate of Approval	38	50	13	8	109
Completed Lots Deposited	14	2	52	8	76
Dwelling Approvals	47	66	34	20	167

Source: Department of Planning, Transport and Infrastructure Residential land development activity report to June 2012.

Moonta, Moonta Bay & Pt Hughes



Commercial
Community Facilities
Country Township
Deferred Urban
Environmental Constraint
Excluded
Heritage
Industrial
Infrastructure
Miscellaneous
No Zones / Data
Open Space
Primary Production / Mining
Recreation
Residential
Rural Living
Local government boundary
Land division deposits
Land division proposals
Cadastre (2012)
Dwellings built 2007 to 2011 (valuation derived 2011)
Major towns
Other towns and localities

N

0 0.5 km

Produced by Department of Planning, Transport and Infrastructure.

Valuation derived data has been supplied by DPTI and is current to 30 June 2012. Topographic data supplied by DEWNR, DPTI and Geoscience Australia. Imagery supplied by DEWNR and Aerometrex.

Government of South Australia
Department of Planning, Transport and Infrastructure

PLN ID: 4048

The data identifies that in the twelve months to June 2012, there were 167 new dwellings approved in the Copper Coast Council, and significant land division activity at the various stages. This recent development activity data confirms the above identified trend that the there has been significant development in recent times. The high amount of land division activity indicates that in coming years a number of these allotments will be developed for new housing, thereby increasing impervious cover and stormwater runoff.

The relatively large amount of development activity is particularly evident when Copper Coast is compared with similar regional coastal Councils. Neighbouring Council Barunga West (which has a smaller population) approved 10 new dwellings in the same time period, while the Yorke Peninsula Council (which with a population of approximately 12,000 people is comparable to the Copper Coast) approved 120 new dwellings in the same time period.

The recent development activity has been spearheaded by a few significant residential projects, as well as sustained 'infill' development as vacant allotments are developed and older homes are redeveloped. Much of the later is resulting in more substantial residential dwellings being constructed in the study area with larger footprint homes being preferred for new holiday homes and retirees, who are key groups driving the residential development activity.

This is evident in recent ABS Census data which identifies that, in comparison with the rest of South Australia, the study area contains a comparatively older population, living in smaller households in homes that have fewer people per bedrooms (see Table 2.4).

Table 2.4 Key Demographic Characteristics

	Moonta	Moonta Bay	Port Hughes	S. Australia
Median Age	55	51	47	39
Average Household Size	1.8	2.2	2.4	2.4
Persons per bedroom	1.0	1.0	1.1	1.1

Source: ABS 2011 Census.

Summary and Implications for Stormwater Management

- There has been a large number of new dwellings constructed in the study area in the past five years, increasing impervious coverage and stormwater run-off (even if all of these dwellings are not occupied all year round)
- 'Infill' development within existing Residential Zones may have incremental impacts on stormwater management infrastructure, especially as the size of new dwellings increases
- The large amount of land division activity indicates that new dwellings are likely to be constructed in the future. New residential developments will require new stormwater management infrastructure to ensure that the capacity of existing networks is not exceeded.

2.5.4 Anticipated Development Activity

The Yorke Peninsula Regional Land Use Framework is the volume of the Planning Strategy that applies to the Copper Coast Council.

The framework acknowledges that the region is growing, and that this growth is concentrated in the Copper Coast Council area, which at the time of the document's publication (2007) was the fastest growing non-metropolitan Local Government Area in the State.

The Plan provides strategic direction for the Moonta, Moonta Bay and Port Hughes to continue to grow in the form of 'compact extensions' as one of the major urban centres and tourist settlements in the region. The region plan, however, does not contain specific population or dwelling targets, or spatially identify where this growth might occur.

The then Department of Planning and Local Government's 2011 population projections anticipate the Cooper Coast's total population to grow to 15,871 people by 2026. This represents an increase of nearly 3,000 people from the 2011 Census figure of 12,949 and would see the Council area grow by nearly 200 people per annum.

It is reasonable to assume that the study area will accommodate much of this population increase, owing to the services already available and the supply of zoned and 'development ready' land, along with the additional development potential created with the reduction of allotment sizes following the provision of the CWMS. It should, however, be equally noted that some of this increase could be attributed to people who move to the District permanently to live in existing dwellings that are currently unoccupied as holiday homes and the like.

It is understood that Council's preferred approach to urban growth is that of infill and development within existing zones, as there is considerable residential capacity within existing Residential and Deferred Urban Zones.

This capacity was noted in DPTI's unpublished 2011 Residential Land Supply Report which identified that, at 30 June 2011, the Moonta/Moonta Bay/Port Hughes area contained 95.3 hectares of broadacre land (most of which is residentially zoned). In addition, there was 243 hectares of rural living land, all of which is located within the study area. This means that all land that is envisaged to supply future needs is located within the study area.

Summary and Implications for Stormwater Management

- The population of the study area is projected to continue to grow steadily
- Most of this growth is likely to be accommodated within existing zones (predominantly the existing Residential Zone), where there is considerable capacity for additional dwellings
- New residential development is likely to increase the amount of impervious coverage and therefore stormwater run-off.

2.6 Non-Potable Water Demand

An assessment has been made of the locations and demands for non-potable water within the catchment. These locations have been prioritised by Council, and some of them will be serviced by recycled water from the CWMS scheme currently under construction. The locations identified (summarised in Table 2.5 below) are all irrigated golf courses, ovals and reserves. The annual average irrigation demand has been calculated based on an assumed requirement of 3.6 ML/ha/yr, which is consistent with irrigation to a 'Turf Quality Visual Standard Classification No 3 - Local sports turf' standard (SA Water, 2007).

It is apparent from inspection of historical aerial photography that some areas are not irrigated sufficiently during summer, which highlights that stormwater harvesting for the purposes of irrigating these areas would not only have a direct stormwater management benefit, but would also create indirect benefits including an enhanced recreational experience for the local community, schools and sporting organisations.

Table 2.5 Non-potable water demand sites

Location	Irrigated Area (ha)	Estimated Demand (ML/yr)	Proposed Irrigation Source
The Dunes Golf Course	42	151.2	CWMS (currently in place)
Moonta Golf Course	15.9	57.2	CWMS
Queen Square	1.5	5.4	Harvested Stormwater
Victoria Park Oval	1.8	6.5	Harvested Stormwater
Moonta Primary School Oval	1.8	6.5	Harvested Stormwater
Minnie Terrace Beachfront Reserve	2.6	9.4	Harvested Stormwater
Bray Street Reserve	2.0	7.2	Harvested Stormwater
Total	**65.6**	**236.2**	

2.7 Local Marine Environment

2.7.1 Introduction

The Moonta Bay & Port Hughes region is well known for its coastal attraction and amenity. The townships have the capacity to provide “sea change” living, as well as being a popular holiday and retirement destination. The Study Area covers agricultural, rural residential, conservation (previously mined) zones and urban catchments, with outfalls to the marine environment located along the coasts of Moonta Bay and Port Hughes, discharging into Spencer Gulf.

The Adelaide Coastal Waters Study (ACWS) considered anthropogenic impacts on the Adelaide Metropolitan waters of Gulf St Vincent (Fox *et al.* 2007). Although outside the zone considered by the ACWS, many findings of that study are still relevant to the environment of Spencer Gulf. The ACWS determined that nutrients, particularly nitrogen (N) from stormwater and wastewater, are likely to be responsible for broad-scale seagrass loss along the Adelaide metropolitan coast, with possible contribution from turbidity due to sediments carried by stormwater, especially in the near-shore zone (Fox *et al.* 2007). Nutrients and sediment loads are also implicated in the loss of large brown canopy algae from temperate reefs, and a shift to turf-dominated assemblages (Gorgula and Connell 2004; Turner 2004). The Draft Adelaide Coastal Waters Quality Improvement Plan (ACWQIP) has adopted the targets recommended by the ACWS, specifically, a 50% reduction in sediment loads and a 75% reduction in N from 2003 levels (McDowell and Pfennig 2011). Heavy metals and other contaminants that are also carried in stormwater have periodically exceeded levels of concern in Adelaide waters; although not considered an important factor in historical seagrass decline (Fox *et al.* 2007), these may pose a risk to receiving environments if present in sufficient concentrations (Mills and Williamson 2008; Gaylard 2009b).

2.7.2 Methods

Information on marine benthic habitats surrounding the Moonta SMP study area was collated from existing data sources and a review of published literature. Data sources used include benthic habitat classifications and supporting video data used by the Department of Environment, Water, and Natural Resources (DEWNR) to create marine benthic habitat maps and, data collected by the South Australian Research and Development Institute (SARDI) Aquatic Sciences during reef health surveys (Turner *et al.* 2007; Collings *et al.* 2008), and video from the vicinity of the boat ramp at Port Hughes (Wiltshire and Tanner 2013). The locations of these data points are shown in Figure 2.8. The region of interest was taken to be that within a 5 km radius of the SMP area, from the shore to a maximum depth of 20 m, or to the extent of benthic habitat data where different (Figure 2.8). A literature review of potential impacts of stormwater on aquatic environments was then performed, with a focus on effects on the major habitats occurring in the region.

2.7.3 Marine Benthic Habitats of the Moonta region

A map of the major marine benthic habitats surrounding the Moonta SMP area is shown in Figure 2.8, with more detailed habitat composition shown in Figure 2.9. Seagrass dominates the region, comprising 87.8% of the total habitat in the area of interest; beds are continuous and medium to dense, with a few areas of patchy and/or sparse cover. Low profile reef occurs along the near-shore from Moonta Bay to the southern extent of the area of interest, with further patches of reef offshore in the south. In total, reef comprises 1.7% of the area, and supports continuous dense macroalgal cover with only a few areas of patchy cover. There is a small area of intertidal salt marsh near Warburto Point at the northern end of the area of interest, comprising 0.2% of the total area. The remainder of the area of interest (10.2%) is bare sand; this is located in intertidal flats extending along the coast.

The majority of seagrass recorded in the Moonta area by DEWNR benthic video data is *Posidonia,* with a small amount of the annual, non-meadow forming, *Halophila* observed. SARDI video data from around Port Hughes also recorded *Posidonia* spp., including *P. angustifolia* and *P. australis*, as the dominant seagrass biota, with some patches of *Amphibolis antarctica* near shore, as well as *Zostera* spp. in shallow water (Wiltshire and Tanner 2013). *Amphibolis antarctica* and *Posidonia australis* have been reported from Moonta Bay, with *Posidonia angustifolia* occurring at Tiparra reef, 15 km offshore (James *et al.* 2009). Although Posidonia meadows in Moonta Bay are generally dense and intact, heavy epiphyte loads have been observed during EPA monitoring, indicating possible nutrient impacts in the region (S. Gaylard, in prep.).

The nearest studied reef to the area is at Cape Elizabeth, around 11 km SW from Port Hughes (Figure 1); this reef was surveyed as part of the Reef Health program in 2005 and classed as being in good condition, with high cover of brown canopy macroalgae and good macroalgal diversity (Turner *et al.* 2007). Species of *Sargassum* (Fucales) were the most common canopy species recorded (SARDI reef health data). The reef within the SMP area is also fucoid dominated (DEWNR benthic video data), while intertidal flats and reef in Spencer Gulf are often dominated by the brown alga *Hormosira banksii*, with a range of other brown and red algae commonly found (DEH 2003). *Sargassum* spp. and *Scaberia agardhii* were observed on subtidal reef near the Port Hughes boat ramp (Wiltshire and Tanner 2013).

Several habitats in the area have been identified as being of high conservation value, including the salt marsh habitats near Warbuto Point (Caton *et al.* 2007). Reef habitats of the Yorke Peninsula support marine invertebrates of potential conservation concern (Baker 2011), and, although fish surveys of reefs of the region have not been carried out, reef habitats in SA commonly support many cryptic and uncommon fish, including protected sygnathid species (Baker *et al.* 2008; Baker *et al.* 2009). Moonta Bay is at the northern end of the Spencer Gulf distribution for sea dragons, with records of weedy sea dragons (*Phyllopteryx taeniolatus*) at Port Hughes and within Moonta Bay to Tiparra reef; leafy sea dragons (*Phycodurus eques*) have not been recorded in the area, but have been found rarely further to the north and west (Baker 2005). The reefs offshore from Moonta Bay form a major abalone fishing ground, while reefs, seagrass and intertidal flats support a range of recreationally and commercially fished species, including King George whiting (*Sillaginodes* *punctata*), garfish (*Hyporhamphus melanochir*) and snapper (*Pagrus auratus*) (Bryars 2003; DEH 2003).

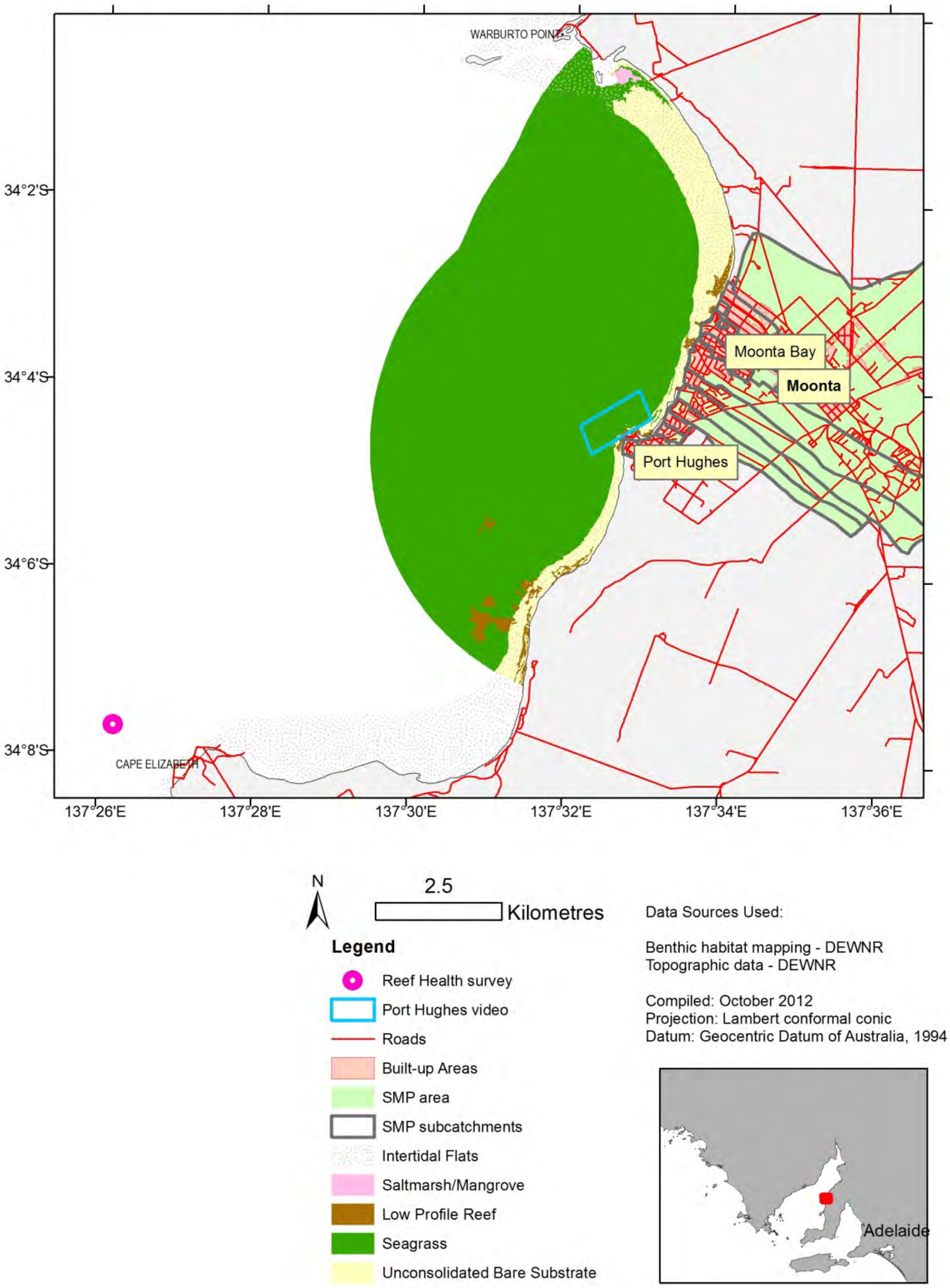


Figure 2.8 Local marine benthic habitat classification

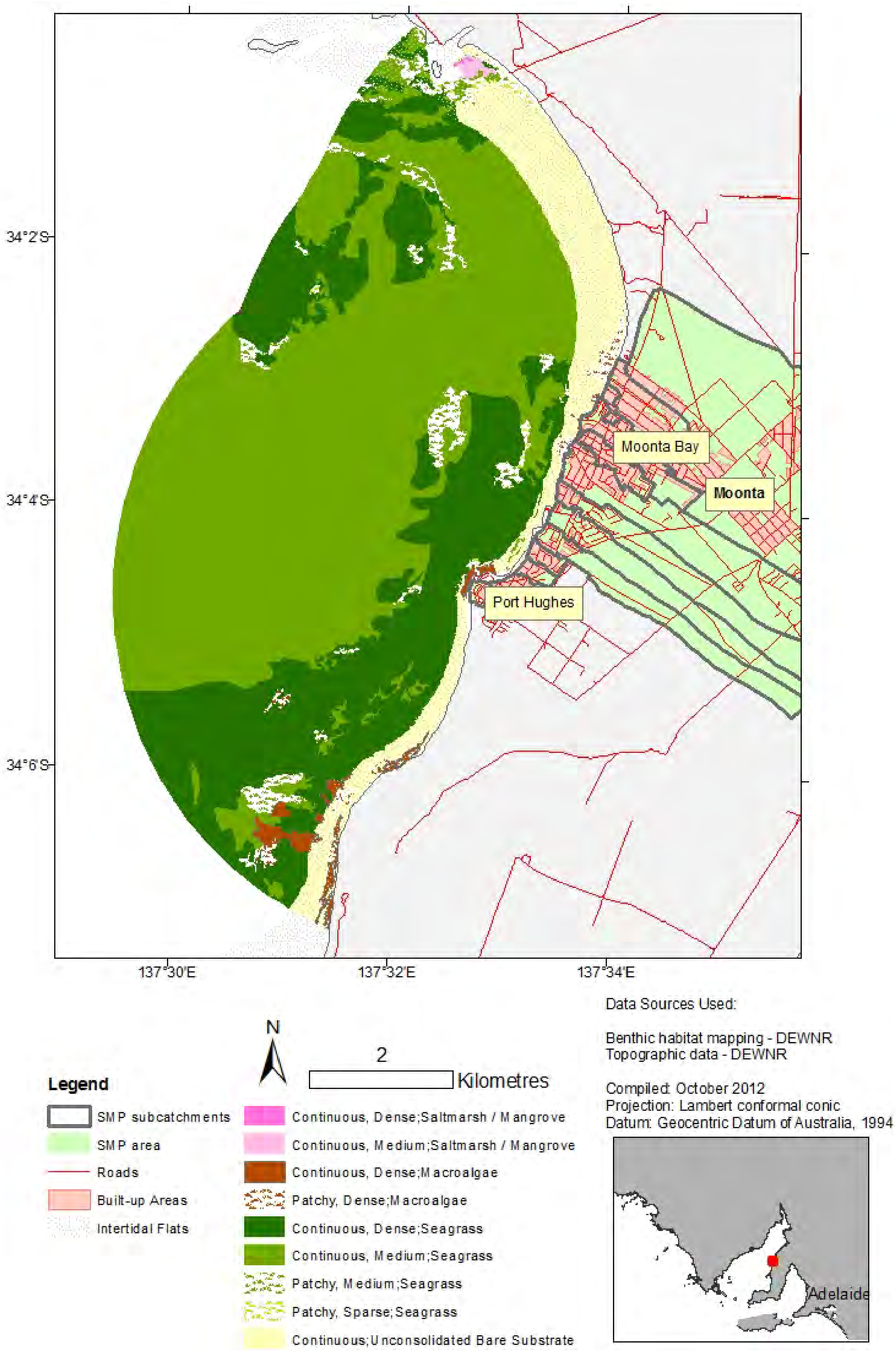


Figure 2.9 Regional marine benthic habitat structure and biota

2.7.4 Habitats surrounding outflows

The habitats within 100 m of stormwater outflows are predominantly bare sand (64.9%) but with considerable macroalgae (32.5%) and some seagrass occurring (2.6%). Within 1 km of outfalls (Figure 2.10), habitats are dominated by seagrass (72.2%), with macroalgae covering 4.5% of the area, and unvegetated sand 23.3%.

2.7.5 Potential risks from stormwater outflows

Potential risks from stormwater are suspended sediments, which have impacts through light reduction (turbidity) and sedimentation, nutrients, other contaminants such as metals, pesticides, and hydrocarbons, and reduced salinity due to freshwater inputs (Gaylard 2009). The ACWS and other investigations on the Adelaide coast have demonstrated negative impacts to reef and seagrass habitats, particularly from sediments and nutrients (Gorgula and Connell 2004; Turner 2004; Fox *et al.* 2007; Gorman *et al.* 2009). The general risks to the environments of the Moonta region are discussed below.

Suspended sediments

Sediments carried by stormwater are the main cause of turbidity in shallow waters (<5 m) along the Adelaide coast and because discharged stormwater in this area tends to move along-shore with minimal mixing with deeper water, discoloration may persist for several days, increasing effects on near-shore habitats (Fox *et al.* 2007; Gaylard 2009). Turbidity increases light attenuation, leading to a lesser proportion of light penetrating to a given depth (Collings *et al.* 2006b). Light limitation has negative impacts on seagrass including reducing maximum depth range for growth (Abal and Dennison 1996), and causing decreased biomass, shoot density and productivity, and depletion of starch resources (Ruiz and Romero 2001; Ruiz and Romero 2003; Mackey *et al.* 2007). Macroalgae are similarly impacted by light reduction due to turbidity (Turner and Collings 2008; Gaylard 2009b). Growth rate of *Fucus* spp. in the Baltic Sea were strongly dependent on light intensity, with reduction in light availability leading to loss of the algae from waters >6 m deep (Rohde *et al.* 2008). Turbidity reduces light penetration in Adelaide's shallow coastal waters (3-6 m deep); average light intensity is in the range sufficient for seagrass growth, but variability in available light due to the periodic nature of sediment influxes may reduce productivity and have contributed to loss of seagrass in this zone (Collings *et al.* 2006b). Interactive effects between turbidity and nutrients may also contribute to seagrass loss and shifts in benthic community composition (De Casabianca *et al.* 1997; Wear *et al.* 2006).

Sediments also have impacts through siltation. Sedimentation may restrict light at the level of seagrass leaves, and smother plants by preventing gas exchange (Ralph *et al.* 2006). Burial of shoots and seeds, and erosion by sediment movement can also cause loss of or damage to seagrass (Marba and Duarte 1995; Preen *et al.* 1995; Duarte *et al.* 1997; Bryars *et al.* 2008). Sedimentation also has negative impacts on reef macroalgae and other biota through smothering, scour and a reduction in available hard substrate for settlement (Airoldi 2003). Deposition from a dredge plume resulted in a decrease in the recruitment of canopy algae species to southern Adelaide reefs (Turner 2004), and increased sedimentation from terrestrial sources promotes a shift toward macroalgal communities dominated by turfing rather than canopy species (Airoldi and Cinelli 1997; Gorgula and Connell 2004). Sedimentation can also cause changes in unvegetated soft bottom habitats by altering sediment structure, smothering or burial of organisms, and clogging of gills and filter feeding structures (Mills and Williamson 2008; Gaylard 2009).

A study of sedimentation on Adelaide's metropolitan reefs found that much of the sediment originated from the adjacent rivers and creeks to each site, although the specific contribution of stormwater was not assessed; coastal cliff erosion was also a significant contributor to sediment loads (Fernandes 2008; Fernandes *et al.* 2008).

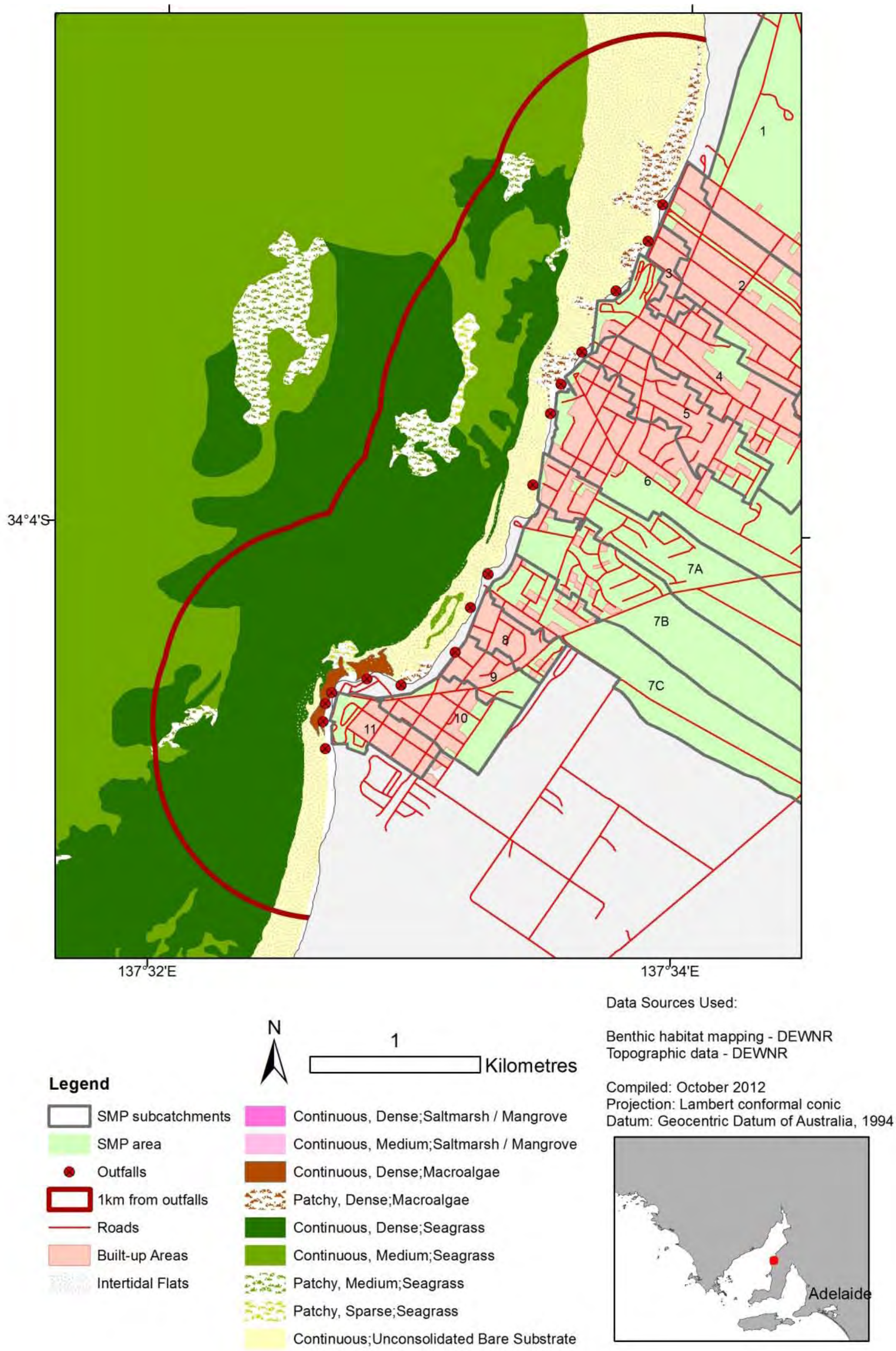


Figure 2.10 Local benthic habitat structure and biota

Nutrients

Wastewater effluent is currently the major source of nutrients entering Gulf St Vincent, but the contribution from stormwater is also significant (Gaylard 2009; McDowell and Pfennig 2011). Elevated nutrients promote the growth of epiphytic algae on seagrass, resulting eventually in loss of above-ground seagrass biomass; *Amphibolis* appears more sensitive to this process than *Posidonia,* which may explain why *Amphibolis* has been lost from Adelaide's coast to a greater extent (Collings *et al.* 2006a; Bryars and Rowling 2008). Eutrophication also promotes a shift in macroalgal community structure, with increased cover of turfing species (Gorgula and Connell 2004). High concentrations of water column nutrients may have acute toxic effects in seagrass (Collings *et al.* 2006a; Ralph *et al.* 2006), or promote algal blooms that reduce available light (De Casabianca *et al.* 1997; Ralph *et al.* 2006), and may lead to hypoxia (Gillanders *et al.* 2008a). Sediment-bound nutrients have fewer toxic effects than water column nutrients, but in high concentrations can lead to sediment anoxia and production of sulphides, both of which negatively impact seagrasses (Ralph *et al.* 2006). Nutrients and sediments may have interactive impacts that are greater than either factor acting alone (Abal and Dennison 1996; De Casabianca *et al.* 1997; Gorgula and Connell 2004). The impact of nutrients is likely to be greatest in waters that are usually oligotrophic (Gorman *et al.* 2009).

2.7.6 Other contaminants

Other contaminants often found in stormwater are trace metals, hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), pesticides (including insecticides, herbicides and fungicides), and litter. Stormwater may also have impacts through localised reduction in salinity (Mills and Williamson 2008; Gaylard 2009). Specific information on several of these contaminants is provided below; detailed aquatic toxicity data and guideline values for toxicants are provided by ANZECC and ARMCANZ (2000a, b).

Metals, hydrocarbons, and pesticides may have acute or chronic toxic effects, and many can accumulate in sediments or in tissues, leading to bioaccumulation and magnification through the food chain (Mills and Williamson 2008; Gaylard 2009). Many toxicants bind to sediment or organic matter and are found at highest concentrations in stormwater that also carries high sediment and nutrient loads, and accumulate in depositional environments (Mills and Williamson 2008). Sediment-bound toxicants are generally less toxic to seagrass than soluble forms (Ralph *et al.* 2006), but may pose a risk to benthic fish and other organisms, e.g. flounder in a contaminated Auckland estuary had higher incidences of liver lesions than those from unpolluted sites (Mills and Williamson 2008).

Metals

Copper, lead and zinc are the metals most commonly found at elevated levels in stormwater, and are derived primarily from road dust and roof run-off (Mills and Williamson 2008; Gaylard 2009). The concentrations of these metals in stormwater increase with the number of dry days preceding each rainfall event, and all have been regularly recorded at above ANZECC trigger levels in Adelaide stormwater, though with decreasing concentrations since the mid-1990s (Gaylard 2009). Many acute and chronic toxic effects of these, and other, trace metals have been described, including toxic effects on seagrass species and the kelp *Ecklonia radiata* (see Gaylard 2009). Toxicity depends largely on bioavailability, which is dependent on water chemistry and sediment organic content (Mills and Williamson 2008; Gaylard 2009). Copper and lead are most likely to be toxic in soft, acidic freshwater with little organic content. Increasing water hardness, alkalinity and pH, and natural dissolved organic matter (e.g. humic acids) generally reduce toxicity, but interactions are complex. Toxicity of lead is also reduced by chloride complexing in saline waters. Zinc toxicity similarly decreases with increasing hardness, alkalinity and salinity, but pH effects are not linear. Below a pH of 8, zinc toxicity increases with decreasing pH, with conflicting results found at higher pH. Zinc binds to clay and organic matter, but resulting impacts on toxicity are variable. Copper and zinc are essential trace elements and so most organisms have mechanisms for regulating sub-lethal concentrations of these metals, meaning that they are unlikely to bioaccumulate; lead may bioaccumulate but is rarely present in sufficient quantities for this to occur (ANZECC and ARMCANZ 2000b; Gaylard 2009). Other metals that may be found in elevated concentrations above background levels in stormwater are cadmium, iron, chromium, nickel, antimony, platinum and molybdenum (Mills and Williamson 2008). Cadmium is of concern in Adelaide metropolitan waters because it has been implicated in toxic effects observed in bottlenose dolphins (Lavery *et al.* 2009). Toxicity of these, and other, metals and metalloids is discussed, and guideline values provided, in ANZECC and ARMCANZ (2000b), although there is no information on platinum.

Hydrocarbons

PAHs may be present in stormwater and are of concern due to their potential toxicity and ability to bioaccumulate (Mills and Williamson 2008; Gaylard 2009). PAHs in stormwater are derived primarily from vehicle emissions, with some contribution from tyre wear (Mills and Williamson 2008). PAHs, especially longer-chained compounds, bind strongly to sediment, particularly fine sand (125-250 µm size fraction), and to organic matter (ANZECC and ARMCANZ 2000b; Mills and Williamson 2008), and accumulate in depositional environments such as estuaries (Mills and Williamson 2008). Lower molecular weight PAHs are more soluble but are removed by volatisation and biological degradation, so are shorter-lived in aquatic environments (ANZECC and ARMCANZ 2000b; Mills and Williamson 2008). Exposure to UV light greatly increases the toxicity of PAHs (ANZECC and ARMCANZ 2000b; Mills and Williamson 2008).

Pesticides

Pesticides are often highly toxic and able to bioaccumulate and biomagnify through the food chain (Gaylard 2009). Organochlorine pesticides (OCPs) have largely been phased out because of these properties (ANZECC and ARMCANZ 2000b), but residues remain in the environment and can be found in stormwater, particularly in run-off from historically horticultural land (Mills and Williamson 2008; Gaylard 2009). The toxicity of OCPs is generally not affected by water chemistry, but some compounds are more toxic to certain species at higher temperature, e.g. >20ºC compared with <10ºC (ANZECC and ARMCANZ 2000b). Organophosphorus pesticides (OPPs) include some currently widely used inseciticides, e.g. chlorpyrifos and malathion. The toxicity of these and several other OPPs increases with temperature; chlorpyrifos is also more toxic at higher pH (9 c.f. 7.5). In general, OPPs are much more toxic to crustacea and insects than to algae, molluscs or fish, but within taxonomic groups species show widely varying sensitivities. Some OPPs have the potential to bioaccumulate (ANZECC and ARMCANZ 2000b). Pyrethroid pesticides bind to suspended matter and biological films and so are rapidly removed from the water column, but may pose a threat to surface-feeding species such as cladocerans (ANZECC and ARMCANZ 2000b). Herbicides are much more widely used than insecticides and are generally more toxic to seagrasses and algae than to fish or invertebrates; most work by inhibition of photosynthesis (ANZECC and ARMCANZ 2000b; Gaylard 2009). The toxicity of some herbicides is increased at higher pH, while toxicity of others increases with temperature. Water chemistry and temperature have little impact on the toxicity of several compounds, but there is a lack of data for many herbicides (ANZECC and ARMCANZ 2000b).

Freshwater

Marine organisms have variable tolerances to salinities above and below their optimal range, and these can vary within a species depending on genotype, acclimation and condition (Nell and Holliday 1988; Westphalen *et al.* 2005; O'Loughlin *et al.* 2006; Gaylard 2009b). Seagrasses are relatively tolerant of periods of lowered salinity, but long-term exposure leads to reduced photosynthetic efficiency and eventually death (Westphalen *et al.* 2005; Touchette 2007). Many macroalgae are also tolerant of short-term low salinity exposure, but this varies greatly between species; estuarine and intertidal species typically tolerate broader salinity ranges than subtidal species (Kirst 1990). Fish and invertebrates that live in estuaries and intertidal zones similarly show greater salinity tolerance than subtidal species (Nell and Holliday 1988; O'Loughlin *et al.* 2006). Australian water quality guidelines recommend that changes to salinity in marine environments should be less than 5% of background levels (ANZECC and ARMCANZ 2000a).

Litter

Litter includes rubbish (plastic bags, bottles etc) and also organic waste, e.g. around 60% of the litter intercepted by gross pollutant traps in the Patawalonga catchment is organic material (Gaylard 2009). A survey of beach litter over several GSV sites found that the majority by quantity (79.7%) and mass (51.3%) was plastics, with glass and ceramic comprising 10.2 % by abundance or 8.5% by mass (Peters and Flaherty 2011). Although this survey was not specifically of material carried in stormwater, it is likely that anthropogenic litter in stormwater will have a similar composition. Plastic waste and ropes have been widely implicated in causing environmental harm including deaths of marine birds, turtles and mammals (Gaylard 2009b; Peters and Flaherty 2011); while organic waste may cause oxygen depletion through microbial breakdown (Gaylard 2009).

2.7.7 Summary

There are important marine habitats in the receiving waters for stormwater outflows from the Moonta region. Marine benthic habitats of the area consist predominantly of *Posidonia* seagrass meadows, with some macroalgal reef present.

Potential risks to these habitats posed by stormwater include sediments, nutrient impacts, and contaminants such as metals, hydrocarbons, pesticides and litter. Stormwater is responsible for the majority of sediment input to Adelaide’s coastal waters, and contributes significantly to nutrient loads (Gaylard 2009); in the Adelaide region stormwater outflows may sometimes be retained in the near-shore zone for several days (Fox *et al.* 2007; Gaylard 2009). The reef habitats and seagrass closest to shore and to the outfalls of the Moonta area stormwater network are the marine habitats at greatest risk, especially if local hydrodynamics do not allow rapid mixing and dispersal of stormwater. In particular, intertidal reef in the vicinity of outfalls in Port Hughes, and the near-shore environments adjacent to outflows from the large catchments 6 and 7B are at risk of nutrient and sediment impacts under current conditions.

2.8 Rainfall

Moonta is situated in a semi-arid location, immediately north of Goyder's Line, with a mean annual rainfall of 370mm.

Daily rainfall data from the Bureau of Meteorology rainfall gauge (Station 022011, located at the post office on Ellen Street) has been obtained for the entire 140 year record spanning 1872 – 2012.

Statistics analysis of the annual rainfall variation is also provided by the Bureau of Meteorology, which reports variations from the annual mean as summarised in Table 2.6 below, and monthly trends as shown in Figure 2.11 below.

Table 2.6 Moonta Annual Rainfall Statistics

Statistic	Annual (mm)	% Difference to Mean
Mean	370	-
Lowest (1876)	172	-54%
5th %ile	243	-34%
10th %ile	262	-29%
Median	359	-3%
90th %ile	491	33%
95th %ile	526	42%
Highest (1889)	681	84%

A search for historical rainfall data (with a 6-minute time step) was undertaken. This data is required for the purposes of water quality and stormwater harvesting / reuse modelling utilising the MUSIC stormwater model.

The nearest available 6 minute rainfall record is the Kadina (Station 022050) gauge record (for the period of June 2005 to November 2009, with a section missing from June to October 2007 inclusive). A comparison of the records over the entire available Kadina daily record (2006-2011) indicates that Kadina has only a marginally (4%) lower rainfall average than Moonta.

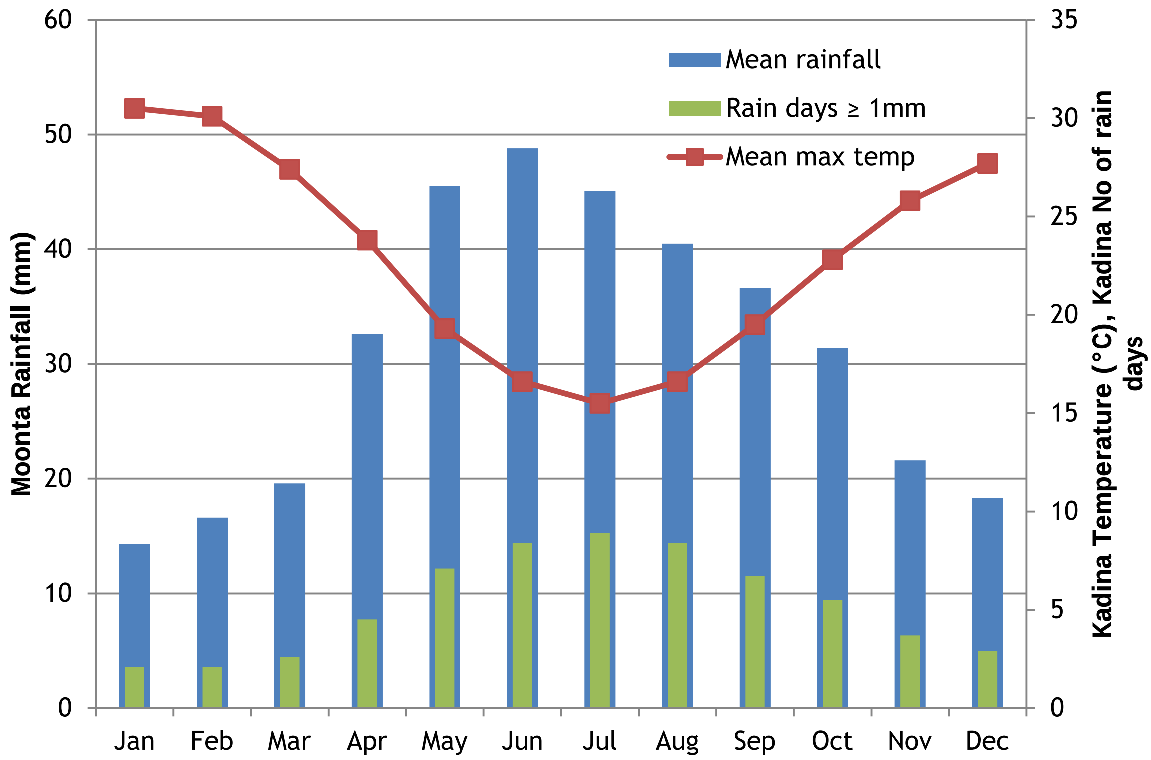


Figure 2.11 Local Rainfall and Temperature Monthly Averages

2.9 Climate Change

Climate change leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events. Within a stormwater management context, potential future changes in rainfall patterns are of particular interest, as this would result in changes in levels of flood protection, stormwater drainage performance, and stormwater availability for harvesting and reuse.

A number of studies and assessments have attempted to improve the understanding of the likely changes to the South Australian climate brought about by climate change. For the purposes of this Stormwater Management Plan, we have assumed that the average annual rainfall over the 30 year life of the Plan will reduce by 10% compared to recent averages.

3 Stormwater Management Objectives

The development of a catchment-based Stormwater Management Plan requires the identification of specific objectives that are relevant to the local context, and measurable. The Stormwater management Planning Guidelines (Stormwater Management Authority, 2007) stipulates that:

> *"As a minimum, objectives are to set goals for:*
>
> - *An acceptable level of protection of the community and both private and public assets from flooding;*
> - *Management of the quality of runoff and effect on the receiving waters, both terrestrial and marine where relevant;*
> - *Extent of beneficial use of stormwater runoff;*
> - *Desirable end-state values for watercourses and riparian ecosystems;*
> - *Desirable planning outcomes associated with new development, open space, recreation and amenity;*
> - *Sustainable management of stormwater infrastructure, including maintenance."*

In recent years, a number of documents have been published which have attempted to define desirable catchment-wide stormwater management performance measures, in relation to water quality improvements to manage marine impacts (CSIRO, 2007), and to mandate Water Sensitive Urban Design principles in new development (Department for Water, 2012).

The *Water Sensitive Urban Design Consultation Statement* (Department for Water, 2012) is a consultation document, and while this has not yet been adopted as State Government policy, it is a carefully considered document drawing on previously published investigations and commissioned research. Hence, the proposed State-wide objectives proposed by this document have been selected as a basis for objectives for this Stormwater Management Plan.

The proposed state-wide WSUD objectives are:

- *To support the sustainable use of natural water resources that provide our water supplies and to help ensure that our water supplies are resilient to climate variation, by conserving water:*
    - *Encourage leading practice in the use and management of water resources to minimise reliance on imported water.*
    - *Promote safe, sustainable use of rainwater, recycled stormwater and wastewater.*

- *To help to protect the health of water bodies and associated ecosystems in or downstream of urban areas, by managing runoff and maintaining or improving water quality:*
    - *Encourage a more natural runoff regime, for example by promoting local retention, detention and slowing urban runoff, where appropriate.*
    - *Maintain and where necessary enhance water quality, for example, by seeking to reduce catchment pollution; mitigating the entrainment of pollutants in surface flows, infiltrated soil and groundwater; and minimising the export and impact of contaminants in wastewater.*

- *To complement other measures (including at catchment scale) that aim to manage the potential flood-related risk associated with urbanisation, by managing runoff:*
  - *Encourage a more natural runoff regime, for example by promoting local retention, detention and slowing urban runoff, where appropriate.*

- *To promote the potential for WSUD to support other relevant State, regional, and local objectives, by encouraging integrated planning, design and management of WSUD measures that maximise the potential to achieve multiple outcomes:*
  - *Recognise the role WSUD can play in supporting other State, regional or local objectives.*
  - *Promote engagement between those responsible for planning, designing and managing WSUD measures and other relevant stakeholders so as to maximise the potential for WSUD to support multiple objectives, for example public amenity, environmental protection and enhancement, reduced water and energy consumption, and affordable living.*

The proposed performance targets considered relevant for adoption as part of this Stormwater Management Plan are:

1 Flood protection
With respect to drainage performance and flood protection, it is considered desirable for minor drainage systems to achieve 5 year ARI design standards and 100 year ARI design standards for major drainage systems.

It is apparent that the recently approved subdivisions in the area were generally developed with these design principles, and the maintenance of these performance standards remains appropriate. It is also important to ensure that any new development occurring upstream of existing development does not overload the existing stormwater networks.

2 Water Conservation
- Outdoor irrigated open spaces: evidence demonstrating how best practice irrigation management can be achieved or enhanced with stormwater harvesting

There are a number of Council reserves and school playing fields across the catchment area that require irrigation to maintain their recreational and amenity values. There is an opportunity to consider other measures, such as sourcing water via stormwater harvesting, to reduce the reliance of mains water to support irrigation of these areas, and potentially to also support the revegetation of some reserve areas where there is scope for this to occur. This second outcome would lead to other associated benefits being realised, such as increased catchment biodiversity, amenity and buffering against the 'urban heat island effect' that is associated with climate change (Centre for Water Sensitive Cities, 2012).

3 Runoff Management – Quality
Reduce the average annual loads of:
- total suspended solids by 80 per cent;
- total phosphorus by 60 per cent;
- total nitrogen by 45 per cent;
- litter/gross pollutants by 90 per cent;

as would be demonstrated based on modelling procedures which compare proposed catchment design with an equivalent, untreated catchment

These pollutant reduction targets will assist towards goal of reducing the amount of suspended solids, nitrogen, and other pollutants that enter the Spencer Gulf waters, which have been identified through the *Adelaide Coastal Waters Study* (CSIRO, 2007) as impacting on the health of Adelaide's coastal sea-grasses.

4 Integrated Design

- Relevant stakeholders to be engaged at relevant stages of planning, designing, constructing, and managing WSUD measures so as to maximise the potential for WSUD to support and sustain multiple outcomes.

Within the Moonta, Moonta Bay & Port Hughes catchment area, relevant stakeholders may include, but are not necessarily limited to the District Council of the Copper Coast, the Northern & Yorke Natural Resources Management Board, the Environment Protection Authority, the Department of Environment and Natural Resources, developers, private land owners and any local volunteer groups. Integrated effort within organisations, such as the District Council of the Copper Coast, is also required to ensure that input is received across the Engineering, Planning and Open Space divisions (or other divisions as appropriate).

4 Hydrological Modelling

4.1 Modelling Approach

A previous ILSAX hydrological model of the study catchment was made available by Council. While ILSAX provides useful information, it is an old modelling platform that has since been superseded and improved by DRAINS.

As described in the model documentation (Watercom, 2011), DRAINS is a multi-purpose Windows program for designing and analysing urban stormwater drainage systems and catchments. DRAINS can model drainage systems of all sizes, from small to very large. Working through a number of time steps that occur during the course of a storm event, it simulates the conversion of rainfall patterns to stormwater runoff hydrographs and routes these through networks of pipes, channels and streams. In this process, it integrates:

- design and analysis tasks;
- hydrology (four alternative models) and hydraulics (two alternative procedures);
- closed conduit and open channel systems;
- headwalls, culverts and other structures;
- stormwater detention systems; and
- large-scale urban and rural catchments

Within a single package, DRAINS can carry out hydrological modelling using ILSAX, rational method and storage routing models, together with quasi-unsteady and unsteady hydraulic modelling of systems of pipes, open channels and surface overflow routes. It includes two automatic design procedures for piped drainage systems, and connections to CAD and GIS programs.

For this study the previous ILSAX model was used, together with GIS based stormwater drainage data, the Digital Terrain Model and as-constructed drawings, to create a DRAINS model of the stormwater network. The parameters developed to establish the model are described in detail below.

4.2 Modelling Parameters

4.2.1 Drainage Data

The ILSAX model was supported by a basic GIS dataset including sub-catchments (ie. boundaries and associated parameters), approximate drain and open channel alignments, and drain sizes. A number of modifications and enhancements were made to the GIS dataset in order to prepare this data into a form that would be suitable for a DRAINS model, and for future incorporation into Council's asset management system.

A comprehensive review of available construction drawings was undertaken to:

- confirm the drain sizes and alignments;
- identify the location and type of all inlet pits (which were not provided with the ILSAX data);
- complete the drain invert data; and
- account for recently constructed drainage infrastructure that was not included in the ILSAX model

The Digital Terrain Model was used to:

- update the alignment of drains and open channels, and the position of inlet pits to reflect their true spatial position;

- assign surface levels to all inlet / junction box nodes;
- generate drain invert data (where construction drawings were not available and the dataset did not have this attribute), through the assumption of minimum cover and positive drain grades;
- confirm sub-catchment boundaries; and
- define surface drainage features such as open channels, overland flow paths, trapped low points, detention basins and wetlands

The GIS dataset was further processed to ensure connectivity of the drainage network within the DRAINS modelling platform and compatibility of the model results with the TUFLOW floodplain model:

- 'rationalise' arc and polyline drain elements into single line segment elements;
- snap end points of connecting drain segments together, and nodes to drain end points; and
- assign unique identifiers to individual drain elements

4.2.2 Urban Catchment Areas - Existing Scenario

Development within the Study Area is almost exclusively residential, with a small area of commercial development within the Moonta town centre. Types of residential development vary across the study area; from areas of older established dwellings to instances of recent infill development and large pockets of new residential developments.

A number of sample areas were selected for an assessment of impervious site coverage. These areas are shown in Figure 4.1 on the following page.

The analysis showed a reasonably varied impervious fraction across the township, ranging from the mid 30's in older residential areas up to the mid 70's for commercial areas and new residential developments.

In determining the split of this fraction between directly connected and indirectly connected impervious fractions, consideration was given to Study Area characteristics including:

- age of development; development in older areas (eg. original 'shack style' dwellings in the coastal areas) typically lacks 'conventional' drainage systems with direct connection to the street;
- land use within the Study Area; recent housing developments and commercial areas are more likely to have 'conventional' drainage systems with direct connection to the street;
- reported nuisance / inundation flooding issues

These factors suggest higher impervious fractions for areas of new development than what would normally be expected in areas of older established dwellings. The 'typical' impervious fractions adopted for residential development in the Study Area are shown in Table 4.1 on the following page. These values have been varied on an individual sub-catchment basis, where varying land uses are identified.

The ILSAX model has been adopted as the default hydrological model within DRAINS, with depression storages of:

- paved = 1mm
- supplementary paved = 1mm
- grassed = 45mm

A custom soil type was selected, with a continuing loss of 3mm/hour.

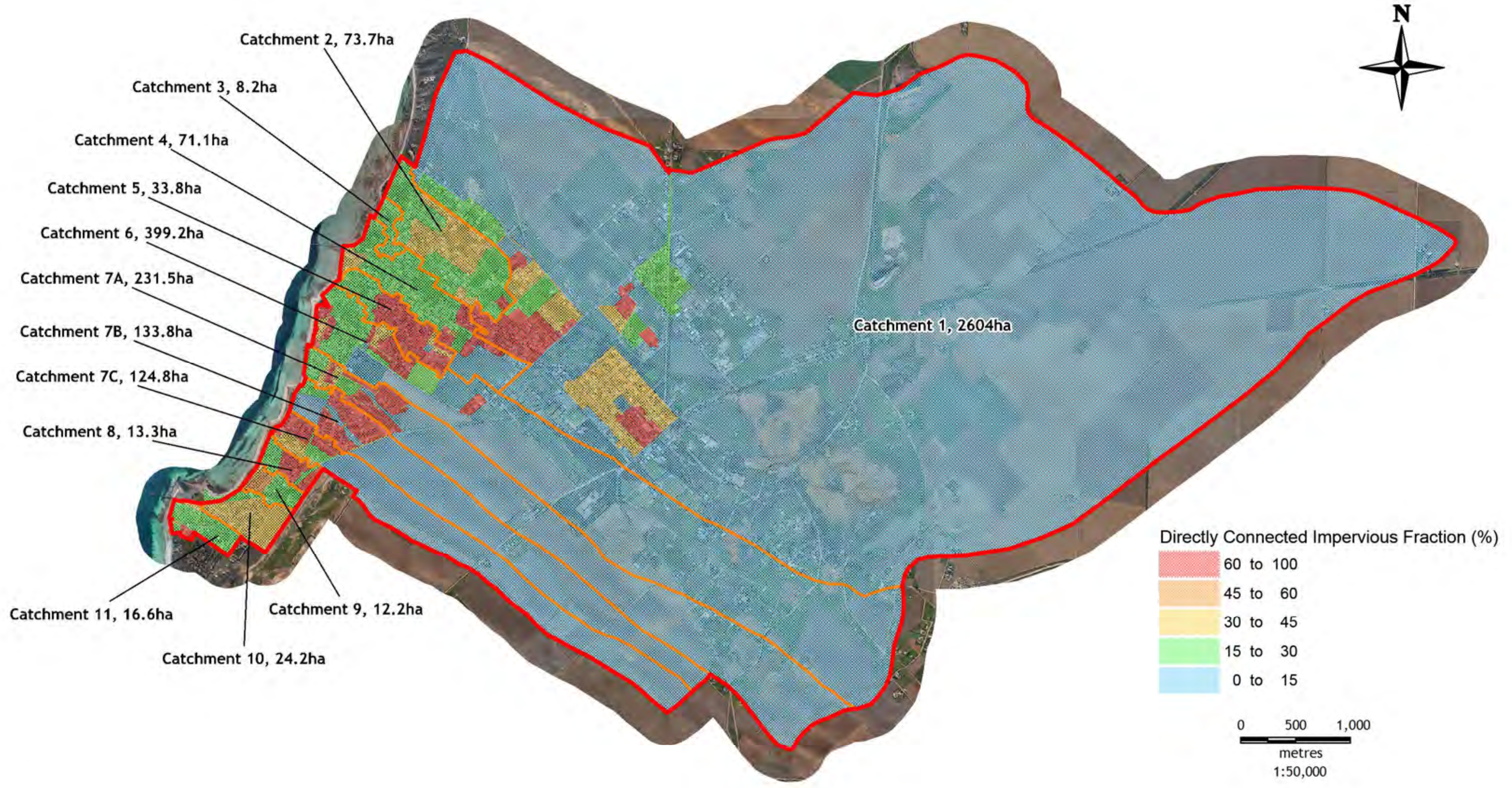
Figure 4.1 Total Impervious Fraction, Sample Areas

Table 4.1 Typical Impervious Fractions, Residential Development

Subcatchment Location	Directly Connected Fraction (%)	Indirectly Connected Fraction (%)	Total Impervious Fraction (%)
Older areas	20	15	35
Older areas with some infill development	25	20	45
New areas [1]	60	15	75

[1] For the purposes of assessing the existing drainage performance a full take-up of allotments has been assumed across the new residential developments

Figure 4.2 on the following page shows the distribution of directly connected impervious fractions within the Study Area within the Existing Development Scenario.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary)

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

southfront

Figure 4.2
Directly Connected Impervious Fractions

4.2.3 Urban Catchment Areas - Future Scenario

An assessment was undertaken of the likely increases to impervious areas under the future development scenario. The future development scenario allows for infill development (as described in Section 2.5) following the construction of the proposed CWMS scheme in the township as well as the re-zoning of certain pockets of land as described in Council's BDP. The extents of the proposed re-zoning are shown in Figure 4.3.

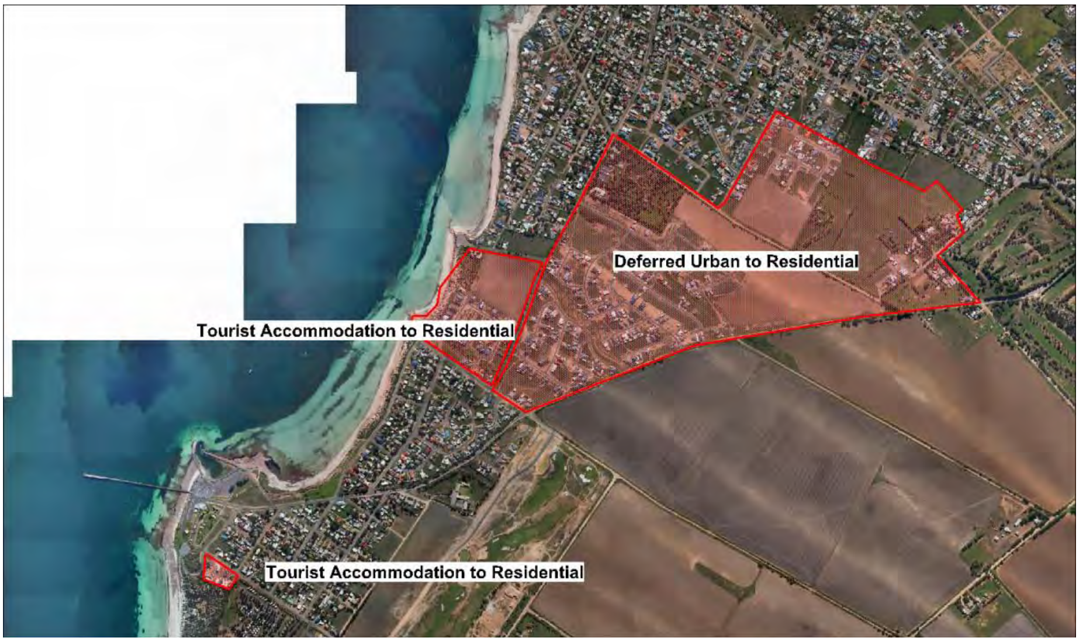
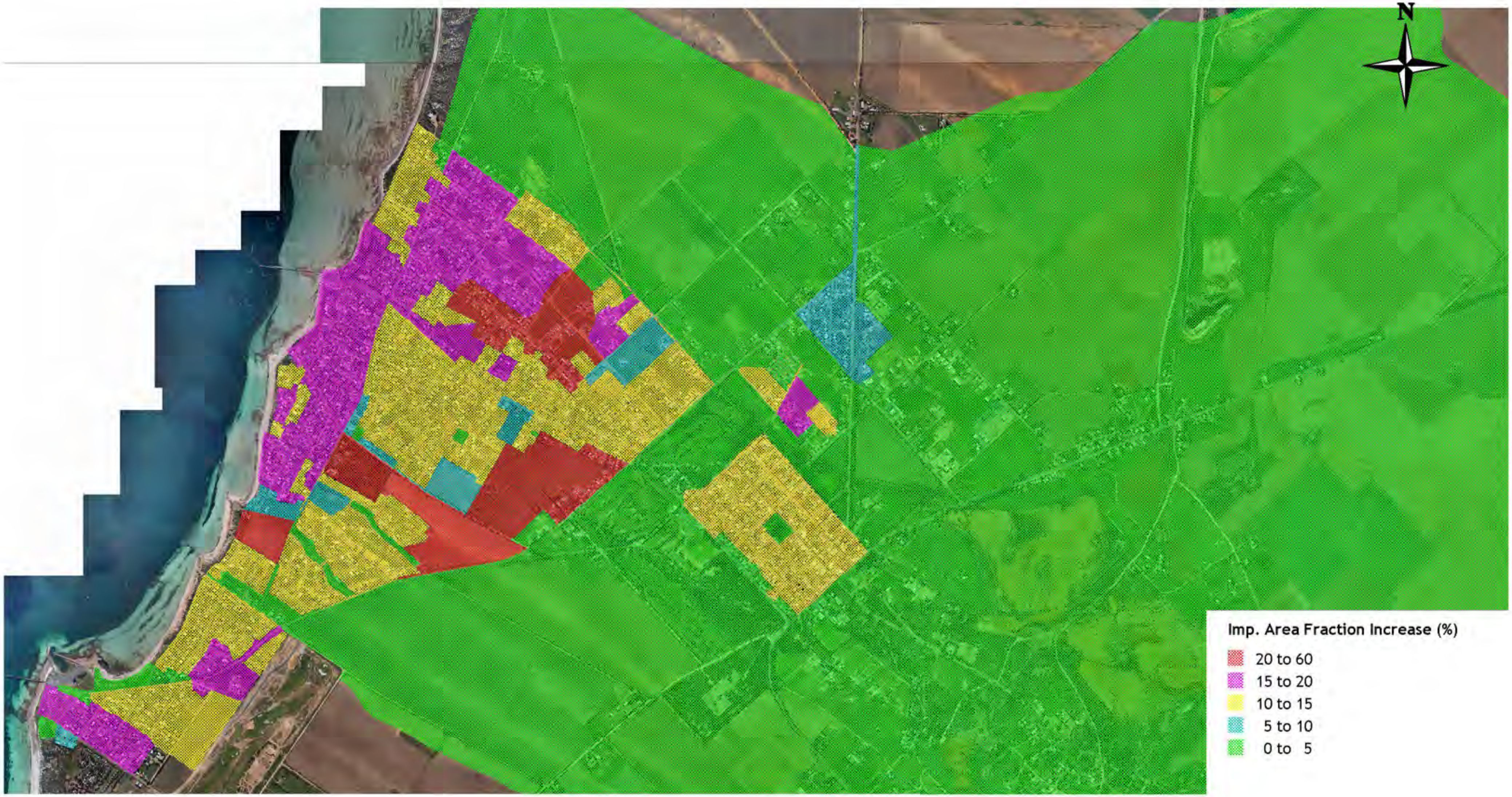


Figure 4.3 Proposed Rezoning as per Council BDP

Based on the results of the analysis it was found that there will be very minor increases (0- 5%) to impervious area fractions in rural areas, with moderate increases (5 - 15%) in recently developed urban areas, and high increases (>15%) in older urban areas as well as parcels of land earmarked for future re-zoning.

Figure 4.4 on the following page shows the distribution of increases to the directly connected impervious fractions as a result of the Future Development Scenario.

The increased impervious area fractions were input into the DRAINS model to generate hydrographs that could be applied in the Future Scenario floodplain mapping models.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Catchment Boundary)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 4.4
Future Increases to Impervious Area Fractions

4.2.4 Rural Catchment Areas

The rural catchments within the Study Area consist of long, thin catchments delineated by old sand dune formations to the east of Hughes Road in Catchments 6 and 7 as well as the northern parts of Catchment 1 and the large Moonta Mines Catchment (discussed separately in Section 5).

The estimation of the rainfall-runoff response of these catchments is challenging given the lack of suitable flow gauge information from local / representative catchments, and the sensitivity of the model results to the selected model parameters. For the purposes of this investigation, historical information was sought through a literature review and liaison with Council staff.

Flooding activity described in the *Floods in SA 1836 - 2005* publication has been compared to daily rainfall records from 1873 - 2012 at the Post Office on Ellen Street to determine if there is any correlation between rainfall depths and occurrences of flooding. Details are presented Table 4.4.

Table 4.2 Flood History and Rainfall Record Summary

Recorded Flood Date	Description	BOM Daily Rainfall	Comments
9-12 February 1869	Main street in township under 4 feet of water. Property damage both in the town and mine	Prior to BoM record for Moonta and Wallaroo	Event would be of interest if rainfall information was available. Newspaper article obtained highlights that property inundation did occur.
8-14 May 1875	Moonta reported as flooded. No other details provided.	Prior to BoM record for Moonta and Wallaroo	Insufficient information
18-26 March 1877	Flood damage reported in Moonta, Wallaroo and Kadina (among other townships). 6.5 inches of rain (165mm) reported at Wallaroo.	Prior to BoM record for Moonta and Wallaroo.	Newspaper article obtained highlights that property inundation did occur. Rainfall > 50mm.
21 September 1885	Rainfall in Moonta of 1.875 inches (47.6mm) led to flooding of some shops, houses and the mine.	47.5mm (matches Floods in SA reports) in Moonta, 25mm in Wallaroo	
11 June 1887	Heavy rains up to 900 points (317.5mm) caused flooding at Moonta.	Recorded rainfall was 27.7mm at Moonta, 13.2mm at Wallaroo.	It is likely the rainfall figure in the Floods publication is in error.
1-6 April 1889	Thunderstorms and widespread heavy rain measuring 4 - 5 inches (102 - 127 mm) reported in many districts of SA. Flood	Records show 90mm of rain over 4 days from 31 March to 3rd April 1889 with a peak of 53.1mm on April 2.	

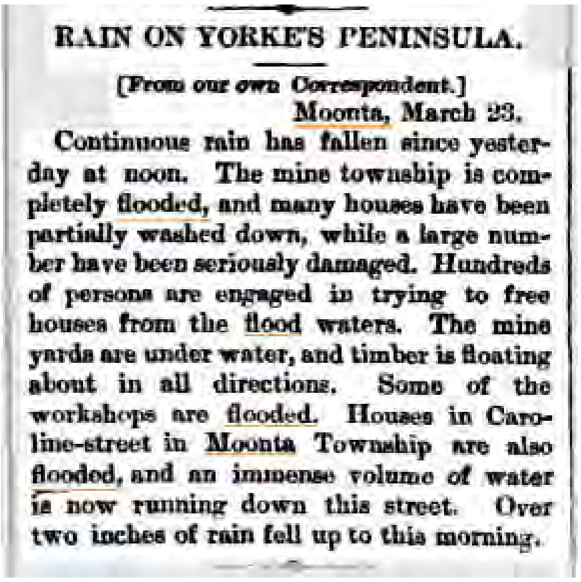
	damage reported in Moonta		
25-26 October 1913	Torrential rain and hail led to heavy floods in different parts of the State. Floods reported in the Kadina / Moonta district.	21.1mm recorded over 2 days on the 26th and 27th of October 1913.	

The Newspaper articles discussed in the Floods in SA publication are shown in Figures 4.5 and 4.6.

THE MOONTA FLOOD.

The *Wallaroo Times'* local correspondent gives a fuller description of this event, and we reprint it condensed:—"Towards 11 o'clock p.m. a watery pall of dull leaden hue overspread the heavens, and the downfall commenced, but about 12 the rain came down in torrents; in fact, a sheet of water almost seemed to descend. About half-past 2 the aspect outside was anything but cheering. The street was a foaming torrent, and in some places the water was from three to four feet deep. Large cases, which had been left outside business places, were sailing down the street at the rate of several knots an hour. People with lanterns, real and extemporised, were stirring about in a vain endeavour to keep the water out of their houses and shops, but it rose gradually inch by inch, until some of the occupants were up to their knees in their bedrooms and shops. The damage done has been considerable. The great proportion of the houses, shops, and cellars in George-street were inundated. At Mr. Jewell's grocer, many pounds' worth of goods have been damaged and destroyed. Mr. Turner, in the same line; Mr. Wigzell, the greengrocer; Mr. Pope, watchmaker and tobacconist; Mr. Ford, bootmaker; Mr. Beckmann, butcher; Mr. Common, bootmaker; Mr. Evers, baker and greengrocer; Mr. Jackson, bootmaker; Mr. Bentley, photographer; Mr. Grummet, hairdresser and mattrassmaker, have all been sufferers to a more or less extent, beside the great inconvenience caused by the invasion of the flood on their premises and in their habitations. In some instances those in bed had to beat a hasty retreat before the stern invader, and in getting out of a warm bed were treated to a cold bath. Roofs supposed to be stanch against all weathers on this occasion did not prove themselves trustworthy against the watery foe. Tanks sprung in all directions, creating impromptu showerbaths, which emptied their contents on those least prepared for the copious overhead descension. Fathers and mothers were carrying their offspring to neighbours' houses in hopes of better shelter. Dozens of persons were working with might and main to stop the ruthless enemy from further devastation. At a quarter past 2 o'clock you could not cross the street in any part in less than two feet of water. Some of the late erections which, it was thought, would be secure from injury, were assailed, if not from the street, from the sandhill at the back. The water came down the slope of the hill in torrents, inundating back premises and outbuildings. The Messrs. Drew kept the flood back from their cellar, which, had it entered, would have destroyed some hundreds of pounds' worth of goods, as the principal part of the stock there stored would have been totally destroyed by immersion, several tons of salt, sugar, and other perishable commodities being in stock at this time; they have sustained loss from goods which were in the yard, and which could not be got under cover. In the lower part of Ryan-street, where the water from George-street joins issue with that running down from the former street, the noise of the running streams was like that of a roaring torrent, and the luckless residents in that locality had a fearful visitation; many of them had to retire from their dwellings till daylight. A large number of men were about, and ready to lend assistance where required. Mine host of the Prince of Wales opened house for the refreshment of those who stood in need of the stimulant. In the morning George-street looked like the bed of a water-worn torrent. All loose matter had been washed from its surface, and the dust from the street, in the shape of mud, lay on the floors and shops of dwellings several inches deep. On the mine matters were quite as bad as in the township, numbers of the residents there having been washed out of their dwellings, and I heard to-day that one house had been washed away or fallen down.

Figure 4.5 South Australian Register, Monday 15 February 1869



RAIN ON YORKE'S PENINSULA.

[From our own Correspondent.]

Moonta, March 23.

Continuous rain has fallen since yesterday at noon. The mine township is completely flooded, and many houses have been partially washed down, while a large number have been seriously damaged. Hundreds of persons are engaged in trying to free houses from the flood waters. The mine yards are under water, and timber is floating about in all directions. Some of the workshops are flooded. Houses in Caroline-street in Moonta Township are also flooded, and an immense volume of water is now running down this street. Over two inches of rain fell up to this morning.

Figure 4.6 South Australian Register, Friday 23 March 1877

Analysis of the BOM records at shows that the highest recorded daily rainfall was 94.7mm in 1946 (139mm over 2 days). 146mm was recorded for the corresponding day in Wallaroo (164mm total over 2 days). This event was not reported in the Adelaide papers, or in the Floods book, although it should be noted that this storm event severely affected many parts of the State and hence the possibility that flooding occurred at Moonta cannot be discounted.

The records also show that there were 29 days with rainfall above 40mm. Only one of those instances (2nd April 1889 - 53.1mm) was recorded in the Flood History of SA publication. Days with rainfall exceeding 40mm are shown in Table 4.5 below.

Table 4.3 Rainfall Days Exceeding 40mm

Year	Month	Day	Recorded Rainfall (mm)
1946	February	18	94.7
1997	October	31	60.8
2010	March	9	60.2
1919	February	16	55.9
1944	April	8	54.6
1889	April	2	53.1
1909	April	20	53.1
1939	November	3	51.3
1903	March	9	49
1946	December	25	48.8
1973	February	6	48.5
1918	October	7	48.3

1885	September	22	47.5
1921	March	1	47.5
2000	February	21	47.2
1910	May	26	47
1941	January	25	46.7
1980	October	6	45
1946	February	17	44.7
1917	February	21	43.9
1963	October	27	43.9
1991	June	3	43
1991	June	11	43
1889	April	17	42.7
1893	May	30	42.2
1997	September	2	42
1893	May	29	41.9
1921	May	23	41.9
1928	February	1	41.7
1946	February	18	94.7

It would appear that there have been a number of 24 hour rainfall events in the range of 40 – 60 mm (2 to 10 year ARI 24 hour duration) that have not produced significant flows from the rural catchments, however there remains some uncertainty as to the initial loss associated with rainfall events exceeding 60mm (greater than 10 year ARI 24 hour duration).

Following hydrological modelling (using the RORB model) for a range of loss values, an 80mm initial loss and a 4 mm continuing loss was selected. The sandy soils generally have a relatively high hydraulic conductivity which supports the adoption of relatively high losses in the model. The initial loss chosen is also consistent with that which would be expected based on the analysis of flood history records described above.

The continuing loss is at the upper end of the 2.5mm - 4mm design loss rate range provided in AR&R for the South Australian Humid (Mediterranean) Zone.

The results of the RORB modelling using the loss values described above for Catchments 6 and 7 are shown in Table 4.2.

Table 4.4 RORB Modelling Results

ARI (yrs)	Catchment 6 Peak Flow - (m^3/s)	Catchment 7A Peak Flow - (m^3/s)	Catchment 7B Peak Flow - (m^3/s)	Catchment 7C Peak Flow - (m^3/s)
10	0	0	0	0
20	0.018	0.011	0.003	0.003

50	1.14	0.78	0.44	0.46
100	3.82	2.81	1.78	1.85

The RORB results show no rural catchment contribution for ARI events of 10 years and less, and only minimal contributions for the 20 year ARI event. These results reflect the expectations of DPTI Stormwater Services staff communicated during the approval process for the rural catchment hydrological parameters. The 50 and 100 year ARI flow rates generated in RORB are of a magnitude which is considered to be appropriate in order for the flood plain modelling to reflect some vulnerability to low lying land downstream of the rural catchments.

4.2.5 IFD Rainfall Data

Design Intensity Frequency Duration (IFD) data has been prepared for the Study Area utilising the online procedure provided by the Bureau of Meteorology (http://www.bom.gov.au/water/designRainfalls/ifd/index.shtml). This data is presented in Table 4.5.

Table 4.5 Moonta Rainfall Intensity (mm/hr) Frequency Duration Data

Duration	Average Recurrence Interval (ARI) (years)						
	1	2	5	10	20	50	100
5 mins	37.8	51.9	75.2	93.3	118	157	192
6 mins	35.2	48.2	69.8	86.5	109	145	177
10 mins	28.3	38.6	55.6	68.7	86.6	114	139
20 mins	20.1	27.4	39.0	47.8	59.9	78.7	95.5
30 mins	16.0	21.8	30.8	37.6	47.0	61.5	74.4
1 hour	10.5	14.2	19.8	24.1	29.9	38.9	46.9
2 hours	6.65	8.96	12.4	15.0	18.6	24.0	28.8
3 hours	5.06	6.81	9.40	11.3	14.0	18.0	21.5
6 hours	3.16	4.25	5.81	6.96	8.54	10.9	13.0
12 hours	1.96	2.63	3.56	4.25	5.18	6.60	7.84
24 hours	1.19	1.58	2.13	2.53	3.07	3.90	4.61
48 hours	0.688	0.91	1.22	1.44	1.74	2.20	2.59
72 hours	0.481	0.639	0.851	1.00	1.21	1.52	1.79

4.2.6 Hydrograph Production

The DRAINS model was executed for a range of Average Recurrence Interval (ARI) events to generate the urban catchment hydrographs necessary for input to the TUFLOW floodplain model. The hydrographs within the rural catchments were extracted from RORB.

5 Moonta Mines Catchment

5.1 Catchment Description

The Moonta Mines Catchment covers an area of 1650 ha to the north and east of the Moonta township as shown in Figure 5.1. The area forms the largest rural catchment within the Study Area and contains vegetated agricultural areas as well as more barren land within the abandoned Moonta Mines. The topography of the catchment has a general fall to the south and to the west, with runoff travelling overland towards the main drain to the north of the township.

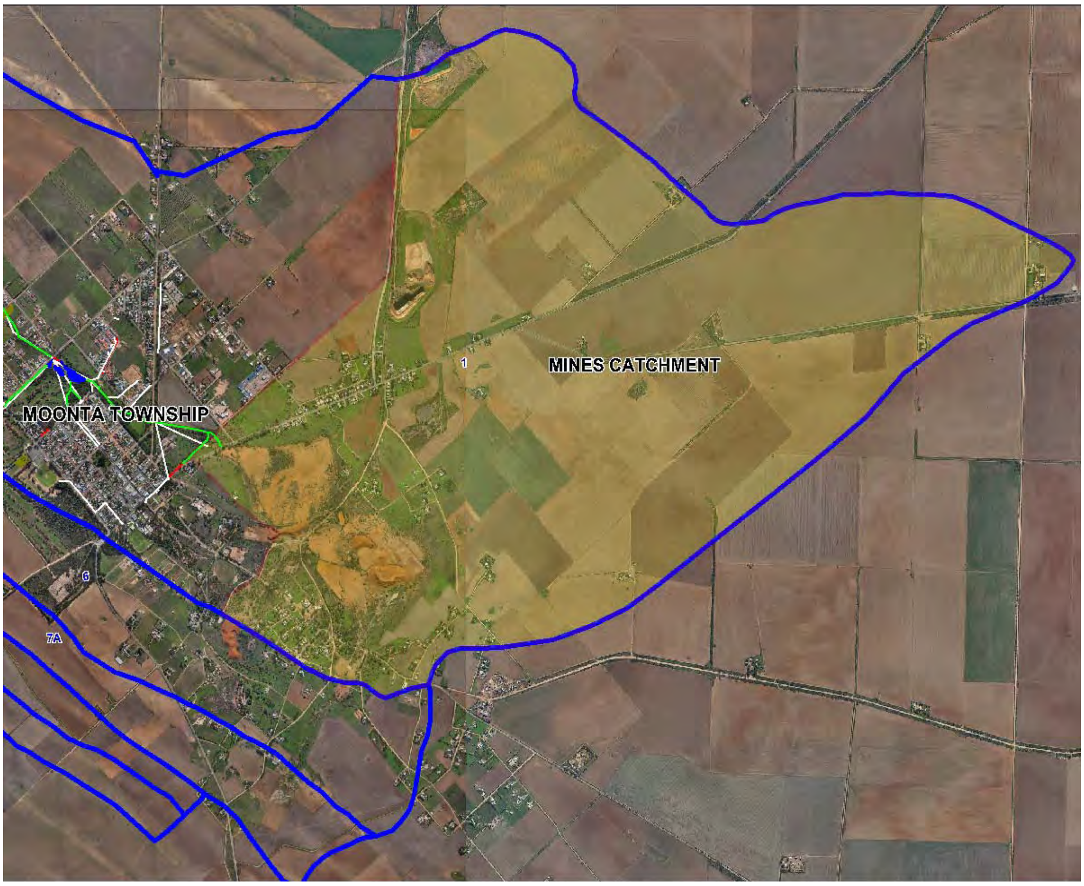


Figure 5.1 Moonta Mines Catchment Boundary

The catchment contains no visible watercourses and has no formal stormwater infrastructure. There is an earth bund (shown right) approximately 1 metre high near the boundary of the Moonta - Kadina Road. A site inspection from the road adjacent to the bund revealed that silt has built up behind the bund to a level that is almost level with the top of the embankment, such that it would now have little capacity to retain flows. The area is fenced off and public access is restricted.

5.2 Ownership

The Moonta Mines is a disused site that is understood to be owned by Crown Lands (DEWNR) and under the care and control of the National Trust.

Council intends on corresponding with the land owner as part of this Stormwater Management Plan.

5.3 Water Quality

Based on discussions with various stakeholders, there is a possibility that runoff being discharged from the Mine Site is contaminated. However the nature and degree of contamination is not currently understood. Confirmation of this issue would require water quality testing to be undertaken which is outside the scope of this Plan. There is clearly also an issue associated with the transport of silt from the mine site, with a plume of deposited silt visible downstream of the mine site (refer below).

Discharge from Historic Mines Area

Overflow from the Moonta Mines site discharges to the main open channel within Catchment 1 which flows into wetlands in Clem McAuley Park. Anecdotal evidence suggests that some small discharges are discharged from the mine site several times each year.

5.4 Hydrological Modelling

Flows from the broader Moonta Mines catchment were modelled in RORB, in a similar fashion to the other rural catchments within the Study Area. The catchment was broken down into several sub-catchments due to its size and the variation in soil conditions between the Mines area and the agricultural areas. Two sets of losses were used in the model. The agricultural areas were modelled with an initial loss of 80mm and a continuing loss of 4 mm, while the historic Mines area was modelled with an initial loss of 55mm and a continuing loss of 3 mm.

The modelling assumed that the mitigating effect of the earth bund is negligible due to the large amount of siltation present and small storage volume available relative to the size of the broader catchment.

The model was established to output a hydrograph at the entrance to the open channel that runs around the northern perimeter of the central township area. This was undertaken to allow the runoff from the catchment to be factored into the floodplain mapping.

5.5 Impact on Moonta Township

The results of the RORB modelling using the loss values described above for the Moonta Mines Catchment are shown in Table 5.1.

Table 5.1 RORB Modelling Results - Moonta Mines

ARI (yrs)	Moonta Mines Peak Outflow - (m^3/s)
10	0.03
20	0.85
50	3.6
100	11.0

The results show that significant contributions from the broader catchment area occur for events greater than a 10 year ARI. These results reflect the expectations of DPTI Stormwater Services staff communicated during the approval process for the rural catchment hydrological parameters, and the known flood history. The 50 and 100 year ARI flow rates generated in RORB are of a magnitude which is considered to be appropriate in order for the flood plain modelling to reflect some vulnerability to low lying land downstream of the Moonta township.

5.6 Summary and Recommendations

This investigation has identified that the Moonta Mines Catchment area has a significant impact on stormwater management through the downstream township, in relation to:

- The generation of very high rates of flow during major flood events, that would appear to be well beyond the capacity of the downstream drainage system
- The generation of potentially contaminated runoff, which may have impacts on the downstream ecology, groundwater, and reuse potential of stormwater stored in downstream basins and wetlands.

Further work is required to develop strategies to address these identified issues, particularly in relation to water quality. This work will require the owner of the mines site developing a stormwater strategy such that improved stormwater management practices can be implemented, that satisfy their obligations as defined by the *Environment Protection Act 1993* and the *Environment Protection (Water Quality) Policy*.

Council has a direct interest in ensuring that these obligations are met, in order to maximise opportunities associated with harvesting and reuse, and to reduce de-silting maintenance activities within the open channels.

6 Assessment of Existing Drainage Performance

6.1 Existing Drainage Performance

The DRAINS model of the existing drainage system has been executed for the 1, 2, 5, 10, 20, 50 and 100 year ARI storm events.

Drainage system 'failure' was defined as occurring whenever the hydraulic grade line level exceeds the corresponding surface level. The performance standard at drainage nodes (ie. the corresponding ARI at which the DRAINS model reported this to occur) is illustrated in Figure 6.1. It should be noted that it is generally desirable for underground drainage networks to achieve performance standards of a 2 - 5 year ARI.

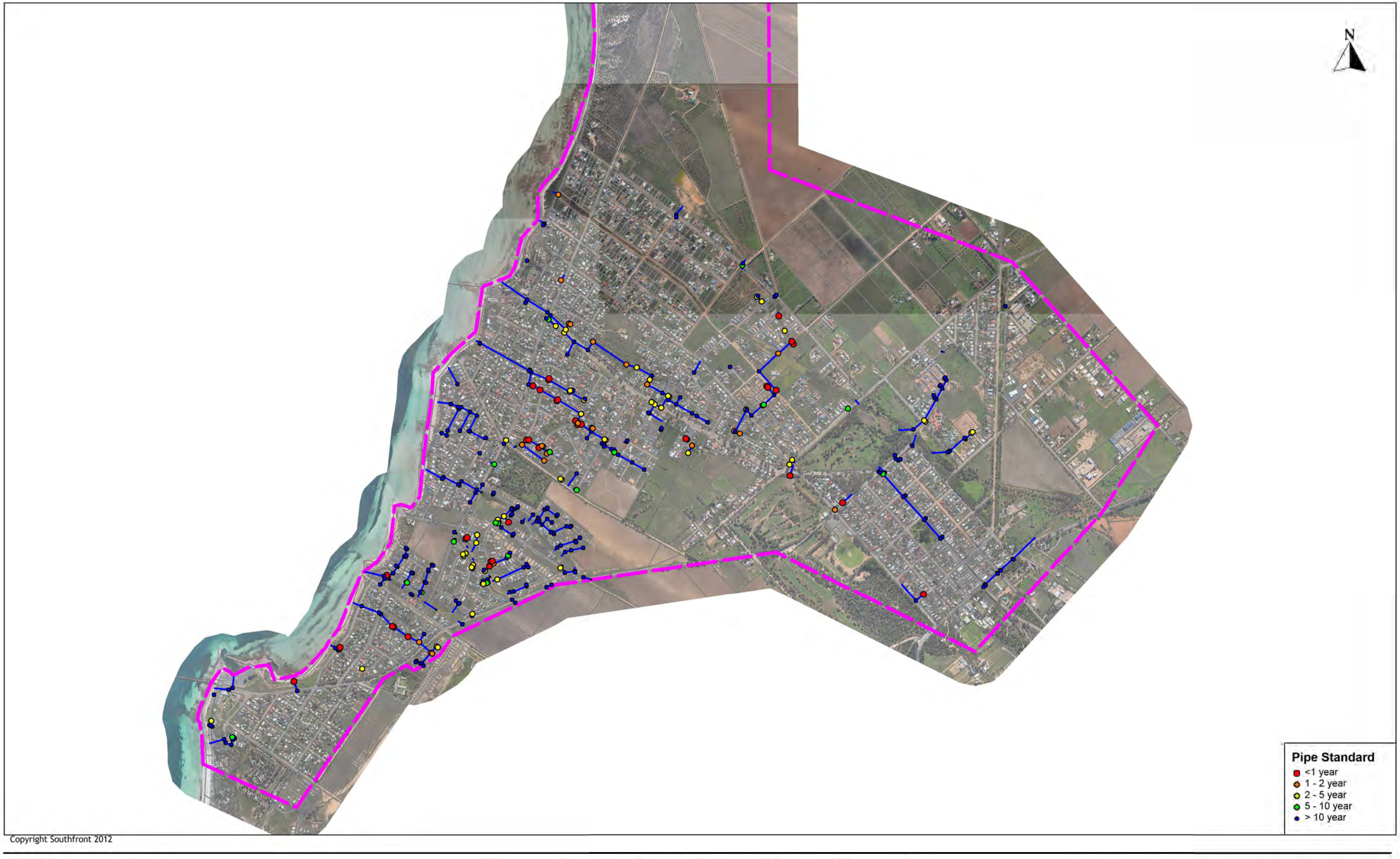
The capture capacity of the existing side entry pits was also assessed by analysing the magnitude of the 5 year ARI approach flows. Figure 6.2 depicts pit locations that experience 5 year ARI approach flows in excess of 100L/s.

The results of the pit and pipe capacity assessment were combined to identify drainage networks that have a low overall performance standard. Table 6.1 lists the existing drainage networks that were assessed to perform below the 5 year ARI target performance standard.

Table 6.1 Existing Underground Drains, < 5 year ARI Standard

Catchment	Drains with Insufficient Performance Standard
1	Ellen Street, Frances Street, Moonta Road, George Street, Majors Road, James Street, North Terrace
2	Moonta Road (outlet)
3	Marine Parade
4	Bay Road, Challa Ct, Martin Street, Roach Court, Victoria Street, Coast Road
5	Lyndon Avenue, Nankivell Street, Westside Avenue, Highview Grove, Loller Street
6	Rossiters Road, Stocker Street, Tipara Court
7A	Trelawney Street, Moontana Avenue, Bray Street
7B	Trembath Street
7C	Richards Terrace, Trenerry Place
8	Minnipa Drive, Minnie Terrace, Cowling Court, Snell Avenue, Dowling Drive
9	N/A
10	Minnie Terrace
11	Port Hughes Beachfront Carpark

It should be noted that the process adopted for the assessment of drainage standards is suitable for the identification of deficiencies in areas containing existing drainage infrastructure. The assessment of areas lacking in drainage infrastructure was undertaken using floodplain mapping which is discussed in Section 7.

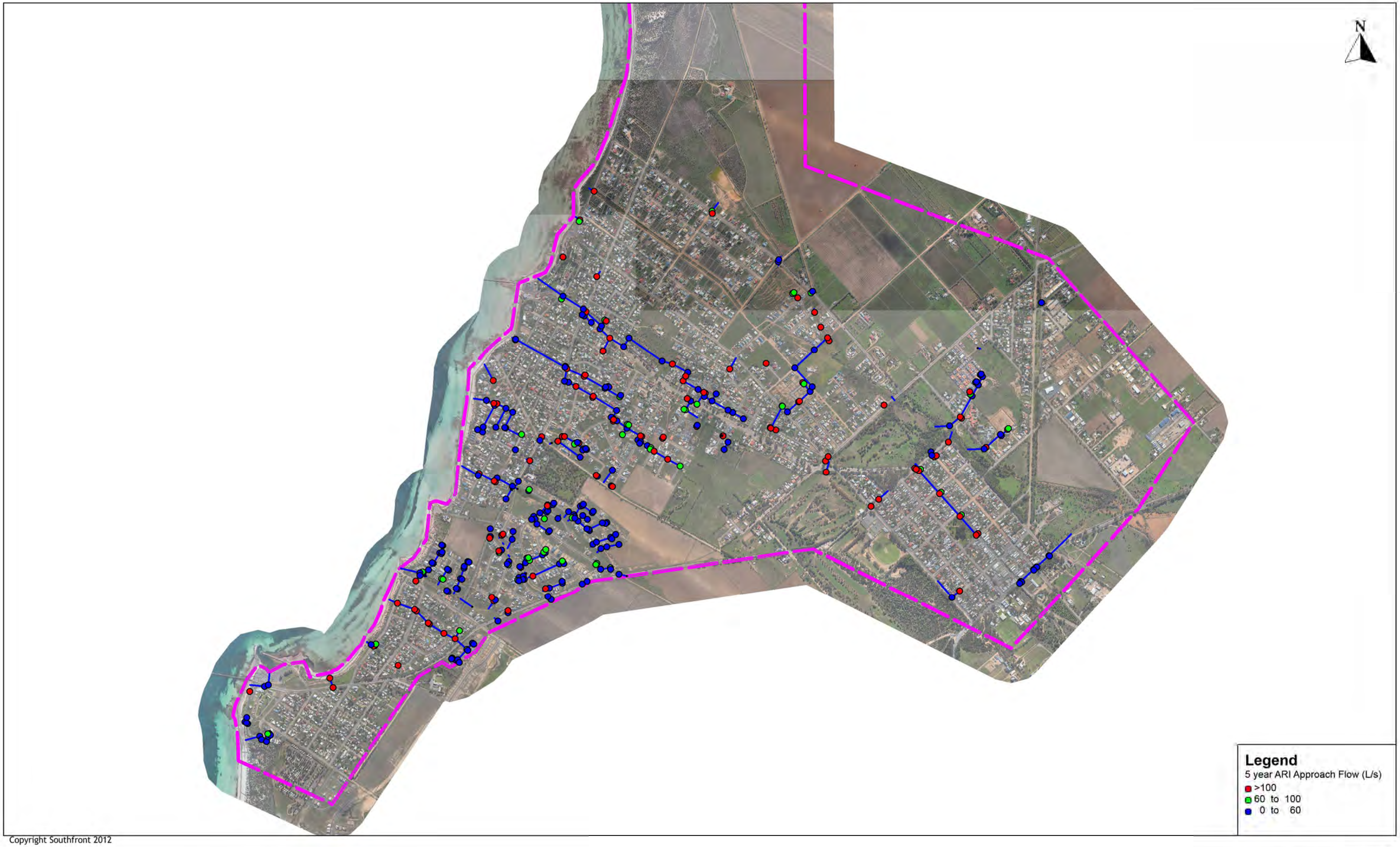


Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Drainage Layout)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 6.1
Pipe Standards Map



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Drainage Layout)

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

Figure 6.2
5 year ARI Approach Flow

7 Floodplain Mapping

7.1 General

Floodplain mapping of the Moonta Study Area was broken up into two separate model domains; Catchments 1 to 4 and Catchments 5 to 11. This was done to allow the models to be run with a finer grid size (improving accuracy and resolution) than would be possible using a single model domain.

The floodplain model boundaries are shown in Figure 7.1, below.

Figure 7.1 Moonta Floodplain Model Boundaries

7.2 Modelling Software

Hydraulic floodplain modelling was carried out using the TUFLOW (and ESTRY) computer program jointly funded and developed by BMT WBM and The University of Queensland in 1990. TUFLOW (Two-dimensional Unsteady FLOW) is specifically orientated towards establishing flow and inundation patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow behaviour is essentially 2D in nature and cannot or would be awkward to represent using a 1D model (BMT WBM, 2010).

A powerful feature of TUFLOW is its ability to dynamically link to 1D networks using the hydrodynamic solutions of ESTRY. The user sets up a model as a combination of 1D network domains linked to 2D domains.

The TUFLOW and ESTRY computational engines use third party software as their interface. These software are typically a text editor (eg. UltraEdit), GIS platform (eg. MapInfo), 3D surface modelling software (eg. Vertical Mapper) and result viewing (eg. SMS).

The TUFLOW model is based on the Stelling (1984) solution scheme, which is a finite difference, Alternating Direction Implicit (ADI) scheme solving the full 2D free surface flow equations. The ESTRY model is based on a numerical solution of the unsteady momentum and continuity fluid flow equations (BMT WBM, 2010).

The models were developed so that the underground stormwater drains and pits were modelled in 1D using ESTRY, while the floodplain on the surface was modelled in 2D using TUFLOW. The pit and pipe network was hydro-dynamically linked to the floodplain, allowing flows in both domains to interact.

The model area was divided into fixed rectangular cells that can be either wet or dry during a simulation. The model had the ability to simulate the variation in water level and flow inside each cell once information regarding the ground resistance, topography and boundary conditions was entered.

7.3 Floodplain Modelling

7.3.1 Modelling Scope

The scope of this Study involved floodplain mapping the 10 year, 20 year, 50 year and 100 year ARI events. Various storm durations were modelled within each ARI event in order to determine the critical durations for each event. The storm durations modelled across all ARI's ranged from 30 minutes to 18 hours.

7.3.2 2D Cell Size

Determining an appropriate 2D cell size to be used by TUFLOW requires a compromise between the accuracy of modelling necessary to sufficiently reproduce the hydraulic behaviour of the floodplain as well as limitations in computing power and processing time. A detailed understanding of the requirements of the Study was also required. In this instance, the Study is a broad scale catchment wide analysis which aims to identify potential flooding hotspots. A detailed site specific analysis on flooding depths at individual property level was not required.

A 2 metre cell size was chosen for these models as this size allowed for at least 3-4 cells to fit within the width of most major overland flow paths such as roads. Given the size of the 10.3 km^2 model area (7.4 km^2 for Catchments 1 - 4 and 2.9 km^2 for Catchments 5 – 11), the 2D domain consisted of approximately 2.6 million cells (1.85 million and 0.75 million cells respectively).

Using a smaller cell size such as 1 metre would increase the number of cells required to 10.3 million which would drastically increase run times and provide minimal benefit in terms of model resolution. Using a larger grid size such as 3 metres would reduce model run times, however it is expected that there would be an accompanying decrease in model resolution and accuracy.

7.3.3 Time Step

The time step selection in the 2D domain is an important aspect of TUFLOW modelling as it is directly proportional to the running time of a model. A small time step will create more accurate results and is less likely to cause instabilities, however the simulation time can often stretch to days for long duration storm events. On the other hand, a large time step will shorten simulation times but may lead to meaningless results.

A general rule for TUFLOW models (although this is not a necessity) is to use a time step (in seconds) equal to approximately half the cell size (in metres). For both models, the time step used was 1 second.

It should be noted that 99% of the computational effort is in solving the 2D surface flow equations and hence the impact of the time step on simulation times is negligible in the 1D domain. Thus the 1D ESTRY time step for all models was set to 1 second.

7.3.4 Topography

A DTM of the Moonta catchment was provided by Aerometrex as described in Section 2. The DTM was used to assign elevations to individual cells within the 2D domain. These elevations are assigned at the cell centres, corners and mid-sides to enable interaction with surrounding cells.

7.3.5 1D Domain Pipe Network

The 1D domain was constructed from drainage construction plans as well as the information output from the DRAINS model. Drain diameters were extracted out of the data provided. However, the drainage information provided was incomplete. Where construction plans were unavailable, pipe and culvert inverts for each drain segment were determined based on the surface levels extracted from the DTM, an assumed level of cover for each drain, and an assumed minimum longitudinal gradient. Enabling a successful interaction between the 1D and 2D domains required significant effort to be invested into achieving a high level of spatial accuracy of the various modelled elements, for example ensuring drain and pit alignments were in the correct position within sag points of the road.

7.3.6 Resistance Parameters

The bed resistance is an essential element used to define the flow and hence the water depth at any location within the 2D model domain. In TUFLOW, bed resistance values for 2D domains are most commonly created by using GIS layers containing polygons with varying Materials values. The Materials values specified in GIS correspond to a user defined Manning's n value described in the Materials File. This approach allows for a relatively quick and simple adjustment of Manning's n values, especially during model calibration.

The bed resistance values used in the modelling for both the Moonta model is specified in Table 7.1.

Table 7.1 Bed Resistance Parameters

Type of Land Use	Manning's Roughness Coefficient
Residential / Commercial Development	0.200
Roads	0.030
Sparsely Vegetated Open Space	0.050
Railway	0.040

Densely Vegetated Open Space	0.070
Dam, ponds	0.025
Creek	0.060

It should be noted that relatively high values of Manning's n are used for residential and commercial development to compensate for the lack of building envelopes in the DTM.

The Manning's n value used for modelling of underground drains was 0.012.

7.3.7 Boundary Conditions

As part of the modelling, consideration was given to the boundary conditions within the 1D and 2D domains.

The 1D boundary conditions are the side entry pits which allow flows to travel between the 1D domain (underground drainage system) and the 2D domain (ground surface defined by the DTM).

Within the 2D domain, the boundary condition is the edge of the model along the coastlines. The boundary condition adopted in the 2D domain was a "HQ" (stage-discharge) type boundary with a water surface slope of 1%. The ground levels of flood plains with ocean outfalls are well above the influence of high tide levels.

The purpose of this approach was to allow water to "disappear" once flood flows reached the model boundaries and ensure that results in the floodplain were not affected at model edges.

7.3.8 Inflows

The inflow hydrographs at each inlet were derived from the DRAINS and RORB catchment modelling. The hydrographs for each storm event were applied as either point inflows at the inverts of each pit within the 1D domain or as surface inflows directly into the 2D domain where catchments are not serviced by underground drainage infrastructure. This approach ensured that the entire inflow hydrograph for each pit was applied to the underground drainage network system.

Due to the hydro-dynamic links between the 1D and 2D domains, this arrangement allowed for flows equal to or smaller than the pipe capacity to travel within the underground network, while flows exceeding the pipe capacity spilled onto the surface and travelled overland within the 2D domain.

7.4 Flood Plain Mapping Results

7.4.1 Scenarios Presented

The results of the TUFLOW modelling were analysed to determine the critical durations for each ARI. It was found that the flooding extents in various parts of the catchment differed based on the storm duration that was modelled. Therefore, the results presented in the floodplain maps are based on a combination of critical events, and can be assumed to represent the worst case scenario or flood envelope for each ARI. The critical storm durations for each ARI are shown in Table 7.2.

Flood plain mapping was undertaken for two separate scenarios as shown in Table 7.3.

Table 7.2 Critical Storm Durations for each ARI

Average Recurrence Interval	Critical Storm Durations
10 year	30 min, 2hrs, 9 hrs
20 year	30 min, 2hrs, 9 hrs
50 year	30 min, 2hrs, 18 hrs
100 year	30 min, 2hrs, 18 hrs

Table 7.3 Floodplain Mapping Scenarios

Scenario	Assumptions
Existing	Existing infrastructure with existing levels of development (assuming all currently vacant allotments have been developed)
Future	Proposed drainage upgrades modelled with the ultimate level of development as per planned re-zoning and infill development expected over a 30 year horizon

7.4.2 Flood Plain Maps

A1 format flood plain maps for each ARI and scenario have been prepared and are presented in Appendix B (8 maps in total). The maps show flooding depths and extents overlaid over information such as aerial photography, cadastral boundaries, roads, and the existing underground stormwater network. Inundation depths are presented in layered colour ranges as per Figure 7.2.

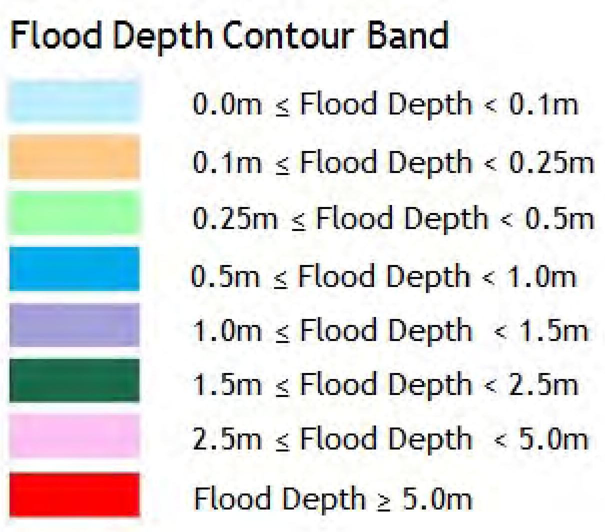


Figure 7.2 Floodplain Map Inundation Depth Colour Range

7.5 Flood Inundation Extents - Existing Scenario

7.5.1 10 Year ARI

The 10 year ARI floodplain map shows areas of shallow flooding that is mostly contained within the road network throughout the main township district. The two areas where flood flows break out of the road network occur between Ellen Street and Milne Terrace where inundation up to 500 mm deep is observed as well as within Queen Square where shallow flooding up to 100 mm deep is depicted on the map.

Within Catchment 1 there is flooding shown up to 250 mm deep along Old Wallaroo Road, Crutchett Road and Majors Road from the breakout of floodwaters from the main open drain to the north of Blyth Terrace. Flooding up to 500 mm deep is shown in the new subdivision to the north of the Moonta Health and Aged Care Service, however this is likely to be from the fact that the DTM was flown at a time when the new subdivision had been excavated out in preparation for roadway construction, forming a localised depression.

There is significant flooding between 250 mm and 500 mm deep shown within the low lying areas between Haylock and Chapman Roads that extends beyond the informal channel and into several properties. Flooding is also present in the recently constructed subdivision between Narranga Terrace and Moonta Road.

At the downstream end of Catchment 1, shallow flooding can be seen along North Terrace and the existing pond to the north of the township overflows to the first of the two major depressions in the north western corner of Catchment 1.

Moderate flooding extents are shown within Catchment 2 as water breaks out of the northern side of Moonta Road and into a number of residential properties. Flood depths between 0.25 m and 0.5 m are shown in a number of properties between Carlisle Street and Coast Road, however the majority of flooding is generally shallower than 0.1 m.

Shallow surface flooding within Catchment 4 is shown to the north of Bay Road, particularly in the depression behind properties 130 to 156. These flows deepen at Recreation Road, where flood depths of up to 0.25 m are shown over approximately 4 residential properties.

Moderate flooding is shown within Catchment 5 at the depression near the intersection of Stocker Street and Nankivell Street. Flood depths of over 0.5 m are shown within the road reserve, with flooding of between 0.1 and 0.25 m over approximately 12 nearby residential properties. Modelling shows shallow flood depths along the length of Nankivell Street, Westside Avenue and Lollier Street (downstream of the existing detention basin) affecting a further 6 residential properties.

Catchment 6 shows large areas of shallow surface flooding. Relatively deep flooding of up to 0.5 m is shown building up against the eastern side of Coast Road, and areas of shallow flooding between Rossiters Road and Stocker Street. Widespread shallow flooding downstream of Coast Road indicates a lack of defined flow paths through this catchment to the coast, with over 25 residential properties on Moontana Avenue, Trelawney Street, Tipara Court and Kemp Place shown to be affected by flood waters of less than 0.25 m.

Flood flows in Catchments 7A, 7B and 7C are generally contained within designated swales, particularly within the newer developments upstream of Coast Road. Deep ponding is shown within the series of swales and detention basins along Hicks Street, Bray Street and Harrys Point Road. A small break out of flood waters is shown on Francis Place affecting up to 3 residential properties. Flood waters are shown to be travelling through a paddock adjacent to Simms Cove Road which forms the outlet to the swale of the upstream development.

Shallow flooding is shown of a through the valleys of Catchments 8 and 9, with flood water of up to 0.1m encroaching onto approximately 15 properties between Furner Crescent and Dowling Drive. Approximately 4 properties are affected by flood waters of up to 0.25m in depth.

Minor flooding near coastal outlets is shown in Catchments 10 and 11 as water overtops Minnie Terrace and passes over the reserves onto the beach.

7.5.2 100 Year ARI

The 100 year ARI floodplain map shows a noticeable increase in flood depths and extents when compared to the 10 year ARI results. There are now significant areas of flooding with depths between 0.1 m to 0.5 m, as well as 0.5 m to 1 m.

Within Catchment 1 there is significant flooding from the channel breakout downstream of the Moonta - Kadina Road. Flooding on Crutchett, Majors and Old Wallaroo Road is present with inundation depths of up to 500mm. There is flooding evident within the Moonta Hospital and the new subdivision to the north of the hospital experiences inundation up to 1.5 metres deep.

Many properties within the main township district that were not inundated during the 10 year ARI event are now shown to be inundated.

The flooding depths and extents are also increased between Haylock and Chapman Roads, as well as the new subdivision between the Narangga Terrace and Moonta Road.

Most properties adjacent to North Terrace become inundated with floodwaters between 100 mm and 250mm. Both of the depressions to the north west of Catchment 1 are shown inundated to depths up to 1.5 metres.

The vast increase in floodplain extents within Catchment 1 can be partly attributed to the Moonta Mines catchment contribution with a peak flow off the old mine site of 11 m^3/s. catchment did not contribute in the 10 year ARI event.

Flood levels within various depressions throughout the township are shown to have significantly increased in the 100 year ARI event, particularly Moonta Road (between Carlisle Street and Coast Road), Recreation Road, Nankivell Street, Rossiters Road (east of Coast Road), and the swales/detention basins of the new developments of Catchments 7A, 7B, 7C and 8.

Flooding of up to 0.5 m is evident in residential properties near the intersection of Bay Road and Roach Court, as well as Martin Street.

Modelling indicates flooding of up to 0.5 m downstream of the Bray Street detention basin, with inundation of approximately 15 residential properties.

The large rural catchments of Catchments 6, 7A, 7B and 7C are shown to be contributing flows in the 100 year ARI event, with increased flood depths within swales and detention basins. Flooding within the depression of Rossiters Road (near the intersection with Kitto Road) is shown to have significantly increased due to the rural contribution due to the lack of underground drainage in this region, with flood depths of up to 1 m covering a large area of rural land. Flood waters are also shown encroaching on a number of properties within Kitto Road and Bowyer Court.

7.5.3 20 and 50 Year ARI

As expected, the 20 and 50 year ARI floodplain maps show flooding depths and extents that generally lie between those shown on the 10 and 100 year ARI event maps. The large rural catchments contribute very little in the 20 year ARI event, and a significant amount in the 50 year ARI event.

7.6 Structural Flood Mitigation Options

Upgrades to the existing drainage network were developed based on the interrogation of the pit and pipe standard maps discussed in Chapter 6, as well as the analysis of the "existing scenario" floodplain maps.

The proposed drainage upgrades were modelled in TUFLOW as part of the "future scenario" floodplain mapping exercise which assessed the impact of increased runoff from future development based on increased impervious areas as discussed in Section 4.2.

It should be noted that many of the proposed drainage upgrades also contain WSUD elements which are discussed in more detail in Section 8.

The proposed drainage layouts and sizes shown in this section correspond to the input data used within TUFLOW to satisfy a minimum 10 year ARI performance standard, with 10 years being the smallest ARI adopted for the preparation of floodplain maps as part of this SMP. It should be noted that each upgrade concept is subject to change during the detailed design stage which is likely to be based on more detailed survey, a different performance requirement (with a 2 - 5 year ARI standard being the most common for underground drainage) as well as the impact of other services along the proposed alignment.

The "future scenario" floodplain maps are shown in Appendix B. These maps show greatly reduced floodplain extents for each ARI, although total elimination of property flooding was not achieved even in the 10 year ARI event. This is because a balance was sought between the extents and costs of potential upgrades and the likely flood protection benefit.

Upgrade Concept Diagrams

Basic diagrams have been produced to provide an overview of the upgrade concepts developed during this SMP. The legend used in creating these diagrams is shown in Figure 7.3.

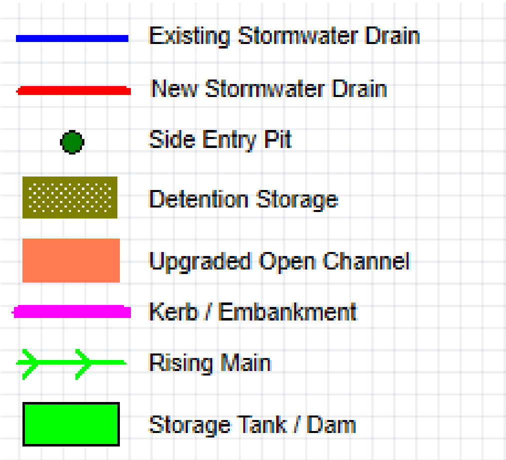


Figure 7.3 Upgrade Concept Diagrams Legend

George / William Henry Street

The existing 1200 x 600 culvert in George Street is proposed to be extended further upstream with a 675 mm diameter drain to Ellen Street. New connecting drains from the existing George Street culvert have also been proposed to capture flows on William and Henry Street with 525mm and 750 mm diameter drains, respectively.

The proposed upgrade has been implemented to reduce overland flow paths as well as provide a conduit to direct stormwater to the proposed harvesting and reuse tanks in Queens reserve which are discussed in more detail in Section 8.

The proposed works are shown in Figure 7.4.

Figure 7.4 Proposed Works, William / Henry / George Street

Figure 7.5 Proposed Works, Caroline Street to Milne Terrace

Caroline Street to Milne Terrace

It is proposed to upgrade the existing drain from Ellen Street to Milne Terrace by construction of a bypass from Caroline Street to Victoria Park.

The bypass drain increases from a 450 mm diameter drain at the upstream end to a 750 mm diameter drain at the outlet. The proposed upgrade connects to the existing drain which passes under a topographical peak on the corner of Milne Terrace and Ellen Street. A number of additional side entry pits have been proposed to complement the proposed drainage upgrade and reduce the potential for flooding of properties between Ellen Street and Milne Terrace.

Discharge from the upgraded network is proposed to be harvested and reused to water the adjacent oval as discussed in Section 8.

The proposed works are shown in Figure 7.5.

Caroline Street to Robert Street

The existing single side entry pit and 300mm diameter drain on Frances Terrace is the only stormwater infrastructure present within this 9 ha catchment.

The proposed upgrade consists of a new underground network from Caroline Street to Robert Street consisting of a 600 - 750mm diameter drain discharging into the Ivan Polgreen Memorial Park. This proposed drain will carry capture excessive surface flows and divert them away from properties to the south of the Park which are prone to flooding.

A 525 mm diameter drain from Caroline Street to Frances Terrace has also been proposed to provide additional capacity prior to discharge into the Park.

The proposed works are shown in Figure 7.6.

Figure 7.6 Proposed Works, Caroline Street to Robert Street

McAuley Park and Catchment 1 Open Channels

The McAuley Park proposed works are one of the most significant upgrades proposed within the Moonta SMP. The existing wetlands are fed by numerous swales and open channels, the largest of which is the main channel from the Moonta - Kadina Road that flows adjacent to Blyth Terrace.

The proposed upgrades (shown in Figure 7.7) include increasing the available storage capacity within the existing wetland by increasing both the depth and the footprint to achieve an approximate 140 ML volume of combined detention and retention storage. The proposed scheme assumes that the existing outlet culverts under Haylock Road will be positioned approximately 1.5 metres above the invert of the wetlands, which will allow for the establishment of a permanent water body with additional volume available above the outlet inverts that can be used for flood flow attenuation. The deepening of the wetland will also allow for increased depth and capacity of the open channels feeding the Park, including the installation of larger culverts (up to 1.8 m wide x 1.2 m high) under Crutchett and Old Wallaroo Road.

The proposed works also include drainage upgrades (both pits and pipes) from Gardiner Street to the main channel, as well as Majors Road with pipe diameters proposed at 750 mm for the Gardiner Street main drain and 525 mm for Majors Road near James Place.

The proposed works cater for improved drainage design standards in the northern part of the township by draining Old Wallaroo Road and Hills Road to the main Catchment 1 open channel. This has been achieved by upgrading roadside swales along Old Wallaroo and Crutchett Roads as providing a new 525 mm diameter drain along Hills Road.

This upgrade concept has been designed to provide a multi-objective outcome as follows:

- Improved flood protection (improved drainage and flood attenuation)
- Water Harvesting and Reuse (using the McAuley Park Wetland)
- Improved Water Quality (filtration and settling via the proposed wetland upgrade)
- Recreation and Amenity (by ensuring walking trails are maintained around the Park)

Due to the magnitude and complexity of the proposed works at McAuley Park it is envisaged that the construction would be undertaken in several stages.

It is important to note that the proposed works may be classified as a "Water Affecting Acitivity" (N&Y NRM, 2009) and hence may require approval from the Board prior to being implemented.

Kitto Road Embankment

An embankment is proposed to be created around the northern corner of the Moonta Golf course to protect the properties on the western side of Kitto Road from flooding during major events. In addition, the existing culvert crossings under Bay Road and Narangga Terrace are proposed to be connected to a 450 mm diameter drain that will discharge to McAuley Park via an upgraded swale adjacent to Haylock Road.

The proposed works are shown in Figure 7.8.

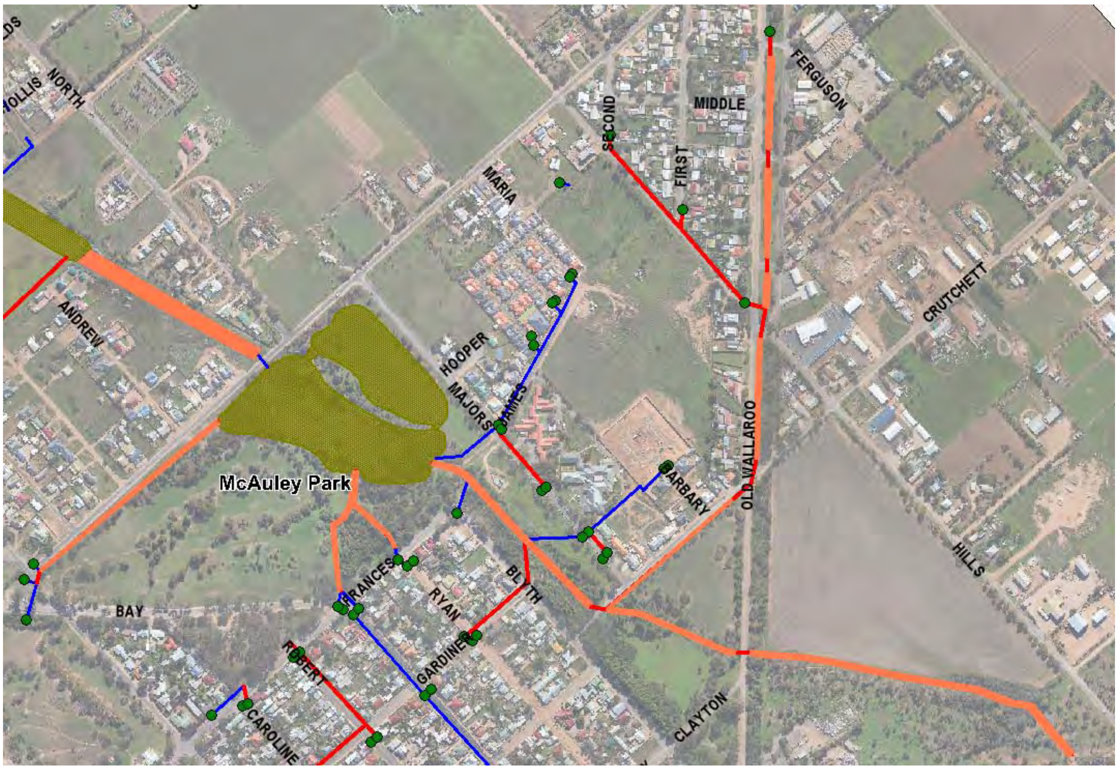


Figure 7.7 Proposed Works, McAuley Park and Catchment 1 Open Channels

Figure 7.8 Proposed Works, Kitto Road

Marilyn Street to Chapman Road

The proposed works involve the formalising of the open channel between North Terrace and Andrew Street with the aim of providing a 100 year ARI level of protection against flooding for the low lying properties in the area. The channel will discharge into a shallow detention basin before entering the 675 mm diameter pipe in Chapman Road.

In addition to the channel / basin works, it is proposed to upgrade the drain from Marilyn Street to the Narangga Terrace with a 450mm diameter drain at the upstream end to a 1200 mm diameter drain from Chapple Street to the basin.

It is understood that Council have recently upgraded the Marilyn Street drain as well as constructed a 675 mm diameter drain from Narangga Terrace to Chapman Road. This nominated solution favours a shorter, more direct route to the new basin due to very shallow horizontal gradients.

It should be noted that this proposed solution for the Marylin Street to Chapman Road drain has been designed to cater for a minimum 10 year ARI "Ultimate Development" scenario, with substantially higher flow rates than those used to design the recently installed upgrades, which were likely based on a 2 - 5 year ARI "Existing Development" scenario.

Figure 7.9 depicts the extent of works required to satisfy the design event.

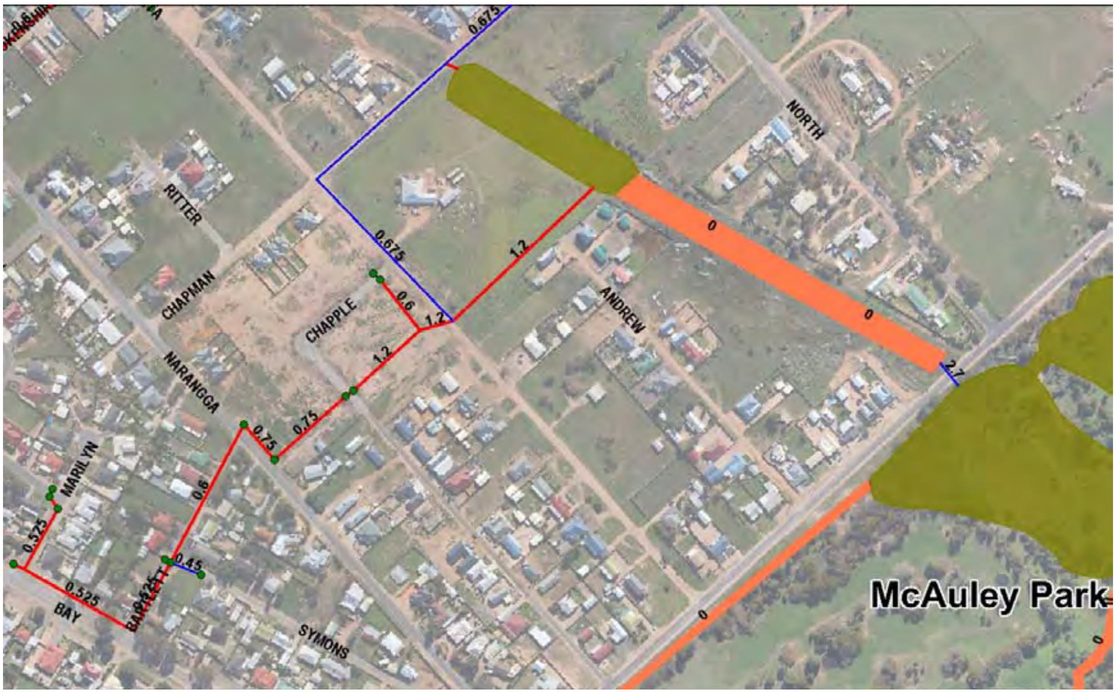


Figure 7.9 Proposed Works, Marilyn Street to Chapman Road

Moonta Road Open Drain

Council have recently upgraded the Moonta Road open channel from Carlisle Street to the downstream outlet. It should be noted that there is very little existing drainage infrastructure within this catchment and this drain forms the main conduit for the conveyance of runoff from the urban areas to the Gulf.

The works involve the creation of a detention basin upstream of Carlisle Street and construction of more open channel between Carlisle Street and East Terrace.

Due to the lack of infrastructure, the proposed works also involve lateral drains and additional side entry pits as follows:

- Lateral drains on Carlisle Street between Cambridge Street and Monmouth Street (up to 750mm diameter)
- A 450mm - 600mm diameter lateral drain along Coast Road (with connections to Monmouth Street and Narangga Terrace)
- New 1200 mm x 600 mm culvert crossings under Carlisle Street and Coast Road to link the proposed upgraded channel.

The proposed channel works are to be designed as vegetated bio-retention swales. Further discussion on this aspect is provided in Section 8.

The proposed works are shown in Figure 7.10.

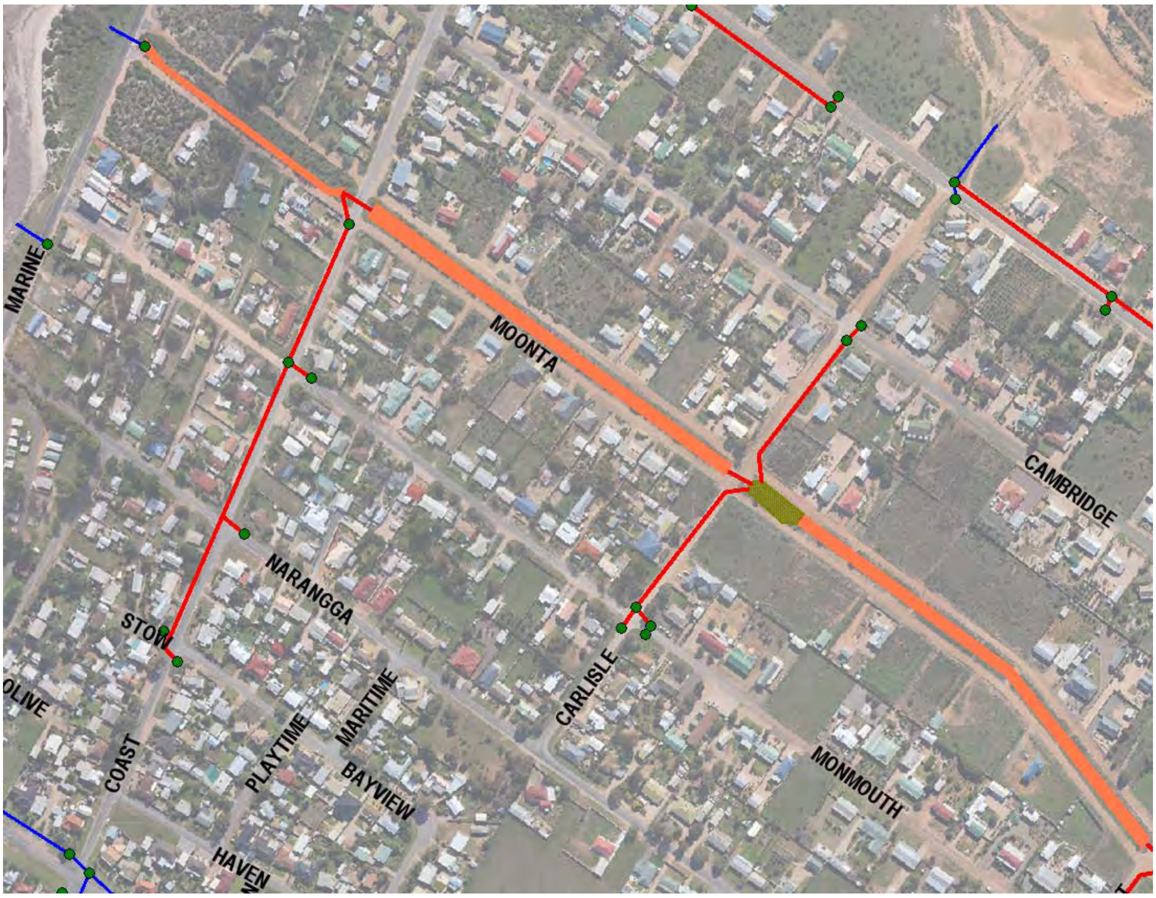


Figure 7.10 Proposed Works, Moonta Road

North Terrace

The proposed works involve the construction of new 525 mm diameter drains in North Terrace as well as an upgrade of the existing outlets into the existing pond to the north of the township as shown in Figure 7.11.

Figure 7.11 Proposed Works, North Terrace

Brokenshire Street to Moonta Road

It is proposed to create a detention basin upstream of the new Moonta Road open channel to attenuate peak flows from the urban catchment. New drains have been proposed as follows:

- A 600 mm diameter drain from East Terrace to the new basin
- 600 mm diameter drains along Moonta Road and Brokenshire Street
- 900 mm diameter drain in Moonta Road downstream of the Brokenshire Street intersection
- a 900 mm diameter drain outlet from the basin to the Moonta Road open channel.

The proposed works are shown in Figure 7.12.

Figure 7.12 Proposed Works, Brokenshire Street to Moonta Road

Bay Road

The proposed works for the Bay Road drain include increasing the capacity of the existing system by implementing a number of measures such as:

- The installation of a kerb and watertable along the length of Bay Road to contain overland flows and minimise flood risk to properties.
- Removing the connecting drain from Anderson Court to Roach Court to divert the flows to the west
- Constructing a new drain within Bay Road from Anderson Court to the connection with the existing 600mm diameter drain exiting the reserve.
- Upgrading the existing drain from 600mm diameter to 900mm diameter downstream of the reserve (some sections of existing drain may be duplicated instead of upgraded)
- Creating a detention basin and embankment to divert floodwaters away from properties between Bay Road and Haven Road

The proposed works are shown in Figure 7.13

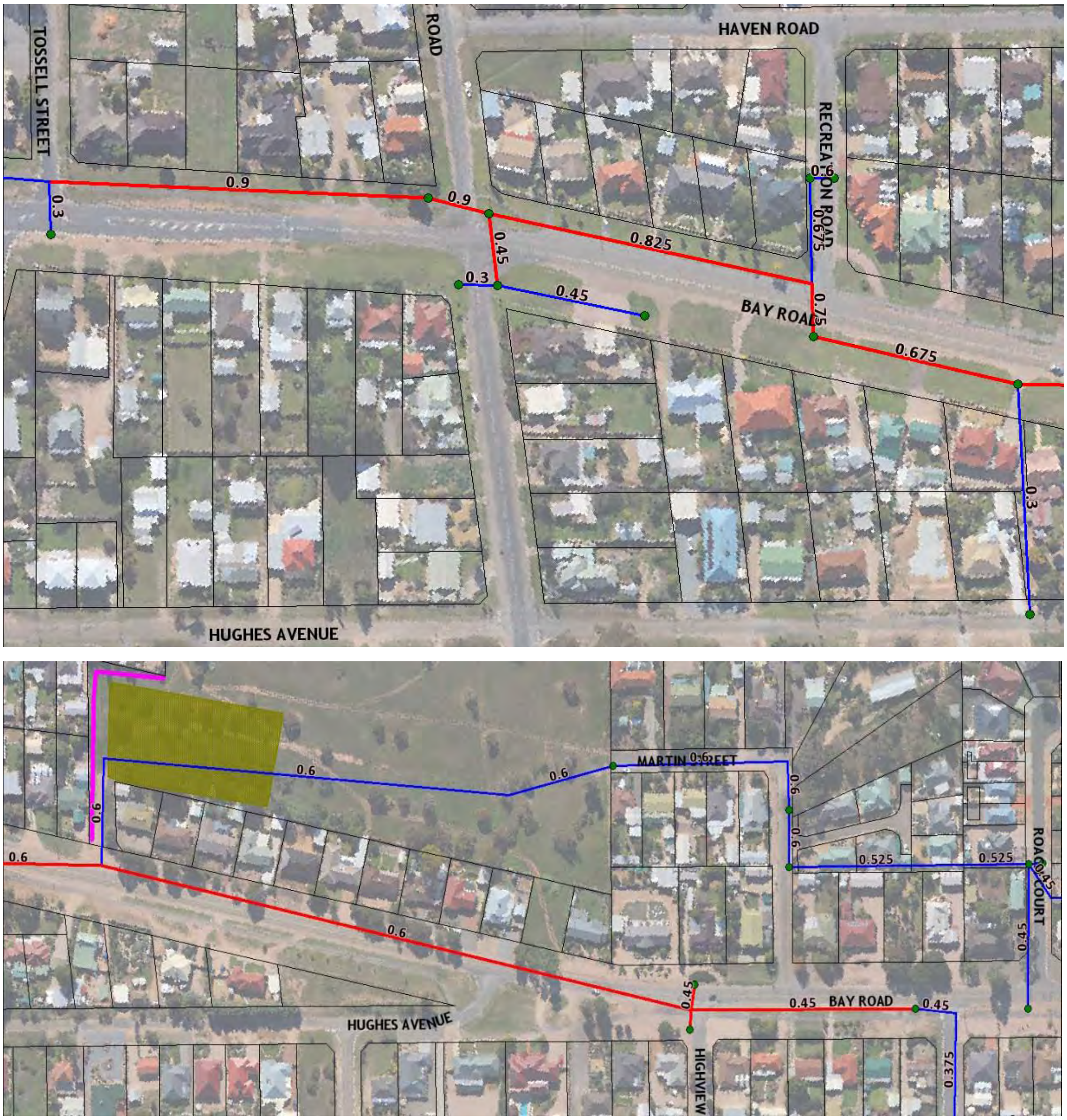


Figure 7.13 Proposed Works, Bay Road

Loller Street to Percy Street

The existing 525 and 600 mm diameter drain on Nankivell and Percy Street has limited capacity and is prone to having flows surcharge from side entry pits (particularly along Nankviell Street) during even minor rainfall events.

The proposed upgrade of this drainage system shown in Figure 7.14 entails increasing the diameter of the existing drain starting with a 525mm diameter drain on Loller Road and gradually increasing the size to a 1050 diameter drain on Nankivell and Percy Street.

The Lyndon Avenue drain is also proposed to be increased to reduce the magnitude and frequency of flooding within the catchment. Additional inlet capacity has been provided throughout the catchment.

Duplication of the existing drain could be considered during detailed design, however the new drain would need to be constructed at a greater depths and longitudinal gradient.

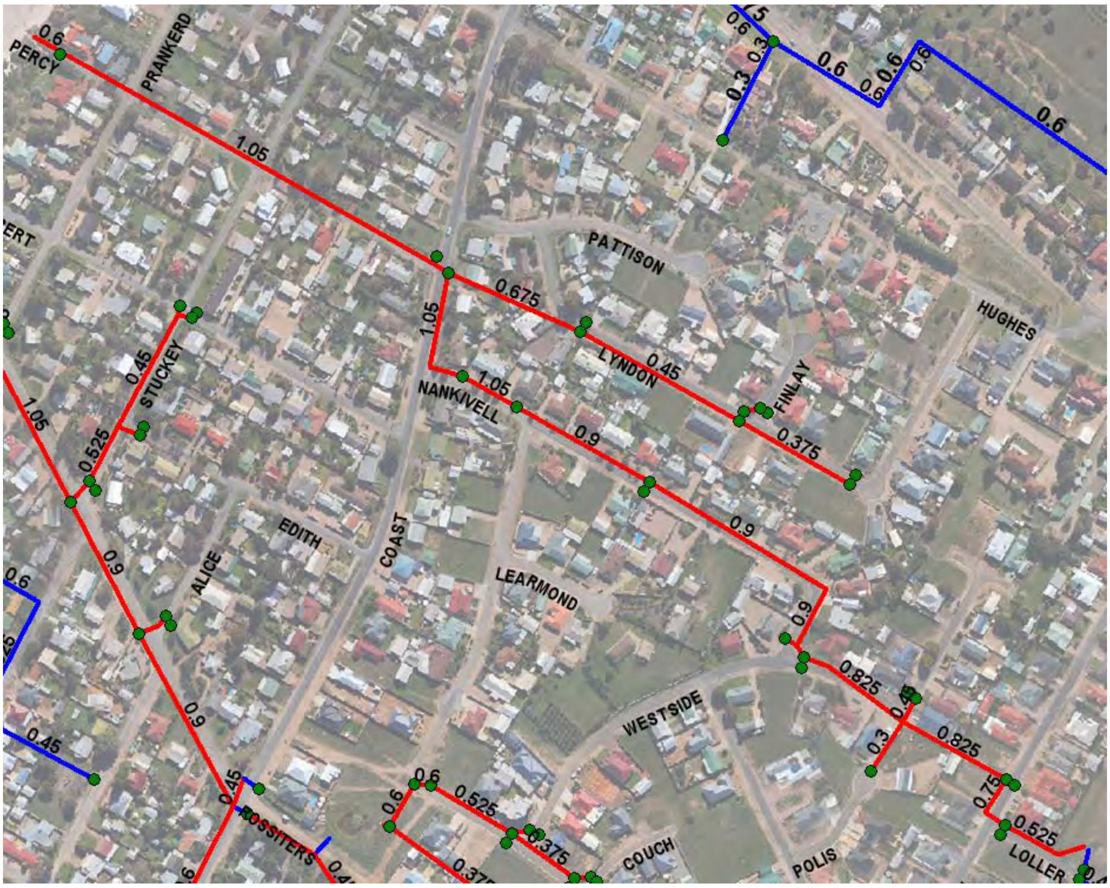


Figure 7.14 Proposed Works, Loller Road to Percy Street

Rossiters Road

Rossiters Road is a major corridor within Moonta Bay that currently has very limited drainage infrastructure. The road can be divided into two major components - the portion of Rossiters Road to the west of Coast Road and the portion of Rossiters Road to the east of Coast Road.

The western portion of the road is sealed and has been developed to a greater extent than the unsealed, eastern portion. However a major part of the eastern catchment has been earmarked for rezoning from "Deferred Urban" to "Residential".

The design of an upgrade to Rossiters Road from the basin downstream of Stocker Street to Rossiters Point has been commissioned by Council, with construction planned for 2014. This first stage of proposed works consists of the following:

- The construction of a 600 mm - 675 mm diameter trunk drain within Rossiters Road
- Connecting the existing culvert crossings under Coast Road to the new drain
- A provision to allow future lateral drain connections to the new trunk drain (expected to be detailed as part of Stage 2)
- An increase in detention storage volume within the Stocker Street basin as well as bio-infiltration to improve water quality
- New kerbing, pits and roadside swale drains to contain surface flows along Rossiters Road
- Two new drainage outfalls from the Rossiters Point car park. The first outflow caters for more frequent low flow events, and will discharge into an infiltration basin constructed within the existing vegetated dune area. This basin is expected to have an average overtopping frequency of once per year. The second main outfall will consist of a headwall through the cliff face at Rossiters point and will only discharge during significant rainfall events.
- Rossiters point car park works including the provision of kerbing to prevent uncontrolled surface flows eroding the cliff face, re-shaping and re-surfacing of the pavement, the creation of fencing to block pedestrian access down the southern ramp and the construction of a boardwalk from the northern side of the car park to the beach.
- Reshaping the road profile to eliminate depressions that are prone to ponding and provide greater flood protection to adjacent properties
- Improvements to the intersection of Coast Road and Rossiters Road.

The proposed works are being designed to cater for the ultimate development scenario within the Rossiters Road catchment. The design of the trunk drain within Stage 1 has assumed that future flows from the eastern portion of the catchment will be throttled to not exceed 400L/s during a 100 year ARI event. Analysis of the eastern Rossiters Road catchment has revealed ample detention storage opportunities that could be implemented as part of future developments to ensure that this requirement is met.

The proposed solution for future stages of Rossiters Road consists of the following:

- The creation of new detention basins as part of any proposed developments in the eastern catchments draining to Rossiters Road
- Drainage works (open channels and underground drains) to connect the outfalls from any new detention basins between Coast Road and Kitto Road to the 600 mm diameter trunk drain proposed as part of Stage 1.
- Upgrading the existing drainage network along Stocker Street
- Connecting the existing stormwater outlets at Stocker Street and Highview Grove to the new drains.

The proposed Stage 1 works are shown in Figure 7.15, with works proposed in future stages shown in Figure 7.16.

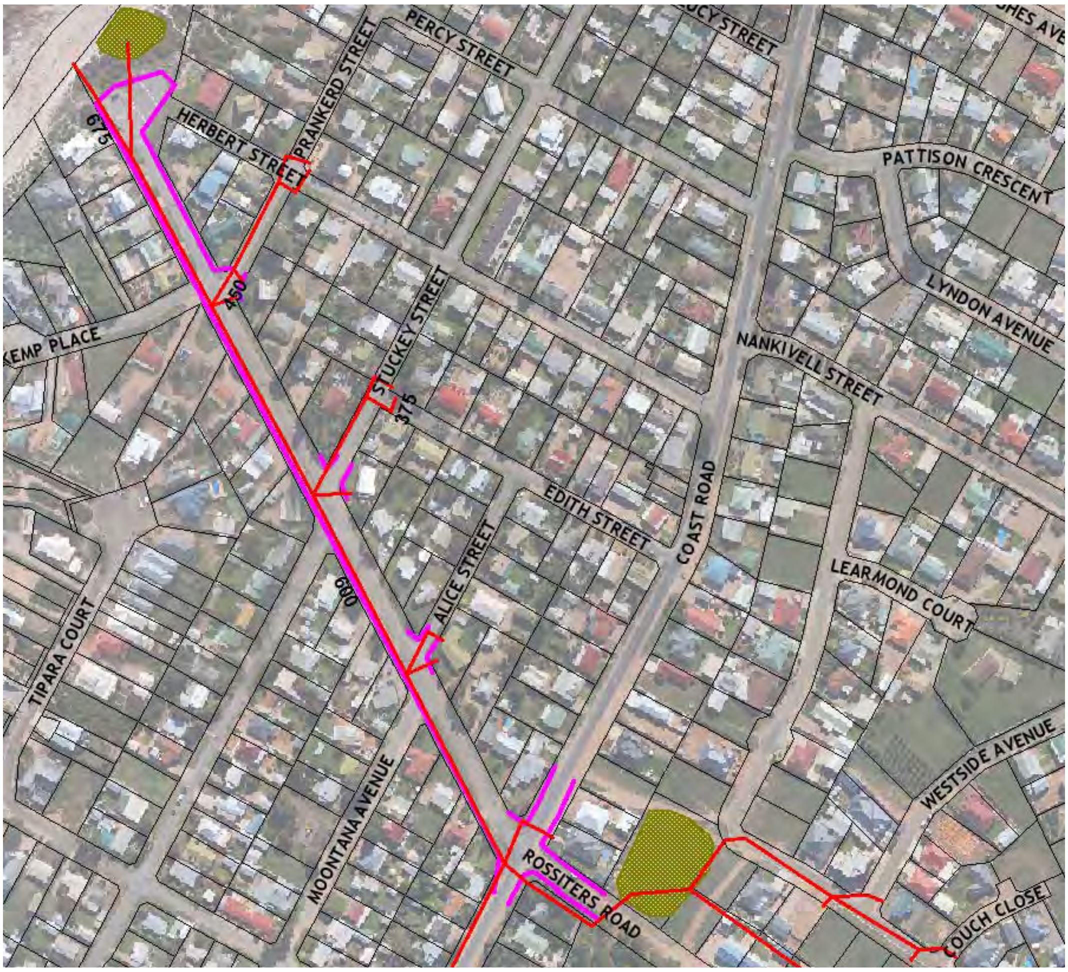


Figure 7.15 Proposed Works, Rossiters Road (Stage 1)

Figure 7.16 Proposed Works, Rossiters Road East (Future Stages)

Trelawney Street / Tipara Court

The proposed upgrades at Tipara Court involve increasing the existing 450 mm diameter drain to a 600 mm diameter drain as well as the addition of side entry pits on Trelawney Street and Tipara Court.

The Trelawney Street system has been proposed to be upgraded to allow for the connection of a 525 mm diameter drain to the north of the existing drain. Additional side entry pits located that the upstream ends will allow for greater capture of surface flows and will reduce the flood frequency and magnitude within the catchment. The proposed works are shown in Figure 7.17.

Figure 7.17 Proposed Works, Trelawney Street / Tipara Court

Simms Cove Road Drain

Simms Cove Road currently has no formal stormwater drainage infrastructure. The existing 1200 x 450 mm culvert under Coast Road takes runoff from Patrick's View into a privately owned paddock on the southern side of Simms Cove Road. From this point, uncontrolled surface flows travel down Simms Cove Road and overtop the edge of the car park contributing to severe erosion of the cliff face. It is important to note that the stormwater volumes that can be potentially generated by the Patrick's View development during major events are of a magnitude that exceeds what can be safely contained on site by constructing retention ponds or wetlands within the available drainage reserve between Hicks Street and Coast Road. Therefore we have considered the requirement for conveyance of stormwater runoff to the coast or to other catchments where feasible.

There are numerous upgrade options that have been considered for the Simms Cove Road catchment, with consideration given to critical factors that will heavily influence the final outcome. These factors include the ability for Council to acquire privately owned land as well as the potential for the creation of a new stormwater outlet into the Gulf, where there currently is no formal outlet.

The preferred design solution will be selected following further investigation that is outside of the scope of this Plan. We have presented three possible upgrade scenarios for Simms Cove Road which are described in more detail below.

Option A

The first proposed solution involves the construction of a new 675 and 750 mm diameter stormwater drain from the existing culvert under Coast Road to a new storage basin proposed in a depression within the existing privately owned paddock (subject to Council being able to acquire the land). This purpose of this new drain is to direct the discharge from the Patrick's View Development to the new basin via the Council road network.

The existing car park is proposed to have a kerb constructed around the perimeter with the surface being reshaped to direct flows towards the proposed side entry pits. The proposed car park reconstruction has been designed to mitigate against the erosion from surface flows travelling directly over the Simms Cove Road cliff faces as detailed in the recently completed Port Hughes - Moonta Bay Cliff Top Stability Study, (AWE 2013).

New side entry pits have also been proposed in Trelawney Street to aid in the capture of surface flows. A new 375 mm diameter drain is proposed to be constructed from the new side entry pits in the car park and Trelawney Street to the proposed basin in the existing paddock.

The new basin adjacent to Simms Cove Road has been designed as a holding basin, from which stored stormwater is proposed to be pumped to an extension of the existing Bray Street detention basin. The proposed works at Bray Street include increasing the storage capacity of the basin as well as the installation of a geo-synthetic clay liner (GCL) to minimise seepage losses. The outlet drain from the Bray Street basin would be raised above the invert in order to provide permanent storage below the outlet, and detention storage above the invert.

A key benefit of this proposed option is that there is no requirement to create a new coastal outlet at the bottom of Simms Cove Road. Another benefit is that the additional stormwater harvested at Bray Street can be utilised to irrigate Council greenspace.

The proposed upgrade concept is shown in Figure 7.18 and 7.19.

Figure 7.18 Proposed Works, Simms Cove Road (Option A)

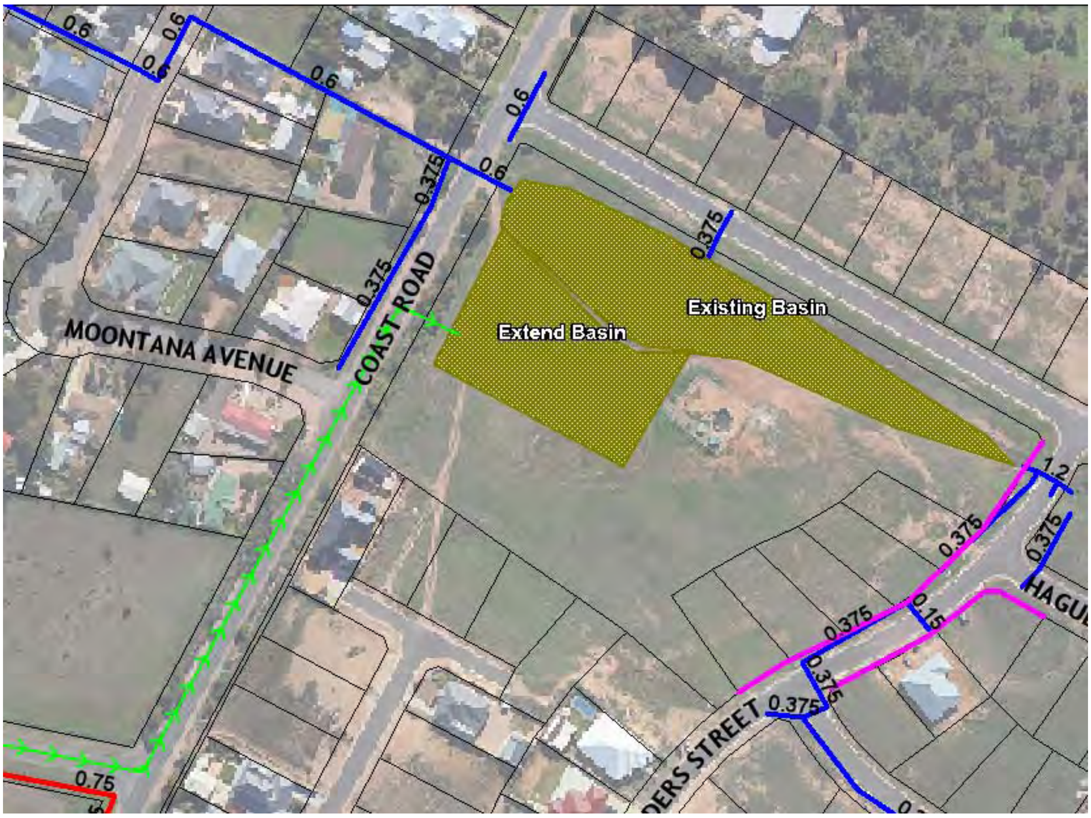


Figure 7.19 Proposed Works, Simms Cove Road to Bray Street (Option A)

Option B

The second proposed solution involves the construction of a new stormwater drain from the existing culvert under Coast Road to a new outlet constructed through the cliff face. A new detention basin constructed at the western corner of the paddock will attenuate the flood flows from the upstream catchment, as well as mitigate against the impact of redevelopment from the rezoning of the "Tourist Accommodation" zone to "Residential".

The proposed drain diameters will be 675 - 750 mm upstream of the basin and 450 mm - 600 mm downstream of the basin. A 375 mm drain with a pair of double side entry pits in Trelawney Street has been proposed to add capture capacity to the system.

The proposed works also include additional side entry pits and kerbing of the cul-de-sac at the bottom of Simms Cove Road to prevent further cliff face erosion. The proposed outlet would be designed in accordance with EPA and Coast Protection Board requirements with a strong focus on erosion mitigation, protection of the marine environment and amenity.

The proposed works for Option B are shown in Figure 7.20.

Figure 7.20 Proposed Works, Simms Cove Road (Option B)

Option C
The third possible solution involves increasing the storage capacity of the existing Hicks Street detention basin and pumping runoff via a new rising main along Coast Road to an extension of the Bray Street detention basin. As described in Option A, the proposed works at Bray Street include increasing the storage capacity of the basin as well as the installation of a geo-synthetic clay liner (GCL) to minimise seepage losses.

Stormwater drainage works within Simms Cove road would consist of a 375 mm drain from Trelawney Street to a new coastal outlet constructed to EPA and Coast Protection Board requirements.

The proposed works also include additional side entry pits and kerbing of the cul-de-sac at the bottom of Simms Cove Road to prevent further cliff face erosion.

The benefits of this solution include a smaller diameter coastal outlet when compared to Option B (reducing pollution entering the Gulf and disruption to the cliff face), as well as there being no reliance on the acquisition of privately owned land.

The proposed works for Option C are shown in Figure 7.21.

Figure 7.21 Proposed Works, Simms Cove Road (Option C)

Port Hughes Road and Trenerry Drive

The proposed works along Port Hughes Road involve the construction of an open channel in the road verge between Keen Street and the existing Hicks Street open channel. This will provide a more defined flow path for runoff discharging from the existing culvert under Keen Street adjacent to Port Hughes Road.

The proposed solution for Trenerry Drive involves extending the existing 375 mm diameter drain around the properties and discharging into the existing open channel.

Figure 7.22 Proposed Works, Port Hughes Road, Trenerry Drive

Minnipa Drive to Dowling Drive

The existing 375 mm diameter drain servicing the Minnipa Drive sub-division flows out through properties between Port Hughes Road and Dowling Drive. Given that the drain corridor locations, it is advisable to ensure that the properties are protected from floods during major events (up to the 100 year ARI).

Our proposed solution involves upgrading the drains from a 375 mm diameter to a 675 mm diameter at the upstream end and a 900 mm diameter at the downstream end. Additional pits have also been proposed at Furner Crescent, Snell Avenue and Cowling Court.

The proposed works are shown in Figure 7.23.

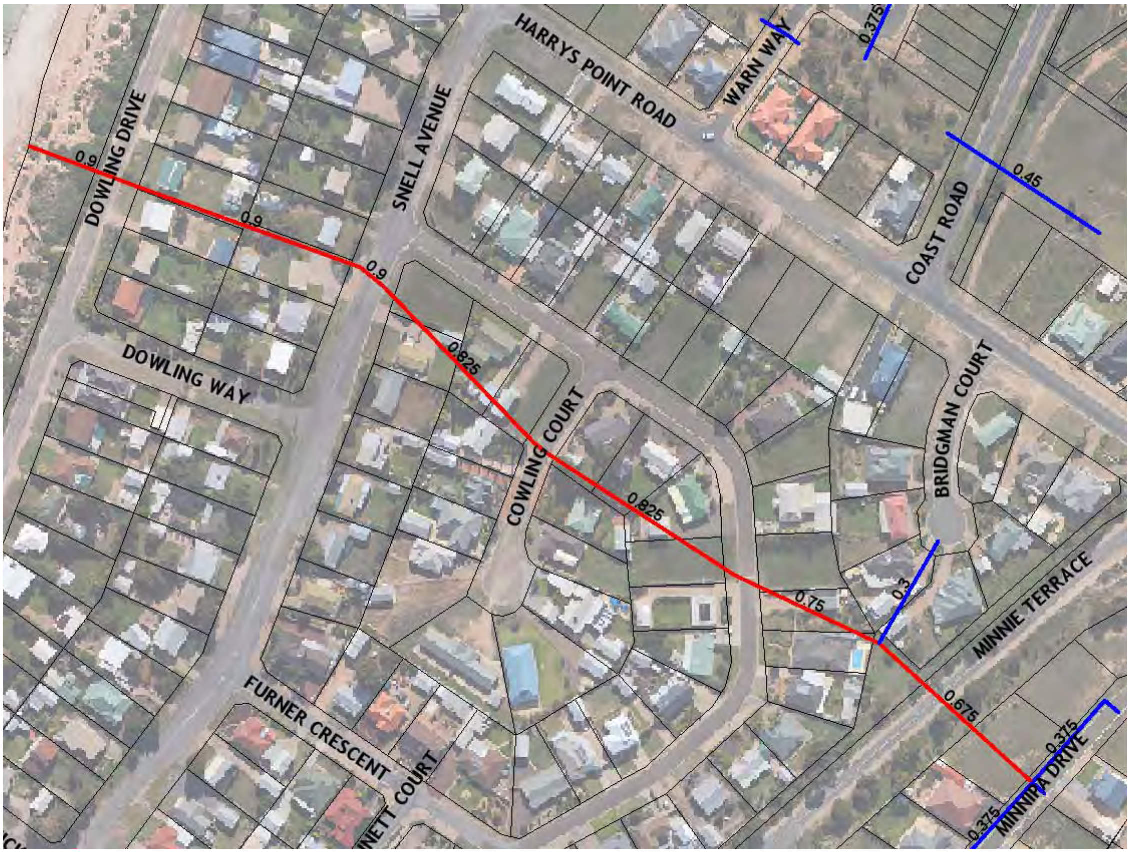


Figure 7.23 Proposed Works, Minnipa to Dowling / Elphick Street

Emerson Street to Minnie Terrace / Randolph Street

There is very little existing drainage infrastructure in Catchments 10 and 11 with the exception of some coastal outlets.

The proposed works within Catchments 10 and 11 involve the construction of new drainage networks as shown in Figure 7.24. A summary is as follows:

- Construction of new 750 mm diameter drains in Cunliffe and Gilbert Streets downstream of Emerson Street that merge into a 1050 diameter drain in Minnie Terrace. Stormwater will be harvested from this catchment to irrigate the reserve (as discussed in Section 8).
- The proposed works also include a new GPT and a new underground drainage outlet through the cliff face designed in accordance with EPA and Coast Protection Board requirements with a strong focus on erosion mitigation, protection of the marine environment and amenity.
- The construction of a 600 - 900 mm diameter drain from Randolph Street to Minnie Terrace with a new coastal outlet.

Figure 7.24 Proposed Works, Emerson Street to Minnie Terrace, Randolph Street

7.7 Non-structural Flood Mitigation Options

To complement the proposed structural options, a number of non-structural flood mitigation options are also proposed. Non-structural options are typically extremely cost effective when the relative benefits are compared against the structural options.

7.7.1 Development Controls

There is clearly significant for future residential development within the catchment, that will exacerbate existing flood risk.

Within all new development, it is recommended that the following controls be applied

- Flood Protection

All new development must have floor levels that are a minimum of 300mm above the 100 year ARI flood level as documented by the (existing scenario) floodplain maps.

- Stormwater Reuse

Each dwelling should be connected to a rainwater tank with a minimum capacity as follows:

- Allotments with an area less than 449 m^2 - 5,000 litres or greater
- Allotments with an area of 450 m^2 to 649 m^2 - 10,000 litres or greater
- Allotments with an area greater than 650 m^2 - 22,000 litres or greater

The above requirement is consistent with Council's current Rainwater Tank Policy.

Within greenfield land divisions, it is recommended that the following further controls be applied:

- Stormwater Discharge (Quantity)

The peak 5 year ARI flow discharged from new development is to match the pre-development peak 5 year ARI flow rate. This can be achieved using on site detention / retention measures.

- Stormwater Discharge (Quality)

All new development must incorporate water sensitive urban design measures that achieve water quality improvement performance of 80% (suspended solids) and 45% (phosphorus and nitrogen).

7.7.2 Community Flood Response and Preparedness

SES Community FloodSafe Program
"Community FloodSafe is a partnership between local councils and state and federal governments. The FloodSafe program uses existing State Emergency Service volunteers, as well as new community volunteers with good presentation skills, to reach into communities to raise awareness in flood-prone areas. Initiatives include articles in Council newsletters, street corner meetings, community group meetings, internet sites, brochures and school education". (*source: http://www.ses.sa.gov.au/site/community_safety/floodsafe.jsp*)

The volunteers talk to community groups, local residents, businesses and schools about what they can do reduce the risk of flood damage and improve the resilience of their community if a flood should occur.

FloodSafe volunteers typically address communities on:

- Local risks
- Historic flooding in the area

- Having a flood plan to reduce the risk to business equipment, stock and staff
- Protecting family and property
- Understanding BOM Flood Watch and Flood warnings
- Having a home emergency kit
- How to call for SES response.

Since its inception in 2009, many metropolitan and regional South Australian councils have joined the FloodSafe program. With the flood plain mapping of Moonta being completed as part of this SMP, it is now possible to nominate key areas for FloodSafe to target. We recommend that the District Council of the Copper Coast consider joining the program.

Guidelines

It is recommended that Council develop a guideline pamphlet to outline simple and effective measures that residents and businesses can taken prior to a flood event to minimise flood damages. Similar materials have been developed by other Councils across South Australia.

Property Specific Information

The flood plain mapping output enables site specific flood maps to be prepared that can inform individual property owners of the identified general inundation risk. This will then enable the owner to understand their level of risk and would assist them in developing their flood emergency response plan.

8 Water Sensitive Urban Design

8.1 Receiving Waters

The total study area of 3747ha is comprised of ten catchments that drain to Spencer Gulf (1142ha) and one catchment that drains to a low lying area adjacent to the coast (2605ha).

Pollution sources within stormwater that impact on these receiving waters include:

- gross pollutants (larger objects, floating litter and ‘green’ waste)
- sediment
- dissolved pollutants (nutrients, hydrocarbons and coloured dissolved organic matter)
- pathogens

8.2 Water Quality Modelling Approach

An assessment of the pollutant loads within stormwater discharges to the receiving waters is outlined in this section. The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) computer software package developed by the Cooperative Research Centre for Catchment Hydrology has been used for this purpose.

MUSIC can be used to simulate the quantity and quality of runoff from stormwater catchments, and predict the performance of stormwater quality management systems. The MUSIC model requires user defined meteorological and catchment data to estimate the quantity and quality of stormwater runoff for a given catchment, as described below.

8.2.1 Meteorological Data

The meteorological data templates used for this project were compiled using average monthly potential evapo-transpiration (PET) values for Adelaide, and 6 minute rainfall data from a gauge at Minlaton for the years 2001-2006. The average annual rainfall for this period was 352mm.

6 minute rainfall data is also available at Kadina for the years 2005-2009, however significant gaps in this record render it not representative of the study area (average annual rainfall 263 mm/yr).

8.2.2 Catchment Area and ‘Effective Impervious’ Fraction

The ‘effective impervious’ fraction adopted in MUSIC should correspond to the ‘directly connected paved’ (DCP) portion of the catchment area. It should be noted that stormwater runoff volumes estimated by MUSIC are highly sensitive to this value.

For the purposes of MUSIC modelling the typical ‘effective impervious’ fractions for residential development in the study area were estimated to be:

- 0.2 to 0.3 for historical low density residential development and areas subject to minor/limited infill development
- 0.4 to 0.6 for high density residential development (assuming full take-up of allotments from recent land divisions)

These values were adjusted for individual sub-catchments based on the relative proportions of urban development and open space within the sub-catchment area; hence the ‘effective impervious’ fractions for the MUSIC sub-catchments varied from 0 to 0.6.

8.2.3 Rainfall-runoff Parameters

A 'rainfall threshold' of 1mm has been adopted for the impervious areas (commonly referred to as the initial loss), which is consistent with the industry standard approach to hydrological modelling of urban catchments.

A 'soil storage capacity' of 40mm and 'field capacity' of 30mm have been adopted for the pervious areas, which is consistent with MUSIC's recommended values. It should be noted that stormwater runoff volumes estimated by MUSIC are not sensitive to variation in parameters defining the pervious area response to rainfall (except where impervious fractions are low).

8.2.4 Pollutant Load Parameters

MUSIC's default pollutant load parameters have been adopted for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP), which are based on a comprehensive review of worldwide stormwater quality in urban catchments undertaken by Duncan (1999), supplemented by local data specific to regional applications.

MUSIC's default pollutant load parameters have also been adopted for Gross Pollutants (GP), which are based on field monitoring data of Allison et al (1997) for 12 storm events in an inner city suburb.

The above parameters are consistent with those recommended for use in *Chapter 15 - Modelling Process and Tools, Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region* (Department of Planning and Local Government, 2010).

8.3 Existing Pollutant Loads

8.3.1 Pollutant Generation

No existing water quality improvement measures have been included in the 'baseline scenario' model. This decision has been made to allow for a baseline to be established of an 'untreated' catchment, against which the effectiveness of a suite of treatment measures can be evaluated in accordance with water quality objective framework.

8.3.2 Existing Water Quality Improvement Measures

There are several existing stormwater basins in the Study Area that are expected to perform a water quality improvement function, and as such these have been included in an 'existing scenario' model. The storage and outlet properties of each basin have been determined using the Digital Terrain Model and GIS based drainage dataset. The basins are assumed to be formed in sandy clay material (median particle size 0.01mm) with an infiltration rate of 36mm/hr.

The existing open channels within the Study Area have been assumed to provide a flow conveyance function only.

8.3.3 Water Harvesting Schemes

Other than small-scale on-site practices (such as domestic rainwater tanks), there are no known existing stormwater harvesting and reuse schemes within the Study Area.

8.3.4 Assessed Performance

A MUSIC model was compiled for both the baseline (no improvement measures) and existing scenario using the input parameters described above. Individual pit level sub-catchments from the DRAINS model were aggregated to form the MUSIC sub-catchments. This approach enables the user to obtain estimates of the quantity and quality of runoff at specific points of interest in the drainage system, in particular the coastal outfalls and stormwater basin sites.

The catchment that does not drain to Spencer Gulf includes the disused Moonta Mines site, and has been excluded from this analysis until the stormwater management practices within the mine site are better understood.

A plan of the baseline MUSIC model layout is shown in Figure 8.1.

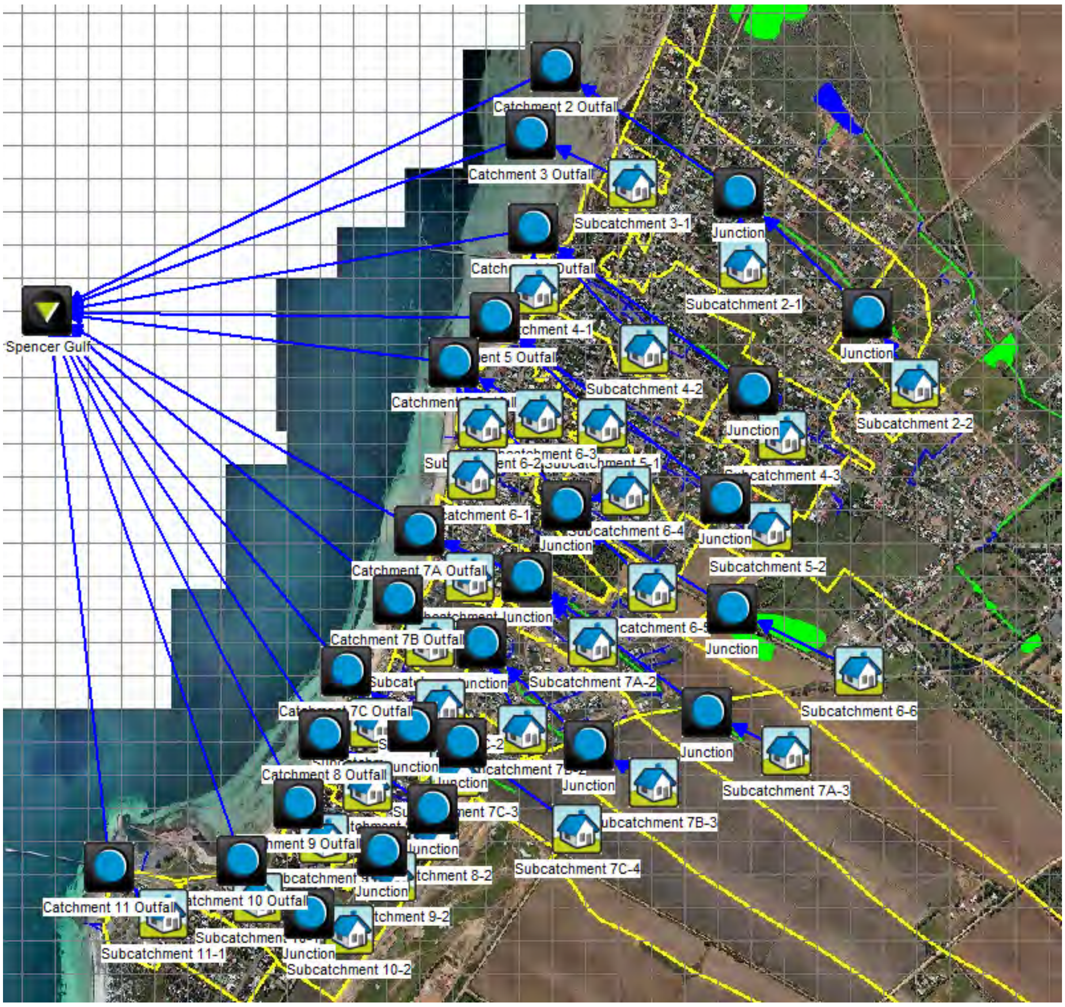


Figure 8.1 Baseline MUSIC Model Layout

The results of the baseline MUSIC model for discharge to Spencer Gulf from each of the coastal outfalls during the years 2001-2006 are as summarised in Table 8.1.

The results of the existing scenario MUSIC model for the corresponding period, which takes into account the existing water quality improvement measures, are summarised in Table 8.2, including the percentage reduction in pollutant loads that are achieved by the existing stormwater basins.

Table 8.1 Baseline Pollutant Generation Estimates

Catchment	Source Pollutant Load (t/yr)			
	TSS	TP	TN	GP
1	-	-	-	-
2	11.90	0.026	0.192	2.63
3	1.18	0.003	0.019	0.23
4	9.84	0.021	0.162	1.90
5	8.53	0.018	0.127	2.01
6	24.90	0.060	0.515	2.14
7A	13.90	0.036	0.293	1.83
7B	10.30	0.025	0.199	1.50
7C	8.92	0.022	0.175	1.24
8	2.47	0.005	0.039	0.56
9	1.76	0.004	0.028	0.33
10	5.41	0.012	0.083	1.20
11	2.24	0.005	0.038	0.46
Total	**101.35**	**0.237**	**1.870**	**16.03**

Table 8.2 Existing Water Quality Improvement Performance

Catchment	TSS		TP		TN		GP	
	t/yr	%	t/yr	%	t/yr	%	t/yr	%
1	-	-	-	-	-	-	-	-
2	11.90	-	0.026	-	0.191	-	2.63	-
3	1.12	-	0.003	-	0.019	-	0.23	-
4	9.78	-	0.021	-	0.161	-	1.90	-
5	6.67	*20*	0.014	*18*	0.111	*13*	1.60	*21*
6	22.40	*14*	0.054	*12*	0.470	*9*	1.04	*51*
7A	7.27	*48*	0.016	*55*	0.121	*59*	0.33	*82*
7B	10.20	-	0.024	-	0.196	-	1.50	-
7C	2.32	*73*	0.005	*76*	0.040	*77*	0	*100*
8	2.46	-	0.005	-	0.039	-	0.56	-
9	1.73	-	0.004	-	0.027	-	0.33	-
10	5.41	-	0.012	-	0.082	-	1.20	-
11	2.24	-	0.005	-	0.038	-	0.46	-
Total	**83.50**	***18***	**0.189**	***20***	**1.495**	***20***	**11.78**	***27***

8.3.5 Risks to Marine habitats in the vicinity of outfalls

Habitats in the immediate vicinity of stormwater outfalls are most at risk, since these will receive largely undiluted stormwater. The load and concentration of pollutants reaching marine environments away from outfalls will be determined by local hydrodynamics, but it is likely that contaminants will be rapidly diluted away from outfalls. The preferred method for determining water quality trigger values for nutrients, suspended solids and salinity is to use reference data applicable to the specific ecosystem and area, but in the absence of such data, ANZECC and ARMCANZ (2000a) provide default trigger values for total nitrogen (TN), total phosphorus (TP), and turbidity. Turbidity is correlated with total suspended solids (TSS), but the exact relationship varies depending on the nature of the solids involved, making assessment of turbidity based on TSS measurements difficult (ANZECC and ARMCANZ 2000b), and no specific guideline value for TSS concentration is provided by ANZECC and ARMCANZ (2000a). TSS is, however, a useful proxy for other contaminants in water quality modelling, since concentrations of these, particularly metals and PAHs, are highly correlated with TSS (ANZECC and ARMCANZ 2000b; Mills and Williamson 2008). Some overseas jurisdictions specify maximum TSS concentrations of 25 mg L^{-1} or a maximum change from background levels of 10 mg L^{-1} (ANZECC and ARMCANZ 2000b). Turbidity trigger values in marine environments should generally be lower than those for estuaries, although inshore waters may be naturally more turbid than offshore (ANZECC and ARMCANZ 2000b).

Existing stormwater quality improvement measures, such as drainage basins, are present in catchments 5, 6, 7A and 7C of the Moonta SMP area, and are expected to reduce TN loads by 9-77%, TP by 12-76% and TSS by 14-73% in these catchments compared with the 'baseline scenario', i.e. without any water quality improvement measures in place. Overall, these measures reduce total loads across the SMP area by 20% for TP and TN, and 18% for TSS. The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) modelling performed shows that, with these current water quality improvement measures, median concentrations of TN and TP exceed the default ANZECC guideline values for slightly disturbed habitats (ANZECC and ARMCANZ 2000a) at most outfalls (Table 8.4), although it should be noted that these are the concentrations in stormwater, which will be diluted away from outfalls. Habitats in the immediate vicinity of outfalls may however, be exposed regularly to concentrations at or near the guideline limits. The guideline values for TN and TP in South Australia (Table 8.4) were based on limited data; EPA studies have since demonstrated that likely nutrient impacts, including seagrass loss, have occurred in regions where nutrient concentrations were within the guidelines, indicating that the trigger values may be too high to afford protection in South Australia's normally oligotrophic waters (Gaylard 2009a). Modelled median TSS concentrations are 13.5 or 13.6 mg L^{-1} at all but one of the catchments, but 90th percentile concentrations, which are expected after heavy rain, reach around 180 mg L^{-1}. Median concentrations of TN, TP and TSS are similar across nearly all outfalls (Table 8.4), but resulting annual fluxes are greatest for the largest catchments due to their greater overall flow. Therefore the EPA sees the reduction in total volume of stormwater runoff being discharged to the marine environment as the highest priority in terms of stormwater management.

Under this existing scenario, it is likely that habitats in the immediate vicinity of outfalls are at risk of impacts from stormwater outflows, particularly from nutrients. High sediment loads following heavy rain may also be a risk to these habitats. In particular, there is dense macroalgae in the vicinity of outfalls from catchments 10 and 11 around Port Hughes that could be adversely impacted by sediment and nutrient. Some macroalgae also occurs near outfalls from catchments 2 and 6, and some seagrass adjacent to the catchment 8 outfall. The largest catchments are 6, 7A, 7B and 7C, but median TN, TP and TSS concentrations are lower for 7A and 7C than most catchments due to the existing water quality improvement measures in place. Annual pollutant loads are therefore greatest for catchments 6 and 7B.

Habitats in the vicinity of these outfalls, including the macroalgae near the catchment 6 outfall and near shore seagrass, may be at risk of chronic impacts from nutrient enrichment.

8.4 Proposed WSUD Elements

New WSUD measures are proposed to be constructed in a number of locations to improve stormwater quality and enable stormwater harvesting and reuse.

Several measures have been proposed to improve stormwater quality, including bio-retention basins, swales, gross pollutant traps and increased stormwater capture and reuse. These proposals aim to achieve an 80% reduction in TSS, 45% reduction in TN, 60% reduction in TP, and 90% reduction in gross pollutants, consistent with the water quality objective outlined in Section 3.

Many of the proposed WSUD upgrades complement the drainage upgrades that were proposed in Section 7, and it is expected that both the WSUD and drainage upgrades for any given stormwater system will be undertaken in tandem.

These proposed upgrades have been modelled within the MUSIC model (refer Section 8.6) to allow for preliminary sizing of elements and budget cost estimation.

In addition to the measures identified, it is expected that further WSUD opportunities will be achieved over time, particularly through land developments, road reconstruction activities and individual site redevelopments.

The existing model was modified to reflect future impervious fractions (see Section 4.2) and some catchment boundaries altered based on proposed future works (see Section 7.6).

8.4.1 Catchment 1

The proposed WSUD upgrades for Catchment 1 are summarised in Figure 8.2. Stormwater harvesting is proposed at 3 separate sites:

- McAuley Park - using the proposed wetland expansion with a combined 140 ML of detention and retention storage.
- Queens Square - via an underground storage tanks fed by the George and William Street drainage upgrades discussed in Section 7.6
- Victoria Park - via a storage dam fed by the Ellen Street and Milne Street proposed drainage upgrade discussed in Section 7.6

Harvested stormwater from the 3 sites will be used to irrigate the Moonta Golf Course, the Victoria Park Oval, the Moonta Primary School Oval and Queen Square.

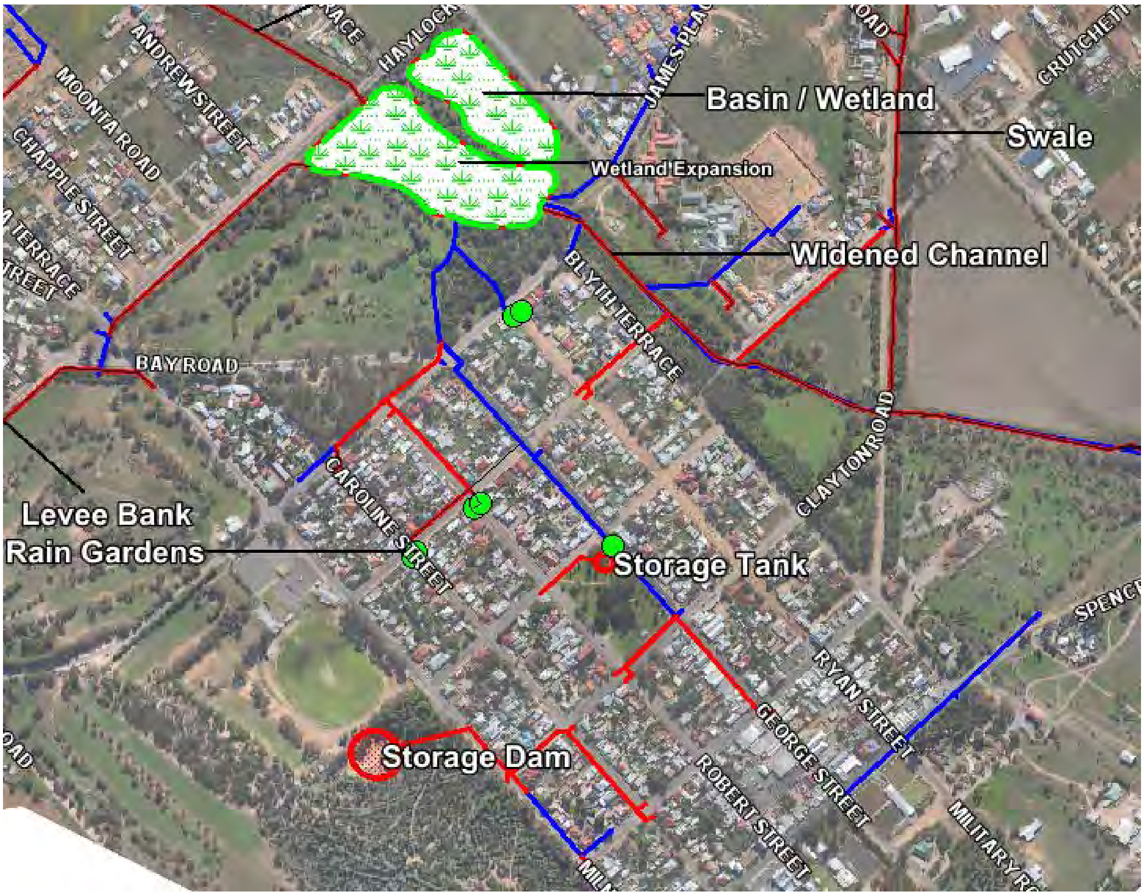
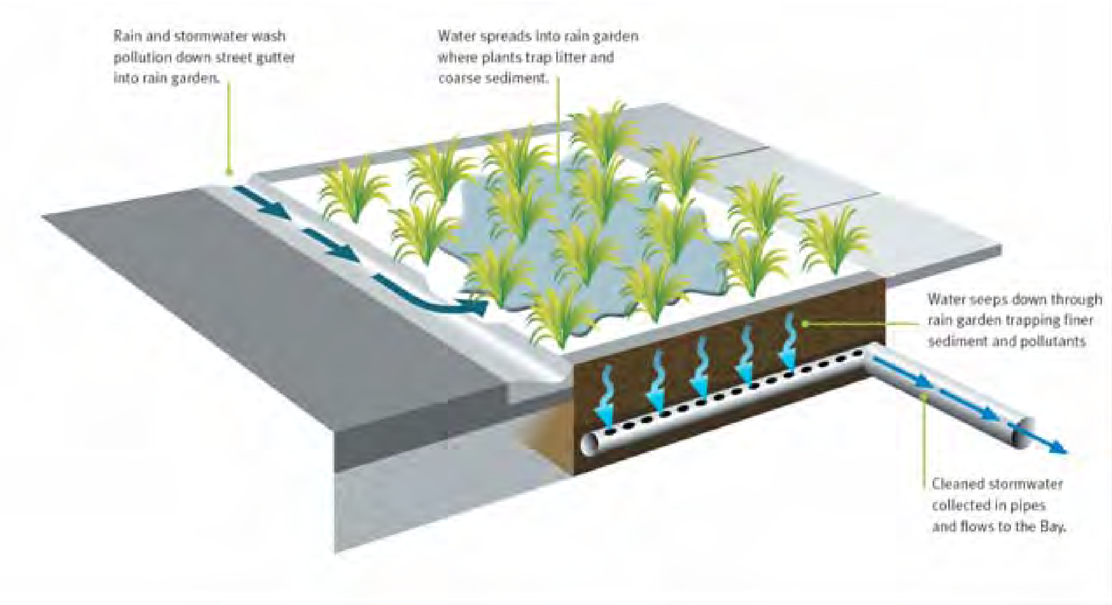


Figure 8.2 Catchment 1 WSUD Concept

Bio-retention basins or rain gardens have been proposed at a number of side entry pits sites on George Street, Ryan Street and Robert Street within the Moonta central township district. Rain gardens are becoming an increasingly popular WSUD technique, with over 10,000 rain gardens built across Melbourne as part of the *Healthy Waterways Raingardens Program* (Melbourne Water, 2013).

Figure 8.3 shows an example of a rain garden installed in the City of Kingston Council area in the southern suburbs of Melbourne where over 130 rain gardens have been constructed since 2001.



Source: City of Kingston, Victoria

Source: wsud.org

Figure 8.3 Raingarden Example

8.4.2 Catchment 2

Swales within the median strip of Moonta Road are proposed for the main trunk drain for Catchment 2. It is recommended these swales be utilised for water quality improvement by establishing appropriate vegetation and constructing bio-retention basins along its alignment.

In addition to the swale drain, two detention / bio-retention basins are recommended within the swale alignment. Bio-retention basins are much more effective at removing water pollutants and are able to retain water during summer, aiding in maintaining plant life for longer dry periods. The swale and basin alignments are shown in Figure 8.4 below.

Figure 8.4 Catchment 2 WSUD Concept

8.4.3 Catchment 3

It is recommended that approximately one third of Catchment 3 (2.7 ha) be directed into the Moonta Road Swale within Catchment 2 (as described above) by constructing a new stormwater pipe along Coast Road to the intersection with Stow Court.

No other water quality measures are proposed for this catchment because it is a small catchment, with no open space and no stormwater infrastructure with the exception of a small pipe on Marine Parade.

8.4.4 Catchment 4

A Gross Pollutant Trap on the main outlet pipe on Bay Road is recommended to provide treatment prior to discharge into Spencer Gulf.

In addition to the GPT, a proposed detention basin intercepting the main trunk drain in the Bay Road reserve will provide water quality benefits to the catchment upstream of Recreation Road. The basin and GPT are shown in Figure 8.5 below.

Figure 8.5 Catchment 4 & 5 WSUD Concept

8.4.5 Catchment 5

Catchment 5 is almost fully developed, with little vacant land and few reserves. As a result, few WSUD options are available for this catchment. A proprietary GPT on Percy Street prior to the pipe outlet is proposed.

8.4.6 Catchment 6

A new major underground drainage outlet system is proposed for Catchment 6 along Rossiters Road to take flow from the relatively large catchment upstream of Bay Road to the coast. A large currently undeveloped area upstream of Bay Road is earmarked for development in the short to medium term. Treatment recommendations for this catchment include:

- A GPT located at the pipe outlet on Rossiters Road
- A bio-retention / detention basin at the intersection of Rossiters Road and Bay Road. This basin would also act as a sedimentation basin during construction periods within the catchment
- Swales parallel to Rossiters Road, upstream of the proposed detention basin
- A second detention basin within the low point adjacent to Rossiters Road, near Bowyer Court

All proposed WSUD features for Catchment 6 are shown in Figure 8.6.

Figure 8.6 Catchment 6 WSUD Concept

8.4.7 Catchment 7A

It is recommended that the Bray Street channel be converted into a vegetated treatment swale / bio-retention system. Appropriate vegetation is to be established along the length of the swale, with a lined bio-retention basin to be constructed at the Sanders Street outlet. The swale and bio-retention basins are shown in Figure 8.7 below.

An infiltration basin is also recommended for the end of Queen Street. This basin is to provide a level of flood protection to properties on Queen Street, however will remove the need for an additional stormwater outlet into the Gulf. The Queen Street infiltration basin is shown in Figure 8.6.

Figure 8.7 Proposed WSUD Works Catchment 7A

8.4.8 Catchment 7B

It is recommended that the Hicks Street channel be converted into a series of vegetated treatment swales and bio-retention systems. There are already a number of existing ponds within the Hicks Street swale which could easily be re-established into bio-retention systems. Lining these basins would prevent drying out in summer months and maintain vegetation.

Simms Cove Road Option A
WSUD features in the future Simms Cove development between Simms Cove Road and Coast Road include a bio-retention / holding basin at the low-lying north-eastern corner of the site as shown in Figure 8.8. Stormwater from this basin is proposed to be pumped to the Bray Street detention basin (Catchment 7A) which is proposed to be extended. Thus the proposed works do not allow for stormwater to be directly discharged into the ocean from this catchment.

Figure 8.8 Catchment 7B WSUD Concept (Simms Cove Option A)

Simms Cove Road Option B

WSUD features in the future Simms Cove development between Simms Cove Road and Coast Road include a detention / bio-retention basin at the low-lying north-eastern corner of the site as shown in Figure 8.9.

Simms Cove Road Option C

No additional WSUD features beyond those discussed in Simms Cove Road Options A and B are present within the scope of works relating to Option C.

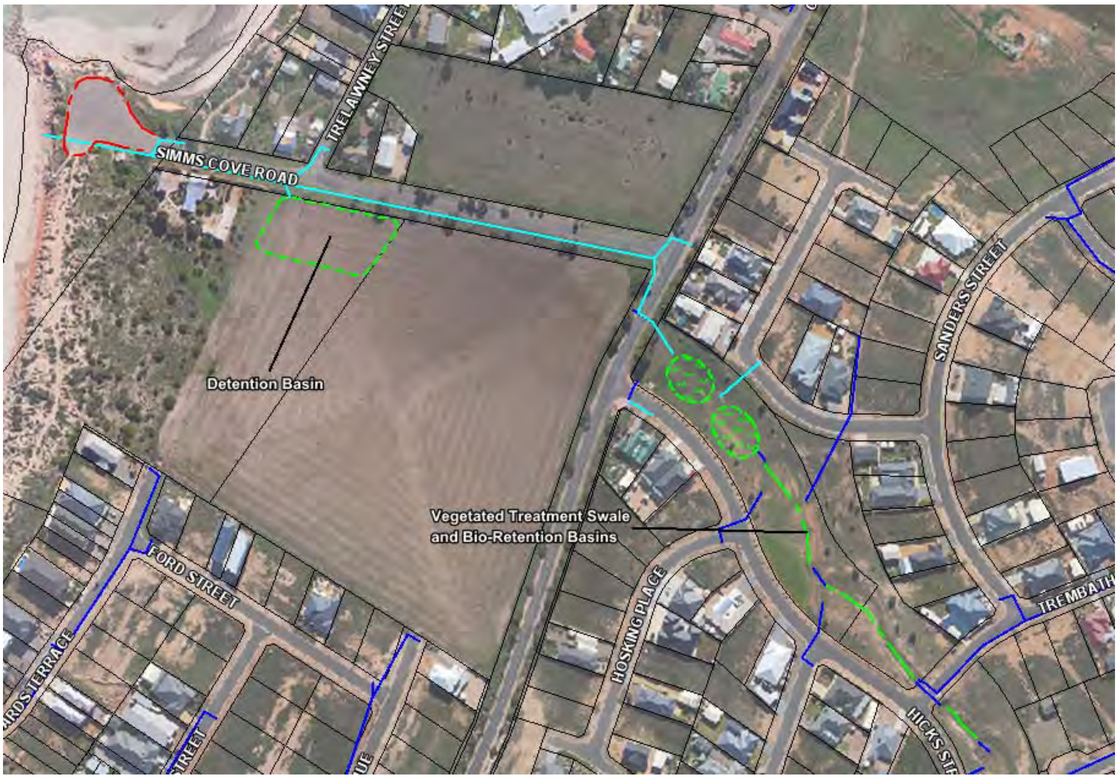


Figure 8.9 Catchment 7B WSUD Concept (Simms Cove Option B)

8.4.9 Catchment 7C

The Patrick's Cove swales in Catchment 7C already contain some native vegetation. Further work to this swale and installation of a bio-retention basin could further improve the swales' water treatment qualities and also improve amenity.

Figure 8.10 Catchment 7C Concept

8.4.10 Catchment 8

No additional WSUD measures are proposed for Catchment 8 because the existing drain runs through private properties and there is no open space that could be utilised for WSUD purposes.

8.4.11 Catchment 9

With the Elphick Street - Bennett Court drain upgrade being recently completed by Council, no further drainage works have been proposed within this relatively small catchment. There is also an existing gross pollutant trap at Dowling Drive. Hence no additional WSUD measures are proposed within this catchment.

8.4.12 Catchment 10

In addition to the existing GPT on Minnie Terrace, a bio-retention basin and water harvesting system is recommended for the coastal reserve. Treated water harvested from this system would be used to irrigate the lawns of this reserve, reducing the amount of potable water currently required for this purpose. The water is to be stored in underground tanks located under the reserve lawns. Bio-retention basins and water storage locations are shown in Figure 8.11.

Figure 8.11 Catchment 10 WSUD Concept

8.4.13 Catchment 11

No additional WSUD measures are proposed for Catchment 11 due to a lack of open space and narrow road widths in this catchment.

8.5 Domestic Rainwater Tanks

The installation of rainwater tanks into new residential development was mandated by State Government a number of years ago. Currently, this stipulation requires that new development provide a minimum 1kL tank to receive site generated stormwater runoff, with the tank plumbed into any combination of toilet, laundry or hot water system demand nodes.

Council's current Rainwater Tank Policy exceeds the State Government requirement with rainwater tank capacities nominated as follows:

- Allotments with an area less than 449 m^2 - 5,000 litres or greater
- Allotments with an area of 450 m^2 to 649 m^2 - 10,000 litres or greater
- Allotments with an area greater than 650 m^2 - 22,000 litres or greater

Council's policy is considered to be appropriate given that:

- Capture of stormwater would reduce the pollutant load discharged to the local marine
- environment
- Capture of stormwater would reduce the volume of runoff directed into the Council stormwater system
- Greater storage capacities would achieve a greater reduction in residential mains water usage
- Rainwater tank prices have become more competitive in recent years, and hence the payback period of providing a greater storage capacity has been reduced

For the purposes of the MUSIC modelling report in Section 8.6, the following (conservative) scenario has been adopted:

- 5kL rainwater tank implemented across all new residential properties, no rainwater tank in the remaining existing residential properties
- Each rainwater tank connected to a daily demand of 50 L/day
- The number of assumed future dwellings was based on the increased pervious fraction for each catchment and a subdivision rate increase of 25% and 50% in developed and undeveloped areas respectively.
- Areas of future development were assumed to have a housing density of 10 houses per hectare, based on recent new developments in Catchments 7 and 8.

8.6 Assessed Performance

A MUSIC model was compiled for the Moonta catchments incorporating various Water Sensitive Urban Design (WSUD) features. The MUSIC model layout is shown in Figure 8.12.

The results of the proposed scenario MUSIC model for discharge to the Spencer Gulf during the years 2001-2006 are as summarised in Table 8.3.

With the proposed improvements, MUSIC modelling shows that median TN and TP concentrations at outfalls would remain above ANZECC guideline levels, but would be less than under the current scenario (Table 1), therefore, after dilution by mixing, concentrations in habitats surrounding outfalls are less likely to exceed the guideline values than currently. Median TSS concentrations would be greatly reduced for most catchments, and 90^{th} percentile TSS concentrations would be <25 mg L^{-1}, indicating a reduction in the risks from turbidity, suspended sediments and other pollutants if the improvement measures are implemented. The proposed increase in water harvesting and re-use further reduce the total annual fluxes of pollutants in combination with the reductions in concentrations. Reduced loads of N and P will decrease the risks from chronic nutrient enrichment on surrounding habitats.

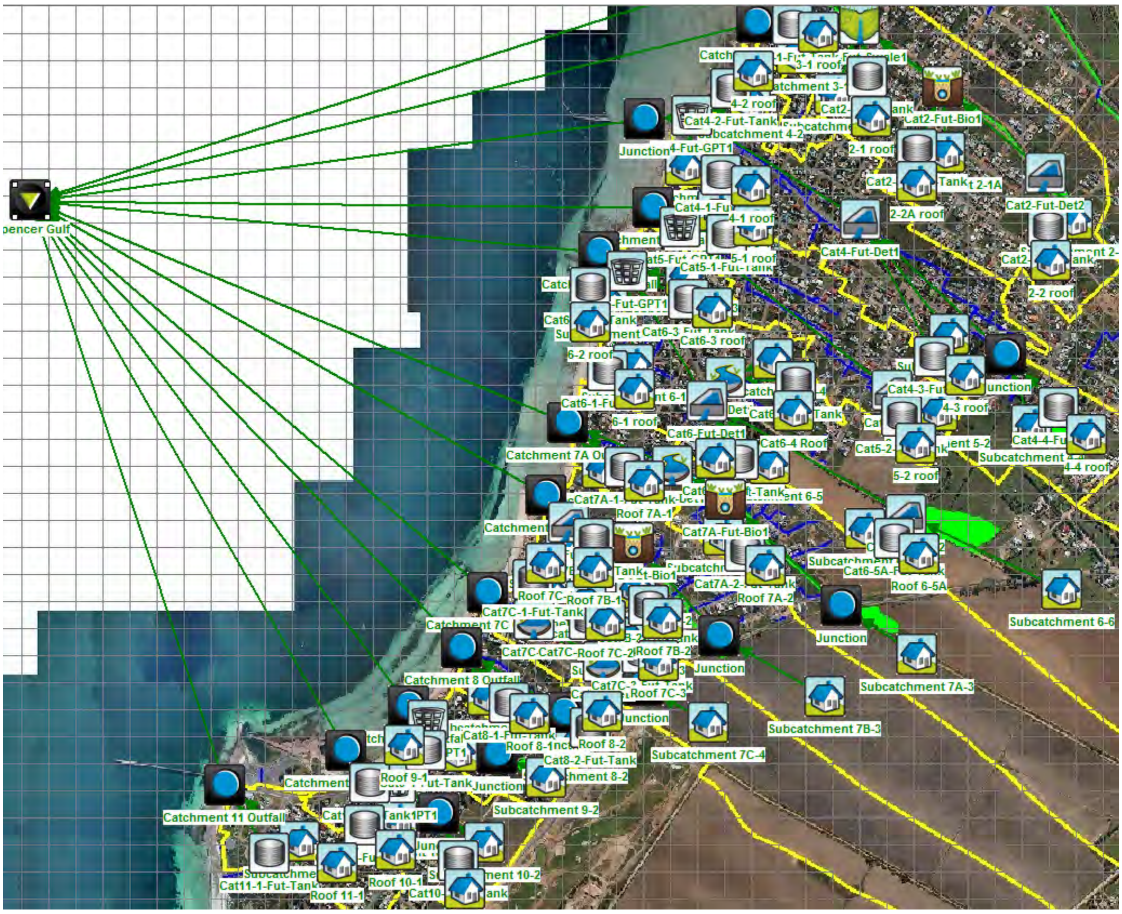


Figure 8.12 Proposed Scenario Music Model

Overall the proposed improvement measures come close to reaching or exceed the stated targets for reduction in TN, TP, TSS and gross pollutants, and would reduce the risks to surrounding habitats. The reductions in annual loads of TN and TP would reduce the risk of chronic nutrient impacts, while reductions in TSS should decrease risks from turbidity, sediments and other pollutants.

Further measures could be considered to ultimately achieve the targets for a number of catchments, however for the overall system, targets are closely met or exceeded.

The opportunity for additional measures exists at the street level (such as WSUD measures incorporated into road reconstructions) and at the site level (such as rainwater tanks and other site-based measures incorporated into new developments).

The modelling also supports maintaining the current rainwater tank requirements, which would achieve some catchment-scale water quality improvements, while also diverting approximately 30 ML/yr of stormwater to residential reuse.

Table 8.3 Performance of Proposed Water Quality Improvement Measures

Catchment	TSS		TP		TN		GP	
	t/yr	%[1]	t/yr	%[1]	t/yr	%[1]	t/yr	%[1]
2	1.43	*92.2*	0.010	*73.2*	0.125	*53.9*	0	*100*
3	0.958	*10.1*	0.002	*7.7*	0.015	*5*	0.21	*12*
4	3.98	*78.5*	0.015	*60.3*	0.16	*40.5*	0.255	*94*
5	4.07	*64.5*	0.014	*39.5*	0.13	*16.7*	0.268	*89.7*
6	3.07	*91.8*	0.013	*84.6*	0.162	*75.8*	0.184	*96.6*
7A	7.41	*57.5*	0.017	*59.9*	0.13	*62.1*	0.462	*82.1*
7B	5.92	*56.6*	0.021	*30*	0.133	*51.5*	0.536	*75.8*
7C	2.48	*74*	0.005	*76.3*	0.041	*77.6*	0	*100*
8	2.89	*8.7*	0.006	*6.7*	0.046	*4.5*	0.677	*9.7*
9	1.21	*53.1*	0.004	*23.9*	0.038	*3.2*	0.083	*86.1*
10	1.53	*77.4*	0.007	*51*	0.075	*24.1*	0	*100*
11	3.35	*8.6*	0.007	*6.9*	0.052	*4.7*	0.741	*10.1*
Total	**38.3**	***73.22***	**0.122**	***61.38***	**1.107**	***53.68***	**3.416**	***87.21***

[1] Percentage reductions are based on the Baseline Scenario of the future model with increased impervious fractions.

Table 8.4 Water Quality Median Concentrations, Existing and Post-WSUD Works

	TN (mg/L)		TP (mg/L)		TSS (mg/L)	
Guideline*	1		0.1		None given	
Catchment	Existing	Proposed	Existing	Proposed	Existing	Proposed
2	2.17	1.4	0.167	0.13	13.6	14
3	2.16	1.76	0.165	0.117	13.5	10
4	2.17	1.91	0.166	0.106	13.6	5.59
5	2.16	1.86	0.166	0.102	13.5	5.38
6	2.17	1.94	0.167	0.11	13.6	5.78
7A	2.16	1.8	0.166	0.12	13.5	10.3
7B	2.17	0.6	0.167	0.222	13.6	1.75
7C	-	-	-	-	-	-
8	2.16	1.87	0.166	0.129	13.5	10.9
9	2.16	1.9	0.166	0.106	13.5	5.58
10	2.17	-	0.166	-	13.6	-
11	2.16	1.85	0.166	0.126	13.6	10.7

*Default trigger value for marine ecosystems in south central Australia - low rainfall areas - slightly disturbed habitats (ANZECC and ARMCANZ 2000a).

“-” catchment does not discharge during most rainfall events, therefore median is no pollutant concentration due to zero flow.

9 Flood Damages

Estimates of Flood damages provide stakeholder groups with important information that can be used to prioritise flood mitigation or flood prevention works. They indicate the magnitude of damages caused by a design flood event of a given Average Recurrence Interval (ARI).

The magnitudes of flood damages are dependent upon a number of factors including property values, property size and the preparedness of the community to respond to the threat of flooding. These factors (and others) are included in the damages assessment calculations and are detailed in the following sections.

9.1 Damages Methodology

An overview of the methodology applied to the damages estimates is described below.

The first step undertaken was to use zoning boundaries overlaid on top of the cadastral layer to separate the residential areas from the commercial / industrial areas as well as other areas such as reserves that are not factored in to any damages calculations.

The 10, 20, 50 and 100 year ARI floodplain extents were then separately overlaid over the residential and commercial/industrial allotments. The flood depth at the centroid of each property was determined for each ARI.

For residential buildings, the flood depths for each ARI were broken up into the following ranges as recommended in the RAM Report (NRE, 2000):

- Inundation depths from 0.15 - 0.6m
- Inundation depths from 0.6 - 1.5m
- Inundation depths from 1.5 - 2.0m
- Inundation depths over 2.0m

For commercial / industrial buildings, the flood depths for each ARI were broken up into the following ranges (also taken from the RAM report):

- Inundation depths from 0 - 0.25m
- Inundation depths from 0.25 - 0.75m
- Inundation depths from 0.75 - 1.25m
- Inundation depths from 1.25 - 1.75m
- Inundation depths from 1.75 - 2m
- Inundation depths from 2 - 10m

The ranges shown above assume that residential properties are only assumed to be flooded if the inundation depth exceeds 150 mm (at the property centroid), whereas commercial/industrial properties are flooded as soon as there is any inundation shown at the property centroid.

The RAM report provides a range of values to be applied to building damages based on the size and condition of the building. For this assessment we have assumed that all buildings are in "fair" condition, and that all the commercial / industrial buildings are "medium" in size.

Damage values taken from the RAM report have been indexed to 2013 units using appropriate CPI factors sourced from Bureau of Statistics (March 2013 Quarter). These values were then applied to each inundation range for each type of property that was shown to be flooded. This process was repeated for all four ARI's as well as for both the 'existing" and "future" scenarios.

The building damages estimates (classified as direct, tangible losses) were then summed to allow the calculation of indirect tangible losses which are directly proportional to the direct losses.

Our damages estimates did not consider the following items:

- Damage to public infrastructure
- Damage to crops and stock losses
- Losses to vehicles
- Intangible losses.

9.2 Direct tangible losses

Losses to buildings including their contents (split between residential and commercial / industrial buildings) were considered in this analysis.

9.2.1 Stage Damage Curves

Both residential and commercial / industrial stage-damage curves were developed for this flood damage assessment. These curves were sourced from NRE (2000) and modified to represent today's (2013) dollar values. The stage-damage data used in this analysis is presented in Table 9.1 and 9.2.

It is worthy of note that the value ranges have a minimum and maximum value that can be applied. Our calculations are conservatively based on the maximum values shown in each table.

Because no data was available on the type, size or condition of each of the buildings considered, the size and condition of each residential and commercial /industrial building was assumed to be medium and fair, respectively.

Table 9.1 Stage Damage Value Ranges, Residential Buildings

Inundation Depth Range	Minimum	Maximum (these values were adopted)
0.15 - 0.6m	$12,570	$31,530
0.6 - 1.5m	$31,530	$47,300
1.5 - 2m	$47,300	$50,490
> 2m	$50,490	$50,490

Table 9.2 Stage Damage Value Ranges, Commercial / Industrial Buildings

Inundation Depth Range	Minimum	Maximum (these values were adopted)
0 - 0.25m	$0	$79,030
0.25 - 0.75m	$79,030	$191,180
0.75 - 1.25m	$191,180	$290,960
1.25 - 1.75m	$290,960	$322,090
1.75 - 2m	$322,090	$342,850
2 - 10m	$342,850	$342,850

The Rapid Appraisal Method (RAM) for Floodplain Management suggests that the stage damage curves (originally sourced from Smith, 1994) underestimate flood damages. To address this issue, the RAM report recommends increases of 60% be applied to both the residential and non-residential curves. Section 3.1 of the RAM report provides a detailed explanation for the increase, but essentially the increase to the stage-damage curves is required as the original curves are based primarily on relatively old data.

Damages to property that actually occur (actual damages) are normally less than those that could occur (potential damages) if residents took no action to reduce damages during a flood, eg, lift furniture. Ratios to convert Potential damages to Actual damages were used in accordance with the recommendations from the RAM. That is, for a community who is generally unaware of their flooding risks and who have a warning time of between 2 and 12 hours, a factor (ratio) of 0.8 is used to reduce the potential damages to actual damages. This factor also applies to communities who regularly experience floods who have a warning time of less than 2 hours.

These factors have been applied to the values shown in Table 9.1 and 9.2.

9.2.2 Damages to Residential Buildings

The number of residential buildings that would potentially become inundated from the four different ARI events was estimated by overlaying the flood inundation maps for these events over the cadastral layer and the aerial photography.

It was assumed that there were no damages to residential buildings if the flood heights were below 150 mm.

The results of the analysis of the number of inundated properties for each ARI, depth range and scenario are shown in Table 9.3 and Table 9.4.

Table 9.3 Number of Residential Properties and Damage Estimates - Existing Scenario

ARI	Properties Inundated at each Depth Range				Damage Estimate
	0.15 - 0.6m	0.6 - 1.5m	1.5 - 2m	Over 2m	
100 years	170	7	0	0	**$5.69m**
50 years	91	1	0	0	**$2.92m**
20 years	33	0	0	0	**$1.04m**
10 years	11	0	0	0	**$0.35m**

Table 9.4 Number of Residential Properties and Damage Estimates - Future Scenario

ARI	Properties Inundated at each Depth Range				Damage Estimate
	0.15 - 0.6m	0.6 - 1.5m	1.5 - 2m	Over 2m	
100 years	118	3	0	0	**$3.86m**
50 years	33	1	0	0	**$1.09m**
20 years	6	1	0	0	**$0.24m**
10 years	3	0	0	0	**$0.10m**

9.2.3 Damages to Commercial and Industrial Buildings

The number of commercial and industrial buildings that would potentially become inundated from the four different ARI events was estimated by overlaying the flood inundation maps for these events over the cadastral layer and the aerial photography.

The results of the analysis of the number of inundated commercial / industrial properties for each ARI, depth range and scenario are shown in Table 9.5 and Table 9.6.

Table 9.5 Number of Commercial / Industrial Properties and Damage Estimates - Existing Scenario

ARI	Flood Range Above Existing Surface Level						Damage Estimate
	0 - 0.25m	0.25 - 0.75m	0.75 - 1.25m	1.25 - 1.75m	1.75 - 2m	2 - 10m	
100 years	33	0	0	0	0	0	**$2.61m**
50 years	17	0	0	0	0	0	**$1.34m**
20 years	6	0	0	0	0	0	**$0.47m**
10 years	1	0	0	0	0	0	**$0.08m**

Table 9.6 Number of Commercial / Industrial Properties and Damage Estimates - Future Scenario

ARI	Flood Range Above Existing Surface Level						Damage Estimate
	0 - 0.25m	0.25 - 0.75m	0.75 - 1.25m	1.25 - 1.75m	1.75 - 2m	2 - 10m	
100 years	30	0	0	0	0	0	**$2.37m**
50 years	11	0	0	0	0	0	**$0.87m**
20 years	6	0	0	0	0	0	**$0.47m**
10 years	2	0	0	0	0	0	**$0.16m**

9.3 Outside Buildings

Damages to equipment outside buildings are not included in the standard stage-damage curves used. Such damages may include damage to fences, driveways, lower level laundries and outdoor equipment. To account for this $2,000 was applied to each property that was inundated as shown in the tables below.

Table 9.7 Outside Building Damage Estimates - Existing Scenario

ARI (yrs)	Number of Flooded Properties	Damage Estimate
10	12	$24,000
20	39	$78,000
50	109	$218,000
100	210	$420,000

Table 9.8 Outside Building Damage Estimates - Future Scenario

ARI (yrs)	Number of Flooded Properties	Damage Estimate
10	5	$10,000
20	13	$26,000
50	45	$90,000
100	151	$302,000

9.4 Indirect Damages

Indirect damages refer to the costs incurred to a community during a flood and include emergency response and disruptions to employment, commerce, tourism, transport and communication. The RAM report suggests that these costs are approximately 30% of direct damages.

9.5 Summary of Total Damages

The total damages for each ARI were determined by simply summing the various types of damages calculated previously.

For the existing scenario, the total damages are shown in Table 9.9.

Table 9.9 Total Damage Estimates - Existing Scenario

ARI (yrs)	Residential Damages	Commercial / Industrial Damages	Outside Building Damages	Indirect Damages	Total Damages
10	$0.35m	$0.08m	$0.02m	$0.13m	**$0.58m**
20	$1.04m	$0.47m	$0.08m	$0.48m	**$2.07m**
50	$2.92m	$1.34m	$0.22m	$1.34m	**$5.82m**
100	$5.69m	$2.61m	$0.42m	$2.62m	**$11.33m**

For the future scenario, the total damages are shown in Table 9.10.

Table 9.10 Total Damage Estimates - Future Scenario

ARI (yrs)	Residential Damages	Commercial / Industrial Damages	Outside Building Damages	Indirect Damages	Total Damages
10	$0.09m	$0.16m	$0.01m	$0.08m	**$0.34m**
20	$0.24m	$0.47m	$0.03m	$0.22m	**$0.96m**
50	$1.09m	$0.87m	$0.09m	$0.61m	**$2.66m**
100	$3.86m	$2.37m	$0.30m	$1.96m	**$8.50m**

9.6 Damage Savings due to Proposed Mitigation Works

The proposed structural works in the Moonta, Moonta Bay & Port Hughes Stormwater Management Plan have been costed and summarised in Section 11.

The total cost of the proposed works has been estimated at over $8 million.

The total reduction in direct tangible damages when comparing the future scenario to the existing scenario is shown in Table 9.11.

Table 9.11 Potential Reduction to Damages

ARI (yrs)	Existing Scenario Damages	Future Scenario Damages	Potential Reduction to Damages
10	$0.58m	$0.34m	**$0.24m**
20	$2.07m	$0.96m	**$1.11m**
50	$5.82m	$2.66m	**$3.16m**
100	$11.33m	$8.50m	**$2.84m**

10 Community Consultation

10.1 Background

Following the completion of the Draft Stormwater Management Plan, a community engagement plan was developed for the community consultation process.

A summary of the community consultation including our response to the feedback received during the process is presented in this Chapter. The complete consultation report including copies of feedback forms and all information released to the public is contained in Appendix C.

10.2 Purpose of Community Engagement

Community consultation was undertaken on the Draft SMP to:

- Communicate the general content of the Draft SMP, specifically findings of investigations (e.g. flood plain mapping) and proposed stormwater management strategies; and
- Gather community feedback in relation to the proposed stormwater management strategies, including the prioritisation of strategies.

Feedback received and collated in this report was considered in developing the Final SMP.

10.3 Consultation Process

Public consultation on the Draft SMP occurred between Monday 23 September and Friday 25 October 2013.

The following consultation activities were undertaken:

- A Community Information Session held in Moonta on Thursday 17 October 2013 between 3.30pm and 6.30pm.

Members of the public were invited to drop in to this session to find out more about the Draft SMP and provide feedback.

The Information Session was staffed by representatives of Council, Southfront and URPS. Poster displays provided information about the Draft SMP, and a laptop was set up to enable members of the public to view flood mapping prepared for the Draft SMP at specific locations.

- Fact sheets and feedback forms were provided at Council's Kadina offices, the Moonta Library, and the Moonta Tourism Office, along with hard copies of the Draft SMP.
- A public notice was published in the Yorke Peninsula Country Times in the week of 23 September 2013 and week of 14 October 2013, and this notice was also displayed on noticeboards at Moonta Foodland and the Port Hughes Jetty;
- Information was included on Council's website including the Draft SMP, flood mapping, and the fact sheet and feedback form;
- A press release publicising the consultation process and Community Information Session was provided to the Yorke Peninsula Country Times.

All consultation activities and materials emphasised the opportunity to provide feedback on the Draft SMP by returning a feedback form by Friday 25 October 2013.

10.4 Consultation Feedback

10.4.1 Community Information Session

The Community Information Session was attended by 8 members of the public, and 3 Council Elected Members.

Three feedback forms were submitted at the Information Session, and these are summarised in Section 10.4.2 along with feedback forms received by post or fax.

The following feedback was provided informally by information session attendees (i.e. verbally to staff, not via a feedback form):

- Overall the Draft SMP is a good plan, and a step forward for Council in managing stormwater;
- Opportunities exist to use stormwater for irrigation, for example on golf courses;
- Concerns about how proposals will be funded and possible rate rises, keen that Council pursue State and Commonwealth Government funding;
- Current stormwater issues and proposals in the Draft SMP were discussed with Information Session staff in relation to the following specific locations:
  - Ivy Place, Port Hughes;
  - Kitto Road;
  - The corner of North Terrace and Haylock Road, and Coast Road; and
  - The retirement village near Military Road and Blanche Terrace.

10.4.2 Feedback Forms

A total of 11 feedback forms were returned during the consultation period. Three of these were submitted at the Community Information Session.

Respondents identified as themselves as property owners and/or residents and/or business owners in Moonta (3 respondents), Moonta Bay (5 respondents), and Port Hughes (3 respondents).

Respondents were asked what information they had accessed as part of the community consultation on the Draft Stormwater Management Plan: the Community Information Sheet, the full Draft SMP, and attendance at the Community Information Session.

As shown in Table 10.1, respondents had accessed all forms of information available during the consultation period, and more than half (6) had reviewed the Draft SMP.

Table 10.1 Information Accessed by Respondents

Community Information Sheet	Draft Stormwater Management Plan	Community Information Session	Number of Respondents
X			2
X	X		0
X	X	X	2
	X		3
	X	X	1

		X	2
X		X	1
		Total	**11**

Respondents were asked how important it is to them that flood mitigation works occur in the Moonta, Moonta Bay and Port Hughes catchments, using a scale of 1 (not very important) to 5 (very important). Responses were recorded as shown in Table 10.2.

Table 10.2 Importance of Flood Mitigation Works

	Not Very Important				Very Important		
Scale	**1**	**2**	**3**	**4**	**5**	**No Response**	**Total**
No. of Responses	0	0	0	2	8	1	11

Respondents were asked to indicate on a scale of 1 (not very important) to 5 (very important) how important it is to them that Water Sensitive Urban Design (WSUD) works occur in the Moonta, Moonta Bay and Port Hughes catchment, including projects to support sustainable use of water resources, improvement of water quality, and protection of watercourse and ecosystem health. Responses were recorded as shown in Table 10.3

Table 10.3 Importance of WSUD Works

	Not Very Important				Very Important		
Scale	**1**	**2**	**3**	**4**	**5**	**No Response**	**Total**
No. of Responses	0	0	0	1	9	1	11

Responses in Tables 10.2 and 10.3 show that flood mitigation and WSUD are of high importance to respondents.

Respondents were asked to indicate their level of support for the Draft SMP using a scale of 1 (strongly oppose) to 5 (strongly support). Responses were recorded as shown in Table 10.4, with all respondents either “neutral” or supportive of the Draft SMP. The most frequent response was strong support of the Draft SMP (5 respondents).

Table 10.4 Support for Draft SMP

	Strongly Oppose				Strongly Support		
Scale	**1**	**2**	**3**	**4**	**5**	**No Response**	**Total**
No. of Responses	0	0	2	3	5	1	11

In addition to answering the questions reported above, respondents were asked to provide their comments on the Draft SMP. Comments recorded are summarised below.

- Concern around proposed stormwater retention on private land at Rossiters Road under the Draft SMP;
- Request for a raised gutter to a property on Rossiters Road;
- Identification of current flooding issues:
  - On Bay Road at Moonta Bay affecting private property;
  - At the northern end of Charles Street at Port Hughes – erosion and marine discharge, some flooding of private property, concern that an existing stormwater easement is not identified in the Draft SMP;
  - On Edward Street and Minnie Terrace at Port Hughes; and
  - On Ryan Street at Moonta – concern that Draft SMP does not account for information previously provided to Council or local topography.
- View that a high priority should be accorded to management of stormwater runoff to the sea, cliff erosion, and better management of coastal outlets;
- Support for management of flooding issues in Moonta and water conservation;
- View that the SMP is a very high priority for Moonta Bay in terms of flood mitigation, and that the area around Chapman Road, Hollis Court and North Terrace should be the highest priority;
- View that Gardener/Ryan Street drains be given high priority in the staging of McAuley Park upgrade works;
- View that better planning and engineering decisions around new development should be part of flood mitigation;
- View that ongoing costs of implementing the Draft SMP should be no greater than current stormwater management costs, that the costs of implementing the SMP should be transparent, and that rates should not increase to fund SMP works - grant funding be sought instead;
- Suggestion that more natural areas be established to improve the health of the environment;
- Suggestion that the area north west of North Terrace where birds currently nest become a wetland, which would be a community and tourism asset, though private land would need to be purchased.

One respondent provided extensive comments in relation to the Draft SMP which included:

- Desire for a wetland such as those in the City of Salisbury area, and increased retention of stormwater for irrigation;
- A view that the Draft SMP does not adequately address local observations of poor coastal water quality and impacts on the marine environment (seagrass loss, reduced nearshore marine biodiversity), and concern that additional coastal outlets are proposed;
- Concern around previous development decisions and the impact on stormwater management;
- Concern around current discharges from private property to the coast;
- Specific concern that the proposed works at Simms Cove Road will result in beach degradation, and suggestion of an alternative option involving:
  - Reshaping and kerbing Simms Cove car park;
  - Deepen upstream ponds in Patricks View (Hicks Street);
  - Pump stormwater from Trelawney Street along Simms Cove Road to Bray Street; and
  - Connect excess discharge from Patricks View to that pipeline.

10.5 Consideration of Feedback

Community feedback summarised herein has been considered during the preparation of the Final Stormwater Management Plan. Feedback provided of a more 'general' nature has been used to update the overall Plan, whilst feedback relating to specific locations of concern has been addressed within the specific sections of the Plan relating to each location.

11 Stormwater Management Plan

11.1 Strategy Action Costs, Benefits and Priority Summary

The actions outlined in Sections 7 and 8 are presented in summary form in Table 11.1, 11.2 and 11.3 together with a brief description of the benefits realised through implementation of each action. The summary tables have been divided into categories as follows:

- Table 11.1 describes proposed works that have a major flood mitigation benefit
- Table 11.2 describes proposed works that have a medium to low flood mitigation benefit
- Table 11.3 describes proposed works that implement WSUD measures. Many of the proposed WSUD projects relate to the upgrades already listed in Tables 11.1 and 11.2 and are assumed to be complementary. In cases where proposed works appear to be duplicated, the "WSUD" costings shown in Table 11.3 have been presented separately to the "drainage capacity upgrade" costings shown in Tables 11.1 and 11.2.

11.2 Prioritisation and Timeframe

The actions outlined in this Stormwater Management Plan will require implementation to be scheduled across many years, in order to be accommodated sustainably within the District Council of the Copper Coast budget, and budgets of other potential funding partners.

Each of the actions within the plan has been assigned one of three priority levels, as follows:

- High Priority (short term implementation)
- Medium Priority (medium term implementation)
- Low Priority (long term implementation)

The prioritisation of each action has recognised greater urgency where:

- There is property (above floor-level) flood risk
- Related projects are underway
- Existing asset condition is poor

It is important to note that the priority rating of actions is flexible and subject to change over time, and that some actions will be 'brought forward', particularly when opportunities for grant funding arise.

11.3 Supporting Activities

The following activities have also been identified to support the implementation of this Plan.

11.3.1 Surface Water Management of the Moonta Mines area

The District Council of the Copper Coast has a direct interest in ensuring that the landowner of the Historic Moonta Mines area (Crown Land) develops and implements a strategy to manage discharge of potentially contaminated surface water runoff. It is recommended that Council pursue this matter with the landowner.

11.3.2 Management of Coastal Outlets and Cliff Faces

Several of the proposed upgrades discussed in Sections 7 and 8 of this report include the upgrade of existing, or the creation of new stormwater outlets to the coast. New or upgraded outlets have been proposed in the following locations:

- Moonta Road / Marine Parade
- Simms Cove Road (Options B and C only)
- Rossiters Road (Carpark)
- At the downstream end of the Trelawney Street to Tipara Court Drain
- Dowling Drive (downstream end of the Minnipa Drive system)
- Minnie Terrace (between Edward and Cunliffe Streets)
- Minnie Terrace (downstream end of proposed Randolph Street system)

Moonta Cliff Top Study Recommendations

The recently completed Moonta Cliff Top Study (AWE, 2013) has stated that surface flows travelling over cliffs between Moonta Bay and Port Hughes are one of the major factors affecting cliff top erosion (other factors include wave action and wind). Management of surface runoff needs to be implemented in these areas, with the 3 main locations at risk of experiencing uncontrolled sheet flows travelling towards the coast include Simms Cove Road, Rossiters Road and Minnie Terrace. Specific recommendations for these areas are to provide new underground drainage outlets and roadside / carpark kerbing to contain surface stormwater flows. Other more general recommendations listed in the Cliff Stop Study include:

- Providing Gross Pollutant Traps or bio-filtration treatment on all ocean stormwater outlets;
- Providing consistent erosion control beaching such as rip rap or reno-mats at beach level on all stormwater outlets;
- Considering stormwater harvesting from existing or proposed retention/detention basins;
- Implementing a strategy that allows private land owners to redirect their roof stormwater drainage outlets away from the cliff face.

We recommend that further investigation into appropriate coastal outlet / cliff top management solutions be implemented as part of the detailed design phase of any proposed stormwater / WSUD upgrades listed above. We recommend that any new or upgraded outlets incorporate the installation of GPT's and/or bio-retention solutions, and that the use of kerbing and additional capture points are implemented to prevent runoff overtopping cliff faces. We also recommend implementing an ongoing monitoring strategy to monitor the condition of outlets and any further cliff top recession.

11.3.3 Periodic Assessment of Development Trends

This Stormwater Management Plan has been informed by a development trend assessment that indicates that the catchment area is unlikely to be the subject of significant development of a nature that would affect the current hydrological regime. To confirm this assumption, it is recommended that a periodic assessment (every 5 years on average) of development trends be undertaken through discussion with Council planning staff and inspection of aerial photography.

11.3.4 A Review of Council Drainage Easements

During the community consultation process, a number of concerns were raised relating to flooding within private properties and drainage easements that may or may not currently be documented within Council's records. These locations include Ivy Place and Charles Street at Port Hughes, as well as the retirement village near Military Road and Blanche Terrace at Moonta. It is recommended that Council investigate whether or not there is existing drainage infrastructure in these locations and whether the drainage performance meets proposed standards set out in this SMP.

11.3.5 Integration with Open Space Master Planning

This Stormwater Management Plan has identified opportunities for works within:

- McAuley Park
- Queen Square
- Victoria Park
- Bray Street Reserve
- Minnie Terrace Reserve

It is anticipated that these opportunities will need to be filtered through a master planning and consultation process, specific to each area of open space.

11.4 Responsibilities for Implementation

The lead agency for all actions within this Stormwater Management Plan is the District Council of the Copper Coast. Many of the stormwater drainage infrastructure or flood protection actions recommended in the Plan are of a sufficient size (ie. serve catchments greater than 40ha) in order to qualify for funding from the Stormwater Management Authority. These are identified in Table 11.1.

The Northern & Yorke NRM Board may provide support for projects that improve the quality of water discharged to the marine environment, as well as the restoration of watercourses, construction of wetlands and other WSUD initiatives.

11.5 Implications for Adjoining Catchments

There are no known boundary interface issues, in relation to exchange of stormwater or floodwaters with the Study Area being impacted by external catchments.

Table 11.1 Stormwater Management Plan Works Summary - Major Flood Damage Reduction

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	McAuley Park and Open Channel Upgrades[1]	1,890,000	20,000	100 years	High - severely reduced flood extents	High - biodiversity enhancement and increased amenity and recreation
High	Moonta Road Open Drain[1]	840,000	10,000	20 years	High - provides containment of flood flows	Improved amenity
High	Marilyn Street to Chapman Road Drain, Channel & Basin[1]	1,250,000	5,000	10 years	High - protects several properties	Reduce excessive gutter flows
High	Bay Road Drainage and Kerbing[1]	1,260,000	10,000	10 years	High - protects several properties	Improved overland flow path capacity
High	Kitto Road Embankment and Drainage	150,000	-	100 years	High - protects several properties	Minimal work required to achieve flood mitigation benefit
High	Caroline to Milne Street Drainage	570,000	-	10 years	High - protects several properties	-
High	Rossiters Road Stage 1 Drainage[1]	1,190,000	10,000	10 years	High - provides formal stormwater conduit	Reduce excessive gutter flows, erosion protection
Medium	Rossiters Road East Drainage[1]	840,000	10,000	10 years	High - allows for safer future development	-
Medium	Minnipa - Dowling Street Drainage Upgrade	700,000	-	20 years	High - protects several properties	-
Total		**8,690,000**	**65,000**			

[1] Project eligible for Stormwater Management Authority funding, based on the 40ha contributing area criteria

Table 11.2 Stormwater Management Plan Works Summary - Medium - Low Flood Damage Reduction

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	Simms Cove Road Drainage, and Erosion Protection (Option A)[1,2]	840,000	20,000	10 years	Low during existing scenario but will cater for future redevelopment	Environmental - Prevents erosion of cliff faces, stormwater harvesting
High	George / William / Henry Street Drainage	490,000	5,000	10 years	Medium	Reduce excessive gutter flows, improves amenity
Medium	Emerson to Minnie Terrace Drainage	890,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Brokenshire to Moonta Road Drain and Basin	500,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street	1,990,000	-	10 - 20 years	Medium	
Medium	North Terrace Drainage	690,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Drainage Easement Investigation	N/A	N/A	>10 years	Medium	Update of Council records
Low	Tipara / Trelawney Street Drainage	390,000	-	10 years	Medium	-
Low	Caroline to Robert Drainage	460,000	-	20 years	Medium	Reduce excessive gutter flows
Low	Port Hughes / Trenerry Road Outlets	80,000	-	20 years	Low	-
Low	Randolph Street Drain	580,000	-	10 years	Medium	Reduce excessive gutter flows
Low	Hills Street & Majors Road	170,000	-	10 years	Medium	Reduce excessive gutter flows
Total[2]		**7,080,000**	**25,000**			

[1] Project eligible for Stormwater Management Authority funding, based on the 40ha contributing area criteria

[2] Only Option A has been presented in the table above due to capital and recurrent costs being higher than those for Options B and C

Table 11.3 Stormwater Management Plan Works Summary - WSUD Projects

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Benefit[1]	Works Supporting Drainage Upgrade	Water Quality Benefit	Other Benefits
High	Coastal Outlet / Cliff Top Management	N/A	N/A	-	Yes	High - due to WSUD / GPT's at each outlet	Minimise erosion of cliff faces, improved amenity
High	McAuley Park WSUD and Harvesting	1,790,000	30,000	Up to 70 ML/yr	Yes	High - provides instream treatment	Biodiversity enhancement and increased amenity and recreation
High	Simms Cove Road WSUD	80,000	5,000	Up to 36 ML/yr	Yes	High	Environmental - Prevents erosion of cliff faces
High	Moonta Road Open Drain & WSUD	180,000	10,000	-	Yes	High - extensive treatment train	Improved amenity
High	Chapman Road, Channel & Basin	150,000	5,000	-	Yes	Medium - treatment using WSUD principles	Improved amenity
Medium	Bay Road WSUD & GPT	140,000	10,000	-	Yes	Medium	-
Medium	Caroline to Milne Street Harvesting	300,000	15,000	Up to 8 ML/yr	Yes	-	-
High	George / William / Henry Street WSUD	280,000	15,000	Up to 24 ML/yr	Yes	Medium - rain gardens remove some pollutants	Reduce excessive gutter flows, improves amenity
Medium	Rossiters Road West GPT	60,000	5,000	-	Yes	Low - GPT at outlet only	
Medium	Emerson to Minnie Terrace WSUD	300,000	15,000	Up to 37 ML/yr	Yes	-	

Priority	Project / Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Benefit[1]	Works Supporting Drainage Upgrade	Water Quality Benefit	Other Benefits
Medium	Rossiters Road East WSUD	220,000	10,000	-	Yes	High - extensive treatment train	-
Medium	Brokenshire to Moonta Road Basin	150,000	10,000	-	Yes	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street GPT	60,000	5,000	-	Yes	Low - GPT at outlet only	
Low	Bray Street WSUD	180,000	10,000	-	No	High	
Low	Hicks Street WSUD	240,000	10,000	-	No	High	
Low	Richards Terrace WSUD	90,000	5,000	-	No	Medium	
Total		**4,220,000**	**160,000**				

[1] Harvesting benefit based on the availability only - further investigation into the storage, demand and possible configuration of harvesting schemes is required to refine these values.

12 References

12.1 General

Allison, RA, Chiew, FHS and McMahon, TA (1997), *Stormwater Gross Pollutants, Industry Report 97/11*, Cooperative Research Centre for Catchment Hydrology, December 1997

Australian Water Environments (2013), *Port Hughes - Moonta Bay Cliff Top Stability Study Draft Strategy Report*

BC Tonkin & Associates (1980) *Stormwater Drainage Investigation - Moonta & Surrounds*, for the Town of Moonta and the District Council of Kadina

BMT WBM (2010) *TUFLOW (and ESTRY) User Manual*

CSIRO (2007), *The Adelaide Coastal Waters Study – Final Report, Volume 1, Summary of Study Findings* for the South Australian Environment Protection Authority

Department of Planning and Local Government (2010), *Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region*, Government of South Australia, Adelaide

Duncan, HP (1999), *Urban Stormwater Quality: A Statistical Overview, Report 99/3*, Cooperative Research Centre for Catchment Hydrology, February 1999

Environmental Protection Agency (1993) , *Environment Protection (Water Quality) Policy 2003*, Government of South Australia

Lange Dames & Campbell (1991), *Report on concept designs and estimates for drainage of Newtown, Russell Street and Port Moonta Catchments*

Melbourne Water (2013) *Healthy Waterways Rain Gardens Program*, http://raingardens.melbournewater.com.au/

McCarthy D, Rogers T, Casperson, K (2006), *Floods in South Australia 1836 - 2005*, Bureau of Meteorology

Northern & Yorke Natural Resources Management Board (2009), *Northern and Yorke Regional NRM Plan Volume D: Regulatory and Policy Framework*

NRE (2000), *Rapid Appraisal Method (RAM) for Floodplain Management*, Department of Natural Resources and Environment, State of Victoria, May 2000.

SA Water (2007), *Code of Practice: Irrigated Public Open Space*

Smith, D.I. (1994) *'Flood damage estimation—A review of urban stage-damage curves and loss functions'*, Water South Africa, vol.20, no. 3, July, pp. 231-238. (in BTE, 2001)

Stelling, G.S. (1984) *On the Construction of Computational Methods for Shallow Water Flow Problems* Rijkswaterstaat Communications, No. 35/1984, The Hague, The Netherlands.

Stormwater Management Authority (2006), *Guideline Framework for Uniform Catchment based Stormwater Management Planning by Local Government Councils*

Tonkin Consulting (2011) *Moonta, Wallaroo and Kadina Stormwater Management Plan*, for the Copper Coast Council

Department for Water (2012) *Water Sensitive Urban Design Consultation Statement*

Watercom Pty Ltd (2011) *DRAINS user Manual*

Wong THF, et al. (2012) *Stormwater Management in a Water Sensitive City*, The Centre for Water Sensitive Cities, Melbourne, Victoria

12.2 SARDI References

Abal EG, Dennison WC (1996) *Seagrass depth range and water quality in southern Moreton Bay, Queensland, Australia*. Marine and Freshwater Research 47, 763-771.

Airoldi L (2003) *The effects of sedimentation on rocky coast assemblages*. Oceanography and Marine Biology an Annual Review 41, 161-236.

Airoldi L, Cinelli F (1997) *Effects of sedimentation on subtidal macroalgal assemblages: an experimental study from a mediterranean rocky shore*. Journal of Experimental Marine Biology and Ecology 215, 269-288.

ANZECC, ARMCANZ (2000a) *Australian and New Zealand guidelines for fresh and marine water quality. Volume 1: the guidelines*. National water quality management strategy paper No. 4. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Managment Council of Australia and New Zealand.

ANZECC, ARMCANZ (2000b) *Australian and New Zealand guidelines for fresh and marine water quality. Volume 2: Aquatic ecosystems - rationale and background information*. National water quality management strategy paper No. 4. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Managment Council of Australia and New Zealand.

Baker JL (2005) *Dragon Search: public report. Summary of South Australian sighting data to May 2005*. Dragon search community based monitoring project, Adelaide.

Baker JL (2011) *Conservation status of marine invertebrates in the Northern and Yorke NRM region - a review*. Northern and Yorke Natural Resources Management Board.

Bryars S (2003) *An inventory of important coastal habitats in South Australia*. Fish habitat program, Primary Industries and Resources South Australia.

Bryars S, Rowling K (2008) *Benthic habitats of eastern Gulf St Vincent: major changes in seagrass distribution and composition since European settlement of Adelaide. In 'Restoration of Coastal Seagrass Ecosystems: Amphibolis antarctica in Gulf St Vincent, South Australia*. Report prepared for the Natural Heritage Trust, PIRSA Marine Biosecurity, SA Department for Environment and Heritage and the SA Environment Protection Authority. SARDI Aquatic Sciences Publication No.F2008/000078-1; SARDI Research Report Series No 277'. (Ed. S Bryars). (SARDI Aquatic Sciences: Adelaide)

Bryars S, Wear R, Collings G (2008) *Seagrasses of Gulf St Vincent and Investigator Strait. In 'Natural history of Gulf St Vincent'*. (Eds SAS Shepherd, S Bryars, IR Kirkegaard, P Harbison and JT Jennings) pp. 132-147. (Royal Society of South Australia Inc.: Adelaide)

Caton B, Detmar S, Fotheringham D, Haby N, Royal M, Sandercock R (2007) *Conservation assessment of the Northern and Yorke Coast*. Prepared by the coastal protection branch and the environment information analysis branch Department for Environment and Heritage SA for the Northern and Yorke Natural Resource Management Board.

Collings GJ, Bryars S, Nayar S, Miller D, Lill J, O'Loughlin E (2006a) *Elevated nutrient responses of the meadow forming seagrasses Amphibolis and Posidonia, from the Adelaide metropolitan coastline*. ACWS Technical Report No. 11 prepared for the Adelaide Coastal Water Study Steering Committee. South Australian Research and Development Institute (Aquatic Sciences), Publication No. RD01/0208-16, Adelaide.

Collings GJ, Bryars S, Turner DJ, Brook J, Theil M (2008) *Examining the health of subtidal reef environments in South Australia. Part 4: Assessment of community monitoring and status of selected South Australian reefs based on the results of the 2007 surveys*. South Australian Research and Development Institute, SARDI Publication Number F2008/000511- 1, Adelaide.

Collings GJ, Miller D, O'Loughlin E, Cheshire A, Bryars S (2006b) *Turbidity and reduced light responses of the meadow forming seagrasses Amphibolis and Posidonia, from the Adelaide metropolitan coastline*. ACWS Technical Report No. 12 prepared for the Adelaide Coastal Water Study Steering Committee. South Australian Research and Development Institute (Aquatic Sciences), Publication No. RD01/0208-17, Adelaide.

De Casabianca ML, Laugier T, Collart D (1997) *Impact of shellfish farming eutrophication on benthic macrophyte communities in the Thau lagoon, France*. Aquaculture International 5, 301-314.

DEH (2003) *Focus: a regional perspective of Spencer Gulf*. Coast and Marine Conservation Branch, Natural and Cultural Heritage, Department for Environment and Heritage, Adelaide.

Duarte C, Terrados J, Agawin N, Fortes M, Bach S, Kenworthy W (1997) *Response of a mixed Philippine seagrass meadow to experimental burial*. Marine Ecology Progress Series 147, 285-294.

Fernandes M (2008) *Sedimentation surveys of Adelaide's coastal reefs, Part 2 (autumn): a report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board*. South Australian Research and Development Institute (Aquatic Sciences), SARaDIA Sciences), SARDI Aquatic Sciences Publication Number F2008/000103-2, Adelaide.

Fernandes M, Theil M, Bryars S (2008) *Sedimentation surveys of Adelaide's coastal reefs, Part 1 (winter and summer): a report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board*. South Australian Research and Development Institute (Aquatic Sciences), SARaDIA Sciences), SARDI Aquatic Sciences Publication Number F2008/000103-1, Adelaide.

Fox DR, Batley GE, Blackburn D, Bone Y, Bryars S, Cheshire AC, Collings GJ, Ellis D, Fairweather P, Fallowfield H, Harris G, Henderson B, Kämpf J, Nayar S, Pattiaratchi C, Petrusevics P, Townsend M, Westphalen G, Wilkinson J (2007) *The Adelaide Coastal Waters Study. Final report volume 1 - summary of study findings*. Prepared for South Australian Environmental Protection Authority.

Gaylard S (2009a) *Abient water quality of Boston and Proper Bays, Port Lincoln 1997 - 2008*. Environmental Protection Authority, Adelaide.

Gaylard S (2009b) *A risk assessment of threats to water quality in Gulf St Vincent*. Environmental Protection Authority, Adelaide.

Gorgula SK, Connell SD (2004) *Expansive covers of turf-forming algae on human-dominated coast: the relative effects of increasing nutrient and sediment loads*. Marine Biology 145, 613-619.

Gorman D, Russell BD, Connell SD (2009) *Land-to-sea connectivity: linking human-derived terrestrial subsidies to subtidal habitat change on open rocky coasts*. Ecological Applications 19, 1114-1126.

James NP, Bone Y, Brown KM, Cheshire A (2009) *Calcareous epiphyte production in coolwater carbonate seagrass depositional environments; Southern Australia*. In 'Advances in carbonate sedimentology. '. (Eds PK Swart, GP Eberli and JA McKenzie) pp. 123-148. (Wiley-Blackwell)

Kirst GO (1990) *Salinity Tolerance of Eukaryotic Marine Algae*. Annual Review of Plant Physiology and Plant Molecular Biology 41, 21-53.

Lavery TJ, Kemper CM, Sanderson K, Schultz CG, Coyle P, Mitchell JG, Seuront L (2009) *Heavy metal toxicity of kidney and bone tissues in South Australian adult bottlenose dolphins (Tursiops aduncus).* Marine Environmental Research 67, 1-7.

Mackey P, Collier CJ, Lavery PS (2007) *Effects of experimental reduction of light availability on the seagrass Amphibolis griffithii*. Marine Ecology Progress Series 342, 117-126.

Marba N, Duarte CM (1995) *Coupling of seagrass (Cymodocea nodosa) patch dynamics to subaqueous dune migration*. Journal of Ecology 83, 381.

McDowell L-M, Pfennig P (2011) *Adelaide Coastal Water Quality Improvement Plan (ACWQIP).* Draft for public comment. Environmental Protection Authority, Adelaide.

Mills GN, Williamson RB (2008) *The Impacts of Urban Stormwater in Auckland's Aquatic Receiving Environment: A Review of Information 1995 to 2005*. Prepared by Diffuse Sources Ltd and Geosyntec Consultants for Auckland Regional Council. Auckland Regional Council Technical Report 2008/029. Auckland Regional Council, Auckland.

Nell JA, Holliday JE (1988) *Effects of salinity on the growth and survival of Sydney rock oyster (Saccostrea commercialis) and Pacific oyster (Crassostrea gigas) larvae and spat*. Aquaculture 68, 39-44.

O'Loughlin E, McCloud C, Sierp M, Westphalen G (2006) *Temperature and salinity tolerances of priority marine pests*. Developed for PIRSA Marine Biosecurity. South Australian Research and Development Institute, SARDI Aquatic Sciences publication number RD06/0751, Adelaide.

Peters K, Flaherty T (2011) *Marine debris in Gulf Saint Vincent bioregion*. Report for the Adelaide and Mount Lofty Natural Resources Management Board.

Preen AR, Lee Long WJ, Coles RG (1995) *Flood and cyclone related loss, and partial recovery, of more than 1000 km2 of seagrass in Hervey Bay, Queensland, Australia*. Aquatic Botany 52, 3-17.

Ralph P, Tomasko D, Moore K, Seddon S, Macinnis-Ng CMO (2006) *Human Impacts on Seagrasses: Eutrophication, Sedimentation, and Contamination*. In 'Seagrasses: Biology, ecology and conservation'. (Eds AWD Larkum, RJ Orth and CM Duarte) pp. 567-593. (Springer Netherlands)

Rohde S, Hiebenthal C, Wahl M, Karez R, Bischof K (2008) *Decreased depth distribution of Fucus vesiculosus (Phaeophyceae) in the Western Baltic: effects of light deficiency and epibionts on growth and photosynthesis*. European Journal of Phycology 43, 143-150.

Ruiz JM, Romero J (2001) *Effects of in situ experimental shading on the Mediterranean seagrass Posidonia oceanica*. Marine Ecology Progress Series 215, 107-120.

Ruiz JM, Romero J (2003) *Effects of disturbances caused by coastal constructions on spatial structure, growth dynamics and photosynthesis of the seagrass Posidonia oceanica*. Marine Pollution Bulletin 46, 1523-1533.

Touchette BW (2007) *Seagrass-salinity interactions: Physiological mechanisms used by submersed marine angiosperms for a life at sea*. Journal of Experimental Marine Biology and Ecology 350, 194-215.

Turner DJ (2004) *Effects of sedimentation on the structure of a phaeophycean dominated macroalgal community*. PhD thesis, The University of Adelaide.

Turner DJ, Collings GJ (2008) *Subtidal macroalgal communties of Gulf St Vincent*. In 'Natural history of Gulf St Vincent'. (Eds SAS Shepherd, S Bryars, IR Kirkegaard, P Harbison and JT Jennings) pp. 264-278. (Royal Society of South Australia Inc.: Adelaide)

Turner DJ, Kildea TN, Westphalen G (2007) *Examining the health of subtidal reef environments in South Australia. Part 2: status of selected South Australian reefs based on the results of the 2005 surveys*. South Australian Research and Development Institute, SARDI Publication Number RD03/0252-6, Adelaide.

Wear RJ, Eaton A, Tanner JE, Murray-Jones S (2006) *The impact of drain discharges on seagrass beds in the South East of South Australia. Final Report Prepared for the South East Natural Resource Consultative Committee and the South East Catchment Water Management Board*. South Australian Research and Development Institute (Aquatic Sciences) and the Department of Environment and Heritage, Coast Protection Branch, Adelaide.

Westphalen G, O'Loughlin E, Collings GJ, Tanner J, Eglinton Y, Bryars S (2005) *Responses to reduced salinities of the meadow forming seagrasses Amphibolis and Posidonia, from the Adelaide metropolitan coast*. ACWS Technical Report No. 9 prepared for the Adelaide Coastal Water Study Steering Committee. South Australian Research and Development Institute (Aquatic Sciences), Publication No. RD01/0208-14, Adelaide.

Wiltshire KH, Tanner J (2013) *Marine habitats in the vicinity of Port Hughes boat ramp and possible impacts of a proposed upgrade to boat ramp facilities*. South Australian Research and Development Institute (Aquatic Sciences), Publication No. F2013/000063-1. Research Report Series No. 683, Adelaide.

Appendix A
Proposed Drainage Area and Staging of CWMS


COMMUNITY WASTEWATER MANAGEMENT SCHEME
PROPOSED DRAINAGE AREA AND STAGING
June 2012

Appendix B
Floodplain Maps

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

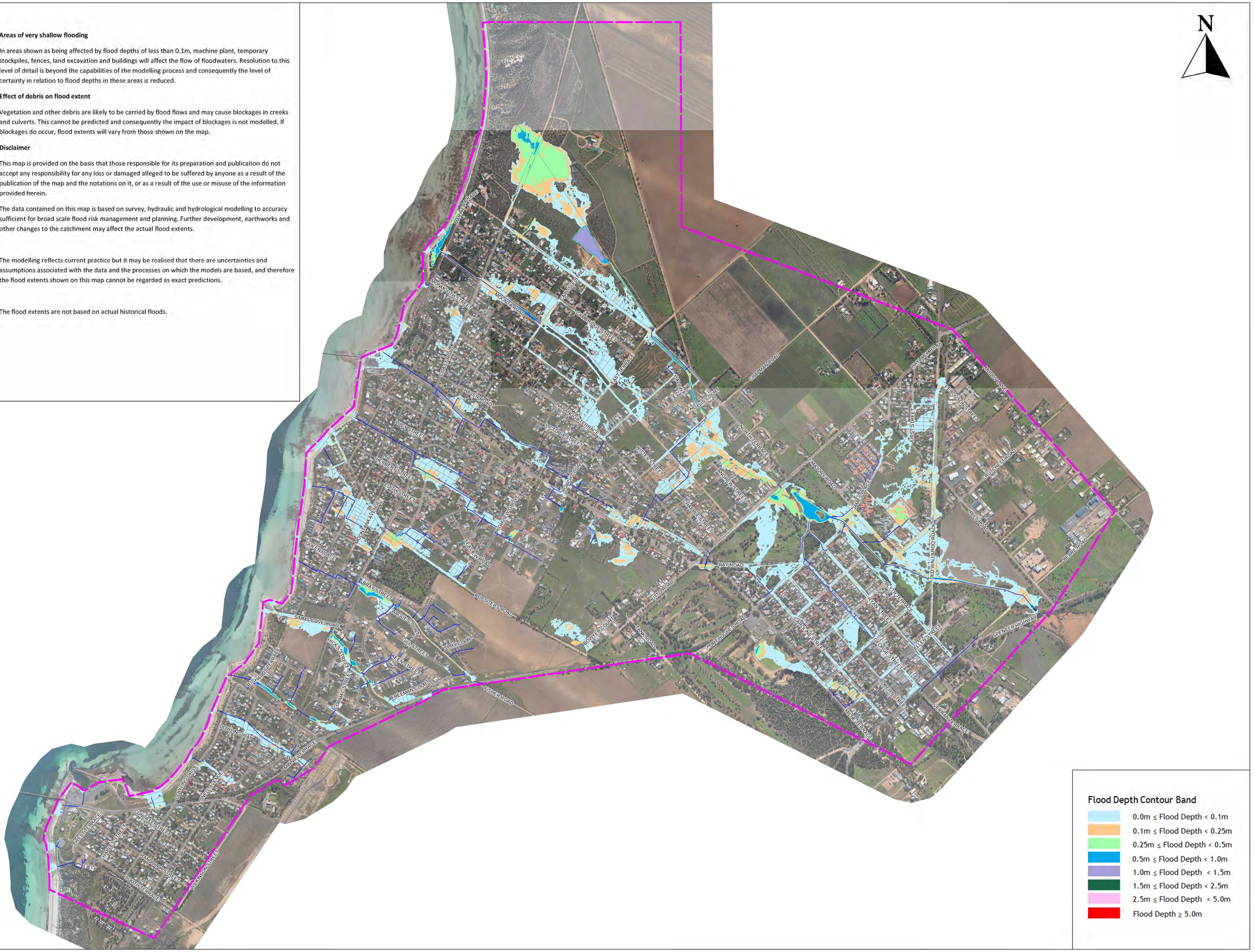
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Flood Depth Contour Band

- 0.0m ≤ Flood Depth < 0.1m
- 0.1m ≤ Flood Depth < 0.25m
- 0.25m ≤ Flood Depth < 0.5m
- 0.5m ≤ Flood Depth < 1.0m
- 1.0m ≤ Flood Depth < 1.5m
- 1.5m ≤ Flood Depth < 2.5m
- 2.5m ≤ Flood Depth < 5.0m
- Flood Depth ≥ 5.0m

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

- Existing Stormwater Network
- Cadastre
- Limit of Mapping

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

10 Year ARI Floodplain Map
Existing Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

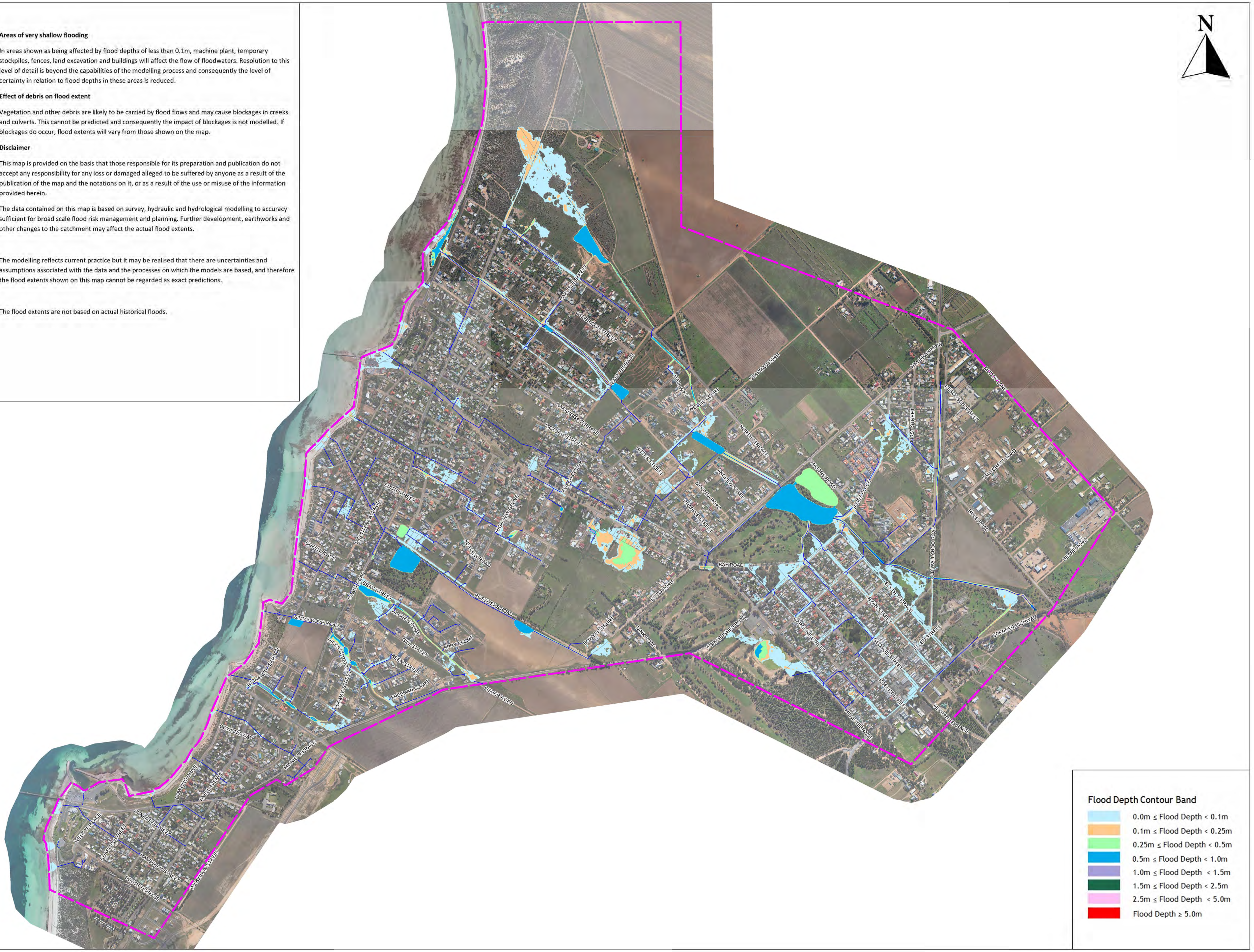
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

Future Stormwater Network
Cadastre
Limit of Mapping

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

10 Year ARI Floodplain Map
Future Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

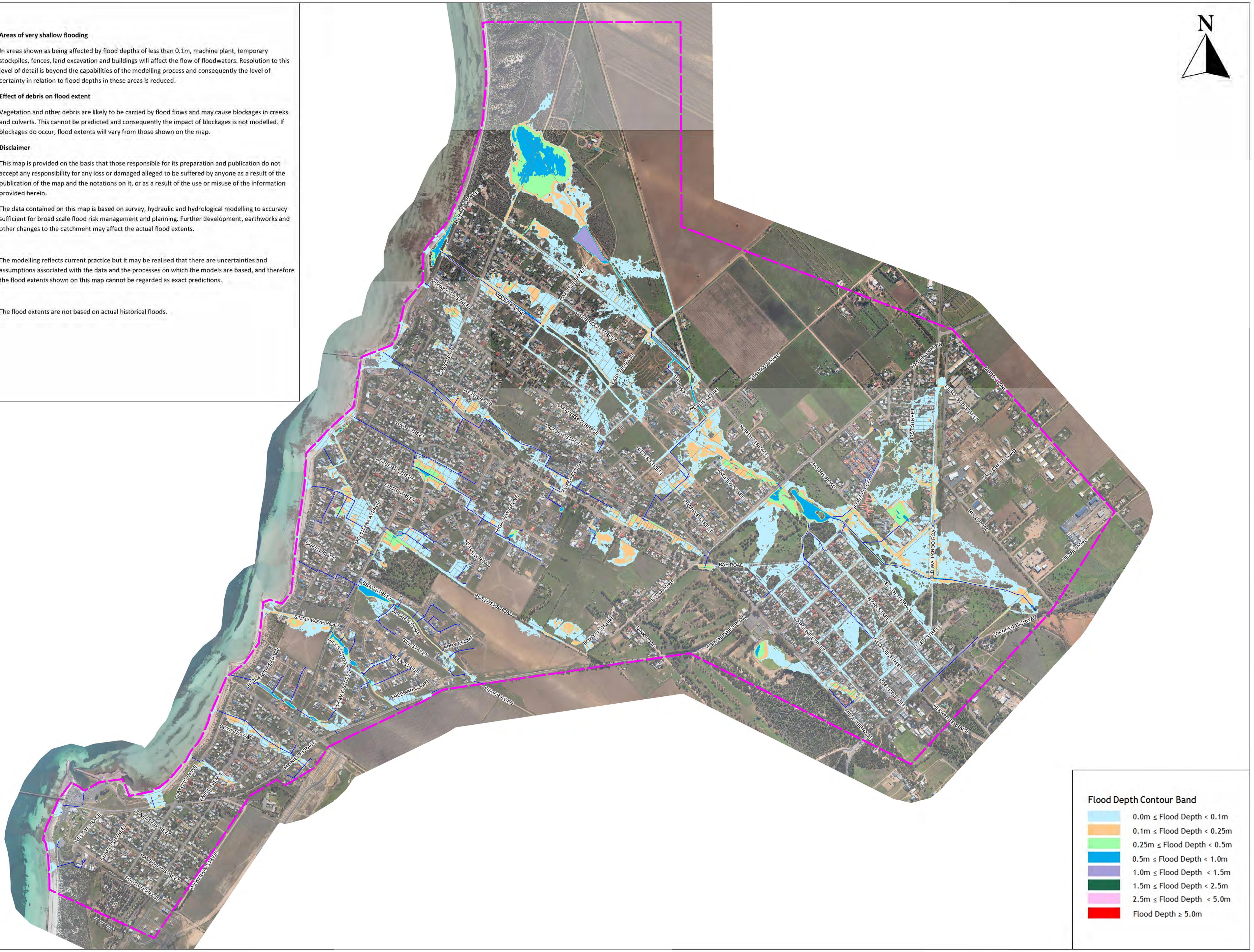
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

Existing Stormwater Network
Cadastre
Limit of Mapping

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

20 Year ARI Floodplain Map
Existing Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

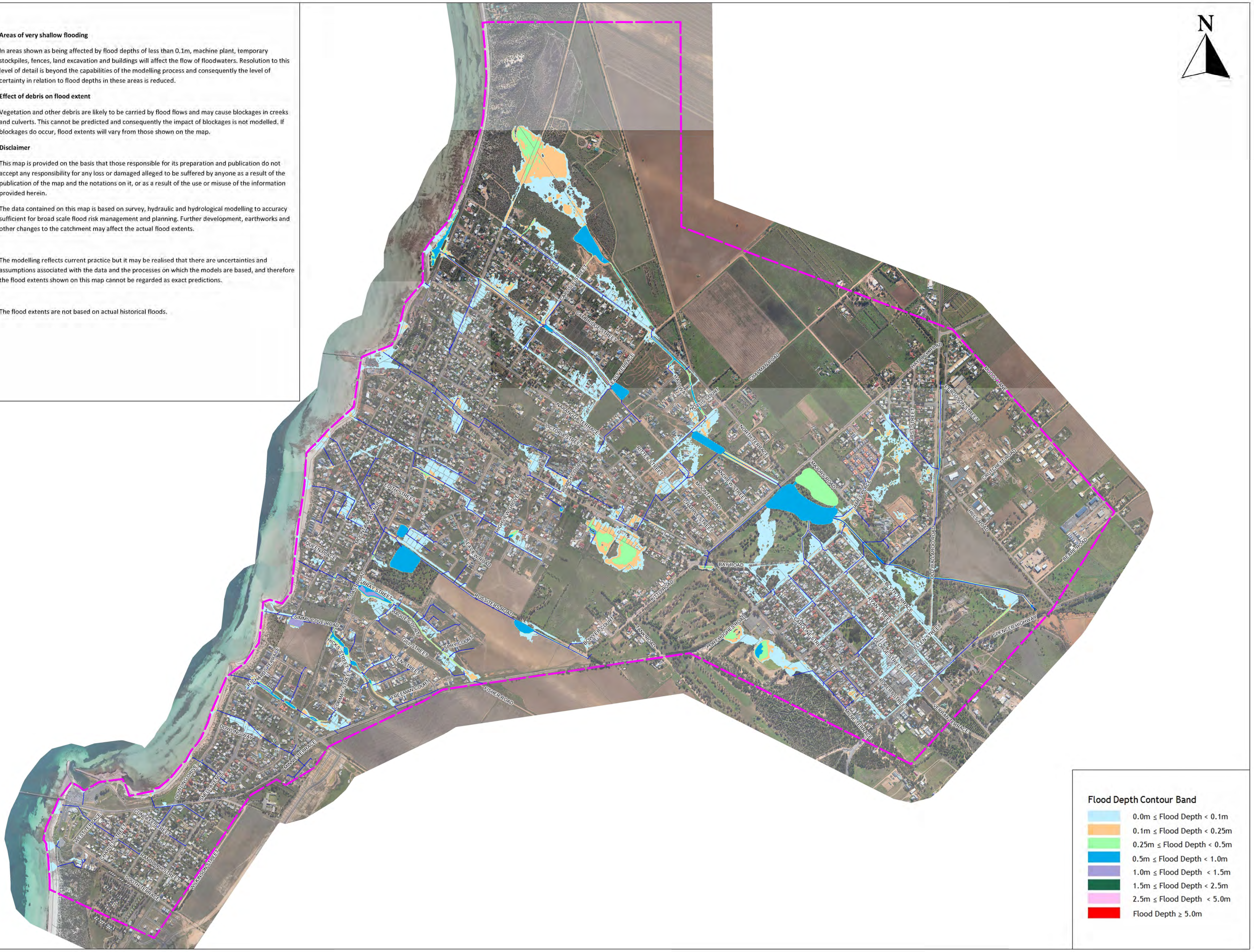
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Flood Depth Contour Band

- 0.0m ≤ Flood Depth < 0.1m
- 0.1m ≤ Flood Depth < 0.25m
- 0.25m ≤ Flood Depth < 0.5m
- 0.5m ≤ Flood Depth < 1.0m
- 1.0m ≤ Flood Depth < 1.5m
- 1.5m ≤ Flood Depth < 2.5m
- 2.5m ≤ Flood Depth < 5.0m
- Flood Depth ≥ 5.0m

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

southfront

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

- Future Stormwater Network
- Cadastre
- Limit of Mapping

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

20 Year ARI Floodplain Map
Future Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

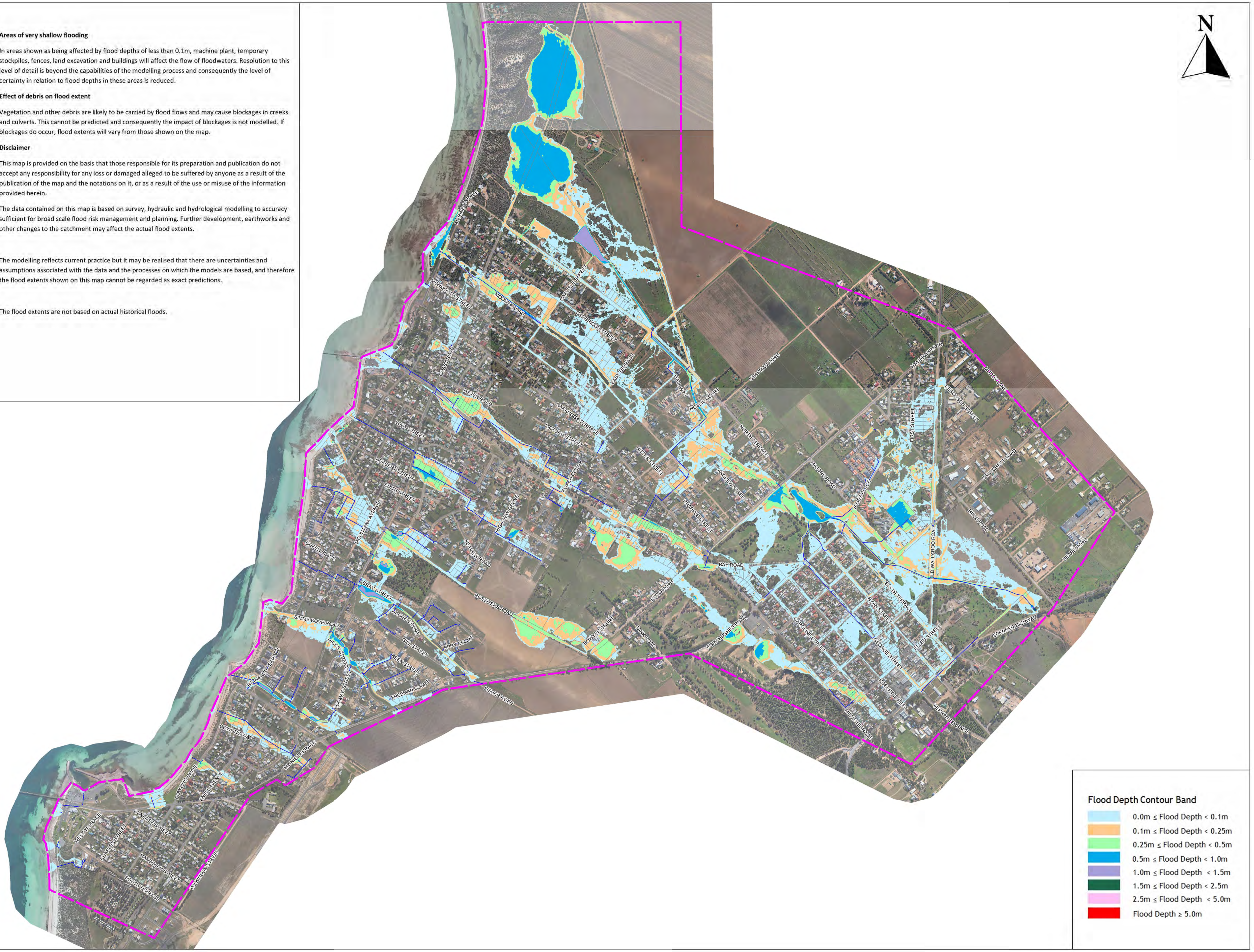
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

southfront

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

Existing Stormwater Network
Cadastre
Limit of Mapping

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

50 Year ARI Floodplain Map
Existing Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

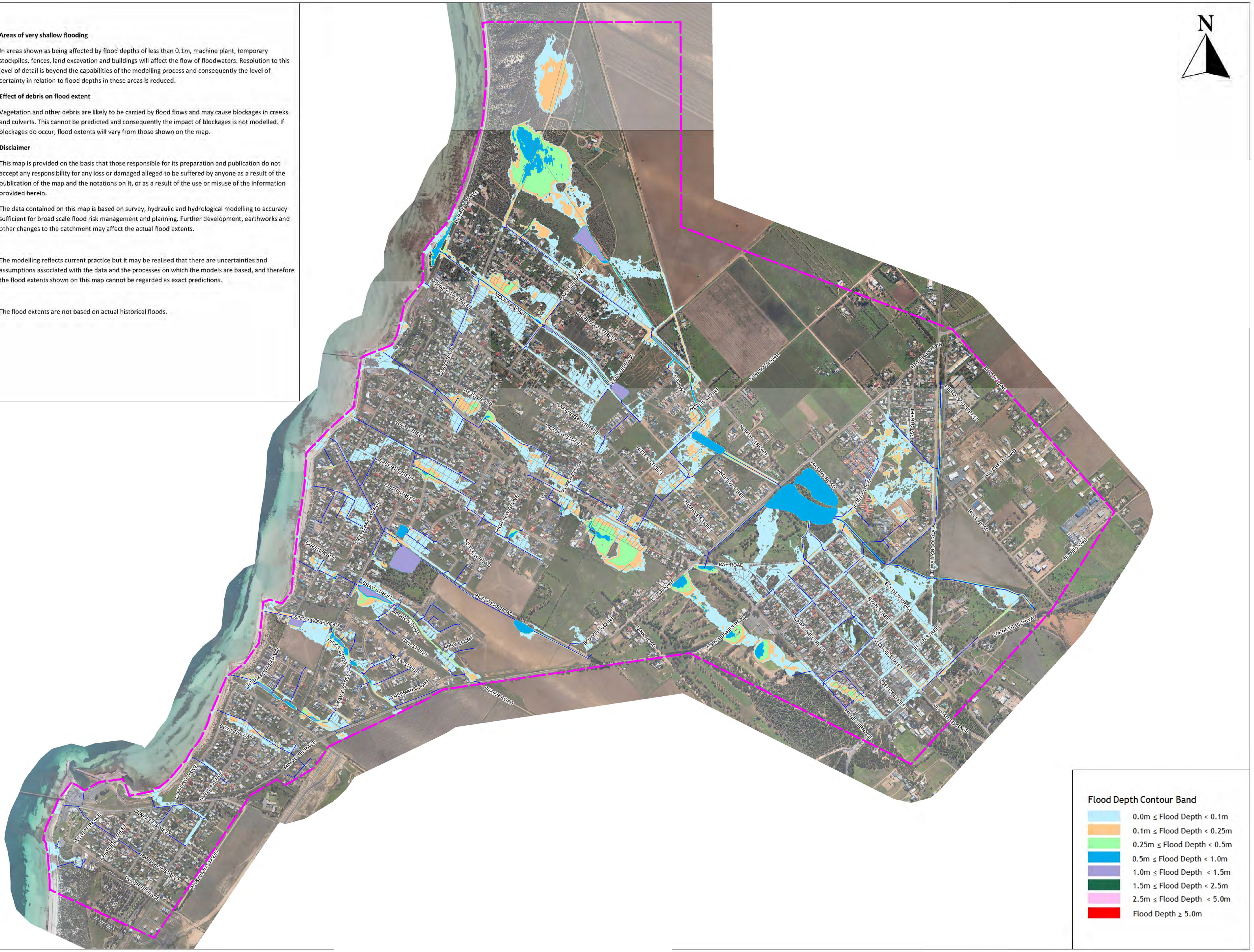
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

southfront

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

Future Stormwater Network
Cadastre
Limit of Mapping

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

50 Year ARI Floodplain Map
Future Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

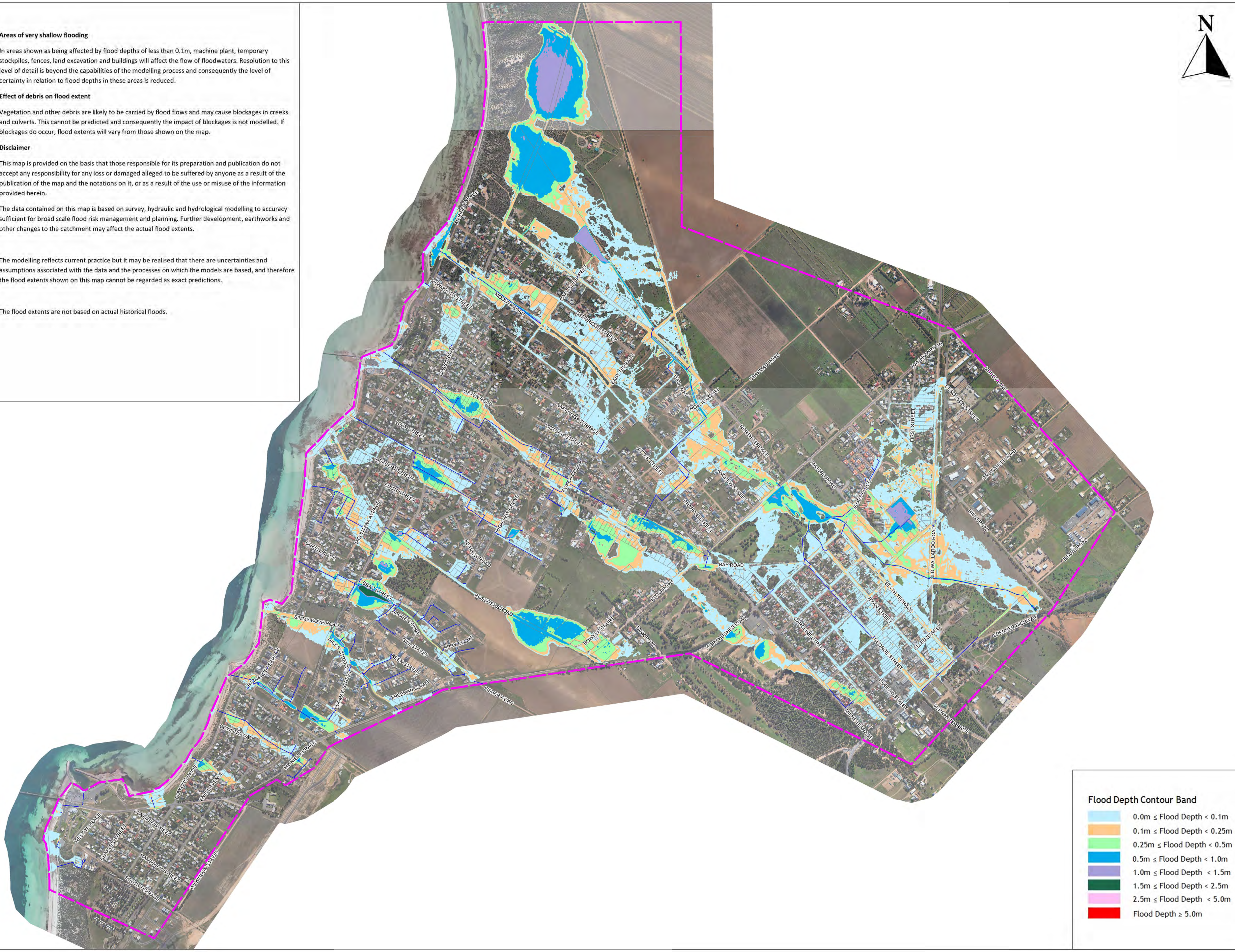
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Flood Depth Contour Band

- 0.0m ≤ Flood Depth < 0.1m
- 0.1m ≤ Flood Depth < 0.25m
- 0.25m ≤ Flood Depth < 0.5m
- 0.5m ≤ Flood Depth < 1.0m
- 1.0m ≤ Flood Depth < 1.5m
- 1.5m ≤ Flood Depth < 2.5m
- 2.5m ≤ Flood Depth < 5.0m
- Flood Depth ≥ 5.0m

Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

- Existing Stormwater Network
- Cadastre
- Limit of Mapping

southfront

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

100 Year ARI Floodplain Map
Existing Scenario

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Annual Recurrence Interval (ARI)

Flood risk can be considered in terms of average recurrence interval (ARI). This is the number of years, on average, within which a given flood will be equalled or exceeded. A 100 year ARI flood will be, on average, equalled or exceeded once in 100 years. A 20 year ARI flood will be, on average, equalled or exceeded once in 20 years and so on.

Due to the random nature of floods, however, a 100 year ARI flood need not occur in every 100 years and conversely several floods which exceed the 100 year ARI flood could occur within any one period of 100 years.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of mapping

The limit of flooding on this map is not a boundary between flood prone and flood free land.

Land outside the flood extent shown on this map could be affected by:

- Storms with different Average Recurrence Interval.
- Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

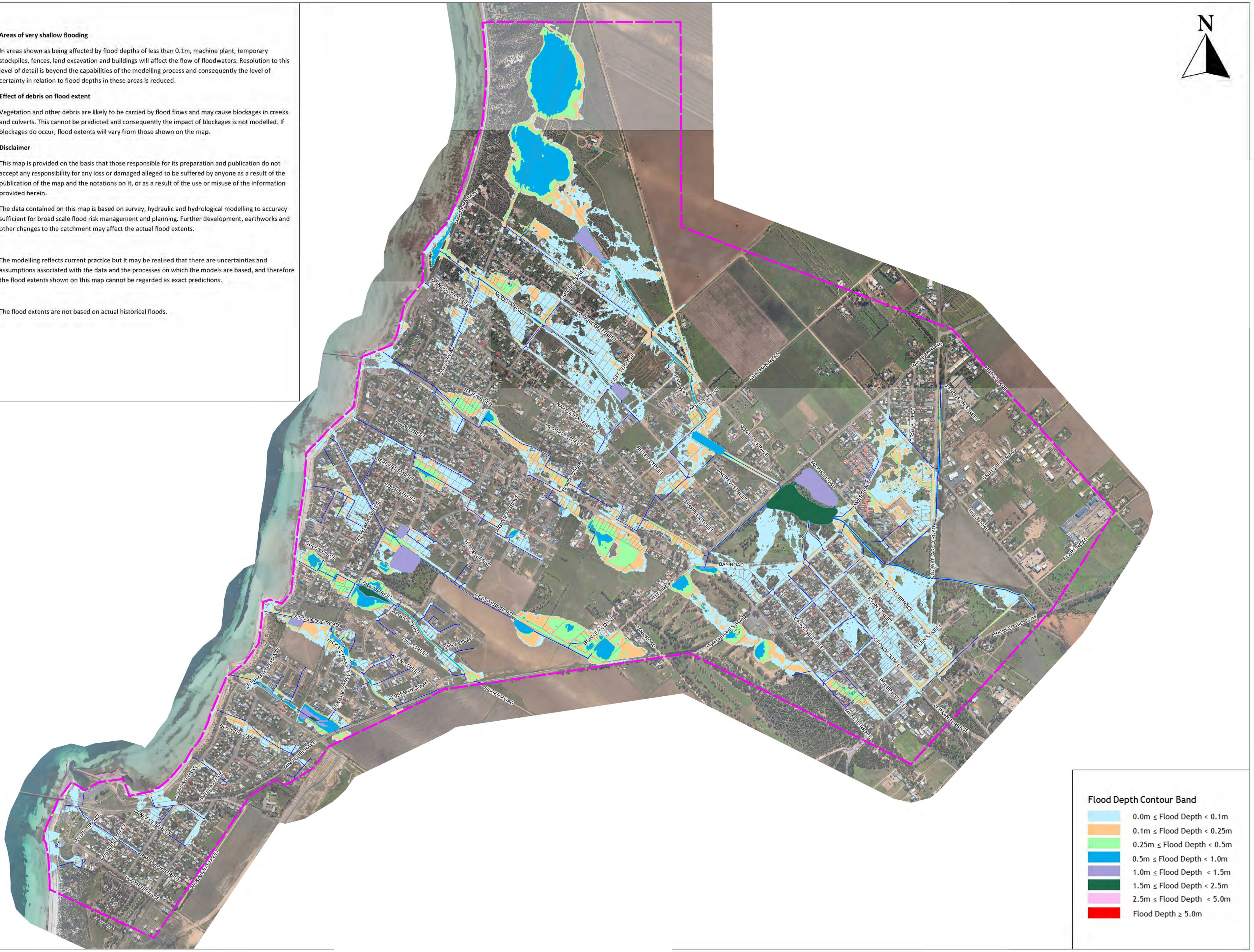
Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged alleged to be suffered by anyone as a result of the publication of the map and the notations on it, or as a result of the use or misuse of the information provided herein.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents.

The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



Data Sources:
DC Copper Coast (Aerial Photograph)
Southfront (Floodplain Mapping)

southfront

-0.2 0 0.2 0.4 0.6 0.8 1
Kilometres

Scale: 1:10,000

Future Stormwater Network
Cadastre
Limit of Mapping

Moonta, Moonta Bay & Pt Hughes
Stormwater Management Plan

100 Year ARI Floodplain Map
Future Scenario

Appendix C

Community Consultation Report

Moonta, Moonta Bay & Port Hughes Stormwater Management Plan

Consultation Report

15 November 2013

Prepared for District Council of the Copper Coast

Consultant Project Manager Victoria Haupt, Associate
Suite 12/154 Fullarton Rd
(cnr Alexandra Ave)
Rose Park, SA 5067
Tel: (08) 8333 7999
Email: victoria@urps.com.au
Website: www.urps.com.au

Contents

1.0 Background

1.1. Stormwater Management Plan

The District Council of the Copper Coast (Council) with assistance from Southfront is preparing a Stormwater Management Plan (SMP) for the townships of Moonta, Moonta Bay, and Port Hughes.

A Draft SMP has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines published by the Stormwater Management Authority (SMA).

The Draft SMP provides an overview of the existing catchments and issues relating to current stormwater management, and sets out opportunities to improve stormwater management to address flood protection and the sustainable management of water and the environment.

In accordance with the SMA guidelines key principles informing the Draft SMP are productive and sustainable use of stormwater, reduction of pollution impacts, enhancement of natural watercourses and ecosystems, and flood minimisation. The Draft SMP proposes strategies to achieve these outcomes in an integrated and coordinated manner.

The Draft SMP has been prepared in consultation with relevant Council staff with involvement from relevant South Australian Government agencies including the Northern and York Natural Resources Management Board, the Environment Protection Authority, and the Department for Planning, Transport and Infrastructure.

Upon completion of community and stakeholder engagement on the Draft SMP, a final SMP will be prepared and adopted by Council.

1.2. Purpose of Community Engagement

Community consultation was undertaken on the Draft SMP to:

- Communicate the general content of the Draft SMP, specifically findings of investigations (e.g. flood plain mapping) and proposed stormwater management strategies; and
- Gather community feedback in relation to the proposed stormwater management strategies, including the prioritisation of strategies.

Feedback received and collated in this report will be considered in developing the final SMP.

2.0 Consultation Process

Public consultation on the Draft SMP occurred between Monday 23 September and Friday 25 October 2013.

The following consultation activities were undertaken:

- A Community Information Session held in Moonta on Thursday 17 October between 3.30pm and 6.30pm.

  Members of the public were invited to drop in to this session to find out more about the Draft SMP and provide feedback.

  The Information Session was staffed by representatives of Council, Southfront and URPS. Poster displays provided information about the Draft SMP (refer Appendix A), and a laptop was set up to enable members of the public to view flood mapping prepared for the Draft SMP at specific locations.

- Fact sheets and feedback forms (refer Appendix B) were provided at Council's Kadina offices, the Moonta Library, and the Moonta Tourism Office, along with hard copies of the Draft SMP.

- A public notice was published in the Yorke Peninsula Country Times in the week of 23 September 2013 and week of 14 October 2013 (refer Appendix C), and this notice was also displayed on noticeboards at Moonta Foodland and the Port Hughes Jetty;

- Information was included on Council's website including the Draft SMP, flood mapping, and the fact sheet and feedback form;

- A press release publicising the consultation process and Community Information Session was provided to the Yorke Peninsula Country Times (refer Appendix D).

All consultation activities and materials emphasised the opportunity to provide feedback on the Draft SMP by returning a feedback form by Friday 25 October 2013.

3.0 Consultation Feedback

3.1. Community Information Session

The Community Information Session was attended by 8 members of the public, and 3 Council Elected Members.

Three feedback forms were submitted at the Information Session, and these are summarised in Section 3.2 along with feedback forms received by post or fax.

The following feedback was provided informally by information session attendees (i.e. verbally to staff, not via a feedback form):

- Overall the Draft SMP is a good plan, and a step forward for Council in managing stormwater;
- Opportunities exist to use stormwater for irrigation, for example on golf courses;
- Concerns about how proposals will be funded and possible rate rises, keen that Council pursue State and Commonwealth Government funding;
- Current stormwater issues and proposals in the Draft SMP were discussed with Information Session staff in relation to the following specific locations:
    - Ivy Place, Port Hughes;
    - Kitto Road;
    - The corner of North Terrace and Haylock Road, and Coast Road; and
    - The retirement village near Military Road and Blanche Terrace.

3.2. Feedback Forms

A total of 11 feedback forms were returned during the consultation period. Three of these were submitted at the Community Information Session.

Respondents identified as themselves as property owners and/or residents and/or business owners in Moonta (3 respondents), Moonta Bay (5 respondents), and Port Hughes (3 respondents).

Respondents were asked what information they had accessed as part of the community consultation on the Draft Stormwater Management Plan: the Community Information Sheet, the full Draft SMP, and attendance at the Community Information Session. As shown in Table 3.1, respondents had accessed all forms of information available during the consultation period, and more than half (6) had reviewed the full Draft SMP.

Table 3.1 Information accessed by respondents

Community Information Sheet	Draft Stormwater Management Plan	Community Information Session	Number of respondents
X			2
X	X		0
X	X	X	2
	X		3
	X	X	1
		X	2
X		X	1
		Total	11

Respondents were asked how important it is to them that flood mitigation works occur in the Moonta, Moonta Bay and Port Hughes catchments, using a scale of 1 (not very important) to 5 (very important). Responses were recorded as shown on Table 3.2.

Table 3.2 Importance of flood mitigation works

	Not very important				Very important		
Scale	1	2	3	4	**5**	No response	Total
No. of responses	0	0	0	2	**8**	1	11

Respondents were asked to indicate on a scale of 1 (not very important) to 5 (very important) how important it is to them that Water Sensitive Urban Design (WSUD) works occur in the Moonta, Moonta Bay and Port Hughes catchment, including projects to support sustainable use of water resources, improvement of water quality, and protection of watercourse and ecosystem health. Responses were recorded as shown on Table 3.3.

Table 3.3 Importance of WSUD works

	Not very important				Very important		
Scale	1	2	3	4	**5**	No response	Total
No. of responses	0	0	0	1	**9**	1	11

Responses in tables 3.2 and 3.3 show that flood mitigation and WSUD are of high importance to respondents.

Respondents were asked to indicate their level of support for the Draft SMP using a scale of 1 (strongly oppose) to 5 (strongly support). Responses were recorded as shown on Table 3.4, with all respondents either "neutral" or supportive of the Draft SMP. The most frequent response was strong support of the Draft SMP (5 respondents).

Table 3.4 Support for the Draft SMP

	Strongly oppose				Strongly support		
Scale	1	2	3	4	**5**	No response	Total
No. of responses	0	0	2	3	**5**	1	11

In addition to answering the questions reported above, respondents were asked to provide their comments on the Draft SMP. Comments recorded are summarised below.

- Concern around proposed stormwater retention on private land at Rossiters Road under the Draft SMP;
- Request for a raised gutter to a property on Rossiters Road;
- Identification of current flooding issues:
    - On Bay Road at Moonta Bay affecting private property;
    - At the northern end of Chrales Street at Port Hughes – erosion and marine discharge, some flooding of private property, concern that an existing stormwater easement is not identified in the Draft SMP;
    - On Edward Street and Minnie Terrace at Port Hughes; and

    - On Ryan Street at Moonta – concern that Draft SMP does not account for information previously provided to Council or local topography.

- View that a high priority should be accorded to management of stormwater runoff to the sea, cliff erosion, and better management of coastal outlets;

- Support for management of flooding issues in Moonta and water conservation;

- View that the SMP is a very high priority for Moonta Bay in terms of flood mitigation, and that the area around Chapman Road, Hollis Court and North Terrace should be the highest priority;

- View that Gardener/Ryan Street drains be given high priority in the staging of McAuley Park upgrade works;

- View that better planning and engineering decisions around new development should be part of flood mitigation;

- View that ongoing costs of implementing the Draft SMP should be no greater than current stormwater management costs, that the costs of implementing the SMP should be transparent, and that rates should not increase to fund SMP works - grant funding be sought instead;

- Suggestion that more natural areas be established to improve the health of the environment;

- Suggestion that the area north west of North Terrace where birds currently nest become a wetland, which would be a community and tourism asset, though private land would need to be purchased.

One respondent provided extensive comments in relation to the Draft SMP which included:

- Desire for a wetland such as those in the City of Salisbury area, and increased retention of stormwater for irrigation;

- A view that the Draft SMP does not adequately address local observations of poor coastal water quality and impacts on the marine environment (seagrass loss, reduced nearshore marine biodiversity), and concern that additional coastal outlets are proposed;

- Concern around previous development decisions and the impact on stormwater management;

- Concern around current discharges from private property to the coast;

- Specific concern that the proposed works at Simms Cove Road will result in beach degradation, and suggestion of an alternative option involving:

    - Reshaping and kerbing Simms Cove car park;

    - Deepen upstream ponds in Patricks View (Hicks Street);

- o Pump stormwater from Trelawney Street along Simms Cove Road to Bray Street; and
- o Connect excess discharge from Patricks View to that pipeline.

4.0 Appendices

Appendix A: Information Session Posters

Welcome

Welcome to the Community Information Session for the Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes.

Today is an opportunity for you to:

- Find out more about the Draft Plan
- Ask questions of the team that developed the Draft Plan
- Gather the information you need to provide feedback on the Draft Plan

Moonta, Moonta Bay & Port Hughes Stormwater Management Plan Catchment

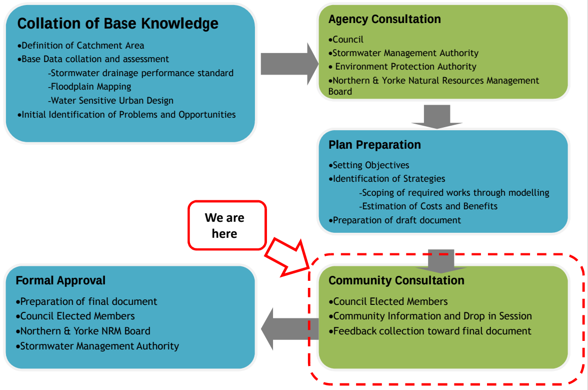
Why a Stormwater Management Plan?

Set objectives for:

- Managing flood risk
- Water conservation
- Water quality
- Integrating with stakeholders in achieving Water Sensitive Urban Design (WSUD)

→**Develop a prioritised list of feasible actions to meet the objectives**

Stormwater Management Plan Process



Stormwater Management Issues for Moonta, Moonta Bay and Port Hughes

- Flooding
- Environmental impacts of quality of stormwater runoff to the sea
- Planning for increased urban development and impacts on stormwater runoff and on infrastructure
- Cliff erosion and management of coastal outlets

Stormwater Management Plan Targets

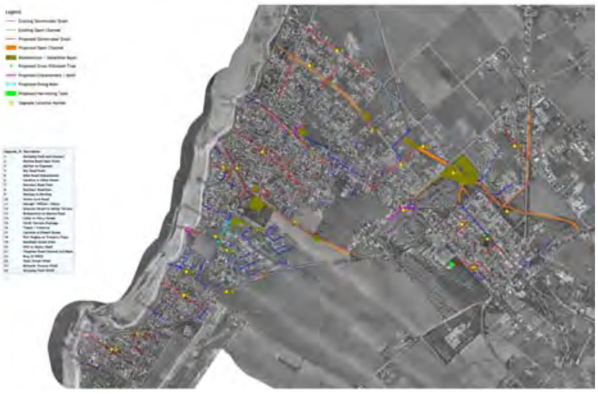
Design Principle	Proposed Target
Flood Protection Service Level	100 year ARI storm protection for the major drainage system 5 year ARI storm protection for the minor drainage system
Water Conservation	Best practice irrigation to reduce reliance on mains
Water Quality	Reduction average annual loads of nutrients, sediments, and gross pollutants by up to 90%
Integrated Design	Engagement of stakeholders at relevant stages
Financial Sustainability	Life cycle costs to maintain asset function are acceptable
Safety	Public safety of all assets comply with Council / Local Government Association requirements

About Flood Protection Service Levels:

A 100 Year ARI storm is a storm that will occur on average once every 100 years, and has a 1% chance of occurring each year

A 5 Year ARI storm is a storm that will occur on average once every 5 years, and has a 20% chance of occurring each year

Proposed Stormwater Management Works



Water Sensitive Urban Design (WSUD)

- WSUD is part of many of the proposed stormwater management works
- Measures include:
  - Gross pollutant traps, swales, water harvesting, bio-retention basins, raingardens
- WSUD outcomes include:
  - Enhanced biodiversity, increased amenity, reduced cliff face erosion

Sample images of typical WSUD works

Bioretention Swale

Raingarden

Gross Pollutant Trap

Constructed Wetland

Prioritising Works

- Proposed works have been assigned one of three priority levels:
  - High Priority for shorter term implementation
  - Medium Priority for medium term implementation
  - Low Priority for longer term implementation
- Priorities have been set with reference to:
  - Areas where there is currently an above floor-level flood risk
  - Related projects already underway
  - Condition of existing assets

Major Flood Damage Reduction Works

Priority	Project/Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	McAuley Park & Open Channel Upgrades	1,890,000	20,000	100 years	High – severely reduced flood extents	High – biodiversity enhancement and increased amenity and recreation
High	Moonta Road Open Drain	840,000	10,000	20 years	High – provides containment of flood flows	Improved amenity
High	Marilyn Street to Chapman Road Drain, Channel & Basin	1,250,000	5,000	10 years	High – protects several properties	Reduce excessive gutter flows
High	Bay Road Drainage & Kerbing	1,260,000	10,000	10 years	High – protects several properties	Improved overland flow path capacity
High	Kitto Road Embankment & Drainage	150,000	-	100 years	High – protects several properties	Minimal work required to achieve flood mitigation benefit
High	Caroline to Milne Street Drainage	570,000	-	10 years	High – protects several properties	-
High	Rossiters Road West Drainage	1,190,000	10,000	10 years	High – provides formal stormwater conduit	Reduce excessive gutter flows
Medium	Rossiters Road East Drainage	840,000	10,000	10 years	High – allows for safer future development	-
Medium	Minnipa – Dowling Street Drainage Upgrade	700,000	-	20 years	High – protects several properties	-
Total		**8,690,000**	**65,000**			

Medium/Low Flood Damage Reduction Works

Priority	Project/Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Performance Standard (ARI)	Flood Mitigation Benefit	Other Benefits
High	Simms Cove Road Drainage & Erosion Protection (Option A – highest cost option)	840,000	20,000	10 years	Low for existing scenario but will cater for future development	Environmental – Prevents erosion of cliff faces, stormwater harvesting
High	George/William/Henry Street Drainage	490,000	5,000	10 years	Medium	Reduce excessive gutter flows, improves amenity
Medium	Emerson to Minnie Terrace Drainage	890,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Brokenshire to Moonta Road Drain & Basin	500,000	-	10 years	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street	1,990,000	-	10-20 years	Medium	-
Medium	North Terrace Drainage	690,000	-	10 years	Medium	Reduce excessive gutter flows
Low	Tipara/Trelawney Street Drainage	390,000	-	10 years	Medium	-
Low	Caroline to Robert Street Drainage Upgrades	460,0000	-	20 years	Medium	Reduce excessive gutter flows
Low	Port Hughes/Trenerry Road Outflows	80,000	-	20 years	Low	-
Low	Randolph Street Drain	580,000	-	10 years	Medium	Reduce excessive gutter flows
Low	Hills Street & Majors Road	170,000	-	10 years	Medium	Reduce excessive gutter flows
Total		**7,080,000**	**25,000**			

Water Sensitive Urban Design Works - 1

Priority	Project/Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Availability	Supports Drainage Upgrade	Water Quality Benefit	Other Benefits
High	Coastal Outlet/Cliff Top Management	N/A	N/A	-	Yes	High – due to WSUD/Gross Pollutant Traps at each outlet	Minimise erosion of cliff faces, improved amenity
High	McAuley Park WSUD and Harvesting	1,790,000	30,000	Up to 70 ML/yr	Yes	High – provides instream treatment	Biodiversity enhancement and increased amenity and recreation
High	Simms Cove Road WSUD	80,000	5,000	Up to 36 ML/yr	Yes	High	Environmental – prevents erosion of cliff faces
High	Moonta Road Open Drain & WSUD	180,000	10,000	-	Yes	High – extensive treatment train	Improved amenity
High	Chapman Road, Channel & Basin	150,000	5,000	-	Yes	Medium – treatment using WSUD principles	Improved amenity
Medium	Bay Road WSUD and Gross Pollutant Trap	140,000	10,000	-	Yes	Medium	-
Medium	Caroline to Milne Street Harvesting	300,000	15,000	Up to 8 ML/yr	Yes	-	-
High	George/William/ Henry Street WSUD	280,000	15,000	Up to 24 ML/yr	Yes	Medium – rain gardens remove some pollutants	Reduce excessive gutter flows, improves amenity

Continued on *Water Sensitive Urban Design Works - 2*

Water Sensitive Urban Design Works - 2

Priority	Project/Activity	Capital Cost ($)	Recurrent Cost ($/yr)	Water Harvesting Availability	Supports Drainage Upgrade	Water Quality Benefit	Other Benefits
Medium	Rossiters Road West Gross Pollutant Trap	60,000	5,000	-	Yes	Low - Gross Pollutant Trap at outlet only	-
Medium	Emerson to Minnie Terrace WSUD	300,000	15,000	Up to 37 ML/yr	Yes	-	-
Medium	Rossiters Road East WSUD	220,000	10,000	-	Yes	High – extensive treatment train	-
Medium	Brokenshire to Moonta Road Basin	150,000	10,000	-	Yes	Medium	Reduce excessive gutter flows
Medium	Loller to Percy Street Gross Pollutant Trap	60,000	5,000	-	Yes	Low - Gross Pollutant Trap at outlet only	-
Low	Bray Street WSUD	180,000	10,000	-	No	High	-
Low	Hicks Street WSUD	240,000	10,000	-	No	High	-
Low	Richards Terrace WSUD	90,000	5,000	-	No	Medium	-
Total		**4,440,000**	**160,000**				

Costs and Timeframes

- Proposed works would occur over approximately 30 years, starting with high priority works
- Funding would come from Council and other external partners
- Present day capital costs of the proposed works are:
  - $8.69M for works with major flood reduction benefits
  - $7.08M for works with medium to low flood reduction benefit
  - $4.22M for WSUD projects
  - A total of $19.99M for all works

Next Steps

Collect feedback on the Draft Plan
- Up until Friday 25 October 2013

Finalise Stormwater Management Plan
- By December 2013

Formal approval of Final Plan
- By January 2014

Thank You

Thank you for attending the Draft Stormwater Management Plan community information session

Please provide your feedback by returning your completed feedback form to District Council of the Copper Coast before Friday 25 October 2013

For more information, visit www.coppercoast.sa.gov.au or contact the District Council of the Copper Coast on 8828 1200

Appendix B: Fact Sheet and Feedback Form

Tel 08 8828 1200
Fax 08 8821 2736
PO Box 396, Kadina 5554
51 Taylor St, Kadina 5554
Email info@coppercoast.sa.gov.au
Web www.coppercoast.sa.gov.au
ABN 36 670 364 373

Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes

Community Information Sheet September 2013

The District Council of the Copper Coast is seeking public comment on its Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes (the Draft Plan) between Monday 23 September and Friday 25 October 2013.

The Draft Plan has been developed to better understand the stormwater catchments and issues in the three townships, and to identify stormwater management options that protect against flooding, and provide for sustainable use of stormwater, reduced pollution, and enhancement of watercourses and ecosystems.

The Draft Plan considers a number of key issues relating to stormwater management in Moonta, Moonta Bay and Port Hughes, including:

- Flood risk
- Environmental impacts associated with the quality of stormwater runoff to the sea
- Continuing urban development in the townships and the impacts on stormwater runoff and stormwater infrastructure
- Cliff erosion / management of coastal outlets

Stormwater Management Objectives

The Draft Plan aims to provide flood mitigation benefit to the townships of Moonta, Moonta Bay and Port Hughes, and to implement Water Sensitive Urban Design (WSUD) principles that support sustainable use of water resources, improvement of water quality, and protection of watercourse and ecosystem health. To meet these objectives, the Draft Plan adopts the following performance targets for stormwater management strategies set out in the Draft Plan:

Stormwater Management Objective	Performance Target
Water conservation	Demonstration of how best practice irrigation management of open spaces can be achieved or enhanced with stormwater harvesting
Runoff quality management	Reduction in average annual loads of nutrients, sediments, and gross pollutants by up to 90%
Integrated approach to WSUD	Engagement with all areas of Council, State Government agencies, developers, land owners, and local volunteer groups at relevant stages of planning, design, construction, and management of WSUD measures

Proposed Stormwater Management Works

The Draft Plan proposes a range of stormwater management works that:

- Have either a major or medium to low flood mitigation benefit. These projects involve works such as new or upgraded pipes, culverts and channels, stormwater entry pits, and detention basins; and

- Implement WSUD measures such as stormwater harvesting and reuse, water quality improvement, and environmental enhancement. These projects involve works such a gross pollutant traps, swales, bio-retention basins, and water harvesting systems, and provide opportunities for enhancement of biodiversity, increased amenity of public, recreational and open spaces, and prevention of cliff face erosion.

Under the Draft Plan, these types of works are proposed at the following locations:

Location of works in Moonta, Moonta Bay and Port Hughes	**Flood mitigation infrastructure works**	**WSUD projects**
William, Henry and George Street	√	√
Caroline Street to Milne Terrace	√	√
Caroline Street to Robert Street	√	
McAuley Park and open drainage channels	√	√
Kitto Road Embankment	√	
Marilyn Street to Chapman Road	√	
Moonta Road open channel	√	√
North Terrace	√	
Brokenshire Street to Moonta Road	√	
Bay Road	√	√
Loller Street to Percy Street	√	√
Rossiters Road	√	√
Trelwaney Street and Tipara Court	√	
Simms Cove Road	√	√
Port Hughes Road and Trenerry Drive	√	
Minnipa Drive to Dowling Drive	√	
Emerson Street to Minnie Terrace/Randolph St	√	√
Bray Street		√
Hicks Street		√
Richards Terrace		√

Costs and Timeframes

The Draft Plan prioritises the proposed works in relation to flood mitigation benefit, meaning the projects with greatest flood protection benefit are identified for implementation in the short term.

Of works proposed in the Draft Plan, those with major flood reduction benefits have a present day capital cost of $8.69M. Works with medium to low flood reduction benefit have a cost of $7.08M, and proposed WSUD projects have a cost of $4.22M.

It is expected that works proposed by the Draft Plan would be implemented over approximately 30 years, and funded by Council and external funding partners.

Community Consultation

Between Monday 23 September and Friday 25 October 2013 members of the public are invited to provide feedback on the Draft Plan.

A complete version of the Draft Stormwater Management Plan is available to view:

- On Council's website: www.coppercoast.sa.gov.au
- In hard copy at:
    - District Council of the Copper Coast Kadina Office, 51 Taylor St, Kadina
    - Moonta Tourist Office - Blanche Terrace, Moonta
    - Moonta Library - Area School, Blanche Terrace, Moonta

Feedback forms are also available for download/in hard copy at these locations.

A Draft Stormwater Management Plan Community Information Session will provide another opportunity to view display information and learn more about the Draft Plan:

DATE: Thursday 17 October

DROP IN ANYTIME BETWEEN: 3.30pm and 6.30pm

LOCATION: Moonta Town Hall, 71 George Street (corner Henry Street), Moonta

Feedback collected during the consultation process will be considered in finalising the Draft Plan.

Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes

Community Feedback Form 2013

1. Please place a tick (√) in boxes below that best describe you:

I am a:	Moonta	Moonta Bay	Port Hughes
Resident			
Property owner			
Business owner			
Community group/club			
None of the above			

2. Please indicate below the information you have accessed as part of community consultation on the Draft Stormwater Management Plan:

- □ Community Information Sheet
- □ Complete Draft Stormwater Management Plan (online at www.coppercoast.sa.gov.au or in hard copy at Council offices in Moonta and Kadina)
- □ Attended the Community Information Session on 17 October

3. Please place a tick (√) on the scale of 1 to 5 below to indicate how important it is to you that flood mitigation works occur in the Moonta, Moonta Bay and Port Hughes catchment:

1	2	3	4	5

Not very important Very important

4. Please place a tick (√) on the scale of 1 to 5 below to indicate how important it is to you that Water Sensitive Urban Design (WSUD) works occur in the Moonta, Moonta Bay and Port Hughes catchment. This includes projects to support sustainable use of water resources, improvement of water quality, and protection of watercourse and ecosystem health.

1	2	3	4	5

Not very important Very important

5. Please place a tick (√) on the scale of 1 to 5 below to indicate your level of support for the Draft Stormwater Management Plan

1	2	3	4	5

Strongly oppose Strongly support

PTO

6. Use the space below to provide your comments on the Draft Stormwater Management Plan (if necessary, please attach additional sheets)

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

Please return your completed form by **Friday 25 October 2013** to *Stormwater Plan, District Council of the Copper Coast, PO Box 396, KADINA, SA 5554* or email to info@coppercoast.sa.gov.au

For more information, please contact the District Council of the Copper Coast on 8828 1200

Appendix C: Public Notice

Tel 08 8828 1200
Fax 08 8821 2736
PO Box 396, Kadina 5554
51 Taylor St, Kadina 5554
Email info@coppercoast.sa.gov.au
Web www.coppercoast.sa.gov.au
ABN 36 670 364 373

Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes

The District Council of the Copper Coast is seeking public comment on its Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes between Monday 23 September and Friday 25 October 2013.

The complete Draft Stormwater Management Plan is available for viewing, along with information sheets and feedback forms at the following locations:

- On Council's website: www.coppercoast.sa.gov.au
- In hard copy at:
    - District Council of the Copper Coast Kadina Office - 51 Taylor St, Kadina
    - Moonta Tourist Office - Blanche Terrace, Moonta
    - Moonta Library - Area School, Blanche Terrace, Moonta

Attend the **Community Information Session** to view display information and learn more about the Draft Plan:

DATE: Thursday 17 October

DROP IN ANYTIME BETWEEN: 3.30pm and 6.30pm

LOCATION: Moonta Town Hall, 71 George Street (corner Henry Street), Moonta

For more information, please contact the District Council of the Copper Coast on 8828 1200

Appendix D: Press Release

Tel 08 8828 1200
Fax 08 8821 2736
PO Box 396, Kadina 5554
51 Taylor St, Kadina 5554
Email info@coppercoast.sa.gov.au
Web www.coppercoast.sa.gov.au
ABN 36 670 364 373

District Council of the Copper Coast

Media Release September 2013

"Feedback sought on our new Plan for managing stormwater into the future at Moonta, Moonta Bay and Port Hughes"

The District Council of the Copper Coast (Council) is seeking public comment on its Draft Stormwater Management Plan for Moonta, Moonta Bay and Port Hughes (the Draft Plan) between Monday 23 September and Friday 25 October 2013.

A Community Information Session will be held on Thursday 17 October 2013 at the Moonta Town Hall, with members of the public welcome to drop in anytime between 3.30pm and 6.30pm to view information and ask questions about the Draft Plan. Information is also available on Council's website www.coppercoast.sa.gov.au, at Council offices in Kadina, and at the Tourist Office and Library in Moonta.

"We encourage the community to learn more about the Draft Plan and provide their feedback during the consultation period. People's views on the proposed infrastructure and environmental works will be taken into consideration in finalising the Draft Plan" said Mayor Paul Thomas.

The Draft Plan has been developed to better understand the stormwater catchments and issues in the three townships, and to identify stormwater management options that protect against flooding, and provide for sustainable use of stormwater, reduced pollution, and improvement of watercourses and the environment.

It is expected that works proposed by the Draft Plan would be implemented over approximately 30 years, and funded by Council and external funding partners.

For more information, please contact the District Council of the Copper Coast on 8828 1200